CHALMERS

Photo Light Concept

A new light solution based on recycled LCD-monitors and LED light for photographers and motion picture producers

Master of Science Thesis in Industrial Design Engineering

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Göteborg, Sweden, 2012

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PREFACE

This report is the result of a master's thesis for the master's programme Industrial Design Engineering at Chalmers University of Technology. It was carried out for BOID in cooperation with CIT Recycling Development and consisted in developing a new light solution for the photography and motion picture industry. Many people have helped us during the project, and we want to thank everyone we have interviewed or received help from in other ways. We also thank Anton Grammatikas at BOID and Stephan Mangold at Chalmers Industriteknik (CIT) who have contributed with their knowledge and expertise. Finally we would like to thank Ulrike Rahe, our supervisor and examiner at Chalmers, who have guided us through this process.

Göteborg 2012

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ABSTRACT

This thesis was carried out for BOID in cooperation with Recycling Development. The purpose was to investigate what requirements photographers and motion picture producers have on light equipment and what would be beneficial in a future light solution, and as a result develop a new light solution based on recycled LCD-monitors and LED light. This was done through phases of literature study, interviews with users and experts, observations and focus groups. This was then followed by idea generation, consisting of brainstorming through sketching, model creation and making a number of concepts. These concepts were evaluated and developed further resulting in a product family where two of the concepts were developed in detail while the others remained on a conceptual level. The result of the thesis is a new family of light solutions, designed to be more portable, energy efficient and environmentally beneficial then current solutions.

SAMMANFATTNING

Detta examensarbete utfördes för BOID i samarbete med Recycling Development. Syftet var att undersöka vilka krav fotografer och filmproducenter har på ljusutrustning och vad som skulle vara fördelaktigt i en framtida produkt. Som ett resultet av förstudien skulle sedan ett nytt ljusutrustnings-koncept baserad på återvunna LCD-skärmar och LED-ljus tas fram. Arbetet skedde genom faser av litteraturstudier, intervjuer med användare och experter, observationer och fokusgrupper. Detta följdes sedan av idégenerering, bestående av brainstorming, modellframtagning och utveckling av ett antal koncept. Dessa koncept utvärderades sedan och utvecklats ytterligare vilket slutligen resulterat i en produktfamilj där två av koncepten har utvecklats i detalj medan de andra har hållits på en konceptuell nivå. Resultatet av examensarbetet är en ny familj av ljusutrustnings-lösningar, utformade för att vara mer portabla, energisnåla och miljövänliga än nuvarande lösningar.

TABLE OF CONTENTS

1 INTRODUCTION

1.1 BACKGROUND

Companies

BOID is a design bureau and affiliated company to Stiftelsen Chalmers Industriteknik. BOID offers a wide range of services in design related areas such as product communication, concept development, service development, usability studies, computer aided design and visualizations.

CIT Recycling Development provides research services for the development of sustainable recovery systems. CIT Recycling Development develops both process technology and separation methods for waste management applications with a focus on recycled materials and components.

Market

The life span of electronic parts today is very short. For a television the expected life span is about 7-10 years and for a desktop monitor it is only 3-5 years. At the same time the amount of sold units, as well as the size of the units increase rapidly every year. This results in that the number of disposed monitors increase likewise and will continue to grow in numbers. Due to the high cost of disassembly of the components (which are being considered as hazardous waste because of the mercury used in the lighting tubes), and the low return of the materials extracted in the process, the recycling process is not economically profitable. In order to benefit from the waste components it is necessary to explore possible alternative values for instance reuse of the components instead of recycling of the materials.

BOID in collaboration with CIT Recycling Development have explored a possible secondary usage of the LCD-screen as a product of illumination, which has a flat and flexible shape with low weight.

A highlighted market for such a product is the photography and motion picture industry. Today's solutions are often very large and heavy and consequently difficult to transport and carry around in photographic setups. Other benefits of a reused LCD-screen are the low energy consumption and high light quality.

Technology

The LCD-screen consists of the LCD panel, the front surface films and the backlight. The LCD panel is built up from millions of pixels and sub pixels (red, green and blue), which when all added together with different intensity can form nearly any color. The front surface films are used to remove glare and reflections as well as protect the screen from scratches.

The basic technology that will be used in this thesis project is the backlight-part of the LCD-screen. The LCD panel will be removed as well as the front surface films since they are of no use for illumination purposes. As a light source LED lighting will be used.

The light in an LCD-screen originate from the backlight which consist of the light source and the light guide, a reflector, diffuser, prism films and polarizer films.

The light from the light source enters the light guide that distributes the light evenly across the back of the LCD panel. Display enhancement films take the uniformity distributed light from the light guide and optimize its angular direction and polarization to make the LCD display appear brighter. Reflectors increase the light entering the light guide reflected from the rear of the backlight unit. Diffusers are placed between the light guide and the backside of the LCD panel to further distribute the light uniformly across the display. The prism films optimize the angle of light exiting the display such that most of it is directed toward the display viewer. The reflective polarizers optimize the light's state of polarization to minimise the amount of light lost by the panel's absorbing polarizers. Diffuse cover sheets are also used to help minimise moiré patterns.

Light emitting diodes (LED) are typically the source of light for LCD panels in cell phones, hand held devises, notebooks and television displays. These light sources are compact, efficient and reliable. LEDs use low-voltage to produce colored or white light.

1.2 OBJECTIVE

The objective of this master's thesis is to develop the next generation of lighting solution for photographers and motion picture producers. The new lighting solution should provide the best product experience possible for its users. The thesis project aims to use the technology and components used in LCD-screens where the parts instead of being recycled can be reused as source of illumination. The benefit from the flat shape and flexible LED-diode systems developed for LCD-screens will be used to design the optimized lighting setup for photographers and motion picture producers in different environments.

1.3 WORK STRUCTURE

This thesis work is a 30 ECTC credits project that is based upon 20 weeks of work for the Industrial Design Engineering programme at Chalmers University of Technology. The main phases planned for the project were information gathering, idea generation, concept development and product development (See Appendix A).

The information gathering consisted of technology research, market analysis as well as user studies of photographer's and motion picture producer's needs in terms of usability and light quality including interviews, observations and focus groups.

As a results from the pre-study a requirement specification was defined which then was used as the basis for the idea generation and concept development phase iteratively validated by user studies.

BOID (Anton Grammatikas) provided with supervision regarding design, technical advice as well as prototype production. CIT (Stephan Mangold) provided further technical expertise. Recycling Development provided with expertise regarding technical aspects of recycling of LCD-screens.

1.4 DELIMITATIONS

Part of the pre-study phase of the project will concern subjects such as light quality and light properties, which lie outside the area of expertise of the students carrying out this thesis. This part will then rely to some extent on guidance from experts in the field. Also, since time is always limited, the core of the thesis will naturally be in matters directly related to the proficiency of a Master of Industrial Design Engineering.

The product or products illumination components should be based on the backlight of the LCD-screen reused from disassembled television sets, laptop and desktop monitors. The source of illumination that will be used should be based on current LED lighting technology.

The thesis is specified to meet the requirements and needs regarding lighting within the photography and motion picture industry. However, these requirements may not correspond with each other and an optimal solution for both industries may not be possible in one product.

The product or products should be designed and developed on the basis of the user studies and interviews conducted within the photography and motion picture industry. Further specifications and limitations will be decided upon on the basis of these analyses.

Manufacturing and production methods will be taken in consideration but not evaluated thoroughly to find optimal solutions.

1 INTRODUCTION

2 PRE STUDY

3 USER STUDY

4 CREATIVE IDEATION

5 CONCEPT DEVELOPMENT

6 CONCEPT REFINEMENT

7 FINAL CONCEPT

8 DISCUSSION

9 FURTHER RECOMMENDATIONS

10 REFERENCES

11 APPENDIXES

2 PRE-STUDY

The project was started off with a phase of information gathering and research. This chapter will present this knowledge base that is important to be aware of in order to understand the development process and the decisions made throughout the process. The information gathered during this phase is used in the continuos development process as a framework in order to utilise the most important aspects for meeting the objectives.

This phase consisted of a literature study on the theory of LCD panels, LED technology and light quality in order to understand the limitations of existing technologies. An analysis of existing products was also conducted with the intention to set a benchmark on current functions, levels of performance and physical attributes. Design format analysis were also made on different kinds of studio environments as well as existing products in order to understand and frame the atmospheric characteristics and design cues that recurs repeatedly in both equipment as well as contexts.

This was complemented by interviews of both photographers and motion picture producers as well as observations in actual studios. The needs and workflow of the users is important to understand so that the product not only fulfils the technological requirements but also can be functional and beneficial for the users in their everyday work.

The collected information from this phase was then used to put together a demand specification.

2.1 LCD OVERVIEW

As mentioned before, the basic component used in this thesis is the backlight from the LCD-panel. This section will describe the build-up structure of this component and the function of its parts. This section will also include the beneficial properties, if any, of each part for an implementation in a light concept.

2.1.1 Components of an LCD

An LCD (liquid crystal display) is built up from millions of pixels and sub pixels (red, green and blue), which when all added together with different intensity can form nearly any color. In an LCD, millions of light valves form the display panel, while a backlight and various display enhancement films create the illumination (3M, 2011). An LED is composed of Backlight (consists of a reflector, light source and light guide, diffuser, prism films and reflective polarizer), LCD panel and Front Surface Films (consists of anti glare/anti reflection film, quick clean film as well as privacy film).

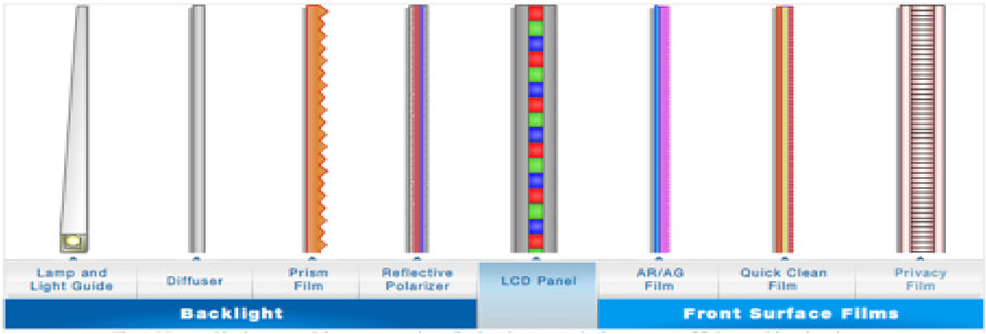


Figure 2.1.1.1 LCD components construction.

The light in an LCD originated from the backlight. The light from the light source bounces between the light guide and reflector that distribute the light evenly across the back of the LCD panel. Diffusers are placed between the light guide and the backside of the LCD panel to further distribute the light uniformly across the display. The prism films optimize the angle of light exiting the display such that most of it is directed toward the display viewer. The reflective polarizers optimize the light's state of polarization to minimise the amount of light lost by the panel's absorbing polarizers (3M, 2011).

Reflector:

The reflector placed underneath the light guide, is made of hundreds of polymer layers, which alternating low and high index produces a mirror like reflector more efficient than a silver mirror. The reflector reflect up to 98% of the light based on a 3M LCD optic study (3M, 2011)

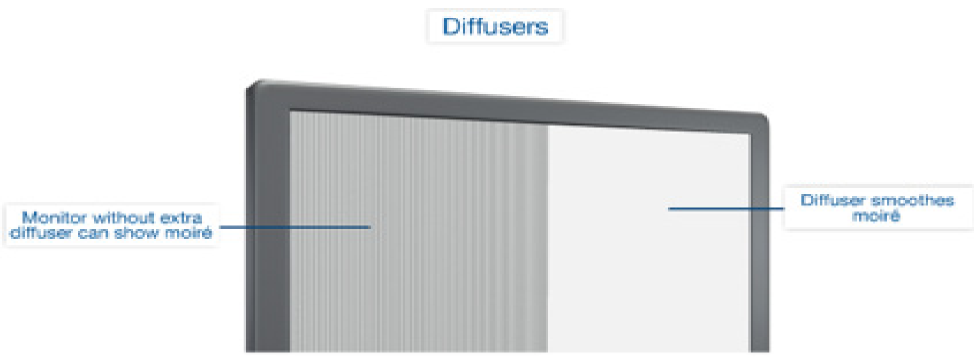


Figure 2.1.1.2 Diffusers effect on moiré.

Diffuser:

Diffusers are used to make light appear more uniform as it fills an LCD display area. Diffusers are necessary to smooth out surface patterns that are part of the light guide structure or illumination system and also used to help minimized moiré patterns (3M, 2011). Some backlights may require multiple diffusers to ensure an acceptable level of uniformity.

Prism film:

Prism films, also called brightness enhancement films (BEF) manage the angle of the light emitted from the backlight to direct more usable light to the viewer. Without those films light would exit an LCD at angles outside the typical viewing range, much of it going to waste.

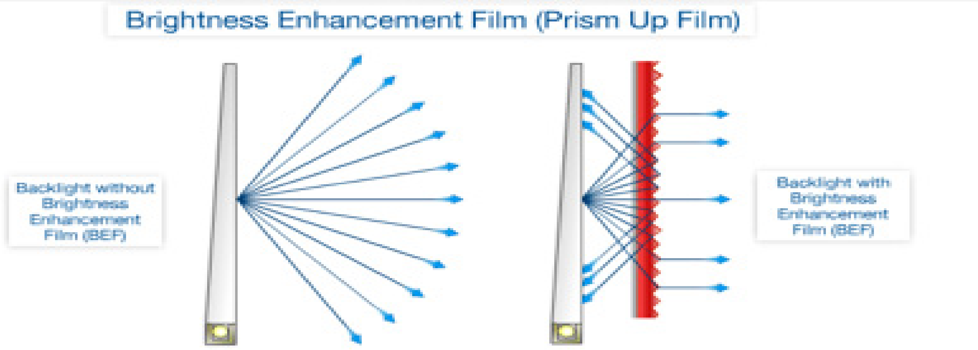


Figure 2.1.1.3 Functional principle of prism film.

