GLØD

From idea to production of GLØD

Bachelor thesis

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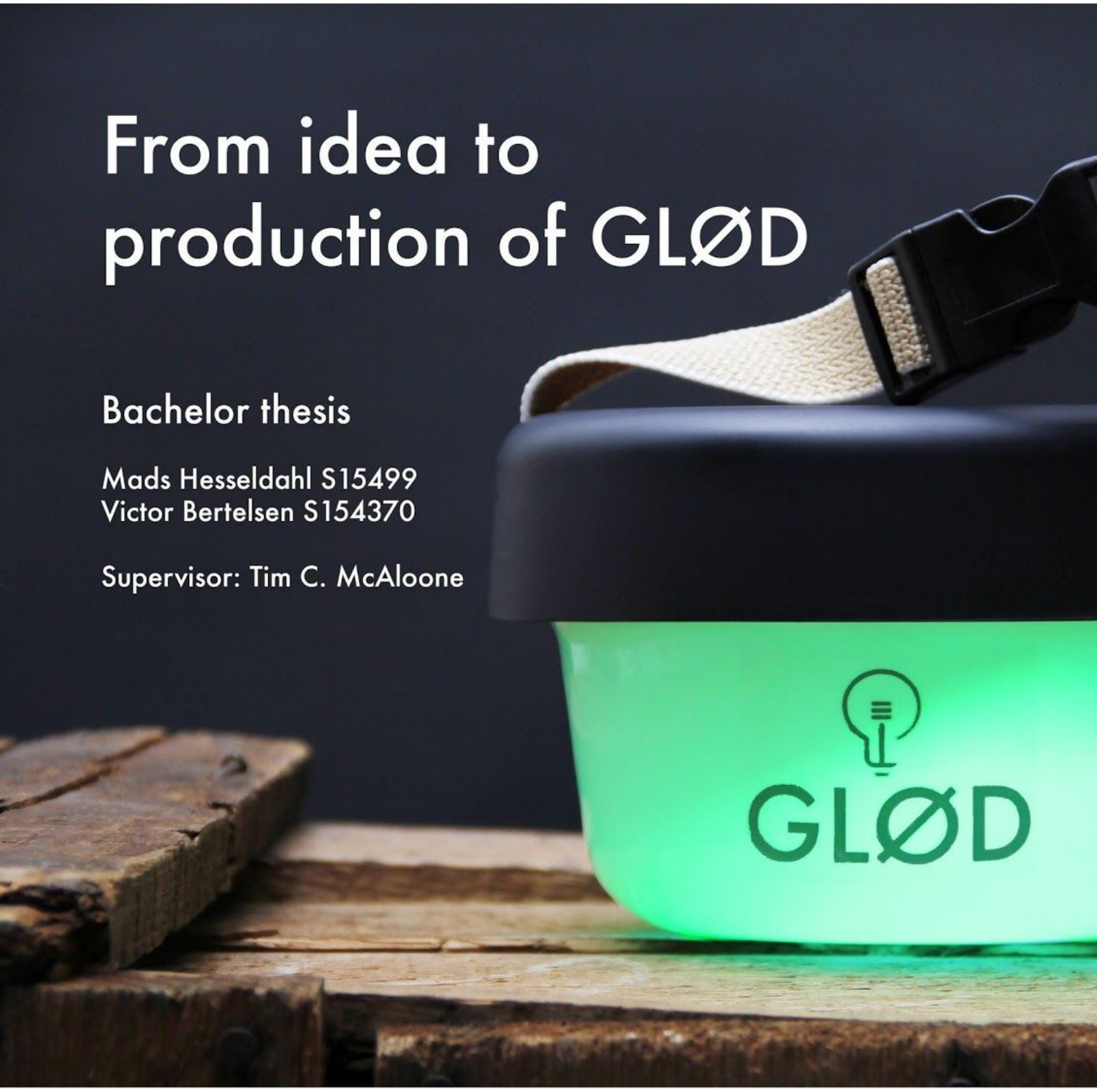

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Abstract

In 2017, for a school project 125 GLØD lanterns were made and handed out at Roskilde Festival in collaboration with Roskilde Festival Powered by DTU Students. The project confirmed the assumption that there is a need for lighting at the camping area, as it gets very dark at night. In 2017, a unique opportunity to follow up on the GLØD project as Volt Power banks invited GLØD to collaborate so Volt would distribute lanterns. It was decided to manufacture 500 units for Roskilde Festival 2018.

This paper will examine how a redesign of the GLØD lantern can be made for manufacturing and what production technologies and innovative ideas this requires. It is structured around the idea product model's eight dimensions and has been extended to include a ninth dimension as legislation was found to be an equally important part of the eight other dimensions.

As the project timespan is very limited it has been chosen to use agile planning to meet the ambitious goal of creating a new product, make and complete a manufacturing process plan while simultaneously marketing the product and creating a business.

The report will initially present the extensive research into production methods both in electronics and plastic molding. By engaging with people with knowledge of different manufacturing processes and calculating the amount of money each manufacturing technique requires it was chosen to use vacuum forming as the production method for plastic. Due to time limitations, electronics will be pick and placed with an assembly line of workers.

The report also describes the development phase. Here five concepts have been designed and prototyped. The concepts used knowledge gained from surveys made with the previous users from 2017. The prototypes were used for experimenting with the vacuum former and engage potential users to come with feedback.

A final concept was created based on the feedback from the users and optimized to meet manufacturing requirements. This report will describe how the production method for the electronics made it impossible to do the production in time.

Preface

This is the bachelor report of the project from *idea to production of GLØD* in relation to the B.Sc. Design and Innovation. The report is made by Mads Dalum Hesseldahl and Victor Domanyi Bertelsen and is produced at the Mechanical Engineering faculty at the Technical University of Denmark, DTU. The project is rated 15 ECTS credits.

Overall the project is distributed evenly, but in the project Mads Dalum Hesseldahl has been in charge of the development of the electronics and Victor Domanyi Bertelsen has been in charge of manufacturing methods.

The project was initially a special course in the spring semester of 2017. Here the product "GLØD lantern" was first developed and took part of Roskilde Festival as a student project in cooperation with the organisation Roskilde Festival Powered By DTU students. At that time, the product did not live up to official standards and requirements for an industrial consumer product. There was no considerations about legal aspects or creating a business regarding the design of the product, since it was meant to be given away at the festival and therefore did not have any requirements.

The aim of this report will be to describe the development of a redesign of the GLØD lantern from 2017 in order to meet industrial standards. The project will stretch from the 5th of february to the 21st of June 2018 and will be available for purchase through all Volt-shops at Roskilde Festival in the period from the 30th of June to the 8th of July 2018.

Acknowledgement

During this project we have teamed up with a number of people whom we would like to acknowledge. Without them this project would not have been possible.

We would like to give a special thanks to Chris Cornaby and Nikolaj Bobek Søndergaard from The Electrical Engineering Faculty of DTU for developing the electronics used in GLØD.

We want to thank our supervisor, Professor Tim McAloone for accepting the task and guiding us during the work with this project.

We want to thank Trygve Dam, CEO of Volt for always believing in the project and make it happen.

We also want to thank Anne Mette McAloone for giving us 200 Novo Nordisk insulin containers for the project in 2017.

Thanks to DTU Skylab for giving us access to network, storage room and daily help with the project.

We would also like to show our gratitude to Torben B. Christensen from the workshop of Mechanical Engineering and Bo Hagelskjær Larsen from the workshop at DTU Ballerup for building the molds needed for vacuum forming.

Thanks to Nicholas Fribert for being an essential part of the GLØD team and building up the business and Anne-Mette Spahn for marketing the product through social media.

We would like to thank Grow Nordic and the fund for Entrepreneurship Denmark for funding the project.

Lastly thanks to Lasse Skovgaard Jensen, Kathrine Jerichau Nissen and Daniel Baurichter from Roskilde Powered By DTU for making the project possible in 2017 and 2018.

Project motivation

When you see an object, you make so many assumptions about that object in seconds. What it does, how well it's going to do it, how heavy it is, how much you think it should cost The object testifies to the people that conceived it, thought about it, developed it, manufactured it. Everything touched by man is transformed by man is by very nature design[1].
[Documentary: objectified 2008]

This is what motivates us as design engineers. Handing in this bachelor thesis we are one step closer to become Design Engineers, having an impact on the products that surround us every day. As Apple's head of design Jonathan Ive puts it: *"The goal of industrial design has always been mass production. It's been producing standardized objects for consumption by millions and millions of people."*[2] For that to happen we need to use all the tools we have been given over the course of education in Design and Innovation. For both of us, this has been a dream since we started in gymnasium six years ago. Back then we both chose a study line called Design and Technology at the technical gymnasium - even as all of our friends chose the much more popular and socially appealing general gymnasium.

The Design and Innovation education has taught us much about product design from the conceptual phase and building prototypes that could represent aspects of the product idea. But there were always black boxes in parts of the development phase, usually the technology or manufacturing processes, which were taken for granted. In this project we wanted to understand every stage of developing a product and therefore the motivation lies in not black boxing anything and taking the product from idea to actual consumer stage.

[1] Hustwit, Gary. (Producer), & Hustwit, Gary. (Instruktor). (2009). *Objectified*. USA: Swiss Dots Production.
[2] Ibid.

Project objective

The camping areas at the various Danish festivals get very dark at night. Based on observations from the first GLØD project in 2017 assumptions have been made. To our understanding, people cannot keep up the party mood and they cannot find their things in the dark camping areas. We want to test a possible solution to this problem by producing 500 lanterns to light up this year's Roskilde Festival.

The aim of this project is to go from idea to consumer product and thereby explore what it takes to get a consumer product on the market.

For Roskilde Festival 2017, there was designed, produced and tested a more simple version of the lantern. The lantern for 2018 have been redesigned and are currently in a semi-large production. The lantern, which will be sold at Roskilde Festival 2018, has been improved for manufacturing.

In the project a investigation will be made of the solution space for the product through a conceptualization phase using relevant design methods. The solution that has been seeked is a product with the least demand for capital in regard to production, time, money and assembly. Relevant prototypes shall be made to test possible solutions before choosing the final concept and moving to production.
The success of the project will mainly be determined by time and money as the project team is working on a tight schedule and a low budget. This requires us to take fast and sometimes drastic decisions necessary to reach the goal. The project will follow a time schedule aiming to rush as quickly as possible to the production phase. This schedule is based on the "fast loop method" where the team will sprint through all of the phases and sometimes do more than one phase at a time.

For this project there has been primarily been focused on exploring requirements for manufacturing. There are other important elements of creating a successful product. The team could, for instance, have spent more time on user studies, usability research, the aesthetics of the design or in exploring opportunities for extending the functionality by connecting the lamp to a smartphone. However, due to the short time available, we have very consciously had to limit the scope of our investigation.

Learning objectives

1. Create a detailed plan of the project process.
2. Create multiple solutions for a specific new design of the product design by combining systematic and creative techniques.
3. Search and create knowledge for the project using experiments, interviews with experts and potential users.
4. Explain the success of the solution based on the needs of specific customers or from a description and assessment of market potential.
5. Design a mold that is best suited for mass production of 500 units.
6. Develop an electrical circuit suitable for mass production of 2000 units.
7. On the basis of an economic and temporal aspect, choose the best manufacturing method and location.
8. Produce a working prototype that can be mass-produced and cost-effective.
9. Design a business strategy and distribution strategy.
10. Use knowledge and skills from several of Design and Innovation's technological lines to find solutions to product features, manufacturing and user-friendliness.

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Introduction

This structure of the report is based on the framework of the product idea model which was introduced in the course "Arenas and Concepts". The model is developed by Claus Thorp Hansen and Mogens Myrup Andreasen in the search of correct use of expressions in the design process. They concluded in their article "ON THE CONTENT OF A PRODUCT IDEA"[3] that eight dimensions can help a company's management and a design team to notice product ideas. Claus Thorp Hansen argue that a complete product has fulfilled all dimensions.

As the main objective of this bachelor thesis is to manufacture a product for the consumer, it has been chosen to use the model as a guideline in the journey towards creating a product. The report is therefore based on the eight dimensions which we have chosen in the following order:

- Strategy, task and goal specification
- Need and user
- Product
- Technology
- Business.

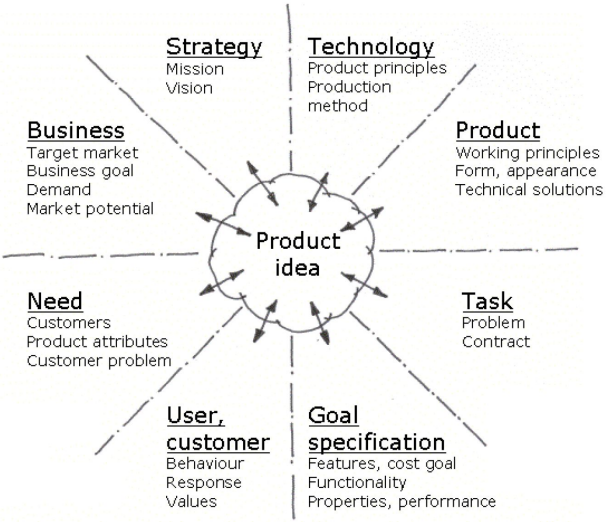


Figure 1: The Product Idea model

This order is found to be the most logical way of presenting the process of the project. Hereby the phases in this report will not be presented in a linear time span.

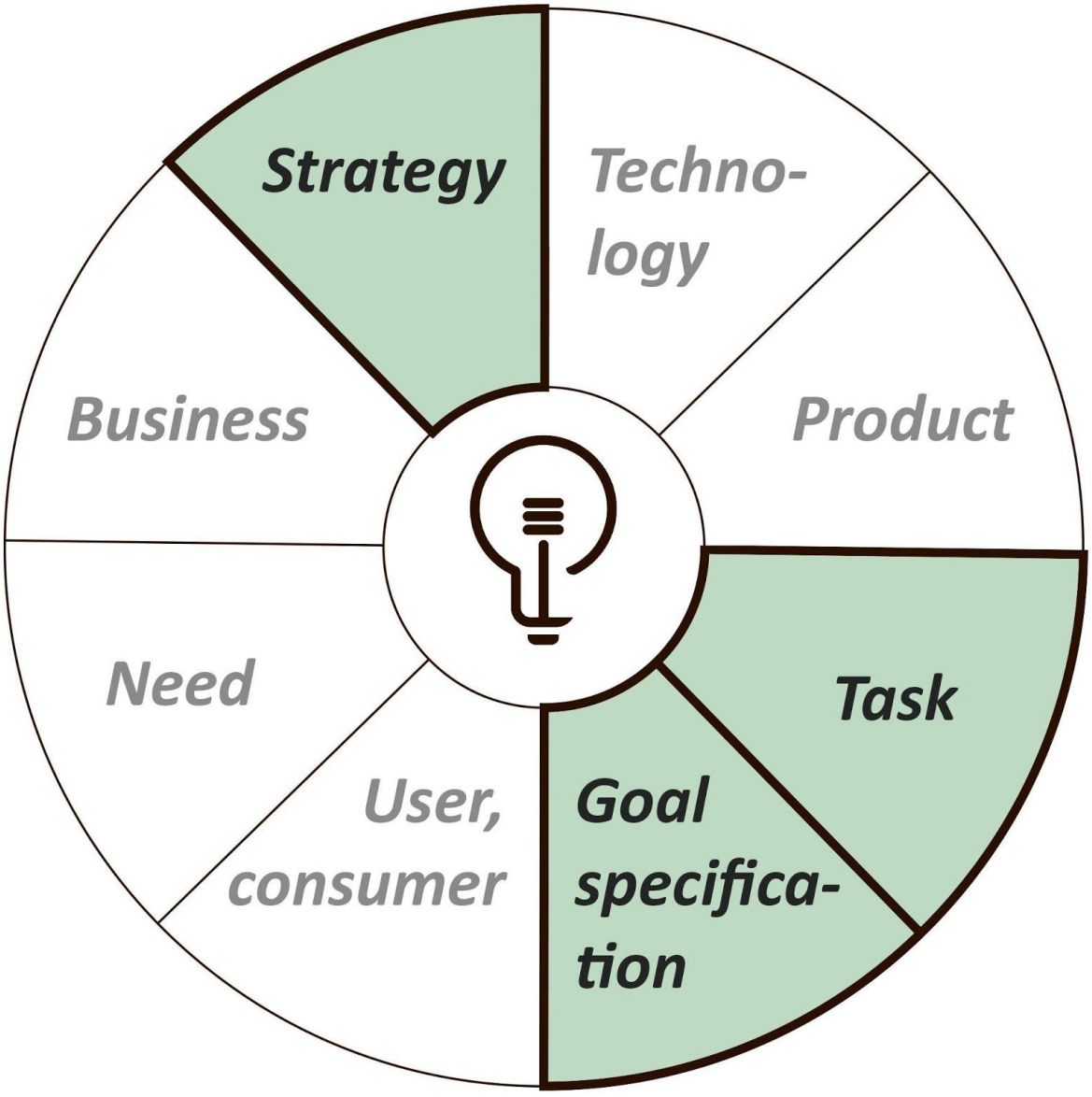
Introducing the team

In this thesis Victor Domanyi Bertelsen and Mads Dalum Hesseldahl will be referred to as the design team. When referring to the team, the report is referring to Victor Domanyi Bertelsen, Mads Dalum Hesseldahl, Nicholas Fribert, Chris Cornaby and Anne-Mette Spahn.

As the project is not only a bachelor thesis but in fact also a startup company, it has been necessary to recruit extra hands. The entire team involved can be seen on appendix 1 (The GLØD Team).

[3] Thorp Hansen, Claus og Mogens Myrup Andreasen: On the content of a product idea. I: *International conference on engineering design*, 15.08.2015, Sektion: page 1-14, s. 3-5 (article)

Strategy, task and goal specification



Phase 1,2 and 3

In this phase the overall problem and project goal will be determined and the teams vision and mission. The task of the project will be presented and based on the observations there will be developed a goal specification that will set the boundaries for the design process.

Task

So far, after three years as students of Design and Innovation, we have learned a lot about product development, user interaction, manufacturing tools and etc. However, all our projects so far have always stopped at the concept phase, because the objective was not to manufacture anything but rather to learn the methods behind Design and Innovation.
This results in neglecting a lot of details, such as electronics and manufacturing during the project, often referred to as “blackboxing”. We wanted to open the black box to understand the actual challenges in making a consumer product ready for sale.
As we produced 125 lanterns for Roskilde Festival 2017 we became familiar with some of the aspects we had neglected before. Since we were producing for a real end-user, we had to have a complete product with no loose ends. This aspect challenged us more than we had expected because we ran into a lot of small details that turned out to be quite complex when taking a closer look. We became aware that we lacked experience that will be useful working as a product developer.

We think that this is a good time to do a project like GLØD as we finish our bachelor in Design and Innovation. This will allow us to test what we have learned during the education, using a variety of methods and combining systematic and creative techniques to achieve a concrete goal.

We want to explore how manufacturing requirements place restrictions on a design and vice versa. Therefore the design explained in this report will be highly influenced by the manufacturing method.
In our education, we have only briefly dealt with economics. Mads Hesseldahl experienced as an intern at LEGO how economics has a great influence on design and choices such as manufacturing methods. LEGOs realization in developing a product is highly influenced by the production.

In our studies we have only worked with Design and Innovation students so far. With this project we saw an opportunity to work in a multidisciplinary environment. Design engineers often have to use other disciplines and competencies to make a product succeed - and through this project we have found a better understanding of role, we as Design and Innovation students can play in a product development teamwork.

Our goal with this project is at two levels. In practical terms we want to solve the problem of lack of lighting at the camping area at festivals. But our underlying, and primary purpose is to gain experience in making mass production possible.

This requires the design team to find solutions for product features, manufacturing, interacting with experts and creating prototypes and mockups to use in the development phase.

At Roskilde Festival 2017 we developed a business relationship with Volt, as they saw a potential in the product. Volt offered to sell GLØD Lanterns through the 17 Volt shops located at Roskilde Festival. This gave GLØD a unique opportunity to get a direct channel to the user.
Since it is a fairly simple product, we found it realistic to develop the methods to a manufacturing process. We are curious to see if this is possible on our current stage of the education.

Strategy

We will approach the project by developing a detailed plan of the project process.
The project runs from the 5th of february to the 28th of June. As 500 units need to be ready produced and assembled before the 30th of June when Roskilde Festival starts.
The schedule is very tight and is divided into sprints and follows an agile time planning. Quick decisions are made and work processes run simultaneously to run short feedback loops. An example of this is our research, which was done at the same time as the iteration phase. Thereby we could get quick feedback to see if we were doing the right research suited for the iteration.
Since we were trying to make all the phases of developing a product and writing a bachelor thesis in 5 months we have split the time plan into the following phases: Explorer phase, create, evaluate, production, report, presentation and sales-distribution.

While working we kept track of our activities in order to compare the schedule with the time we actually end up spending on different activities, to see if there is a difference.

The time plan was used during the entire process and was changed multiple times as the team became more aware of what possibilities and limitations there were for the manufacturing of the lanterns. Looking back at the plan, it was well estimated in terms of time for the different processes in the beginning, but as unexpected things came up such as the electronics not being ready in time, we had to consider other ways to manufacture the electronics, and we had to make changes in the timeplan accordingly.
In appendix 2. (Timeplan compared) the first plan is compared to the last plan of the project and it can be seen that approximately halfway through the project the first timeplan had to be changed drastically. This will be further discussed in the technology phase.

Figure 2: Time plan

Besides the time plan a day plan was used for the team to get more hands-on tasks to focus on during the weeks. The day plan can be viewed as a “to-do-list” and the time plan worked more as the overall view of the project.

Mission statement

To clarify the goal of this product, the team made a mission statement that is consisting of a problem, vision and a mission based on last year’s experience. It has been important as it functions as a direction for the product’s overall purpose and has created consensus in the team.

Problem

Festive mood is a big part of festivals and light can be a tribute to this. Due to the limited access of electricity at festivals camping areas, light at night is little or not existing. The problem this project wish to solve is the lack of lighting at the camping area of festivals.

Vision

We want to change people's attitude towards partying so that light becomes as integrated a part of the festival environment as portable music systems are today.

Mission

The market for mobile lighting is booming and it is becoming more common to have a power bank at festivals. Power banks, meant as a backup battery for mobile phones, have increased in capacity and duration. The market focus for the established companies in the lighting industry is on garden and home use. But the need for mobile lighting at festivals and other outdoor gatherings still has an unexplored potential.

The mission of this project is to add an extra dimension to the mood that light creates by making light interactive and portable.
The mission is to manufacture lanterns that are easy accessible at the festivals and cheap enough for a regular festival participant to buy and create parties in small camps at festivals. Longer term, there may be further market opportunities in home gardens and outdoor parties, since these types of parties can also enjoy and benefit from interactive lighting.

Goal specification

The team has written a design specification that is a quite short, but complemented by a more detailed document providing information about the specifics of the product such as dimensions, materials, manufacturing method, cost, aesthetic, functionality and etc.

Design Specification

A design specification was created to achieve consensus about the product in the design team. Here, we wrote requirements such as “The lanterns power source is a power bank” and criteria such as “A solution with a strap, so the lantern can be hung, is preferable”.
The design specification was created early in the process based on the questionnaire analysis and knowledge from last year. The Design Specification can be found in appendix 3. (Design specification). It was changed three times during the project and each change was related to a reduction in the amount of units we intended to produce; first from 2000 units to 650 units and then to 500 units as the team gathered more knowledge about what a mass manufacturing process required.

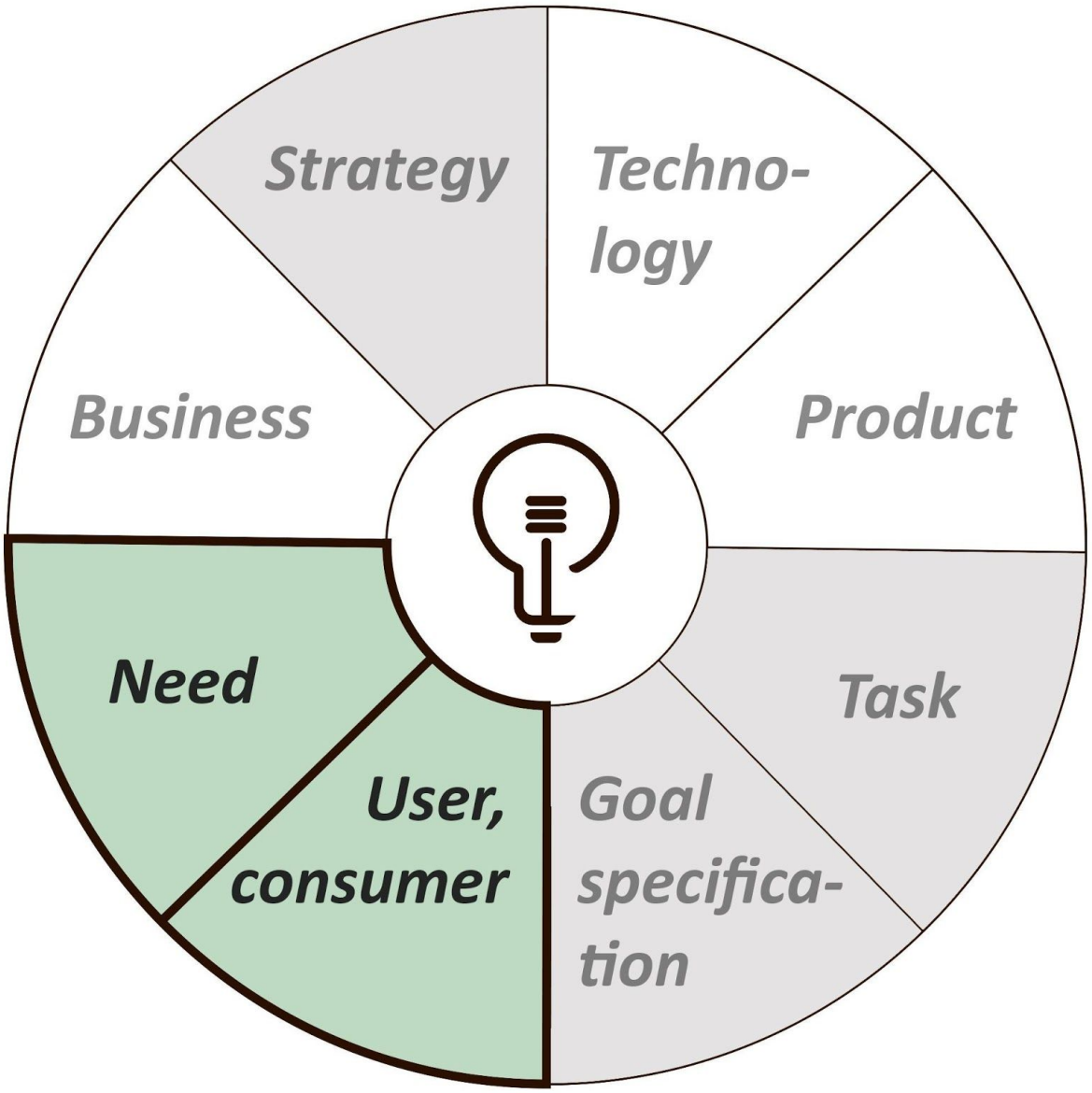
Power bank determination of size

As the lantern is driven by a power bank, the design team found it necessary to research on power bank sizes. There are many power banks in different shapes and sizes available on the market. The size of the power bank has a big influence on the lanterns dimensions. We have made an analysis to determine the right size of the power bank so most power banks will be able to fit inside the lantern. We therefore created a sheet of dimensions and used the web to search for 113 different power bank sizes (Appendix 4. Power bank size). The analysis showed us that power banks vary quite a lot in size. Some of the power banks were very big and we knew from our survey that people had requested that the lantern got

smaller. Therefore we had to decide the maximum dimensions of the power bank we could accept in our design. From the power bank sheet, we estimated what size would be suitable. We made a decision to dimension the biggest power bank to fit inside the lantern to be 140x85x35mm and made it a criteria in the design specification. This covers 52.8% of the power banks in our sheet. We figured that this would allow the lantern to have a handy size. Trygve Dam, CEO of Volt Power Banks, has informed the design team that one-third of the Roskilde Festival guests use the Volts power bank service. A Volt power bank's dimensions are 75x75x12 - and this is within the lantern's dimensions.

Using the design specification, the team are able to create consensus. In the case of GLØD the team had a very clear idea of what the design specification needed to contain and a discussion did not follow. The design specification was later used to evaluate the concepts and was a good tool to measure how well the different prototypes was fulfilling the needs and requirements of the team.

Need & user



Phase 4 and 5

In this phase focus will be on evaluating the product from last year with a questionnaire analysis and the products attributes.

Introduction

During this project, the design team has involved the user in the different stages of the product development with quantitative and qualitative interview methods. In this section the team will explore the need and the profile of the user of the product from 2017 by using a quantitative approach.

The team created an online survey and asked participants from 2017 about the lantern. The goal of this was to collect information about what aspects of the product needed to be improved from a user perspective. The survey should tell in which situations the product was used and give an idea of who the user was and what they were using the product for. The need is an important aspect of the product development phase to explore. We do not want to create something that nobody wants. We had in mind, what Eric Ries says in his book, The Lean Startup: "As a result of getting to know customers extremely well, it sometimes becomes clear that the problem we're trying to solve for them is not very important"[4].

A description of the GLØD-lantern from 2017 can be seen in Appendix 5. (Produkt 2017).

Background for questions

At the two workshops held at Roskilde Festival 2017 in coorporation with Roskilde Powered by DTU Students, all participants were asked to share their observations and opinions to help in the product development phase of a GLØD lantern 2.0. The questionnaire, which the workshop participants filled out at the time can be seen in Appendix 6. (Contact info form before workshop).

At the time, the workshop was a great opportunity for the team to make a large scale test of the product and to gather data about the user experience.

The questionnaire was developed to collect empirical data on the users' experiences with the lantern and to get new ideas of potential improvements. The questionnaire was created in collaboration with Nicholas Fribert, who is a student at Copenhagen Business School, it was sent out on thursday the 9th of february at 12 o'clock as this is the time most people are available[5].

65 out of the 125 people that received a lantern at Roskilde Festival agreed to be part of the survey, and 34 of these 65 people answered the questionnaire.

It was a surprisingly high percentage of people answering given that the questionnaire was sent out approximately 8 months after they had received a GLØD lantern.

[4] Ries, Eric. (2011) The lean startup. New York: Crown Business. Page 113

[5] Coopper, B. B. (13/01/2018). A Scientific Guide to Posting Tweets, Facebook Posts, Emails, and Blog Posts at the Best Time. Buffer Social. Found [04/01/2018]. At [https://blog.bufferapp.com/best-time-to-tweet-post-to-facebook-send-emails-publish-blogposts].

The idea behind the questions

The team acknowledged that the user were doing this voluntarily, so it was important to make the questionnaire as short and easy to fill out as possible. Therefore it was chosen to make a questionnaire with only 10 multiple choice questions in Danish with the possibility to add comments.
An online program called survey-monkey.com was used. We chose Survey-monkey since it is compatible with smartphones, to make it as appealing to users as possible. The questions were mostly objective, but in some cases such as about price, we consciously chose to take an active standpoint in order to provoke a reaction from the user. In such a question it was asked if the users would to pair a higher price than expected. This was recommended by The Design Guide of The Technical University of Delft[6].

According to Surveymonkey, the participants spent an average of 3 minutes and 10 seconds on the questionnaire, which was in accordance with The Design Guide of The Technical University of Delft which says that the participants do not want to spend more than 5 minutes on a questionnaire. The questionnaire is summarized in a worksheet in appendix 7-9 (Questionnaire analysis).

The Design team needed to collect as much data as possible to increase the chance of drawing the right conclusions. Therefore participants were both contacted on email and SMS. An example of this can be found on appendix 10. (Mail to workshop participants).

Analysis of the answers

From the questionnaire approximately 63% of the festival guests were at the age between 20-25 years and most of them were men (64,7%). This correlates to the age of the most common Roskilde Festival participant[7].

The Design Team were curious to know if the user had a power bank, when they built a GLØD lantern at the event at Roskilde Festival 2017 where the lanterns were distributed. The response showed that around 82% of the participants had a power bank, of which approximately 50% had a Volt.

In one of the comments, it was mentioned, that a solution where there was room for another power bank than Volt would be appreciated. This result was very important to the design team since GLØD is differentiating itself on the market by not having an inbuilt battery. Therefore this question showed that the team should focus on building a lantern that would be adaptable with other power banks than Volt.

[6] Van Boejien, Annemiek with others. (2014) Delft Design Guide. Amsterdam: BIS.
[7] Tüchsen, Henrik. (03/07/2015). Her er den typiske Roskilde-gæst. FødevarWatch. Found [01/04/2018]. At [https://fodevarewatch.dk/Fodevarer/article7846984.ece].

The fact that 82% of the participants had a power bank indicates that the team had good reason not to integrate a battery in the future product, as a large part of the participants already have access to a power bank but not specifically a Volt. But as it was announced that the lantern was power bank driven, one could argue that people without a power bank would not participate in last year's workshop.

In the questionnaire, 76% of the participants brought the lantern with them home. Many people commented that they had wanted to bring it home, but could not do so since it was either stolen or lost. This shows us that many people value the lantern as more than just a festival party gadget, and actually want to bring it home to keep.

The first version of the GLØD lantern had two modes, "the party mode" and "white light mode". The design team were curious to know if people used the party mode or simply just the "casual light mode". We decided to ask the participants "What did you use the lantern for?". What surprised us most was that while almost all functions were used by the user, the lantern was actually mostly use to *chill* in the camp and in the tent. The design teams assumption was, that the lantern would only be used for partying or to find participants things.

Many of the participants commented "the party mode does not work" or "the lantern is not properly made for festivals" and also "the sound level the party mode detects should be better adjusted". Based on this, the design team recognized that there is a lot to improve on the party mode. The questionnaire shows that people appreciated the party mode and the design team assumes that many have tried it, but then realized that it was not working as they expected.

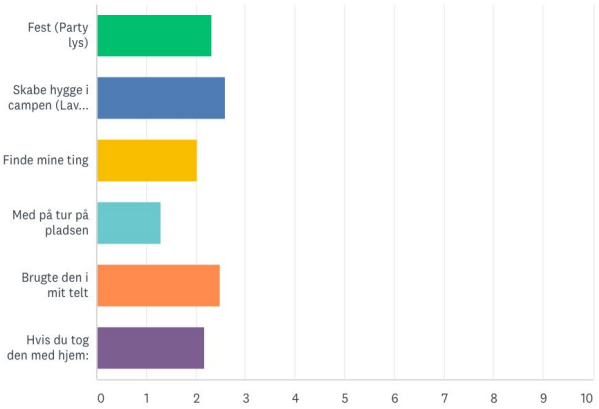


Figure 3: Time plan

Regarding the "white mode", the team did not expect it to be such an important part of the lantern. The mode was mostly intended for people to find their things. But since the lantern was used for "hygge" in the camp the design team will investigate how to improve this functionality. But the "white light"-mode was also used as intended since approximately 40% did use the lantern for finding things.

People that have brought it home and used it commented that they use it in their living room or as an outdoor accessory. This sounds very promising since the lantern is then moving to a an additional market that seems to be popular, as indicated by the sales of outdoor garden lights and the many outdoor lights presented at the Stockholm Furniture and Light fair. This will been further discussed later in the report.

Our survey shows that users were not satisfied with the way the GLØD lantern was supposed to be hung. This tells the design team that a new way of hanging the lantern should be explored. The old locking mechanism for the strap of the lantern was magnets. The team assume that the magnets was not strong enough.

70% thought that the light was sufficiently intense. That was a surprise to the team, because it was assumed that the lighting was rather weak. One person mentioned that when the lanterns were brought home the light should be more intense.

55% thought that the party mode added value to the party. That was not as much as expected since the assumption was that the party mode was a key factor for the lanterns functionality.

About 80% thought that it was easy to plug in the power bank - which tells the design team that focus should not be on a new method for connecting the power bank, but rather focus on the size of the space where the power bank is mounted.

Around 70% thought that the lantern was easy to carry around and that it was the right size. We did not expect this since we thought the lantern was rather big. However, many of the participants added comments that they would only buy the lantern if it was smaller. So the team are not certain if the answer can be trusted since it seems that it is not correlating with the comments.

Approximately 10% would buy the lantern next year if the price was 299 DKK. About 65% of the participants would buy a GLØD lantern if it had a lower price. 33% would not buy it at all. This made it very clear that the price needs to go down. Most people suggested a price around 100-200 DKK. At the time of the survey, such a low price seemed achievable since the last lantern was a prototype and needed a lot of improvement, which we assumed could lower the cost.

One comment requested a version with a solar panel. Some suggested that it should be more water resistant. It was also mentioned that the product needed to “mature a lot” for it to be sold and that the strap should be better attached.

A user appreciated the different labels that could be chosen for the sides of the lantern, and found the label decorative for the lantern. Multiple participants suggest that the design of the front should be designed at home and then the lantern could be picked up at the festival. The design could also show one of the bands playing at the festival on the front of the lantern. A participant appreciates that the Roskilde Festival logo is on the lantern.

We asked what the user found most important; size, price, light intensity, the party mode or useability? They were all given almost equal, but It seems that price and size are the most important factors for the users.

Overall, the design team estimates that the data quality of our survey is relatively good. The answers seem reliable and the suggestions of the participants relevant. The team knew many of the problems of the last lantern, as it was collecting qualitative interviews at the festival. But using the online survey it is easier for the team to have the product evaluated in a somewhere objective and measurable manner.

Inscription og description

Based on the questionnaire analysis the design team realized that some of the inscriptions in the product did not follow the intended understanding that the designer had.
As design and Innovation students we were introduced to the terms inscriptions and descriptions through the course Technology Analysis. We used these concepts to systematize the inputs from the two workshops (see appendix 11. Inscription and Description) to get an understanding of what the designers could improve.
The *inscription* is the designers subjection of usage and the *description* is users subjecting usage of the product and follows the statement. Using this method, the overall script that the designer and user can agree on is placed in the middle of the figure.

The aim of this method is to align the understanding of a product's properties between the user and the designer, so the product's properties make it clear how the product should be used. The inscription shall follow the description of the user and hereby follow the statement: "*..the inscription establishes a normative vision and thereby a preferred understanding of the object of knowledge*"[8].

Using the method it was interesting to discover where the designers were not aligned with the users understanding of the product, as many inscriptions did not correlate with the descriptions.

[8] Jennifer Whyte, Boris Ewenstein, Mike Hales & Joe Tidd (2008): Managing Knowledge Representation in Design. Kap. i H. Scarbrough (red.): The Evolution of Business Knowledge (page 194). Oxford: Oxford University Press.

Functioning

Based on the inscription and description sheet a functioning sheet of pros and cons was created. The sheet involved the three main actors of 2017: the user, the designer and Roskilde Festival (see appendix 12: Functioning - Pros and cons). The pros and cons sheet and the inscription sheet created a overview of what the product from 2017 lacked. This worked as elements that had to be considered in the product development phase. The elements are listed below:

- Party mode is not used all the time
- The lantern are mostly used to create “hygge” and a chill mood.
- The lantern is too big.
- The materials used are not made for festivals. The leather gets gross, foil tears off and the glue at the magnet loosens.
- Party mode flashes too much and does not react well enough to the music.
- The space for the power banks does not fit the majority of power banks.
- The straps closing mechanism is not strong enough for the lantern to hang.
- The product looks more like a container than a lantern.
- The act of placing the power bank is counter intuitive for the user as the lid can be screwed of and hereby the raw electronics will be exposed.
- There are no off button, which is usually the case with electronic products.

This list gave the design team a concrete list of elements that should be changed when starting the development phase.

An example of this is the strap on the lantern. The first lantern was designed with a leather strap. The design team originally thought it would be more elegant and saw the magnet lock as a simple locking mechanism. But the users found it annoying that the leather became dirty and wet.
With the list, the design team realized that the users are not as focused on aesthetic details such as the leather strap, the magnet locking mechanism and the cork lid. But the users are more practically oriented and focus on functionality such as the materials being able to withstand the harsh environment on the festival.
It is important to keep in mind, that these users are not sitting at home in a clean apartment. Rather, they are drunk at a dirty and wet festival, which means that the new product needs to be robust, simple to use and easy to carry and hang.

The right path?

The questionnaire analysis confirmed that the solution for the problem *darkness in the camping area at night* is a lantern, and it indicated that the lantern from last year needed some adjustments to function as a marketable consumer product.

We realize that we could have chosen a different, more fundamental approach by initially collecting data to determine more precisely if the darkness is really a problem for users. Thereby we would have taken a step up the abstraction ladder by asking the question "why" - is darkness a problem? An answer to this could, for instance, have been "the festival participant does not have enough fun at night".
We could also have gone another way *down the abstraction ladder* and asked how do we solve the problem? It does not necessarily have to be a lantern, it could just as well be a projector that lights up the festival camping area - or simply making a plan for Roskilde Festival for organizing better lighting.
Going down the ladder of abstraction, the lantern might not have been the right solution. But as the design team wanted to explore the task of manufacturing lanterns, the team assumed that the lantern would be a useful product and a good solution, as they were popular in 2017.
It is obviously hard to measure if the popularity in 2017 was due to the lantern being free and a fun building project as the lanterns were handed out from a workshop.
Such questions can all be part of a design process. But as the team followed a strict time plan and wanted to focus on the manufacturing aspects of the innovation process, we deliberately choose not to climb up the abstraction ladder to seek alternative solutions.

A question that the team has tried to find an answer to multiple times, is whether people are willing to pay for a GLØD Lantern to have their need satisfied? In the survey the team asked participants from 2017 if they were willing to pay for the lantern at the price of 299 DKK. However, since it is just a questionnaire, people do not commit themself to buying the product.

In the book, The Lean Startup, Eric Ries writes that a startup must to be able to sell a minimal viable product (MVP)[9]. A good way of doing this, is to locate a small group of very committed customers, that are the most likely to buy the product. The startup shall then test if the group will buy the MVP.
In a sense, GLØD missed this opportunity, as we had our MVP (the product from 2017) and the target group – the early adopters that answered the questionnaire. Since the team did not give the early adopters the possibility to purchase the product, the team could not make sure that a potential user is actually willing to purchase the product. To test it, the team should have tried to get potential customers to bring out their wallet and buy, this would have confirmed if there is a market. Before that point it cannot be assumed that there is actual buyers.
The Lean Startup advises: *"If we've discovered that one of our hypotheses is false, it is time to make a major change to a new strategic hypothesis"*[10]. In that case, the team should have

[9] Ries, Eric. (2011) The lean startup. New York: Crown Business. Page 8
[10] Ries, Eric. (2011) The lean startup. New York: Crown Business. Page 77

considered that if participants are not willing to pay the price of the product, then we should have changed something drastically. By not having sold the MVP, the startup runs a big risk of manufacturing a product without knowing if there is a need for the product.
The few early adopters that the team had a conversation with one on one argued that they already had a GLØD-lantern and were not interested in buying another one.

User

As we found out doing the inscription and description analysis, there are a number of issues that the design team did not consider when designing the first GLØD lantern. We concluded that we need to know our user better and reach a consensus in the design team about who we are designing for and what their weekday looks like.

Observe users in action

Thus, the design team created a user trip based on memories from earlier trips to Roskilde Festival (appendix 13: User trip). The user trip was done according to Nigel Cross' method, described at page 60-61 in Engineering and Design Methods[11].
The design team chose to make a user trip since we noticed that the product from 2017 lacked practical and functional needs. The goal of the user trip is to become familiar with the environment that the product is used in. Nigel Cross says that a simple first step in user research is to use the product or service yourself with a critical mindset. Since the Roskilde Festival is only once a year, we have chosen to base the user trip on our experience in 2017. This user trip was formed so that the design team had the "festival participant's" point of view and therefore, the user trip describes the typical situations that a festival participant might experience. The user trip was used to create ideas about what functions the GLØD lantern should have and what it should be able to withstand.

According to the user trip a Roskilde Festival starts by packing for the festival. This is usually done the day before leaving and that means "not very carefully". One might argue, that this is a reason why the festival lacks lighting. In a rush festival participants does not think about light as a priority. One of the reasons why this is not a priority is also because portable light is not an integrated part of a classic packing list (appendix 14. Packing list). Most of the things participants bring are put in a big bagpack or sports bag and therefore there is basically no space left for a portable lantern, except if it could hang on the outside of the backpack. Also, if participants go to the festival by train, there is little space for luggage.

These considerations made it clear to the team that it will be beneficial to have a distribution channel at the festival. The lantern should be distributed at the festival, from where people also pick up their Volt power bank and buy a subscription for recharging.

[11] Cross, Nigel . (2016) Engineering Design Methods. Sussex: Wiley.

Going through the user trip we also identified some situations where GLØD can potentially add value to the experience:

- When people stay in the tent and chill because it is raining outside.
- When people come home from a concert and need something to keep the mood going.
- When people need to light up the tent to change clothes.

Identifying opportunities

The user trip gave us the idea to create a user scenario (Appendix 15. User scenario). The user scenario was done according to Nigel Cross[12]. This worked as a way of visualizing the situations and context GLØD could be involved in and therefore the scenarios could serve as a “guideline for the designer” as Nigel Cross describes it.

We expect people to buy the lantern at the festival and bring it home, which is why we added the ”transport back from the festival” scenario. We also added new scenarios such as “beach tour” and “chill in the yard” based on the competitor analysis (that will be discussed later in this report).
All these scenarios have one thing in common, they are outdoor activities and therefore it is very important that the lantern can handle the conditions.

[12] Cross, Nigel . (2016) Engineering Design Methods. Sussex: Wiley. Page 63-64.

Research inspiration

Stockholm Furniture & Light Fair

As part of our research, we visited the Stockholm Furniture & Light Fair. The purpose of the trip was to gain insight into the market for lamps and especially mobile and outdoor lamps that are available for the consumer. We found the fair relevant since all the exhibitors at the fair are Scandinavian brands, which goes hand in hand with our aesthetic design ambition for GLØD as a nordic design product. The fair was also a way to gather inspiration for the upcoming product development phase.

Figure 4: TEKO lamp

Research and inspiration

As part of the research phase in the timeplan. Victor traveled to Stockholm Furniture and Light fair to gather information about the lamp industry and where it is heading.

The overall impression at the fair was that the market for mobile outdoor lights is growing and that consumers want to be flexible in placing their lamps in the living room and gardens. This was something that several sales personnel at the fair informed Victor about. As the battery capacity have increased many brands are now exclusively making portable lamps. These are brands such as fatboy, Follow-me-lamp, Fermob and some part of the Phillips Hue series. See appendix 16. (Stockholm Furniture and light fair) where the full research process at the fair is described.

Competitiv analysis

Based on our observations at the Stockholm Furniture & Light fair and from various webshops, we made three competitor analysis in the categories design, price and alternatives. The purpose of the competitor analysis was to get an understanding of the competitors' price, design and functions.

What we saw at Stockholm Furniture & Light fair was mostly design lamps, so the *design category* analyses was created on basis of the fair (see appendix 17. Analysis of competitors design). As we are aiming for GLØD to have the same design language as the portable lamps in this category, it was relevant to create this analysis. As GLØD is a newly started startup the company does not have the same brand and integrity as the brands at the fair.

The category "price" consists of practical and cheap lanterns that are made to light up to see at night - but not suitable for "hygge". They are simply made to satisfy the purpose of seeing in the dark (appendix 18. Analysis of competitors price). As GLØD is targeting

students with a limited budget these competitors is most likely to be bought by our target group for the festival.

The last category of the competitor analysis is *"the alternatives" category.* Here the analysis is made wider and include artefacts such as people's smartphone and non portable lamps. In this category an LED-strip and a light controller is included as many bigger camps at Roskilde Festival use this to create a party mood (see appendix 19. Analysis components alternatives).

Image board

The design team chose to make four imageboards in *Cambridge style*, which was introduced in the course Industrial Design.

- Lifestyle. Illustrates the target groups lifestyle.
- Mood. Illustrates moods and feeling associated with the product.
- Styling. Shows product and product qualities that create a desired atmosphere.
- Usage. Shows products that are used and handled in a similar way.

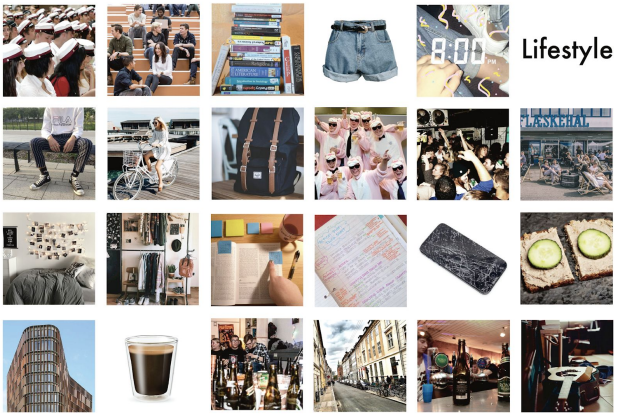


Figure 5: Image board - Lifestyle

This method was used to create consensus in the design team about what the product should make the user feel, what user the product is targeting and what style the product should have.

As seen on the board the product is targeting students in Denmark.
The Lifestyle board shows, the target group does not have a lot of money so they eat cheap but healthy food such as rye bread with cucumbers. They study hard and get up early, they drink beer whenever possible and live in big cities, drink a lot of coffee and get around on bicycles.
The board for styling contained a number of the products from Stockholm furniture and Light fair that we found attractive. There is a clear contrast in the colors used on the products and they are mostly made of plastic. Usually very simple products.
The usage board is mostly RGB lights and portable things, lights for parties and cozy moments.

The mood board is closely related to the usage board. It also resembles parties, and specifically outdoor parties, mostly at festivals (appendix 20. Image board Lifestyle, 21. Image board Mood, 22. Image board Styling and 23. Image board Usage).

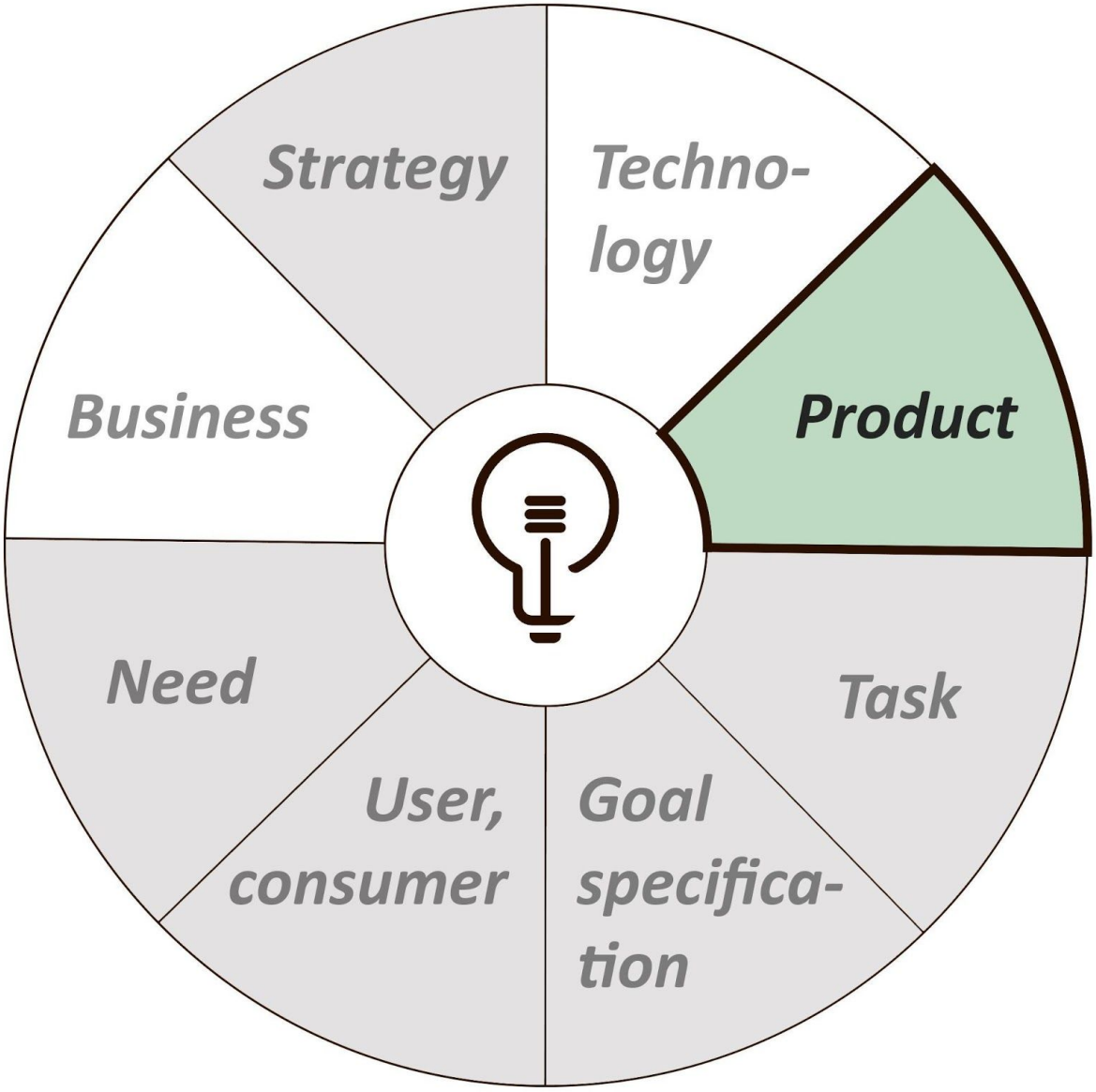
GLØD on the market

When the competitor analysis was made our focus was on products that we had seen at Stockholm furniture and light fair and products found on the internet.
Since the team assume that GLØD is the only actor with portable interactive lights on the arena for festivals in Denmark, it is somewhere not relevant with a competitor analysis. The question is not as much rather the consumer buys a similar product but more if they have a need to buy the product in the first place.
Students have a limited budget when it comes to purchasing products at the festival and might be more interested in spending their money on other festive items such as beer, music or funny hats. The conclusion to this can be, that there is limited competition on the festival arena, might be one of two things: either there has not been developed a smart solution for the need yet or the need is not existing.

The analysis showed that there was two very different price and quality categories. According to the design specification the GLØD-lantern should be priced at 200 DKK which is in the cheap category. But if an external power bank is added to the price, the price will raise to app. 599 DKK (using a Volt power bank[13]). This makes the GLØD lantern stand out of the categories as it is priced in the middle. Therefore it was difficult to see a direct competitor from the analysis.

[13] Buy Volt power bank. Found [06/21/2018]. On [https://getvolt.dk/da/festivals/roskilde-festival-2018].

Product



Phase 6

In this phase focus will be on creating a product that lives up to the design specification. This will be done in four different phases.

Introduction

In this phase we will determine the design of the lantern with the knowledge obtained from the target group, the user survey and the research from Stockholm Furniture and Light Fair. Since the product has to be developed and produced before Roskilde Festival 2018, the manufacturing will play a key role in the product development.

The product phase can be expressed through The Double Diamond Model. The double Diamond model consist of four phases: discover, define, develop and deliver.

First the design team **discovered** different manufacturing methods through fieldwork at potential factories. This together with the empirical collection of the users feedback from the survey of the lantern will help the team **define** possible solutions to the users need by the iteration process. The iteration process will be diverted into five different concepts. The concepts will be **developed** using prototyping methods and be evaluated using user feedback and knowledge from the discover phase. This will turn into one final concept that will be manufactured to be able to **deliver** to the consumer at Roskilde Festival 2018.

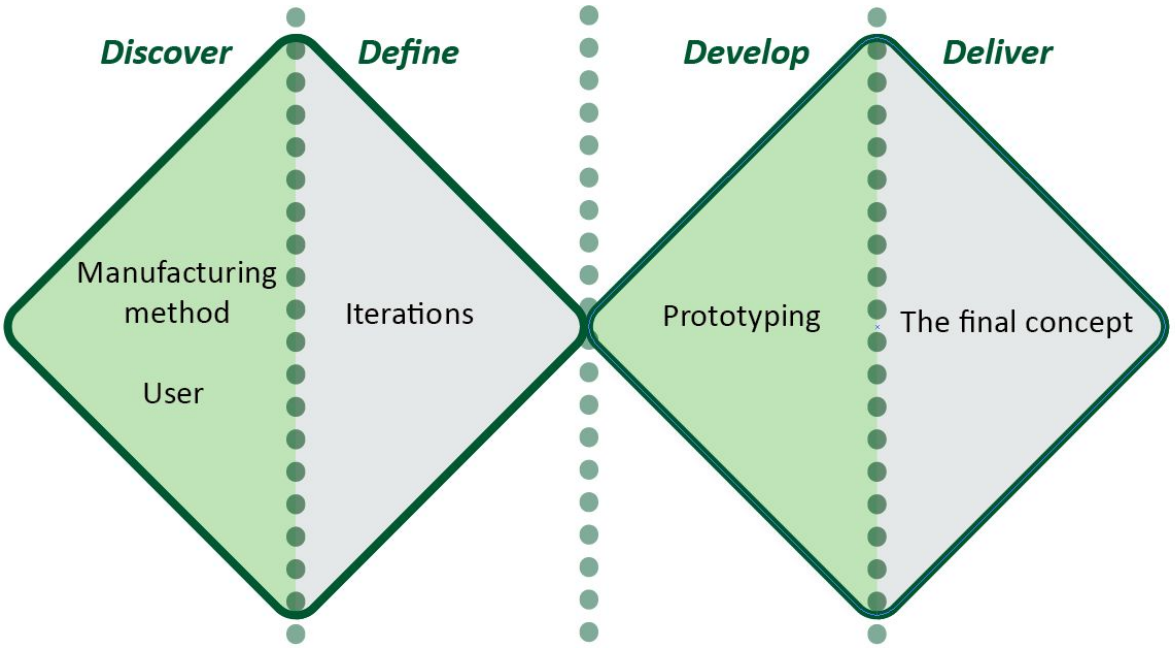


Figure 6: Double Diamond Model

The four phases in the Double Diamond model has been used to guideline the product phase and will be presented in the following order: Manufacturing methods, iteration, prototyping and the final concept.