In highly diffuse backlights, a single piece of prism film can increase brightness by approximately 60%, while 2 pieces of BEF with prisms crossed to one another can increase brightness by approximately 120% in perpendicular direction (3M, 2011).

Figure 2.1.1.4 differences on the cell-phone screen with or without prism films.

Approximately 37% of the light entering the prism film will be refracted in a direction perpendicular to the display face toward the viewer (3M, 2011). Light that instead refracts in a different angle will reflect back to the backlight and be recycled. Light that has been recycled will pass through and be reflected by the backlight optics in a variety of new angles.

2.1.2 Summary LCD

The basic idea of this thesis is to take full use of the LCD from recycled televisions. By using the method of the LCD back light, which provide a flat even light source, while replacing the light tube with LED light, it is considered environmental friendly as well as it utilizes assets from the TV recycling industry.

The basic components of an LCD backlight consist of a reflector, a light source, a light guide, and three films. The reflector and light source as well as the light guide provide a flat light source while the films direct the light in some way. Depending on what requirements the user have, different combinations of the films can be used in order to create different light properties.

2.2 LED OVERVIEW

LED (Light Emitting Diode), is a light source that successfully unite several very desirable qualities; to be as small as possible, emit light with a high efficiency, to have a long lifetime, to have continuous brightness control, emit no ultraviolet or infrared radiation, etc. The light in an LED is generated through a semiconductor that is electronically stimulated to emit light (electroluminescence).

As commonly used in signal indication in traffic lights in the beginning, LED has become widely spread within the car industry as tail lights, head lights, and lately found ground in office, home and outdoor lighting as well.

The luminous efficiency from LED is rapidly improving and is today exceeding the effective output incandescent light bulbs and halogen lamps can produce. It has even become compatible with the high luminous efficiency of luminescent light tubes.

There are LEDs in red, orange, green, blue and white. White light can be generated by a mixture of the three primary colors of red, green and blue or in the same way as the fluorescent lamps by using a blue InGaN LED coated with a cerium (Ce) doped yttrium aluminum garnet (YAG) inorganic phosphor that generates blue light which excites the phosphor to emit pale-yellow light resulting in a combined white light (Jones, 2001). The phosphor compound is constantly developed and the white LED lightning that exists has very good color reproduction (Ra> 90) which makes LED really comparable with other light sources.

2.2.1 Properties of the LED

LEDs are still undergoing rapid development. The LEDs that is available today has a luminous flux between a few lumens (lm) for low power LED and up to several hundred lumens of the high performance LED.

The two most important criteria that to be considered for LEDs used for lighting are the light intensity and color quality.

Luminance:

Today the market offers everything from dim to intense bright LEDs. Like so many other product areas there are however differences in quality among different LEDs. These differences are perceived above all in different life cycles, chromatic aberrations and a faster lumen decline.

Luminous flux is a physical quantity in photometry that measures the perceived power of light. Differing from radiant flux which refers to the total power of the light emitted from source, luminous flux reflects the "perceived power" of light where radiant flux has been adjusted in accordance with luminosity function which describes the varying sensitivity of the human eye to different wavelengths of light.

Since human eye can only responses to limited wavelengths, luminous flux therefore represents the power of light at all wavelengths in the visible band, the power from invisible light doesn't count. Lumen is used as the SI unit of luminous flux. One lumen equals to one candela of luminous intensity uniformly across a solid angle of one steradian.

There is another important SI unit in photometry, lux, which measures luminous flux per unit area. It is a measurement of the intensity of light penetrating a surface. One lux equals to one lumen per square meter.

Color temperature and color rendering:

Color temperature is a characteristic of visible light that refers the temperature of an ideal black-body radiator that radiates light of comparable hue to that of the light source. Color temperature is conventionally stated in the unit of absolute temperature (Kelvin) having the unit symbol K.

Color temperatures over 5,000K are called cool colors (blueish white), while lower color temperatures (2,700–3,000 K) are called warm colors (yellowish white through red) (Smith & Guild, 1931). See Appendix B.

Figure 2.2.1.1 Color temperature.

The color next to the Average noon daylight (5500K) is white which is the preferable color temperature by photographers. This 5500K color temperature is also used for color calibration of equipment meaning that when shooting using daylight the photograph will record white objects as white and all the colors in an image will appear natural in the picture.

The light color do not just relate to daylight conditions artificial light but also introduces a color cast. With fluorescent lights this is often green and with tungsten lighting it will be yellow, while flash can be slightly blue (Jones, 2001).

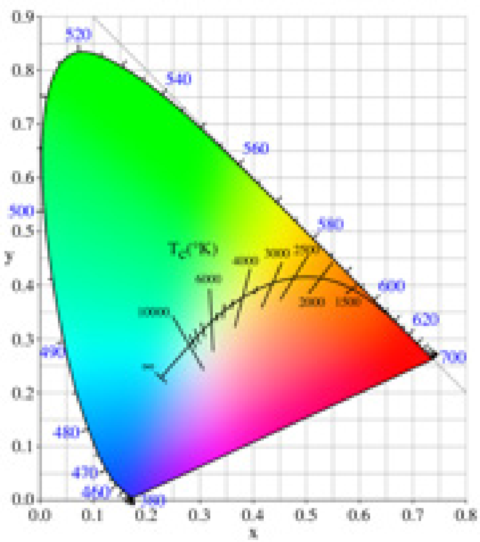
Due to the need of appropriate white color and good color rendering performance for illuminating objects, the color temperature and color rendering are important and it is crucial for photographers to have a 5500K color temperature as a standard (Smith & Guild, 1931).

The light we use to see with is mere a reflection by the various things we see. The LED emits the light which then hits the object that we are watching and then reflect the light into the eyes as well as cameras. If the LED color spectra include all colors, the reflected object becomes accurately and lifelike visualized and the data could be caught by the camera's CCD (Charge-coupled Device) sensor.

Initially, the color temperature of white LEDs was quite cold (color temperature > 4500 K). While as the fast developing technology, today's market offers almost any color temperature which is considered more efficient because unlike traditional lighting methods, LEDs can emit light of an intended color without using any color filters.

The standardized method, the color rendering index (CRI), is defined by the CIE (Commission Internationale de l'Éclairage = International Commission on Illumination). Color rendering of a light source is evaluated by comparing the appearance of various object colors under illumination by the given light source with that under reference illumination. The smaller the color differences of the object colors are the better the color rendering is.

Color Rendering Index (CRI) is measured in Ra. With the maximum value of 100, Ra gives a scale that matches well with the visual impression of color rendering of illuminated scenes (Schanda & Sándor, 2006). For example, lamps having Ra values greater than 80 may be considered to be high quality and suitable for interior lighting, and Ra greater than 95 may be suitable for visual inspection purposes. Today, high-qualitative LED has a CRI of > 90 (Schanda & Sándor, 2006).



Spectrum locus is the plots of monochromatic light that on the boundaries of the horseshoe-shaped diagram. The color on the plotted near the center of the diagram can be specified by the blackbody temperature in Kelvin and is the so-called color temperature. The colors around the plotted near the center of the diagram from about 2,500 to 20,000K can be regarded as white, from 2,500K reddish white to 20,000K bluish white.

Figure 2.2.1.2 Spectrum locus.

As is well known, the three standard colors, red, green, and blue, can be mixed together to generate white light. However, based on the interview information from the LED technician from Aluwave (Aluwave, 2011), the RGB LEDs can not provide full color spectra equivalent to daylight or tungsten light since much of the colors of the spectra do not exist in the light source formed by RGB LEDs (see figure 2.2.1.3).

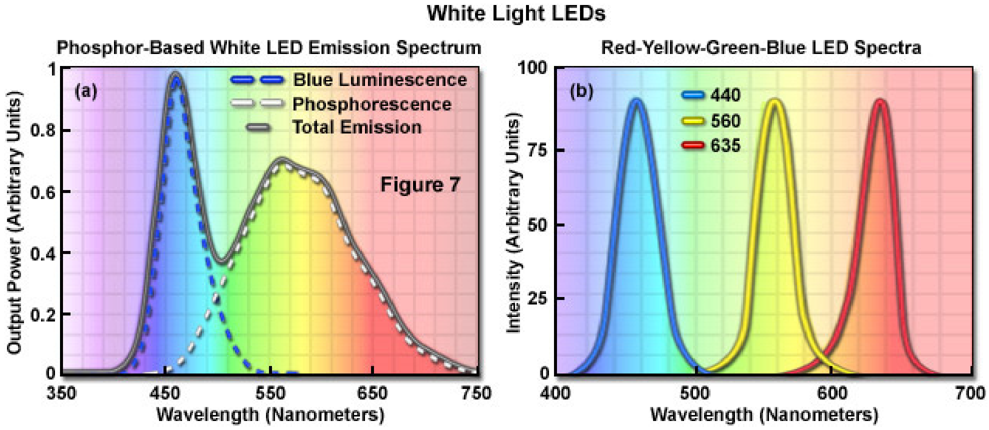


Figure 2.2.1.3 Comparison on wavelength on Zeiss product.

On way to achieve a better color rendering index could be using red, green and blue LEDs in combination with a white LED covered in a phosphor which converts some of the radiation and forms a white light with high color rendering index.

The RGB LEDs and white LED light with phosphor mix with each other in a mixing chamber. The light would be seen as three different colors on a short distance while it further away would be perceived as white light. In this way the Ra could be considered high enough for the CCD in the camera to catch as much of the color spectra as possible for the post editing.

Compared to multiple-chip LEDs for red, green, and blue color output (even though multiple-chip LEDs have relatively more complete color spectra), an advantage of phosphor-white or hybrid-white LED devices is that it only requires one blue or ultraviolet (UV) LED which is more energy efficient and cost less in manufacturing. In addition, white-light LEDs based on phosphors have been shown to have relatively stable color with little variations in temperature (Jones, 2001).

Efficient sources of light:

The luminous efficiency of light sources involves the efficiency of energy conversion from electrical power (W) to optical power (radiant flux in watts), and also the conversion from radiant flux to luminous flux (lumen = lm), which is determined by the eye sensitivity over the spectral distribution of light, and is called luminous efficiency of radiation having units of lm/W.

LED is a very efficient source of light. Year 2009 white LED achieved a luminous efficiency of more than 100 lm/W. These high values are obtained at optimum conditions. In the future the LED technology will more and more serve as functional lighting. This will lower the energy consumption of the light sources.

Cooling system:

The lifetime of LEDs is dependent on the operating and ambient temperature. With the proper temperature, the LED as well as the LED modules will have a very long lifespan of up to 50 000 hours (EERE, 2006). Therefore, the circuit board or additional heat sink must dissipate the heat in a reliable manner to prevent circuit damage. In addition, the unit must be adapted to the expected use.

Unlike incandescent bulbs, where a broken filament means that the bulb is exhausted, total failure is very rare for the LED. Light output instead decreases very slowly and continuously. The lifetime of LEDs is defined as when the flux has been reduced to 70 percent.

Regulation of light:

LEDs can easily be dimmed. To be able to dim LED a requirement is that the ballast is adjustable. The dimmable LED ballasts use a technology called pulse width modulation (PWM) (Prathyusha & Zinger, 2004). This means that the LED modules are operated through a square wave varies the frequency depending on the desired light intensity. This happens so fast that your eyes do not notice any flicker. If this technique is used to regulate separate light colored LED (e.g. red, green and blue LEDs), one can easily create color mixes. PWM technology is the only professional way to dim LED today.

Environmental benefits:

LEDs have very long lifespan of up to 50 000 hours results in low maintenance costs. The high efficiency means very low energy consumption as well.

In many applications the low energy consumption contributes to reduced energy requirements. The long lifetime also means that fewer light sources need to be disposed for recycling. Furthermore, LEDs have low toxicity which do not contain mercury unlike fluorescent lamps.

2.2.2 Summary of LED

The LED technology is in a fast developing status. The LED light source is considered compact, efficient and reliable with high luminance. LEDs react very quickly; a typical red indicator LED will achieve full brightness in under a microsecond.

LEDs can be dimmed throughout the entire range from 0 to 100 percent and use low-voltage to produce colored or white light.

White LEDs first produce blue light which is then converted by a phosphor to white light resulting in a broad spectrum accompanied by a specific blue wavelength. Colored LEDs have a narrow wavelength spectrum such as red, green or blue light (RGB).

Illuminance is a measure of the intensity of the incident light of how much luminous flux is spread over a given area. The unit to describe illuminance is lux which is equal to one lumen per square meter: ($1 \text{ lx} = 1 \text{ lm/m}^2 = 1 \text{ cd x sr x m}^{-2}$).

Illuminance (lux)	Example
10^{-4}	Total starlight, overcast sky
0.002	Moonless clear night sky with airglow
0.01	Quarter moon
0.27	Full moon on a clear night
1	Full moon overhead at tropical latitudes
3.4	Dark limit of civil twilight under a clear sky
50	Family living room
80	Hallway/toilet
100	Very dark overcast day
320-500	Office lighting
400	Sunrise or sunset on a clear day
1,000	Overcast day, typical TV studio lighting
10,000-25,000	Full daylight (not direct sun)
32,000-130,000	Direct sunlight

Table 2.2.2.1 Examples of intensity of light measured in lux.

2.3 EXISTING PRODUCTS ANALYSIS

2.3.1 Basic equipment used today

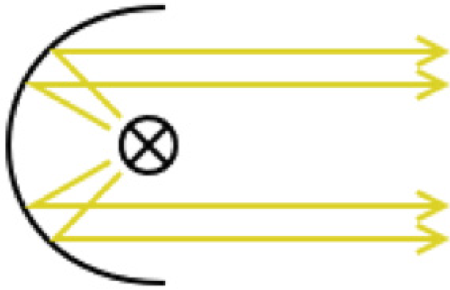
Flash:

As well as dedicated studio use, flash may be used as the main light source where ambient light is inadequate, or as a supplementary source in more complex lighting situations. Basic flash lighting produces a hard, frontal light unless modified in some way. Umbrellas and soft boxes are commonly used for this purpose (even with small hand-held flash units).

A flash is a device used in photography producing a flash of artificial light (typically 1/1000 to 1/200 of a second) at a color temperature of about 5500 K to help illuminate a scene. A major purpose of a flash is to illuminate a dark scene. Other uses are capturing quickly moving objects or changing the quality of the light.

In professional studios, flashes are quite large, standalone units, or studio strobes powered by special battery packs or connected to main power. Most of the time, there are fans behind the flash bulbs to cool down the high temperature generated by the flash bulbs. They are either synchronized with the camera using a flash synchronization cable or radio signal, or are light-triggered, meaning that only one flash unit needs to be synchronized with the camera, and in turn triggers the other units.

Reflector & Soft-box:



Different kinds of umbrellas (aluminized fabric surface, white fabric, etc) are used as reflector or diffuser to bounce and direct the light. Sometimes, walls or ceilings could be used as reflectors too.

The best known form of bouncing source is the umbrella light where the light from the bulb is bounced off the inside of a metallized umbrella to create a soft indirect light. There is another widely used flash called “bounce flash” in the photography industry today, providing a large area of illumination lit by wall off- camera.

As this very broad, flat lighting is more typical of an overcast day outdoors, a more realistic interior illumination is achieved by reducing the power of additional lighting relative to the available light, so that either source may act as a fill to the other. Hence bounce lighting may provide either the primary or secondary (fill) light source, depending on its intensity.

Figure 2.3.1.1 Lamp reflector.

In order to get a soft shadow and bigger light source, photographers often use soft-boxes. Soft-box is an umbrella or square shape enclosure with a constant light bulb or flash inside, with diffusing material in the front, in order to create soft light.

The other sides of the soft box are made of highly reflective surface to act as an efficient reflector.

2.3.2 DFA - Existing lights

The Design Format Analysis (DFA) is a method used to analyze what design cues that are typical for a certain brand, as well as the typical product of the brand regarding these design cues. First all of the brand's current products (or relevant subsets of products) are studied and every design feature that can be found are listed. The products are placed on the x-axis of a matrix and the features on the y-axis, then every product is evaluated against each feature. If a product match the feature, it is given two points in the matrix. If it matches to some extent, one point is assigned. If it does not match at all, then no points at all are assigned. Finally the total score for each product and each feature is summarized. The products with the highest scores are the most typical products for the brand, and the features with the highest scores are the most typical features for the brand (Warell, 2001).

Figure 2.3.2.1 DFA on existing lights (See Appendix C1).

The lights used today within the photo and motion picture industry are mainly based on space and energy consuming technology in order to create as high intensity as possible. This results in very bulky, heavy and unwieldy products.

Most of the products used today have industrial attributes, as they were designed for fulfilling a purpose only, not to be ecstatically appealing in a studio environment. The black color is a regular feature as well as the highly reflective light inside color.

Most of the products are robust looking, a good feature for conveying quality and good functionality. The robust feeling is created through a combination between the metal materials and the use of basic shapes in the design. The dark colors such as black and dark grey further enhance the robust sensation.

There is little development in design of the more modern LED-technology lights on the market today. The industrial attributes are still present as well as the basic shapes and dark colors. What is noticeable is that the development of technology has not extended to the development of design.

As can be seen in the DFA, all the light products got a very even total score. The conclusion that can be made from this is that they all share more or less the same attributes with little features that stand out from competitors, resulting in low recognition on the market.

The form of the equipment used today is in most cases following the function of the equipment or trying to find common ground in the forms of existing camera equipment, where the design already has an established and distinct form language. Little or none consideration has been taken to the elements of the actual studio where the equipment is situated, in many cases creating a conflict of characteristics.

2.3.3 DFA - Photo studio

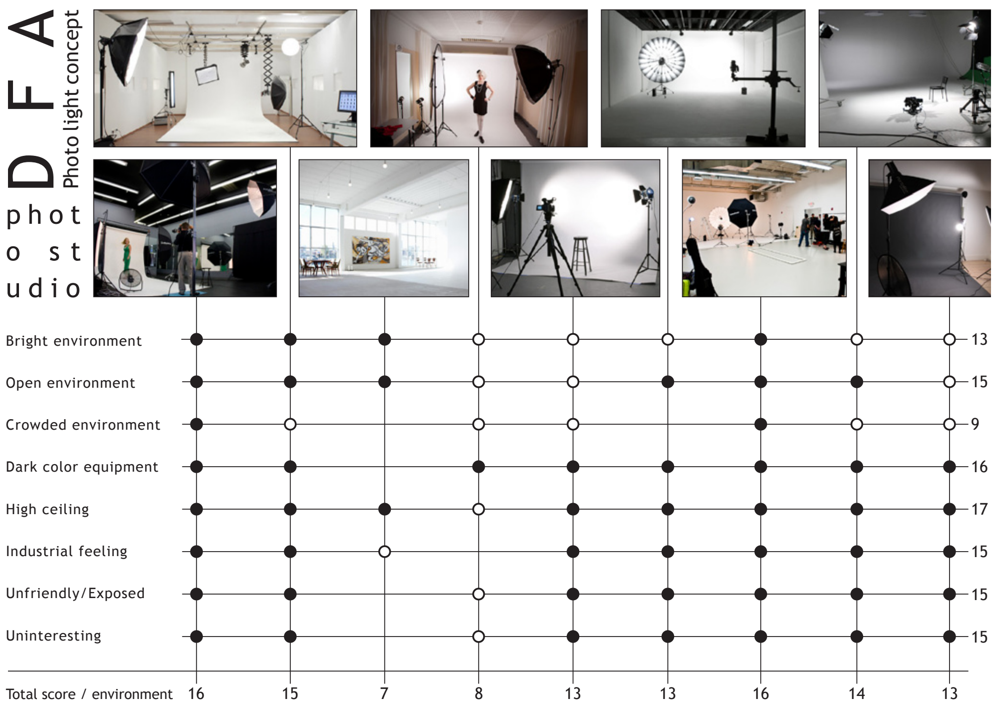


Figure 2.3.3.1 DFA on photo studio (See Appendix C2).

The photo studios all share the same attributes of being white, bright and spacious. In contrast, the studio equipment such as lights, stands and camera equipment most commonly have a dark color that stands out and create a conflicting sensation.

Because of that the equipment stands out and is directed towards one common focal point in the studio, the sensation of being exposed and observed becomes present for the object in front of the camera.

There is a common sensation of unfriendliness also created by the industrial associations of the studio environment. The studios are often spacious and bright, both in colors and as filled with light which creates a positive feeling. However, because of the conflicting attributes of the equipment and the amount of equipment in the studio, the overall impression often becomes crowded, industrial and hostile.

The reason why the studio equipment is not coherent with the studio atmosphere is unclear – a spacious, bright and liberated environment is perceived as more friendly and creative. A studio environment where the equipment blends in and becomes a part of the context would reduce the sentiment of hostility and give a greater freedom of expression.

2.3.4 DFA - TV/Film studio

Figure 2.3.4.1 DFA on TV studio (See Appendix C3).

By comparing TV studios, one significant feature is that most of the TV studios have a high ceiling with dark color equipment. Then environments are also quite colorful due to the vivid backgrounds. Due to the limited spaces for some of the TV studios, it appears quite crowded because of the cables messed up on the ground, cameras fixed on tripods, as well as lighting equipment moving around in the studio.

The focal point should be light enough while other spaces are very dark. Because of the intensive light directing to the focal center, there is a high heat generation.

Most of the TV studios have the same layout and toneless single color equipment which are considered as uninteresting working environments. The equipment is for the most fixed on tripods, and the tripods can easily be moved around. Other lights are fixed in the ceiling and seldom adjusted or moved around.

2.4 CONCLUSIONS OF PRE STUDY

The light quality of the LEDs is crucial due to the desire of containing all the color spectra wavelengths equal to sunlight, in order to get a realistic and accurate color reproduction of the object being illuminated.

Why to use RGB LEDs and a blue LED with a phosphor mixture to get the white color or use only white LED instead of to use a combination of RGB LEDs is because the RGB LEDs lack of too many color wavelengths.

In the photo and film industry, colored light can be created directly without a filter. With the high color saturation as well as the large selection of colors, you can create any shade of color and color changing system easily.

White LEDs are available in different color temperatures. The small size allows for extremely compact luminaries.

While on the other hand, there are some potential problems with multi-chip LEDs:

- Even when using the multiple-chip LED as a light source, it is still quite difficult to contain the full visible light spectra as tungsten light or fluorescence light do.

- Due to the discrete wavelengths of light being used, the color of the light source may change considerably with viewing angle.

- The multiple-chip LED light sources are relatively expensive.

The LED-diode should be placed directly against the side of the light guide. Any distance in between will result in loss of efficiency. A flat diode is preferred to be used.

Regarding current lighting products, they to a high extent share the industrial visual appearance found in both camera equipment and accessories. This for the most contradicts the visual appearance of the studio environments in which the equipment is used. As a result the equipment stands out from the surroundings.

3 USER STUDY

An interview is the most basic way to gather information about different opinions. A semi structured interview is an interview where questions are prepared beforehand to serve as support for the interviewers. The questions are used as guidance but also allow the discussion to evolve based on what is said during the interview. The semi structured interview enables gathering of both qualitative and quantitative data but should be used in combination with observations to see how people really behave in use situations (Bohgard, et al., 2008).

In total a number of thirteen end users and experts in the Gothenburg area were interviewed during ten sessions; five related to the photography industry and five related to the motion picture industry. All the interviewees were chosen because of their large knowledge or long experience with lighting within their profession.

This section is a summery of all the interviews divided into respective profession; photographers and motion picture producers. The answers have also been divided into their respective topic in order to be more comprehensible. In the end a summery is presented with the main findings from the interviews.

Participants of the interviews include; Jerker Andersson (photographer), Christer Ehrling (photographer), Svante Örnberg (photographer), Tomas Yeh (photographer), Magnus Johansson (photographer), Magnus Cimmerbäck (photographer), Jan Olof Yxel (photographer), Fabian Tellermark (Silverbullet film), Luisa Södergren (Lightcenter), Torgny Johansson (Lightcenter), Bo Hansson (SVT), Jesper Olsson (KSE), Mattias Carlsson (TV4). The interviews were conducted during February and March, 2011.

3.1 INTERVIEWS WITH PHOTOGRAPHERS

3.1.1 Equipment used today

It is important for photographers to have a ”flow” in the apparatus used, meaning that what you see in reality is what the camera will catch and then be transferred to the computer screen and later be what you see when you print the photo. This is created through standardizations of the temperature of the light. The lights, camera equipment and computers are calibrated to match daylight (usually 5500 Kelvin).

For photographers the preferred source of light in most situations is the flash, producing a high intense light for a very short period of time. Usually the flash is used in combination with different additional accessories such as soft-boxes, umbrellas, beauty dishes and filters to vary the properties of the light.

• Soft-box is an enclosure around a bulb comprising reflective side and back walls and a diffusing material at the front of the light. This is used to spread the light over a larger are at the same time as it creates a soft and diffused light by directing the light through the diffusing material. A large soft-box will eliminate all shadows on the photographed object.

• Umbrellas are used to bounce the light off a second surface to diffuse the light. The light from the bulb is bounced off the inside of a metallized umbrella to create a soft indirect light.

• Beauty dish use a parabolic reflector to distribute light towards a focal point. The light created is between that of a direct flash and a soft-box, hence giving the image a wrapped, contrasted look, which adds a very dramatic effect.

• Filters are used for a large variety of different effects, created by changing the light properties (temperature, spread, color etc.). Most filters decrease the intensity of the light source.

In addition, accessories like reflectors are commonly used. The reflector is an improvised or specialized reflective surface used to redirect light towards a given subject or scene in order to further enhance the light or cover a larger area of the object.

For photographers it is preferable to have a short exposure time when the object is moving, in order to get a sharp photo, and for this an intense light source is needed.

The light equipment used is generally decided upon the situation and type of photography that is performed. The difference between studio photography and "on the spot –photography" (such as editorial photography), is that in on the spot –photography the equipment needs to be portable and battery powered while in studio photography more equipment and grid power can be used. This creates limitations that need to be considered. In some cases the photographer is required to adapt for the existing possibilities, and in these situations most photographers will use a small, camera-mounted, electronic flash – the ability to be flexible is more important in these situations.

If the possibility exists to use a secondary light source in an on the spot – situation, many photographers prefers a strong constant light that can either be directed away from the object to give an over-all light, or focused onto the object to give a sharp and strong light.

Many photographers also stick to a certain brand of equipment. This is because different brands have different standards of compatibility. Dealerships and suppliers have created a system that only allows expansion within the same brand, the accessories you can ad is a part of the product/brand. This is resulting in that decisions when investing in a product many times also is based on the expansion possibilities within that segment.