Manufacturing methods

Picking the right manufacturing method

This project examines how to move an idea into actual production. Due to the tight schedule timewise, most of our focus has been on manufacturing and understanding the benefits and restrictions of potential manufacturing methods.

We chose to do the manufacturing in Denmark for several reasons. At the beginning of the project we needed to get a sense of what possibilities there were for placing the manufacturing from an economic, design properties and time perspective. The team gathered knowledge about what restriction the different manufacturing process' had. Speaking to manufacturing consultants the design team was advised to keep the production in Denmark.
Michael Pil, who is a plast engineer and has worked with production in China multiple times, told us in a mail-correspondence:

"Hold jer fra Kina. Hvis ikke det er simple produkter, bliver I snydt. Så enkelt er det, med mindre du har din egen fabrik" [Appendix 24. China Mail korrespondance for full mail correspondence]

Manufacturing method for plastic

The design team was introduced to several different manufacturing methods in the course of Analysis and Redesign. According to our design specification a container that is robust, fairly cheap and semi transparent is preferable. These properties suited plastic very well and according to the agile time planning the design team took an early decision to have plastic as the main material for the container. To accompany the design specification we visited two companies in jutland that could be potential manufacturing partners.

The first company was Letbæk plast and the second is FC Systems.
Letbæk plast is a company that was recommended by our bachelor supervisor Tim McAloone. The company focuses on circular economy and is experimenting with recycled plastic from fishing nets. This would not only add value to the product but would also be more sustainable.
The other company, F.C. system, specializes in vacuum forming and was a tip we got from a TEKO student at Stockholm Furniture and Light fair.

Letbæk Plast

During a visit at Letbæk Plast the design team gathered valuable knowledge about injection molding. The design team had expected that in order to get the right flow of plastic in the mold specific calculations about the inlet and outlet was needed. As an unexpected factor most molds' plastic flow is decided by the gut feeling of a experienced toolmaker and not advanced computer calculations. The process of making a mold is
often done by trial and error. Usually the toolmaker will make the first iteration of the tool and then test it at the factory to see if any adjustments is needed. If so, the tool is brought back to the toolmaker and the adjustments are made.
Adjustments are usually made 5-6 times before the mold is perfected.
Speaking to the head of development, Martin Holm, he informed the team that a formbox holding the injection mold told is required. The form box often costs from 30.000 kr and upwards and producing the mold can easily cost 50.000 kr. This is further discussed in appendix 25. (Letbæk Plast).

Figure 7. Letbæk factory

FC systems

Visiting FC system the team spoke to managing director Heine Smith Dinesen. The manufacturing technology available at FC Systems is vacuum forming and CNC-milling (see appendix 26. FC systems).
Vacuum forming only requires a tool that is easy to make with the requirements there is. For prototyping, the tool can be made of cheap materials such as MDF or 3D printed objects. But the manufacturing is both expensive in materials, man hours and waste.

Figure 8. FC Systems factory

DTU Ballerup

To seek advice about production methods the design team visited DTU Ballerup prototyping laboratory as they have experience with both injection molding and vacuum forming. The design team spoke to Bo Hagelskjær Larsen that informed about the school having a vacuum former available.

Figure 9. Vacuum formed sheet

The vacuum former could be used for production, but equally important to create prototypes in the prototyping phase to gather knowledge for the exact requirements of the manufacturing (see appendix 27. DTU Ballerup).

Comparison of production methods for plastic parts

To conclude our research we made an estimate of the
project cost, using the production prices given from FC systems and Letbæk plastic. These estimates include the factory's initial cost, such as setting up form and material stock.

When comparing the two production methods (appendix 28. Comparison of production method) it is clear that the making of a form for plastic injection molding is significantly more expensive than the form of a vacuum former. As the complexity of a vacuum mold is much lower we can build the mold our self or have the faculty of mechanics do it for free. The price evens out when you produce larger numbers of units. Looking at the graph below we can see a drastically drop in price for plastic injection molding pr unit while vacuum forming stays very constant.

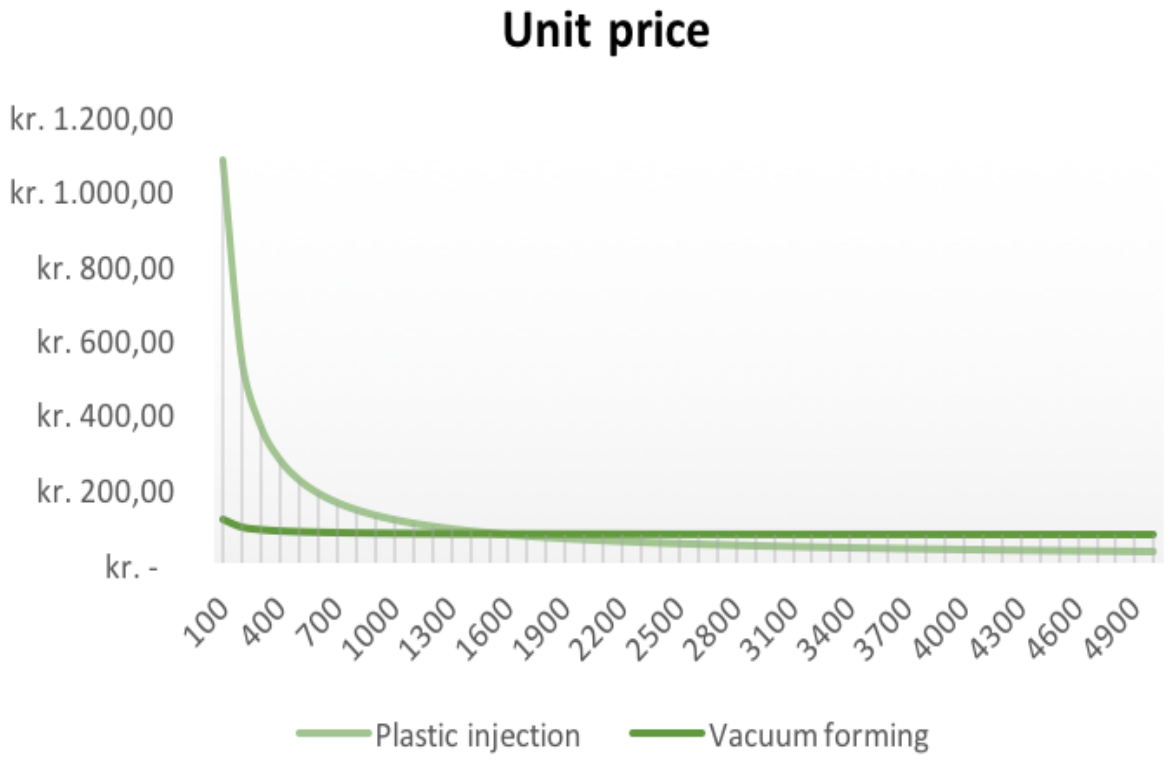


Figure 10. Unit price

Since we estimate to manufacture 500 units we can see on the graph below, that vacuum forming will be the best suited for production. Our calculation shows that if the production run exceeds 1650 units it will be cheaper to use plastic injection moulding as the price pr. unit is much lower when the initial cost is paid.

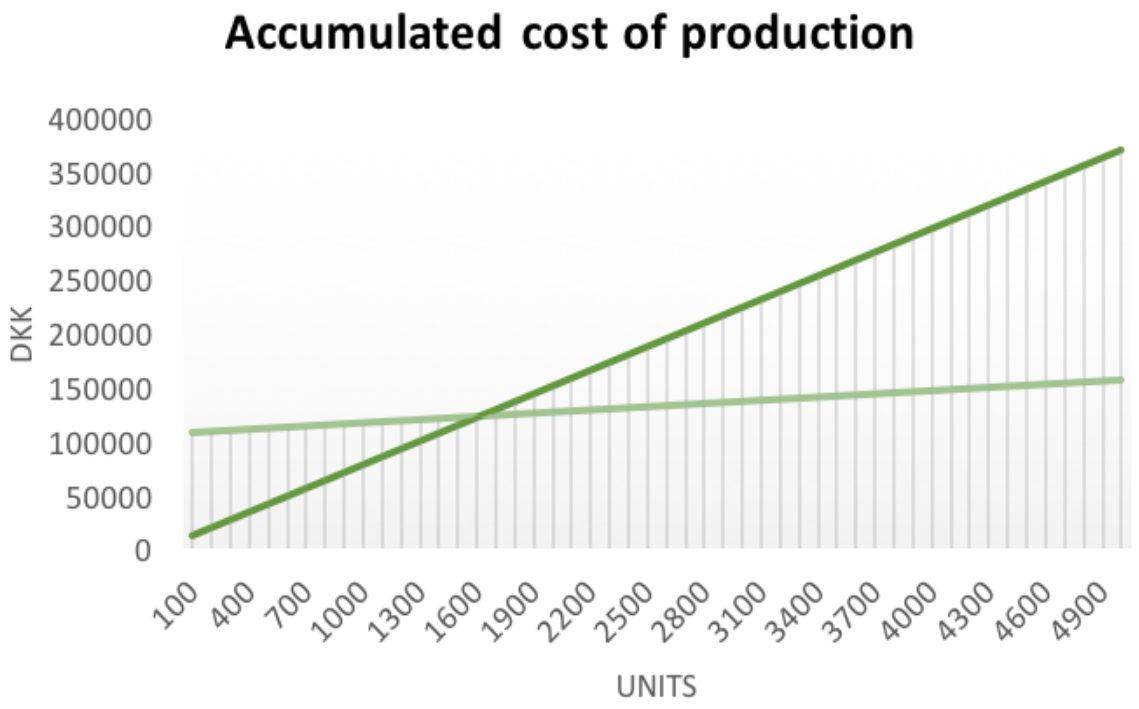


Figure 11. Unit price

Choice of production method

Based on the calculations we have chosen to use vacuum forming as the manufacturing method for producing 500 units of the plastic shell. According to the design specification "The lower the initial investment for the manufacturing method the better" - it will make more sense to use vacuum forming rather than plastic injection molding. Our estimates of price say that vacuum forming would be 102.500 kr. cheaper in initial costs compared to plastic injection molding. However, if the number of units go up, there is no doubt that we should use plastic injection molding. The team found that the vacuum former at DTU Ballerup was suited for a small production of 500 units. Thereby initial cost, man hours and so forth could also be cut from the production price.

Using vacuum forming at DTU Ballerup also gives a possibility to try different prototypes before picking the final concept as the machine is located close and accessible.

Manufacturing method for electronics

In 2017 the GLØD lantern was made of expensive electrical components such as Arduino Nano and a Adafruit Microphone. Based on our experience from 2017 it was clear that the circuit needed to have cheaper components, easier assembly and certification. Overall the price of the entire electronics should not exceed 50 kr. The specifications of the electronics was developed in a special course in January that will be further discussed in the report. The electronic specifications can be found on appendix 29. (Electronic specification).

Choosing manufacturing method for the electronics

The project was aiming for using a pick and place machine as the manufacturing method. The factory should be located in Denmark because of logistically, legal and cultural reasons. But due to multiple problems in development phase, further discussed later in this report, the manufacturing will have to be done by hand. This is mostly due to the PCB not being ready in time, but also since the offers given were too expensive and the team did not get enough funding to proceed. Multiple offers was received from 135,73 kr down to 118 kr pr. PCB. See appendix 30: PNP manufactures.

Since the plan was to use pick and place machine, the PCB has been designed for such a manufacturing technique.

Iteration

Coming up with ideas

In this phase the design team used many of the methods that have been introduced in the education Design and Innovation. The research that we had made on production methods had a high influence and set many restrictions on the design.

As the design entered the iteration phase, further knowledge was still being gathered about production methods materials, survey and competitors simultaneously.

Virtual morphology scheme

The design team had collected many pictures from Pinterest, magazines and also Stockholm Furniture & Light Fair and needed a way to sort it so it could be used as inspiration for the design.

A method called a virtual morphology chart was used. It functioned in the same way as a regular morphology chart but instead of using sketches or post-its, images were printed out or cut out of magazines and then sorted.

Figure 12. Virtual morphology overview

The virtual morphology chart was broken down into functions or sub functions, such as materials, shape, handle etc. These were parameters of the morphology chart that gave a way to sort the different images. The images gave inspiration both to aesthetics- and manufacturing considerations.

Figure 13. Virtual morphology close-up

Pictures could fit into multiple categories, but by placing them in a certain category, this gave a quick overview of how to provide a certain function. An example of this was the category “handle”. Many of the lamps had handles, so by using the virtual morphology chart the method visualized 30-50 possible solutions for a handle.

Every image was investigated and Post-It notes with comments about what was found interesting or inspiring in the image were placed. This was done to highlight specific details in the images to all members of the design team. This way the design team could read each

others' notes and either add to the comments or get inspired. After all the post-its were placed, it was discussed individually.

The morphology chart suggested possible solutions by looking at individual images from the categories and combining them with images from other categories. If a concrete idea about something came up, it would be made into a quick sketch and hung on another wall in a loop process. These sketches could be about everything from aesthetics or functionality to basic structures.

We did this process as a loop where we would get inspiration, write it down, get an idea and sketch it. In this way we combined the different subfunctions of the lantern in our head and "borrowed" ideas from existing lamps.
For us, this method felt natural. It's a method that is used by many design studios such as the London-based design studio Worrells[14]. Worrell says that *"It's important to note that the goal of collecting inspiration is not to copy others, but rather to combine ideas from many products to create new products.*[15]

Sketching

For sketching, we decided to use some of the methods from "Systematic Design of Industrial Products". The design team knew what kind of requirements there were for the product (this was specified in our design specification), and we started figuring out where the GLØD-lantern had its functional surfaces and banned areas[16]. The team recognized that by having a PCB, a power bank and some sort of handle to mount the lantern, it was important to know which areas had to be reserved space (Appendix 31. Banned areas and functional surfaces).

Figure 14. Sketches

[14] From Idea to Visualization–Worrell's Use of Mood Boards in the Design Process. (22/08/2016). Worrell. Found [01/04/2018]. At [https://worrell.com/using-mood-boards-to-drive-design-decisions/].
[15] ibid.
[16] Tjalve, Eskild. (2003) Systematic Design of Industrial Products. Kgs. Lyngby : Institute of product development Technical University of Denmark. Page 69

Basic structures

The sub-functions from the morphology chart were used to figure out what was the most relevant constraints for the new basic structures[17].

Figure 15. Structures

It did not seem realistic to find a solution where the container consisted of one part. By looking at the lantern's banned areas, the container could not cover the PCB in one piece. On the other hand, it would be too expensive to produce a container that was made of more than three parts. The design team agreed that if the container should have three parts it should be able to contain the power bank inside the container. This was a prefered solution as the power bank then would be covered from rain and weather.
Generally, we concluded that it did not make sense to make the container in more than three parts or in less than two.

The basic structures were split up into three different categories:

- The container made up of three parts and the power bank inside (page 1, appendix 32 Quantified structures)
- The container made up of of two parts and the power bank inside (page 1, appendix 33 Quantified structures)
- The container made up of two parts and the power bank outside. (page 1, appendix 34 Quantified structures)

As we had chosen to use vacuum forming, the constraints of this manufacturing method had to be considered. Therefore it was added in the design specification to have a radius of at least 15 mm and no negative angles.

Quantified structures

To create variation of specific basic structures we made quantified structures. This was done to explorer the full potential of those basic structures[18] (page 2-5, appendix 32)(page 2-4, appendix 34).

[17] Ibid.. Page 10

[18] Tjalve, Eskild. (2003) Systematic Design of Industrial Products. Kgs. Lyngby : Institute of product development Technical University of Denmark. Page 11

Foldable plastic

During the iteration phase the design team stumbled across a book with folded packaging designs[19]. A big potential was seen in this, as the designs assume that folding plastic can easily be mass produced. By using laser cutting it is not necessary to invest in any tools for the production and far less materials would be used with a thin sheet of plastic. Since origami is pretty hard to imagine and generating ideas from with sketches, the team picked a concept from the book. It was considered easier to make iterations when prototyping.

Choosing 5 concepts

From the quantified structures the best, according to the design specification, were picked. While choosing the different concepts the manufacturing was kept in mind.

The different concepts were chosen for the following reasons:

Concept 1: The design team wanted to know if it was necessary to use two different tools for vacuum forming and three plastic parts to mount the power bank inside the lantern (page 2 of appendix 32).

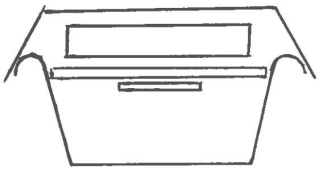


Figure 16. Structures *of concept 1*

Concept 2: This concepts was made to see if the user would prefer a small solution and was assumed to be a good solution for vacuum forming since more tools can be fitted under one sheet of plastic (page 2 of appendix 34).

Figure 17. Structures *of concept 2*

Concept 4: The concept was chosen to see what the smallest possible solution could be. The design team wanted to know if it was necessary that the lantern could stand upright on its own (page 3 of appendix 34).

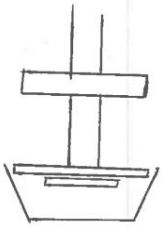


Figure 18. Structures *of concept 4*

[19]Found at https://issuu.com/designpackaging/docs/packaging-dielines-free-book-design_7fb37ab8a1c323 (12/06-2019). Page 32-33.

Concept 5: This concept only requires one tool. This would save costs, since we would only need to manufacture one tool(page 5 of appendix 32).

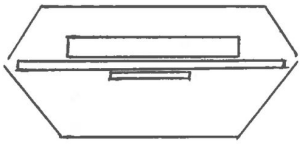


Figure 19. Structures *of concept 5*

Concept 3: This concept was was not found with quantified structures as earlier mentioned. It was chosen to explore if the folding of plastic sheets to create an origami-like design would be a good solution for the user and the production.

To confirm that five selected concepts lived up the manufacturing method they were drawn in CAD-software. The five concepts can be found described in appendix 35. (Concepts).

The team chose to have a big diversity in the 5 concepts as the concepts should illustrate possible directions the product development phase could go. The idea was to test the abilities of the concepts for both the user and for manufacturing and thereby determine what direction the project should take. Further development would then be done at a later stage after choosing the final concept.

Prototyping

Introduction

The design team tested how the concepts' usability, looks and realization held up against each other. The manufacturing of the prototypes were very similar and therefore the prototyping phase will be discussed in general terms.

Vacuum forming

Vacuum forming was done at DTU Ballerup. Vacuum forming is a method where a sheet of plastic is heated to a forming temperature. Then, the plastic is stretched and forced against a mold with vacuum[20].

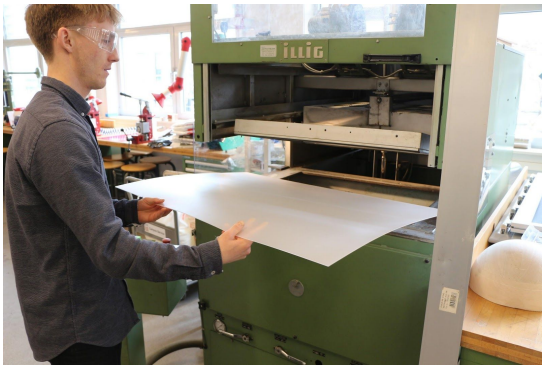


Figure 20. DTU Ballerups Vacuum former

Tools

Vacuum forming requires a tool, which is the shape of the object. The tool must be able to withstand the pressure from the vacuum and the heat from the oven.
The design team assumed that there would be a lot of calculations behind making a tool, but as the project progressed, the team found that it was rather simple, since there are angles on all sides of the tool and the tool does not have any radius smaller than 10 mm.
In the prototyping phase tools made of MDF-wood and 3D-printed ABS-plastic were used. These materials are fairly cheap and easy to process and they gave the team a great sense of abilities and restrictions of the vacuum forming technique. The tools for concept 1, 2, 4 and 5 were made at the Mechanical Engineering workshop at DTU see technical drawings in appendix 36 (Technical drawings of concept 1, 2, 4 and 5).

Figure 21. Vacuum formed object and tool

It was surprising how small the tool had to be in order to get a successful vacuum forming with no deformations in the plastic. The thickness of the plastic after processing is highly dependent on the tool. The steeper the slope on a tool, the thinner the plastic will get and the more fragile the object will become. It was clear that the tools made in wood and plastic would be damaged over time and therefore the final tool would have to be made in a more

[20] Serope Kalpakjian & Steven R. Schmid "Manufacturing Engineering and Technology", 7. edition, Prentice-Hall, 2014. Page 502

suitable material. Therefore the design team followed Bo Hagelskjær Larsens recommendation and used aluminium (see appendix 37. Tools).

Materials

Finding materials suited for vacuum forming

For material suppliers, we chose the company C.R. Steglich and Ingemann Components, where we ordered different types of plastics for prototyping - such as polystyrene (PS), acryl (PMMA), polyethylene (PE) and polycarbonate (PC). (see Appendix 38. Materials for prototyping).

Prototyping with materials

For the part of the lantern where light must shine through, a semi transparent material was needed. An opaque material was needed for the other part to create contrast. Appendix 39 (Materials) describes the materials that were tested during the prototyping phase.

Figure 22. Concept 1

Apparently it is rare that manufacturers vacuum form less than 1 ton of plastic. For large volume production, suppliers can customize the plastic for the specific production. However, our project only needed app. 600 kg of plastic for both the lid and bottom. This meant that we only had limited materials to choose from.

As the acrylic was less brittle and a lot more tough than polystyrene, the design team selected this material for the translucent part, while black shock proof polystyrene would be used for the lid of concept 1.

By looking at the prototype of concept 1, the black polystyrene and the white acrylic suited each other well, which is why the design team chose to use these materials for the final product.

Time and heat

On the vacuum forming machine there were two things to regulate: the time that the plastic would be subjected to heat and the temperature that was applied to the plastic. The design team experimented with the time and temperature to reduce the time as much as possible (see appendix 40. Vacuum time and temp).

Figure 23. Interfered thermometer

Polystyrene

According to the data sheet of polystyrene, the plastic has a forming temperature at 140°C[21], but from the test the design team had made, we found that the most optimal combination of time and heat was 400 °C at 1 min and 10 seconds.

Acrylic (PMMA)

The acrylic plate had to be between 140-160 °C[22] before it reaches its forming point and can be shaped. From the test it was determined that the most optimal combination of time and heat was 450 °C at 1 min and 50 seconds.

Materials for everything

When the design team started to look for materials we thought that there were a certain material, which was best suited for vacuum forming. We realized that there are many options and the best material depends completely on the object of manufacturing.

Getting the most out of a plate

The tool for the vacuum former is placed on a table that can move up and down as needed. The table in the vacuum former used for this project measured 580 x 850 mm. It is important that the table is larger than the vacuum former, since the frame that keeps the plate in place has to have some material to hold on to.

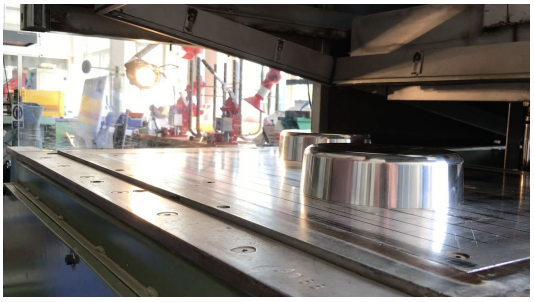


Figure 24. Table is up

[21] PS - HIPS 4-400/15 (Tør)(06/16/2018). *Tekniske data*. Found [06/16/2018] on [https://www.rias.dk/industri-visuel-kommunikation/sortiment-data/tekniske-data.aspx].
[22] (06/16/2018). PMMA Datablad . *Tekniske Data*. Found [06/16/2018] on [https://www.rias.dk/industri-visuel-kommunikation/sortiment-data/tekniske-data.aspx].

These dimensions cannot be changed and therefore the use of available space has to be carefully optimized. The aim was to have as many tools on the plate as possible. But this was not easy due to the amount of stress the material is exposed to.

The thickness of the plates used was 2 mm. When vacuum formed, the material gets stretc-hed around the tool and therefore loses some thickness. We noticed that for the last object that was vacuum formed, the material was stretched the most, in some places down to a 0,8 mm shell thickness. Also, If there were too many tools on the plate this would create strings or deformations in the plastic plate between the tools.

Figure 25. Table is down

The design team tested different placements of the objects on the table, hoping that one tool would be sufficient. This would cut the cost of plastic expenses a lot. In the end we realized that with the chosen design we were only able to place two tools on the plate.

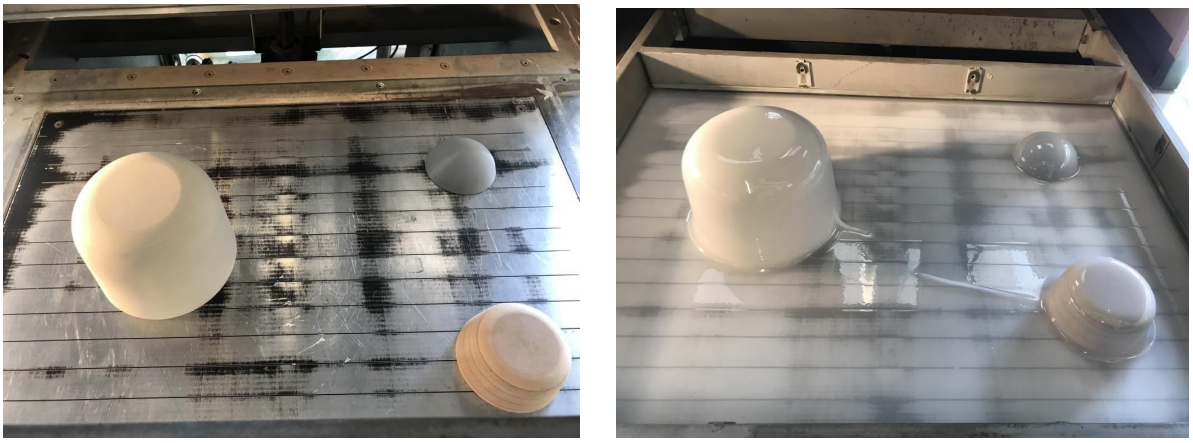


Figure 26. Multiple tools on table

Detaching an object from the plate

After vacuum forming a plastic sheet is formed. Then the object needs to be detached from the rest of the plate it was formed from. There are two ways of detaching the object from the plate; vertically or horizontally. This is illustrated in the figure 27:
We found it easier to cut it from the top.

As appendix 41 (detaching the object from the plate) explains, many methods such as horizontal sawing and rotating engraving attachment could have been used to detach the

object. Most of them were too slow and not precise enough. We found that the best method for detaching the PMMA object was laser cutting vertically using a central point tool.
As for polystyrene, the design team chose to focus on CNC-milling . These two methods will be used in the manufacturing process.

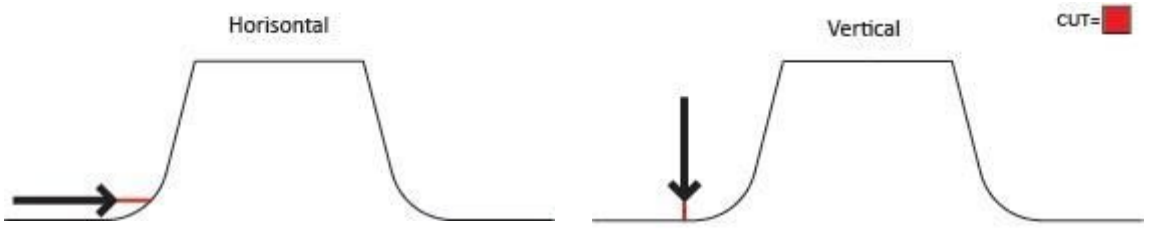


Figure 27. Detaching methods

Laser cutting

To make concept 3 - which used an origami-like approach - the team chose to use laser cutting as this was a simple tool to prototype with. However, had we selected concept 3 for the final design, stamping would have been more suitable for mass manufacturing 500 units. Concept 3 was created to get a quick test of the potential of a foldable design, and we did not go further with the idea.

Figure 28. Laser cut cardboard

Strap

Polypropylene strap

We have tested a number of different textiles for the strap. The Danish textile manufacturer Kvadrat kindly sponsored textiles for the strap, but because it would require a lot of processing, we chose not to use textile. This is further explained in appendix 42. (Kvadrat tekstile)
Since the strap should be suitable for the harsh environment at Roskilde Festival, we decided to use the material polypropylene for the strap. Polypropylene is a very common materials for straps, and it's usually seen on backpacks. It can be purchased in DIY stores Bauhaus fairly cheaply. The material does not absorb liquid and it can easily be washed. These factors, and the great strength made the material ideal to use as a strap.
The fibers can be cut with a scissor and burned so the textile does not floss. With a hot tool this can be done in one operation.

Color considerations

From an aesthetic perspectives, having an element which is in clear contrast to the rest of product can often make a design more interesting and pleasing[23] - and the design team wanted the strap to add that effect. The strap should stand out from the black lid and should be a warm color. We chose to order the warm grey and green from Kvadrat and buy multiple colors in Bauhaus. From Bauhaus red was considered the biggest contrast to black, but the design team ended up picking a cream colored strap as this was a color seen in many products at Stockholm Furniture and light Fair such as the Fermob lamp and the FollowMeLamp.

Figure 29. concepts with straps

As our survey had shown that last year's participants were not satisfied with the magnetic locking mechanism, we chose a less sophisticated solution: a buckle. We chose a buckle of a type that is common for backpacking and other outdoor gear, and which is also extremely cheap (1,1 kr each when buying 500[24]).

Mounting of power bank

Because of a little bit of friction between the surface of the power bank surface and the strap, the power bank could not be held in place. Therefore, the design team chose to add a piece of elastic material with silicone to create friction. This is further discussed in appendix 43. (Mounting of power bank).

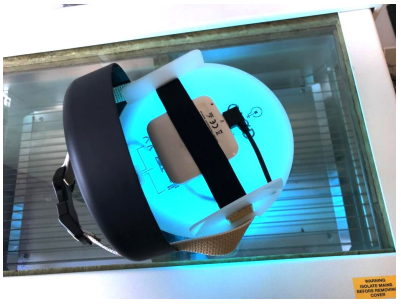


Figure 30. Mounted power bank

[23] Bruens, G. N. (2011) Form/Color Anatomy. The Hauge: Eleven International Publishing. Page 81

[24] Buckle Ebay. *Prices*. Found [06/16/2018] on [https://www.ebay.com/schblack+buckle+&_sacat=0]

Stickers

The team recognized that a strong brand identity is important. A strong brand *"helps customers to know what to expect"*[25]. Therefore the team found it important to place the GLØD logo centrally on the product to ensure that customers understand what the product is and where it is from.
DTU also saw a potential in branding themselves through the product. Therefore DTU helped fund the project in return for having a sticker on the product that said "Invented by DTU students". On the picture below is Tore Vind Jensen from DTU press approving the size of the stickers.

Figure 31. Tore Vind Jensen looks at stickers

The user survey of the lanterns from 2017 indicated that there was a problem with the folio in the front getting damaged quickly. One way to solve this problem was to place the sticker on the inside of the lantern. Therefore the text was flipped before being sent to production.

Figure 32. Stickers on concepts

[25] Why is branding important (03/10/2017). *Strategy, market and business solutions*. Found [06/16/2018]. On [https://strategynewmedia.com/why-is-branding-important/].

Figure 33. Flipped sticker design

Prototyping of the electronics

As part of a 5-point course at the faculty of Electrical Engineering, Chris Cornaby and Nikolaj Bobek Søndergaard, two master students, joined Mads Hesseldahl in a 3-week course in January 2018. The objective of the course was to create a circuit for the GLØD lantern suitable for mass production. Last year, the circuit for the GLØD Lantern was not ready to be transformed into an assembly ready unit (see appendix 44: Electronics improvements).
The expected outcome from the 3-week course was a manufacturing and assembly-ready unit, including all desired features (continuous lighting and frequency-based color response, long battery life, low cost).
The 3-week special course and how that resulted in a collaboration with Chris Cornaby is further discussed in appendix 45 (3-week special course).

It was decided that the circuit should have three functions:

- The “white light”-mode where it emits bright white light.
- A “party mode” where the circuit listens to surrounding music with an inbuilt microphone. The colors and the light intensity then change according to the beat of the music.
- A “color mode” where the LED’s on the circuit simply circle between different colors. This function was added based on the assumption that people want to “hygge” - and our user survey later proved this right.

As the project was rather big for a 3-week course, the task had to be very clearly distributed (see appendix 46. Task handling).

To secure at least 8 hours of light from the lantern, the specifications for the circuit was based on a Volt power bank of 3500 mA. The Volt power bank is a relatively small power bank and it is considered to be the most commonly used power source at Roskilde Festival.

To bypass the inbuilt sleep function many power banks have, to ensure that is does not

discharge when it's not being used, we decided to keep the LED lighting at a minimum of 30% lighting.

The circuit of the lantern from 2017 was digital with a microchip. For the redesigned circuit we chose an analog circuit. This seemed most reasonable at the beginning of the project, but has caused a lot of problems later on. The considerations that let to this conclusion can be found in Appendix 47 (From digital to analog).

Before the circuit was built, it was simulated in a computer program called LT Spice, since it is very time consuming to build and debug an entire circuit. As the simulated circuit is made with ideal values it will differentiate from a real, built circuit. But the simulation is a good tool for designing and testing a circuit. The circuit and the simulations is discussed in more detail in appendix 48 (simulations).

To make sure that the microphone was functioning according to the design and electronics specification, tests were made in the laboratory using an oscilloscope and a decibel meter. The test was successful and the microphone lived up to the requirements and worked up to 110 db. See appendix 49. Microphone.

First prototype of the electronics

The first circuit was constructed with a breadboard. Because the breadboard consisted of long wires and bad connections between the components, it led to a lot of errors. However, after debugging, the circuit was functioning but far from perfect. See appendix 50. Breadboard.

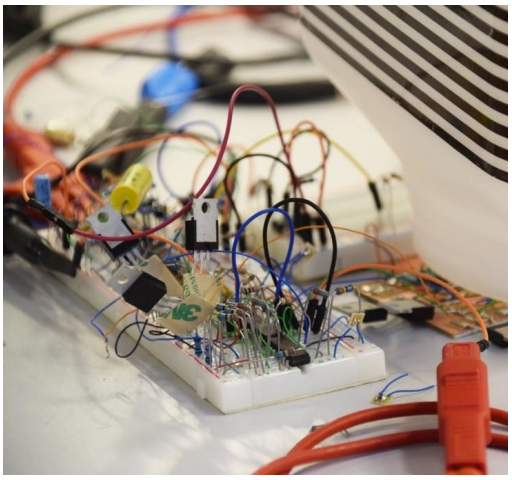


Figure 34. Breadboard

Second prototype of the electronics

After the 3-week course ended, the first iteration of the PCB arrived. There was a lot of flipped foot prints and wrongly connected wires. Hacks had to be made in order to get the PCB to function. In particular, the circuit "fademode" needed many adjustments and therefore became very unstable. Since the part of the circuit responsible for "party mode" relies on fademode it did not make sense to test this part before fademode was perfected. The mistakes were

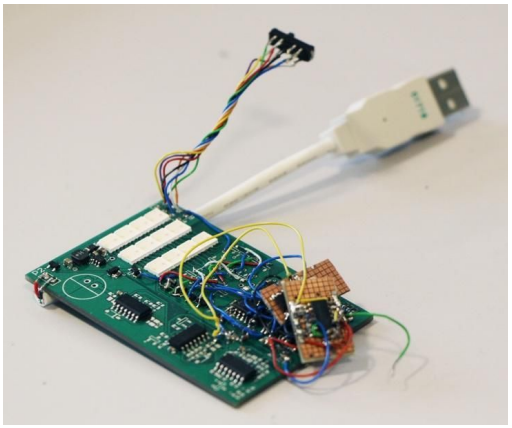


Figure 35. First PCB

corrected and a new PCB was ordered (see appendix 51. First PCB).

Third prototype of the electronics

Once “Fade mode” was up and running, the party mode still needed adjustments to work. The third PCB had minor errors and it was mostly a matter of calibrating the board using specific resistors and capacitors.
For the process of analysing music the circuit must be able to handle some diversity. If the circuit only had to be calibrated for one song, this would have been a lot easier.

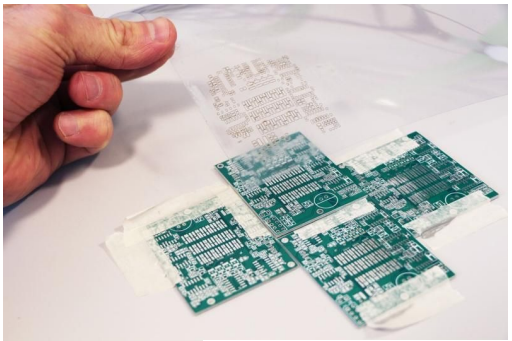


Figure 36. PCB stencil

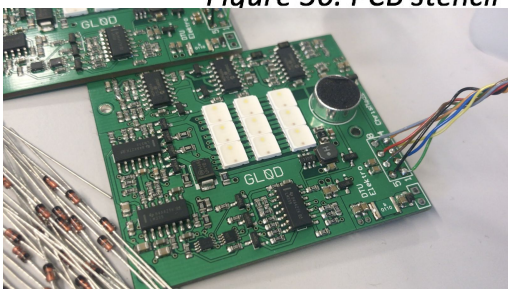


Figure 37. Second PCB

The more sensitive it was to the beat of the music, the more clearly it reacted - but the more it would also flicker and sometimes be unpleasant to look at. The team found a balance, which meant that the party mode functioned, but it did not work as well as intended.

In the process of placing components, solder paste had to be added to the PCB. To reduce time a stencil for the solder paste was made using laser cutting.
(see appendix 52. Second PCB).

Fourth and final circuit design

Soon after the second PCB was done, a new and final PCB-layout was designed and ordered. When receiving the third PCB, the design did not have any errors left. But the time for setting up pick and place manufacturing by machine had run out. At this point the electrical engineering faculty advised the team to pick and place by hand. We estimated that a board with 160 components would take 15 minutes to assemble if we were placing one component every 5 seconds.

The circuit needed some calibrations. The party mode was still not functioning as well as intended. The problem was still finding the right sensitivity for the signals. At a medium high volume the circuit was reacting well to the music. If the volume got higher, the LED’s would light constantly - and visa versa, if the volume was lower the LED would not react at all. This was due to the variable gain from the SlowPeak not functioning properly.

Current status

The fourth prototype was the final iteration of the circuit. The development of the electronics had taken much longer than expected. According to the time plan, the circuit should have been done by the end of the 3-week period of january and be manufactured approximately 12 weeks before Roskilde Festival. But as the fourth PCB was not done until the 7th of june this completely eliminated the possibility of having the circuit manufactured by a pick and place machine.

The reason for the long development period, was the complexity of the party mode. The party mode function had become better but it is far from perfect. It is still flickering and is not as good at following the music as we had expected.

Light test

The design team tested the light emitting properties of the 5 concepts for the lantern designs , to determine, which plastic container was most suitable. This was done using white light mode to get the same conditions (See appendix 53: Light test).

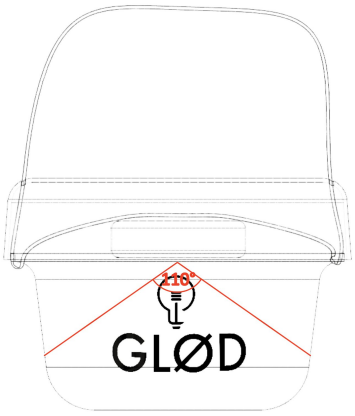


Figure 38. Light angel

The test showed that concept 1 and 2 both had a good shape for light emitting. The light was distributed well in Concept 1's shell. This was due to its bigger dimension, which allowed the light to defuse. The angle of the LEDs light at 110 degrees was taken into consideration when designing concept 1 and 2 by aligning the shell radius with the angle. An example of this is shown in figure 38.

Sound test

In the lab the party mode was tested using a small speaker. A playlist for testing the circuit was made. The playlist contains music that is popular in 2018 with different genres and intensity, in order to observe how the circuit reacted to different music. The test showed that the circuit reacts best to electrical dance music since there is a clear beat in the music.

Figure 39. Sound test

Even before testing the circuit in more realistic environments the team was concerned that the

lantern's gain would max out. This was confirmed when tested with more realistic sound volumes (closer to the festival environment) at parties such as the Line party at DTU, Jellinge Festival, Heartland and Diamanten summer party. Pictures can be seen in appendix 54. (Soundtest).

The circuit is functioning well around 90 db, which is a medium high level and can be compared to the loudness of a lawn mower. Unfortunately, our test showed that parties can easily be louder than this.

Interface and controlling the lantern

Button

The circuit was made so that a switch could change the different modes of the lantern. As the electrical engineers had chosen a very specific switch that was hard to replace without changing the PCB, the design team chose to make an add-on to the switch, as the switch's interaction surfaces were considered too small and therefore too difficult to operate. A laser cut rectangle was made and could be assembled with a press fit on top of the switch. See figure 40.

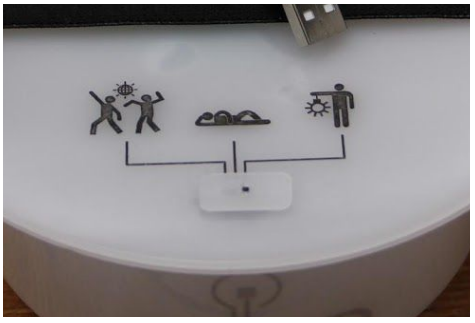


Figure 40. Button add on

Symbols

Because the lantern has three modes, it is important for the user to know what mode the lantern is on. The design team assumed that by having festival participants from many countries such as Germany, England, Sweden, Norway and Denmark, it would be most obvious to use symbols. However, through a user interview we found out that using text was the most intuitive. The argument was that this is most familiar users because other products, such as a tv-remote control, also use text. See appendix 55. Interface.

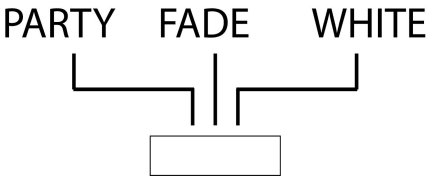


Figure 41. Final interface

It was decided to engrave the interface in the middle piece with a laser cutter. Since the engraving was not visible due to the lack of color differences, black ink was applied on the the engraved part. In this way the

Figure 42. Paint on middle piece

text would always be placed correctly. The engraving took 7 minutes on the first try, but by modifying the laser cutter's laser strength and its movement we reduced the time to 3 minutes pr./ piece.

Assembly

The lantern consisted of three parts: the lid, middle piece and the bottom. The middle piece and bottom was both acrylic and would have to be glued together as vacuum forming does not allow threads or snap fits.

Different glue has been tested to find the most optimal solution for the assembly. The conclusion to use Acrifix glue is drawn from the knowledge gathered appendix 56. (Glue). Acrifix glue was the strongest, quickest to dry and transparent.

The final concept

Introduction

To get feedback on the five prototypes some potential users in the target group were invited to view the prototypes. Their feedback together with the design team's experiments from the prototyping phase were used to evaluate the many aspects of the concepts.
The concepts had both good and bad aspects that were summed up using WOM - Weighted objective method. The result from the WOM allowed the design team to create the final product using only the good aspects from the different prototypes.

WOM - Weighted objective method

In order to make an evaluation of the different concepts in a objective way a set of criteria were listed based on the design specification and on the knowledge gathered in the prototype phase.

A: Best suited for production method
B: Detachment from plastic sheet
C: Size
D: Power bank placement
E: Aesthetics
F: Brand placement
G: Exploitation of material
H: Light test

As some of the requirements were considered more important than others, the design team ranked the requirements to determine the relative weights of the objectives. This was done by ranking each requirement against each other. As seen in the figure below, 1 or 0 is entered into the relative matrix cell in the chart, depending on whether the first objective is considered more important than the second.

	A	B	C	D	E	F	G	H	Row totals
A	-	1	1	1	1	1	1	1	7
B	0	-	1	1	1	1	1	1	6
C	0	0	-	1	0	0	0	0	1
D	0	0	0	-	0	1	0	0	1
E	0	0	1	1	-	1	1	0	4
F	0	0	1	0	0	-	0	0	1
G	0	0	1	1	0	1	-	0	3

H	0	0	1	1	1	1	1	-	5

After ranking the objectives, the row total indicated the rank order of the objectives. The result confirmed the design team's assumption that the production method was the most important aspect to consider. The rank order was converted into a weighted grade in the following matrix to multiply with the grade given for each concept. A grade between 1 and 3 were given for each requirement. The grade 1 is poor and 3 is good.

In appendix 57. Evaluation of concepts, the grade for each concept is discussed.

	WG	**Concept 1**	**Concept 2**	**Concept 3**	**Concept 4**	**Concept 5**
Best suited for production method	7	1	3	2	3	2
Detachment from plastic sheet	6	1	1	-	1	3
Size	1	3	2	2	1	1
Power bank place-ment	1	2,5	1	2	1	3
Aesthetics	4	3	2	1	1	2
Brand placement	1	3	1	3	1	1,5
Exploitation of material	3	1	3	2,5	3	2
Light test	5	3	2,5	-	1	1
Overall points		51,5	60,5	32,5	48	56,5

The evaluation of the concepts show that concept 2 and 5 are both ranked high. This is in a large part due to their ability to be manufactured, which was weighted heavily.

It is important to mention, that the design team does not consider concept 2 to be the optimal solution. In several of the other concepts there were certainly aspects that might be used in further development.
To create the final prototype based on the best aspects of the prototyping phase, the chart below was constructed. The chart presents the different criteria from the WOM and concludes which aspects should be further developed in the final prototype.

Best suited for production method	Concept 2 and 4 were the best when it came to vacuum forming. The design team has learned that a bigger angle and more soft curves is preferable when vacuum forming.
Detachment from plastic sheet	Concept 5 was the best when it came to detaching the object from the plate after vacuum forming it. The final product should be laser cut from the top.
Size	Since the size of concept 1 was prefered by the users, the final product should be of similar size.
Power bank place-ment	The final concept should have the power bank placed inside the container. It should be attached with a elastic band as in concept 1 and 5. This results in a more complete product, according to the user group.
Aesthetics	The users liked concept 1 because of the size and the strap. They also liked the shape of concept 2 without the power bank. The final solution should be something between these two concepts.
Brand placement	The placement of the brand sticker is easier on larger straight surfaces such as concept 5. But concept 1 also works as it is not a double curved surface as concept 2 and 4.
Exploitation of material	Concept 1 could only fit one object on a plate for the vacuum former. Because of the height and the steep angle, more forms on the plate would mean that strings between the objects would occur. Concept 2 and 4 were so small that it was estimated that between 6-8 forms can be fitted on the plate, also due to the soft angle and low height of the form. Concept 5 exploited the material very well compared to the big size. This was due to the low height and the soft angles on the side.

The final concept

The final concept was mainly inspired by the users' favorite, concept 1, for aesthetic reasons. But it was adjusted to be manufactured easier like concept 5 and 2. Thus, the final prototype will have a size and shape that lies between concept 1 and 2.
The method to detach the object from the plastic sheet will be the same as concept 5. The power bank will be placed with an elastic band inside the lantern as in concept 1 and 5. The GLØD brand will be placed in the front of the lantern, as in concept 1. use of the material has been optimized so two tools can be fitted inside the vacuum former.

The final concept consists of three plastic parts, a strap and an electrical circuit. The prototyping phase for the final project can be seen in appendix 58. (The final concept).

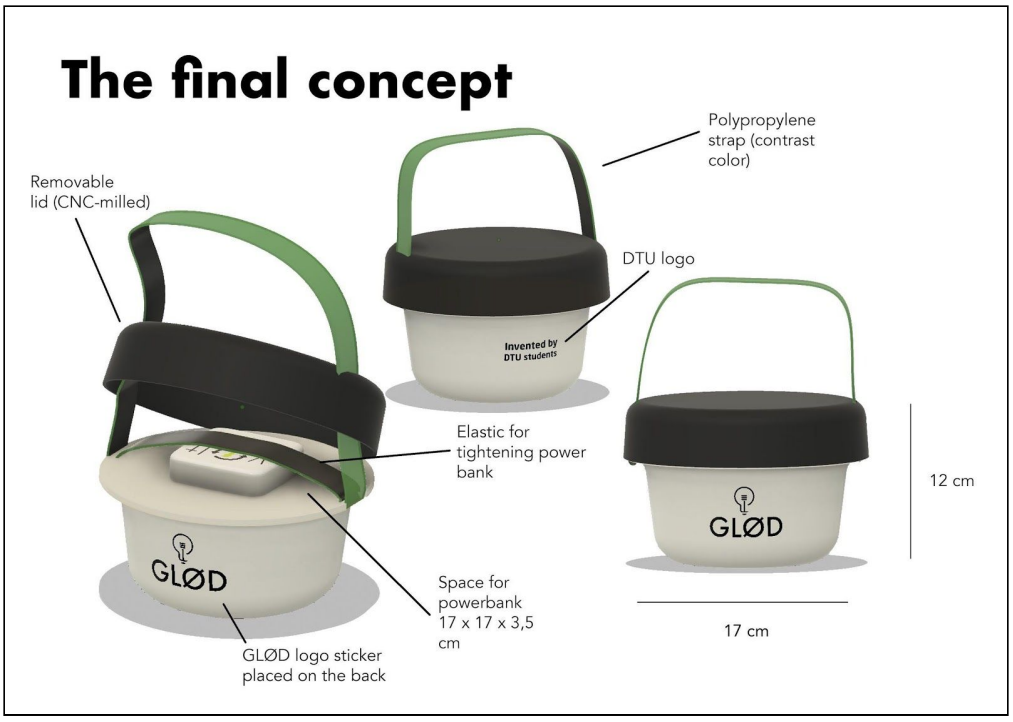


Figure 43. Final concept

Prototypes of the final concept has been made with the manufacturing methods intended for production of 500 units and the concept lives up to the design specification.
With a well-working design, the team could now move on to the manufacturing phase.

A broad spectrum of solutions

After the iteration phase, the five concepts were ready for prototyping. The design team had some assumptions about how the concept prototypes would turn out. Because of the diversity in the concepts we were allowed to explore a broader spectrum of solutions that might function well.
After the evaluation of the different concepts and the user feedback, the design team had a clear overview of what worked and what did not. This made it easier to design the final concept by choosing the best aspects of the concepts and creating a hybrid of them.

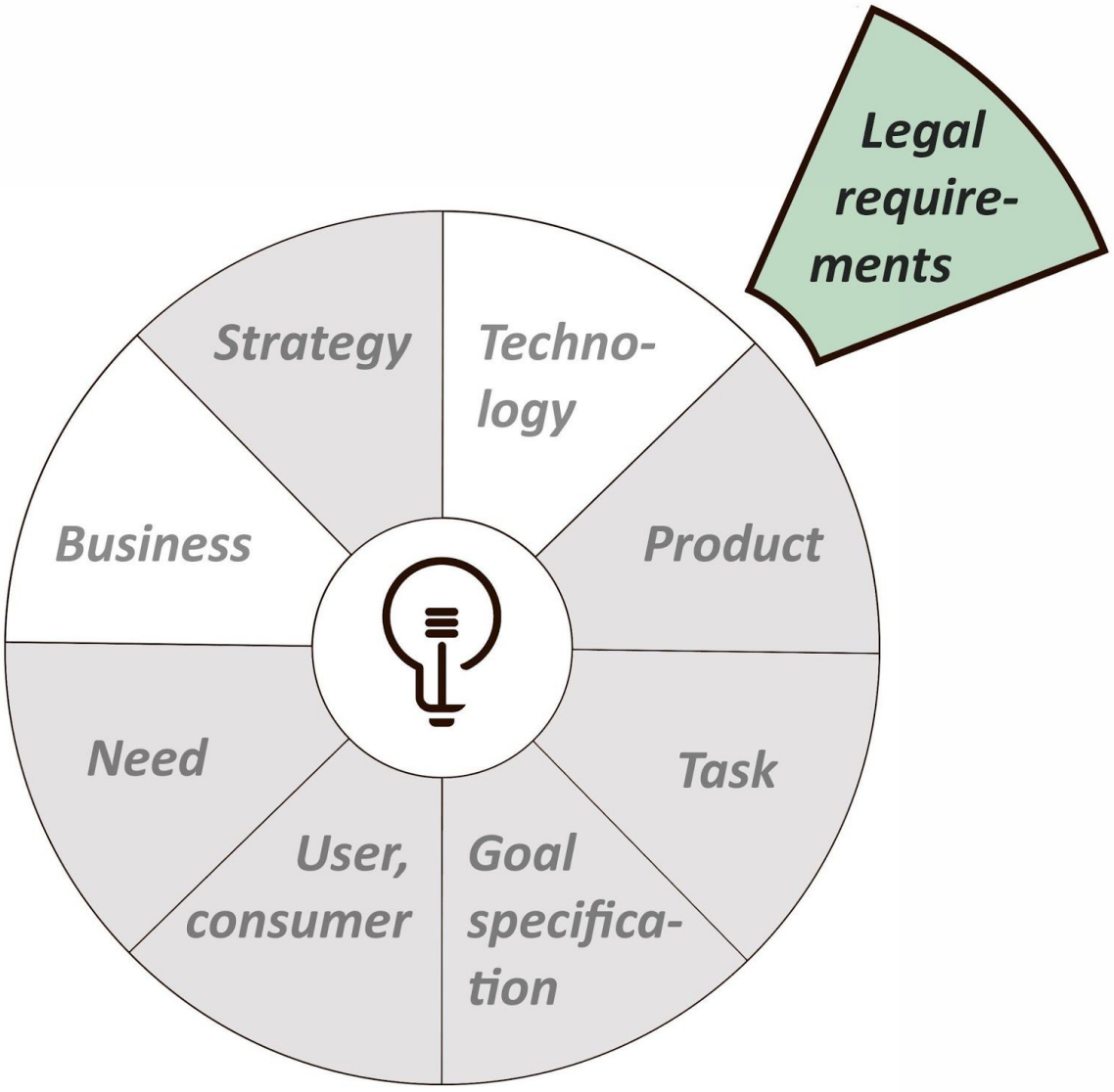
Using the Double Diamond model as a guideline, it became clear to the design team that a design process is not as linear as the model illustrates. We experienced that the design process was more dynamic as the team worked in multiple phases at the same time.

In a high level perspective, the design team has been through two converging and divergent phases.

In the evaluation phase of the concept, we set a number of requirements to find the best solution. At this point, the design team had chosen to work further on concept 3 - even though it had been decided that the manufacturing technique would be vacuum forming. This lead to concept 3 not receiving any points in the categories concerning vacuum forming. In hindsight, the categories should have been formulated in a more general way or concept 3 should not have been part of the evaluation. As the focus group confirmed our assumption that the construction concept 3 was too weak to bring on Roskilde Festival. It was decided not to do further prototyping with solutions other than vacuum forming, since concept 3 had until then worked as a representative for stamping or laser cutting.

In the future the design team hopes to be involved in projects with bigger budgets so that manufacturing consideration are not quite as crucial. The manufacturing method for this project set a lot of limitations and restrictions on the product development phase, which can make it hard to create the ultimative product for the user.

Legal requirements



An additional phase

In this phase legal requirements will be introduced and it will be discussed how the product can fulfill the requirements.

Introduction

In the pursuit of fulfilling the 8 dimensions it was discovered that the product idea model lacks one vital part for the product to reach market: “Legal requirements”.

Legal requirements

Since this was a design for manufacturing and sale, the product had to fulfill all legal constraints. Our research determined that the product had to be CE- and WEEE certified.

A WEEE certification is a requirement for the production of electronic products. WEEE is made to protect the environment and is short for “Waste from Electrical and Electronic Equipment”. It is used in EU as a regulation for waste from electronic products. Companies have to report how much weight is produced and pay a fee for this. A WEEE-certification is not complicated to get as it only requires the manufacturer to report the weight of the product and pay. In the case of GLØD, the weight fee for the WEEE-certification will be fairly cheap since the production of the GLØD-lantern is small.
It is the responsibility of the producer to put the WEEE certification on the product so it is visible[26]. DPA’s calculator was used to figure out how much a WEEE certification would cost [27]. It was approximated that GLØD would produce around 200 kg of waste. In that case, GLØD would pay 2394 kr the first year and 1394 kr in the following years (appendix 59. DPA).

The lantern also needed a CE certification. This requires that the product is in accordance with the ROHS- and EMC directives.

RoHS is short for Restriction of Hazardous Substances Directive. RoHS sets requirements that limit the usage of certain harmful materials in electronic products, to protect people's health and the environment[28]. Lead, quicksilver and cadmium are among the harmful materials that must be avoided. Since GLØD is not not making any of the materials or electrical components itself, the product has to only consist of components that are RoSH certified.

EMC is short for Electromagnetic compatibility. The EMC directive sets requirements for units that can produce electromagnetic disturbance. Since the circuit designed has power electronics, the product has to be within this standard.

[26] Mærkning (21/09/2014). Dansk Producent Ansvar. Found [01/04/2018]. At [https://www.dpa-system.dk/da/WEEE/Produkter/Maerkning].
[27] DPA-SYSTEMS ON-LINE BEREGNER. (12/04/2016). *Dansk Producent Ansvar*. Fundet [01/04/2018]. At [https://www.dpa-system.dk/da/WEEE/Producenter/Økonomi/On-line-beregner].
[28] RoHS - 2011/65/EU. (21/06/2011). Dansk Standard. Found [01/04/2018]. At [https://www.ds.dk/da/standardisering/ce-maerkning/produktgrupper/rohs].