3.1.2 Problems today

The biggest problem with today's light equipment, according to photographers, is the large size and heavy weight of the products when moving them around or changing location, as well as the large quantity of products needed for different situations. There is no single light that fits all different situations and therefore the total amount of equipment needed becomes large. Difficulties with portability become a problem when the photographer need to compromise the use of equipment according to the situation, and the ideal conditions are being lost.

A large soft-box creates a nice smooth light as well as it eliminates all shadows on the object. It is however very large and unwieldy when transporting it resulting in that it seldom is used when photographing outside the studio. However when it is being used outside the studio the lightweight of the actual soft-box becomes a problem when there is wind blowing, making it to fall over. To prevent this, heavy sand bags are needed to put on the legs of the tripod as weights.

The lights used today are in general very energy consuming in relation to the intensity that can be extracted. Also only a small amount of the intensity of the light is being utilized toward the object being photographed, most of it is lost through different reflection accessories or filters that is needed. The light is in most cases directed outwards, away from the object and then reflected back via the walls of the room, umbrellas and reflector screens, a lot of it going to waste in the process.

The high energy consumption is negative through an environmental perspective as well as it results in the need of large and heavy batteries that is difficult and harmful to carry around. High energy consumption also results in a high heat generation of the constant lights, something that can be both dangerous from a fire perspective as well as uncomfortable for the model or object being photographed.

A disadvantage with flashes is that there is no instant feedback from the light. The photographer needs to set up the scenery and then do try-outs to test the lights attributes and how it is affecting the object. If the result is not satisfying, adjustments need to be done and then new try-outs will be performed. This process is inefficient and time consuming. With a constant light the scenery and object can be sculpted with instant feedback and the photographer can immediately see the object in real-time as it would look on the photo or make adjustments to the light with direct and constant feedback.

Another problem is the lack of possible intensity adjustments in the light. In some cases the intensity is too high, such as when photographing with a large aperture and the picture will get overexposed.

A flash release its energy in form of light within a split second. The energy then needs to load up before it can be released once more. A problem with this is the variations in temperature the flash will have if it is not fully loaded. If the flash is being used before it is fully loaded it will vary in intensity and quality, something that will not show until the post-production.

The photography industry is a market where the price of the equipment in many cases is unreasonably high. When buying a product there are also a lot of additional accessories that you need to buy as well, all adding up to a large quantity of equipment and a high price in the end.

3.1.3 Most important qualities

Quality:

All photographers state that the most important thing in a light is the intensity it can produce. The intensity should also be dimmable so that the photographer can adjust the light depending on the situation. The dimming functionality should have large possibilities of adjustment, preferably be step-less from 0-100%.

An important aspect is the intensity loss of the light, how much the light looses in intensity per meter of distance.

The color representation (Ra-value) needs to be very high in order to represent as many colors as possible for a high quality picture. If a wavelength in the color spectra is missing, that color will not be represented on the object and the information of that color will be non-existing.

Another important thing is the “stability” of the light – that the light have the same temperature no matter if it becomes hot or old of age. The Stability and quality of the light is essential to get a consistence in the light which will be translated to the pictures. This is important for the pictures to look the same or when you have several light sources that they do not vary in temperature, which will make it harder in post-production.

Adjustability:

The adjustability of the light is very important; to be able to change the quality of the light such as intensity, as well as it is very important to be able to adjust the height, pitch and angle of the light to the object being photographed.

Most photographers also think it is important to be able to adjust the temperature of the light, from a warm indoor light temperature to a cold outdoor temperature. This is today performed by adding different colored filters in front of the light or in post-production.

An important aspect is also to be able to control and adjust the spread of the light. In some cases a soft and scattered light is preferred and other times the light should be intense and focused on to the object.

They also thought that a modular system –light would be preferable, where you can build up the size or shape of the light as you like by putting together several smaller screens. By creating a large screen one would have the possibility to change the hardness of the light since shadows depends on the size of the light source, it is not the distribution angle of the light but the width/size of the source.

Mobility:

There are many advantages with a portable light. The size and weight of the light as well as amount of accessories needed such as batteries, reflectors etc.

determine the portability possibilities. A more energy efficient light would need less battery power resulting in a reduction in battery size.

An advantage would also be to have cord-less equipment in the studio as well. This is mainly for the mobility when moving stuff around but also that it is easy to trip over a cord, making the light to fall over and break which can be very expensive due to the high cost of the equipment.

To have the possibility to choose between cord-power and battery-power would be beneficial. When there is no electricity - a good solution would be to incorporate everything in the same piece of equipment, to have the battery inside the body of the light, eliminating the need of extra equipment and to make it more portable.

Standardization:

The light should use the same standard that is used today for other equipment, to be possible to use together with equipment from other brands and manufacturers.

Durability:

The light should be robust and qualitative so it can be handled roughly. It is sometimes important for photographers to be able to change location quickly – just grab and run without caring too much about the equipment. The quality is very important, the product should be, look and feel robust.

Manageability:

The light should be easy to assemble and disassemble - how quickly it can be unpacked and mounted together and packed down when done.

Cost:

If the light is comparable to similar products in quality, the cost would be a decisive factor when investing in equipment.

Design:

Studio environments are often ”fashionable” and it is important for photographers to be trendy and have the right equipment in terms of brand, design, fashion etc. The appearance of the studio environment is very important.

3.1.4 Qualities for a higher value

The size of the light is dependent on what kind of shadows you want on the object. A small light source will create sharp shadows while a larger light source will create softer shadows. If it would be possible to adjust the light source to what kind of shadow effect you want that would be very good - adjust the intensity and size (modular) of the light.

It would be beneficial to create a product family with different functions for different situations - different sizes, shapes e.g. for macro pictures, mounting possibilities etc.

When photographing, it is preferable to use the standard of daylight temperature in the light (5500 K). When taking a picture you should not use different temperature lights e.g. a flash with temperature 5500 K and a secondary light with a warmer temperature at the same time. But it would be good to have the possibility to choose the temperature in the light (standard daylight, warm and cold). This can however be adjusted through filters, not necessarily through the light itself (RGB LED).

The shape of the light itself will be reflected in e.g. the eyes of a person or on highly reflective surfaces. In some cases a certain shape is wanted. A benefit would be to be able to change the shape of the light depending on the situation.

Remote control settings would be a plus, especially in situations where several lights are being used at once or when the lights are placed in inaccessible places.

3.2 INTERVIEWS WITH MOTION PICTURE PRODUCERS

3.2.1 Equipment used today

In movie production, using flashes is impossible. Therefore constant light has to be used. An advantage with constant lights is the instant feedback it gives when lighting the object and the way it is possible to see how the light is shaping the objects.

The basic light covering a large area is usually created with the use of soft-boxes. However when a soft-box is used together with a so called “hot light” such as halogen bulbs or tungsten bulbs, the user must be sure the soft-box is heat rated for the wattage of the light it is attached to in order to avoid fire hazard. Fresnel lights are used to collect or focus the light and are usually adjusted through flaps. Profile lights (spotlights) are used to create high intensity light on a single spot from a long distance. These lights are usually controlled through a lens system.

In a motion picture studio it is not unusual that there is between 100-150 lights used at the same time. Different types of lighting are also used simultaneously, the need of using a certain standard of light temperature is less important in motion picture production than in photography. In many cases the camera is adjusted for the light conditions and not vice versa. The intensity of the lights and the ability to cover a large area from different angles at once are the main objectives.

When there is a need for being mobile such as for news teams on the field, they usually bring only a camera-mounted spot light consisting of small LED lights. The reason is because they usually work alone being cameraman and journalist at once; they usually put the camera stationary on a tripod while interviewing the person. If they are two in the team they usually bring more lights which they in that case mount on tripods.

3.2.2 Problems today

The most important aspect in lighting motion picture productions is the ability to light up the complete scenery at once, from different angles. The object is usually moving around and the optimal light conditions change constantly, the lighting is therefore usually a compromise. High intensity lights as well as large light sources are needed.

In most cases the budget of the production limits what and how many lights to use. Here compromises also have to be made that often affect the outcome of the production negatively.

A high color representation value (Ra-value) of the light does not necessarily mean that you have a good color representation, you can still lack certain wavelengths and some information in the light can still be missing in the linear spectrum. This results in that some colors look grey and is the reason why LED lights have not been popular in the past.

When being outdoors they seldom have access to a power grid. Because of this they have to bring heavy batteries are required. The HMI light have strong intensity with relative low energy consumption. The result is that it in some cases therefor is used as light source even if it is not the ideal light, it depends on how much light that can be extracted with the possible power that is available.

In many cases a soft light is desired. This is created through a large light source and diffuser films or soft-boxes to widen the light distribution, however these filters significantly decreases the intensity of the light.

In a studio where between 100-150 lights are used at the same time in a production, it is very difficult to adjust the light to get the exact setting you want. Instead the camera equipment usually has to be calibrated to fit the environment.

When using a large quantity of energy consuming lights that produce a lot of heat, the system need effective ventilation to cool down the equipment and to be comfortable for actors and studio audience, and it is a big cost.

All the lights in a studio are connected to a control table where adjustments can be made. Some adjustments that cannot be made electronically such as the angle or tilt of the light, is physically being performed with the help of long sticks or a ladder. This is a matter of cost, it would be possible to motorize everything but the cost is too high.

3.2.3 Most important qualities

Quality:

The most important thing in a light for motion picture producers is just like for photographers the intensity it can produce. The intensity should also be dimmable so that the light can adjust depending on the situation. The dimming functionality should have large possibilities of adjustment, preferably be step-less from 0-100%. When filming outdoors the intensity needs to be even greater to compensate for the strong natural lighting.

An important aspect is the intensity loss of the light, how much the light looses in intensity per meter of distance. The light usually needs to be placed further away than in photographic situations.

The color representation (Ra-value) needs to be very high in order to represent as many colors as possible for a high quality outcome. However this aspect varies a bit between different motion picture producers depending on what camera equipment they use, some use high quality cameras and for them the color representation is more important than for those who use low budget cameras that are less sensitive.

The stability of the light is important for motion picture producers as well but not crucial. The stability and quality of the light is essential to get a consistence in the light, and since large quantities of lights usually are used at the same time it would be beneficial to have control of the color temperature.

Adjustability:

The adjustability of the light, such as intensity, is just as important for motion picture producers as for photographers. It is as well very important to be able to adjust the height, pitch and angle of the light in the scenery.

Most motion picture producers also think it would be advantageous to be able to adjust the temperature of the light, but not crucial. In many cases there is only need to adjust the temperature in two steps – one for being outdoor (orange filter) and one when being indoor (blue-white filter). In other cases there is a desire to be able to adjust the light for the individual person's skin tone, hair color etc.

It is also important for motion picture producers to be able to control and adjust the spread of the light. In some cases a soft and scattered light is preferred and other times the light should be intense and focused on to the object. The spread could be adjusted either by diffuser filters or "flaps" on the sides.

They also thought that a modular system –light would be beneficial, where you can change the size or shape of the light so that it would have a wider light distribution in order to change the hardness of the light. To put several panels together creating a large one (the larger the source of the light is, the better), but that at the same time is foldable would be a very useful for motion picture producers.

Mobility:

There are many advantages with a portable light for motion picture producers as well, especially if the light is camera mounted. The size and weight of the light determine the portability possibilities as well as a more energy efficient light would need less battery power resulting in a reduction in battery size and lower weight. A camera mounted energy efficient light with integrated power supply would be a useful application.

An advantage would also be to have cord-less equipment in the studio as well. This is mainly for the mobility when moving stuff around but also that it is easy to trip over a cord, making the light to fall over and break which can be very expensive due to the high cost of the equipment.

To have the possibility to choose between cord-power and battery-power would be beneficial. It should be easy to change between the two power options and it should also be easy to change the batteries when the old ones are used up. A rechargeable battery-pack and a battery-pack for AA-batteries (batteries that you can buy in regular stores) could be a very useful solution.

The light should also be possible to mount both on a tripod and in the ceiling.

Standardization:

An important thing is to make the product compatible with all kinds of stands and mounting equipment that is available (tripods, camera mount, ceiling mount etc.). The light should use the same standard that is used today for other equipment, to be possible to use together with equipment from other brands and manufacturers.

Durability:

The light should be robust and qualitative so it can be handled roughly. The quality is very important, the product should be, look and feel robust. Some motion picture producers also recommended that it should be waterproof, in order to withstand rough outdoor environments.

Manageability:

The light should be easy to assemble and disassemble - how quickly it can be unpacked and mounted together, and packed down when done. The light should also be easy to carry around when disassembled, either incorporated in the casing of the light itself or in specially made cases for all parts of the equipment.

Cost:

If the light is comparable to similar products in quality, the cost would be a decisive factor when investing in new equipment.

Design:

The need for trendy equipment and fashionable studio environments is less important for motion picture producers than for photographers. The fashion within this industry is rather driven by technology and performance in relation to cost. The design should be driven by functionality such as portability and adjustability.

3.2.4 Qualities for a higher value

It would be a plus to be able to change the temperature of the light but not necessary. The intensity is in that case more important.

A remote control or even have an iPhone control application would be very useful for some motion picture producers and a cool experience enhancer.

The product should be strongly recognized among the users, through design language and colors (e.g. red screw) that represent the product line and brand.

The round shaped ring-light is also a possibility which could be mounted on the camera or used as a beauty dish. Different shaped lights or filters in a product family would increase the usability for different users in a larger spectrum of possible situations.

Sometimes, motion picture producers print out patterns or logos on a film and put it in front of the light, in order to get a pattern on to whatever the light is focused at. This is not a huge user need but could be easy to incorporate to enhance the value for the user.

3.3 SUMMARY OF INTERVIEWS

By interviewing photographers and motion picture producers, their preferences show that the light quality and intensity should be equal to the existing lighting equipment that is being used today.

The color representation (Ra-value) needs to be very high in order to represent as many colors as possible. How this will affect the price and if it is worth it, to what extent a lower quality will be noticeable, is very hard to say.

A high color representation value does not necessarily mean that you have a good color representation; you can still lack certain wavelengths. Some information in the light can still be missing in the linear spectrum. This results in that some colors still look grey.

The intensity of the light is the most important thing, but also the biggest problem with constant lights. The high light intensity that is needed for the equipment, could be inconvenient for the model or object being exposed to the light and also leading to unwanted effects such as making the eyes of the model squinting or the pupils small. On the other hand, a constant light might actually instead be more comfortable for the model than a flash, as the flash might disturb the concentration where you will get used to a constant light and not disturbed by it.

Another benefit with constant lights is that the light and shadows can be "sculpted" in real time where what you see is what you get.

However, "one light does not fit everything" – there is no light that is optimal for every situation, it needs to be somewhat changeable or have a high level of adjustments.

Photographers do not need to adjust the temperature of the light to the same extent as motion picture producers do. For photographers it is more important with the standardization of the light temperature (daylight, around 5500 K).

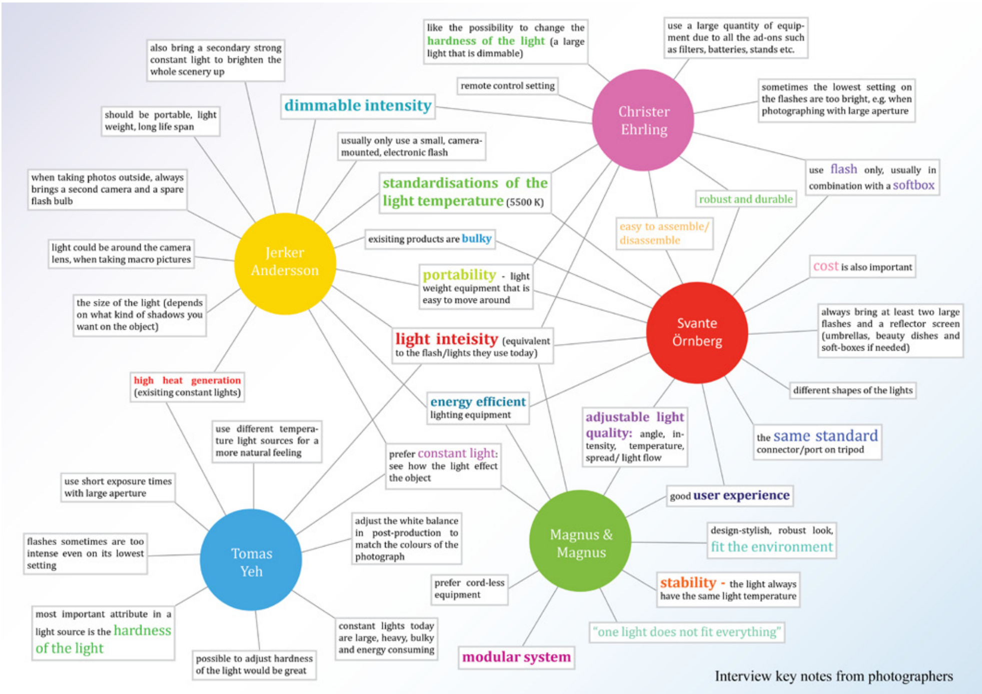


Figure 3.3.1 Summary of interviews - photografers (See Appendix D1&D2)

It is also important to be able to change the spread and flow of the light. Sometimes the users want extremely focused light and sometimes not. However, when changing the spread of the light the intensity also changes, from having higher intensity when being focused to loosing intensity when being spread out.

The higher price for more expensive equipment does not give you higher quality light (as for e.g. cameras where the quality of the picture gets better). Instead the robustness and quality of the gear is better, you are able to handle it with less care and a greater roughness then with cheaper equipment. It can usually also endure rain and dirt to a larger extent.

The quality of the battery usually also improves with a higher price where a longer lasting battery is preferable. A higher price usually also mean that there are more steps or levels of adjustments that can be made to the light.

The black color of existing light products and photo equipment is among other things due to the low amount of unwanted reflections a black color creates. However the black color has been standardised within the photo and motion picture production industry without any other obvious reasons.

The user experience is also very important. The user experience should fit the user's needs in terms of having a robust quality as well as other auxiliary proper- ties such as easy to grab the equipment or longer battery life span, or compatibility with standard equipment.

A modular system where several panels can be put together would also be very useful and further increase the multiple uses of the light. A modular system of arranging several screens together would be very beneficial, to be able to change the size and attributes of the light depending on the situation – perhaps put several screens together creating one big screen or put them together in a row for having the light coming from several directions at once.

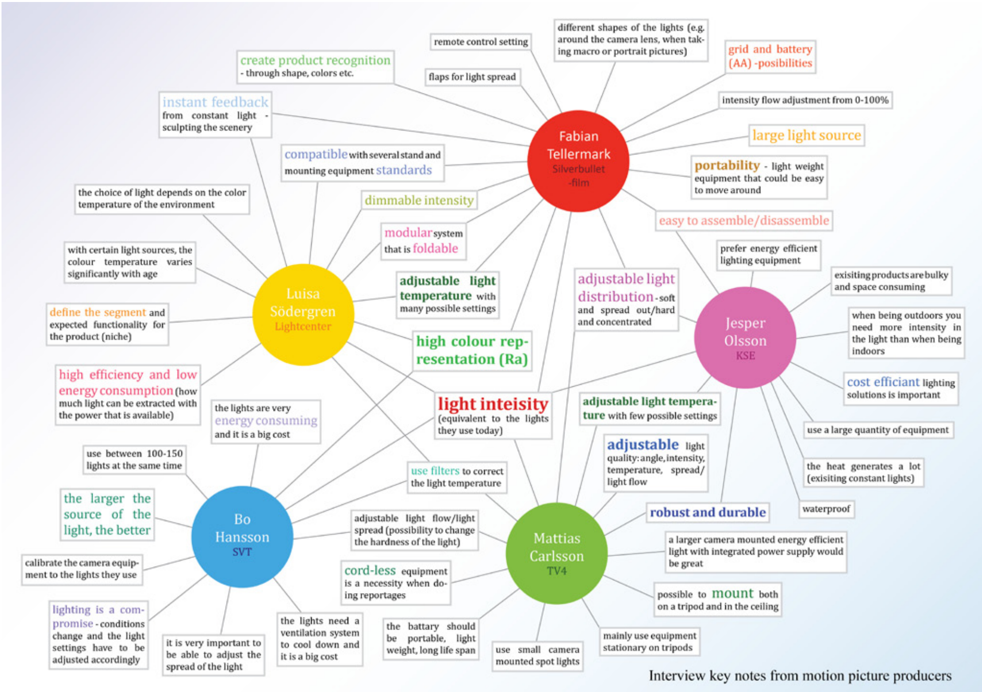


Figure 3.3.2 Summary of interviews - motion picture producers (See Appendix D1&D2)

3.4 LIGHT INTENSITY MEASUREMENTS

In order to get a perception about the light intensity commonly needed in a real studio environments measurements were performed in connection with the user studies using a Lux meter. The Lux value (lx) is a measurement of illuminance or luminous power per area and is commonly used by professionals. This Lux value was important to collect for the continuos work of the master's thesis in order to set a requirement of the light intensity output needed from the product.

Lux measurements were performed in both photography studios as well as in television studios at Swedish television SVT and channel 4, all in the Gothenburg area. The measurements were taken at the point where the illuminated object would be positioned. The results can be seen in table 3.4.1 below.

Lux measurements in television studio environment:	Shooting centre from front	400-700 lx
	Shooting centre from back	400-500 lx
Note: The light intensity in a television studio environment is usually the result of the combination of several lights directed to one focal point.		
Lux measurements in photography studio environment:	Shooting centre from front	1000 lx
	Shooting centre from back	600 lx
Note: It is not possible to get measurements of the intensity from a flash since the energy is released during a very short period of time. Because of this the measurements are merely estimations on the basis of the setup light from the flash lamps. The actual flash intensity is in reality higher.		

Table 3.4.1 Light intensity measurements in studio environments

According to the light intensity tests the intensity at the focal point should be at least 500-1000 lx when the light source is about two to three meters away from the focal point. This results is that the intensity from the light source should reach at least 4000 lx but preferably twice the intensity.

3.5 USER OBSERVATIONS

User study or observation is a way to learn how people behave in real use situations. It provides information about e.g. how much a product is used and how a task is performed. Observations can unveil user behavior that they are not aware of themselves, information that therefore is hard to acquire through interviews. The method enables gathering of both qualitative and quantitative data (Bohgard, et al., 2008).

As a complement to the interviews, user studies where performed in connection with the interview sessions. This resulted in a more extensive knowledge base and a deeper understanding about the practical part of the everyday work for photographers and motion picture producers.

The user observations also resulted in support for the findings from the interviews.

Figure 3.5.1 User observation during recording of a motion picture.

Figure 3.5.2 User observation during photoshoot.

Figure 3.5.3 User observation during photoshoot.

Figure 3.5.4 User observation in television studio.

Figure 3.5.5 User observation in photo studio

Figure 3.5.6 User observation in television studio.

3.6 CONCLUSIONS OF USER STUDY

Conclusions that can be drawn from the user studies are the importance of a portable product that can easily be transported and assembled/disassembled, and that one light does not fit all situations.

The portability is dependent on the technology and previously there has been little innovation or development of light equipment, current equipment is in most cases heavy, large in size and inefficient. The fact that one light can not fulfil the requirements of all possible situations results in that a large quantity of equipment is needed. This further limit the portability.

In addition, although both photographers and motion picture producers refine their work in post processes, it is preferred to finalise as much of the work as possible during the actual shooting. This is mainly due to the time limitation and the fact that post processing is a time consuming activity. Better quality lighting effects the outcome positively and less time is required for post production. As a result this creates high demands on the equipment. For the end user more qualitative light equipment is directly translated to higher revenues for their work.

It is also not only the quality of the light that is important but also the build quality of the product; the robustness and durability. The equipment is often handled without care and a fragile product would not stand the strains it can be exposed to.

As for making the product strongly recognizable among the users, a complete design language should be developed including shape and colors of the actual light panel, as well as its accessories. The design language should incorporate a stand made specifically for our product in order to further enhance the fashionable styles of studio environments, but also be standardised in order to be able to be used together with other brands and existing products.

There are two possible directions for a compatible product:

• Find the right market segment for the product in terms of possible qualities we can achieve, and design regarding this segment. Create a “niched” product aimed for this specific segment of the market - low budget, low adjustability or high quality, large adjustability, high intensity etc. What kind of users are we designing for and how can we reach their needs? Where and in what situations will the light be used?

The market is moving in two directions:

- Low budget productions using 5D, 7D -cameras etc. in need of strong intense lights.

- High budget productions using RED, ARRI Alexa -cameras more sensitive to light (not in need of high intensity lights but a larger extent of possible adjustments and a more qualitative light output).

• In order to meet a larger extent of user needs and requirements, multiple solutions for the light should be constructed to be used in many different situations. Several uses for the light create a higher usability and the light can be used to a larger extent. A large coverage of adjustability of the light is important in order to create a compatible product on a demanding market.

3.7 DEMAND SPECIFICATION

The demand specification serves as a control document for the development process and specifies what the product must be able to do (Baxter, 1999). The demand specification is a summary of the requirements found and defined in the pre-study phase of the project work. In this project the demand specification is based on the results from the previously performed theoretical study and user-study.

The demand specification lists and specifies all the design and function criteria in order to set the outline of the continuous project work. The demand specification can also be used as a communication tool in order to create a common viewpoint of the project goals, between the members of the project group as well as clients and stakeholders.

The functions listed in the demand specification were categorized and given a priority value from 1-3 (1 being lowest priority and 3 the highest) depending on their importance of implementation in the final product. The full demand specification can be seen in appendix E.

In order to be a high quality product the most essential criteria are the light quality and strong visual qualities. The product should also be innovative in its functionality as well as visual appearance in order to create interest for and match the new technology of LED being used in the product.

Other important utilities are standardization and environmental aspects. The standardised functionality is important for compatibility with existing products on the market such as battery packs, tripods and ceiling mounts. In this case the user can continue using previously invested accessory equipment.

The environmental aspect is important since the basic elements of the product originate from recycled LCD monitors and the usage of LED technology can reduce the energy consumption compared to existing products. The environmental element should therefore further be enhanced in design and functionality.

The demand specification is essential in order to get a comprehensible understanding about what the product should be and how it should function. It is also a great tool for communicating these outlines and creating a common focal point for the parties involved in the project.

The result from creating priority values for each quality was a more manageable and more easily foreseeable hierarchical structure highlighting the most important criteria.

1 INTRODUCTION

2 PRE STUDY

3 USER STUDY

4 CREATIVE IDEATION

5 CONCEPT DEVELOPMENT

6 CONCEPT REFINEMENT

7 FINAL CONCEPT

8 DISCUSSION

9 FURTHER RECOMMENDATIONS

10 REFERENCES

11 APPENDIXES

4 CREATIVE IDEATION

The next stage in the project was to start visualizing ideas and thoughts, based on the information that had been gathered in the pre-study phase. In order to generate and develop as many different solutions as possible a number of creative methods are implemented.

The purpose of the methods is to facilitate the designer to be creative and to think outside the limits that current product are enclosed by. To generate new ideas is also known as divergent activity, meaning that the ideas generated have a tendency to lead to a variety of possible solutions. The proposed solutions that arise subsequently results in a number of different concepts which are then evaluated and criticized for providing the basis for further development of the concepts (Isaksen & Treffinger, 1985).