It was found that the circuit would most likely have to apply to the international standards: DS_EN 55015_2013 and DS_EN 61547_2009.

According to Danish Standard it is not required to have an authorized unit test our product for EMC. According to 55015_2013 chapter 5.3.2.2 and 5.3.3.3 the circuit had to be tested for the subjects in 2a, 2b, 3a og 3b. According to DS_EN 61547_2009 chapter 5.2 it had to be tested to the requirements in chapter 2 (Appendix 60. Dansk Standard and EMC immunitetskrav).

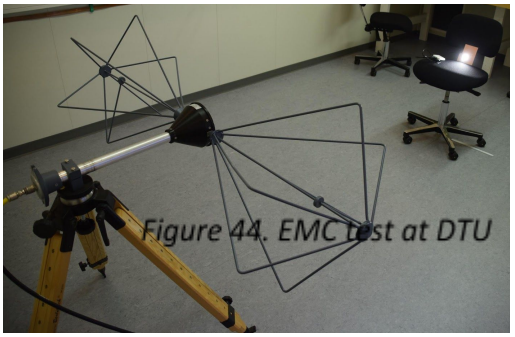
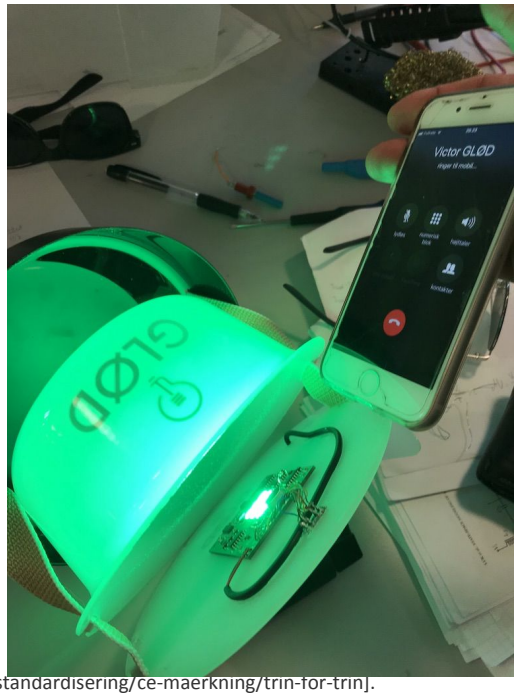


Figure 44. EMC test at DTU

Unfortunately, DTU did not have the proper equipment to do such measurements. The EMC room at the faculty of electronics is too small and the antenna they have could not measure at the frequency rate needed.
Equipment can be rented for testing. We did a setup and made some simple tests but none of the
data we got was useful. The equipment was just not made for it.

It is important to emphasize that it is not required to pass a test before a CE-mark is placed on the product. The company has to assure that the product is within the requirements, and and is responsible for this statement[29].

As the team did not have experience in creating documentation, it was chosen to seek professional advice.



The team visited Bolls Aps, a company that specialises in advice and testing of safety regarding electronic products. They recommended the team to do an EMC test to make sure that the product lived up to the standards. As DTU did not have the facilities to test the EMC, it was recommended to make small tests with the circuit. This was made to ensure that the circuit would not interfere with other electronic devices, as direction in appendix 60 is made to prevent. The product could be tested in critical environments such as when dialing a mobile phone or playing a radio next to the circuit.

[29]Dansk Standard. *Mærkning*. Found [06/04/2018]. At [https://www.ds.dk/da/standardisering/ce-maerkning/trin-for-trin].

Since it is a personal responsibility and none of the tests gave negative results, the team feels comfortable CE-certifying the product.

Figure 45. Test with smartphone

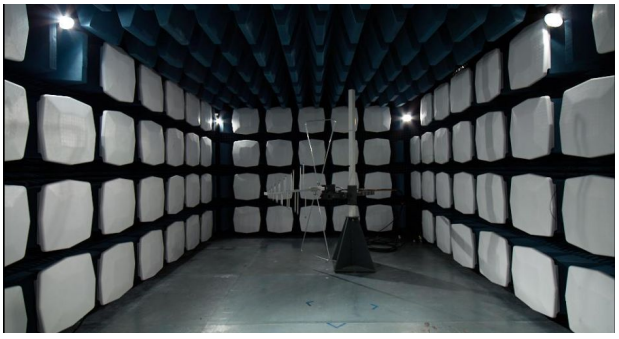
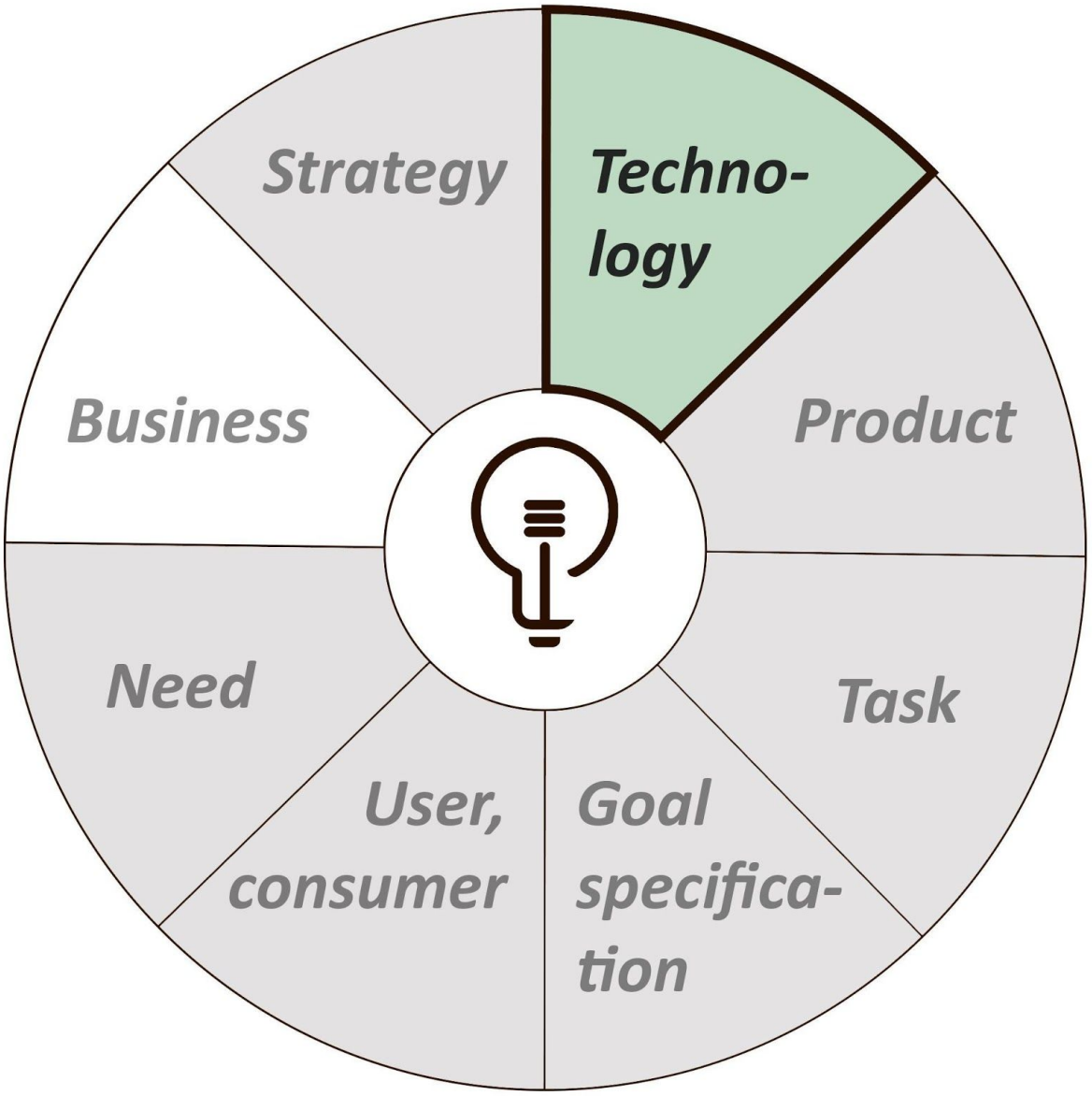


Figure 46. BOLLs

Technology



Phase 7

In this phase we will explain how the manufacturing process went for GLØD and how it was optimized

Production

Introduction

In this section we will discuss and reflect upon the manufacturing of the lanterns. Why decisions were made and what went wrong.

We have chosen to split the manufacturing process into six different categories: the lid, the middle piece, the bottom part, the pcb, the strap and assembling the entire product.

Figure 47. The lid

Figure 48. Bottom

Figure 49. Middle piece

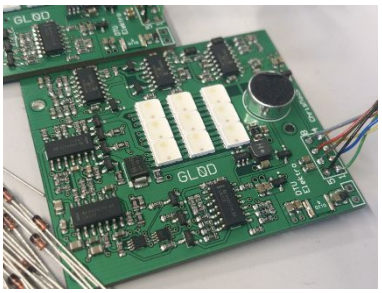


Figure 50. PCB

Figure 51. Assembly

Figure 52. Strap

Chosen production method

The bottom and the lid

As mentioned earlier the chosen manufacturing method for forming the plastics was vacuum forming. A storyboard for the manufacturing process of the PMMA- and PS-plastic can be seen in appendix 61. (PMMA storyboard) and appendix 62. (PS storyboard). First the plastic is cut in to pieces according to the size of the vacuum machine. Each plate was cut out in the best possible way to fit the vacuum former, see appendix 63 (PMMA cut) for PMMA-plastic and appendix 64. (PS cut) for PS-plastic.

Figure 53. Vacuum formed objects

When the plates were cut in the right size they were put in the vacuum former. Here the plastics were shaped in two different operations as PMMA has a higher forming temperature and were placed in the vacuum former at 450 degrees for 1 minute and 50 seconds. PS was placed in the vacuum former for 1 minute 10 seconds at 400 degrees. These times and temperatures are based on earlier mentioned appendix 40.

Figure 55. Bottoms after laser cutting

Afterwards PMMA plastic was once again cut out to a laser cutter. This was done with an electric hand saw as a jigsaw tend to break the material. The PMMA was then placed in a form and laser cutted. PS was cut using a jigsaw. This was all done at DTU Ballerup. After the PS was cut out it was delivered to C.R. Steglich for CNC-milling of the lid. The reason why PS was not laser cut was that it emits toxic fumes when it is burned.

The PCB

The PCB could unfortunately not be made in a pick-and-place machine as first planned. As the team was very unexperienced in the electronic field and depended on electrical engineer student Chris Cornaby, the assembly of the PCB would be done by using an oven and placing the components by hand. An estimation of app. 15 minutes pr. board was made earlier in the report. The project would also be saving 36.126 kr (not including components) which was the offer from the electronic manufacturer ETK (see appendix 30. 2. ETK offer) with this method. PCB was ordered with a stencil for placing the components. Soldering paste was placed on the stencil with the PCB underneath, hereafter components were placed on the paste. When the 160 components was placed the PCB was run through an oven and the solder paste would solder the components to the PCB. See storyboard for the process in appendix 65 (PCB storyboard).
The footprints on the PCB was 2.0x1.25 mm and 1.6x0.8 mm, so it was quite challenging to place the components.

The middle piece, the strap and assembling

The middle piece was also made from the same material as the bottom, PMMA. This made it possible to laser cut and engrave it. For the production two laser cutters at skylab were used and the PMMA plate was optimized to the fullest. This can be seen in appendix 66 (middle piece optimization). After the material was laser cutted the engraved part was painted with black paint using a cloth. The electronics was placed and glued on the middle piece. The USB-cable and button were soldered onto the PCB.

The strap was then run through the middle piece and hereafter the middle piece was glued unto the bottom part. After the middle and bottom had dried the strap was run through the lid and into buckle where it was sewn. The full process is visualized in appendix 67. (Middle piece storyboard).

The strap was made in another operation in Odense by Victors sister in return for a Roskilde ticket. Appendix 68. (Manufacturing of the strap).

Figure 56. Paint on middle piece

Figure 57. Middle piece

Figure 58. Middle piece assembled

Ordering materials and components

A list of the materials that were ordered can be found at appendix 69 (List of materials ordered).

As we found out in the product phase to use 2 mm PMMA plastic opal white with a light emission of 70% and shock proof black polystyrene plastic also of 2 mm this was ordered at Ingemann Components. Ingemann Components informed that every cut in the plastic plate would cost 30 kr and we calculated to have 5 cuts in the small PMMA plastic plate and 12 cuts in the larger PS plastic plate. A quick estimation followed and showed that cutting all the plates at Ingemann would cost more than 40.000 kr so we choose to do this our self at Ballerup Campus. We were aware of the plates had to be cut out as soon as we got the measurements of the plates, but we did underestimate how much it required to move 92 plates (600 kg of plastics) from the parking

lot to the saw. The sawing itself was done within a day which we had estimated would take two days.

Figure 59. Moving plastic

All electrical components were ordered at Mouser and RS-components that were both shops that were placed in Sweden and Denmark and had all the necessary documents for Rohs-certification.

As we knew that the a third of the budget for the electronics was used on LEDs, we had tried to find an alternative but did not succeed. See appendix 70 Finding a alternativ to CREE

As we did not receive funding from Skylab we had to find ways to cut cost.
Skylab recommended us to try to seek sponsorships for companies and we chose to follow their advice and tried with the textiles and elastic band needed for the strap. We contacted two companies, Kvadrat and ELAS. Kvadrat agreed to a sponsor textile to the project and a application was needed to be filled (appendix 71. Kvadrat application). ELAS agreed to a sponsor the elastic band. The e-mail correspondence with ELAS be seen in appendix 72 (Elas correspondence).
After receiving the textile from Kvadrat we realized how much processing the textile would require and chose therefore to order the strap from Bauhaus.
The CNC-milling was done at C.R. Steglich, this required the design team to send a technical drawing of the lid (appendix 73 Technical drawing lid). Steglich had already given us a price estimate of vacuum forming and processing of the bottom and the lid, where we got a 10% discount. We tried to get the same discount on the CNC-milling of the lid, but this was not possible as it was such a small order (the e-mail correspondence can be seen in appendix 74 Order at Steglich).
Stickers, buckles, sewing thread were all ordered online.

Production plan

When starting the production a time estimate of each operation had been made. To make sure that the manufacturing was done within the deadline of Roskilde Festival each individual task was overestimated. In this section we will compare the estimations of the different manufacturing parts with the actual time spend. A comparison of the full manufacturing plan can be found in appendix 75. (Manufacturing plan).

Analyzing the manufacturing method

As the manufacturing started it became clear that the estimations was not off, but followed very well the time it took for each operation. But one operation did not follow the estimations, the electronics. The electronics was a part that has been the least known part of the manufacturing process and therefore it had been necessary to seek advice from people that had experience. Chris Cornaby that was responsible for developing most of the electronics had never tried manufacturing a “larger” production of PCBs, so he also seeked advice from lectors and professors from the faculty. Their estimates and gut feeling could not see a problem with the production method, which was to place the components by hand and let them through an oven as earlier described, but as soon as the team started it was clear that each PCB could not be made within the 15 minutes but closer to an hour. This can clearly be seen in the visual graph below. This would not be considered a problem if 20 or even 50 units should be made but a huge problem for 500 units.

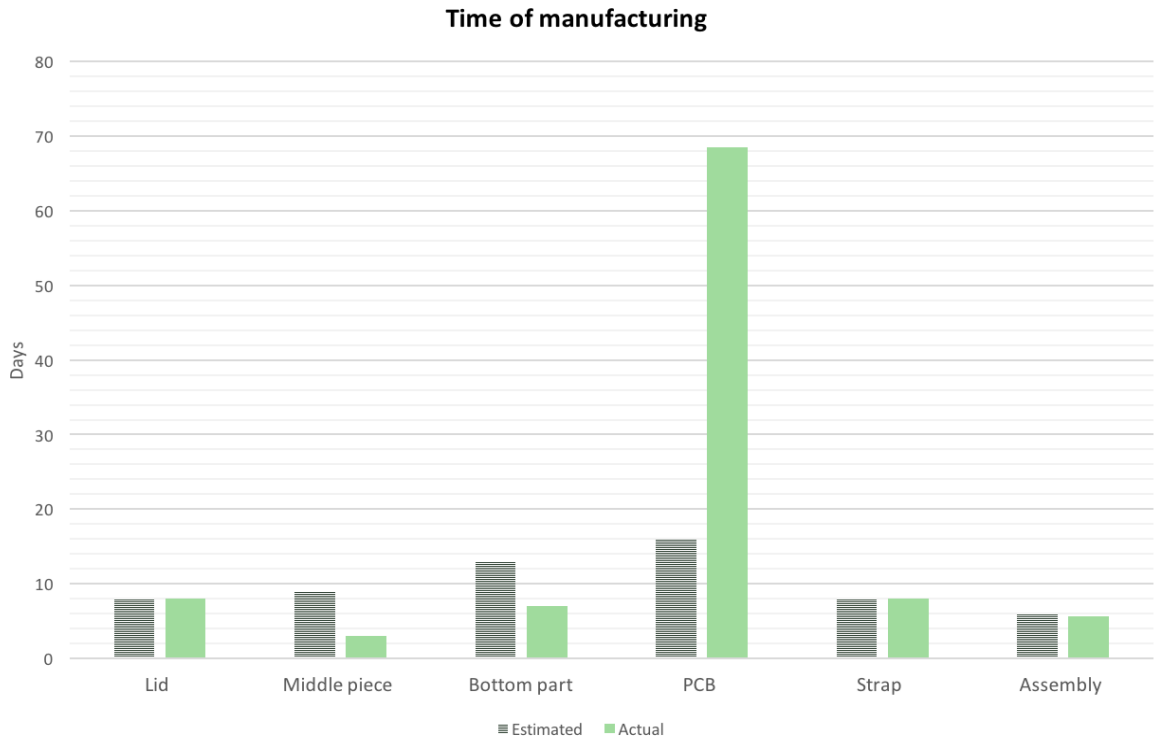


Figure 61. Time of manufacturing

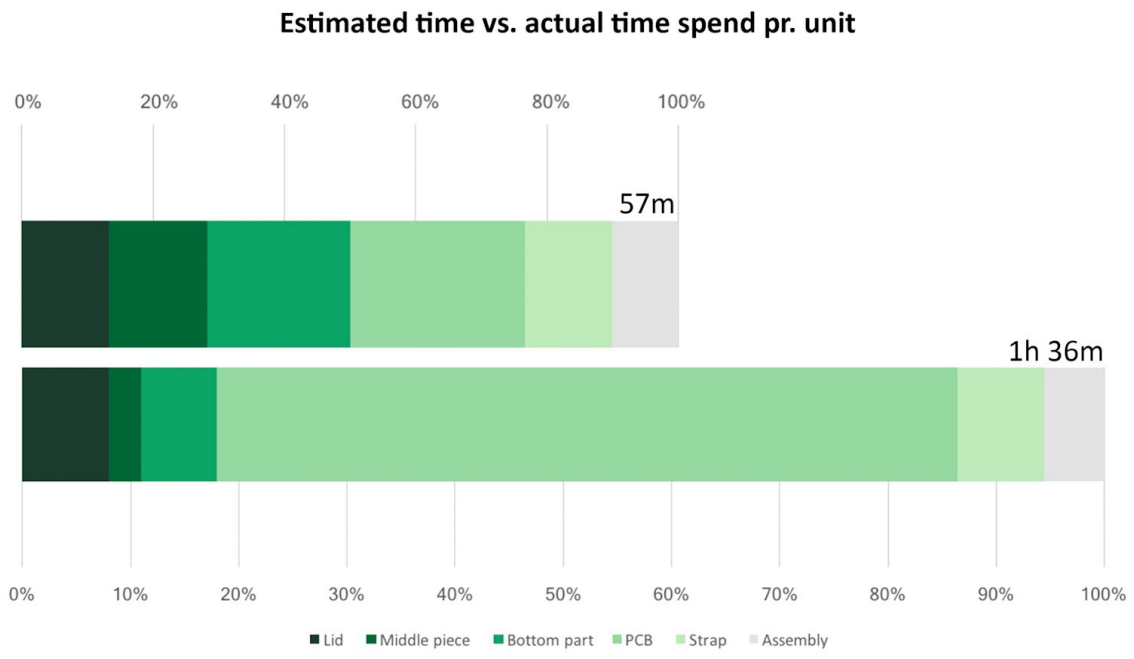


Figure 62. Graph of manufacturing time

As seen on the graph above, the manufacturing time went up with almost 170% for the manufacturing of the PCB. When starting this project, the electronics was made for being manufactured by a pick-and-place machine, this would have been ideal for the circuit. With the current solution it would be hard to get 500 units ready for Roskilde Festival.
Due to the underestimation of the PCB the total manufacturing time also went up. Before the estimation of the manufacturing time had been around 57 minutes pr. GLØD Lantern and now with the knowledge of the time spend pr. PCB the time went up to 1 hour and 36 minutes.
It can also be seen that many of the other production methods took less time than estimated which follows the overestimation of time.

Besides the problems with the PCB, the rest of the production process had also breakdowns as the sequence model for the manufacturing of the middle piece shows in appendix 76: (sequence model middlepiece) .

As we used two laser cutters we were able to manufacture each middle piece within 1 minute and 5 seconds compared to our estimation that had been with using just one laser cutter and we hereby bisected the process. But as it turned out the laser cutters did not follow the same tolerances and we could therefore not use the same file. There had to be made individual tests with especially the USB cable and the button to make sure the holes in

the middle piece fitted. As this problem was solved and we were to assemble the USB-cable in the middle piece, we discovered that the diameter of the cable were not the same for all cables. This meant that the cable was extremely tight in some of the middle pieces and sort of loose in others.
The PCB was placed on the middle piece with glue. The PCBs microphone was sticking out on the back, this made it not planar to the the middle piece and resulted in use of more glue. This meant that the glue had to dry for longer.
The switch that was did not have a clear direction of which was around to put it. This meant that in some cases the “party mode” would be placed as “white light mode” and the other way around.
The sewing was done at a regular sewing machine and as the material was app. 3 mm thick the sewing machine had a hard time moving and penetrating the material. Thick needles were broken a couple of times.
When receiving the finished strap from Victors sister it was supposed to run smooth through the holes placed in the container, but could not. This was due to the burned nylon at the end of the strap that was done to stop the textile from flossing.
The stickers was placed on the bottom part. This was an operation that the team had considered a hard task before the production, but with the manufacturing of a “sticker form” it was easier to place the sticker, seen in figure 64.

Figure 63. Assembled middle piece

Figure 64. Sticker tool

Figure 65. Supporting piece

A form was also made to keep the supporting piece in the right place as they were glued on to the middle piece. The supporting pieces were added as the lid otherwise would be hard to place correctly. But during fieldwork at Jelling and Heartland festival, the supporting pieces were broken and therefore it was chosen late in the manufacturing process not to use the supporting pieces.
The manufacturing process of the PMMA bottom and the PS lid went more smooth with only one breakdown for the PMMA process. See appendix 77: sequence analysis vacuum forming PMMA and appendix 78: sequence analysis vacuum forming PS.

Looking back at the production chosen production method

When we initially formulated the learning objectives for the bachelor thesis we wanted to manufacture 2000 units. This number was later reduced to 650 and soon after to 500. Now we realize that once again the number of units that can be made might not exceed 150-200 units before Roskilde Festival.

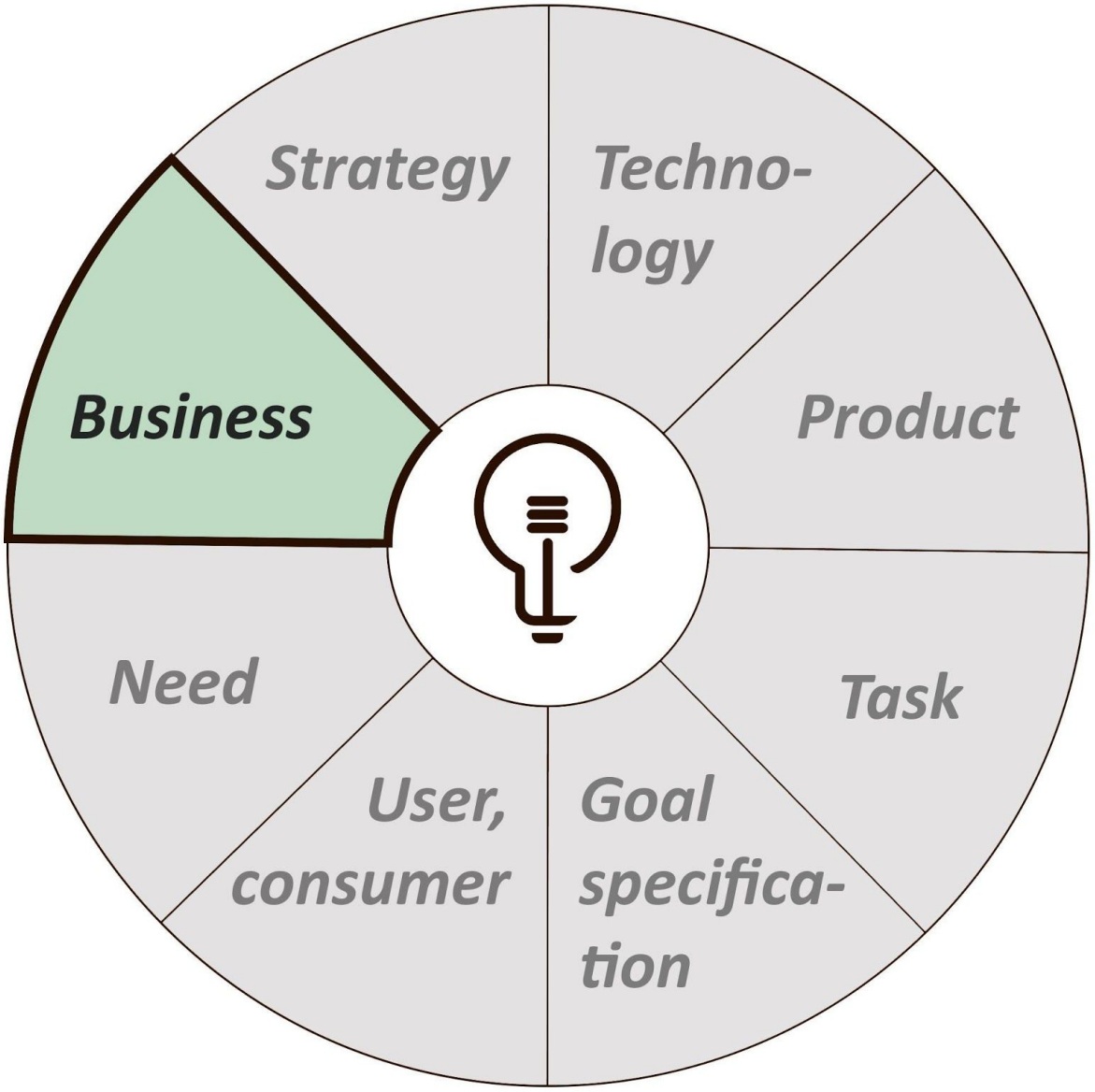
We have in this phase of the project learned that a manufacturing process requires a great amount of money and a high number of units (at least 2000 probably closer to 10.000) for the unit price to be reduced to a reasonable amount that can lead to a healthy business. It also requires time and several loops of manufacturing optimization.

We had in the timeplan estimated to be ready in 12 weeks before the deadline with the electronics. But even seven weeks before the deadline the electronics were still not ready and we didn't dare to take the risk of debugging 500 PCBs so we chose the current manufacturing setup that are now creating huge time issues. If the electronics had been ready just a few week before it would have been possible to manufactur with a pick and place machine. Then the estimations in the timeplan would have been fulfilled. Looking back at this from a business point of view, the team should probably have considered to only manufacture 20 units in hand and get proof of concept by sales, before stepping up to 500 units. But as this bachelor project task was to experience a mass manufacturing process, unit numbers had to be higher.

As the development phase of the product was not done when visiting potential manufacturers at Letbæk and FC Systems it was hard to get a full overview of the cost of the product. At that point we did not have a total overview of how much money the project would receive in funding and this also made it difficult to get an idea of what to design for and hereby manufacture.
As it turns out their is a great amount of breakdowns in the process of manufacturing the lanterns and especially in the assembling of the lanterns. Here the team notice to have lack of experience as we realize how much tolerances matter in assembling different components. The amount of time spend on the project have until this point not been a consideration as the team considered their time for an endless bank of seconds. But as we now realize the amount of time it requires to manufacture 500 lanterns, cannot be done even if the team spends all hours until Roskilde Festival simply because the PCB requires so much time.
Even though the design team had considered mass manufacturing all the way through the product development phase, we should have used even more module based and simpler design. The glue that holds the lantern together makes it difficult to assemble but also disassembling if a mistake has been made or for recycling of the product. If the team had

the money to upscale the unit number so that a plastic injection molding machine could be used then there would have been a possibility to use threads or snap-fits for the assembly of the plastic instead of glue. Due to the agile time planning the team had to push themself to make quick decisions and looking back at this the 5 months that the project was considered to last for all the eight phases of the product idea model is simply not enough time.
The team did finish everything in the production but the electronics. The reason for this is probably because the design team had little experience with manufacturing of electronics and therefore we had to rely on other people. We could not pay these people and they were not as fully integrated in the project as the design team. Hereby they were not committed on the same level as the design team and did not have the time available to spend on the product development of the electronic circuit. As the design team were counting on friendly deeds from Chris Cornaby, that was using his spare time on the process, it is very difficult to demand him to do additional work.

Business



Phase 8

In this phase we will briefly describe deals that were made with distributors, sponsorships and etc., also about receiving funding and building a sales platform.

Building a business

Introduction

In the following section GLØD's business plan will be reviewed. At first, the choice of company structure will be discussed. Secondly, the market potential and choice of market is analyzed. Based on the choice of market a pricing strategy is discussed. Lastly, the financial plan is analyzed where both costs, budgets and financing are explained.

Creating a company

When starting and creating a company in Denmark, considerations about company structure has to be made. In this case, there was three possible choices for our start-up; *Iværksætterselskab (IVS), Anpartselskab (ApS) and Interessentselskab (I/S).*

	IVS	ApS	I/S
Limited liability	Yes	Yes	No
Share capital required	DKK 1	DKK 50,000	DKK 0
Insurance needed	Yes	Yes	No
Audit required	No	No	No
Taxation	Company	Company	Personal

GLØD prioritized to have limited liability in case of default as well as not having to be personal taxed, as we want to continue operations next year. Since the team did not have DKK 50,000 in share capital we went for an IVS company structure.

When creating an *iværksætterselskab* we had to write an article of association as well as a owner's agreement in case of future disagreements or conflicts. The article of association was based on a template but customized to our needs.
Although only DKK 1 was required, it was decided to post DKK 24,000 in share capital. Each share have a nominal value of DKK 1.
Further banks, insurance companies and sellers of auditing programmes had to be contacted in order to fulfill legal requirements. The team collected offers from minimum three companies in each category and picked the best fit based on the criterias *price, user-friendliness* and *benefits to our operations.* The choices was Danske Bank (bank), Codan (Insurance) and Dinero (Audit).

Market potential and estimation

New market opportunities

The team have spotted a rapid development in the market for LED, batteries and smart-bulbs but the market for outdoor smart-lights remain untouched. The potential for the GLØD Lantern is yet to be discovered but we estimate our product can serve different markets.

If targeting only Denmark, we have divided the market into two possible markets: The festival market and what we have named “the retail market”.

The retail market

There are pros and cons in dealing with the retail market. The pros are: a big market, it can be scalable and there are multiple segments which means that the product can be sold at a higher price. But if the product is sold through retail stores the cons are higher costs and if we then choose to sell it through our own webshop there might be too much logistics involved and a big possibility of a small amount of units sold.
On the retail market, there is plenty of competition for lights, although GLØD has unique features that are currently not on the market. The closest we got to GLØD was the Philips Hue lamp, but as it needs a box hooked up to the local wifi and is made for indoor living, we do not see it as a real competitor.

The festival market

The festival market is an “easy to access”-market when we have partnered up with Volt and the target group has been chosen to be students in the age of 20-30 years old. But as the festivals are only a few weeks a year the number of units sold will be lower and there will be limited scalability.
On the festival market there is no direct competitors which offers users the same as GLØD - at least we have not been able to find any. The closest competitor is regular lanterns, although they do not provide interactive light.

Chosen market

When choosing the market we considered going all in on one market (waterfall method) or try to target multiple markets at once (sprinkler method). The advantage of targeting multiple markets would be to see which market performs the best and then afterwards focus more on that market.
Although, due to the fact that the team had to produce everything and have limited financial funds, GLØD were forced to only target one market at first.

Based on the previous arguments, the first market that will be focused on is the Roskilde Festival in Denmark. In the long run focus will be on the market for outdoor transportable lamps, as the team have seen a growing potential in this market as batteries have increased in capacity. The team plans to do direct sales through a webshop as well as semi-direct sales on festival through the established company VOLT, whom GLØD have a good business relation to. The partnership with Volt is important to the strategy as it otherwise would be difficult to enter the festival market.
As mentioned earlier the development arena around GLØD which we have called "outdoor lighting" is interesting to get into in the long run, as we relate this arena to a high number of potential customers and hereby larger turnover. Stockholm Furniture and Light Fair underline this as it was observed there that many actors are in this arena which gives an impression of the market size. GLØD will benefit from a larger number of units sold as the company hereby can reach economies of scale and it is the company's long term goal to get into this arena.

Market estimation:
The festival market consists of more than 200.000 consumers in Denmark. At Roskilde Festival, about 80,000 guests choose to stay at the camping area, in which we estimate to be 10,000 different camps. We estimate that there will be a sale of 1.3 GLØD Lanterns per "customer camp". If we have a 5% purchase rate of all the camps on Roskilde Festival, we can sell 650 GLØD Lanterns the first year. This, of course, is only for Roskilde Festival, however sales could also be made through other festivals or online. As a consequence of the limited market potential on festivals, it has been made possible to connect the lantern to an electric socket which enables the user to use the lantern at home. In addition, the team sees a potential in targeting households with gardens, as it accounts for more than two-thirds of the population.
Because of financial reasons we have chosen only to produce 500 lanterns but we still estimate that it will be possible to sell 650 units.

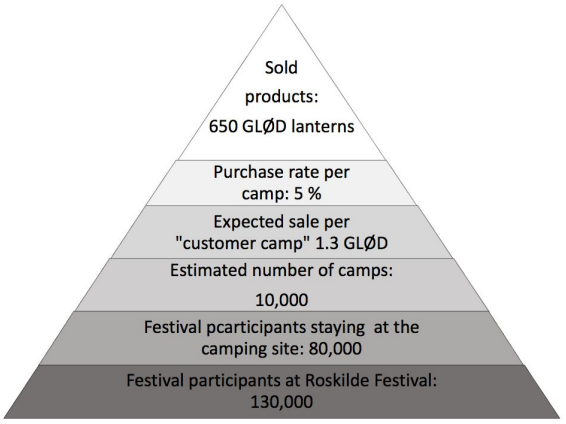


Figure 66. Market estimation

Pricing on the festival market
According to the survey of the users of the 2017 lantern, GLØD should be in the price range around DKK 200. This would put the lamp in the cheap category, but many of the functionalities, such as the party mode or fade mode imply that GLØD could also be represented in the Alternative category as the earlier competitor analysis shows.

The price of GLØD is not including a power bank, which the consumer would have already or buy seperately. A power bank from Volt would add 399 kr[30] to the price of the lantern so that the price would jump to 599 kr - which would put the lantern in the design category. So it seems that GLØD could fit in all categories of the competitor analysis. As the lantern can be viewed of in different ways according to the price and hereby function in the cheap or design category, the team assumes that it gives the possibility to sell the lantern in a broader variety of shops. But as the lantern is specially developed for the festival market, selling it at a regular retail shops can have its difficulties.

Marketing

Our marketing strategy is to promote GLØD Lanterns as under the following vision:

"GLØD Lanterns aims to create memorable summer experiences through interactive lights"

As the funding and almost the entire budget have been spend on the production there are a small marketing budget. Marketing will be done through the means that the team have such as social media and a webpage.

SoundBox is another company GLØD has been in contact with. GLØD were negotiating a concept for bringing light to the SoundBox stage by numerous GLØD-lanterns. This would result in good marketing display and product association with SoundBox. SoundBox is a powerful portable speaker system for outdoor and festive moments also based on large batteries. In the process of negotiating with SoundBox the company wanted to receive the lanterns for free or GLØD to pay an amount of DKK 10-15.000 for a place next to the SoundBox stage. This was something GLØD could not live up to and the negotiations were stopped.

At Jelling festival we noticed that people at the camping area did not explicitly know about GLØDs possibilities. The lantern did not sell itself and festival participants did not understand that the lantern could interact with music. Volt also noticed the team that people need to be made aware of the products existence and what it can do. With limited funding we have chosen to focus mainly on GLØDs Facebook group[31]. We have also started a web page where it is possible to buy the product.

A solution to communicate the products function, was to make multiple short promotion videos. The short videos (short 30-45 sec.) included music, text describing the product and a direct message in the end that described the price of the product and how to purchase it. This resulted in higher numbers of visitors at the webpage. Shortly after the first video was launched the first online sale was made. As seen in the graph below, the post that reach most Facebook users was the first promotion video that was published at the 12th of june.

[30] Buy Volt power bank. Found [06/01/2018]. At [https://getvolt.dk/da/order?ipa=329].

[31] https://www.facebook.com/GlodLanterns/

The second highest reach was the post when GLØD launched its webpage at 7th june.

Published	Post	Type	Targeting	Reach	Engagement
06/16/2018 7:09 pm	GLØD was at a great PARTY and created a fantastic atmosph			950	105 26
06/12/2018 1:25 pm	We have created a short video to show how the GLØD Lantern			1.6K	269 46
06/07/2018 4:44 pm	Do you want to create memorable summer experiences? – So			1.3K	213 57
06/06/2018 1:34 pm	We've been working so hard to get this product done and soon			402	165 26
06/05/2018 10:32 pm	One year ago, Ingeniøren wrote this amazing article about GLØ			492	99 36

Figure 67. Facebook graph

Looking at the webpages analytics it is clear that there is a direct relation with the posts made on the Facebook page and the number of visitors at the webpage. For example the launch post, where almost 60 people visited the site and the day after and the Facebook groups most popular post on the 12th of june.

Figure 68. Webpage graph

At Jelling Festival the team realized that Instagram was very important for the target users and therefore created an Instagram account[32]. As many potential users asked for GLØDs, at the time, none existing Instagram. The GLØD team were not aware of the Instagram possibilities and used its network to locate a marketing student from Århus University, Anne-Mette Spahn. She was made in charge of Instagram, to gain experience. The GLØD team hereby only use its network to share the story of GLØD.

[32] https://www.instagram.com/glodlanterns/

The team hope to get in touch with journalists that can promote GLØD through articles before Roskilde Festival starts, but this has not yet been an option. Besides DTU that are writing two stories about the project. As seen at the 5th of june from the earlier graph on the Facebook reach, this is also getting visitors on the website.

Financial planning, budgeting and financing

An important element to consider when starting a business is the financial planning. GLØDs approach was to first set a target for our production and then apply for funding and external financing. GLØDs target production was 500 lanterns which required approximately DKK 100,000 inclusive of VAT and costs revolving prototyping.

Financing and funding

The team applied to multiple grants and received the following grants inclusive of VAT; Fonden For Entreprenørskab: DKK 50,000 and SmartCampus: DKK 5,000. In addition, we sold advertisement worth DKK 18,750 to DTU communications and products worth DKK 5,000 to Roskilde Festival Powered by DTU Students. Finally, we decided to post the remaining, DKK 24,000, in equity. A total of DKK 102,750 was collected.

Cost drivers

GLØDs budget was changed multiple times due to changes in production methods, unexpected costs or discounts on procurement. The final budget can be seen in appendix 79 (Budget GLØD). Please note, that costs are exclusive of VAT. We managed to stay within budget, although everything was utilized.

The costs can be divided into 5 categories; Electronics, Plastic, Other product specifics, Marketing and Administrative costs. Costs related to electronics and plastics accounted for 87 % of GLØDs costs and are by far the most expensive in our production. The production of the plastic containers amounted to DKK 75 and electronics components DKK 74.5 per unit. One of our considerations throughout the prototyping process, was the payoff between quality and price. As the high unit cost might imply, we choose to buy quality products as well as buying most parts in Denmark or northern Europe.

Due to financial constraints, we had to limit our marketing budget to a minimal. Marketing costs accounted for less than 2 % and is mainly costs related to our web shop and a small fraction related to online and physical advertisement.

Our spendings on administrative costs amounted to 6.3 % or DKK 5,564 which is primarily driven by two tickets for Roskilde Festival which we need to operate. One could argue, the tickets should be classified as marketing costs. Other administrative costs include insurance worth DKK 2,000. The team were fortunate to be granted a free bank account.

Production costs per unit amounted to DKK 169. DKK 169 is considered to be high but is due to the fact that most procurement is made in Denmark. It is estimated that costs per unit

can be significantly lowered by higher unit numbers and components bought in China or similar countries. In addition to this, production in low-wage countries such as regions in Asia or eastern europe, will also decrease the production price.

Liquidity issues

One of the main issues for the team was to match liquidity. When producing, most costs will lie in an early phase, although funding might first arrive later. Therefore, we have had to negotiate with creditors and investors, to postpone payments or receive payment earlier.

Setting up agreements

Volt

The company Volt was involved in the project of 2017. Therefore Volt has been an integrated part of the project throughout the whole process. The team has participated in multiple meetings with Volt and have agreed that the company will sell the GLØD-lantern at their 17-shops at Roskilde Festival the cost of 30% of the lanterns price at DKK 199. The team recognize that this price will remove all profit compared to the unit price, but as the project is in the development phase, and the objective is to get proof of concept, the team agrees to these circumstances.

Figure 69. Volt logo

Webpage

The GLØD-webpage was developed approximately one months before the festival for potential users to pre order their lantern. The website can be visited at www.glodlanterns.com. The website was made using the platform of shopify which made it possible to order the product with GLØD only losing 2% of the price compared to 30% at the festival.

In the website the design team together with the business student Nicholas tried to use the things that went wrong in the production phase to our advantage. This for example that everything was handmade in Denmark. We had a hard time knowing if this was a good or bad thing, as the

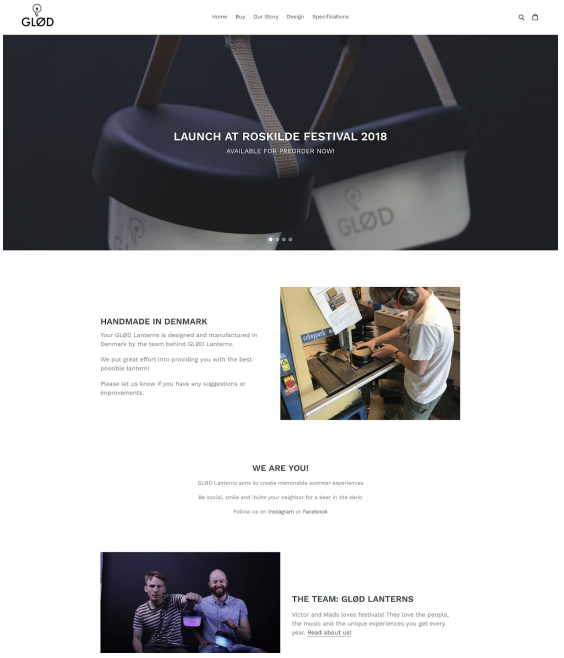


Figure 70. Webpage

product was priced at 200 kr and did not live up to quality products that usually fall in the category of handmade products in Denmark such as designer items. But this was a way to get credits for the hard work that had been put into the product, which was the reason why the team chose to brand this at the website.

Sponsorships

Besides the sponsorship of materials from Elas and Kvadrat, that was described in the production phase, GLØD also received a sponsorship from DTU for 15.000 (excluding vat). The deal was that a text would be displayed at the lantern where it said "Invented by DTU students". This sponsorship was valuable for DTU as it went hand in hand with the universities branding of "Det blir til noget" - at DTU things will happen.

Team extended with other students

When creating GLØD as a business we quickly noticed how important it had been to partner up with Nicholas Fribert from CBS.
As students of Design and Innovation, we have not been introduced to the formal parts of creating a business so this was something that Nicholas Fribert took care of. He introduced different company structures for the design team and together we choose the IVS-structure. Nicholas Fribert also wrote the owner's agreement which we all agreed upon. Here different titles were given to the members of the team. Mads became CTO and head of electronics, Victor became CTO and head of design and product development and Nicholas Fribert the CEO and head of finances. The interesting part of this, was how the titles did not matter much. There was no doubt that all major decisions was made by the design team and it was the design team that communicated with Nicholas Fribert as responsible for business and Chris Cornaby who were working for the electrical development. But as the design team received all informations from Nicholas Fribert and Chris Cornaby consensus could be made in the entire team.

Meeting the "real world"

The budget for the project was at 102.750 DKK and this was even though we did not receive Skylab funding. As we found out this was not enough to have 500 units manufactured with a pick-and-place machine and professional vacuum forming even though the price pr. unit would be app. 200 DKK, which we had estimated the price for the product to be sold at. This underlines how expensive it is to manufacture products at least in Denmark and at this unit number. This is something that surprised us a lot during this project. Everything cost money and in the "real world" (outside university) especially production cost money – a lot of money. We learned this the hard way when seeking prices on production, this have lead us to understand that for producing things in Denmark the prices are fair for prototypes, but as soon as something shall be mass produced it is much cheaper to have it done in eastern Europe or China. This is the easy thing to say, but as we also learned during the process it is

extremely hard to get in contact with Chinese or even polish manufactures and especially when the unit size is only 500 and the amount of time it takes to have things produced is also much longer as shipping usually takes around 6-8 weeks.

If we were to make a similar product in the future, the unit size should be much larger and we should travel to China to get in contact with factories, as the web is not good enough for communicating. Producing products in Denmark require the product to be much more complex and unique than a GLØD lantern is, so that a higher price would be acceptable for the consumer.

A startup in Denmark

During the project we have noticed how much Denmark and our university DTU, is focusing on innovation and helping startups. At DTU we participated in Ignite, the 12-week startup program at DTU Skylab. The team also received a lot of feedback from the fond of Entrepreneurship and were invited to meetings. As we can see, Denmark is trying hard to help the startups. But we still think that the programs have a lot to learn, as we don't see them as geared to really help the startup companies where it actually matters. It seems that it is very acceptable to fail and it almost come as a surprise to the funds when a team actually does what they say they will do.
We noticed that most of the startups in Ignite were consisting of a team with a very early stage of an idea or concept. A program like Ignite, which is a very common startup program, focus on pitching and good group work – which we did not see as real challenges to GLØD as a startup company. We found it much more relevant to get guidance and consultants in how to seek legal advice, funding, getting to know the consumer, building a website and most importantly to get in contact with manufacturing facilities. The definition of a startup is *to grow fast* otherwise it is just a company and that is why we found the subjects discussed in the startup program Ignite as more focused on building teamwork in a company and not a startup.

Reflection

The design engineers role

The job for a design engineer usually involves communicating with many practice domains. This can be done since the Design and Innovation education is very multiple directional allows design engineers to communicate with practice domains such as those from CBS and electrical engineering.

It can be seen that Chris Cornaby and Nicholas Fribert come from two very different practice domains. The two practice domains has a hard time communicating as they are not from the same community of practice. Nicholas Friberts community of practice comes from the Copenhagen Business School. This practice domain is focused on optimizing profit from selling products. Chris Cornabys community of practice on the other hand comes from a practice domain, electrical engineering, which focus on optimizing electrical circuits. Nicholas Fribert was uncomprehending towards Chris Cornaby difficulties in finishing the circuit faster and making it cheaper. Chris Cornaby also failed to see some of Nicholas Friberts qualified estimations that was made on behalf of analysing the market. An example of this was pricing. Chris had difficulties accepting Nicolas Friberts decision of lowering the price of the product, even though he had not been involved in any analytics regarding price. As a result of this almost all communication and decisions worked through the design team. We have realized that communication like this is a big part of leading a team. By this, we experienced that the education Design and Innovation gives a good foundation for being a project leader as the students are used to have the overview of the project and therefore can make qualified decisions and distribute tasks. We assume that this is due to a large amount of time spend working in groups and on projects with many differents tasks.

With this project we have explored what is possible to make with the tools that have been giving to us during the past three years at Design and Innovation. It is clear to us, that the role of a design engineer has is the role to make a chaotic situation clear and more tangible. This requires that the design engineer can communicate and act within many fields. With this project we, as design engineers, have certainly met and worked with many fields. This helps in communicating and translating messages and ideas between different fields and get the most out of the potential. We realized that this is leadership. The team experience how central the product is for a company as the product affects every other area of a company. We therefore argue that it is very natural to function as a project manager.

In this project we have realized that a design engineer cannot overcome all aspects of a product development. By only working in the "surface" of certain parts of the project and

delegate tasks such as electronics and business, we can get around a development of a project like GLØD and go beyond our own competences. As a design engineer we have to rely on other praksis domains. But just as insuring, as this projects confirms, other practice domains rely on the design engineer to take the lead and make important decisions.

The product idea model

In order to have good chances of a product succeeding all of the phases of the product idea model needs to be fulfilled, according to Claus Thorp Hansen and Mogens Myrup Andreasen.

As shown in figure 71 the product idea model is not completely fulfilled. The team behind GLØD has prioritized the manufacturing higher than the other parts of the project and this had influence on the end result.
Further work needs to be done in order to develop a complete product.

More research is needed to conclude that there is a need for the product and that this need can be fulfilled with our product. It is hoped to gather that information a Roskilde Festival this year, since the product will be for sale.

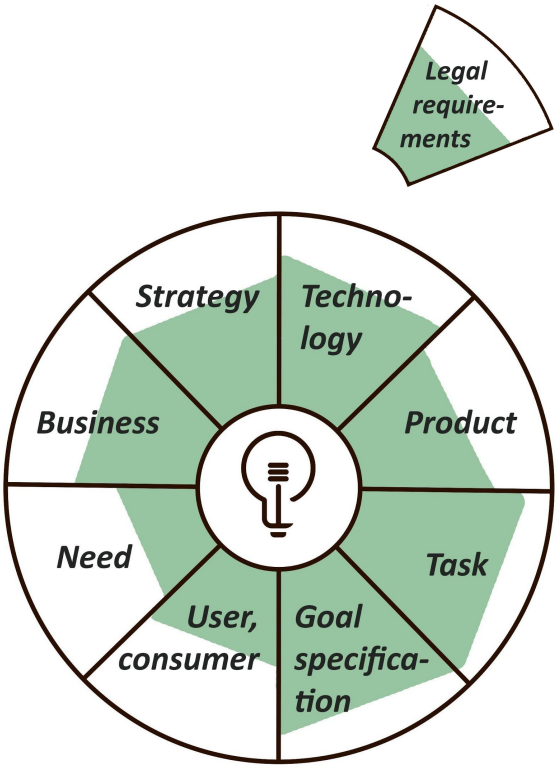


Figure 71. Complete product idea model

The product needs more development, as the design could be more robust and the electronics functions more precise.
The user of the product might be in a completely different target group than we had expected.
Since the production of the GLØD lantern is only at 500 GLØD, the inteted manufacturing methods used are suited when it comes to the manufacturing of the plastics. But not suited in terms of manufacturing of the electronics.
In the process we have learned that legal requirements matters so much that we have added it as the ninth dimension. The team is fully aware of the legal requirements for the products, but not completely certain that they are fulfilled.
During the bachelor project we have realized that in order to fill all the phases such as researching a demand, designing a new product, making a complete production plan and producing the product it will require more than 5 months to fulfill or a bigger team.

Conclusion

To conclude this report we will discuss how we have met the 10 learning objectives that was first formed when starting this project. The learning objectives were set as the boundaries of the bachelor thesis together with the learning requirements of a technical bachelor thesis from The Technical University of Denmark. The numbers are referring to the number of the learning objectives introduced in the beginning of this report.

In the beginning of the project a detailed plan was created to get an overview of the entire project process (1). The timeplan was later compared with the actual time spent on each process and it was found that the estimations were not off until it reached the manufacturing of the electronics. The electronics was designed for manufacturing on a pick and place machine with help from electrical engineer students (6). But it was later decided that the electronics were not ready for manufactured and would be pick and place in hand instead.

To manufacture the product it was chosen to use vacuum forming in Denmark, as this was the cheapest production method when manufacturing 500 units according to our calculations. The electronics had been chosen to be manufactured by ETK in Denmark, but due to time limitations it was not possible and therefore done by hand (7).

Through an iteration phase different ideas were made that turned into five different concepts. By prototyping seven molds in both plastic and MDF were made to create the concepts for user feedback. On behalf of manufacturing knowledge obtained in the prototyping phase and the user feedback a final concept were made. This meant creating four final molds in solid aluminium for vacuum forming 500 units (5).

The final prototype lived up to the chosen production method vacuum forming.
The production of the final prototype can be repeated to make 500 functioning lanterns (8).

Before the final concept had been created, five concepts was made on behalf of multiple creative techniques such as virtual morphology scheme and systematic techniques such as basic and quantified structures (2).

We have gained knowledge about existing products by visiting Stockholm Furniture and Light Fair. Besides this, we have also gained knowledge about different manufacturing techniques by visiting manufacturing companies and dialog with DTU tool shops at both

Lyngby and Ballerup Campus. We have interviewed a focus group regarding the first five concepts. The electronics was tested at different parties such as DTU Line Party and the final prototype were used at Jelling and Heartland Festival to get potential user feedback (3).

Different methods from courses is used in this report. Such as the Product Idea model from Arenas and Concepts. Morphology scheme and basic knowledge of production method from Product analysis and Redesign. Basic and quantified structures from Product Design and Documentation (10)

By forming a survey early in the project, we had a guideline of which aspects of the product from 2017 that needed improvements. The success of the solution is discussed by the use of the product idea model and points out that further improvements needs to be made (4).

To design a business strategy and distribution strategy we extended the team with a business student Nicholas Fribert. Based on his recommendations and a market estimate from the survey we set the price of the newly designed lantern at 199 kr. Marketing of the product was chosen to be done through social media and a website shop. A distribution strategy is created with Volt Power Banks, that will distribute and sell all lanterns at the festival for a 30% cut (9).

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From idea to production of GLØD

Appendix

The Techical University
of Denmark

Mads Hesseldahl S15499
Victor Bertelsen S154370

Supervisor: Tim C. McAloone

1. The GLØD team

Victor Bertelsen is our main design engineer. He has recently returned from a semester abroad on TUDelft in the Netherlands where he specialised in design of lamps. In addition, to his great commitment in GLØD, Victor has also chosen to write his bachelor project about GLØD.

Mads Hesseldahl has his hands on most parts of the project. He is responsible for the electronic development as well as designing our product. Mads is key in combining the different elements in our product. Mads recently returned from an internship in Lego's development department and has also chosen to write his bachelor project about GLØD.

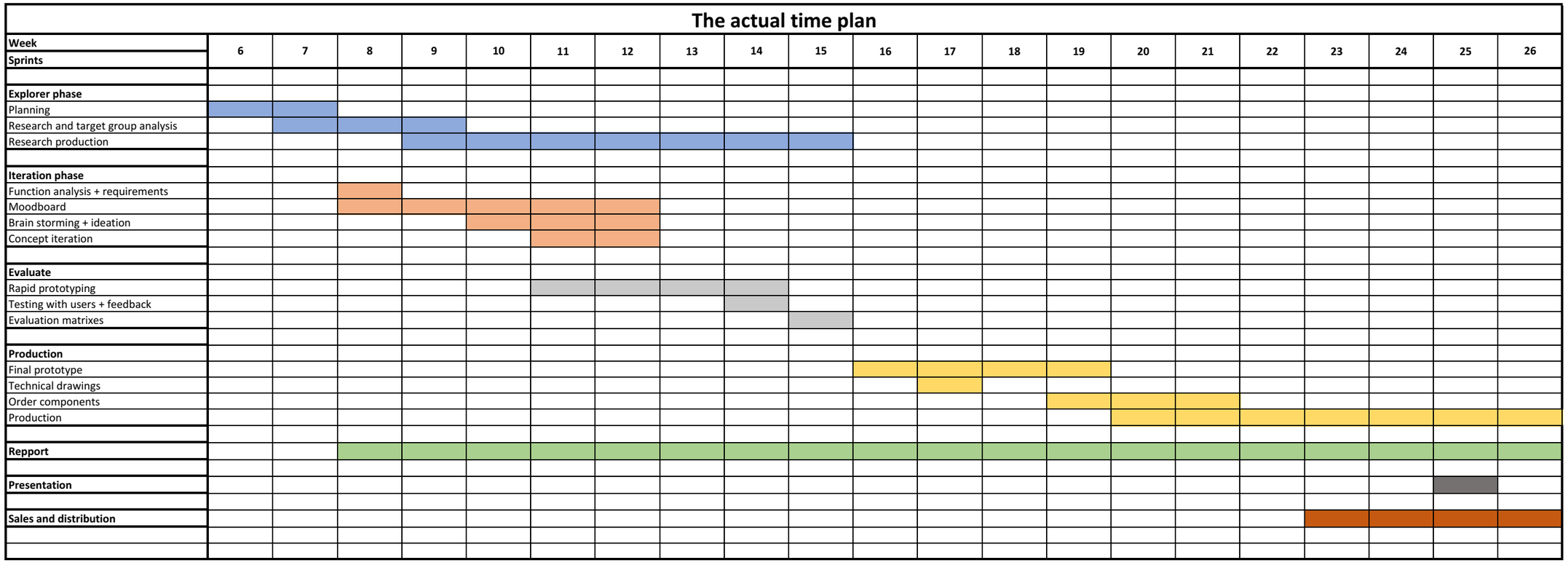
Nicholas Fribert joined GLØD post Roskilde Festival 2017 and is responsible for business development and finance. Currently, he is studying a master in Finance & Investments on CBS and has experience in Carnegie Investment Bank. Nicholas is key keeping costs low, keeping track of liquidity and developing market and segmentation strategies.