Visions were expressed by preparing image boards, sketching different ideas as well as using computer modelling and paper mock-ups in order to examine the three-dimensional aspects of different shapes. A lot of focus went into brainstorming functional solutions for making the product more portable. In order to explore all possible solutions to a problem the task or function should be broken down into sub categories and considered one by one.

Regarding problem solving and design one should also consider the creative aspect where the idea generation also functions as an artistic and inventive source of inspiration. The idea generation started out as a broad process, gradually narrowed down so that it in the end could result in a handful of concepts for development.

4.1 IMAGE BOARD

To start the design phase and define the expression and context of the product, several image boards were put together. An image board is a collection of images and/or graphics put together in a composition to represent an intended mood or emotional response of a design. The method allows designers to express themselves and communicate beyond the limitations of written text. It can be used to confirm a design brief and to help make teamwork towards the same goal. The images can be literal or abstract and can be used both to generate ideas and to evaluate different designs later in the process (McDonagh, Bruseberg, & Haslam, 2002).

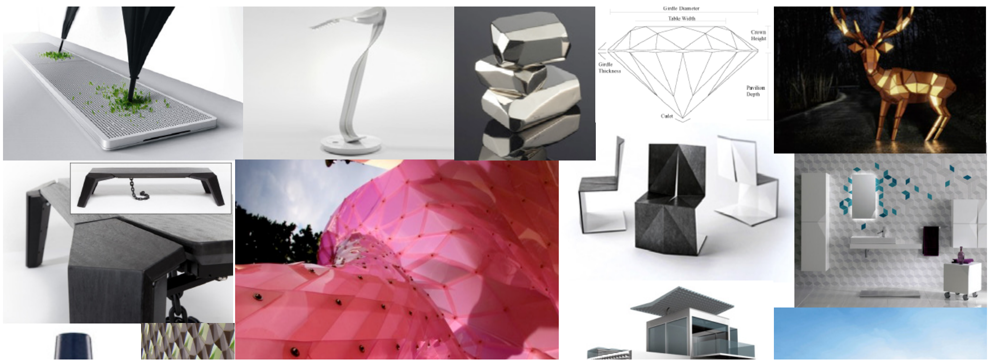


Figure 4.1.1 Selection of the image board used in the Photo Light Concept development.

The image boards were made to express beauty and innovation in shapes, materials as well as functions. The method resulted in an extensive set of inspirational boards compiled of product images. Each product image was handpicked for its beautiful and/or innovative characteristics that to some extent could be translated as inspiration in the following idea generation process (see Appendix F).

The keywords used were: Cool, diamond, simplicity, precision, protection.

4.2 INSPIRATION BOARDS

An inspiration board is a collage of images, words, and objects that a designer has collected and wants to organize and keep at hand as a reference for a project they are working on, which could be in the form of a paper poster, a bulletin board, a digital graphic, or any visual medium. It is a way to organise references and research to create a framework for inspiration (McDonagh, Bruseberg, & Haslam, 2002).

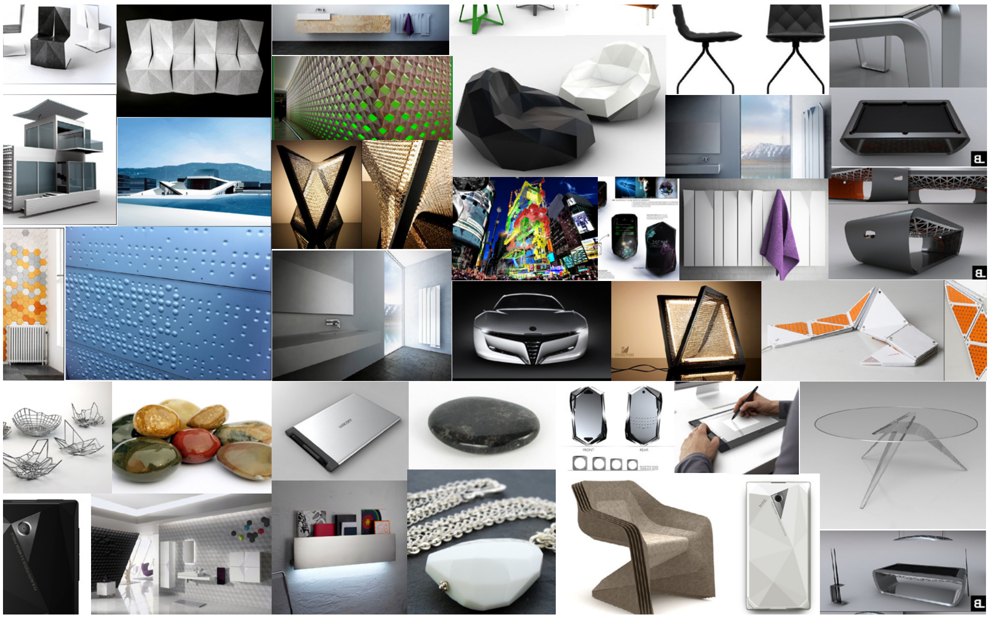


Figure 4.2.1 Example of inspiration board used in the Photo Light Concept development.

Products, interior designs, architectures, patterns were selected to create the inspiration boards which tell us how the design will look like and to some extend, respond to the image boards. The complete inspiration board can be seen in appendix G.

4.3 BRAINSTORMING

Brainstorming is a common method for quickly generating many ideas. It is a group process aimed at that the participants evolve each other's ideas. The approach is that the group tries to come up with as many different solutions as possible to a predetermined problem. It is important to keep an open-minded atmosphere, therefore no criticism or negative comments are allowed and divergent thinking and crazy ideas are encouraged as they may lead to new realistic ideas. All ideas are documented during the session and evaluated afterwards (Bohgard, et al., 2008).

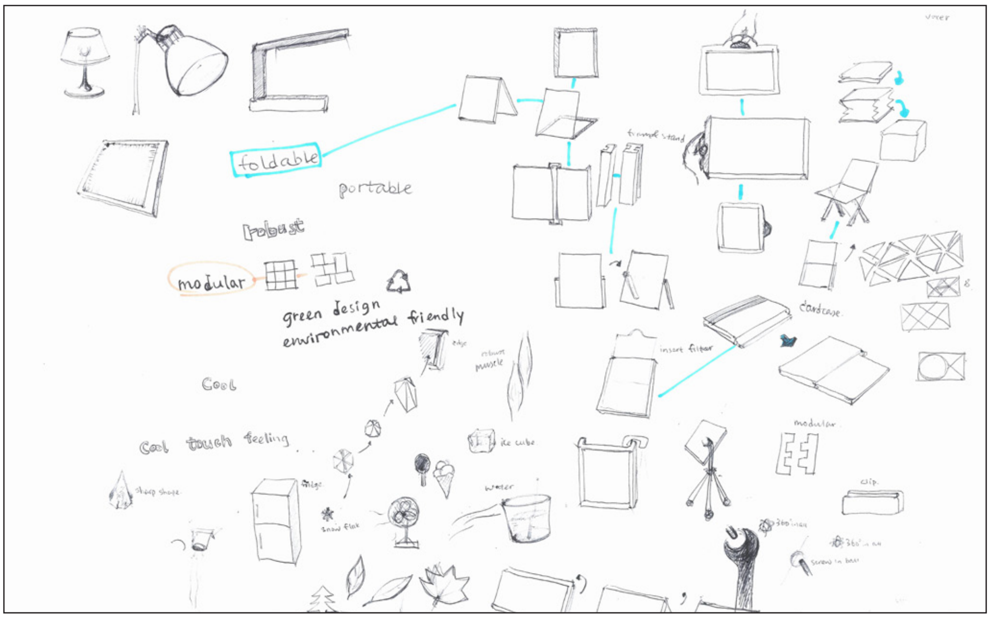


Figure 4.3.1 Brainstorming sketches

The brainstorming sessions were started off by general sketching of ideas based on different properties defined in the demand specification. The words were gone through one at a time, to try to get every idea on paper that might have surfaced during the pre-study phase. When these initial ideas had been exhausted, efforts were instead put into finding solutions to specific functions. These functions were also drawn from the demand specification. In between these brainstorming sessions, pure form design sketching session was held.

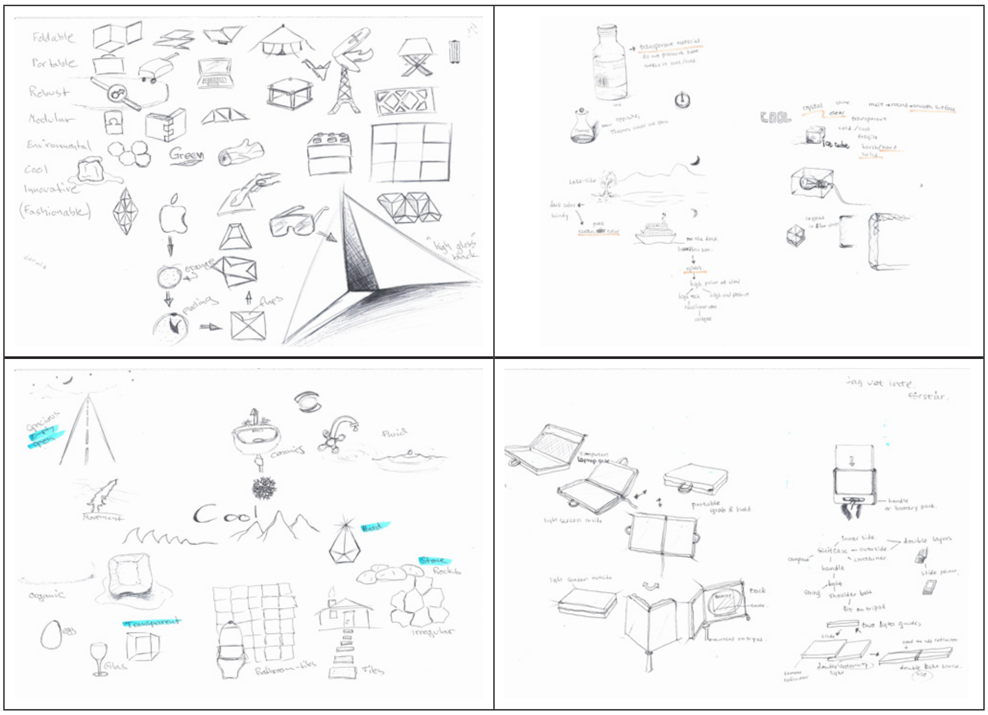


Figure 4.3.2 Brainstorming sketches

4.4 FUNCTIONAL PRINCIPLES

The design phase was continued by idea generation regarding functional possibilities for greater portability of the lighting solution.

In order to explore the area of portability to a fuller extent the main objective was further defined as foldable, modular, lightweight and manageable.

4.4.1 Paper folding

On the basis of the definitions for portability several functional principles could be defined and considered. These were: sliding, folding (book folding, map folding, fan folding), rotating, overlapping, peeling, intersecting, pop-up, wrapping, snapping connect, puzzle connect, rolling and scrambling. Much inspiration was taken from the nature, origami, architecture and astrophysics where these principles are at use. Each of the principle was investigated and explored in detail resulting in a large extent of possible functional solutions for each, some more realistic than others.

One most famous example of paper folding application is the Miura-ori, which has been considered as a method for folding up the antennas of satellites before they are launched. This technique allows an antenna to be unfolded and collapsed simply by pulling on opposite diagonal corners. Normally, complicated procedures are required to be unfolded and collapsed when a machine is folded in fourths or eighths. With an origami-inspired folding method, however, it can be made extremely simple.

Since simple but innovative could be the basic design criteria in this thesis project, and considering origami could have a huge possibilities when exploring portable methods, paper folding has been chosen to be used as a tool to explore more ideas.

Figure 4.4.1.1 Ideation through paper folding

Origami structures can be found in nature principles as well, such as in the growth process of plant leaves or flower buds, and in the wings of butterfly or the fins of fish. It is interesting to know that one form could be transformed into other form just simply by folding.

Creating paper structures initially in the idea generation phase proved being a great starting point for inspiration and thinking in unconventional paths. The result from this method was a great extent of ideas with problem solving principles that would not have been discovered otherwise and where many showed large potential for further development.

4.4.2 Mock-ups

A mock-up is a design model, a simple physical model, which is used in the design process to clarify certain requirements, forms, dimensions or features that the outcome should fulfil. The model should be simple, both in terms of structure and materials. The model also does not need to be built in full scale. However, for all models a consistent quality must be maintained to not endanger any concept to be deselected on the wrong grounds.

The mock-ups were used for evaluating the folding principles and the ideas that emerged during the creative ideation.

Figure 4.4.2.1 Examples of mock-ups created during the creative ideation.

4.5 IDEA SELECTION

During the idea generation phase a large number of ideas was developed resulting in a large number of different concepts. The concepts show no solutions in detail, but only basic shapes and basic functions.

As a first step in the idea selection phase, the method PMI was performed in order to evaluate the concepts that have been selected for further development and also the interesting features that have been identified to be useful in developing the concepts. PMI stands for Plus, Minus, Interesting, and is a method used to analyze the existing solution proposals and divide them into positive, negative and interesting aspects. These aspects can then be used in the further development of the solution proposals. The PMI-tables can be seen in Appendix H1-H3.

The PMI-table was then analyzed and interesting concepts were selected. Some concepts were also considered to have properties that may be of interest to develop further and apply to future suggestions, and where therefore also kept in mind.