Chris Cornaby joined GLØD post Roskilde Festival 2017 and is responsible for electronics. He is currently studying a master in Electrical Engineering at DTU. Chris has experience in Nordic Power Converters and specialises in developing LED lighting. Chris is the main person behind the circuit and the design that makes et possible to mass produce.

Anne-Mette Spahn is responsible for Instagram and social media. She has studied Business and communication at Aarhus University and wanted to use her skills with GLØD.

GLØD

2. Timeplan compared



GLØD

3. Design specification (version 3)

CATEGORIES	REQUIREMENTS	CRITERIA	COMMENTS
Construction	The lanterns power source is a power bank. The lanterns electronics consives: RGBW LEDs, a microphone, a unit that controls the intensity of the LED's, a cable with a USB male type A connector and a three stated switch. The lantern has storage room for a power bank. The electric circuit is covered with the shell.	The more "hygge" and good mood the lamp can create the better. It would be preferable if the plastic shell can be produced with the fewest components possible.	
Manufacturing	There will be produced 500 units within the 24th. of June. The production time of the of the shell is under 4 weeks. The production time of the of the electronics is under 8 weeks. The production price shall not exceed DKK 200,- incl. moms.	The lower initiativ investment for the manufacturing method the better. The lower time and cost used pr. unit the better.	The number of produced units should be regulated at a yearly basis.
	The PCB layout shall not exceed two layers.		
Design	The LEDs can light through the shell with 250 lumen. The lantern has a inbuilt microphone that can function on a sound level up 110 db. The container has to have a radius of at least 20 mm and no negative angles.	Design solutions were the power bank is more easy accessible is prefered. Solutions where the container is robust is prefered. The shell is preferred not to exceed a volume of 2 liters. The lantern should be able to stand on its own.	The design should appeal to people in the age of 16-30 years old.
Use	The electronics, when on, cannot use more than 1A at 5V and cannot use less than 50mA. There is a safety mechanism against static electricity, in the electronics on a factor of 4. The shell is able to contain a power bank with the dimension of 140 x	A solution with a strap, so the lantern can be hung, is preferable. The more secure the power bank is secured the better. Materials that is long lasting is prefered. The easier the lantern is to transport for the	

	85 x 35 mm.	consumer the better.	
Functions	The lantern has three modes: - White light mode (the lantern emits constant white light) - Fade mode (the lantern fades between all clear colors) - Party mode (the lantern fades between all clear colors with intensity varying by the input of the microphone). The electronics can run on “party mode” for 8 hours with a 3500 mWh power bank		
Usability	The user shall be able to control the lantern with a switch.	The more easy the switch to access for the user the better. The more easy the lantern is to hang the better.	
Logistics		The prefered solution is a design that is easy to ship and store.	
Legislation	The lantern complies to the CE requirements. The lantern complies to the WEEE requirements. The materials used shall be within the ROHS-criteries.		
Environmental impact		The shell is prefered to be made of materials that does not harm the environment and easily can be reused.	The lantern could be a part of a deposit system, where the users hand in the lantern. The electronics can then be put into another shell and the used plastic is thrown out. Roskilde Festival appreciates environmentally friendly products.

GLØD

4: Power bank size

Within 140 x 85 x 35 is green:

Capacity	Output	Dimentions	Prize	Link	Capacity	Output	Dimentions	Prize	Link
10.400 mAh	5V/1A & 5V/2A	130 x 81 x 36mm	349 kr.	https://powerbanken.dk/pro	50000mAh	5V/1A&5V 2A		DKK 114.55	https://www.ebay.com/itm/
26.800 mAh	5V/3A	80 x 180 x 24mm	999 kr.	https://powerbanken.dk/pro		5V / 1.5A 5V / 2A	156 * 81 * 23MM	DKK 24.18	https://www.ebay.com/itm/
10.000 mAh	5V / 2,4A	92 x 60 x 22mm	349 kr.	https://powerbanken.dk/pro	50000mah	5V / 1-2.1A	120*70*15mm	DKK 84.13	https://www.ebay.com/itm/
20.100 mAh	2 usb	165 x 58,4 x 22,9mm	599 kr.	https://powerbanken.dk/pro		5V/1A	90x20	DKK 4.65	https://www.ebay.com/itm/
5.200 mAh	5V / 2A	97 x 43,4 x 22,3mm	249 kr.	https://powerbanken.dk/pro	20000mAh	5V 1A, 5V 2A	124 * 79 * 21 mm	DKK 23.58	https://www.ebay.com/itm/
20.000 mAh	5V/2A	166 x 62 x 22 mm	649 kr.	https://powerbanken.dk/pro	5600mAh	5V 1A, 5V 2A	96*44*22mm	DKK 4.65	https://www.ebay.com/itm/
7.800 mAh	5V/1A & 5V/2A	113 x 78 x 30mm	299 kr.	https://powerbanken.dk/pro	300000mAh	5V 1A/ 2A		DKK 42.24	https://www.ebay.com/itm/
2600 mAh	DC 5.0V / 1,000 mA	98 x 18 x 13mm	99 kr.	https://powerbanken.dk/pro	10000mAh		98*27 mm	DKK 90.85	https://www.ebay.com/itm/
4000 mAh	5V/1A	110 x 69 x 9,8mm	149 kr.	https://powerbanken.dk/pro	8000mah	5V=1A	152 x 76 x 10mm	DKK 96.91	https://www.ebay.com/itm/
10.400 mAh	DC 5.0V / 2,000 mA	170 x 110 x 30 mm	299 kr.	https://powerbanken.dk/pro	10000mAh	5.1V2.4A	130 x 71 x 14.1	241.83	https://www.ebay.com/itm/
10.050 mAh	5V / 2A	96 x 61 x 23mm	499 kr.	https://powerbanken.dk/pro	50000mAh	5V / 1A	76×153×9.8 mm	DKK 72.67	https://www.ebay.com/itm/
10.000 mAh	5V/1A & 5V/2A	146 x 76,5 x 14,5mm	329 kr.	https://powerbanken.dk/pro	10000mAh	5V/1A	141.5 x 73 x 14mm	DKK 21.70	https://www.ebay.com/itm/
10.400 mAh	5V/1A & 5V/2A	130 x 81 x 36mm	349 kr.	https://powerbanken.dk/pro	10000mAh	5V-1A	155 * 85 * 10 mm	DKK 25.40	https://www.ebay.com/itm/
10.400 mAh	5V/1A & 5V/2A	130 x 81 x 36mm	99 kr.	https://powerbanken.dk/pro	50000mAh	5V/1.0-1.2A	90x60x6 mm	DKK 10.97	https://www.ebay.com/itm/
5200 mAh	DC 5.0V / 1,000 mA, DC 5.0V	115 x 78 x 30mm	249 kr.	https://powerbanken.dk/pro	20000mAh	5V-1A	145*70*17mm	DKK 102.97	https://www.ebay.com/itm/
7.800 mAh	5V/1A & 5V/2A	113 x 78 x 30mm	299 kr.	https://powerbanken.dk/pro	10000mAh	5V 2.1A	135 x 73 x 19mm	DKK 51.09	https://www.ebay.com/itm/
2600 mAh	DC 5.0V / 1,000 mA	98 x 18 x 13mm	99 kr.	https://powerbanken.dk/pro	20000mAh	5V-1A	150*73*9 mm	DKK 48.43	https://www.ebay.com/itm/
7.800 mAh	5V/1A & 5V/2A	113 x 78 x 30mm	299 kr.	https://powerbanken.dk/pro	20000mAh			DKK 60.55	https://www.ebay.com/itm/
10.000 mAh	5V/1A & 5V/2A	146 x 76,5 x 14,5mm	329 kr.	https://powerbanken.dk/pro	300000mAh	5V 1A / 2A	147 × 74 × 18 mm	DKK 39.03	https://www.ebay.com/itm/
7.800 mAh	5V/1A & 5V/2A	113 x 78 x 30mm	299 kr.	https://powerbanken.dk/pro	10000mAh	5V ⎓ 2.1A	140 x 74 x 13.5mm	$24.99	https://www.amazon.com/Y
5.200 mAh	5V / 2A	97 x 43,4 x 22,3mm	249 kr.	https://powerbanken.dk/pro	20000mAh	5V ⎓ 2.1A	174 x 93 x 15 mm	$35.99	https://www.amazon.com/Y
5.200 mAh	5V/1A	110 x 60 x 26mm	249 kr.	https://powerbanken.dk/pro	20100mAh	5V 4.8A		$41.99	https://www.amazon.com/Y
20.100 mAh	5V / 2,4A	62 x 186 x 24mm	899 kr.	https://powerbanken.dk/pro	10000mAh	5V 2.4A	2.4 x 3.6 x 0.9 in	$26.99	https://www.amazon.com/Y
5200 mAh	5.0V / 2600 mA	182 x 70 x 70mm	499 kr.	https://powerbanken.dk/pro	22000mAh		6.50 x 0.94 x 2.76 inch	$39.99	https://www.amazon.com/Y
20.100 mAh	5v /2,4A	165 x 58,4 x 22,9mm	579 kr.	https://powerbanken.dk/pro	13000mAh	5V 3A	3.8 x 3.1 x 0.9in	$29.99	https://www.amazon.com/Y
7.800 mAh	5V/1A og 5V/2A	110 x 73 x 31mm	299 kr.	https://powerbanken.dk/pro	10000mAh	5V 1A & 5V 2.1A	6.1 x 1.7 x 0.8 inches	$10.99	https://www.amazon.com/Y
8.000 mAh	5V/1A & 5V/2A	140 x 75 x 17 mm	399 kr.	https://powerbanken.dk/pro	24000mAh	5V/2.4A,2.4A,2.4A	7.1 x 4.3 x 0.8 inches	$39.98	https://www.amazon.com/Y
8.000 mAh	5V/1A & 5V/2A	140 x 75 x 17 mm	399 kr.	https://powerbanken.dk/pro	24000mah		3.15 x 6.3 x 0.59 in	$29.99	https://www.amazon.com/Y
5.200 mAh	5.0V / 1,000 mA	91 x 55 x 22mm	179 kr.	https://powerbanken.dk/pro	15000+mAh	5V 1A & 5V 2.1A	2.3 x 6.1 x 0.8 in	$12.99	https://www.amazon.com/Y
3.350 mAh	5V / 1A	95 x 23 x 23 mm	169 kr.	https://powerbanken.dk/pro	20100mAh	5V 4.8A	6.5 x 2.3 x 0.9in	$41.99	https://www.amazon.com/Y
5.200 mAh	5V/1A	110 x 60 x 26mm	249 kr.	https://powerbanken.dk/pro	5000mAh	5V ⎓ 2A	5.5*2.7*0.35inc	$18.50	https://www.amazon.com/Y
4000 mAh	5V/1A	110 x 69 x 9,8mm	149 kr.	https://powerbanken.dk/pro	30000mAh		5.6 x 7.8 x 1.3 in	$39.99	https://www.amazon.com/Y
7.800 mAh	5V/1A og 5V/2A	110 x 73 x 31mm	299 kr.	https://powerbanken.dk/pro	10000mAh	5V/2.1A	156*79*13.5mm	$24.99	https://www.amazon.com/Y
10.050 mAh	5-6V = 3A / 6-9V = 2A / 9-12V	96 x 61 x 23mm	499 kr.	https://powerbanken.dk/pro	26800mAh	5V/5.5A	3.15 x 6.77 x 0.79 in	$51.99	https://www.amazon.com/Y
5.200 mAh	5.0V / 1,000 mA	91 x 55 x 22mm	179 kr.	https://powerbanken.dk/pro	16000mAh	5V 2.4A	5 x 7.9 x 1 in	$12.99	https://www.amazon.com/Y
2600 mAh	5.0V / 1,000 mA	91 x 25 x 25mm	99 kr.	https://powerbanken.dk/pro	20100mAh	5V 2.1A	165*80*20mm	$20.99	https://www.amazon.com/Y
5.200 mAh	5V/1A	110 x 60 x 26mm	249 kr.	https://powerbanken.dk/pro	24000mah	5V/2A	160*77*22 mm	$29.99	https://www.amazon.com/Y
2600 mAh	5.0V / 1,000 mA	98 x 18 x 13mm	99 kr.	https://powerbanken.dk/pro	27000 mAh	5V 2A	5 x 7.1 x 1.3 in	$19.99	https://www.amazon.com/Y
2600 mAh	5.0V / 1,000 mA	98 x 18 x 13mm	99 kr.	https://powerbanken.dk/pro	6000mAh	5V/2A	3.7 x 2.3 x 0.9 inc	$18.99	https://www.amazon.com/Y
10.050 mAh	5V / 2,4A, 5V / 1A	117 x 72 x 23 mm	489 kr.	https://powerbanken.dk/pro	10050mAh	5V, 2.4A og DC 5V, 1A	117mm x 72mm x 23mm	297,00 DKK	https://www.mytrendyphon
8000 mAh	5V 1A, 5V 2.1A	138*76*19MM	84.79 kr.	https://www.ebay.com/itm/	30000mAh	5V-6.5V/3A, 6.5V-9V/2A, 9V-	150 mm x 82 mm x 30 mm	579,00 DKK	https://www.mytrendyphon
10000mAh	5.1V2.4A 9V/12V	130 x 71 x 14.1	DKK 123.15	https://www.ebay.com/itm/	10000mAh	5V/3A, 9V/2A, 12V/1.5A	140mm x 42mm x 15mm	249,00 DKK	https://www.mytrendyphon
600000mAh	5V 1A		DKK 321.23	https://www.ebay.com/itm/	20000mAh	5V, 2.1A	158mm x 80mm x 18mm	259,00 DKK	https://www.mytrendyphon
5600mAh	5V/1.0-1.2A	90x60x6mm	DKK 8.41	https://www.ebay.com/itm/	16750mAh	5V, 2.4A	127mm x 81mm x 22mm	329,00 DKK	https://www.mytrendyphon
20000 mAh	5V/1.0-1.2A	141.9 x 73 x 21.8	241.83	https://www.ebay.com/itm/	8000mAh	5V (DC) 2 A		189,00 DKK	https://www.mytrendyphon
12000mAh	5V / 1A	100x35x35cm	DKK 6.00	https://www.ebay.com/itm/	26800mAh		180 mm x 80 mm x 24 mm	659,00 DKK	https://www.mytrendyphon
20000mAh	5V 1A, 5V 2A	18 0* 80 * 22 mm	DKK 28.30	https://www.ebay.com/itm/	30000mAh	5V, 2.1A	162mm x 100mm x 12mm	287,00 DKK	https://www.mytrendyphon
300000mAh	5V 1A/ 2A	147 x 74 x 18 mm	DKK 42.43	https://www.ebay.com/itm/	10000mAh	5V/3A, 9V/2A, 12V/1.5A	140mm x 71mm x 15mm	259,00 DKK	https://www.mytrendyphon
30000mAh	5V/3A	143 * 74 * 15 mm	DKK 44.18	https://www.ebay.com/itm/	10000mAh	5V/5A, 5V/4.5A, 5V,9V/2A	138mm x 71mm x 15.9mm	399,00 DKK	https://www.mytrendyphon
10000mAh	5V 2.1A	144mm x 72mm x 17mm	DKK 121.16	https://www.ebay.com/itm/	10000mAh	5V, 2A	105mm x 65mm x 23mm	164,00 DKK	https://www.mytrendyphon
500000mAh	5V 1A/ 2A	147x74cx18 mm	DKK 36.06	https://www.ebay.com/itm/	8000mAh	5V, 1A	130 mm x 70 mm x 15 mm	199,00 DKK	https://www.mytrendyphon
30000mAh	5V/3A	143 * 74 * 15 mm	DKK 49.42	https://www.ebay.com/itm/	10000mAh	5V, 2.1A		219,00 DKK	https://www.mytrendyphon
300000MAH	5V/1A	155*75*15mm	DKK 78.57	https://www.ebay.com/itm/	8000mAh	5V, 1A	130 mm x 70 mm x 15 mm	199,00 DKK	https://www.mytrendyphon
5000mAh	5V/1.0-1.2A	106.5*68*10mm	DKK 9.83	https://www.ebay.com/itm/	20000mAh	5V/3A	153mm x 76mm x 25.5mm	261,00 DKK	https://www.mytrendyphon
20000mAh	5V 3A	L160*W80*H22.6mm	DKK 161.46	https://www.ebay.com/itm/	20000mAh	5V/2.4A	149,5 mm x 82,5 mm x 21 mm	569,00 DKK	https://www.mytrendyphon
2600mAh	5V/1.0-1.2A		DKK 5.27	https://www.ebay.com/itm/	10000mAh	5V/3A, 9V/2A, 12V/1.5A	120 x 68 x 28 mm	429,00 DKK	https://www.mytrendyphon

From idea to production of GLØD
Design and Innovation 2018

5. Product 2017

The GLØD Lantern from 2017

Product description

This is the GLØD-lantern from 2017. It is a power bank driven lantern that can light regular white light or be switched to a “party mode” using a red bottom placed underneath the cork lid. The “party mode” lights in different colors and intensity to the beat of music. The lantern is powered by a Volt power bank, that fits perfectly in the lid.

The lantern consist of a Novo Nordisk insulin container, a leather strap as a handle, a cork-lid, a decorative foil at the front and a electrical circuit.

Placement of the powerbank

The lantern is turned on by lifting the cork lid and plugging in the power bank. The lantern will then turn onto white-light and by pushing a red button, placed on the containers black lid, it will change between the two-modes. The electrical circuit is placed in the container under the black lid.

There were 8 different fronts

At a workshop at the festival, festival participants had the option of personalizing the front of the lantern and could pick between eight different designs.

GLØD

6. Contact info before workshop

This flyer was handed out before the workshop in 2017 at Roskilde Festival

GLØD

As part of our bachelor project we would like to be in contact with you during Roskilde festival

CAN WE CONTACT YOU?

☐ YES ☐ NO

NAME

CAMP NAME CAMP NUMBER

AGE NATINALITY

E-MAIL

PHONE NUMBER

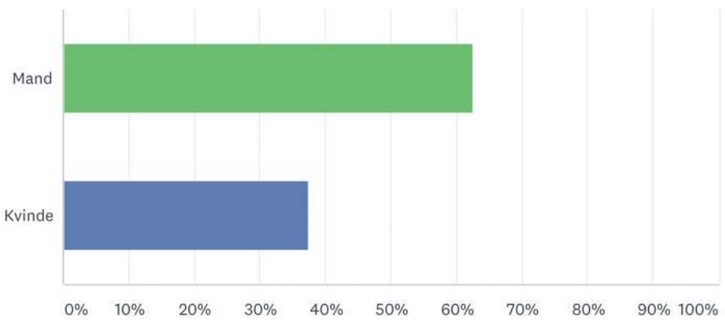
THANK YOU
If you want to know more:

facebook

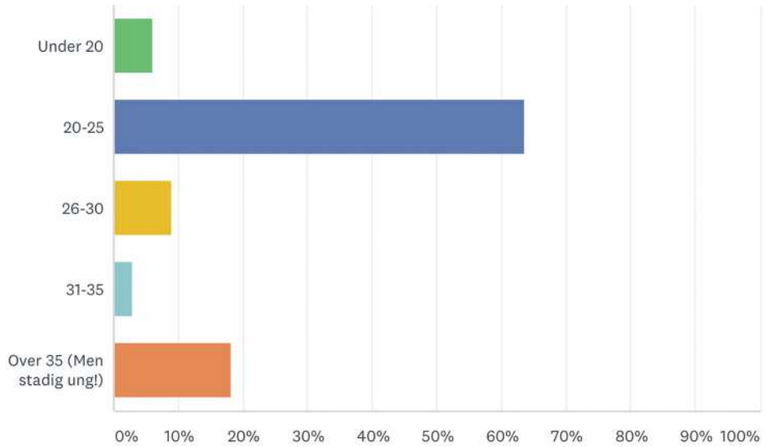
7. Questionnaire from workshop RF 2017

The questionnaire has been made on behalf of the 125 people who received a lantern .
Of them 65 were willing to share there information and 35 answered this questionoarie. They were 10 questions and can be found on:
https://da.surveymonkey.com/r/MK8CZGR

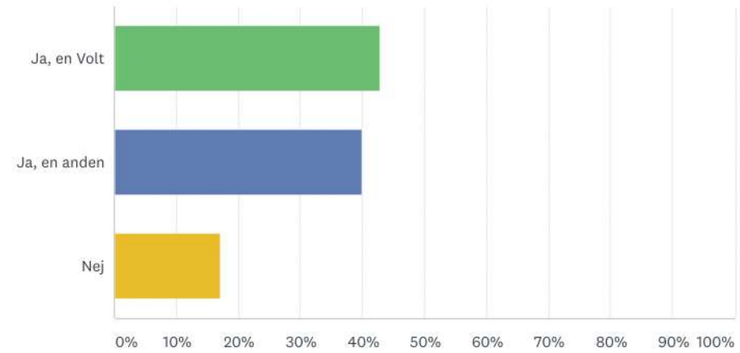
WHAT IS YOUR GENDER?



HOW OLD ARE YOU?



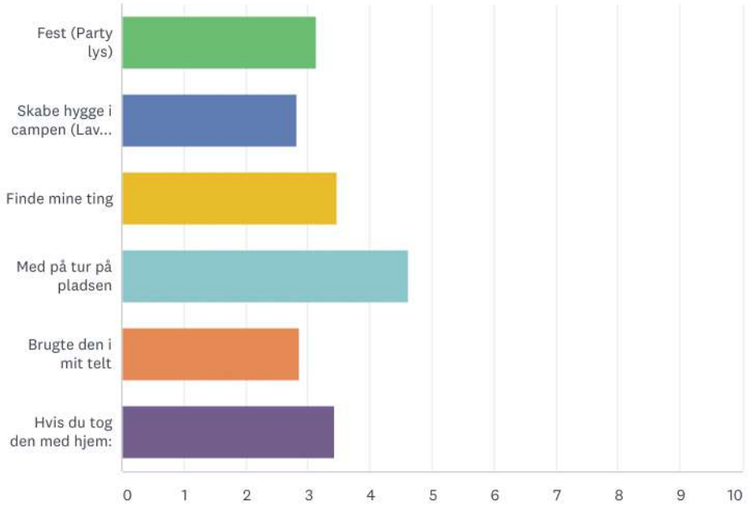
DID YOU BRING A POWERBANK ON THE FESTIVAL?



GLØD	Bachelor project Interactive lantern to festival guest.	Subject:	Questionnaire
		Date:	19/02-2018
The Technical University of Denmark. 2800 Kongens Lyngby.		Name:	Victor
Mads Hesseldahl & Victor Bertelsen		Page:	1 of 3

8. Questionnaire from workshop RF 2017

WHAT DID YOU USE THE LANTERN TO?



COMMENTS:

pga. regn kunne den ikke være udenfor

Bruger den nu på terrassen som hyggebelysning (ja, ikke nu, men når det er varmt nok udendørs....)

Den er blevet en fast lampe i min stue

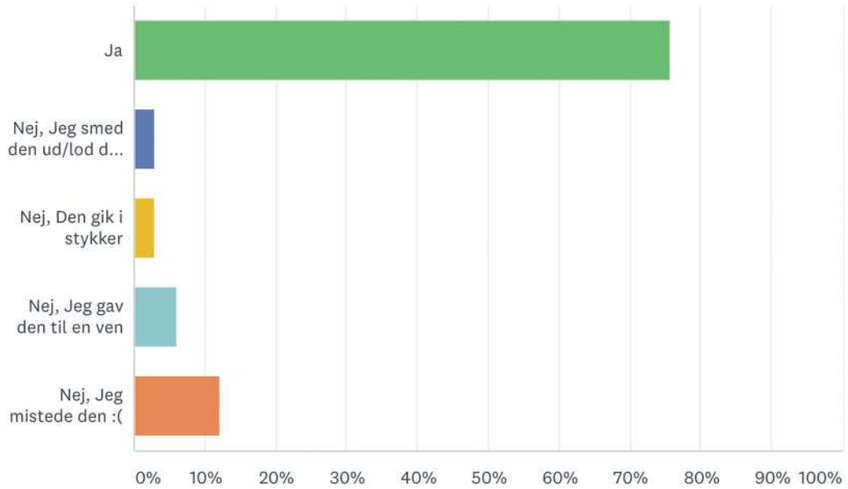
Den er et fedt mine fra festivalen ??

Underholdende element

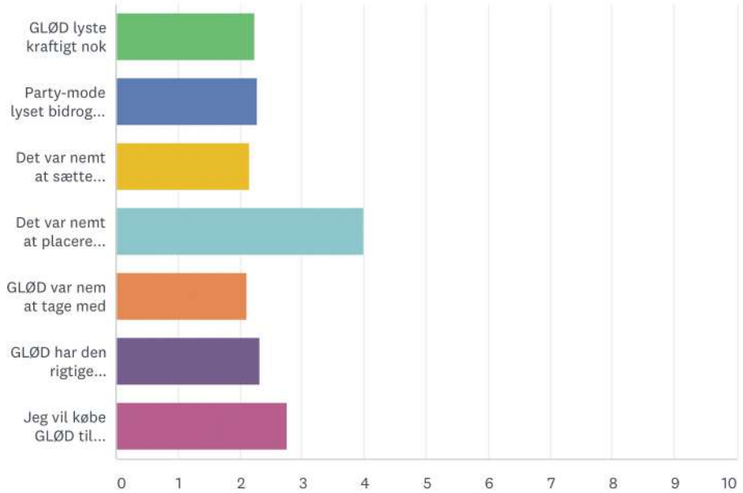
Vi havde den hængende i loftet af vores pavillon og sidste mand glemte at tage den med så dagen efter var den væk.

Har ikke været hjemme. Ellers ville jeg bruge den mere til privat fester

DID YOU BRING YOUR LANTERN HOME?



NOW WHEN YOU HAVE TRIED THE LANTERN, WHAT DO YOU THINK ABOUT?



COMMENTS:

Gløds design er ikke så egnet til festivalsvejr (regn)

Partylyset virkede ikke rigtigt, det blinkede bare, så vi gik over til at bruge den som almindelig lampe. Hanken var det svage punkt, vi måtte selv lave en alternativ løsning. Der er ikke helt plads til powerbanken (med hætte på)

For stor

Den kunne fint være mindre

Glæder mig til en solcelle version ;)

Købe ja men kun i et mindre format

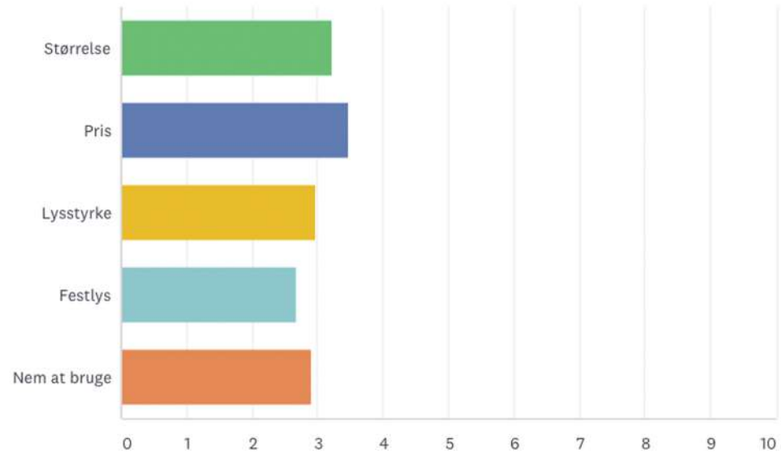
Kommet an på pris

Den kunne godt være mindre. Lydniveaut under party mode kunne godt være bedre justeret. Virkede mere som en strobe i farver der svingede i frekvens.

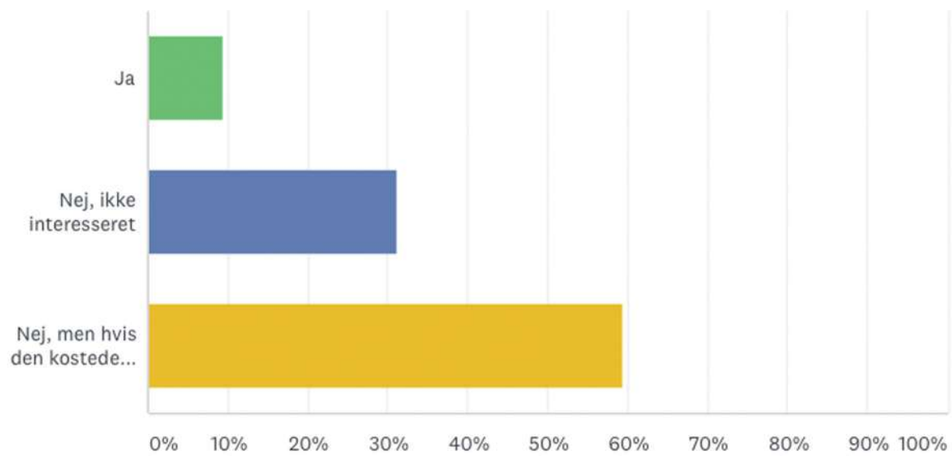
GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Questionnaire
		Date: 19/02-2018
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: Mads & Victor
Mads Hesseldahl & Victor Bertelsen		Page: 2 of 3

9. Questionnaire from workshop RF 2017

PRIORITIZE - WHAT IS MOST



GLØD LANTERN WOULD HAVE COSTED DKK 299,- WOULD YOU HAVE BOUGHT IT?



I WOULD HAVE BOUGHT THE LANTERN IF IT COSTED:

100, 89, 79,95, 150, 150, 150, 199, 99 - 149, 200, 50, 99, 99, 200, 100-150, 200-250, 200, 100
omkring 150. Men den er reelt for stor til at tage med.
100 eller 200

OTHER COMMENTS

- Regntøj til den eller regntæt design - limen går op pga fugt, så magneterne falder af + den bliver lidt klam
- Jeg ser lampen som en god prototype, men den skal modnes lidt mere. Hanken, som er lækker at have i hånden, skal fastgøres på en bedre måde. Partylyset skulle reagere på lyd, det mener vi ikke, at det gjorde, det blinkede uafhængigt. Dunkens størrelse er god til brug, men gør den meget lidt attraktiv at transportere, når den ikke er i brug. Ville det virke med en foldbar dunk? Den skal jo være stor for at give godt lys.... Dekorationen var flot.
- Sælg dem på større plan, det er en fed ide der kan anvendes til mere end festival.
- Det kunne være fedt vis man kunne designe den hjemme fra og så hente den på pladsen. Eller at nogle af de band som spillet det år kunne kommer på glødlampen ??
- Mulighed for eget design - samarbejde med folieskærer eller evt. vælg dit eget klistermærke eller noget i den retning
- Ang. Lysstyrke, det ville være rart hvis der var måske 3 forskellige Lysstyrker og/eller temperaturer så man havde både "hyggemode" og "let there be LIGHT-mode"
- Held og lykke drenge! Håber det bliver mega fedt, og glæder mig til at se jer og lampen til rundvisningen i Techlab!
- Den er lidt begrænset af at den ikke har mulighed for at tage alle typer powerbanks. Den havde svært ved at hænge når powerbanken lå løst oven på lygten
- Synes den er disse fed og har brugt den til meget, men party funktionen kunne være bedre optimeret. Den blev mest brugt til at lyse telt op - det var den til gengæld genial til.
- Jeg synes GLØD lampen var super nice, og gemmer stadig på værelset hvor den hænger som dekoration (fordi den ser lækker ud). Den måtte gerne lyse lidt kraftigere - ud over det er jeres projekt super nice, og godt fundet på! :)
- Supert at det er med Roskilde logo mv på.
- Held og lykke med projektet <3

GLØD	Bachelor project Interactive lantern to festival guest.	Subject:	Questionnaire
		Date:	19/02-2018
The Technical University of Denmark. 2800 Kongens Lyngby.		Name:	Mads & Victor
Mads Hesseldahl & Victor Bertelsen		Page:	3 of 3

10. Mail to workshop participants

This message was sent out to all participants using the lantern in 2017 that agreed to be part of the development phase.

GL

Glød Lanterns
to 08-02, 12:20
naldal130@gmail.com

Kan du huske os? Vi mødtes på Roskilde Festivalen sidste år, hvor du byggede en GLØD lanterne til vores workshop.

Vi er nu i gang med at gøre lanternen endnu federe og håber at du vil hjælpe os med et kort spørgeskema! Klik på linket her: https://da.surveymonkey.com/r/MK8CZGR

Det ville betyde alverden for os!
Håber vi ses på Roskilde Festival.

Mads, Victor og Nicholas
AKA Team GLØD

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Mail
		Date: 8th of February
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

GLØD

11. Inscription and Description

Inscription	Script	Description
- It is smart that it uses a power bank. - It is good to have light in the camp - It is good that the lantern is so simple to use (Minimal settings and no off switch - Party light keeps the party going - It is made with beatiful materials such as leather - The folie is cool	- The lantern is powered by a power bank - The lantern has two settings - It is a mobile lantern - It can be hung	- Party mode is not used all the time - We are using the lantern to create “hygge” and a chill mood. - The lantern is way too big - The materials used are not made for festivals. The leather gets gross, folie tears of and the glue goes up. - Party mode flashes too much and does not react well enough to the music. - It does not fit to our power banks - The magnets for the handle is not strong enough for the lantern to hang. - It looks more like a container than a lantern. - I screw the lid of instead of the cork - the system of placing the power bank does not work well. - Where is the off button?

GLØD

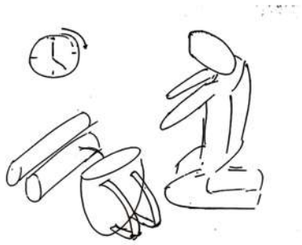
12: Functioning pros and cons

We focus on the GLØD lantern from 2017 and base the comments from the questionnaire analysis on the following.

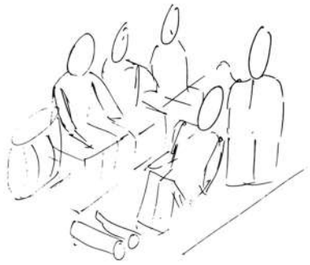
Pros	Cons
The folie fonts were cool - the user	The folie quickly damaged and were torn of - the user
The Volt power bank fittet exactly in the container - the designer	You can only use Volt power banks - the user
Robust container - the designer	The lantern was to big - the user
The lantern works with a power bank - the designer	You cannot use the lantern without owning a power bank - the user
It is free! - the designer	It does not emit enough light - the user
As the button is placed underneath a cork lid there is less of a chance that water gets in and destroys the power bank and electronics. - the designer	It is difficult to get to the button when changing modes - the user
It was an advantage that the button was placed so that the user didn't accidentally press it. - the designer	The buttons placement was bad as the power bank sometimes hit it and changed mode. - the user
The leather strap was beautiful - the designer	The leather quickly gets dirty and nasty - the user
The cork lid is beautiful and environmentally friendly - the designer	Cork lid was fragile (flakes of cork fell off) - the user
The lantern is USB powered so it can be plugged into any adapter - the designer	The USB-cable always jumped out of the Arduino - the user
The container is upcycled and is therefore good for the environment	We support products that are environmentally friendly - Roskilde Festival
	The container is badly shaped since there is not space for a power bank but a lot of space for light - the user
Party mode creates a party - the designer	Party mode does not function - the user
The magnetic system makes the lamp easy to hang or bring around. - the designer	Magnetic system was not strong enough and broke if the glue got moisture - the user

13. User trip

The user trip is done from the perspective of the design team at Roskilde Festival 2017. The time span of the trip is from 24th of june to the 1st of july 2017.

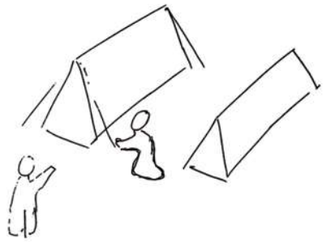


Packing to Roskilde Festival
Little space in the backpack.
There is a lot of things to remember when packing.

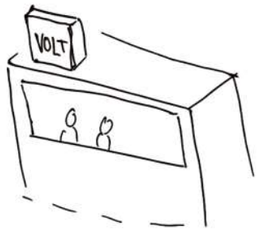


Transport to Roskilde Festival
The train is full of others that are also going.
Going from the train station to the festival.
The user is carrying a lot.

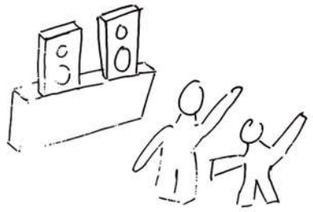
Arriving at Roskilde Festival
The user has to lay in line for hours.
It is raining.



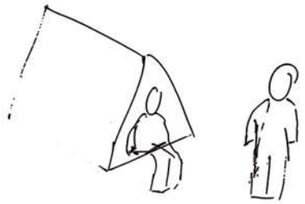
Camping area opens
When the camping area opens people are running to get a good spot.
Raising a tent within a few minutes.



Picking up a Volt Power bank
The festival participant has to locate shop



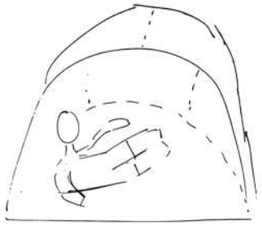
First night at the festival
A lot of energy and big parties
The festival participants are still clean



Arriving home from a concert
The mood in the camp dies
The festival participant is moving to bigger camps

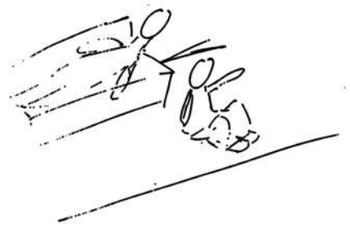
Hangover day
Low on energy
Drinking beer in the camp
Going early to bed

First shower
The festival participant is feeling dirty



Next day: Raining
The festival participant is staying in the tent or under a festival pavilion
Buying tarpaulins to secure the camp from water

The night is approacing
Changing from shorts to long pants. Has to find things in the tent.



Train home
It is late and the user is wet and dirty

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: User trip
		Date: 21st of February
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
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14. Packing list

Roskilde Festival participant:

We can see that a festival participant has to carry a lot of things to the festival and will already have spent approximately DKK 3000,- before entering the festival area. We estimate that during the whole festival the user will spend approximately DKK 5.325,-. The high price is including food and alcohol, which we estimate to be 1.650 kr. This is an indication of the amount of money people are willing to spend at this event. These approximations is based on the design team's experience and online packing list from web pages such as festivaltips.dk[1].

Pakke liste (Pris):

Billet
Telt
Sovepose – brug vores guide til at
Luftmadras
Stole – find
Borde
Hovedpude
Tæppe
Køletaske
Anlæg / Musik
Pavillon
Håndskovl
Badetøj
Håndklæde
Bukser
Regntøj
Gummistøvler
Undertøj
T-shirt
Sko / Sneaker / Sandaler
Nattøj
Shorts
Strømper
Bluse
Jakke
Hat / Kasket
Kjole
BH
Bæltetaske

Øl og alkhol!
Kontanter
Kreditkort
Sygesikring
Telefon / Oplader
Gaffatape
Lighter
Kamera
Bestik
Øloplukker
Ølbong
Lommekniv
Affaldsposer / Fryseposer / Elastikker
Solbriller
Spillekort
Bold
Powerbank
Vandflaske
Tyggegummi
Lommelygte
Førstehjælpskasse

Investering for at tage på Roskilde festival

Billet (DKK 2125)
Telt (DKK 300)
Stole – find (DKK 35)
Anlæg / Musik (DKK 200)
Pavillon (DKK 50)
Gummistøvler (DKK 50 Gummistøvler)
Øl og alkohol! (DKK 850)
Gaffatape (DKK 30)
Ølbong (DKK 10)
Affaldsposer / Fryseposer / Elastikker (DKK 20)
Spillekort (DKK 5)
Bold (DKK 10)
Powerbank (DKK 200)
Tyggegummi (DKK 20)
Førstehjælpskasse (DKK 20)
Kondomer (DKK 60)
Vådservietter (DKK 20)
Tør Shampoo (DKK 20)
Togbillet (DKK 500)
Mad (DKK 800)

Total: DKK 5325

[1] http://festivaltips.dk

GLØD

15. User scenario

User scenario

All of these scenarios in visions we have for GLØD

User scenario	Description
"Hygge" in the camp	Color-mode is in. People is sitting around the lantern in camping chairs chatting.
Party in the campen	The camp has a Soundbox in the camp that plays loud music. GLØD is gathering people in the camp.
Finding things in the tent	It is becoming darker and colder and people changing clothes in the tent. This is easier with the light from GLØD
Out and peeing	The ground is wheat of urine and people has to be aware of where they go. This is easier in the evenings with the light from GLØD
On tour	People takes GLØD out to visits other camps to add to the party.
At the concert	GLØD is a part of the light show.
Hygge in the garden	GLØD is used at the in the evening on the terrass when friends are coming over.
At the beach	GLØD is used at the in the evening at the beach after a dip in the sea.
Transport	GLØD is hanging in its stop on a backpack on the way home from Roskilde Festival.

16. Stockholm Furniture and light fair

Victor Bertelsen visited Stockholm Furniture and Light Fair the 9th to the 10th february 2018 to get an overview of the lamp market.

Entrance at the fair

Ticket at the fair

At the fair many potential competitors on the market. Overall the biggest potential competitor was probably Philips Hue bulbs and lamps, which can basically do the same as GLØD. Philips Hue works through an application on your smartphone. Multiple apps can then be downloaded for Hue. For instance, one app makes it possible to use a music program such as iTunes or Spotify on the phone to make the lightbulb change intensity and color according to the music. The sales personnel at Philips also think that this will be possible using the phones' inbuilt microphone in the future. However, for this to work, the consumer needs to buy a Philips Hue Receiver, which is a box that the bulb is hooked up to via the local wi-fi. This receiver costs 750 DKK and the bulb are priced at 350 DKK. The bulbs can not be used with the app without the receiver. Some of the Philips Hue lamps are portable but are not waterproof and start at the price of 600 DKK. They also need the Hue Receiver to work.
So overall we don't consider Philips Hue to enter the festival market as it would not work with the current setup requiring the Philips receiver.


Philips Hue

Besides Philips Hue we saw many lamp companies introduce new mobile light lamps. Many of the sale people that we spoke to said that there was a growing market for mobile lights and that people would like to be flexible in their living room and gardens.

Besides Philips, potentiel components suchs as Fatboy, Fermob, FollowMeLamp (who introduced four new mobile lamps at the fair) and Floss could be considered. But all their lamps have an inbuilt power bank and no party mode (except for Philips).

Fatboy has gone all in on outdoor lamps and is today only producing lamps that have an inbuilt power bank. Besides this Fatboy makes it possible for the consumer to change the fronts of the lamps.
Fermob was a lamp made in PVC-plastic and with an aluminium strap.

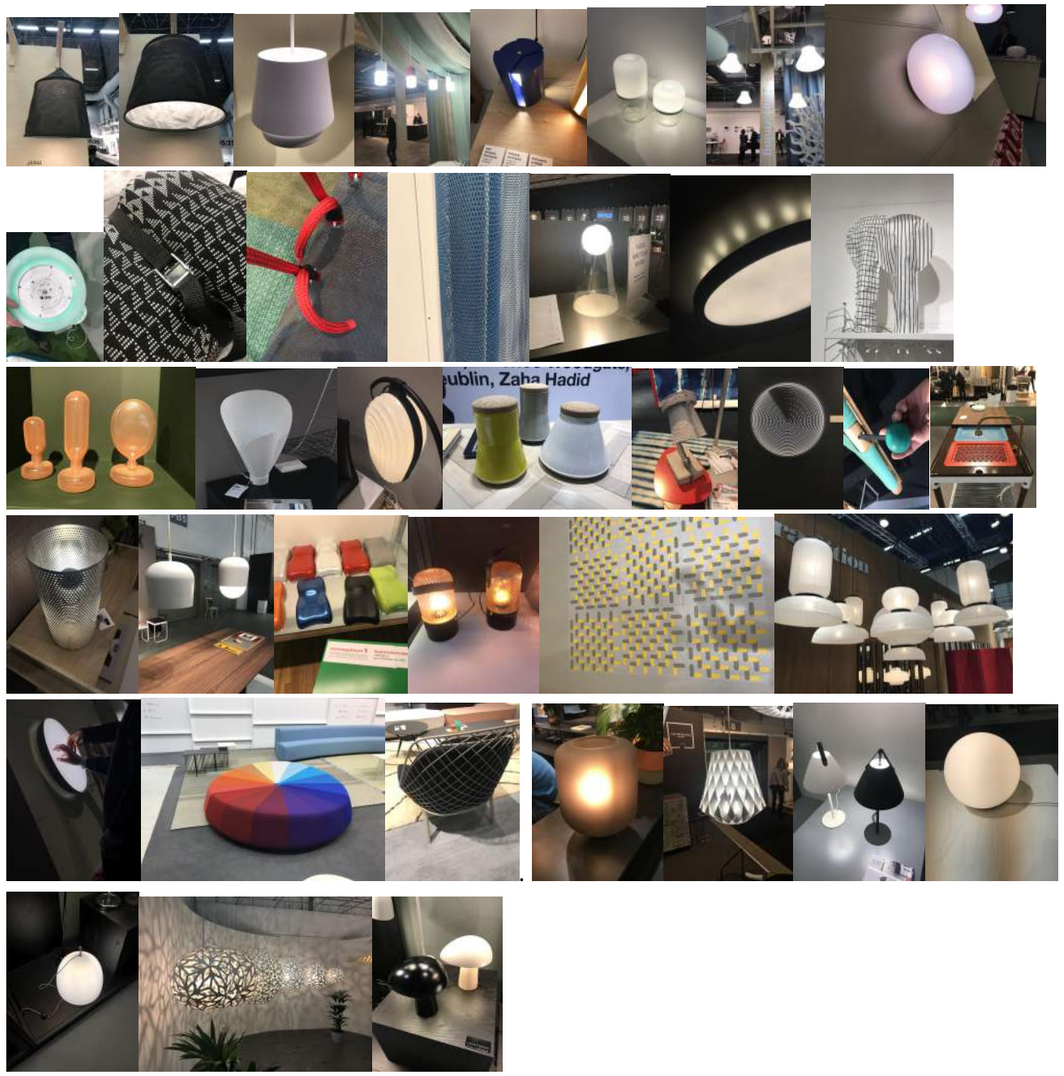

Faboy lamps

At the fair we met the startup company Shade that had received $448.860 in funding from the crowdfunding site Indiegogo[2] for their pendant lamp. Their lamp can change color with the in-built RGB LED and this made them interesting to talk to. We were interested in the production of the electronics. The founder of the company, Bo Puggaard Hansen, advised us to use electronic manufacturers in Denmark since electronics today can be SMD-mounted to a PCB. According to him the price for renting a SMD-machine in Denmark is the same as in China. The only difference is a higher start cost in Denmark and the longer shipping time from China. According to Bo Puggaard Hansen there is a certain risk associated with doing business with China and from the cultural barriers this implies. Besides that, the uncertainty of shipping time and the lack of quality check makes Danish manufacturers better suited for small productions as ours. Bo Puggaard Hansen recommended us to contact the managing director Thomas Hansen from Paul E. Danchell to get a price for electronic manufacturing.

Shade

Many of the following lamps were used in the virtual morphology chart:

[2] Vestergaard, A. E. (27/10/2017). Her er makkerparret bag crowdfunding-succesen 'The Orb': "Vi vil gøre for lys, hvad Apple har gjort for mobiltelefoner". Euroman. Found [04/01/2018]. At [https://www.euroman.dk/design/her-er-makkerparret-bag-crowdfunding-succesen-the-orb-vi-vil-goere-for-lys-hvad-apple-har-gjort-for-mobiltelefoner].



Especially lamps from Fermob was a good inspiration for the design team:

Another company was FollowMeLamp, that intoduced 4 lamps at the festival:

The brand Floss also introduced a number of lanterns at the fair:

Cheap chinese lamps were also showcased at the fair.

Overall the fair was used in the iteration phase and get overview of potential competitors in the lamp business.

17. ANALYSIS OF COMPETITORS: DESIGN

The portable lamps in this category is in the price range of 450-1000 DKK and the lamps can mostly just turn white in different degrees of brightness. Philips Hue is considered to be a potential competitor, since their portable lamp has a party mode with changing colors to the music. But due to the high price and Phillips targeting of the home market we do not see it as a real competitor. All the portable lamps at the fair had an inbuilt battery.

Many of the lamps had longer light time, than a GLØD-lantern with a Volt power bank, which we estimate can deliver approximately 8 hours of battery. In comparison, the FollowMeLamp and the Fatboy lamps had power capacity for up to 24 hours. The light that the lanterns emit is mostly warm light and we therefore found these lantern suitable for “hygge”.

Philips Hue lamp
From DKK 599,-
Inbuild battery capacity 3 hours. Needs to be connceted to a network with an additional box (DKK 750,-). Apps avalileble. Light: RGB LEDs.

Menu carrier
DKK 995,-
Inbuild battery capacity 10 hours. Has one light mode.

Follow me lamp
DKK 945,-
Inbuild battery capacity 20 hours. Can be dimmed but has only one light mode.

Fatboy Edison petit
DKK 486,-
Inbuild battery capacity up to 24 hours. Has three light modes.

Fermob Balad lamp
DKK 599,-
Inbuild battery capacity up to 6 hours. Has two light modes of 50% to 100% light emission. 24 colors to choose from for the handle.

FatBoy Bolleke
DKK 599,-
Inbuild battery capacity up to 24 hours. Has one light mode. Weight only 600g.

Fatboy Lampie
DKK 599,-
Inbuild battery capacity up to 9 hours. Dimmerable light. Has many fronts that can be changed or custumized.

Mayday lamp from Floss
DKK 739,-
Easy to move, but has a 3 meter long wire.

GLØD	Bachelor project Interactive lantern to festival guest.	Subject:	Analysis of components
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18. ANALYSIS OF COMPETITORS: PRICE

These are mostly lanterns that are made for camping, in the price range of 20-250 DKK. Most of these lanterns are foldable, so they can be made smaller when travelling. Besides this, most of the lanterns in the price range around 150 DKK have inbuilt batteries - even though the price is so low. It is also possible to charge the lanterns in the wild using solar panels. The cheaper lanterns starts at prices around 50 DKK. They are powered by AA-batteries and are mostly made as a flashlight.

Camping lantern
DKK 159,-
Functions: white light with 6LEDs, rechargable inbuild battery, solar chargable, can be hung

Multi light from Harald Nyborg
DKK 18,95
Functions: white light with LEDs, uses 3 AAA batties, has a hook on the back, 100 lumen.

Multi light from Harald Nyborg
DKK 29,95
Functions: white light with 24 LEDs, uses 4 AAA batties, can be hung with the foldable hook.

Solar powered lantern
DKK 175,-
Functions: white light with LEDs 3, rechargable solar battery, SOS-mode.

Solar powered lantern
DKK 210,-
Functions: white light with LEDs 3 fade modes, rechargable solar battery, can charge a phone.

LED lantern from Harald Nyborg
DKK 39,95
Functions: white LED light, uses 2 AA batties, can be hung with the hook.

Easy Camp Coral
DKK 55,-
Functions: two modes night light blue and white light, AAA-batteries, hook.

Outwell lantern
DKK 219,-
Functions: white light with LEDs 3 fade modes, rechargable, waterproof, strap.

Rattlesnake Lantern from Føtex
DKK 149,-
Functions: two light modes, inbuild compass, rechargable with 14 hours of battery, strap for hanging.

Easy Camp Cantil lanterne Føtex
DKK 135,-
Functions: three light modes, foldable and portable, a hook for hanging.

Outwell Morion from Føtex
DKK 134,-
Functions: 4 light modes (flashing, low, medium, high), hook.

GLØD	Bachelor project Interactive lantern to festival guest.	Subject:	Analysis of components
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19. ANALYSIS OF COMPETITORS: ALTERNATIVES

These are mostly products that might not at first hand look like competitors but in many cases might serve the same purpose for the consumer. We also included some products in this category that are meant for camping or trekking. The LumenAid is a light that can be inflated to create a bigger volume in order to emit more light. It can be compressed to take up no more space than the inbuilt power bank.

Luci MPowered
DKK 200,-
Functions: inflatable, chargable by the sun, weight 130g, waterproof

Lumen AID
DKK 249,-
Functions: white light with LEDs, 16 hours power, solar powered, blow up with light

Lumen Nova AID
DKK 200,-
Functions: white light with LEDs, 75 lumen, 24 hours battery, foldable, water proof

The smart phone
Free (everytone has one)
Functions: white light (10-50 lumen). Take a lot of power from the phone espacially if it is also cold.

Solar powered lantern
DKK 75,-
Functions: USB powered light bulb (LED). From alibaba, min. order 10 pcs.

JBL music player and LED light
DKK 1299,95
Functions: 10 hours of battery time, bluetooth speaker, changes light not arccording to the music.

LED strip from Amazon
DKK 200,-
Functions: can change color with a remote control.

Change light according to the music
DKK 150,-
Functions: add on to a LED strip.

Flash light from Harald Nyborg
DKK 39,95
Functions: white LED light, uses 2 AA batties, can be hung with the hook.

Easy Camp Sinai lanterne Føtex
DKK 249,-
Functions: two light modes, two portable flash lights, AAA-batteries.

Solar powered light bulb from Jem&Fix
DKK 38,-
Functions: solar powered, hanging, uses 1 AAA-battery.

GLØD	Bachelor project Interactive lantern to festival guest.	Subject:	Analysis of components
		Date:	19/02-2018
The Technical University of Denmark. 2800 Kongens Lyngby.		Name:	Victor
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20.

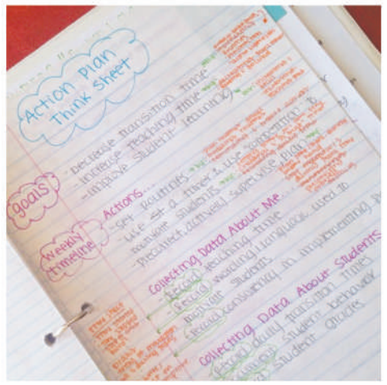
Lifestyle














21.

Mood













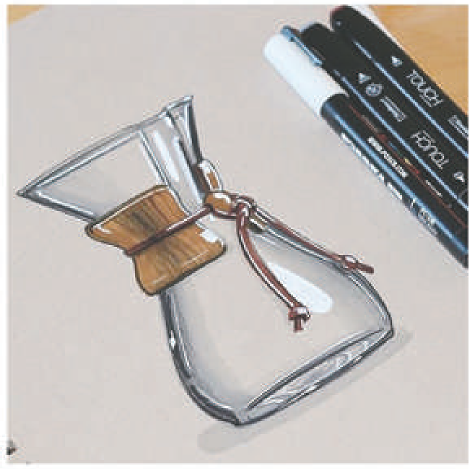










22.

Styling















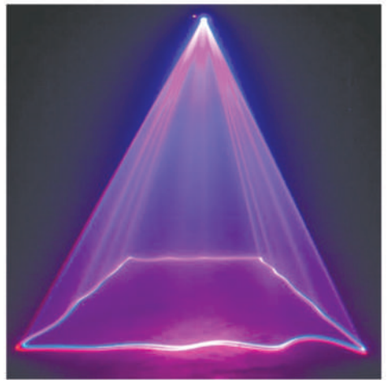



23.

Usage







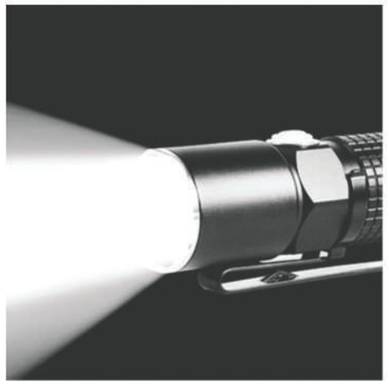













24. Mail correspondance about manufacturing place

Mail correspondance with Michael Pil and Peter Eduard, that Victor met at a Scinece Camp in Gymnasium. They both work as consultents and have experience with manufacturing in foreign countries.

Hej Victor,
Hold jer fra Kina. Hvis ikke det er simple produkter, bliver I snydt. Så enkelt er det, med mindre du har din egen fabrik. Glem det! Det samme med Indien, hvis der er nogen der foreslår dette for jer. Det koster noget mere at får produceret i EU, men her vil I være mere på sikker grund. Japan kunne måske også være mulighed. Jeg ved ikke lige hvem der kan lave produkterne til jer.

I skal ganske rigtigt bruge en kravspec. til produktet, inden I begynder at kontakte nogen... og husk nu en NDA, som skal underskrives, inden i åbner munden.

Prøv lige at ringe til Kai Ormstrup Jensen hos Delta. Delta er lige fusioneret med FORCE, men har været et GTS-institut med specia-le i elektronik. Det er ikke utænkeligt at han kan pege jer i den rigtige retning. Her behøver I ikke en NDA, fordi man som GTS-institut allerede er underlagt de strengeste krav til tavshedpligt. Jeg har ikke lige hans direkte nummer, men bare ring til omstillingen.

Jeg kan godt huske jeres projekt. Fedt at I er videre med næste idé, og allerede er så langt som I er. Held og lykke med projektet. Håber det bliver en succes!

Pil

Hej Victor
Jeg er delvist enig med Pil. Lad være med at sende hele produktet til kina (eller Indonesion). Jeg vil i stedet anbefale at I sender dele af produktet ud og så samler (og kvalitetsikre) herhjemme. Det gør jeg fx. selv.
Hvad de er gode til i Kina:

1) Lave MEGET billige PCB's.
2) Pakke billige komponenter

Hvad de også er gode til:

1) Relancere jeres produkt under eget brand
2) Relancere jeres produkt under eget brand.

Hvad de er dårlige til:
1) Kvalitetssikring koster det samme i Kina som i Danmark. De er ikke dårlige, men ikke billigere.
2) "Kvalitetssikring" - den billige variant - dur ikke. Jeg har haft ting der er ankommet med de forkerte skruer, for korte ledninger, tilfældige farvekoder, ting der er varmlimet sammen etv.

Hvad jeg gør: Jeg bruger fx. http://dirtypcbs.com/store/pcbs

Og så går jeg til alibaba for at få lavet poser med komponenter, samlet og sorteret.

Mit behov er nok et andet, men dirtypcb's kan også SMD montere efter dine ønsker. Igen, det kræver at DU tester resultatet og er klar til at smide 1/20 ud.

Men billigt og så holder du selve samlingen og kvalitetschekningen herhjemme i .dk

Jeg har oplevet at få en ting kopieret OG SAT TIL SALG inden jeg selv nåede at få den første sending hjem. Jeg var så helt og aldeles ligeglad, men det er i jo nok ikke. ;)

Peter.

Following up on Kai Omstrup Jensen from Delta consultants on a phone meeting. He informed the team that small companies are not taken serious in China and that people working with manufacture in China travel to the country to make sure that the manufacturing plants are in good condition.

”I have tried that the product are being copied and relaunched under a new brand”

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Manufacturing in China
		Date: Febuary
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
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25. Letbæk Plast

Letbæk is a plastic manufacturer. The company has the capacity of producing plastic elements from 1-3000 g of plastic. The company has a vision of becoming completely circular and is therefore reusing old plastic in most of their production. For example in their production of roadblocks for traffic signs and etc.

The company recently developed a reused plastic granulate from fishing nets and this is the material that we are most interested in using in our lanterns. The material does not allow light to go through, which is a bit of a problem, but it can be used for other parts of the lantern.
The design team was told that translucent plastic cannot be made from reusable plastic since there is no way of separating different plastics colors at the moment.
Martin Holm (head of development in Letbæk) suggested that another way of contributing to a more sustainable future would be to hand the plastic part back to Letbæk or Ove Vestergaard (another plastic manufacture) after having used lanterns at the festival. Hereby would the plastic be reused and not end as landfill. This would require GLØD to have a sort of deposit scheme.

From the top: Letbæks plastic injection molding machine, examples of plastic pieces made from fishing nets and the VDI-scale

Martin Holm informed that there would be difficulties using 100% recyclable plastic since the plastic has already been heated up one time and is therefore already made amorphous.

He suggested that we use 40% regenerated plastic and 60% new plastic. In that way the plastic injection molding process would be able to inject the plastic and let the plastic flow around in the mold. In the case of 100% regenerated plastic, the plastic cools down too quickly and therefore does not reach the entire mold. This can only be done with very small pieces.

Martin Holm told the design team to use PP-plastic or PE plastic for the transparent part of the lantern. In his opinion, it would be optimal if we could get hold of a formbox and manufacture that at DTU. The mold could be made in that way, and Letbæk should only produce the plastic object for us. A formbox in aluminium often costs from 30.000 kr and upwards. The processing of a mold can easily cost 50.000 kr, said Martin Holm.

Besides the manufacturing of the mold Martin Holm told us about some specific design requirements:

- The thickness of the object should not exceed more than 2mm.
- A thread in the object is not a possibility with regard to cost.
- Only one object pr mold.
- A specific texture in the plastic can be obtained by etching the surface in the die with an etch machine, sandblasting or powder blasting (finer than sandblasting). This is measured in a VDI-scale. We were recommended to use VDI 36 as this is matte and not glossy, which makes scratches in the plastic less visible.
- Text such as “CE-marked” can be made in the die by milling after etching the mold.
- Slip angles in the mold should be at least 0,5 degrees.
- It is better to make our plastic object more wide than long as regard to the cylinders that run in between the two molds called the ejector pins.
- The price of a plastic unit (with a mold made somewhere else than Letbæk) would be 6-7 DKK and worst case 7-14 DKK when manufacturing at least 2000 units.

26. FC systems

The design team visited FC system that have their factory located in Herning. Here the basics of vacuum forming was explained. Vacuum forming works is that a sheet of plastic (thickness 0,5-3 mm) is placed in the vacuum former. First the sheet is heated so it reaches a plastic elasticity point and then a mold is pushed up in the sheet so it forms around the tool.

Vacuum former at FC Systems

Information given by Heine Smith Dinesen to further consideration:

- It was recommended us to use polystyrene (PS) in opal white or polycarbonate (PC). PS is cheap and can also be laser cut. PC is very strong (also used for bulletproof glass), but takes longer time to cool down and is more expensive than PS.
- The height of the part dictates the thickness of the material, as corners will be thinner than the bottom as the material is stretched. The vacuum form FC system has a work area of 1500 x 700 mm and the sheets of plastic comes in the size 2x3m.
- The object cannot have straight sides but needs an angle of 3-4 degrees to get the object of the mold (this is done with air pressure). The width of the object shall be larger than the height.
- The mold can be made from wood or metal. It was recommended us to use aluminium as our unit number is fairly large, and wood that is heated multiple times can deform. But for prototyping MDF-wood should be used.
- The price of the object depends on how many objects can be fitted on the table of the vacuum former. There has to be at least 20 mm between each object and the sides of the mold as the machine otherwise cannot create enough vacuum.
- It is important that the mold has ventilation holes for the air to be sucked in at the right places.
- Materials that can be used for vacuum forming is PETG, ABS, PVC, PS or PC.

27. DTU Ballerup

We then met with head of DTU Skylab, Rasmus Barfoed, where we asked if DTU Skylab would be able to manufacture a plastic injection mold for Letbæk to use. DTU Skylab does not have the capacity to do such a big project and we were recommended to seek advice at DTU Ballerup prototyping laboratory as they have more time for such projects. A meeting was set up by Rasmus Barfoed with Bo Hagelskjær Larsen that would help us with a mold.

Victor is discussing vacuum formed object with Bo Hagelskjær Larsen

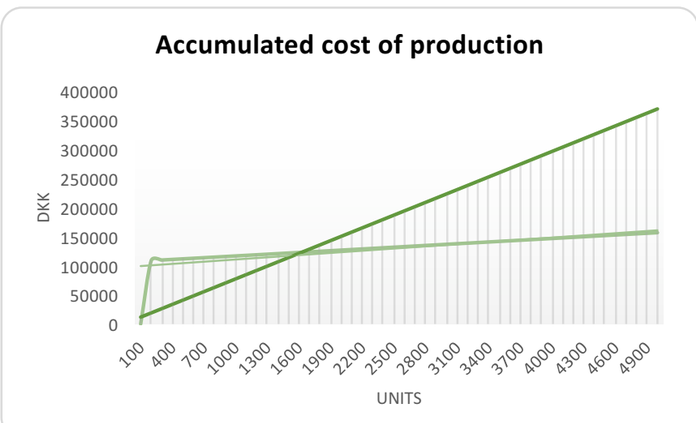
At DTU Ballerup we looked at potentiel form boxes. These lived up to the dimensions and could be used for plastic injection moulding. But Bo Hagelskjær Larsen did not have the time necessary to help, so it was recommended to use vacuum forming or have a mold for injection molding done at a professional firm. Bo Hagelskjær Larsen says that if we go with vacuum forming we should try to make all radiuses in the product design at least 20 mm and 4 degrees on all angles.
Bo Hagelskjær Larsen recommended us to order materials for vacuum through Rias or Linatex as they delivered plastic to DTU Ballerup. Rias did not know much about vacuum forming and therefore told us to call the factory C.R. Steglich as they were known to have a lot of knowledge about this manufacturing technique.

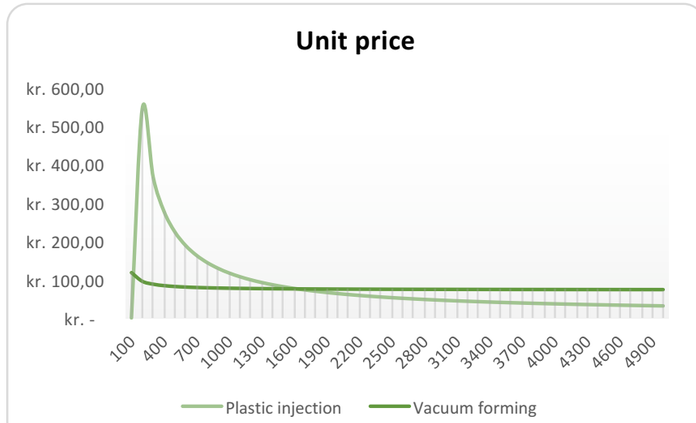
GLØD

28. Estimatation of manufacturing plastic pieces

	Plastic injection		Vacuum forming	
Faste omkostninger				
Mold		100000	kr.	500,00
Start up fee	kr.	5.000,00	kr.	2.000,00
Delivery	kr.	2.000,00	kr.	2.000,00
Total	**kr.**	**107.000,00**	**kr.**	**4.500,00**
Variable cost				
Materials	kr.	10,00	kr.	70,00
Wages, manual labour	kr.	-	kr.	3,00
Unit number		500		
Total price	**kr.**	**112.000,00**	**kr.**	**41.000,00**
Break-even, unit number		1602		
Break-even price	kr.			76,77
Check-cell				

Units	Plastic injection		Vacuum forming	
100	kr.	1080,00	kr.	118,00
200	kr.	545,00	kr.	95,50
300	kr.	366,67	kr.	88,00
400	kr.	277,50	kr.	84,25
500	kr.	224,00	kr.	82,00
600	kr.	188,33	kr.	80,50
700	kr.	162,86	kr.	79,43
800	kr.	143,75	kr.	78,63
900	kr.	128,89	kr.	78,00
1000	kr.	117,00	kr.	77,50
1100	kr.	107,27	kr.	77,09
1200	kr.	99,17	kr.	76,75
1300	kr.	92,31	kr.	76,46
1400	kr.	86,43	kr.	76,21
1500	kr.	81,33	kr.	76,00
1600	kr.	76,88	kr.	75,81
1700	kr.	72,94	kr.	75,65
1800	kr.	69,44	kr.	75,50
1900	kr.	66,32	kr.	75,37
2000	kr.	63,50	kr.	75,25
2100	kr.	60,95	kr.	75,14
2200	kr.	58,64	kr.	75,05
2300	kr.	56,52	kr.	74,96
2400	kr.	54,58	kr.	74,88
2500	kr.	52,80	kr.	74,80
2600	kr.	51,15	kr.	74,73
2700	kr.	49,63	kr.	74,67
2800	kr.	48,21	kr.	74,61
2900	kr.	46,90	kr.	74,55
3000	kr.	45,67	kr.	74,50
3100	kr.	44,52	kr.	74,45
3200	kr.	43,44	kr.	74,41
3300	kr.	42,42	kr.	74,36
3400	kr.	41,47	kr.	74,32
3500	kr.	40,57	kr.	74,29
3600	kr.	39,72	kr.	74,25
3700	kr.	38,92	kr.	74,22
3800	kr.	38,16	kr.	74,18
3900	kr.	37,44	kr.	74,15
4000	kr.	36,75	kr.	74,13
4100	kr.	36,10	kr.	74,10
4200	kr.	35,48	kr.	74,07
4300	kr.	34,88	kr.	74,05
4400	kr.	34,32	kr.	74,02
4500	kr.	33,78	kr.	74,00
4600	kr.	33,26	kr.	73,98
4700	kr.	32,77	kr.	73,96
4800	kr.	32,29	kr.	73,94
4900	kr.	31,84	kr.	73,92
5000	kr.	31,40	kr.	73,90





29. Electronic specification

Electronic specifications

When we started the course, the first task we completed was to make the electronic specifications for the circuit to reach consensus on how the circuit should end up. Since Chris Cornaby and Nikolaj Bobek Søndergaard had not worked on the project before, this was very helpful for their understanding of what the goal and purpose of the circuit was (appendix 4: Electronic specification).

First of all, it was important to know what kind of power source the circuit would be driven by. We had to do some research on power banks to find out what we could typically expect from the power banks most people use. Since the goal was that the user would use their own power bank we could not require that only some specific power banks would work with the lantern. We could expect that there would be some differences in the output power and the capacity of the power banks. For the research we looked at the most popular pages on the internet that sold power banks and made a sheet listing the data we got (appendix 25: Power Banks).

It was important to know what the maximum power draw from the power bank was. We were concerned that if we pulled to much power from the power bank, it might just turn off, due to an inbuilt security function that ensures that a power bank does not short circuit.

To make sure this did not happen, we adjusted our specification to fit the power bank in our sheet with the lowest output. The power bank that had the lowest output was 1A at 5V, so the circuit had to function at this power.

We were also aware that some power banks have a sleep function, so it does not discharge when it isn't connected to anything. This function was problematic with the old circuit. When the sound volume was too low, the LED's became so inactive that they did not draw enough power to keep the power bank above the limit for the sleep function, and it would then turn of. We needed to take this in to consideration for the design of the new circuit. Getting the data for this was more challenging because it wasn't in the specifications of the power banks we had in our sheet. We found specifications for one power bank, which had a minimum power level of 50 mA. We also called Trygve Dam CEO of Volt and he told us that Volt's sleep level was also around 50 mA. One way we could work around this was to never turn of the LED's and keep them lighting at minimum 30%.

Power banks are a very stable power source, since they are a batteri. If we used a plug from the wall, the power source would vary a bit. The variation from the power source might be able to interfere with the signals in the circuit. The reason for this is that there might be other devices connected to the power source and that can lead to fluctuations.
We figured that the circuit had to be able to light for at least 8 hours in the Party Mode, with a power bank at 3500 mAh. We thought that this was a suitable time because parties usually do not last longer and there is limited number of hours of darkness in the summertime when Roskilde Festival is happening.
We chose to look at a power bank with the capacity of 3500 mAh, because that is the capacity of the Volt power bank. This capacity is relatively small, so choosing it for our specifications, we would also be sure that the circuit could light for at least that long with most other power banks. According to Volt, one out of three guests at Roskilde festival use Volt. So we figured that a big part of our target users would use a power bank that was similar.

We wanted the lantern to be able to light up a camp at Roskilde Festival, but still not use the batteries power to quickly. That is why we decided to require that the LED's on the circuit had to be able to deliver at least 250 lumen which is about the same as an 25W light bulb[1].

As mentioned earlier we had to reduce the cost of the circuit. We made a requirement that the circuit had to cost less that 50 kr in total. We believed that this was a realistic goal, since the design did not include any special components that would increase the cost. We would just need some LED's, op-amps, resistors and capacitors.

Since it had caused problems when there was too much sound at the 2017 festival, the new circuit had to function up to around 110 db. A rock concert from 15 feet distance is usually around 110 – 130 db and hearing loss occurs at 120 db[2]. We figured that a party at Roskilde Festival would not exceed more than 110 db.

Finally, the circuit had to be within the legal regulations for commercial electronic devices in Europe, since it was a product we had intention of selling.

CATEGORIES	REQUIREMENTS	CRITERIA	COMMENTS
Battery	The lanterns power source is a power bank. The circuit has to be able to run for 8 hours on party mode with a 3500 mAh power bank. The circuits power consumption is 1A 5V.	The longer the battery can last the better.	

[1] Hvad er lumen? (02/01/2017). *Lampeexperten* . Found [01/04/2018]. At [https://www.lampeexperten.dk/hvad-er-lumen].

[2] BGI-akademiet. (18/03/2015). Fysik/Kemi. Decibel. Found [01/04/2018]. At [https://sites.google.com/a/bgi.dk/fysik-kemi/lydens-hastighed/decibel].

	The circuit can not use less than 50mA when its on.		
Light	The circuits LEDs has to light with 250 lumen on bright white mode		
Legal	The circuit has to be able to get the certifications that is necessary to sell it in Denmark.		
Modes	The circuit has the modes the user has swich between. The circuit has to have a “bright white light”-mode where it emits bright white light. The circuit has to have a“party mode” where the circuit listens to surrounding music with an inbuilt microphone. The colors and the light intensity then change according to the beat of the music. The circuit has to have a “color mode” where the LEDs on the circuit simply fades between different colors.		
Price	The circuit has to cost less than 50 kr.		

30. PnP manufactures

Factory location

Even before the second iteration of the PCB arrived, we were trying to contact electronic manufacturers that did PCBA (PCB and had pick and place (PnP) machines). Local production is an advantage for several reasons. Obviously, logistics are simpler. Local production means you are able to meet the manufactures and see the equipment without having a lot of traveling. Another reason to do the production in Denmark is that the manufacturers would have the same culture and legal regulations as us. We wanted to explore the Danish market for electronics to see if we could have the production closer to home as the startup Shade had recommended us to do at the Stockholm Furniture and Light fair and multiple others.

Receiving offers

The first manufacturer we contacted was ETK EMS. They gave us an offer of 135,73 kr per unit (appendix 30.1 ETK offer). That was a bit of a shock and seamed unreasonably expensive. After debating the price with them they used some of their co-workers to look more carefully through our BOM to see if they could find some cheaper alternatives. They brought the price down a bit, to 118 kr, but it was definitely not the price we were hoping for. (appendix 30.2 ETK offer). We were also in contact with other companies that did not lead to progress such as Micro Technic A/S and Danshell.

To our surprise they also used suppliers like RS Components and Mouser, so the prices' we had found ourselves in the BOM (see appendix 30. 3 first BOM) was not that far off. They also told us that a good rule of thumb when approximating the price of a PCB is by multiplying the price of the BOM with 1,7.

Not enough time

A production at ETK of 500 units would take up to 9 weeks. After receiving the electronics, we would need some time to assemble it in the rest of the product. Therefore we had to be ready with the final design of the circuit and PCB by the 13/04, that would leave us with 2 weeks for the assembly after the electronic production. When we got closer to the date it got obvious that we were not going to make it in time. Chris Cornaby had not got the time to finish the final design completely. We had to make a rapid decision. Even though we had gone through two PCBs it was too risky to make the order. Chris Cornaby needed more time to adjust the circuit. We were pretty sure that the PCB would be error free the next time we ordered since, the latest PCB had minor errors that had been corrected. The challenging part was that the circuit was not calibrated properly with the right components. The party mode was not functioning as intended but it was still functioning. We were considering just sending what we had to ETK and then hope that there would not be any mistakes.

What took so long for the production was for ETK to get the PCBs ready. To buy us some time we suggested that we could order the PCB ourselves in the right shapes and sizes so they would fit ETKs machines. It usually took about 10 days for ITEAD to produce and deliver PCB's, so we would approximately save 5 weeks on the production. We asked for the price for a production like this.

Torben Bysted from ETK's sales department told us that it would approximately the same as the offer they had given us minus the BOM. That would add up to 36.126 kr from the earlier mentioned offer at appendix 30.2 (ETK offer). We were ready to look further in to this solution but then we got to know that we did not get Skylab funding. We realized that using pick and place machines was simply not an option since we did not have the money and time for it.

We asked for advice from PhD student Niels Elkjær Iversen and engineering assistant Hans-Christian Andersen at the electrical faculty. They recommended to PNP everything by hand. Time was a very important factor and they knew that it was going to take some time to assemble it all by hand. Niels offered to help assemble the PCB's. They also told us that it would be more time efficient to assemble the PCB's by hand and get it right the first time, instead of sending an error in an order and therefore have to debug 500 PCBs.

We made some approximations on how much time it would take to assembly a board. We calculated that if there were 160 components per board a we were to assemble a full board in 15 min, we would have a little over 5 and a half second to put each component on the board. This method would not cost the project anything but time and that was something we were willing to spend.

We ordered the PCB's at the 8 may and the rest of the components Mouser 21st of May and they arrived at the 24 of may. To our luck there was not any errors on the PCB.

Appendix 30.1: ETK Offer

ETK EMS

GLØD - Mads Dalum Hesseldahl Skanderborg 22-02-2018

CPH.

We are pleased to respond to your request for LED board . The below presentation is based upon the information given out in the open calculation in the following pages. Pricing is based upon total agreement of 2000 pcs. with production in batches of 2000 Pcs. delivered in packages of 2000. Pricing is based upon production in Skanderborg and prices are all in DKK exclusive VAT and TAX. Should there at the last delivery be a liability for excess parts, these will be invoiced. USD percentage of BOM is , % if less than 5% price expected to be stable

Description

There is a part count of total 136 SMT parts mounted at 1 side(s) and 3 HMT or Mechanical parts.
3 operations will be normal hand insertion and 0 will be processed after wave soldering including mechanical assembly and packaging. There is 0 test and 0 Programming The different process and cost are presented in The below lines of process descriptions. The product is made to Class 2 specifications

Parts and logistic

Budgetary price in DKK 135,73 each

Your part no:		ETK part no:	LED board	DKK
Total Costed Bom				81,85
Customer delivered parts	0 pcs			0,00
Logistic fee				23,08
Stock logistic	3 Month			0,00
Production cost including setup[1]				30,79
NRE Cost[2]				10.206,57

Production cost including setup[1]

			Cost DKK
SMT Mount	136	Parts	17,31
AOI Control	544	Points	3,46
HMT insertion and preparation	0,75	Minutes	4,27
IMT mounting / hand soldering	0,17	Minutes	-
IMT mechanic mounting	-	Minutes	-
Wave soldering	0,33	Minutes	1,90
Selective soldering	-	Minutes	-
Masking / wave solder preparation	-	Minutes	-
Programming	-	Unit	-
Lacq / Silicone -Glue	-	Minutes	-
Wash	-	Minutes	-
Test	-	Minutes	-
ISO control	1	Label for IPC-610 kl. 2.	1,49
Handling	-	Customer specific label	-
Receiving inspections	-	Minutes	-
Burn-Inn chamber	-	Units per batch	-
PCB separation	1	Handling	1,24
Production setup[3]		Part of batch size	1,12
		Sum	30,79

Production setup[3]

			Cost DKK
Picking	20	components	639,47
Feeder setup	16	Feeders	357,43
Setup	1	IPC 610 class 2 control	170,90
Setup	1	HMT process	170,90
Setup	1	IMT Process	-
Setup	0	IMT mechanic process	-
Setup	1	Wave process	170,90
Setup	0	Selective process	-
Programming	0	Setup	-
Setup	0	test fixture	-
Masking	0	preparation	-
Lacq	0	preparation	-
Setup	0	Wash	-
Setup + print of	0	Customer specific label	-
Stencil	1	Pcs. Control and cleaning	357,43
Setup Burn. Inn Chamber	0	Minutes	-
Receiving inspection	0	preparation	-
Setup	1	for separation PCB	85,45
Setup + print of	1	ISO label	113,93
Warehouse	1	Packaging and handling	170,90
		Sum	2.237,31

NRE cost[2]

Data tooling	20	Lines converted to Database	1.687,01
Smt program	136	Lines of programming	1.694,83
AOI setup	136	Lines of programming	2.118,53
Build of testing equipment		As specified	-
Stencil steel	1	pcs. for screener	2.099,92
Pcb tooling	1	set, prep from PCB manufacture	2.606,28
Other expenses, if any	-	pcs, estimate	-
		Sum	10.206,57

Appendix 30.1: ETK Offer

Bill of Materials are based upon the data provided from you and listed below, we urge you to verify this for any errors prior to acceptance of part and the associated cost of the actual parts

Your Part#	ETK Part#	Part Description	BOM Qty	Price each DKK	Total DKK	Currency base	MOQ
XXX	XXX	Components	1,00	78,9101	78,910	[DKK]	2000
YYY	YYY	PCB	1,01	2,7563	2,784	[DKK]	2000
	000 ETK ISC	LABEL TIL ETK ORDER FOR ISO SPORING 19x6mm.	1,00	0,1518	0,152	[DKK]	1

Appendix 30.2: ETK Offer

ETK EMS

GLØD - Mads Dalum Hesseldahl Skanderborg 26-02-2018

CPH.

We are pleased to respond to your request for LED board . The below presentation is based upon the information given out in the open calculation in the following pages. Pricing is based upon total agreement of 2000 pcs. with production in batches of 2000 Pcs. delivered in packages of 2000. Pricing is based upon production in Skanderborg and prices are all in DKK exclusive VAT and TAX. Should there at the last delivery be a liability for excess parts, these will be invoiced. USD percentage of BOM is , % if less than 5% price expected to be stable

Description

There is a part count of total 136 SMT parts mounted at 1 side(s) and 3 HMT or Mechanical parts.
3 operations will be normal hand insertion and 0 will be processed after wave soldering including mechanical assembly and packaging. There is 0 test and 0 Programming The different process and cost are presented in The below lines of process descriptions. The product is made to Class 2 specifications

Parts and logistic

Budgetary price in DKK 118,51 each

Your part no:		ETK part no:	LED board	DKK
Total Costed Bom				66,67
Customer delivered parts	0 pcs			0,00
Logistic fee				21,05
Stock logistic	3 Month			0,00
Production cost including setup[1]				30,79
NRE Cost[2]				10.206,57

Production cost including setup[1]

			Cost DKK
SMT Mount	136	Parts	17,31
AOI Control	544	Points	3,46
HMT insertion and preparation	0,75	Minutes	4,27
IMT mounting / hand soldering	0,17	Minutes	-
IMT mechanic mounting	-	Minutes	-
Wave soldering	0,33	Minutes	1,90
Selective soldering	-	Minutes	-
Masking / wave solder preparation	-	Minutes	-
Programming	-	Unit	-
Lacq / Silicone -Glue	-	Minutes	-
Wash	-	Minutes	-
Test	-	Minutes	-
ISO control	1	Label for IPC-610 kl. 2.	1,49
Handling	-	Customer specific label	-
Receiving inspections	-	Minutes	-
Burn-Inn chamber	-	Units per batch	-
PCB separation	1	Handling	1,24
Production setup[3]		Part of batch size	1,12
		Sum	30,79

Production setup[3]

			Cost DKK
Picking	20	components	639,47
Feeder setup	16	Feeders	357,43
Setup	1	IPC 610 class 2 control	170,90
Setup	1	HMT process	170,90
Setup	1	IMT Process	-
Setup	0	IMT mechanic process	-
Setup	1	Wave process	170,90
Setup	0	Selective process	-
Programming	0	Setup	-
Setup	0	test fixture	-
Masking	0	preparation	-
Lacq	0	preparation	-
Setup	0	Wash	-
Setup + print of	0	Customer specific label	-
Stencil	1	Pcs. Control and cleaning	357,43
Setup Burn. Inn Chamber	0	Minutes	-
Receiving inspection	0	preparation	-
Setup	1	for separation PCB	85,45
Setup + print of	1	ISO label	113,93
Warehouse	1	Packaging and handling	170,90
		Sum	2.237,31

NRE cost[2]

Data tooling	20	Lines converted to Database	1.687,01
Smt program	136	Lines of programming	1.694,83
AOI setup	136	Lines of programming	2.118,53
Build of testing equipment		As specified	-
Stencil steel	1	pcs. for screener	2.099,92
Pcb tooling	1	set, prep from PCB manufacture	2.606,28
Other expenses, if any	-	pcs, estimate	-
		Sum	10.206,57

Appendix 30.2: ETK Offer

Bill of Materials are based upon the data provided from you and listed below, we urge you to verify this for any errors prior to acceptance of part and the associated cost of the actual parts

Your Part#	ETK Part#	Part Description	BOM Qty	Price each DKK	Total DKK	Currency base	MOQ
XXX	XXX	Components	1,00	63,7582	63,758	[DKK]	2000
YYY	YYY	PCB	1,01	2,7300	2,757	[DKK]	2000
	000 ETK ISC	LABEL TIL ETK ORDER FOR ISO SPORING 19x6mm.	1,00	0,1503	0,150	[DKK]	1

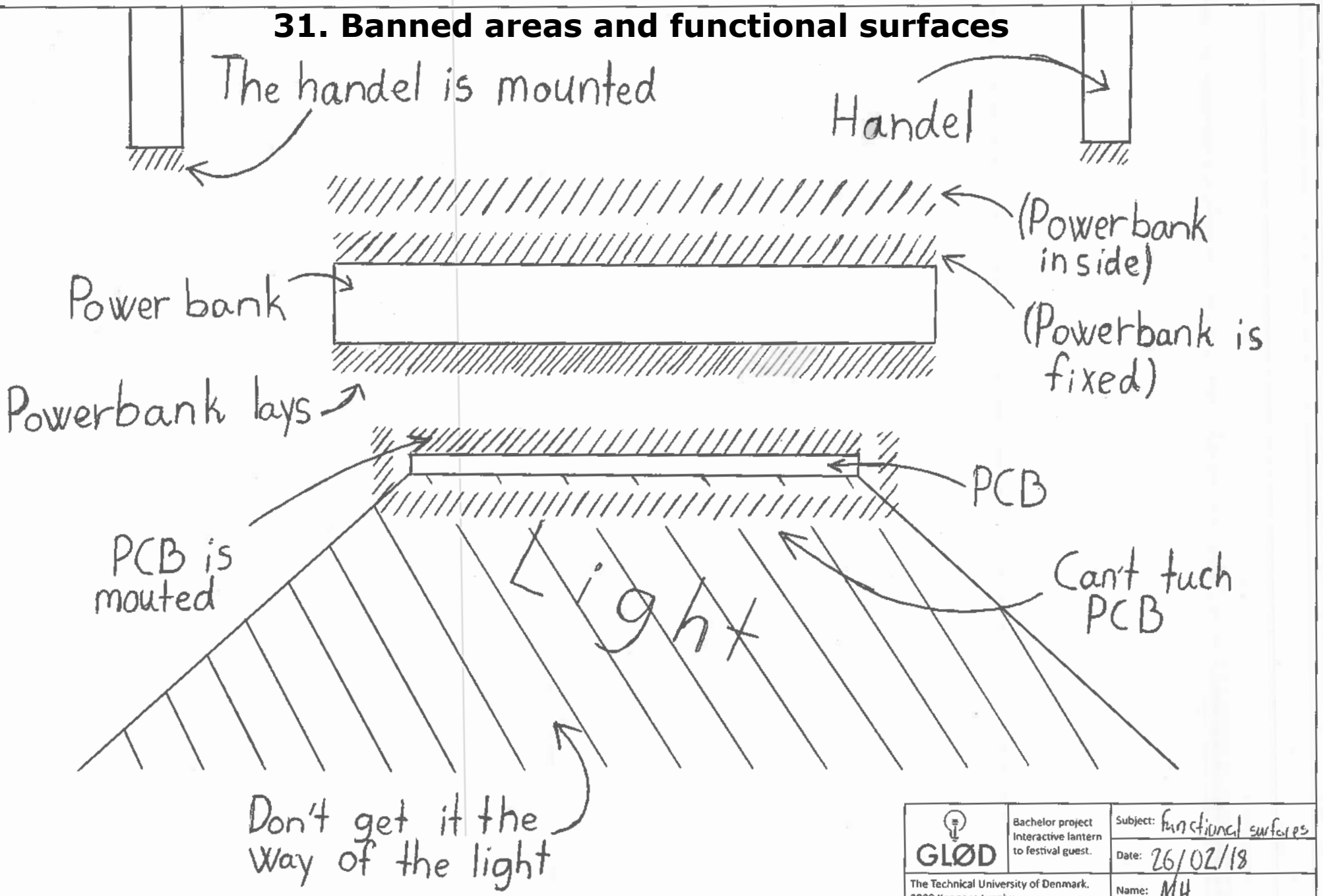
30.3 First BOM for electronics

Component name	Units	Total units	Price (euro):	Price DKK:	Total price:	Link	Number:
LED	12	24000	0,42	3,15	37,8	https://www.mouser.dk/productdetail/cree-inc/clq6a-	CLQ6A-TKW-C1L1R1H1QBB7935BB3
Microphone	1	2000	0	1,63	1,63	https://www.mouser.dk/productdetail/db-unlimited/mo09	MO093803-1
Comparator	3	6000	0,079	0,5925	1,7775	https://www.mouser.dk/productdetail/texas-instrume	LM339DR
Opamp	3	6000	0,243	1,8225	5,4675	http://dk.farnell.com/microchip/mcp6004t-i-sl/ic-op-a	MCP6004T-I/SL
LED Driver	1	2000	0,208	1,56	1,56	https://www.mouser.dk/productdetail/diodes-incorporate	AP3031KTR-G1
N-Mosfet POWER	7	14000	0,047	0,3525	2,4675	https://www.mouser.dk/productdetail/on-semiconductor/	NTR4003NT1G
P-Mosfet	3	6000	0,044	0,33	0,99	https://www.mouser.dk/productdetail/rohm-semiconduct	RSC002P03T316
Inductor	1	2000	0,111	0,8325	0,8325	https://www.mouser.dk/productdetail/taiyo-yuden/nrs401	NRS4018T4R7MDGJ
Diode Power	1	2000	0,122	0,915	0,915	https://www.mouser.dk/productdetail/avx/sd1206t040s2r	SD1206T040S2R0
Cin	1	2000	0,043	0,3225	0,3225	https://www.mouser.dk/productdetail/vishay-vitramon/vj0	VJ0805G106KXQTW1BC
NAND	1	2000	0,106	0,795	0,795	https://www.mouser.dk/productdetail/on-semiconductor/	NL27WZ00USG
USB cabel	1	2000	0,678	5,085	5,085	https://www.mouser.dk/productdetail/molex/88738-8000	88738-8000
OR	1	2000	0,175	1,3125	1,3125	https://www.mouser.dk/productdetail/texas-instruments/s	SN74LVC2G32DCUR
Schottky diode	2	4000	0,024	0,18	0,36	https://www.mouser.dk/productdetail/nexperia/bat54gwj	BAT54GWJ
NPN BJT	3	6000	0,022	0,165	0,495	https://www.mouser.dk/productdetail/diodes-incorporate	MMBT3904-7-F
Switch	1	2000	0,261	1,9575	1,9575	https://www.mouser.dk/productdetail/ck-components/js2	JS203011CQN
TVS(ESD prot)	1	2000	0,033	0,2475	0,2475	https://www.mouser.dk/productdetail/torex-semiconduct	XBP1010-G
Resistor	69	138000	0,009	0,0675	4,6575	https://www.mouser.dk/productdetail/susumu/rr0816p-33	RR0816P-3320-D-51A
Capacitor	27	54000	0,032	0,24	6,48	https://eu.mouser.com/productdetail/vishay-vitramon/vj08	VJ0805Y473JXAAC

Total:		75,1525

Octopart price:		63,98

31. Banned areas and functional surfaces



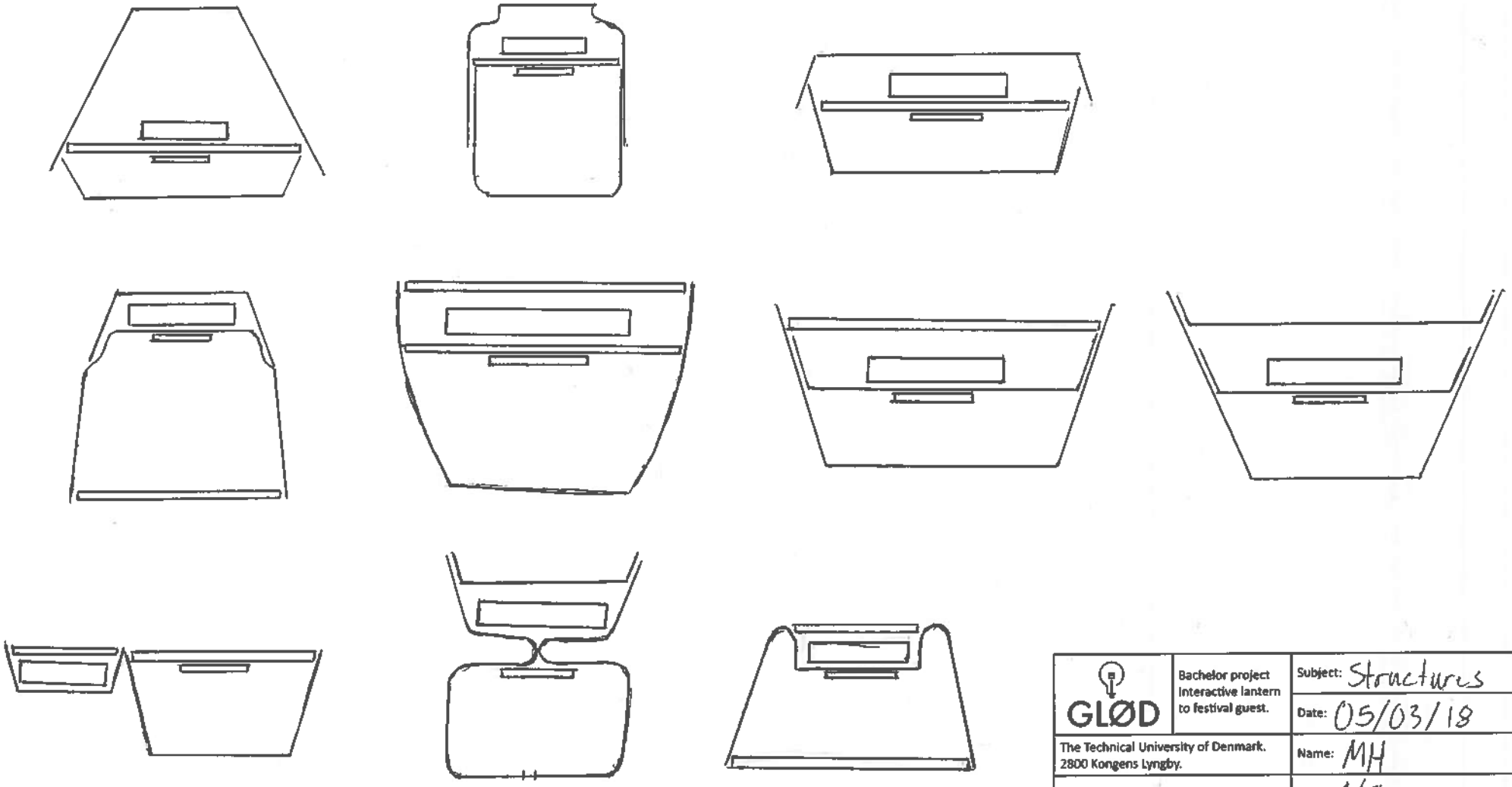
GLØD	Bachelor project Interactive lantern to festival guest.	Subject: functional surfaces
		Date: 26/02/18
The Technical University of Denmark, 2800 Kongens Lyngby.		Name: MH
Mads Hesseldahl & Victor Bertelsen		Page: 1/1

32. Quantified structures

Vacuum shaping

- Three parts
- Powerbank inside

Symbols
PCB
Powerbank



GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Structures
		Date: 05/03/18
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: MH
Mads Hesseldahl & Victor Bertelsen		Page: 1/5

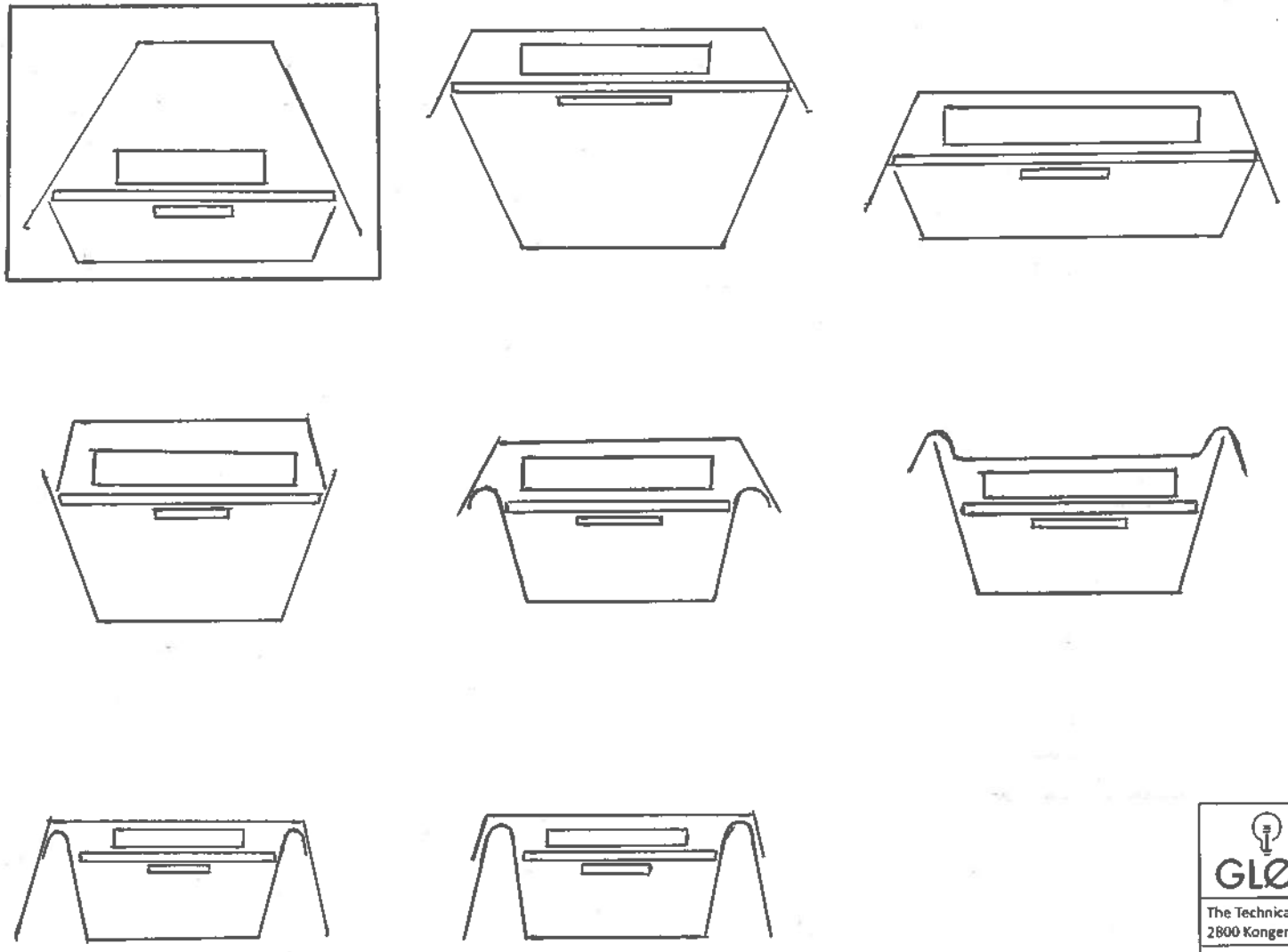
Iteration

Three parts
Powerbank inside

Symbols

PCB

Powerbank



GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Structures
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The Technical University of Denmark. 2800 Kongens Lyngby.		Name: MH
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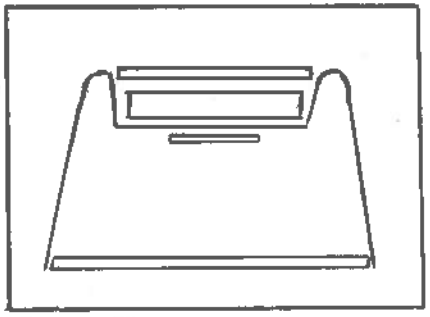
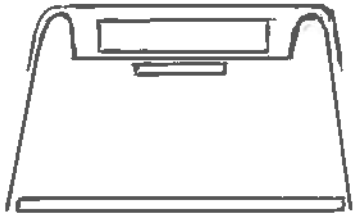
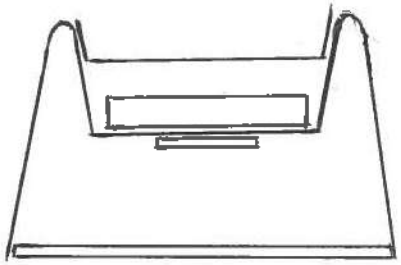
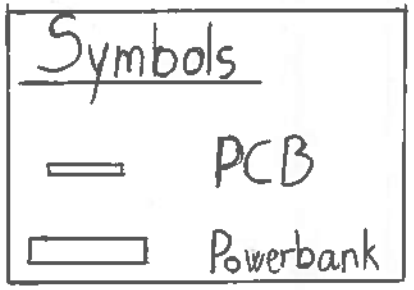
Iteration

Three parts
Powerbank inside





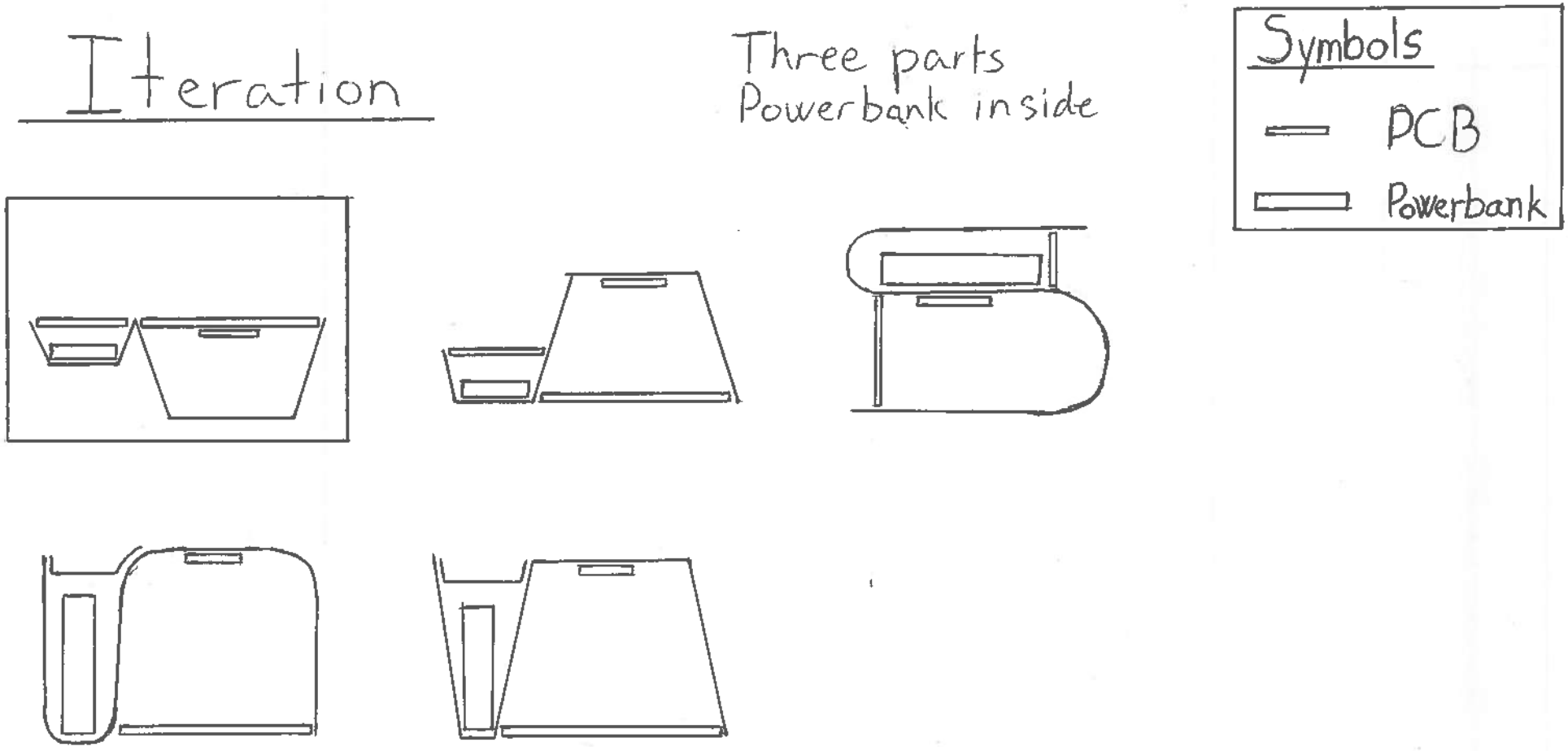




GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Structures
		Date: 06/03/18
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: MH
Mads Hesseldahl & Victor Bertelsen		Page: 3/5

Iteration

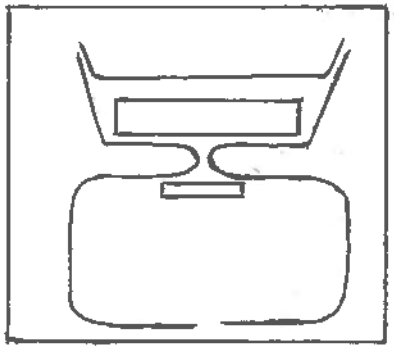
Three parts
Powerbank inside

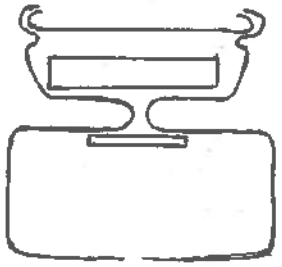


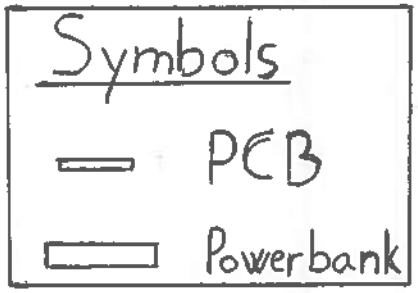
GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Structures
		Date: 09/03/18
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: MH
Mads Hesseldahl & Victor Bertelsen		Page: 4/5

Iteration

Three parts
Powerbank inside





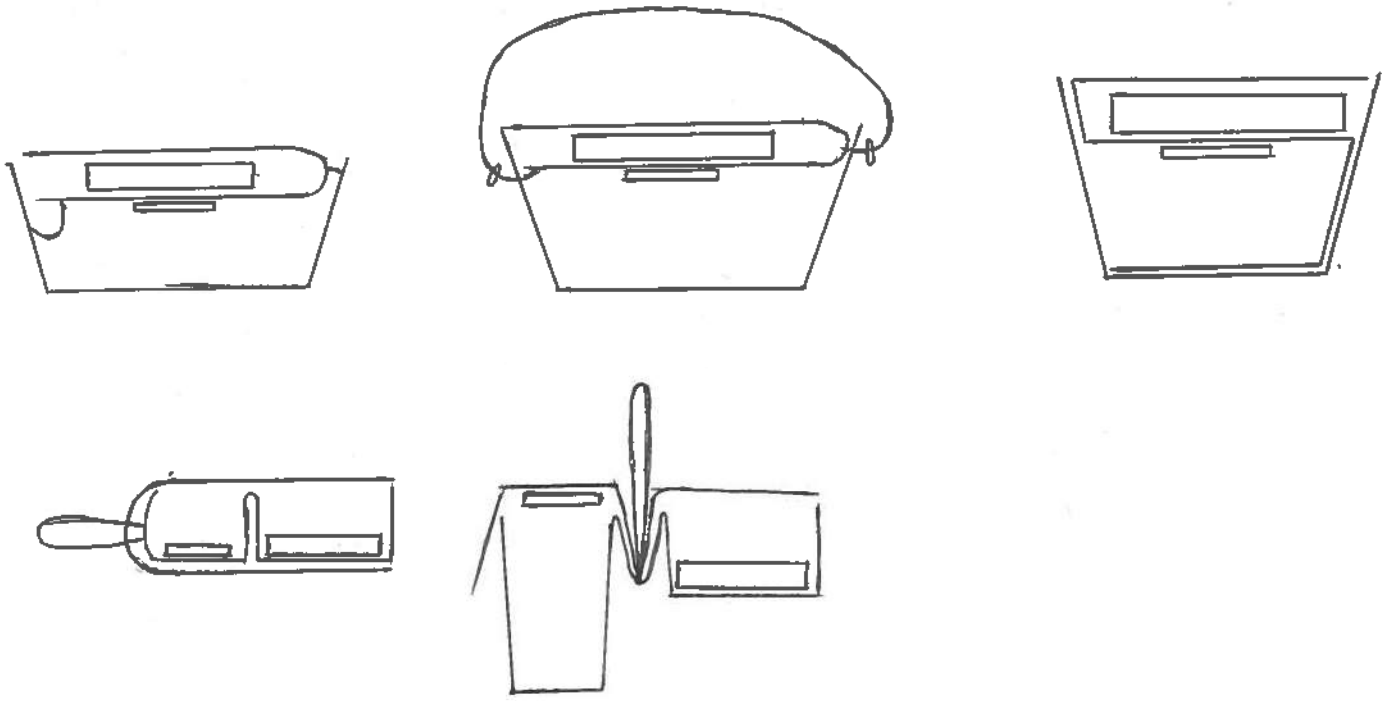


GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Structures
		Date: 09/03/18
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: MH
Mads Hesseldahl & Victor Bertelsen		Page: 5/5

33. Quantified structures

Vacuum shaping

Two parts
Powerbank inside



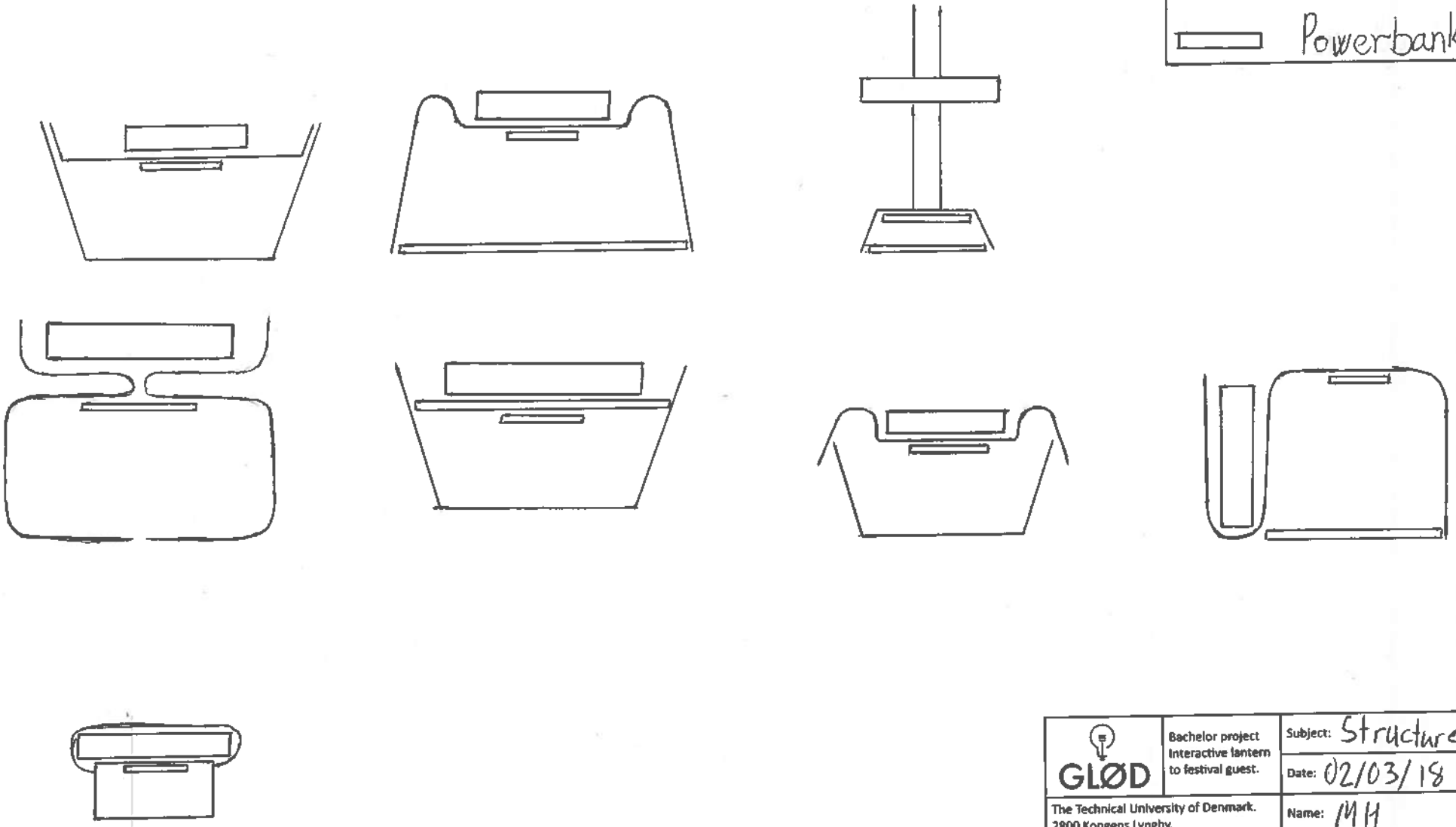
Symbols
PCB
Powerbank

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Structures
		Date: 28/02/19
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: MH
Mads Hesseldahl & Victor Bertelsen		Page: 1/1

34. Quantified structures

Vacuum shaping

Two parts
Powerbank outside



GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Structures
		Date: 02/03/18
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: MH
Mads Hesseldahl & Victor Bertelsen		Page: 1/4

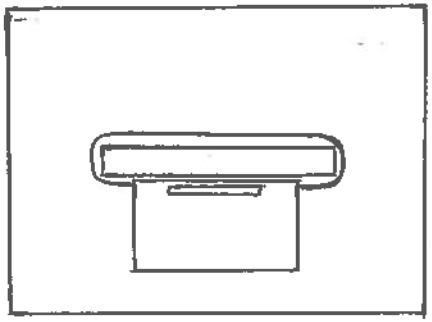
Iteration

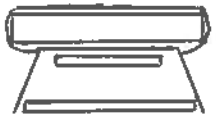
Two Parts
Powerbank outside

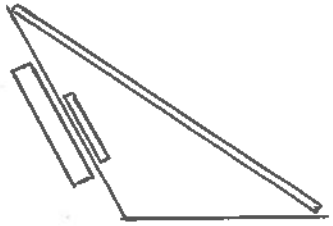
Symbols

PCB

Powerbank



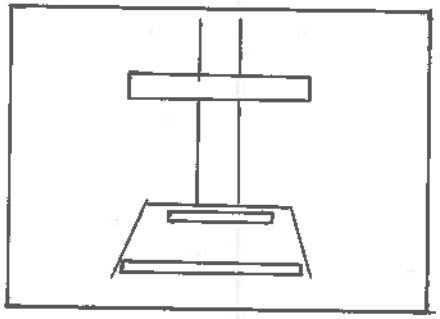


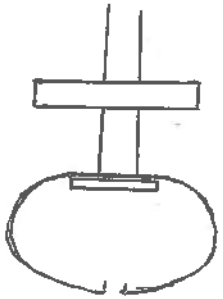


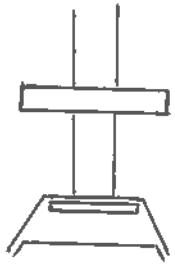
GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Structures
		Date: 02/03/18
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: MH
Mads Hesseldahl & Victor Bertelsen		Page: 2/4

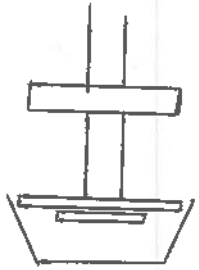
Iteration

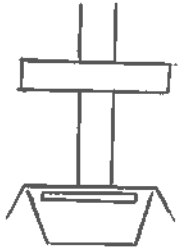
Two parts
Powerbank outside

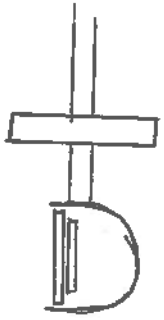


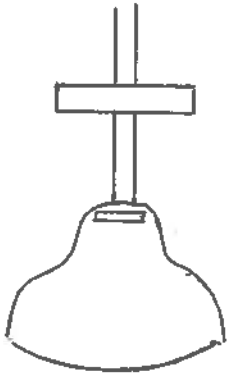












Symbols

PCB

Powerbank

Strap

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Structures
		Date: 05/03/18
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: MH
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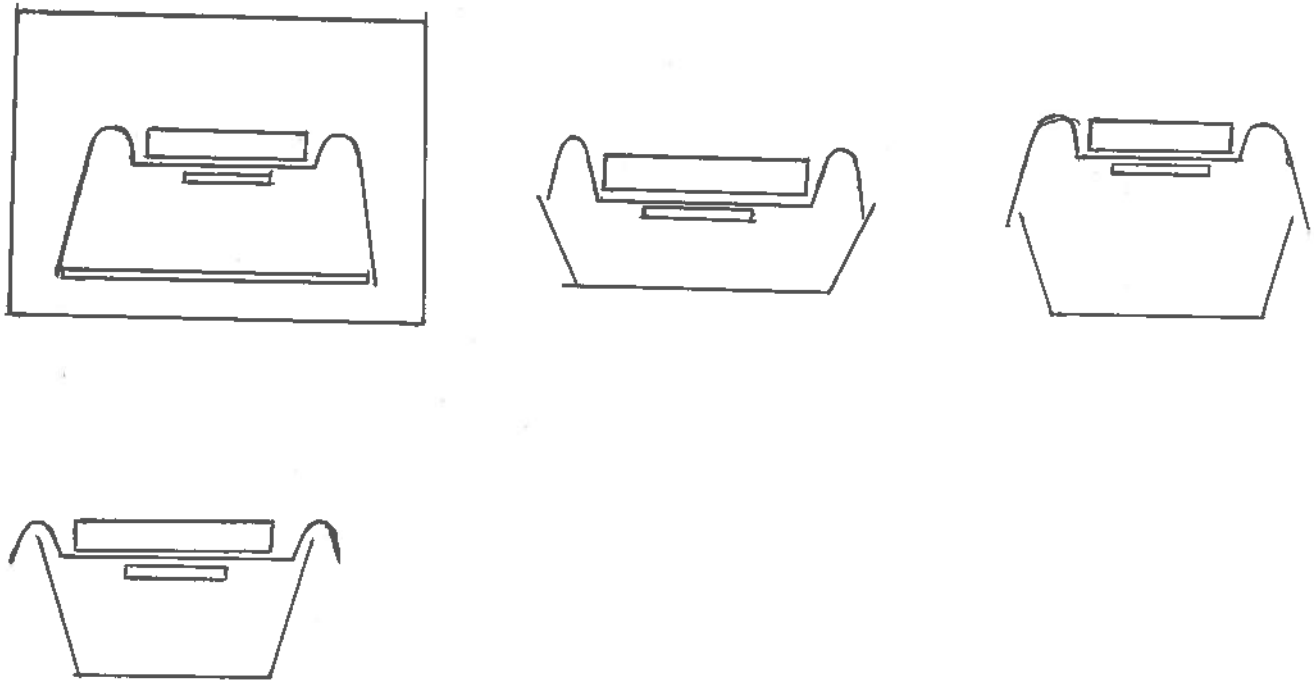
Iteration

Two parts
Powerbank outside



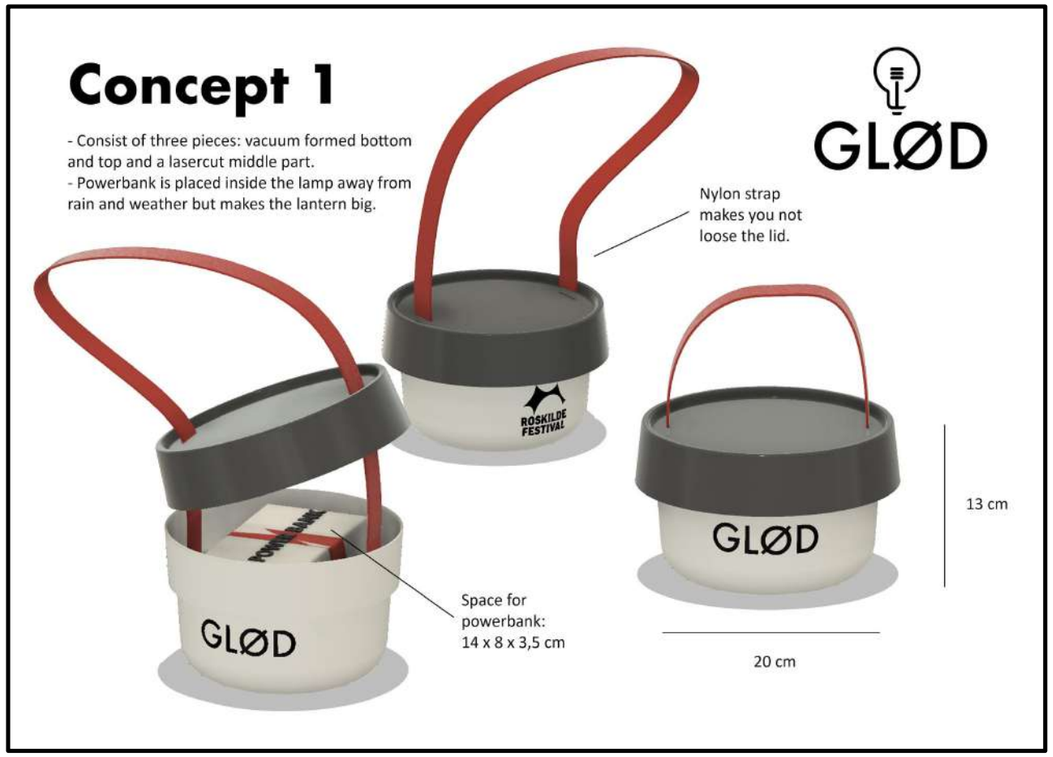
Symbols

PCB

Powerbank

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Structures
		Date: 05/03/12
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: MHP
Mads Hesseldahl & Victor Bertelsen		Page: 4/4

35. Concepts



Idea

This concept emphasized that most common power banks should fit inside the lantern - away from weather and rain. The idea is that the lantern shall be easily carried around the festival, on the shoulder or in the hand while it can also be hung from a festival pavilion.