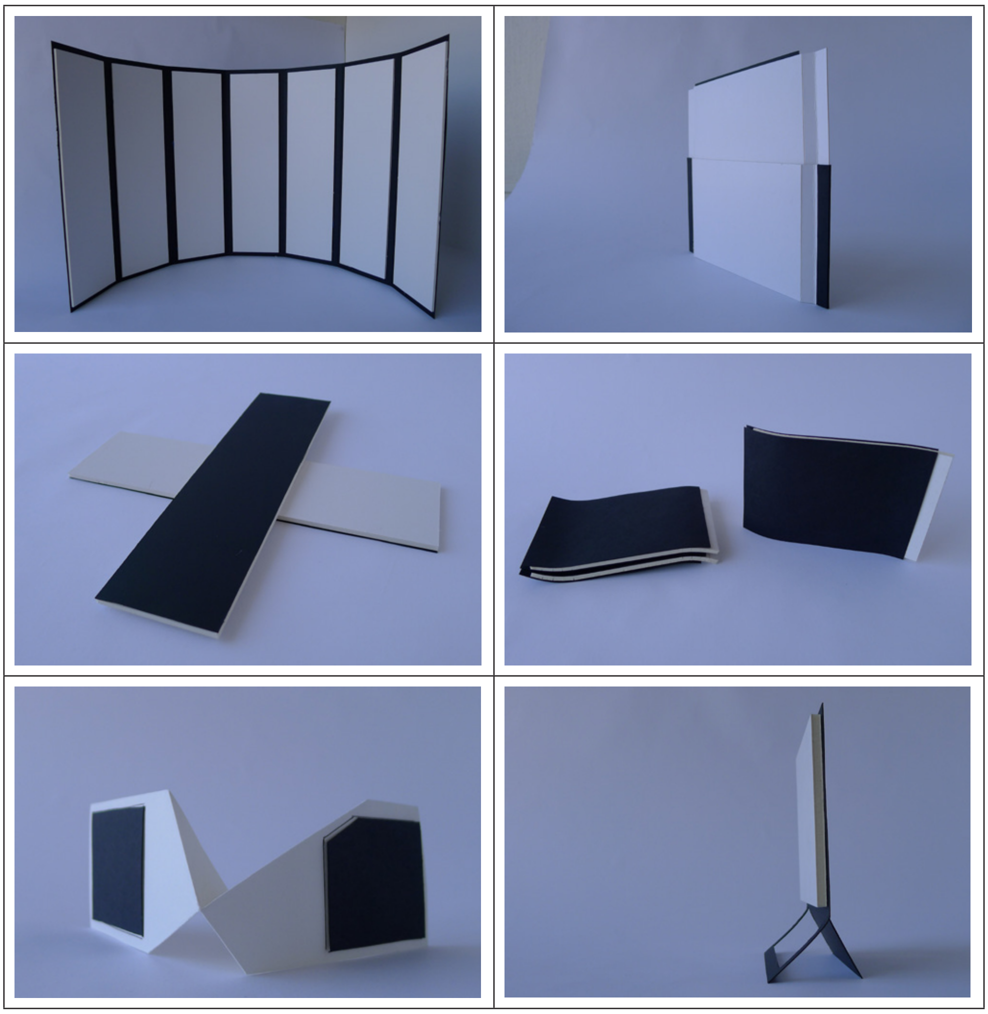


Figure 4.5.1 Compilation of functional principles for evaluation during the idea selection.

In order to evaluate the ideas furthermore and sort out good concept for further development, a meeting was arranged with the supervisors from both BOID and Chalmers where the first idea selection was carried out.

During the idea selection, areas such as appearance, functionality, design, manufacture, market and demand where considered.

Most of the concepts were considered to have potential for further development but some were judged to have greater potential than others and were therefore selected for further development. Positive attributes from other concepts were also applied to the inferior concepts in order to create interesting combinations. Several ideas were both innovative and fun, but these were, after all not selected because they were not realisable in practice.

Based on the results from the PMI and discussions during the meeting with the supervisors, three concepts were selected for further development. These concepts can be seen in figure 4.5.1.1, figure 4.5.2.1 and figure 4.5.3.1.

Some solutions were considered being interesting but not fully feasible or too functionally complicated for being practical. Other solutions were considered being interesting but for other applications such as common lighting or interior lighting.

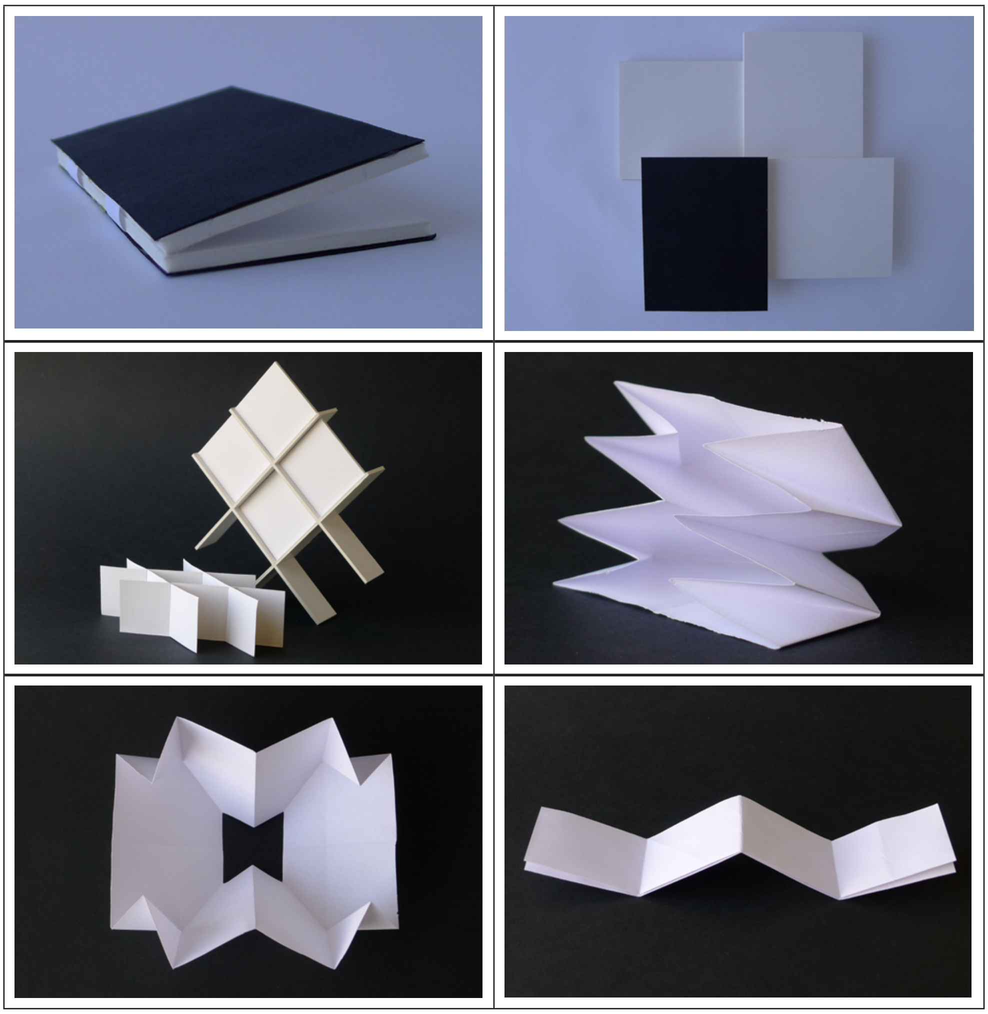


Figure 4.5.2 Compilation of functional principles for evaluation during the idea selection.

The chosen solution principles for further development were: rolling, book folding and map folding. These solutions were selected since they showed high innovation and problem solving for greater portability, but at the same time being simple in their construction principle and therefore have a better usability for the end user.

4.5.1 The rolling concept

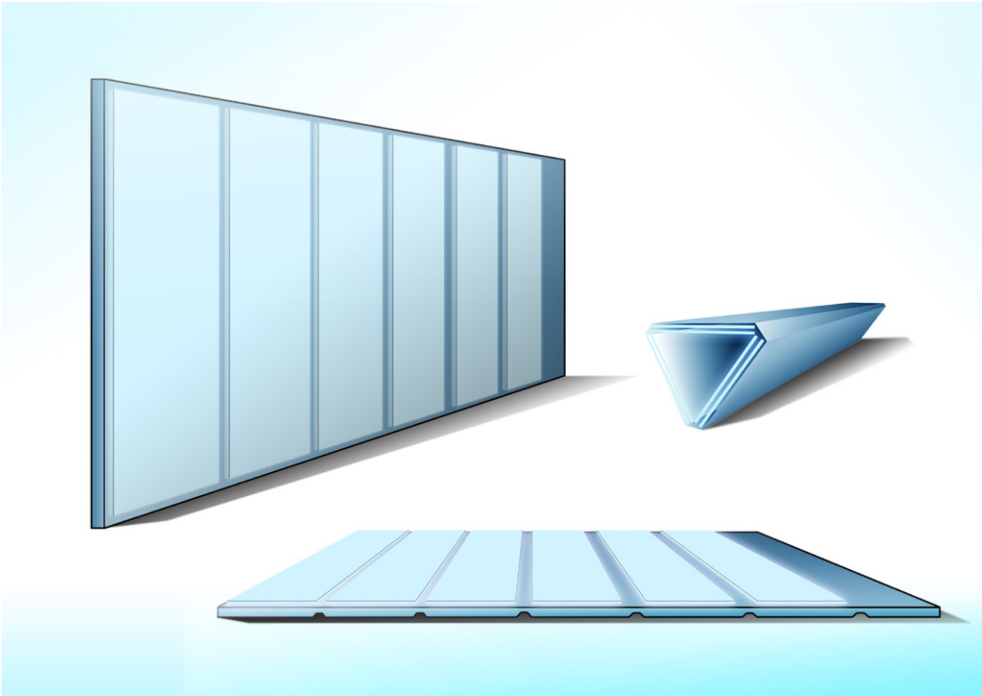


Figure 4.5.1.1 Rolling concept.

The concept is based on functionality where the light guide has been divided into long and thin segments so that the complete module can be rolled up. This functionality makes the product easy to pack and carry which increases the portability of the product in a highly innovative and interesting fashion.

In the rolled up state the shape created when viewed at from the end sides can take many forms depending on the amount of light guide segments used. In figure 4.5.1.2 we can see a triangle become a square and then a pentagon creating the appearance of a rose. Interesting possibilities with the roll-up functionality that should be further explored are the different shapes and rolling methods that can be applied to the concept.

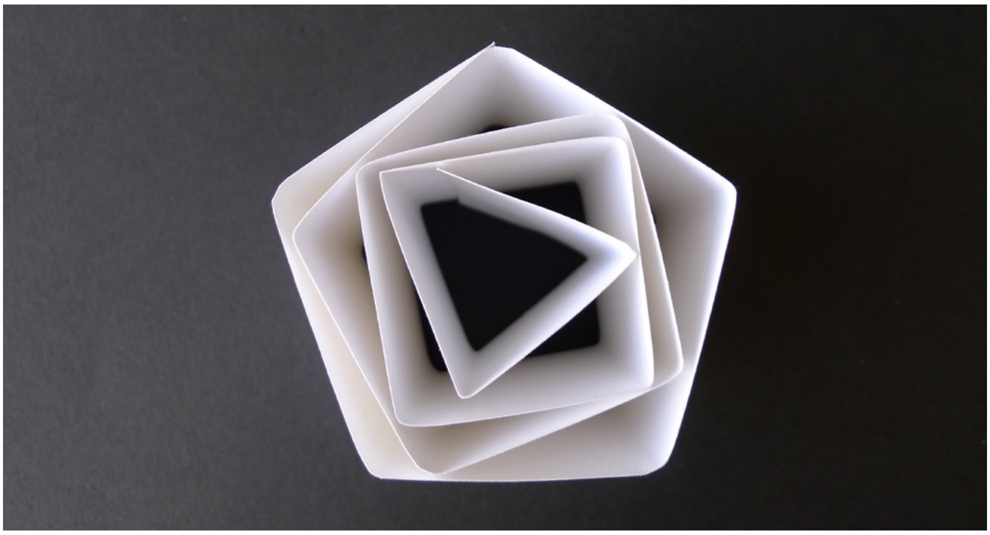


Figure 4.5.1.2 Rolling concept in rolled-up state.

Because the light guides are divided into segments a higher light intensity can be achieved. More LED lights can be fitted around the edges of the light guide cut in segments than if it is one complete pice.

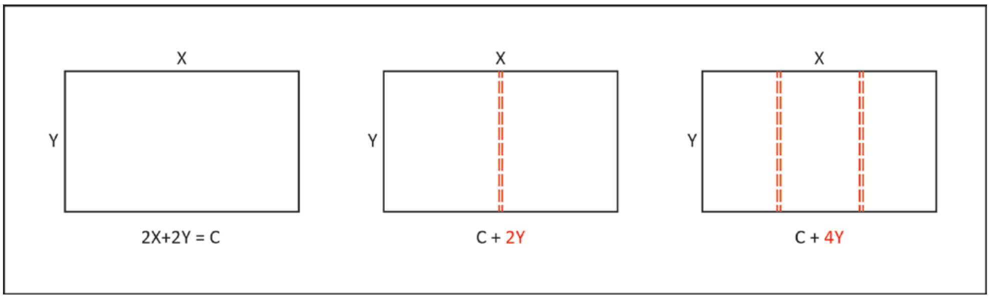


Figure 4.5.1.3 Intensity increase due to larger area for LED lights around the edges.

As a protecting backside and connection between each segment a flexible material, such as fabric or polymer, can be used. If so the complete module can be angled inwards or outwards in order to focus or spread the light.

The rolling concept can also be mounted on a tripod, ceiling mount or directly onto the wall.