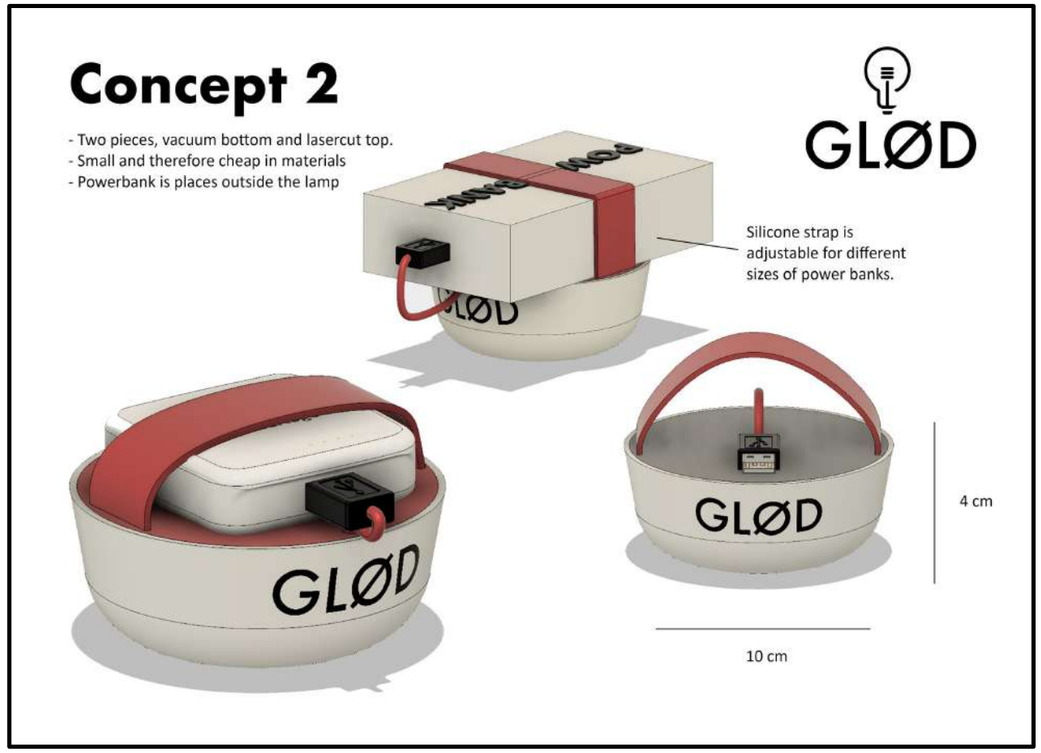
Solution

This concept is based on the user-survey, where most people said they used other power banks than Volt and that there was not enough space inside the old container for their power bank. This new container is optimized to fit power banks in the size of 140 x 85 x 35, which we estimate is the most common size for the power banks.
In the concept the strap should be made of nylon as this a material that is strong, reliable and cheap. The proportions of the lid and the bottom is made by using the golden ratio where the bottom half is 1,66 times bigger than the lid.
The lantern consists of a top and a bottom that are vacuum formed and has one middle piece that is laser cut and glued to the bottom piece. The shape of the container is optimized to fit the production method of vacuum forming. The strap is placed in a way that prevents the lid from falling off and it is rapped in the middle part of the lantern so that the weight of the power bank is carried as much as possible with the strap.

Compared to the design specification

This lantern concept lives up to the design specification as there is storage room for a power bank and because the electric circuit is covered with the shell. By using a 2 mm opal white polystyrene as material with a light transmission of 80% we believe that the LEDs can light through the shell with 300 lumen and that the LED bulbs are not visible. With this design the lantern can both stand on its own and hang from a festival pavilion.

The switch is placed inside of the lid which makes it less easy to access for the user. The design specification says that “the easier accessibility the better”. The design specification also says that “The prefered solution is a design that is easy to ship and store”. As this design cannot be flatpackaged or compressed in any way the design does not qualify for these criteria.



Idea

A small size makes the lantern more practical and easy to transport. There is no lid to cover the powerbank, but this has the advantage of the user being able to use any power bank, no matter what size.

Solution

This concept solves the same problem as concept one; that users are saying that there was not enough space for their power banks in the old container. This container has a elastic strap to mount the power bank. Since the power bank can exceed the edge of the lantern the size of the power bank does not affect the lantern size. The downside is that the power bank will not be covered from rain and weather.
Since it is a small and short shape it is optimized for the production method vacuum forming. The top part is laser cut and covers the electronics (that are placed underneath) from water. The size of the container fits to the size of a Volt power bank and the width of the estimated size of most commonly used power banks. The height of the container is determined from the light angle of the LEDs of 120 degrees. So the container is fully covered in light.

Compared to the design specification

This concept lives up to the design specification as it says that it would be “preferable if the plastic shell can be produced with the fewest components possible”. Here there are only two parts and the electronics. It is assumed that the power bank and the switch is easy accessible when placed on the laser cut part.

This concept is not easy to hang from a festival pavilion and the container does not cover the power bank. The lantern can stand on its own, but it will not emit a lot of light standing.

Idea

This concept is a foldable lantern made out of a thin layer of PP-plastic. The concept was developed when looking at different folding techniques and the idea is that the user receives the lantern in a thin sheet of plastic and then simply folds it. It should be so simple that the user won't need a manuel and it should be cheaper and easier to ship than the other concepts.

Solution

For this concept the plastic covers the powerbank in case of rain. The strap is nylon and is tied around the lantern in such a way so that when the lantern is lifted the lid will be closed and the power bank inside secured. The PCB is glued to the other side of the plastic where the power bank is located.
This concept could be manufactured with laser cutting, stamping or a water cutter. The design team assume that water cutting or laser cutting is most preferable due to the small unit numbers, since these manufacturing methods do not require a form tool.

Compared to the design specification

This concept is also produced with few components. Since the entire container is made from one sheet of plastics, there is only three components: PCB, plastic sheet and strap. Thus, this is the concept with the fewest components. The thin plastic sheet does let the LED light shine through, however it is not very robust.
We have not come up with a folding mechanism yet, but assume that it will be impossible to make the bottom part completely watertight.
The design does live up to the easy shipping part of the design specification and it also lives up to the easy to carry part as it has a nylon strap attached.

Idea

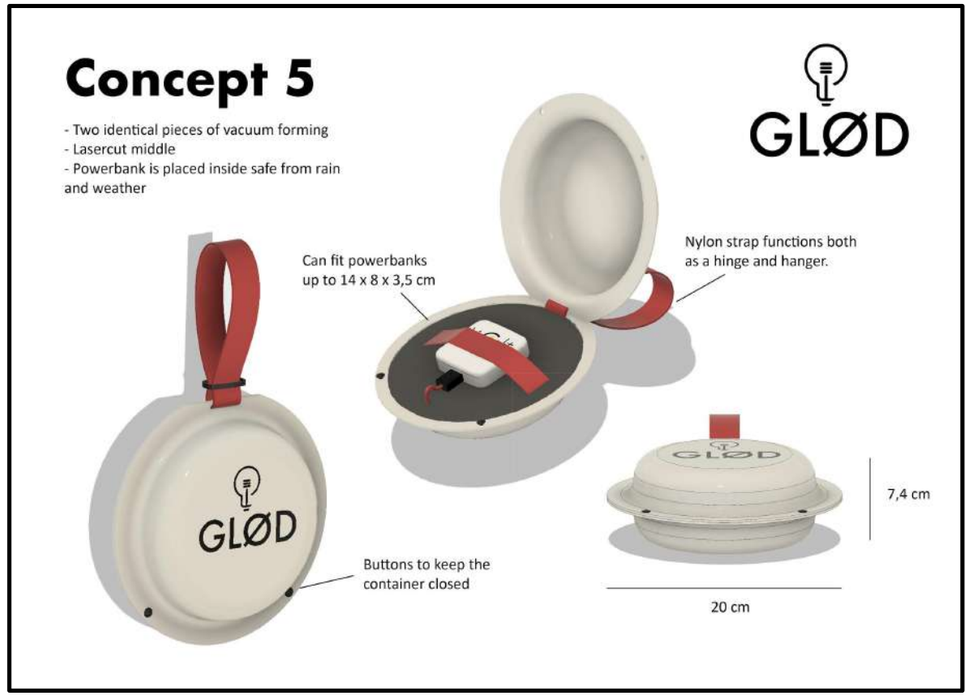
The idea is to create the smallest possible lantern while being able to carry any power bank, no matter the size.
Here the strap functions as the part where the user attaches the power bank. The power bank is outside of the lantern and is hereby exposed to water. The manufacturing method should be vacuum forming for the bottom and laser cutting for the top.

Solution

The dimensions of this concept is made by looking at the PCBs measurements. The lantern is 85 mm in the diagonal which provides enough space for the 54x45 big PCB. The strap is made in such a way that the grip around the power bank is tightened when the user carries the power bank. The strap is made out of nylon and works as a decorative color contrast to the grey lid.

Compared to the design specification

This design lives up to most of the requirements of the design specification- except that the lantern cannot stand upright on its own and there is not room for a power bank inside, which means that in case of rain, the user will not be able to use the lantern outside.
The user scenarios showed that all the activities GLØD are involved in are outside activities.



Idea

This lantern design is symmetrical from top and bottom as it is made with the same vacuum mold. The strap plays two functions, both as a hinge and a way to carry the lantern. The idea is that the lantern will be opened as the strap functions as a hinge. When the lantern is in use, the two parts are kept together by two buttons.

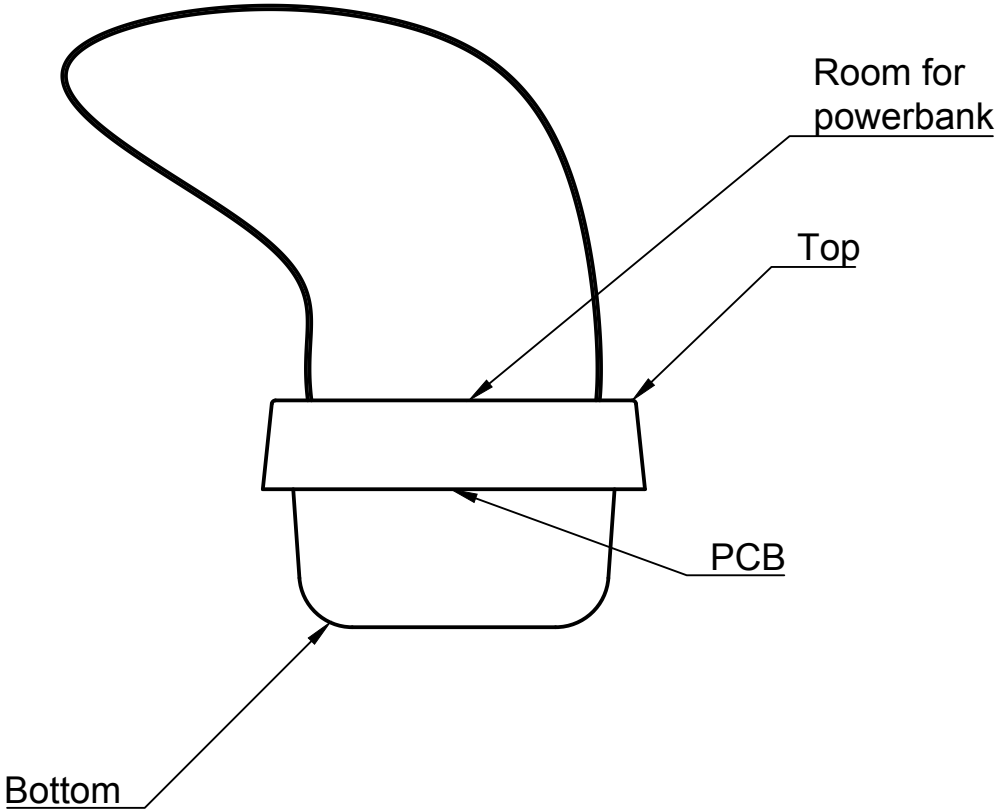
Solution

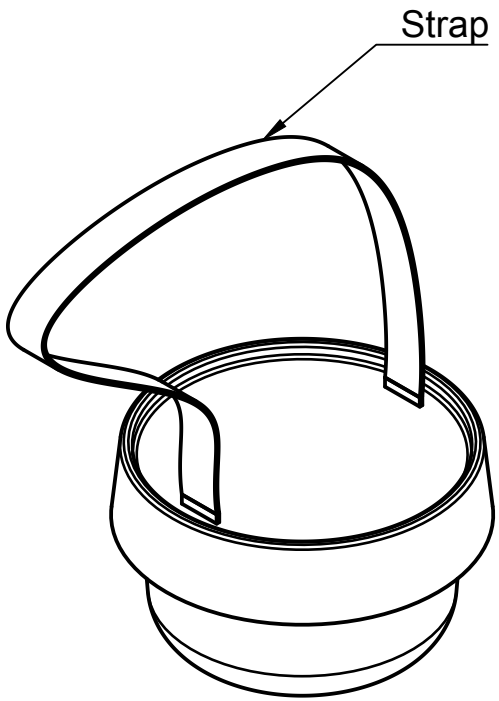
As the concept is symmetrical there only need to be fabricated one mold. The dimensions are made to match the estimated common power bank (140 x 85 x 35 mm) but a silicone strap also allows a Volt power bank to fit as it is elastic. The middle part is a laser cut plastic plate in acrylic that will be glued on to the bottom part. The design is optimized for vacuum forming. It is actually better shaped for this then any of the other concepts since it does not require a horizon saw to be cut out, but only a CNC-machine as the rounding part goes into a plane part that won't be formed. The front is plane, which makes it easier to place a logo or a folio with pattern on.

Compared to the design specification

This design meets the design specification by covering the powerbank from water and rain, and as it is easy to carry and easy to mass produce. With this design we need to be aware that while the buttons can seem a "smart" solution, it might not be the best solution as it reminds of the magnet from the strap of the lantern from 2017. Secondly, the position of the strap means that the light will come sideways when hung and not downwards.

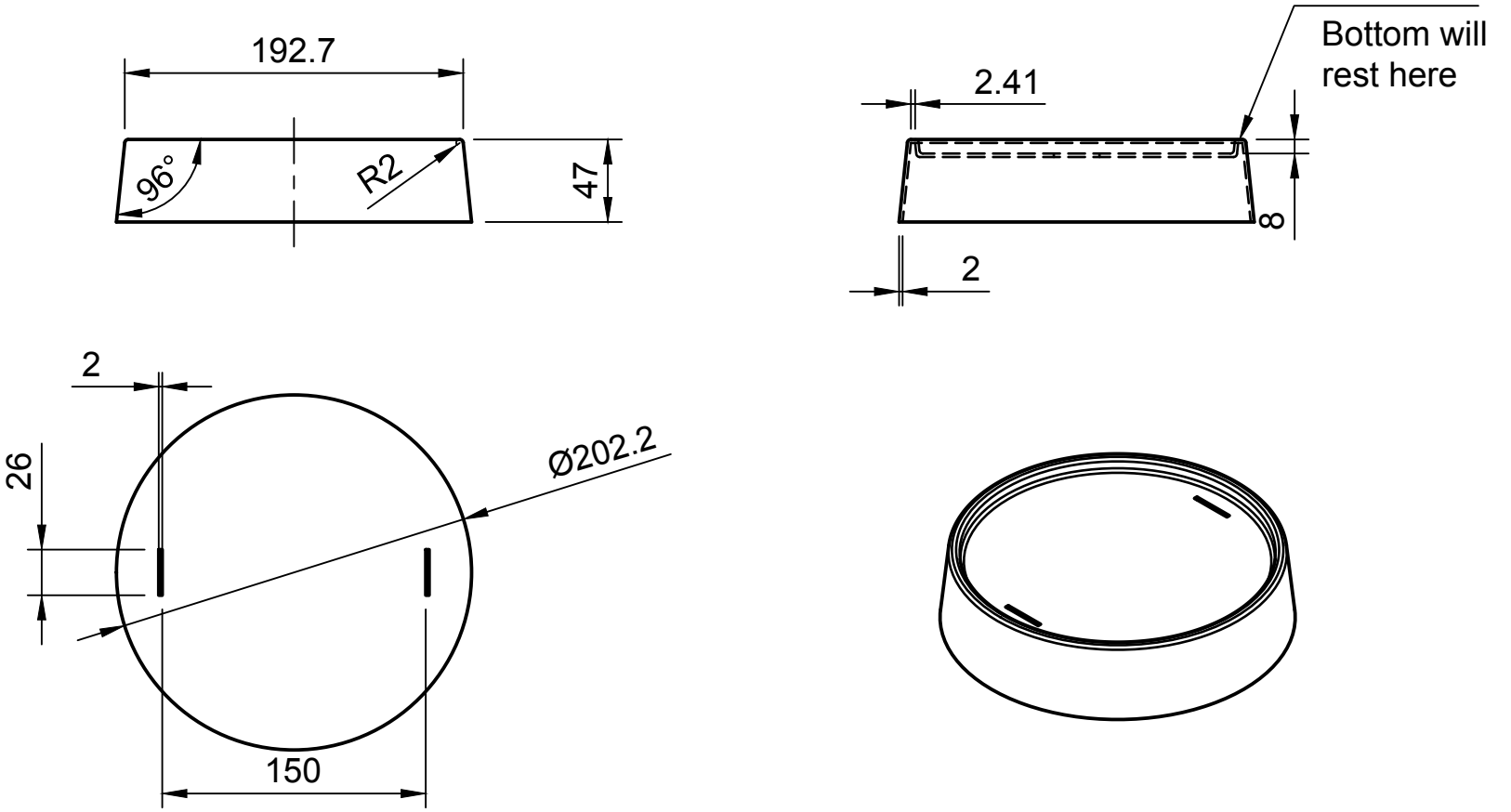
36. Technical drawings of concepts





Dept.	Technical reference	Created by Victor Bertelsen 05/03/2018	Approved by
Material: 2mm Polystyrene Scale: 1:4 Tolerance: DS/ISO 2768-1 Fine		Document type	Document status
		Title GLØD Lantern Production method: Vacuum formed	DWG No. 1 of 6
			Rev. / Date of issue 05/03-2018 / Sheet 1/1

GLØD



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	1:4	Victor Bertelsen 05/03/2018	
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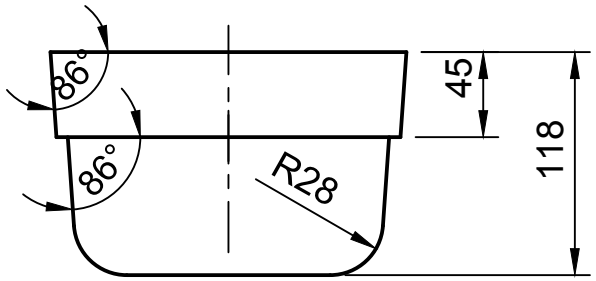
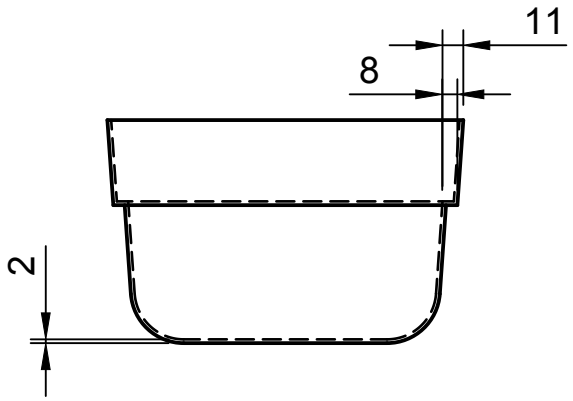
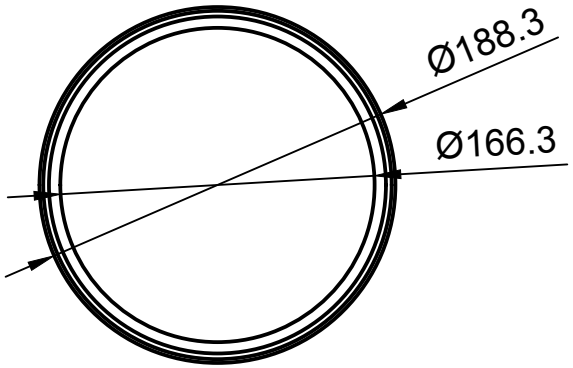
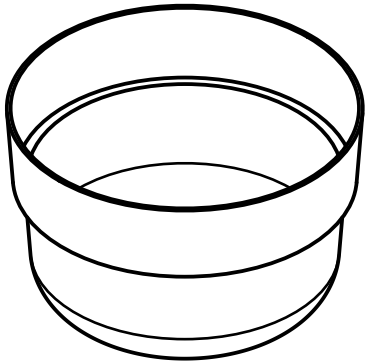
			Rev. / Date of issue / Sheet 1/1









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	1:4	Victor Bertelsen 05/03/2018	
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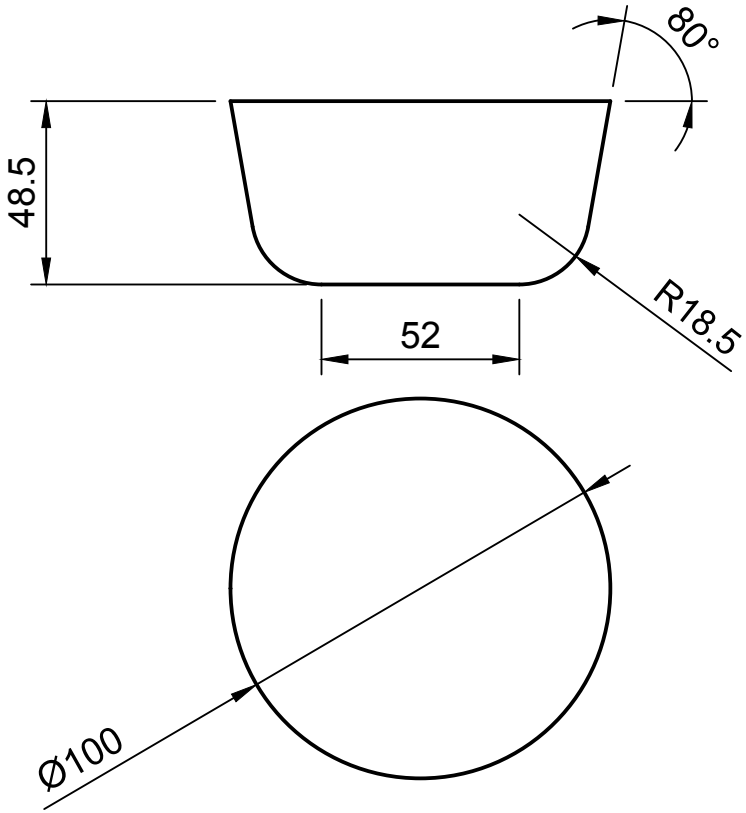
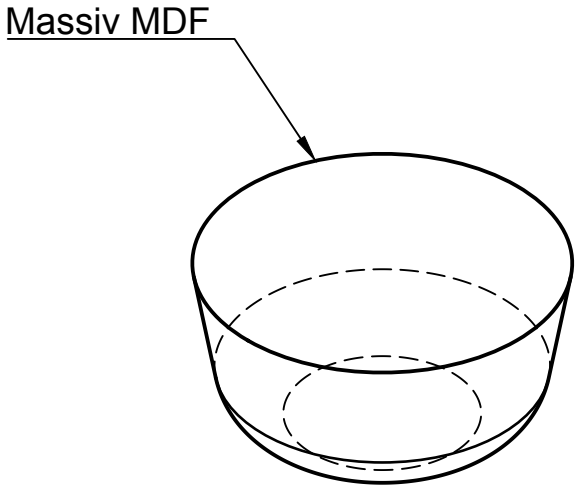
		Title GLØD Lantern Bottom	DWG No. 3 of 6
			Rev. / Date of issue: 05/03-2018 / Sheet: 1/1

GLØD





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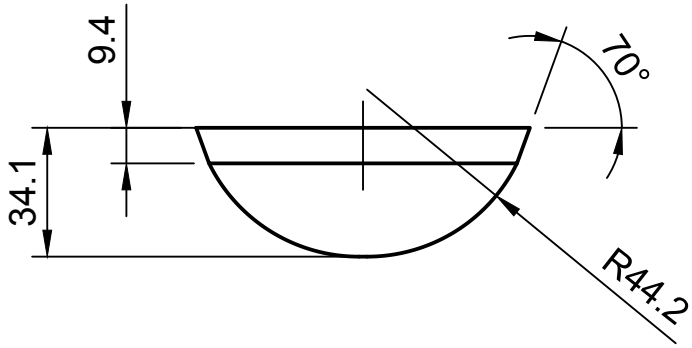
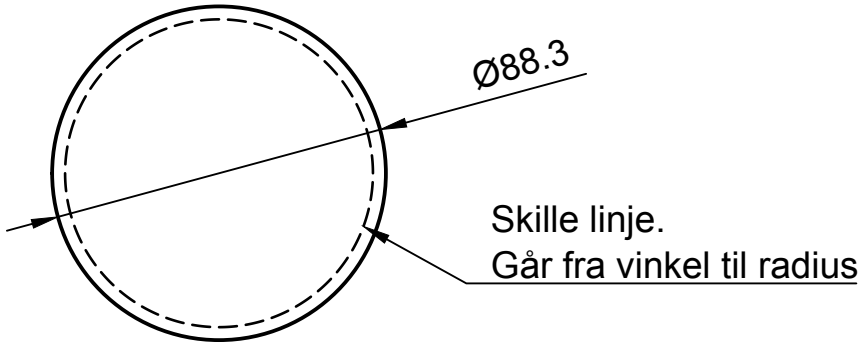
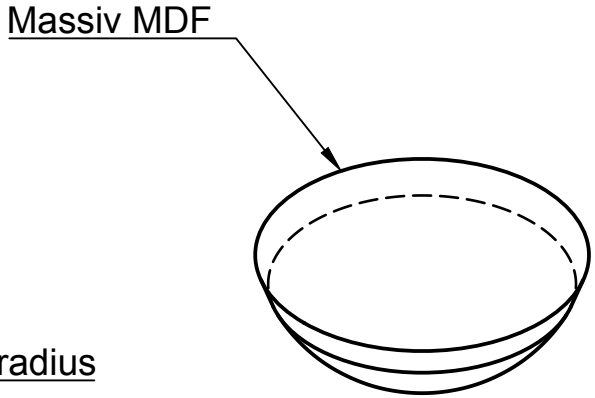
Bachelor	1:2	GLØD Lanterns	Victor Bertelsen
Material MDF Skale: 1:2 Tolerance: DS/ISO 2768-1 Fine		Document type 04/04/2018	Document status S154370
		Title Concept 2 Lathe Vacuum forming	DWG No. Page 4 of 6
			Rev. / Date of issue / Sheet 1/1

GLØD







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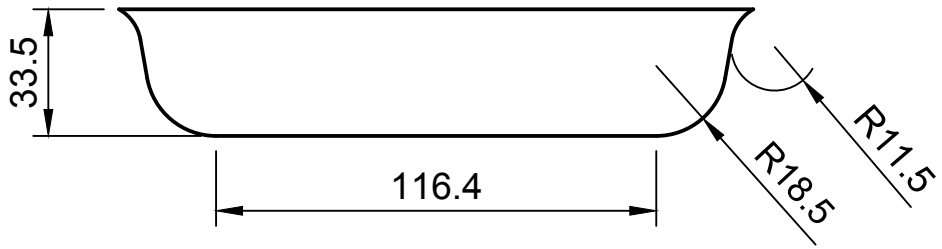
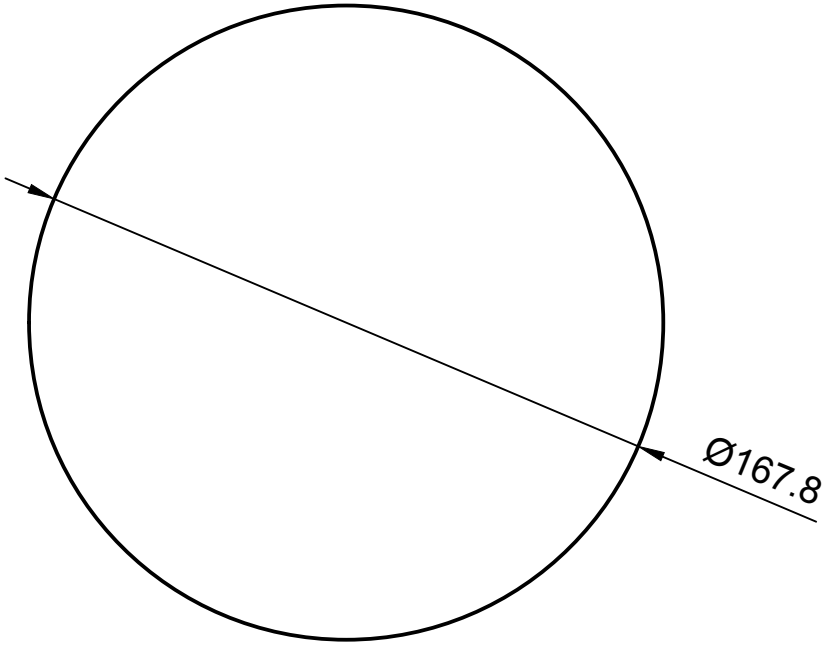
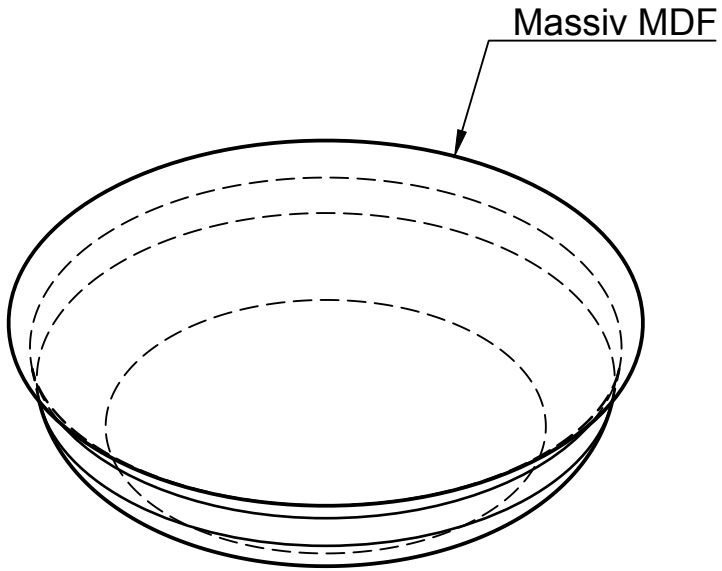
			Rev. / Date of issue / Sheet

GLØD







Dept.	Technical reference	Created by	Approved by
Bachelor	1:2	GLØD Lanterns	Victor Bertelsen
Materiale: MDF Skale: 1:2 Tolerance: DS/ISO 2768-1 Fine		Document type S154370	Document status 04/04/2018
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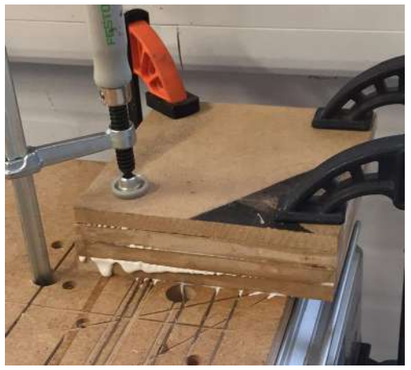
37. Tools

MDF

The first tools for the vacuum former was made in MDF. This was a tip we got from F.C. Systems as MDF is cheap and easy to process, but can only stand a low number of uses. When vacuum forming the tool gets very hot and that can deform the wood, which will cause uneven forming of objects.
We had to know i little bit in advance when we needed the tool, since some of the processes of making it took some time. The MDF tool was processed by first gluing MDF plates together until you got the desired high and then dried for a day. We had been in a dialog with the student workshop at MEK (Mechanical Engineering). We asked them if we could use their lathe, but we realized that it was much easier for them if they did all the processing them self.
MEK is a very structured workplace and therefore they require the students to have all drawings and materials ready if the work personal shall spend time on them. Something we had experience in previous projects and were therefore always very careful when handing MEK anything. Drawings was checked with Skylab staff for mistakes before handing them to MEK. This led to a very good relationship to MEK and the staff there enjoyed to work on the project and helped us much more than we would expect. Since we at the same time were getting more knowledge about vacuum forming from using the tools we had to make adjustments to our design and make a new tool.



The MDF is being glued before lathed at MEK

The mold after it had been lathed

3D-print

Some of the small tools were made on a MakerBot 3D printer. The printer used Fused Deposition Modeling (FDM) which printed the object in layers. The printer printed in ABS-plastic which has a higher melting point temperature than the plastic used in vacuum forming and therefore does not cause any problems during the forming.
We reinforced the structure inside the tool to make sure that it could withstand the pressure

The 3D print

DTU Ballerup also printed some tools for us. The printer used here was a high precision FDM-printer. The benefits of this printer was that it could print larger objects. After printing the object, the object was placed in a base to dissolve the support structures. The 3D print from Ballerup needed some processing afterwards with sandpaper to make the surface completely smooth.

The 3D print after the support structure was dissolved

Aluminum

The final tool would have to be another material than 3D-print or MDF as they will both deform under repeatedly heating and pressure. We got recometed using aluminium by Bo Hagelskjær Larsen. The final tool had specific requirements for the radiuses which can be difficult to make at a manual lathe. MEK did not have the specialized tools for making the desired radiuses at a manual lathe. Therefore we decided with MEK to make the tool in a CNC-lathe. This time they needed a 3D file they could use directly for the CNC-lathe.

The aluminum being processed in CNC-machine

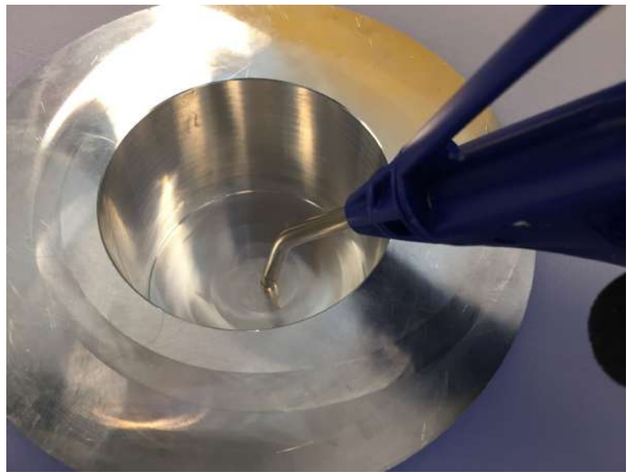
The final aluminum molds

After the first test of the final tool in the vacuum former the tool got stuck in the plastic plate and could not get out without breaking the plastic.
To overcome this we drilled a hole in the top of the tool. The hole were made so the form could be retracted with pressurized air after the vacuum forming process.

Drilling a hole in the aluminum mold

With the drilled hole it was easy to get the mold out of the vacuum formed plate

Using air pressure the mold could get out easy



38. Materials for prototyping

C.R. Steglich

The team contacted managing director of C.R. Steglich, Per Nielsen to have a talk about materials as the company specializes in vacuum forming.
Since the material has to be cheap, he recommended that we use polystyrene (PS).

Example of similar products C.R. Steglich have made in the past

Per Nielsen told about the following:

- Polyethylene (PE) is a possibility, as it is very strong but also expensive.
- ABS will give you good strength, finish and impact resistance, but it is more expensive than PS.
- At C.R. Steglich they usually use polycarbonate in the thickness 2-3mm and a light transmission of 70% in opal white. But there is one downside. The material gets quickly cold and therefore has to be warmed up more than other plastics such as PS. Therefore he usually used an oven at 70-130 degrees 24 hours before vacuum forming PC since there is no water particles left in the material. If there was water particles they would boil and the plastic would be uneven around the mold and in worst case break.
- Drill holes in the form
- Acrylic is good but has to be kept in a warm place as it attracts water that can cause it to build inside of the material when vacuum formed.

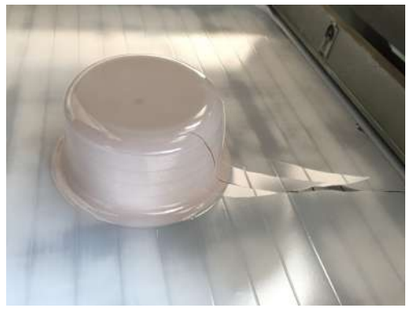
Following up on Per Nielsens advice we bought PS in different thicknesses, different light transmission percentage and color. The materials would be used in the prototyping phase to gain some experience. The price will drop when buying large quantities. The material cost were all covered by DTU Skylab.

Material	**Dimensions [mm]**	**Pris [DKK]**
Ingemann PS frosted white Light transmission 60% Lumio GLACIER 60	1850 x 2050 x 1,5	350,-
Ingemann PS frosted white Light transmission 80% Lumio GLACIER 80	1850 x 2050 x 2	350,-
Shipping cost		250,-
Nordisk plast PS Grey mat	1406 x 1006 x 2	100,-
Shipping cost		100,-
Total price:		1.150,-

39. Materials

Polystyrene

The first vacuum forming for the transparent part was made by using an opale white polystyrene. When trying to detach the processed object from the plate, there would very easily form cracks at the edge that rapidly increased with minor stress. This was unexpected and there had to be found an alternative to polystyrene.



Polystyrene cracked after vacuum forming

Acryllic (PMMA)

The team had a meeting with Ingemann components where we brought our polystyrene prototype. To get a less brittle product Ingemann components advised us to vacuum form in acrylic. Ingemann components had two kinds of transparency in acrylic available, 70% and 80%. To test how the transparency would fit our need they had a table with light in it. This way we could get a view of transparency.

We got a sample to test how the material reacted when vacuum formed and how the transparency held up to our LED's.

Using acrylic also gives another advantage as it's possible to laser cut in this material. This gives us another method to detach the processed object from the plate. We will go more in details with this later.

Picking materials at Ingemann Components

Shockproof polystyrene

For parts that did not have to emit light we had ordered polystyrene from Nordisk Plastik in charcoal gray. The gray we got was much whiter than we had expected. We tried the material on the lid of concept 1, but we thought that the color was off as the contrast between the light grey and opal white was not big enough. The colors were simply too identical. It was a very good material to vacuum shape with and it was robust. When we cut the object from the plate we noticed that it was a much less brittle than the transparent material, even though it was polystyrene. We found out the material was shockproof polystyrene. Besides from the color this was a good material.

Unfortunately we could only get the material in black, white and gray. If we wanted the material in other colors we had to have it specially made. Before Ingemann Components wanted to go through that process, we had to order 3 tons. This was over our capacity, so we chose to go with black polystyrene.

On a visit to Ingemann Components, we got a small piece of the shockproof polystyrene in black. The piece was only wide enough to fit the vacuum former in one direction. We had to test out if we would like this material. In order to get vacuum on the whole plate, we put a thin layer of plastic foil on top of the plate that fitted the vacuum former and would keep the vacuum. We got it to work with a lot of heat and we got the shape that we decided. Due to the plastic foil and the heat the surface of the plate was deformed. To our luck we recovered the object by using sand paper and sandblasting.

Experimenting with shockproove polystyrene from Ingemann Components

40. Optimizing vacuum forming

To reach the point where the material is ready for vacuum forming, the material have to be at its forming temperature.
This information were found in the datasheet of the material (see appendix 39.1: Formningstemperaturer PS and appendix 39.2: Formningstemperaturer PMMA)
To know which temperature the material was at we used an infrared thermometer.

The higher temperature that was applied to the plate the faster it will reach the forming temperature. The plate had to be warm all the way through. If the surface of plate becomes too hot it will start to bubble and get a white film. So if applied too much heat too quickly, the plate would not get heated all the way though and might start to bubble on the surface. If the plate was heated to long it might get too soft and get cloaked in the vacuum formers tabel as the tools get shot up in the plastic.
This was a balance that was important to figure out since we had to repeat it so many times.

PMMA

Temperatur (C)	Tid (min)	Succes
300	6	
300	6	fail
300	12	fail
350	04.30	
350	04.30	
350	04.45	
350	06.13	
350	05.45	
400	02.20	
400	02.40	
400	02.30	
400	02.24	
400	02.08	
400	02.22	
400	02.21	
450	01.12	fail
450	01.30	fail
450	01.40	
450	01.40	
450	01.40	
450	01.40	fail
450	01.50	
450	01.50	
450	01.50	
450	01.50	
450	01.50	
450	01.50	
450	01.50	
450	01.50	
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450	01.50	
450	01.50	
450	01.50	
450	01.50	
450	01.50	

Polystyrene

Temperatur (C)	Tid (min)	Succes
300	17	
300	9	
300	4	
360	02.51	
400	01.11	fail
400	01.24	
400	01.22	
400	01.22	
400	01.22	
400	01.22	
400	01.27	
400	01.24	
400	01.24	
400	01.24	fail
400	01.10	
400	01.10	
400	01.10	
400	01.10	
400	01.10	
400	01.10	
400	01.10	
400	01.10	
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400	01.10	
400	01.10	

41. Detach object from plate

After vacuum forming a plate, the object is still attached to the rest of the plate it was made from. In order to get the formed object out we had to figure out how to detach the object from the plate. Our biggest problem was to figure out how to cut the item horizontally of the plate. 3 out of the 5 concepts had a part that had to be cut this way.

Saw

The saw was an obvious choice to start out with, to quickly get the first prototypes of the plate. We made a tool that could keep the object and the plate in place and at the same time make sure that the saw was in level. This was not as easy as we had hoped. It was time consuming and imprecise. It was therefore necessary to use a sandpaper machine to get a leveled edge. This method gave a good result but it was a very time consuming process that definitely could not be done 500 times.

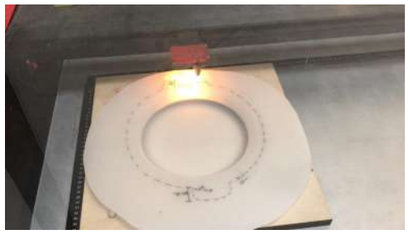
The tool shop worker cutting the vacuum formed object off.

When vacuum forming professionally, it is common to use a horizontal saw to detach the object. Unfortunately DTU did not have a horizontal saw available. We thought of using a normal band saw to do it, by placing the plate horizontally, but quickly realized the danger of this procedure and we never made any experiments with a band saw.

Laser cutting centering tool

The acrylic material made it possible to use laser cutting. Concept 5 required to be cut from the top, which meant that we could cut it out using a regular laser cutter. First the object was roughly detached from the formed plate using a grinder.

To solve how to locate the center of the object a tool was made. The tool was a square with a hole in the middle that fitted the diameter of the object. Since we knew what the dimensions of the square was, we could calculate the center from there.



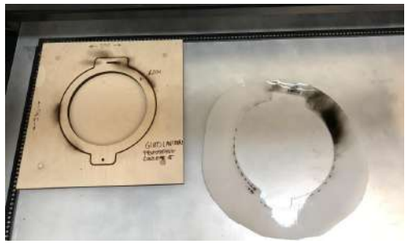
Laser cutting concept 5

Rotary Engraving Attachment (laser cutting)

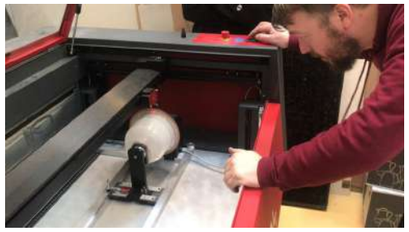
To overcome the challenges of cutting horizontal we used a device called a Rotary Engraving Attachment at the Mechanical Engineering workshop. This device allows to laser cut around an object.

This gave the object a more even height than sawing the shape did and the result had a better finish. The setup for each laser cutting took a while since the container had to be mounted on the device and the laser had to be adjusted every time. When laser cutting we had to take into an account that the material was thinner that originally. This made it difficult to determine the measurements in the laser cutter.

Mechanical Engineering workshop told us that it was highly unlikely that we could use their laser equipment to produce 500 units. To operate the equipment there had to be a person from the tool shop with us at all times. So even though the solution seemed as the best choice for horizontal the circumstances made us move on to finding a better solution.

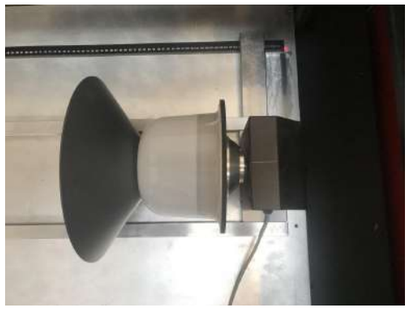


The form used to laser cut concept 5



Laser engraving

We used the Rotary Engraving Attachment on concept 1,2 and 4



Laser engraving

The lid of concept 1

We couldn't laser cut the lid since it was made of polystyrene. Therefore we had to find another way to detach it. In the prototyping phase a sandpaper machine was used. The shockproof polystyrene could handle a this better than PMMA and was easier to get leveled.

To get the holes cut out for the straps we made a template and used it to guide a drill and then clean it up with a dremel tool and a file.

After that we filed it with sand paper, sandblasted it and gave it some oil. This gave it a matte surface that was even and had a good finish.

Milling

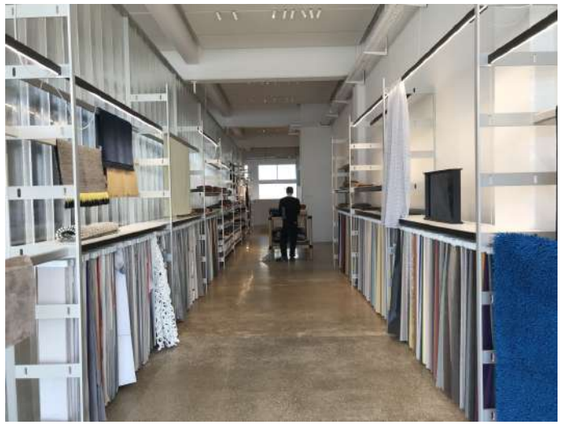
As we quickly realized that the lid of concept 1 would require too much time to process this way, we contacted a company called C.R. Steglich. The company had been recommended to use by a plastic supplier. C.R. Steglich is a company specialized in vacuum forming and CNC-milling. Detaching an object horizontally from the plate was a well-known procedure for C.R. Steglich. C.R. Steglich had a horizontal saw available but we were informed that it was too rough on the objects and left a bad finish. Therefore he recommended us to use CNC-machine and cut the bottom of the object first and hereafter mill the two holes for the strap.

We decided that this would be the best way to process the polystyrene lid. As it would save a lot of time in a busy period with writing bachelor thesis and the rest of the production. The price would be 28,50 ex. VAT pr piece.

Filling the lid of concept 1

42. Kvadrat textiles

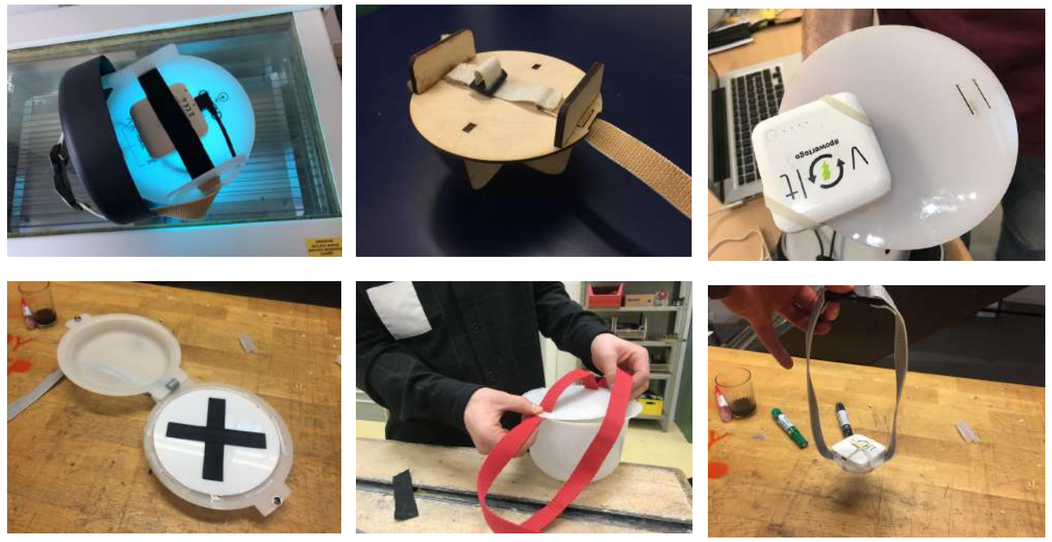
The project also received materials for the strap from the Danish textile manufacture Kvadrat as part of a sponsorship. The material was also polypropylene and was their only outdoor material the com-pany. But as the material was received in whole pieces 180 x 200 cm it required a lot of processing. This would have required the team to cut out every piece and then prevent it from flossing in the sides somehow. The thickness of the material was only 0,5 mm and therefore we would have to put it double and sew it together. Therefore we went with the textile found in Bauhaus as it would cost us much more time to process Kvadrats textile.



Visiting Kvadrats showroom in Nordhavn, Copenhagen to pick textiles.

43. Mounting of power bank

The design team had to come up with a secure mechanism for the power bank. The power bank is a central part of the product and is mentioned many times in the design specification. In the design specification it is mentioned that: *"The more secure the power bank is the better"* and *"Design solutions were the power bank is more easy accessible is prefered"*. With that in mind we created approximately 10 different ways of attaching the power bank underneath is shown the most successful ones:



Difference solutions for mounting power bank

After having tried to secure the power bank with polypropylene strap, a normal elastic, velcro and textile elastics used in sport clothes, we realized that the best mechanism is the textile elastics. The elastic can contain a power bank with the dimension of 140 x 85 x 35 mm but also subtract to hold smaller power banks.

A mockup of a power bank with dimensions 140 x 85 x 35

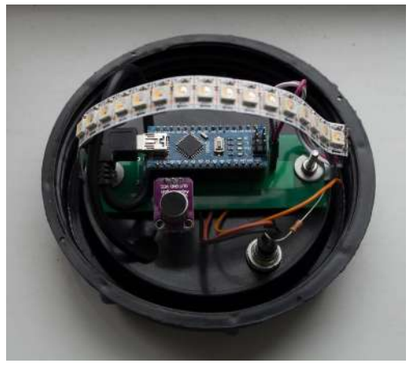
Since there is almost no friction between a power bank on a plastic shell or between the power bank and the elastics, the design team chose to use an elastics that had silicone on the back to create friction. This kind of elastic band was difficult to get in semi large quantities. But was found at a company called Elas located in Jutland. The company found the project interesting and donated 50 meters of elastic with silicone that was needed for the project.

The solution for mounting the power bank in concept 5 worked good.

44. Electronics - improvements

Where were we and where do we want to be?

As mentioned earlier, we made the first iteration of the lantern for Roskilde Festival 2017. That year, our electronics were designed to be assembled by the festival guests themselves. Since it was at a festival and we could not assume that people knew anything about electronics, the goal was to make the difficulty level of the assembly about the same as a Kinder Egg. The way we achieved this was by making the design modular, so there were only a few pieces to plug together by hand.



The electrical circuit from 2017

None of us had worked with electronics before so we had to use some fairly easy components to work with. We chose to work with Arduino, which suited us well, because we had some experience in programming. The hardware part was still very challenging, but we gained a lot of experience in the usage of soldering laboratory equipment by trial and error.

When we had constructed a finished circuit that met our criteria, we ordered components online from countries around the world like China and Britain. The production of the circuits was done by our selves by soldering everything together by hand - and the circuit functioned and served its purpose well. We managed to get all parts ready for Roskilde Festival.

When we started considering commercializing the product, we quickly realized that we had to improve some things to make it possible. The circuit was not suited for mass production if we wanted to do it at a reasonable price.
The first thing we had to improve, was that the circuit was mostly made up of prototyping components such as an Arduino Nano, LED strip and an Adafruit microphone. These components are quite expensive. Furthermore, we were not sure that the components or the combination of them was legal to sell in Denmark due to regulations such as CE- certification.

Another issue was to make the function of the circuit more robust. The LED's flicked too much and the microphone picked up a lot of noise and false signals. This could sometimes make it unpleasant to look at, and therefore it was damaging the purpose of the "party mode".
It was partially because of the code that was written for the Arduino, but also because of the low quality of the microphone. If the music was too loud, the microphone would overload and distort - cancelling any variation in the intensity of the light.

The last reason to improve the circuit was that it was all soldered by hand. The circuit was not optimized for mass production and we had chosen components that were easy to assemble by hand, but were not suited for a manufacturing pick and place (PnP) machine. Therefore, manufacturing the original circuit would inevitably be expensive.

We knew that if we wanted to make a business out of this we had to take a different approach. We had to redesign the circuit so it was better suited for mass production.

45. 3-week special course

Constructing the first circuit had challenged us to the limits of our knowledge, and we did not know how to make the improvements that would make a new circuit suitable for mass production.
We contacted the faculty of electronics at DTU and asked if they could help us. In particular, we were in contact with Tiberiu-Gabriel Zsurzsan, Assistant Professor. He recommended that we presented our project at a seminar at the faculty, so people would become aware of the project and could start helping us find a solution.
After the seminar, Tiberiu-Gabriel Zsurzsan agreed to help us set up a 5-point special course for Mads Hesseldahl and some other students, if we could find any, that could help him in the 3-week period of January 2018.
We made a description (appendix 45. 1. Project description for electrical engineers) of the project to invite others on board and we were very lucky to get two master students, Chris Cornaby and Nikolaj Bobek Søndergaard of Electrical Engineering to join the course. The course was supervised by Michael A. E. Andersen, Professor and Deputy Head of Department, and Niels Elkjær Iversen a Ph.d. student.

General course objectives

During this course, participants would be tasked with developing a low-cost power converter and signal processing unit for the GLØD outdoor lamp, while adhering to DFM (design for manufacturing) rules as much as possible.
The expected outcome was a manufacturing and assembly-ready unit that includes all desired features (continuous lighting and frequency-based color response, long battery life, low cost). The nature and complexity of the task required good teamwork and clear delimitation of individual tasks. Upon completion of the course, the participants would have obtained knowledge and skills to design both an LED driver and signal processing unit, while adhering to a strict set of rules, specific budget and consumer-electronics certification standards.

Learning objectives of the course were:
A student who has met the objectives of the course will be able to:

- Analyze the feasibility of a feature-rich portable light
- Evaluate several possible implementations
- Select the best solution based on given figures of merit (cost, light output, battery life)
- Implement a high-efficiency battery-driven LED converter
- Create a microphone feedback path for music-based intensity and wavelength modulation
- Apply DFM procedures throughout the design process
- Perform a cost and production optimization
- Identify specific certification requirements for consumer electronics in desired areas of operation

Chris as a co-worker

When the course was over and Chris and Nikolaj did not have any specific reason to continue to finish the design, apart from the fun of it and to help us. In the GLØD team, we did not know how much we could count on them. Chris agreed to help us make his part to work on the first iteration of the PCBs and then, if there was further work, we had to discuss some kind of payment if he was to continue. We debated internally in the group how we should pay him if that was necessary. We proposed that we could donate a Roskilde Festival ticket or he could join the team and therefore could be counted on as a coworker. Chris really liked the idea of being part of a project that potentially could make it to the market for the purpose of his CV. So, he agreed to be a part of the team and get a Roskilde Festival ticket.

45.1. Project description for electrical engineers

"The goal is always mass production"

- This is how we as two industrial design engineers think about product design. For the past year we have worked on an interactive lantern. That can listen to music and change color according to the beat. So far we have made 125 lanterns for DTU Roskilde and worked with various people during the projekt.

Now we want to take the project to the next level.

The plan is to produce 2000 lanterns for Roskilde festival 2018 and therefore we have teamed up with companies like Volt and Soundbox that will distribute the lamps on the festival. The team behind consist of two design engineers from DTU and one business student from CBS. So far we have made all the elctronics ourself, but going from the prototype stage to a mass production friendly design is not easy.
So we need your help as an electrical engineer.

We offer a special course together with Mads Hesseldahl and Ph.d. Gabrial LALALA. The task will be to make a PCB design and choose the right components suitable for a design that can be made cheap and fast 2000 times. If we find you qualified we can offer a perminant spot on the team and then you will get shares in the startup GLØD.

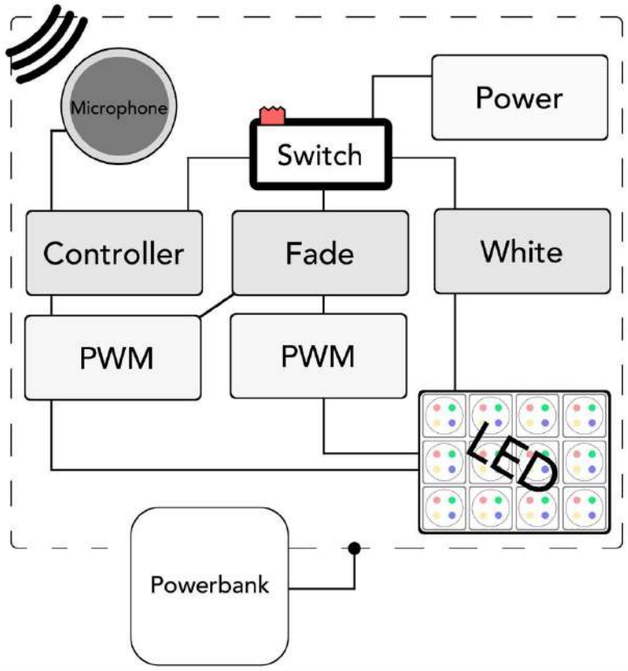
If interest please contact us at:
E-mail: Gloed@outlook.dk

46. Task handling

To be most efficient, we split the project up in three, two for the electronics and one for research. As we can see from the block diagram underneath, the circuit consists of three main sections; one for white light, one that made the fading cycle for the colors, and one that processed the signal from the microphone.
We agreed that Chris was in charge of the color fading and white light mode. Nikolaj was in charge of designing the section that was controlled by the input from the microphone. Mads was in charge of research of which legal regulation we had to take in to an account and finding cheaper components.

Block Diagram

When we had agreed on making the circuit analog, we could start considering the overall design of the circuit. The way we did this was by making a block diagram:



As shown, the three different modes are controlled by three different parts of the circuit. On the left we see the microphone that give an input to the controller and the pulse width modulation (PWM), which controls the intensity of the LED's. This section also gets an input from the fade section, to control the colors of the LED's. The signals from the fade and the controller gets multiplied and lead into the LED's.
Say for example that the intensity of the sound, which the microphone hears is 40%. You would multiply the signal from fade with 0.4, so it would light up 40%. This would be the so called "party mode".

In the middle is the fade and PWM that controls the color mode. To the right we see white, which controls white light mode. The LED's are connected to all three sections so it can get an input.

The switch is a three-stated switch to choose between the different modes. If the switch is set at the first stage from left, it would activate the part that listens to the microphone.
The second state is the color mode where the LED's would fade between colors at 100% light emitting. The third state is the white light mode that lights white at 100% light emitting.

47. From digital to analog

Once the design specifications were clear, we could start focusing on the construction of the circuit. We debated whether the circuit should be based on a digital microchip or a purely analog circuit. There were both positive and negative consideration to be made for both of them.
The advantage of a microchip is that you can reprogram it and add more functions to the circuit without adding any extra components. If you were to change anything on an analog circuit, then you would have to change the design of the circuit or add components. Therefore, the analog approach could cause problems, if we wanted to make some small iterations on the circuit in the future.

We assumed that the microchip would add a big expense the circuit because each chip has to be boot loaded and programmed before mounted on the board. We later found out that this was a wrong assumption.

Chris Cornaby and Nikolaj Bobek Søndergaard did not have any experience in boot loading and writing code for a microchip. This was also something we had to consider, since we only had 3 weeks to make the circuit. It would take much more time for Chris and Nikolaj to figure out how to make a digital circuit than to make an analog.

Through our discussions we found out that it would not have much of an impact to add a microchip to the design of the circuit since a lot of it would still have to be analog, because the input from the microphone has to go through an analog variable gain that is regulating the signal.

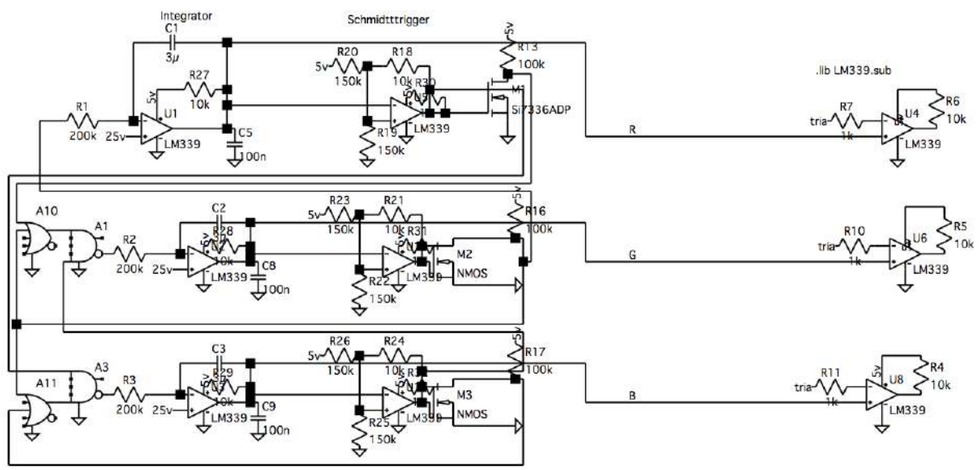
One of the problems with the old circuit was that it wasn't very tolerant of very low or very loud sound. One of the reasons for this was that we did not regulate the gain of the microphone.
This is hard to do digitally, but you can amplify an analog signal as much as you want without harming the signal. If we wanted the system to be adaptable to the level of volume, we had to be able to regulate the gain of the microphone analogously.

Based on these considerations we agreed on the analog approach. This would save us time, probably give us the best result, and it was the most realistic.

48. Simulations

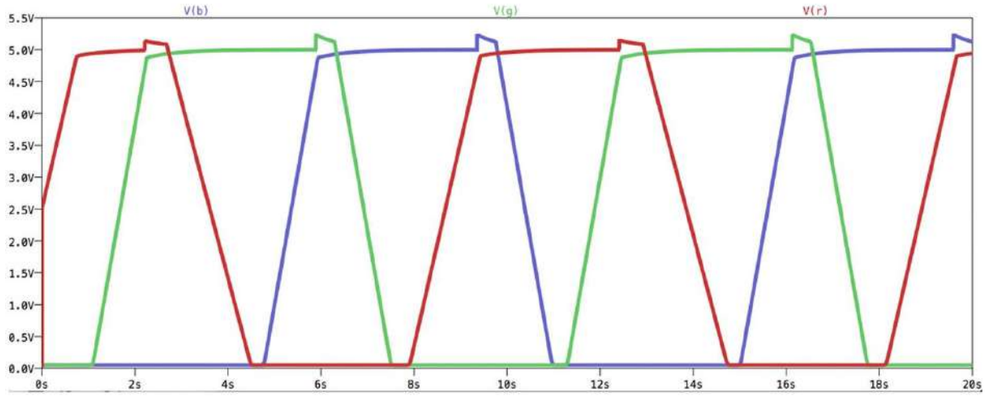
The way we designed the circuit was first to simulate it to save time so that we didn't have to build it to test it. We used a program called LT Spice, where we could import components and measure how the circuit would react to inputs before it is build.
The idea was that we would build the circuit in the program first, so we could do quick prototyping to get a good idea about how it's reacting.
A lot of the circuit is rather sensitive because we are working in pretty high frequencies, and therefore a little bit of disturbances in the signals can have big consequences. If we had to make a quick physical mockup of the circuit, we would probably have to make it on a breadboard and therefore the chance of bad results would be big.
The downside to making it in a simulation is that you cannot be 100% certain that it works in the real world since the simulation is made with ideal values, which you can never quite achieve in the real world.

The diagram below show the part of the circuit that makes the LED's fade between colors.
The LED's are mixing the colors with full light admitted. When two LED's are both on full power, one of them will slowly turn off and then another LED will slowly turn on. That way, the system cycles through all the possible colors. It has no other input than the 5V power source.



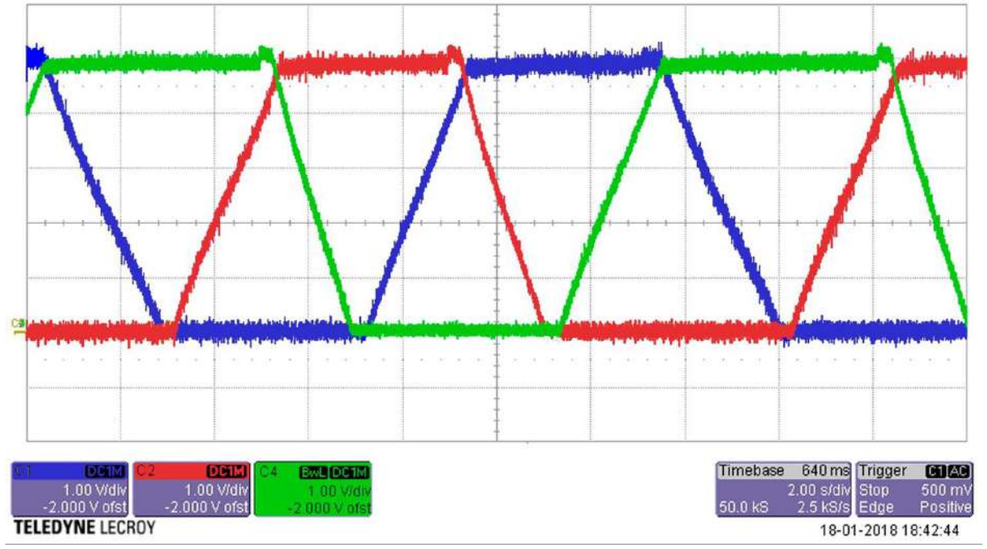
The way we do this is by making the LED's react to each other. If we look at the circuit, the top part controls the red LED. The red LED starts at 100%. The green part registers if the red LED is at 100%. As long as the red is at 100%, the green will slowly increase its intensity. When the green is at 100%, the red LED starts lowering its intensity. Then, when the red is at 0%, the blue starts increasing its intensity. This will continue in a loop which brings the LED's through every color.

The computer simulations for the fade part of the circuit looked like this in LT Spice:



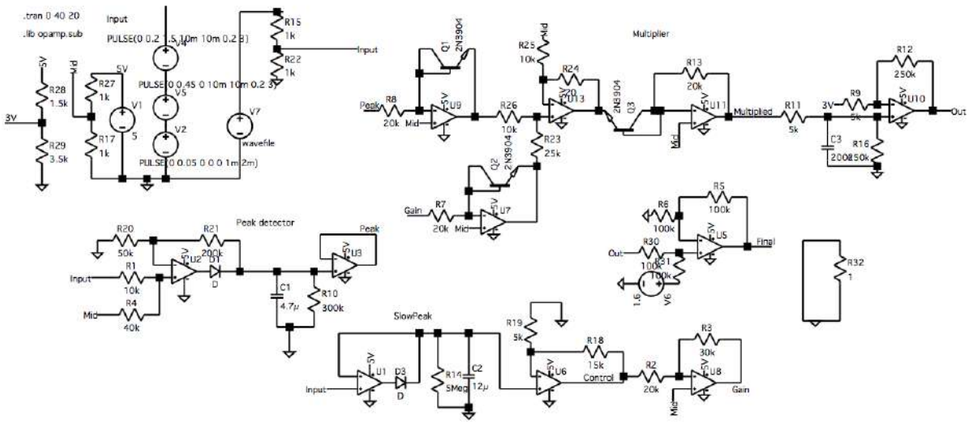
We can see how the LED's increases and decreases in respect to each other as we expected.

This is a measurement made on an oscilloscope we got when we tested the circuit on a breadboard.

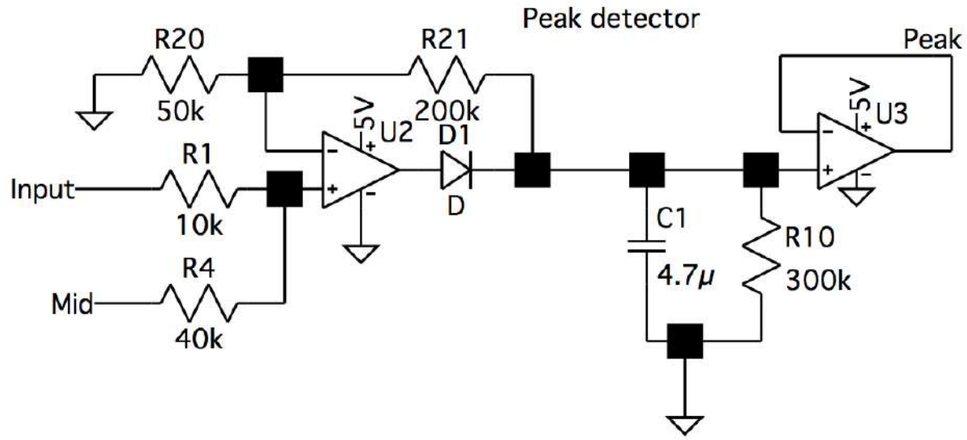


Luckily, the signals from the oscilloscope looked very similar to the computer simulations and this indicated that the fade mode was working. This was later confirmed when the circuit were build and the LEDs were connected.

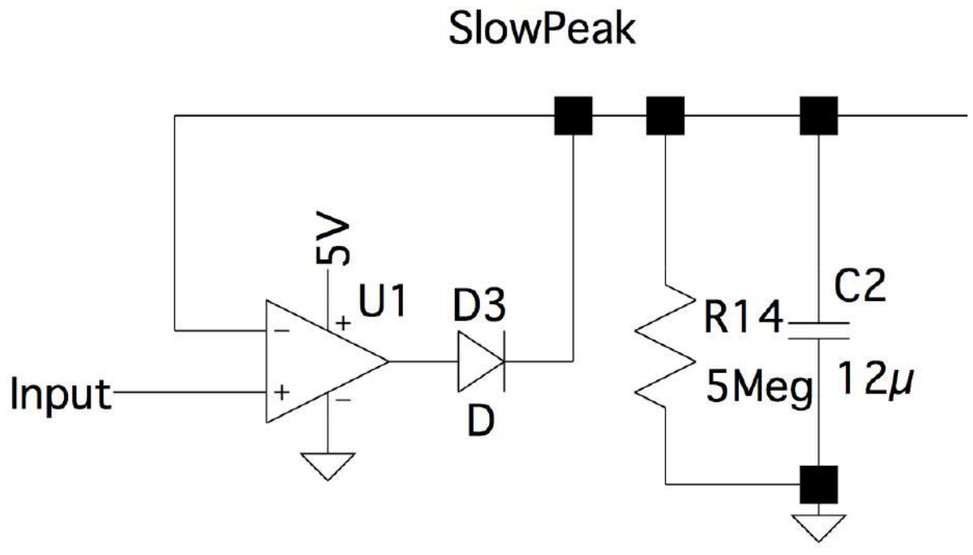
The diagram below shows the part of the circuit that makes the LED's pulsate in different colors to music. The way we do this is by using the signal from the microphone to vary an intensity and then multiply that with the fade signal.



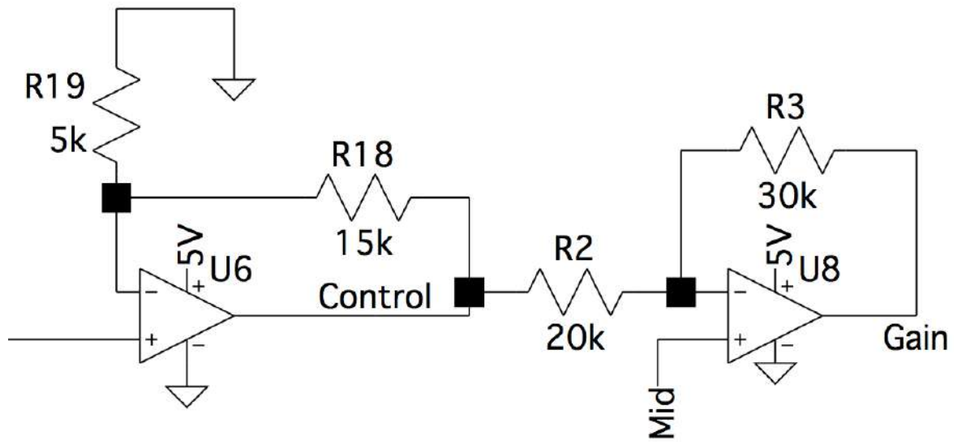
We use a number of different sections on the circuit to process the data in different ways.
First, we have a peak detector that cancels out unnecessary noise in the signal. Sound waves come with a lot of information, and we do not need to listen to all of it, we only need to know the volume of the sound. So instead of having a signal with a lot of fluctuations, we get a smoother and more even signal that shows us the volume of the music. The peak detector is also enlarging the signal a bit.



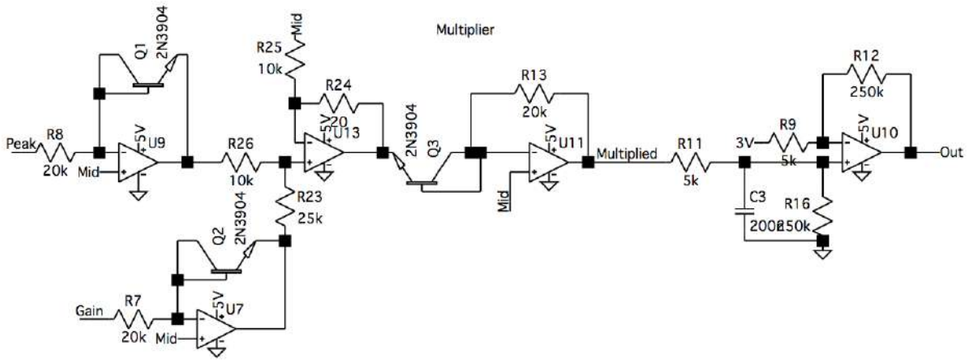
Slow peak is made to vary the gain of the microphone. This allows us to get the same reaction from the light either if we play loud or quiet music. The way it works is that if there is high level of volume the slow peak will increase rapidly and then fall slowly. That way we make sure that the slow peak slowly falls down to where the sound is and it quickly changes if the music becomes louder.



The gain amplifies the signal from the microphone. When the signals are bigger they are easier to work with and trigger reactions from. In this part of the circuit, the gain is controlled. When the slow peak is high, it turns the gain down. This way the signals matches the music at different volumes.



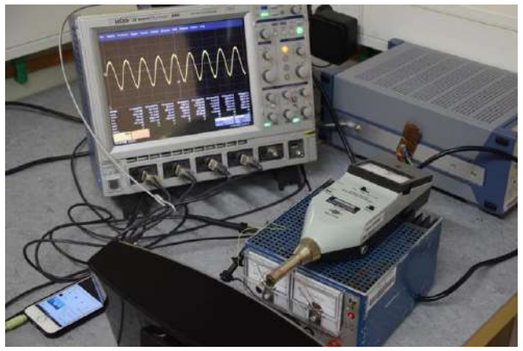
The multiplier multiplies the signal from the fade and the signal that comes out of peak detector. As described earlier, the output runs in to the LED's and makes them fade in different colors with different intensity.

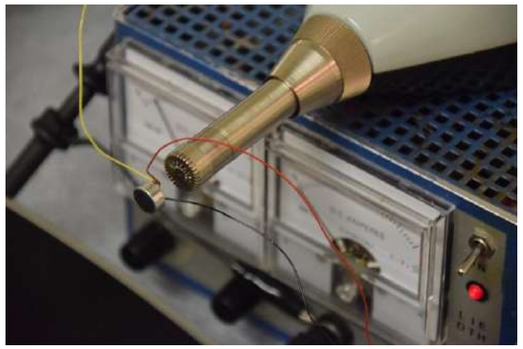

Multiplier
Peak
R8
20k
Mid
U9
Q1
2N3904
R26
10k
R25
10k
Mid
R24
20
U13
R23
25k
Q2
2N3904
Gain
R7
20k
Mid
U7
2N3904
Q3
R13
20k
U11
Mid
Multiplied
R11
5k
3V
R9
5k
C3
200
R16
50k
R12
250k
U10
Out

49. Microphone

Microphone

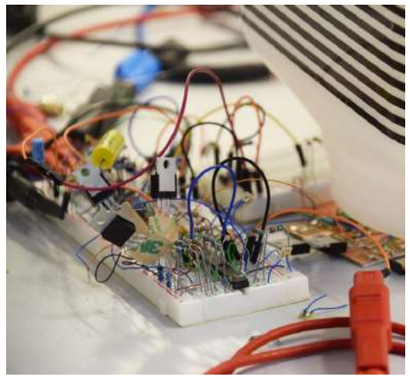
One of our requirements was that the microphone would react at 110 db. We tested this with an oscilloscope and a decibel meter. We placed the microphone and the decibel meter side by side right in front of a speaker. The microphone was connected to an oscilloscope so we could see the output. The microphone started clipping around 117, so the microphone was within our electrical specifications.





Testing the microphone

50. Breadboard



The first circuit on a breadboard

When we had completed the first design for the PCB, we send it off to a PCB manufacturer called ITEAD and ordered the needed components for the PCB through RS Components, Mouser and Farnell.
ITEAD is located in China and therefore there is some delivery time. First they have to produce the PCB and then send it express to us. RS Components offers day to day delivery to DTU, but for some reason our components were 4 days delayed.
This decreased our time for debugging a lot since at that point we only had about a week left of the course.
The components arrived before the PCB and because of the time limit, we decided to try and build it on a breadboard - even though the chance of failure was big. The problem with a breadboard is that the connections are typically not very good and if you have to use longer wires to connect different parts of the circuit, the signal might be weakened or could pick up noise.
With some clever hacking and good luck, we got it to work. All three modes were up and running but they were not working perfectly. The fading between colors was a little weird and got stuck at the red light for much longer than the other colors. We figured that this was probably because of the bad and long connections on the breadboard. Even though it was not working perfectly, this was a very good sign, because if we could get it to work on a breadboard it would most definitely work on a PCB with much steadier connections.
When the breadboard was done, the 3-week period was almost over and the PCB had not arrived in time.

51. First PCB

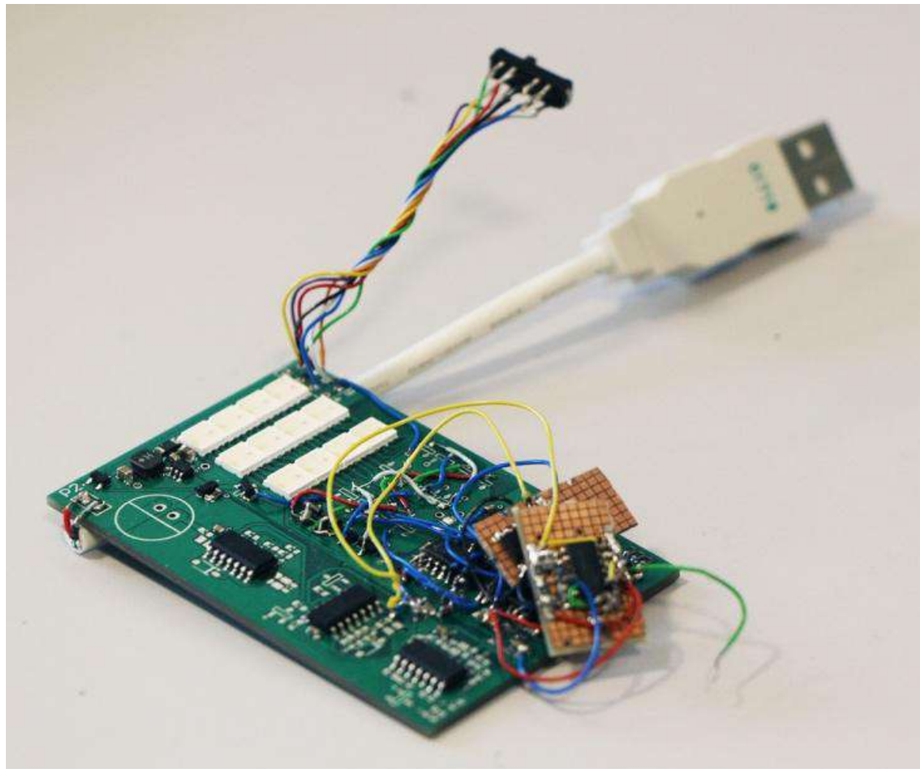
First PCB

The first PCB design arrived about a week after the course had ended.

The footprints on the PCB was 2.0x1.25 mm and 1.6x0.8 mm, so it was quite challenging to solder the components on. We used a method called Reflow soldering to solder the LED's. With this method you use soldering paste and an oven. First you apply the soldering paste to the footprints, then you apply the components and finally it is placed in an oven where the soldering paste liquefies and solders the components to the footprints. The rest of the components was hand soldered.

We started testing the part responsible for "fade mode" separately. As the "party mode" part of the circuit was depending on this. When all the components were placed on the PCB, it was not functioning but we did not expect it to work in first try. There were a lot of basic mistakes on the layout of the PCB such as flipped footprints and wires connected the wrong way. Therefore, there was a lot of rewiring. One part of the circuit could not be saved as a part of the PCB. It was easier to make on a separate prototyping board and connect it to the PCB (as seen on the picture). After three days of testing we succeeded in making the "fade mode" function. Fade was still a bit off, but Chris was sure that it was caused by the hacks we had had to make. Because of all the rewiring, the circuit was very fragile and even small manipulations could disconnect a wire.

After we had debugged the PCB, we could correct the mistakes and send a new PCB design off to ITEAD.



The first PCB with components soldiered on

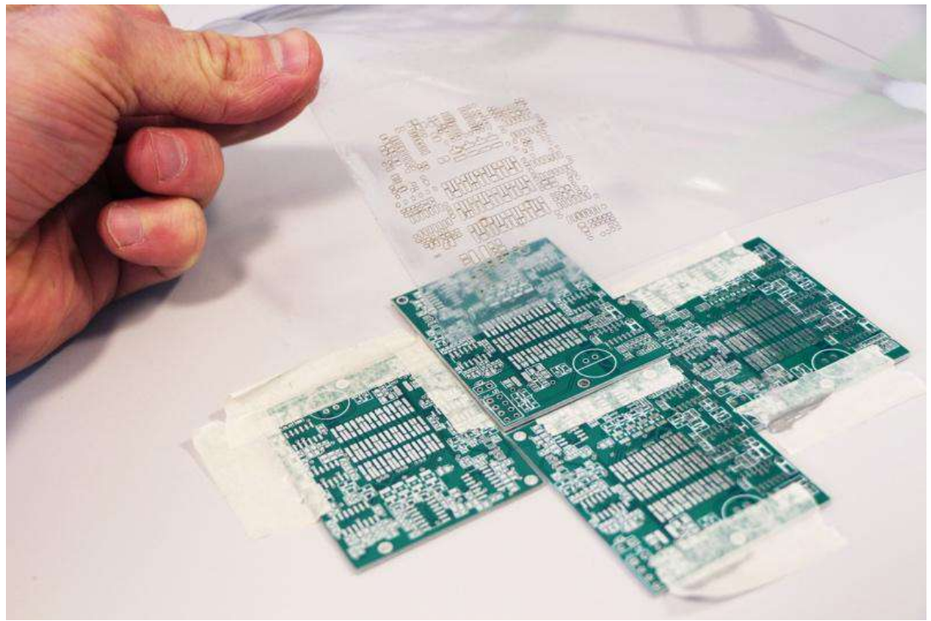
52. Second PCB

Because of the Chinese new year, the PCB was delayed a lot. We ordered the PCB on 20th February and recieved it on the 16th of March.
The faster we could get the PCB ready, the faster we could show the product to potential customers, do some proof of concept and send it off to production. Therefore these waiting periods are very critical.
When we got the PCB, we had to be efficient so we could have it tested as quickly as possible. Instead of putting soldering paste in every footprint by hand, we used a laser cut stencil. We taped the PCB and the stencil to the table so they were in a fixed position where the holes in the stencil was covering the footprints. We put a layer of soldering paste on the stencil so the soldering paste would go through the holes on to the footprints on the PCB. With minor adjustments the soldering paste ended in all the right places for the foot prints and we could start adding components.

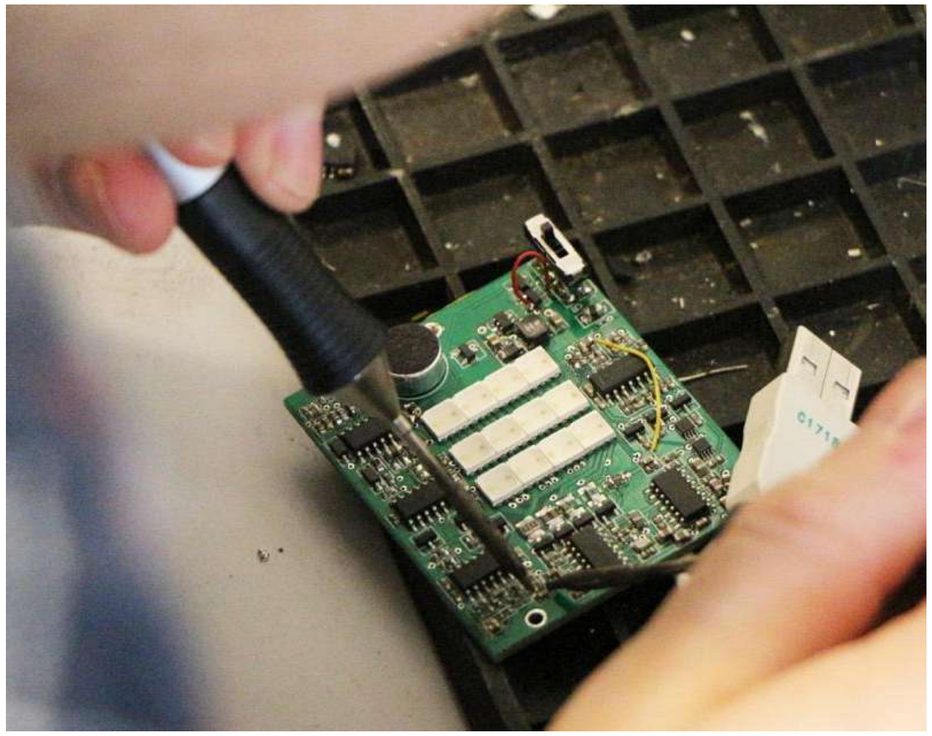
The “fade mode” needed minor adjustments but was quickly up and running. The “party mode” part was not functioning properly. We asked if Nicolaj Bobæk if he was interested in helping, since he had made the design for that part. To our luck he was.
We knew that there was a good possibility that all footprints and the wires were connected correctly, but the size of the capacitors and resistors needed some calibration.

It took a while to figure out what needed calibration and in the process, we discovered two problems:

- The idea of Nicolajs part (the party mode) was that it should follow the beat of the music. If there isn’t a very clear beat in the music, it is very hard to see the beat in the signal. We tried just looking at the input from the microphone on the oscilloscope and we had a very hard time telling the beat with just the naked eye. It would be a lot easier if we only had to calibrate the circuit for one specific song, but since there is a lot of differences in music, it had to be able to handle the diversity. One of the things we could calibrate was how much the circuit reacted to the music. The more it reacted, the more sensitive it was to the beat of the music - but the more it would also flicker and sometimes be unpleasant to look at. We tried to find a balance where it made most sense.
- The other problem was that it is very hard to vary the intensities of LED’s; either they are on or they are off. They have a very little span in between that and it is hard to regulate. If you want to regulate the intensity of the light emitting, you usually use digital signals so the LED is pulsating at different frequencies. When Nikolaj made the design for the circuit he thought that they would vary more than they did.



The PCB stencil



The second PCB

53. Light test

A light test was done in order to see how the light was in the different concepts. The concepts were rated on four different parameters. Light intensity, which describes how suitable the shell is to look at. Visable LEDs, describes if the light source can be located. It is not considered to be aestetic if it can be located trough the shell. Light distribution, describes look well the shell distributes the light in a room. Light describution in plastic shall, describes if all plastic is light emittid. Each concept is rated with a overall grade that will be used in the evaluation matrix of the concept. 1 is bad and 3 is good.

Concept 1

Light intensity
Comfortable

Visabel LEDs
No

Light distribution
Good

Light distribution in plastic shell
Good

Overall points
3

Concept 2

Light intensity
Very intense

Visabel LEDs
No

Light distribution
Good but sharp

Light distribution in plastic shell
Good

Overall points
2,5

Concept 4

Light intensity
Very intense

Visabel LEDs
Yes

Light distribution
Too sharp and not very good distributed

Light distribution in plastic shell
Does not light up the whole shell

Overall points
1

Concept 5

Light intensity
Bad

Visabel LEDs
Yes

Light distribution
Bad. Not a good lighting angle

Light distribution in plastic shell
The intensity of the LEDs were concentrated in the middle of the shell.

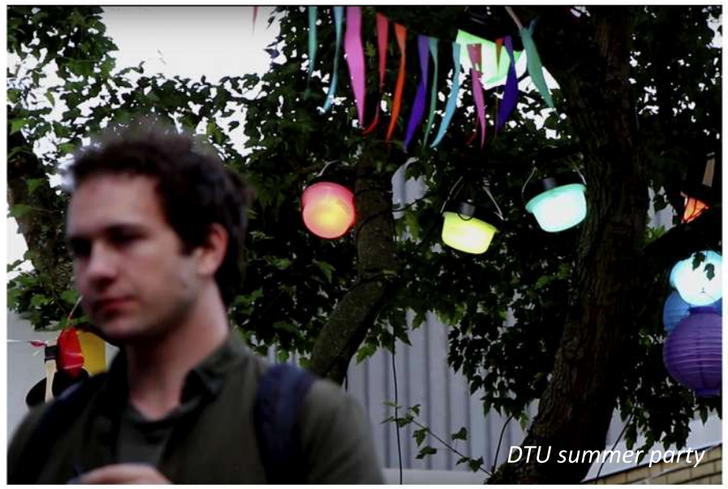
Overall points
1

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Light test
		Date: 12th of april
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: Both
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

54. Sound test

Multiple soundtests were done at different parties to test the lanterns party mode, to see if the party mode was tuned correctly. Some of the tests were done in the early stage of the project, after having received the second PCB. At this point the only available container to conduct the test with was the container from Novo Nordisk from the project of 2017.


Jelling Festival


DTU summer party

DTU line party

DTU line party


Jelling Festival

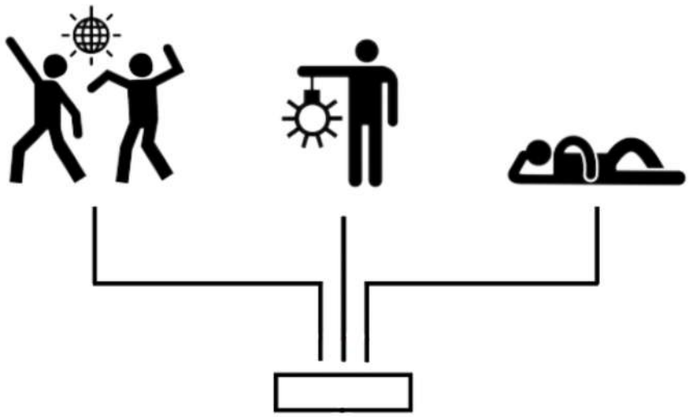

DTU line party

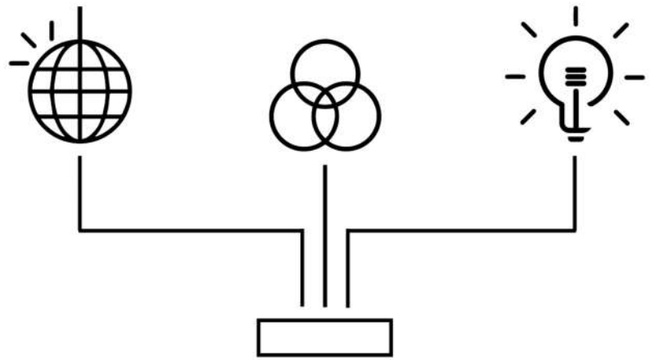

DTU Summer party

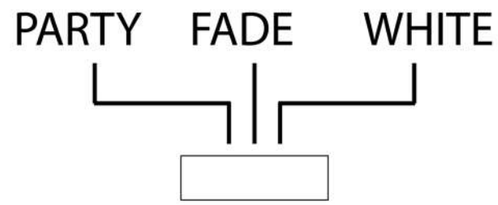
GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Sound test
		Date: April, may and june
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

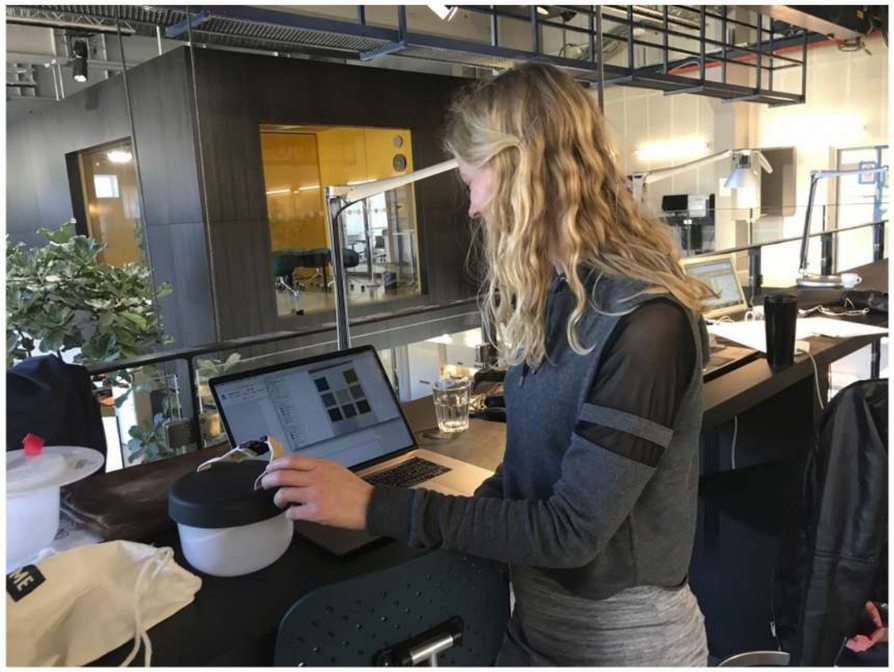
55. Interface

To pick the right interfase three different options were set up and a user interview with three students were used to pick the right one.
The students found the symbols cute, but could not understand their message. They all agred that the text was the most explainable and related it to regular remote controls where text is also used to communicate functions.









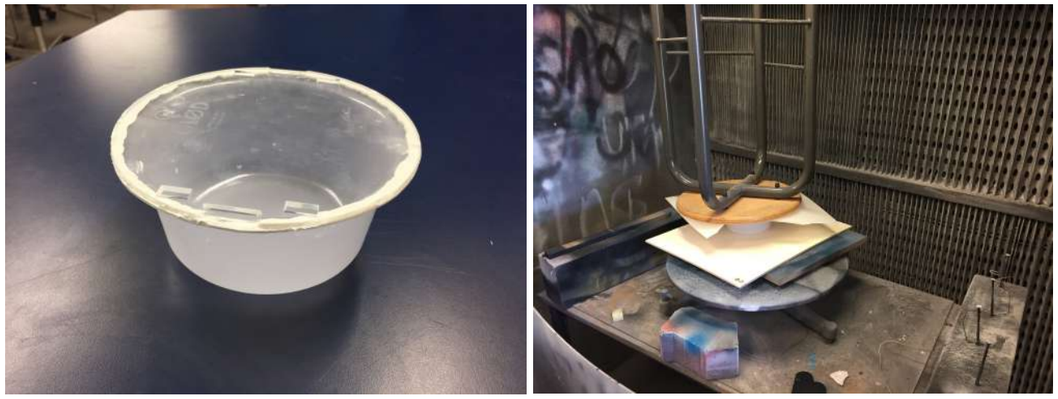
GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Interface
		Date: 14th of may
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

56. Glue

Silicone glue

The design team assumed that silicone glue would be suitable for the lanterns assembly since it was used in high humidity areas. Tests were made that showed the following:

- It took a long time to dry between 24-48 hours.
- It was not transparent but white and could therefore be seen on the outside of the container.
- The two pieces that were glued together had to be glued under pressure, otherwise they did not stick.



Testing the silicone glue. A transparent lid was used, but underneath the container the silicone glue was still visible.

Acryl glue (Acrifix)

This glue was recommended by Ingemann components. It is specially made for gluing acrylics together. The glue was incredible strong, dried within a few minutes and most important of all – it was transparent and could not be seen on the outside of the container.

Gluing the final prototype using Acrifix glue

57. Evaluation of concepts

To evaluate the concepts the team used a focus group consisting of eight students in the age 20-25 years old. All of the students had been at Roskilde Festival before and gave us feedback in size, power bank placement and aesthetics.

The user group coming with feedback on the different prototypes

Concept 1

Suited for production method. The concept was not suited for vacuum forming as the angles were too steep and there easily came unwanted deformations in the plastic.
1 point

Detachment from plastic sheet. The concept required a rotary engraving laser cutter to be detached from the vacuum formed plate.
1 point

Size. The size was in general considered suitable by the user as it related to other lanterns. This was unexpected since it was assumed that a smaller and practical lantern would be more preferred.
3 points

Power bank placement. It was mentioned that by power bank inside it seemed like a more complete product and the power bank would be more protected. It was noticed that not every power bank could fit inside the concept.
2,5 points

Aesthetics. The contrast of the black lid with the white plastic suited the concept. The users found this concept as most aesthetically appealing.
3 points

Brand placement. The placement of the brand seemed like a natural appearance on the concept.
3 points

Exploitation of material. Since only one tool could be fitted on the table of the vacuum former a lot of waste material was created.
1 point

Light test. The light was comfortable to look and nicely distributed in the entire shell.
3 points

Concept 1 prototype

Testing the brand placement

The focus group looking at the light transmission in the material

From idea to production of GLØD
Design and Innovation 2018

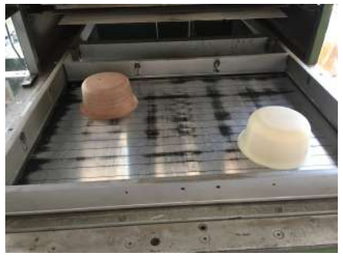
Here the forms can be seen. First the 3D printed form and the the MDF-wood form.

Manufacturing of the mold for the final concept. A mold in plastic and MDF was made.

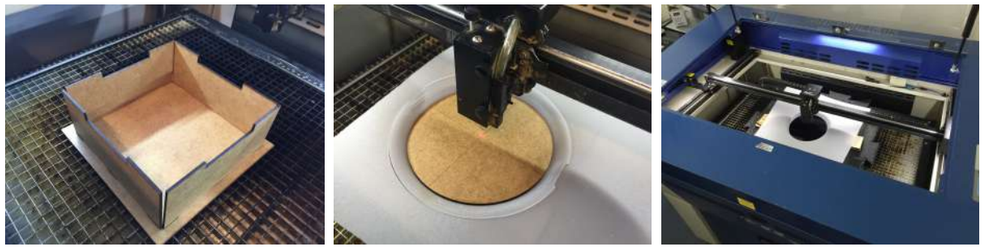
The two forms were created to test the placement in the vacuum former. This was an important test as if only one tool could be fitted on the table, this would require the double amount of plastics. Luckily the test showed that it was possible to vacuum form with two tools. A request of CNC-lathe two aluminium forms for the final productions were sent to MEK.

Getting consultants from production engineer Peter Bjørn

Detaching the bottom from the plastic sheet was done by a laser cutter. A holder was constructed in order to keep the plastics in place. This was important to get a even and precise cut every time. By placing a circled plate with a cross on in the vacuum formed object the laser cutters coordinates could be calibrated from this (see figure XX).



Trying the mold in MDF and 3D print in the vacuum forming



From the left: the holder, the circle plate and the setup

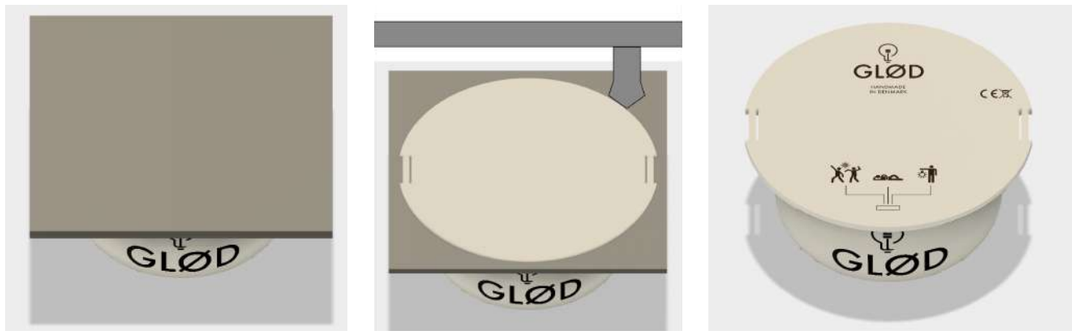
Two tools for the lid were manufactured in aluminum. To detach the lid from the plate, it was decided to CNC-mill at C.R. Steglich.

Middle piece

The middle piece was changed a few times due to the production methods. To improve the construction of the middle piece, the team was consulted by Peter Bjørn, a production engineer. He recommended that the corners of the holes for the strap should be changed from 90 degrees corners to round corners, as the material have a much higher chance of splitting if stress is applied.

In order to cut down the number of operations the middle piece should before prossed be glued on the bottom piece. This would only require one laser cut operation to cut both and engrave the bottom and middle piece. But as the design team found that this method requires a high degree of precision and the strap was extremely hard to get through the hole, the laser cutting was done in two separate operations.

By cutting a hole in the bottom and middle piece the strap hold on to both pieces and this therefore made it a lot stronger, whereas concept 1 was only held together in the middle piece, which meant there was less material to hold a higher weight and that the glue would have to hold the bottom up.



Concept 2

Suited for production method. The geometry and angles on the concept made vacuum forming easy.
3 points

Detachment from plastic sheet. The concept required a rotary engraving laser cutter to be detached from the vacuum formed plate.
1 point

Size. The concept was considered too small and was related more to a flash light that a lantern.
2 points

Power bank placement. The power bank was not kept in place by the elastic strap and fell easily off.
1 point

Aesthetics. Most of the participants liked the prototype without a power bank on, but with a power bank it was considered clumsy and did not become a part of the product.
2 *points*

Brand placement. It was hard to place the brand on the small surface as it was too curved. The small brand surface was hard to see.
1 point

Concept 2 prototype

Light test

Exploitation of material. Due to its size and height it was optimal for vacuum forming as multiple tools could be fitted on one table.
3 points

Light test. The shell was nicely lit up, but the light was very sharp and intense.
2,5 points

Concept 3

Suited for production method. The concept is easy to laser cut or stamp, but it is compleks to fold the plastic into a shape.
2 points

Detachment from plastic sheet. Is the concept is not vacuum formed this is not relevant.
- point

Size. The size for the light emitting part is assumed to be too small like concept 2 and 4.
2 points

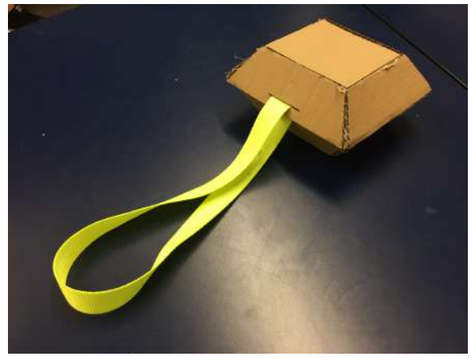
Power bank placement. The strap function that kept the power bank in place did not hold the power bank tight and got in the way of mounting the power bank.
2 points

Aesthetics. The look of the concept was associated with packaging design. One of the users named the concept “the big mac container”.
1 point

Brand placement. The brand was placed at a large surface that could easily be placed. The mounting of the sticker was easy on the straight surface.
3 points

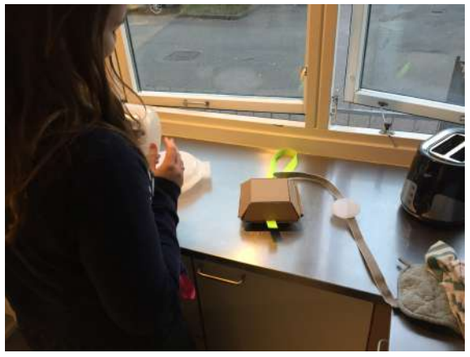
Exploitation of material. If the plates dimensions fit the product, little waste is produced when cut out.
2,5 points

Light test. Since the prototype was made of cardboard no light test was made.
- point



A mockup of concept 3

Laser cut of concept 3



Focus group giving feedback on concept 3

Concept 4

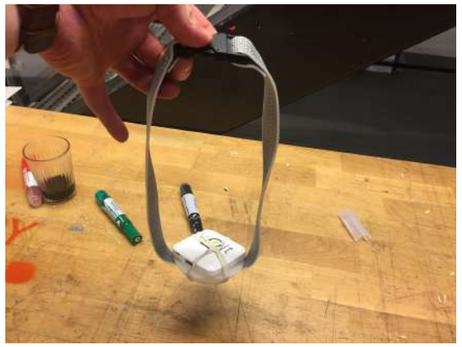
Suited for production method. The round geometry is optimal when vacuum forming and the small size allows many tools to be placed on one table.
3 points

Detachment from plastic sheet. The concept required a rotary engraving laser cutter to be detached from the vacuum formed plate.
1 point

Size. The size was considered too small by all user participants. The concept was, once again, related to a flash light.
1 point

Power bank placement. Most participants did not understand how to place the power bank. The idea of the placement of the power bank were not possible.
1 point

Aesthetics. User participants thought the concept looked like a head torch and didn't find it aesthetically appealing. Again the power bank it was considered clumsy and did not become a part of the product.
1 point



Concept 4 prototype

Attaching strap to concept 4

Brand placement. As the surface for the brand was double curved, the brand could only be placed on the top underneath the power bank.
1 point

Exploitation of material. Due to its size and height it was optimal for vacuum forming as multiple tools could be fitted on one table.
3 points

Light test. According to the light test the LEDs did not lit up the whole shell. The LEDs could be seen through the translucent plastic and too intense.
1 point

Concept 5

Suited for production method. The shape was well suited for vacuum forming but as size was big only two tools could be fitted in the vacuum former.
2 points

Detachment from plastic sheet. As this could be done in regular laser cutter it was possible, precise and efficient.
3 points

Size. The concept was considered to big by the users and unhandy for festival purposes.
1 point

Power bank placement. The power bank was easily placed under a elastic band. Due to the closed container the power bank was kept in place.
3 points

Aesthetics. Due to the way the lantern is hung with the strap it stand out and gives it sort of a "cool factor". The concept was also related to plastic plates.
2 points

Brand placement. The brand was easy to place but was not visible with LEDs on, as the light was too intense in the middle.
1,5 points

Exploitation of material. Because of its short but wide shape, it could exploit most of the material on one sheet of plastic.
2 points

Light test. The intensity of the LEDs were concentrated in the middle of the shell. As the LEDs were facing one way only half of the lantern was lit up.
1 point

Concept 5 prototype

Placing the power bank in concept 5 worked good

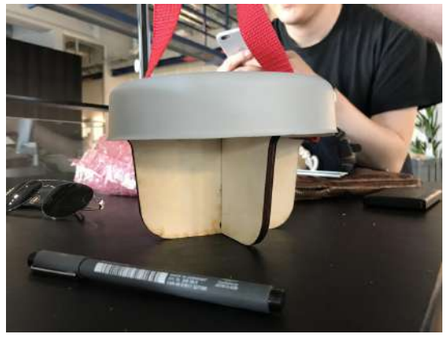
Concept 5 getting feedback from the focus group

58. The final concept

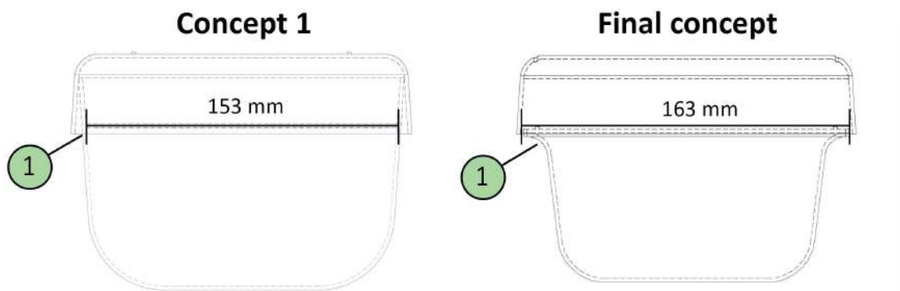
The final concept

The design in the final concept is similar to concept 1 but due to changed geometry of the bottom three different improvements were made.

Using the same lid but changing the geometry of the bottom, there has been created more room for the power bank. This is due to the way the lid and the bottom part is connected (see highlight 1 in the figure). Concept 1s lid is resting on the top of the bottom piece. As the design removed this part an additional 10 mm has been gained in the diameter for the power bank placement.



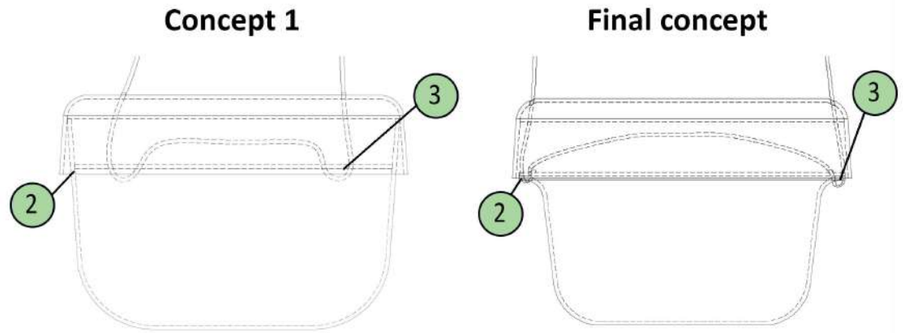
Mockup to test the proportions of the final concepts



The connection between the bottom and the middle piece in concept 1 was glued in an inconvenient way (see highlight 2). The surface between the bottom and the middle piece was very little and at an angle. The final concept gives a lot more surface area between the middle and bottom piece for the glue to stick on.

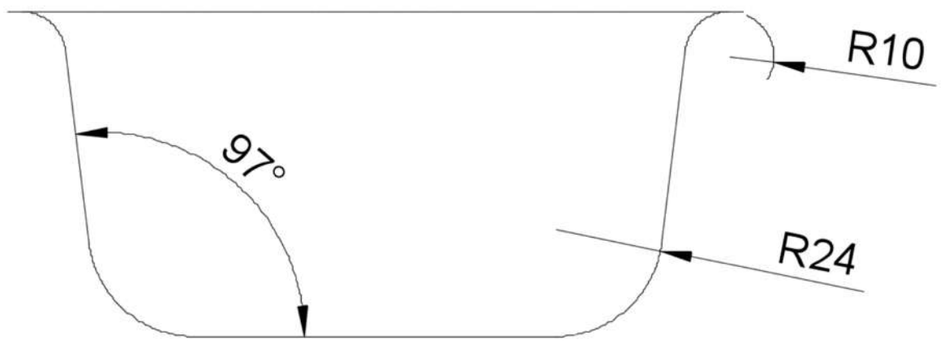
The strap of concept 1 is hung in the middle piece, see highlight 3. This puts a lot of stress on the connection between the bottom and middle piece. In the final concept the strap grabs on to both the bottom and the middle piece the weight is much more evenly distributed.

As seen on the rendering the straps grabs onto both the bottom and the middle piece



By making a form as concept 5 that tangens with the bottom the tool saves the additional centimeter (see figure XX) . The final concept is cut with the same method as concept 5, as this does not require a rotary laser cutter.

By making the angles 7 degrees (instead of 3 for concept 1) and the radius 24 mm instead of 10 mm (compared to concept 1) the chances of unwanted deformations is decreased a lot.



A mockup was made before the real forms were created to test if the new proportions between the lid and bottom was correct. See figur XX

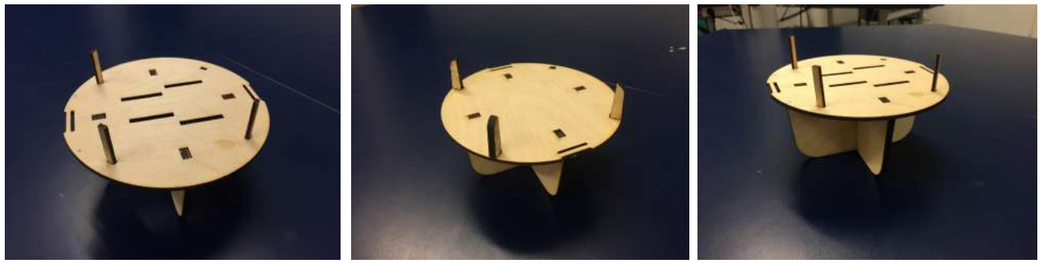
The mockup lived up to the requirements and the drawings for a MDF-wood tool was handed to the workshop at Mechanical Engineering DTU (MEK) and a file for 3D printing was sent to DTU Ballerup.

The lid

The lid for the final concept was the same design as concept 1. It was known from prototyping that two lid-tools could be vacuum formed at the same plastic sheet.
Since the lid of the final concept was not resting on the top of the bottom piece as in concept 1, it was hard to place the lid leveled .

The design team used the mockup to experience with small sticks to make the lid leveled. This solution worked, but the assembling time was long. Due to the thickness of the sticks they were not very strong.

The lid was hard to place leveled as this rendering shows.



Mockup of the final concept to find a solution to get the lid leveled

The design team got a better solution that was easier to place for production and also worked as a way to separate the strap and elastic band. This solution would be laser cutted and placed with press fit and glued onto the middle piece.

The solution to get the lid leveled

The final prototype

59. DPA

DPA system
Dansk Producent Ansvar

Resultat A: Nyoprettelse i registret

(ny producent/importør)

Registreringsgebyr i alt	1000,00
Årligt mængdebaseret gebyr i alt	250,00
Sikkerhedsstillelse for elektrisk udstyr til husholdninger	1144,00
Beløb i alt	2394,00

Resultat B: Årligt gebyr

(uden registreringsgebyr)

Årligt mængdebaseret gebyr i alt	250,00
Sikkerhedsstillelse for elektrisk udstyr til husholdninger	1144,00
Beløb i alt	1394,00

Ansvarsfraskrivelse: Denne beregner er udelukkende udviklet som et retningsgivende hjælpeværktøj til producenter og importører, som ønsker er kende omkostningsniveauet i forbindelse med registrering for producentansvar. DPA-System tager forbehold for ændringer i lovgivning, gebyrsatser og andre regulative forhold, som kan influere på det endelige resultat.

Sidst redigeret: 30. september 2015

60. Dansk standard and EMC Emmunitetskrav

55015_2013 (left) and 61547_2009 (right)

5.3.2.2 Independent directly operating light regulating devices

Where such devices incorporate semiconductors, they shall comply with the terminal voltage limits given in Tables 2a and 2b, otherwise no limits apply.

When several light regulating devices are contained in one product or enclosure, and when each individual device consists of an entirely self-contained regulating circuit (including all suppression components) and operates independently of the others (i.e. does not control, either by design or fortuitously, any load controlled by another individual regulator), then each device is tested separately.

5.3.3.3 Independent convertors

Independent electronic convertors for incandescent lamps or LED light sources shall either:

a) comply with the terminal voltage limits given in Tables 2a and 2b and with the radiated disturbance limits given in Table 3b; or,

b) where the convertor has a non-detachable load supply cable, or where the manufacturer gives strict installation instructions which define the position, type and maximum length of cable(s) to be connected to the lamp(s), then the convertor shall comply with the terminal voltage limits given in Table 2a and with the radiated disturbance limits given in Tables 3a and 3b, under these conditions.

5.2 Electrostatic discharges

These tests are carried out according to IEC 61000-4-2, with test levels as given in Table 1 of this standard. Contact discharge is the preferred test method. Twenty discharges (10 with positive and 10 with negative polarity) shall be applied on each accessible metallic part of the enclosure (terminals are excluded). Air discharges shall be used where contact discharges cannot be applied. Discharges shall be applied on the horizontal or vertical coupling planes, as specified in IEC 61000-4-2.

NOTE "Accessible" means accessible under normal operating conditions including user maintenance.

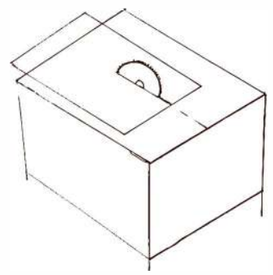
Table 1 – Electrostatic discharges – Test levels at enclosure port

Characteristics	Test levels
Air discharge	±8 kV
Contact discharge	±4 kV

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Middle piece
		Date: 2nd of June
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

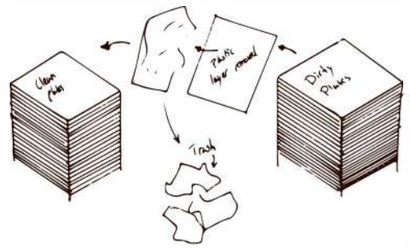
61. PMMA storyboard

Here the manufacturing process for PMMA is visualized using the storyboard method.



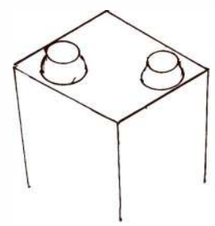
PMMA and polystyrene are cut out and the correct measurements

→



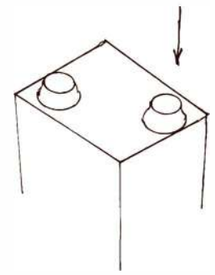
A plastic foil is removed and the plates get blown with air to clean them

→



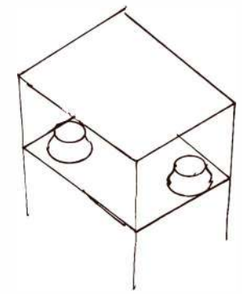
Two forms are placed on the vacuum formers plate

→

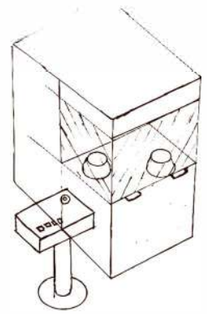


The plate is lowered inside the machine

→

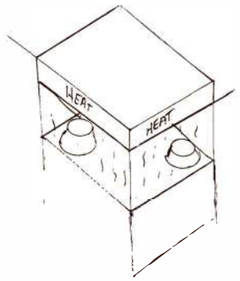


PMMA and PS are respectively placed in the vacuum former



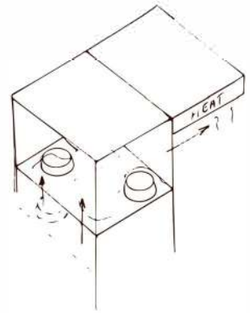
The door is closed in the vacuum former is turned on

→



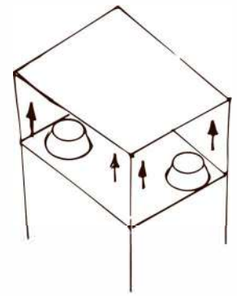
The vacuum former heats:
PS to 400°C
PMMA to 350°C

→



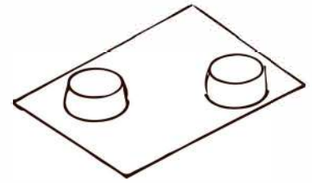
The heater moves after for 1min. 10 sec. for PS and1min. 50 sec. for PMMA.

→

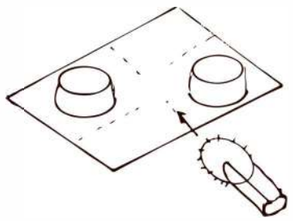


Vacuum is turned on and the forms are pushed up in the plastic plate

→



A sheet has been formed with two plastic objects.



The forms are cut out with a hand saw

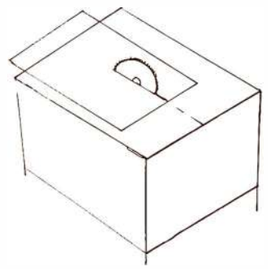
→

The object is placed in a wood form in a laser cutter and are cut out.

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: PMMA
		Date: 22nd of april
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

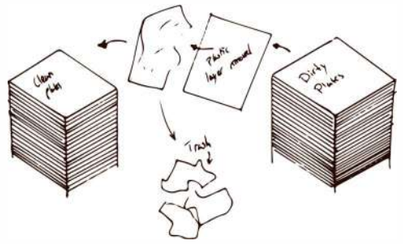
62. PS storyboard

Here the manufacturing process for PS is visualized using the storyboard method.



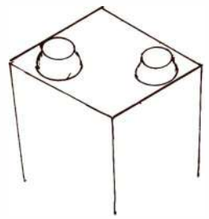
Polystyrene are cut out after the optimized measurements

→



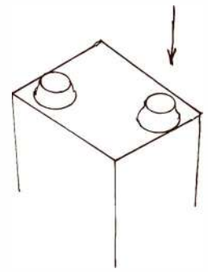
A plastic foil is removed and the plates get blown with air to clean them

→



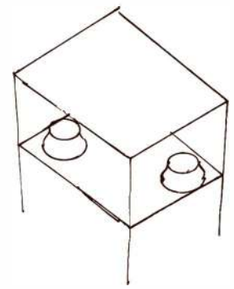
Two forms are placed on the vacuum formers plate

→

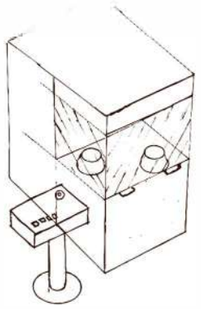


The plate is lowered inside the machine

→

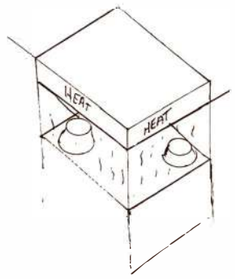


PS are placed in the vacuum former



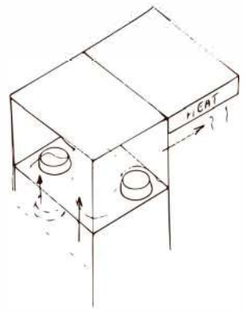
The door is closed and the vacuum former is turned on

→



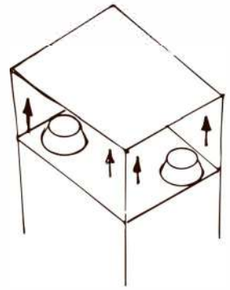
The vacuum former heats the PS-plate to 400°C

→



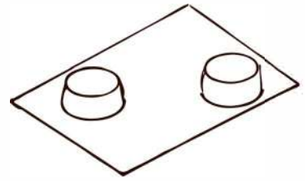
The heater moves after 1min. 10 sec. for PS

→

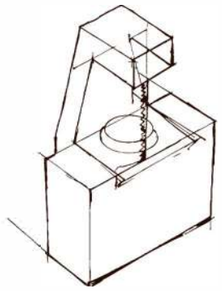


Vacuum is turned on and the forms are pushed up in the plastic plate

→

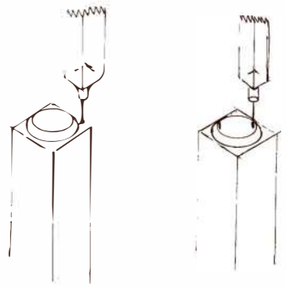


A sheet has been formed with two plastic objects



The forms are cut out with a band saw

→

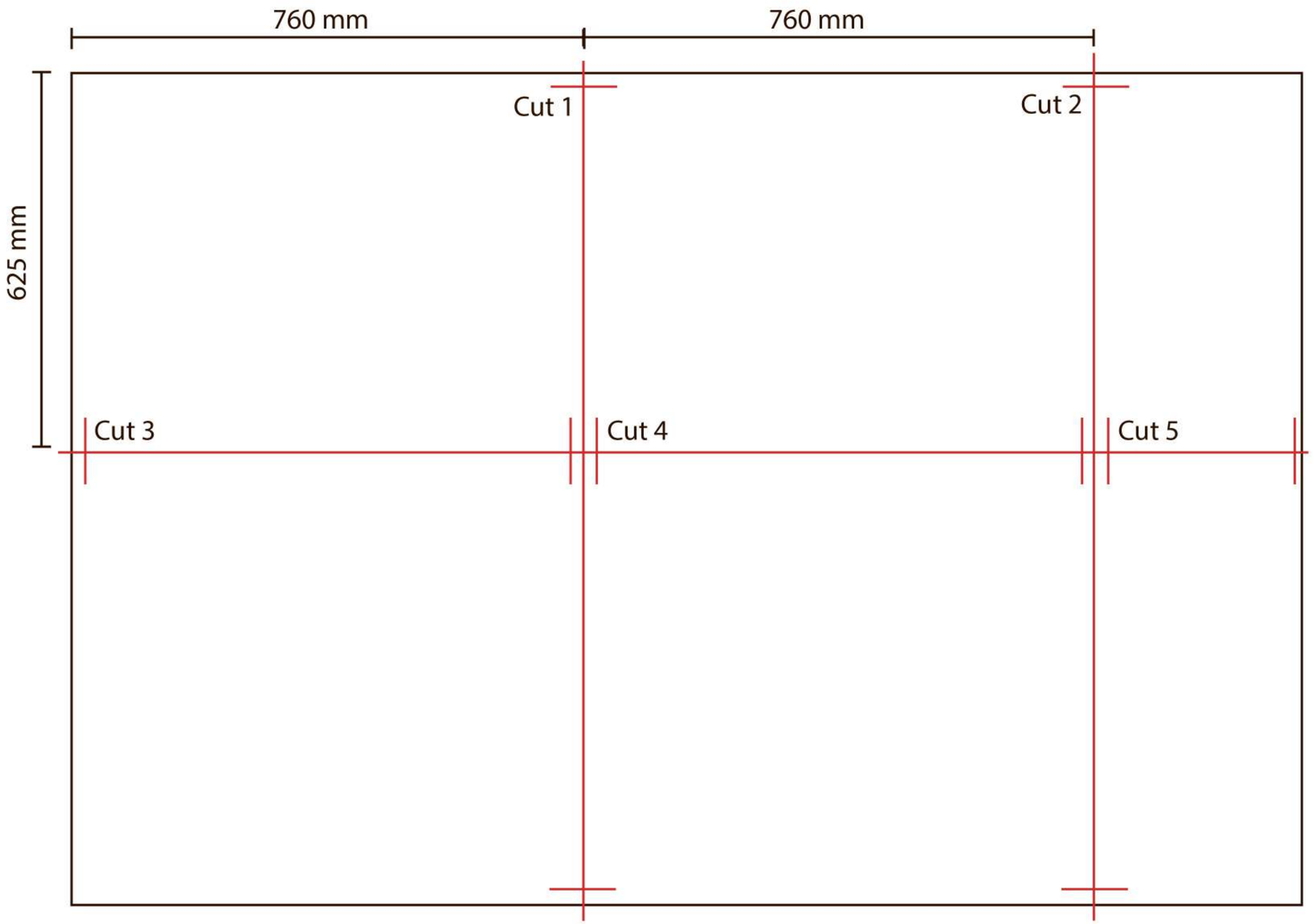


At Steglich a CNC-machine cuts the bottom off and mill out two holes for the strap

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: PS
		Date: 22nd of april
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

63. PMMA cut

The 70 PMMA plates were cut out using the following measurements. Note the figure on this papar is not scaled.

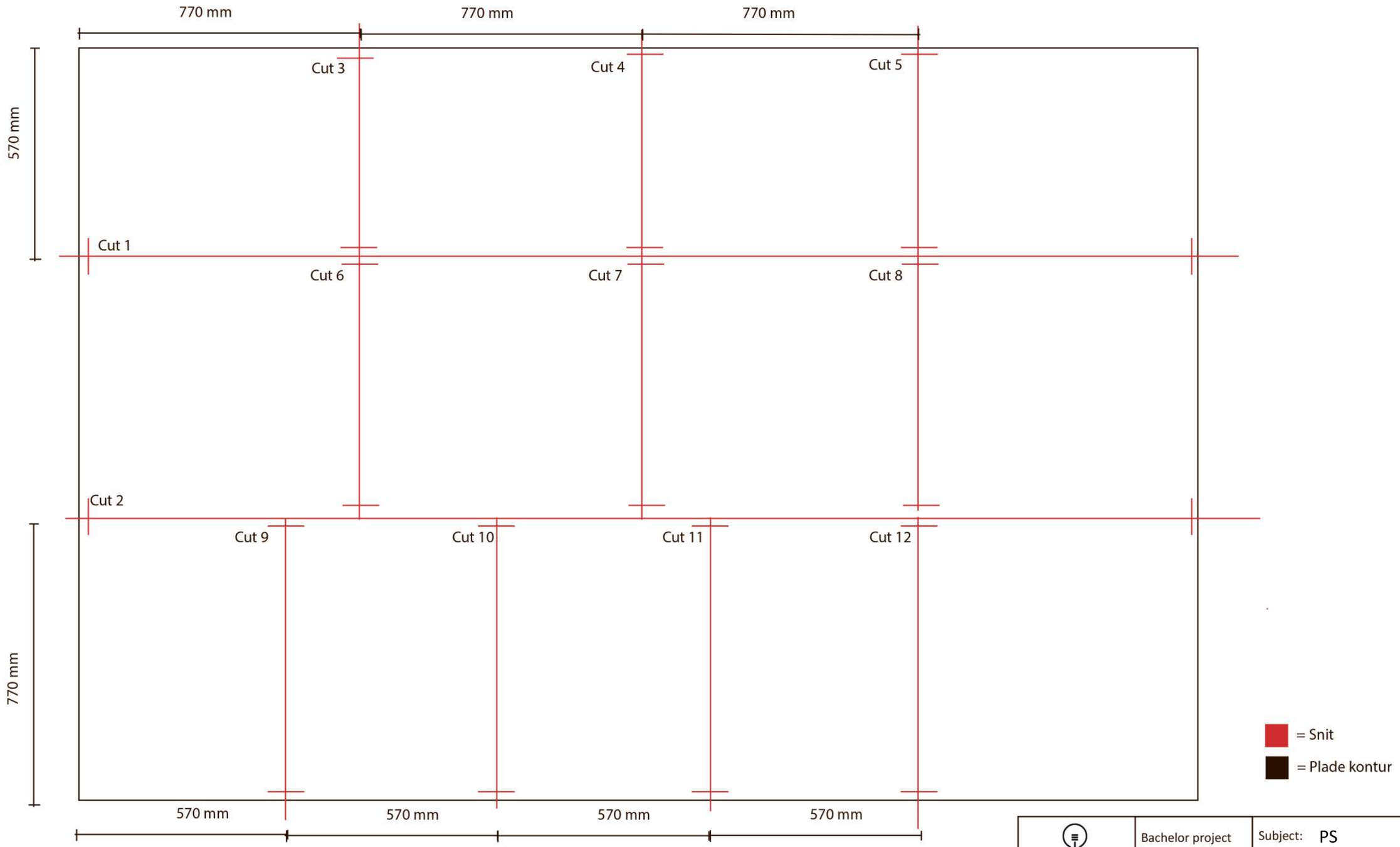


= Cut

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: PS
		Date: 22nd of april
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

64. PS cut

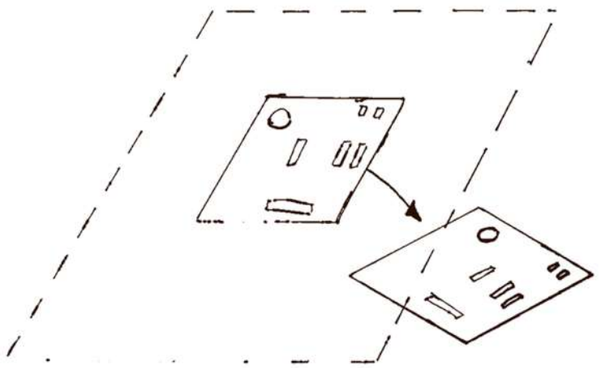
The 22 PS plates were cut out using the following measurements. Note the figure on this papar is not scaled.



GLØD	Bachelor project Interactive lantern to festival guest.	Subject: PS
		Date: 15th of may
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

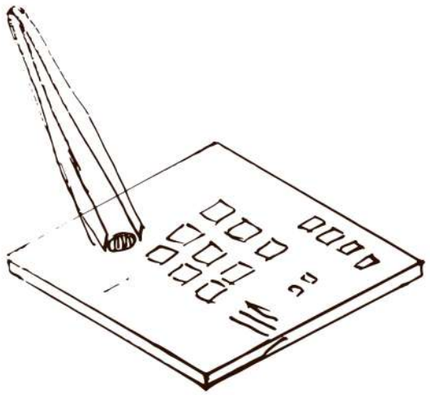
65. Electronics storyboard

Here the manufacturing process for the electronics is visualized using the storyboard method.



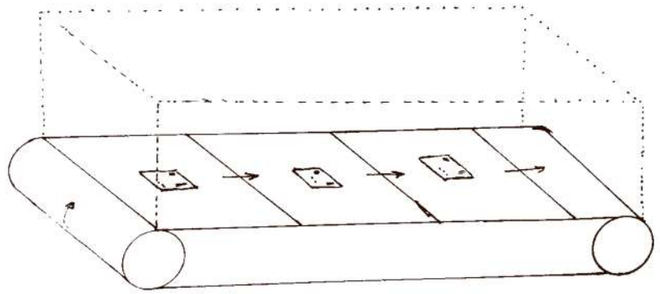
Stencil is used to place solder paste

→

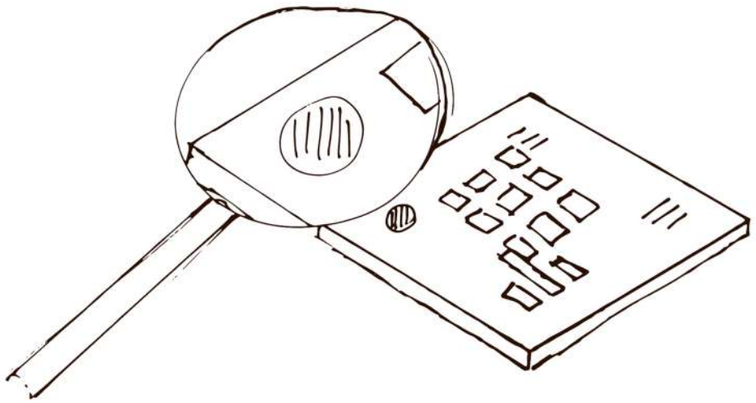


165 components is pick and placed using a tweeser

→

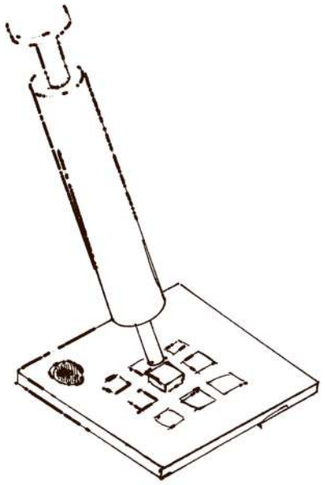


An oven melts the pcb in 3 stages: 120°C, 180°C and 240°C.



A quality test is made

→



The microphone is hand soldered on

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Storyboard
		Date: April and May
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

66. Middle piece optimized

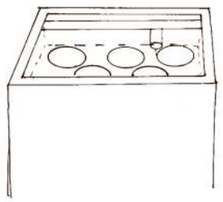
This layout was used to optimize the PMMA plate to manufacture middle pieces.

Red = cut
Black = engrave

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Middle piece
		Date: 2nd of June
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

67. Middle piece storyboard

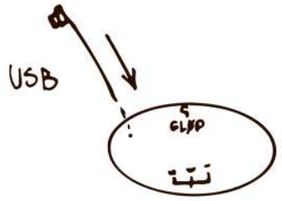
Here the manufacturing process for the middle piece is visualized using the storyboard method.



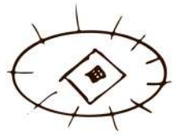
Lid holders, holders and middle plate is cut out and engraved.

The middle plate is painted with a clothe covered in black acrylic paint.

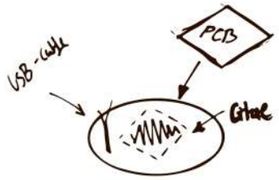
The middle plate dries for app. 10 minutes.



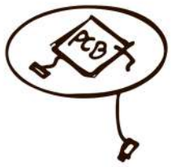
A USB-cable is pressed through the middle plate.



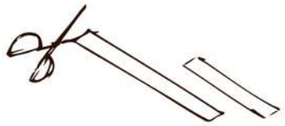
The PCB curcuit is tested



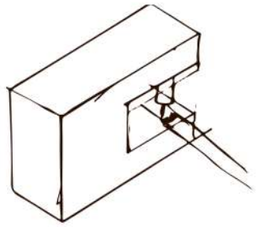
The PSB is glued on to the middle plate and the USB is soldered on.



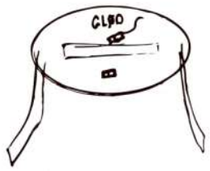
The 8 wires from the button is soldered on to the PCB.



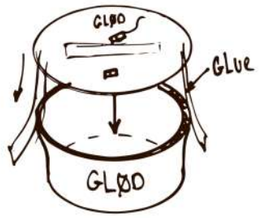
The nylon and elastics are cut out respectively in 20 cm and 10 cm.



The strap is made by stitching the elastics and nylon together.



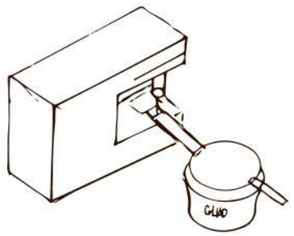
The strap is run through the middle plate



A sticker is placed and the middle plate is glued on the bottom.

The holders are placed on the middle plate

The strap runs through the holes on the lid



The buckles are stitched onto the strap

The buckles are closed and the lantern is done.

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Storyboard
		Date: 12th of april
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

68. Manufacturing of the strap

The sewing was done in Odense by Victors sister as she helped with making the lanterns in return of GLØD paying her Roskilde Festival ticket.

The design team gave instructions to sew zig-zag with extra thick needle and string. But as the textile was so thick the sewing machine could not move the textile and the think needle broke and it was extremely hard to keep a straight line.

Therefore we went from a zig-zag sewing line to a normal straight sewing line, this made it a lot easier for the sewing machine and made the time spend on each strap decrease tremendously.

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Light test
		Date: 12th of april
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: Both
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

69. List of materials ordered

Material	Supplier	Units/ size	Price
PMMA opal white PMMA LumFrost 70	Ingemann components	1850x1250x2 70 plates	19.838,- DKK (VAT included) Unit price: 226,73 DKK (incl. vat)
PS Black High Impact PS	Ingemann components	3050 x 2050 x 2 mm 22 plates	8.387,5 DKK (VAT included) Unit price: 305,- DKK (excluding VAT)
CNC-milling of lid	C.R. Steglich	500 pieces	36 DKK/ piece
Strap	Kvadrat or Bauhaus	Length: 200 m Width: 25 mm	Free or app. 2000 DKK (VAT included) *Sponsorship from Kvadrat*
Elastic	Elas	Length: 50 m Width: 25 mm	Free *Sponsorship from Elas*
Sewing thread cream (extra strong) Sewing thread black (extra strong)	Stof2000	2 rolls of 1000 m	88 DKK (VAT included)
Buckle black	Aliexpress	Width 25 mm	743 DKK (VAT included) Shipping 14-23 days
Acrylic paint	Viking or Ikea	One tube	60 DKK (VAT included)
Stickers for GLØD-brand		500 pieces	2000 DKK (VAT included)
Stickers for DTU-brand		500 pieces	1200 DKK (VAT included)
PCB BOM		500 pieces	70 kr/piece (VAT included)
Metal stencil			Included in PCB-price
Acrifix 192 Glue for acrylic sheets	Ingemann Components	10	195 DKK/ pieces (VAT included)
USB-cable	Ali Express	500 pieces	app. 1500 kr (VAT and shipping included)

70. Finding a alternativ to CREE

Finding a alternativ to CREE

We quickly found that the LED's are the most expensive part of the PCB. The best LED was an RGBW LED from CREE[1], which is very powerful compared to its size - but it is rather expensive. We did a lot of effort to find an alternative to the CREE LED. One way in which we tried was by using a separate RGB and a separate white LED and combining them - or by using separate Red LEDs, Green LEDs, Blue LEDs and white. However, we could not find a better alternative. The CREE LED costs around 3-4 kr per unit and we needed 12 of them per circuit. The problem was that the CREE LED definitely was the LED on the marked were we got the most lumen per kr. We tried contacting CREE to figure out if we could buy them directly from them, but they just referred us to their supplier, Mouser.

At the end of the 3-week period we had a BOM for the circuit on 63,98 kr. (Appendix 30.3 BOM). This was much higher than we had expected, because we knew that the expense of the PCB and assembly would be added to this.

Later in the process we tried again to contact suppliers to find a cheaper LED. Most of them were confident that they could find a cheaper alternative but after a while they all had to reply that it was not possible.

Skylab had Ole Valeur visiting from RS Components so students could ask questions about components and orders. We asked him if he would be able to find a cheaper alternative to the LED. He responded that this was very likely and it would surprise him if he couldn't. We informed him that size or number of LED was not important but it was the cost per lumen that was important. After a couple of days, he responded that he could not find a cheaper or better solution to the LED's, even if he broke it up in separate LED's. We also asked another electronic component company, Arrow, but they also replied that they could not find a better solution for us (appendix 70. 1 Mail correcspondance CREE-LED).

We have been looking on the Chinese website Alibaba and there are definitely some cheaper alternatives. The only problem is that we can't be sure that the LED's are CE certified. We have been in contact with multiple suppliers and we have got some CE certification, but the CE certification we got was for the wrong product. An example is the CE certification for a RGBW LED: When we got the certification the name of the product was LED Strip (appendix 70. 2 Wrong certificate of compliance). It is hard for us to tell if the suppliers can be trusted.

If we buy any component that has to be integrated in our circuit it has to be CE certified, otherwise we can't CE certify our product. All products have to be CE certified to be legally sold in EU.

[1] https://www.mouser.dk/datasheet/2/90/ds-CLQ6A-TKW-1140398.pdf

70.1 Wrong certificate of compliance

Certificate of Compliance

Certificate Number: BST10050075Y-1EC-1

Applicant : SHENZHEN YULIANG OPTOELECTRONIC TECHNOLOGY CO.,LTD.
6th Floor, B Building, Hengchangrong Industrial Park,
Huaning West Road, Dalang Street, Longhua Town, Shenzhen, China

Manufacturer : SHENZHEN YULIANG OPTOELECTRONIC TECHNOLOGY CO.,LTD.
6th Floor, B Building, Hengchangrong Industrial Park,
Huaning West Road, Dalang Street, Longhua Town, Shenzhen, China

Product : LED STRIP
Trade Name : YLL
M/N : YLL-F1208W30-35, YLL-F1208W30-12, YLL-F1210W30-35, YLL-F1210W15-50, YLL-F1212W30-50, YLL-F1212W15-50, YLL-P1208R30-50, YLL-P1211W60-F5, YLL-P1212V30-50-AL YLL-F1210RGB15-50

Test Standard : EN55015:2006+A2:2009
EN61547:2009
EN61000-3-2:2006+A2:2009
EN61000-3-3:2008

The EUT described above has been tested by us with the listed standards and found in compliance with the council EMC directive 2004/108/EC. It is possible to use CE marking to demonstrate the compliance with this EMC Directive.
The certificate applies to the tested sample above mentioned only and shall not imply an assessment of the whole production. It is only valid in connection with the test report number: BST10050075Y-1ER-1.

CE

Christina
Manager
May 12, 2010

Shenzhen BST Technology Co.,Ltd.
3F,Weames Technology Building,No. 10 Keta Road,Science Park,Nanshan District,Shenzhen,Guangdong,China
Tel:86-755- 26747751~3 (100 lines) Fax:86-755-26504032 http://www.bst-lab.com

The
certificate were
supposed to show
that the LED-compo-
nents was complient with
european standards. But
the cerfication showed a
whole other product,
an LED-strip.

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Cree LED
		Date: May
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

71.2 Mail correspondance of Cree-LED

VO

Valeur, Ole <Ole.Valeur@rs-components.com>
fr 16-03, 08:34
Dig

Kopi af BOM v2.xlsx
27 KB

Vis alle 1 vedhæftede filer (27 KB) Hent Gem til OneDrive - Personlig

Hej Søren,

Undskyld det sene svar!

Jeg har vedhæftet et dokument dem RS vare nr (og nogle alternativer) samt hvordan lager status ser ud (I kan få en bedre pris ved at købe det med en Skylab rabat kode (Denne fås fra Poul Thorbjørn Sørensen)).

Jeg har arbejdet som en gal på at finde nogle alternativer til LEDerne og det kan ikke gøres billigere end den som i har fundet hos Mouser – uanset hvilken kombination (af lager førte LED'er) som jeg har prøvet for at nå op på 300Lumen RGB + W.

Den største udfordring er at der kun er 456 stk på lager af LEDerne hos Mouser og de har 2*4000stk i order – Det ser også ud til at Arrow (USA) har 4000 stk på lager.
Vi kan skaffe dem MEN hvornår vi kan få dem hjem og til hvilken pris ved jeg ikke endnu. Umiddelbart så har CREE 9 ugers leveringstid – HVIS at de har plads på fabrikken!

Genneralt så er markedet for passiver MEGET udfordret og vil være det minimum resten af '18. SÅ det giver rigtig store udfordringer med at skaffe det som skal bruges!

Min vurdering er at det IKKE kan nås til Roskilde i år – hvis at i skal op på 300Lumens i lys mængde!

Venlig hilsen / Best regards
Ole Valeur

Vis meddelelsesoversigt

JD

Jesper Dyrsting <JDyrsting@arroweurope.com>
fr 23-03, 11:25
Dig; Helle Hertz (HHertz@arroweurope.com)

> Der er indhold i denne meddelelse, der er blevet blokeret for at beskytte dine personlige oplysninger. Hvis du vil genaktivere de blokerede funktioner skal du klikke her.

> Hvis du altid vil vise indhold fra denne afsender, skal du klikke her.

Hej Mads

Jeg har kigget rundt og kan ikke lige se en løsning med samme styrke som CREE CLQ6A.

Nedenstående enkelte LED bliver dyrere end CREE.
L135-R625003500000
L135-G525003500000
L135-B475003500000
MXA7-PW65-0000

https://www.lumileds.com/products/color-leds/luxeon-3535l-colors

Og alm 1kr RGB lyser 10 gange mindre.

Mvh Jesper Dyrsting

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Cree LED
		Date: May
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

71. Kvadrat application

kvadrat

Kvadrat A/S
Lundbergsvej 10
8400 Ebeltoft Denmark
T +45 89 53 18 66 F +45 89 53 18 00
www.kvadrat.dk kvadrat@kvadrat.dk

CVR 45998517 Jyske Bank 5073 117977-1

Ansøgning om tekstil til projekt for designstuderende.

Vi får rigtigt mange henvendelser fra designstuderende i forhold til sponsorat af tekstil til deres projekter. Vi er derfor nødsaget til at vurdere hver enkelt forespørgsel, og har brug for informationer omkring den studerende og projektet for at gøre dette.

Projektbeskrivelse samt billeder eller tegninger.
Hvilken designskole går du på samt hvilken linie?
Hvor langt er du i skoleforløbet, hvilket år går du på?
Hvilket tekstil, farve og hvor meget, skal du bruge?
Hvor skal det leveres henne?

Vi skal yderligere have bekræftet de ovenstående informationer fra designskolen, som skal skrive under på med stempel, at oplysningerne er korrekte.

Herefter vender vi retur indenfor 24 timer.

Med venlig hilsen
Kvadrat A/S

www.kvadrat.dk

Skolens navn:
Danmarks Tekniske Universitet, DTU

Hvilken linie går du på:
Bsc. Design og Innovation

Hvilket år går du på:
3. år, 6. semester

Tekstil, farve og mængde:
Jumper 3 011, Jumper 3 013, Jumper 3 014 og Jumper 3 016
Storrelse: 1,5 x 2 meter af hvert tekstil.

Leveringsadresse samt kontaktperson inkl. telefonnummer og mailadresse:

Kontaktperson
Nicholas Fribert

Telefon
30 26 25 09

Mail
glod@outlook.dk

Leveringsadresse
Nicholas Domanyi Fribert
Zinnsgade 2, 1. th.
2100 København Ø

30/4-2018 Kristoffer Buch DTU Skylab
Diplomvej 373
2800 Kgs. Lyngby
Skolens Navn og stempel, samt dato

GLØD

Projektbeskrivelse

GLØD er en interaktiv transportabel, powerbank dreven lanterne designet til festlige udendørs aktiviteter såsom festivaler. Vi har udviklet et elektriskkredsløb som har tre funktioner: “Party mode” hvor GLØD lanternen pulserer til musik i forskellige farver og lysintensitet. “Casual light mode” hvor lanternen lyser med almindelig hvidt lys, som kan bruges når man vil finde sine ting. “Fade mode” hvor GLØD lanternen stille skifter imellem farver, til når man vil hygge.

GLØD startede som et skoleprojekt på DTU i 2017, hvor vi i gennem støtte fra DTU producerede 125 lanterner, hvilke blev delt ud på Roskilde Festival i en workshop. Produktet blev revet væk, hvor flere festivalgængere ventede i flere timer for at få fat i én af vores GLØD prototyper. På billede ovenfor kan køen fra sidste år ses. Projektet fik mediedækning af Ingeniøren, OrangePress og DTU Paper. På baggrund af den store succes og gode feedback har vi brugt det sidste år på at udvikle og designe et nyt og forbedret produkt.
Vi har lagt en ambitiøs plan for GLØD som løber frem til d. 30. Juni hvor Roskilde Festivalen 2018 starter. Her skal 500 lanterner være fremstillet og klar til at blive distribueret på festivalen.
Vi håber, at Kvadrat vil støtte os i vores projekt, da vi både beundrer jeres design og kvalitet men også har begrænsede midler, hvorfor jeres hjælp virkelig vil flytte vores projekt.

Vi besøgte jeres showroom i Nordhavn og blev vist rundt af Astrid Skovsgaard. Hun hjalp med at vælge tekstiler til lampen. Vi ansøger derfor om følgende tekstiler: Jumper 3 011, Jumper 3 013, Jumper 3 014 og Jumper 3 016. Astrid Skovgaard sagde at tekstilerne var udgået og at der var gode chancer for at få nogle rester. Tekstillet vil anvendes til lampens strop. PÅ billedet til højre ses lampen ved Kvadrats showroom med Astrid Skovgaard i baggrunden. Vi har estimeret, at vi får brug for 1 stk. af hvert ovenstående tekstil i målene 1,5 x 2 meter.

Projektet er et bachelorprojekt for Mads Hesseldahl og Victor Bertelsen, som med projektet vil dimittere fra Design og Innovation i sommeren 2018. Desuden er to elektroingeniørstuderende samt et CBS-studerende tilknyttet projektet.

Vi håber I finder projektet relevant og vil hjælpe os i processen.
Team Glød

72. Elas email correspondance

After a phone call to ask for a donation of straps to GLØD. Elas send ann email containing pictures to varify that they were sending the correct.

TJ

Tina Juel <tj@elas.dk>
Tor 26-04-2018, 16:06
Dig;

ATT00001.txt
297 byte

2 vedhæftede filer (97 KB) Download alt Gem alle i OneDrive

Hej Victor

Hermed 2 forskellige kvaliteter

Vi har 45 meter 25mm sort med bølger
Og ca. 60-70 meter 25mm hvid med prikker :-)

I kan få begge kvalitet hvis det kan bruges :-)

God bededagsferie

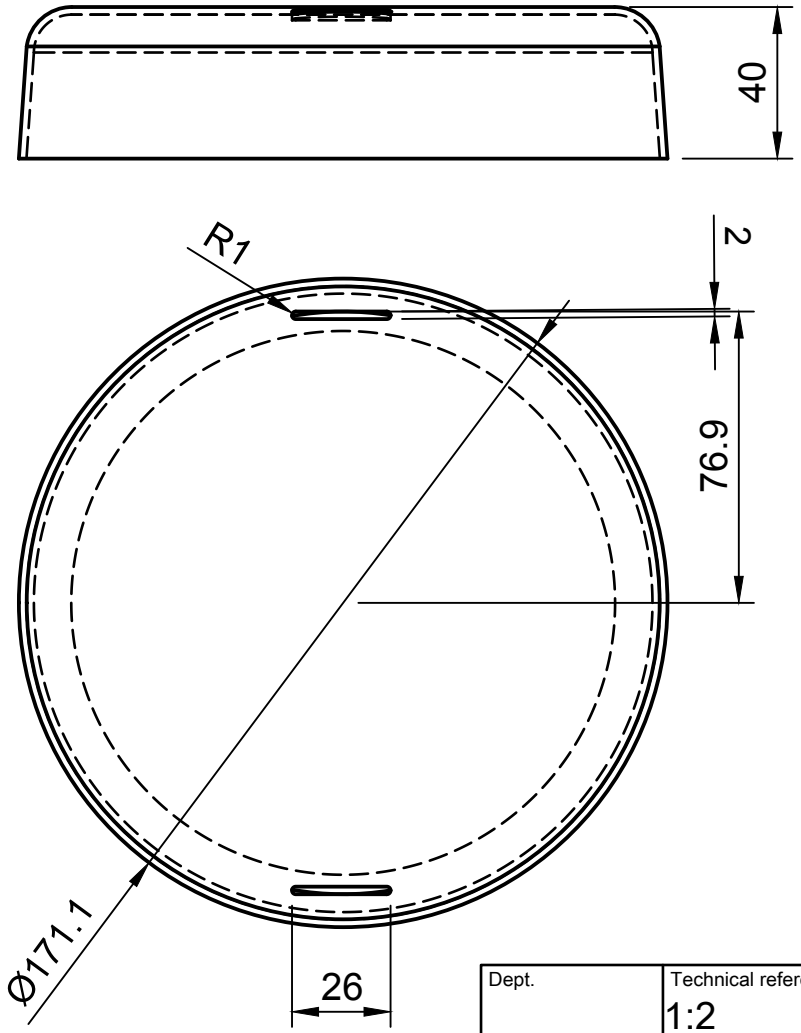
Med venlig hilsen/Best Regards

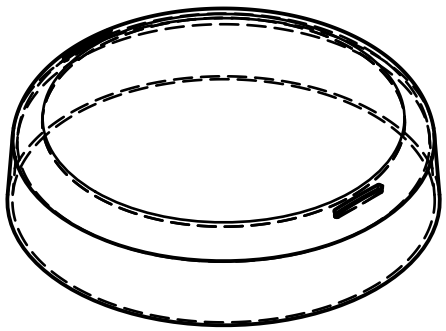
ELAS A/S
Tina Juel
Sales Account Manager

Phone: +45 9712 1322
Cell: +45 4060 9276
E-mail: tj@elas.dk
Web: www.elas.dk

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Confirmation from Elas
		Date: 26th of april
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: Victor
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

73. Technical drawing of lid





Dept.	Technical reference	Created by	Approved by
	1:2	Victor Bertelsen	Glød Lanterns IVS
Shall be milled free of polystyrene plate and two long holes shall be milled. Tolerance: DS/ISO 2768-1 Fine		Document type Technical drawing	Document status Request of price
		Title CNC-milling of lid Material: PS 2mm	DWG No. Page 1 of 1
			Rev. / Date of issue 20/04/2018 / Sheet 1

74. Order at C.R. Steglich

Glød Lanterns
Tor 26-04-2018, 17:29
Per Nielsen, Steglich & Co A/S;

Hej Per

Da du synes det er et spændende projekt vil jeg foreslå, at vi får en rabat på 10 % på det samlede beløb for emnerne før moms.
Dvs. en emnepris på 25,65 kr.

Hermed vil priserne se ud som følgende:

DKK 12.825 for 500 emner eksl. moms.

Vi leverer formet polystyren plader af mål på ca. 80x60 cm, hvor du fræser de to emner ud.
Emnerne kan være klar ca. d. 30 maj. Hvor meget tid skal du så bruge til fræsning?

Vi modtager emnerne bulk pakket. Prisen er inkl. opstart, CNC-programmering samt fræse fixtur og vi husker at tilføje 10 mm i højden på vores form til emnerne.

Har vi en aftale?

Med venlig hilsen

Victor Bertelsen

GLØD

Per Nielsen, Steglich & Co A/S <crsteglich@mail.dk>
Man 30-04-2018, 10:06
Dig;

Hej Victor,

Tak for din tilbagemelding.

Jeg har desværre ikke mulighed for at give rabat på dette emne. Prisen er ekskl. moms, leveret ab fabrik, det vil sige uden fragt og evt. emballage.

Hvis vi skal bearbejde dem for jer må i meget gerne skære emnerne ud af arket, på en båndsav eller lignende, da vi ikke har kalkuleret med at skulle håndtere og grov skære flere emner på et ark.

Alt efter hvornår vi modtager varerne, er leveringstiden ca. 3 uger.

Ser frem til at høre fra dig.

Med venlig hilsen / Best regards

Per Nielsen
C.R. Steglich & Co. A/S
Islandsgade 38
DK - 4690 Haslev
Denmark
Tlf.: + 45 5631 3569
Fax: + 45 5631 3575
E-mail: crsteglich@mail.dk
Website: www.crsteglich.com
...

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: PS
		Date: 30th of april
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

75. Manufacturing plan comparison

Estimated time of manufacturing

	15/maj	16/maj	17/maj	18/maj	19/maj	20/maj	21/maj	22/maj	23/maj	24/maj	25/maj	26/maj	27/maj	28/maj	29/maj	30/maj	31.maj	01/jun	02/jun	03/jun	04/jun	05/jun	06/jun	07/jun	08/jun	09/jun	10/jun	11/jun	12/jun	13/jun	14/jun	15/jun	16/jun	17/jun	18/jun	19/jun	20/jun	21/jun	22/jun	23/jun	24/jun	25/jun	26/jun	27/jun	28/jun	29/jun	30/jun
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26	Day 27	Day 28	Day 29	Day 30	Day 31	Day 32	Day 33	Day 34	Day 35	Day 36	Day 37	Day 38	Day 39	Day 40	Day 41	Day 42	Day 43	Day 44	Day 45	Day 46	Day 47
Operations																																															
Cutting polystyrene	Victor																																														
Vacuum forming polystyrene	Mads						Mads																																								
Cut polystyrene											Mads																																				
Cutting PMMA																					Mads																										
Vacuum forming PMMA																							Mads					Mads																			
Steclich CNC-milling														Mads																																	
Middle piece																							Victor					Victor																			
Lasercut bottom																																Mads			Mads												
Paint middle piece																																				Victor											
Making the electronics															Mads og Victro						Chris							Chris							Chris												
Sewing strap															Lucia (Odense)																							Mads									
Glue PCM on																																						Victor									
Assemble lanterns																																									M&V						

Actual time of manufacturing

	15/maj	16/maj	17/maj	18/maj	19/maj	20/maj	21/maj	22/maj	23/maj	24/maj	25/maj	26/maj	27/maj	28/maj	29/maj	30/maj	31.maj	01/jun	02/jun	03/jun	04/jun	05/jun	06/jun	07/jun	08/jun	09/jun	10/jun	11/jun	12/jun	13/jun	14/jun	15/jun	16/jun	17/jun	18/jun	19/jun	20/jun	21/jun	22/jun	23/jun	24/jun	25/jun	26/jun	27/jun	28/jun	29/jun	30/jun
	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21	Day 22	Day 23	Day 24	Day 25	Day 26	Day 27	Day 28	Day 29	Day 30	Day 31	Day 32	Day 33	Day 34	Day 35	Day 36	Day 37	Day 38	Day 39	Day 40	Day 41	Day 42	Day 43	Day 44	Day 45	Day 46	Day 47
Operations																																															
Cutting polystyrene	Victor																																														
Vacuum forming polystyrene	Mads				Mads			Mads																																							
Cut polystyrene					Victor			Mads																																							
Cutting PMMA	Victor																																														
Vacuum forming PMMA																	Mads				Mads																										
Steclich CNC-milling								M&V																																							
Middle piece																			Victor																												
Lasercut bottom																							Victor																								
Paint middle piece																							Victor																								
Making the electronics																				M,V&C				Chris																							
Sewing strap															Lucia (Odense)									Mads																							
Glue PCM on																								M&V																							
Assemble lanterns																								M&V																							

GLØD	Bachelor project Interactive lantern to festival guest.	Subject: Manufacturing plan
		Date: 12th of june
The Technical University of Denmark. 2800 Kongens Lyngby.		Name: The design team
Mads Hesseldahl & Victor Bertelsen		Page: 1 of 1

76. Sequence model (middle piece and assemble)

Lid holders, holders and middle plate is cut out and engraved

Break down: The computer that controls the laser cutter goes on standby after 5 minutes and the laser cutter stops. Different tolerances for the two laser cutters used.

The middle plate is painted with a clothe covered in black acrylic paint.

The middle plate dries for app. 10 minutes.

A USB-cable is pressed through the middle plate.

Break down: The cables vary in size and not all can fit in the hole.

The PCB curcuit is tested

Break down: The chance of a mistake on the PCB with 165 different components are huge.

The PSB is glued on to the middle plate and the USB is soldered on.

Break down: The glue does not always stick and this can lead to the PCB falling off

The 8 wires from the button is soldered on to the PCB.

Break down: The button direction is not clear and can lead to the button placed wrong.

Loop x500

The nylon and elastics are cut out respectively in 20 cm and 10 cm.

Loop x500

The strap is made by stitching the elastics and nylon together.

Break down: The thickness of the strap makes it hard to stitck together and the needle breaks.

The strap is run through the middle plate

Break down: The end of the strap is burned the size is too big and can the nylon cannot run trough the hole of the plastic container.

A sticker is placed and the middle plate is glued on the bottom.

Break down: The strap has to be placed before the lid is placed it makes it difficult not to get glue on, this leads to cracks between bottom and the middle part.

The holders are placed on the middle plate

Loop x500

Break down: It is hard and time consuming to place the holders in an upright possition.

The strap runs through the holes on the lid

Break down: As the strap is only 4 mm thinner than the hole in the lid, assemblying the two parts is difficult.

The buckles are stitched onto the strap

Break down: As the male-buckle is a little longer than the female part, the stitching is extremely difficult and the chances of stitching crooked is big.

The buckles are closed and the lantern is done.

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77. Sequence model (vacuum forming PMMA)

PMMA are cut out after the optimized measurements

↓

The plates get blown with air to clean them

↓

Two forms are placed on the vacuum formers plate

↓

The plate is lowered inside the machine

↓

PMMA are placed in the vacuum former

↓

The door is closed and the vacuum former is turned on

↓

The vacuum former heats the PMMA-plate to 450°C

↓

The heater moves after 1min. 50 sec. for PMMA

↓

Vacuum is turned on and the forms are pushed up in the plastic plate

↓

A sheet has been formed with two plastic objects

↓

The forms are cut out with a hand saw

x500

↓ Break down: Sometimes the saw is so harsh on the material that it cracks.

The object is placed in a wood form in a laser cutter and are cut out.

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78. Sequence model (vacuum forming PS)

Polystyrene are cut out after the optimized measurements

↓

The plates get blown with air to clean them

↓

Two forms are placed on the vacuum formers plate

↓

The plate is lowered inside the machine

↓

PS are placed in the vacuum former

↓

The door is closed and the vacuum former is turned on

↓

The vacuum former heats the PS-plate to 400°C

↓

The heater moves after 1min. 10 sec. for PS

↓

Vacuum is turned on and the forms are pushed up in the plastic plate

↓

A sheet has been formed with two plastic objects

↓

The forms are cut out with a band saw

↓

At Steglich a CNC-machine cuts the bottom off and mill out two holes for the strap

Loop x500

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79. Budget

Budget for 2018, production of 500 units

		Total ex. VAT	Per unit (500 units)
Electronics			
	- LED	13,705	27.41
	- USB cables - Short	2,689	5.38
	- Electronic components	18,001	36.00
	- USB cables, long	720	1.44
	- PCB	2,141	4.28
	Electronics, total	**37,256**	**74.51**
Plastic container			
	- Plastic	22,581	45.16
	- Proffesional production of lids	15,219	30.44
	- Stickers, DTU & GLØD ***Plastic***	1,661	3.32
	container, total	**39,461**	**78.92**
Other product specific costs			
	- Side buckels	598	1.20
	- Elastic bands	-	-
	- Acrylic fabrics	2,000	4.00
	- Tools, glue etc.	2,280	4.56
	Other product specific costs, total	**4,878**	**9.76**
Marketing costs			
	- Webshop	183	0.37
	- Web domain	91	0.18
	- Jelling Festival tickets	1,244	2.49
	- Google Adwords	200	0.40
	Other product related cost, total	**1,518**	**3.04**
Administrative costs			
	- Banking services	-	-
	- Insurance	1,620	3.24
	- Fees paid to Virk.dk	536	1.07
	- Roskilde Festival ticket x2	3,408.00	6.82
	Total administrative costs	**5,564**	**11.13**
	Total costs	**88,677**	**177**
Grants accounted as sales			
	- RF Powered by DTU Students	4,000	
	- DTU Communication, advertisement	15,000	
Grants			
	- Fonden For Entreprenørskab	40,000	
	- Smart Campus	5,000	
Self-financing			
	- Self-financing through ownership	24,000	
		88,000	