The concept is applicable for all kinds of light guide sizes but probably best suited for larger but thin light guides.

Issues that need further attention are the diffusion of the light since many small light sources is not equivalent to one large light source, and the gap in between each module. However, the light characteristics and shadow/reflection attributes on to the object being photographed, could be a design in itself differentiating the rolling concept from traditional lights used today.

In the beginning, the rose shape in rolled-up state was considered as a nice shape. Much effort went in to trying different shapes and how it could be rolled-up depending on the numbers of segments and the angle between each segment.

The triangular shape was developed instead of the pentagon or rectangle shape. The decision was made not only because the triangular shape has more sharp corners which makes it easier to grip, but also when rolled-up in a triangular shape, less space is wasted on the inside of the roll which makes the size of the roll smaller and more suitable for a good grip when holding it. The smaller area in rolled-up state is also beneficial during transportation as well as it further enhances the property of being portable.

4.5.2 The book folding concept

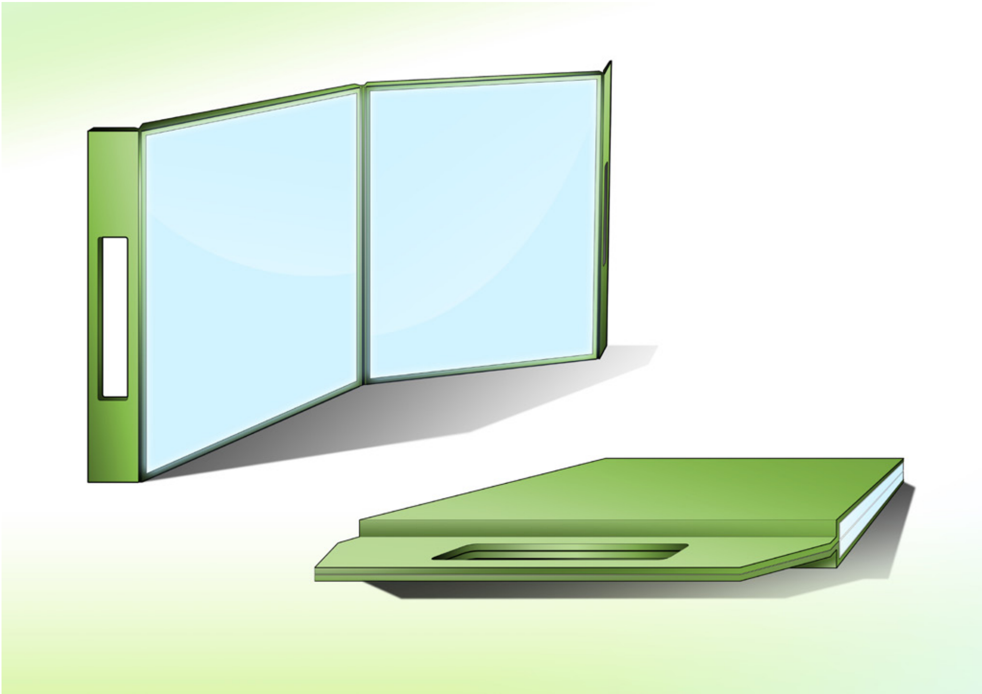


Figure 4.5.2.1 Book folding concept

In this concept the folding principle is performed in the same fashion as how you open and close a book. By doing this the light guide segments can be protected when transporting the product.

The concept also enables a quick and easy way of setting up the light on location but at the same time contain enough light output for reportage photography or smaller sceneries. The slim, agile and convenient qualities remain even when folded and makes the product highly portable yet sufficient and effective in professional use.

The light can also be focused or spread out depending on how the modules are angled in relation to one another.

The concept is probably best applicable for smaller size light guides. Using larger sizes could result in difficulties in operation and transportation of the product. However, thicker light guides could be used in this concept utilizing a larger amount of existing recycled parts.

The drawbacks with the concept are the somewhat conventional functionality as folding principle, and the low possibilities to make it modular. However, the innovation of the light guide and LED -technology is game changing in itself and since the book folding concept enhances the portability it was chosen to be developed further.

4.5.3 The map folding concept

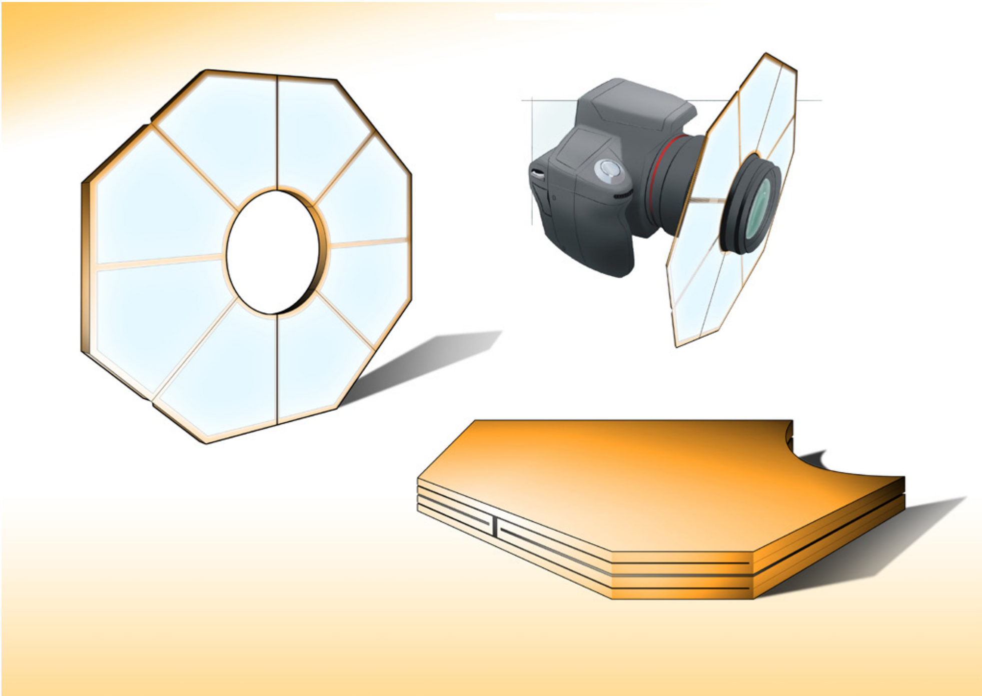


Figure 4.5.3.1 Map folding concept

The inspiration for the map folding concept is taken from one type of method of folding maps called Turkish map fold.

In folded state the object is only one fourth of its unfolded state area creating an object with very high portable qualities. However, since the folding principle instead builds up the total thickness when folded, the concept is best applicable for thinner light guides.

The concept could either be used in a large size suitable for fashion photography, taking advantage of the hole in the centre of the light, where the photographer wants to take the picture from the centre of the light source, or as a small ring light mounted on the lens of the camera for macro photography.

The concept could also be suitable for creating a module-based product.

Because of the structure for folding the concept, the light can be focused, spread and sculptured with large variation. The folding parts function as flaps and can be adjusted by changing the angle between them in relation to one another.

Issues could be the structure stability of the material. The product should be flexible yet has a stable but adjustable structure in unfolded state.

4.6 DISCUSSION

The creative ideation resulted in three concepts for further development. The concepts where chosen because they showed great potential and high but realistic level of innovation of their respective functional principle.

Much inspiration in the creation of these concepts was taken from the art of origami and the method of folding paper. For idea creation this method showed to bring valuable solutions to the principle of portability.

Building simple mock-ups was also a great tool for evaluation of the different principles as well as a good tool for communicating the ideas, something that otherwise could be difficult merely by sketches.

At this stage no deeper considerations had been taken regarding design, choice of materials or practical functionality, these are aspects to consider further in the development process.

5 CONCEPT DEVELOPMENT

5 CONCEPT DEVELOPMENT

After the concept solutions of interest have been chosen, a further development of selected concepts began in which all the positive characteristics were taken into account. At this stage there was a need for more accurate and advanced models in order to evaluate the form, functionality and design solutions in detail. Because of this the CAD software ProEngineer and Alias were used. Additional software used for visualization at this stage were Adobe Illustrator and Adobe Photoshop. Additional information collection was also performed in areas such as, materials manufacturing processes and opportunities/difficulties with different structures such as dimensioning of materials for satisfactory strength properties.

Several solutions from the idea generation where selected since they all showed product potential. Each solution also showed potential for different segments within the photo and motion picture industry. The result was to create a product family where the different solutions can be used for what application they show the greatest value in. Common attributes in design, functionality and materials need to be considered for a uniformed product expression.

The concept development resulted in more detailed and refined solutions of the three concepts.

5.1 SKETCHING AND VISUALIZATION

Sketches and images are used in different stages of the development process and for different reasons. Images are used for both exploration and communication; for the individual, within the team and to external steak-holders. An initial sketch can describe a fuzzy idea of something that requires further development while a more finished rendering can help sell a concept to a client or business partner. Sketches can be made traditionally and digitally in 2D as well as in 3D (Pipes, 2007).

In the beginning of the brainstorming phase, we started to sketch randomly. Some initial feelings that we would like our design to represent such as cool, diamond, simple have been decided. A focus point during the sketching was also functional principles and technical solutions of the different principles.

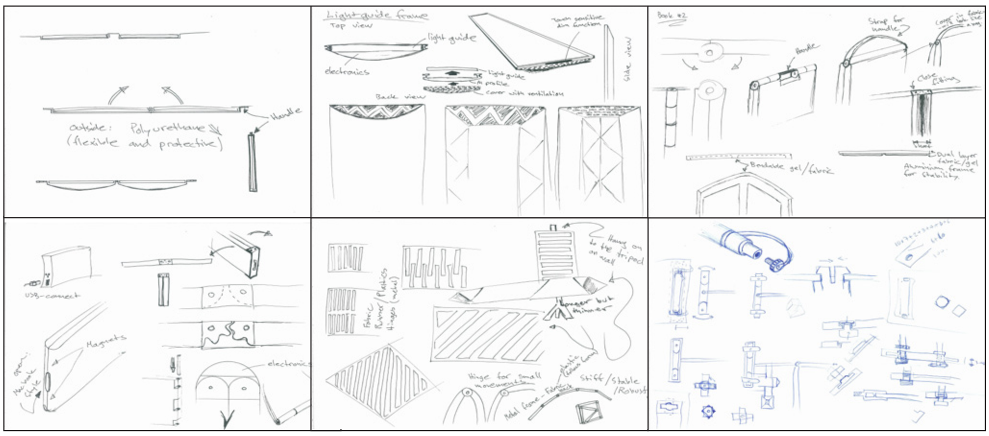


Figure 5.1.1 Sketches of functional principles.

5.2 CAD-MODELLING AND MOCK-UPS

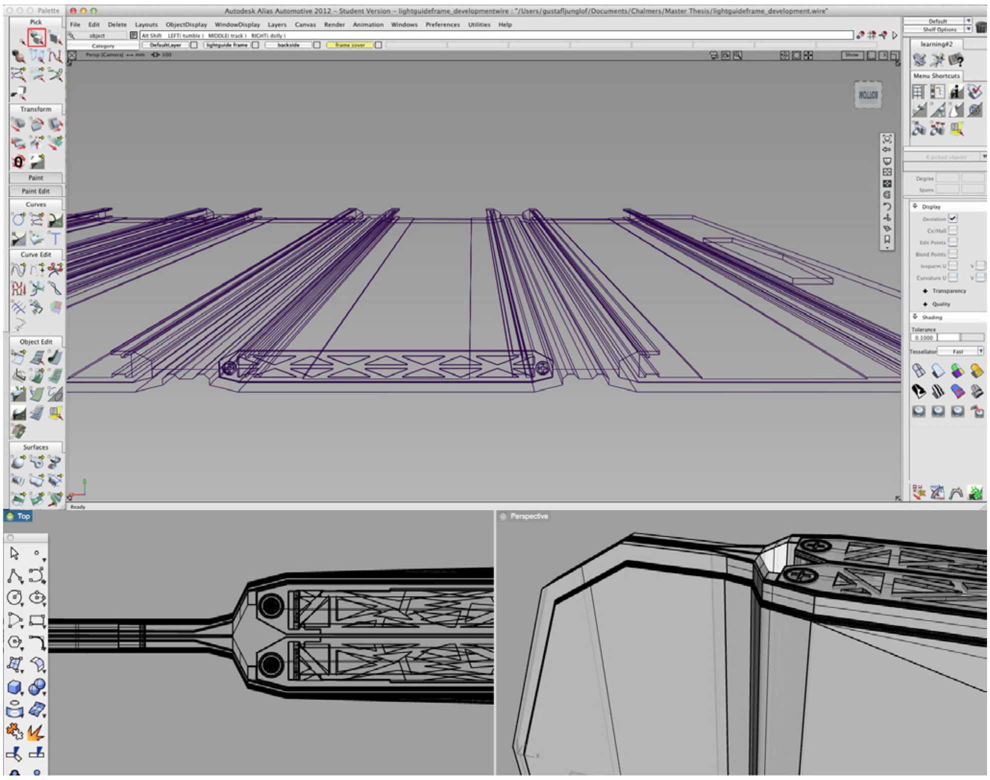


Figure 5.2.1 Screenshot from a CAD modelling session.

With the help of today's technology advanced models can be built and visualized in the computer in a relatively short time and there be evaluated after the required standards that have been set up on beforehand. To generate these computer models CAD (Computer Aided Design) software is used, an effective and useful tool for creating virtual 3D models. These models can then be used to visualize ideas and demonstrate how the finished product would look like. Based on the models created, you can also make 2D drawings and make calculations on various characteristics of the model such as weight and durability. Computer models can also be animated to further communicate the concept.

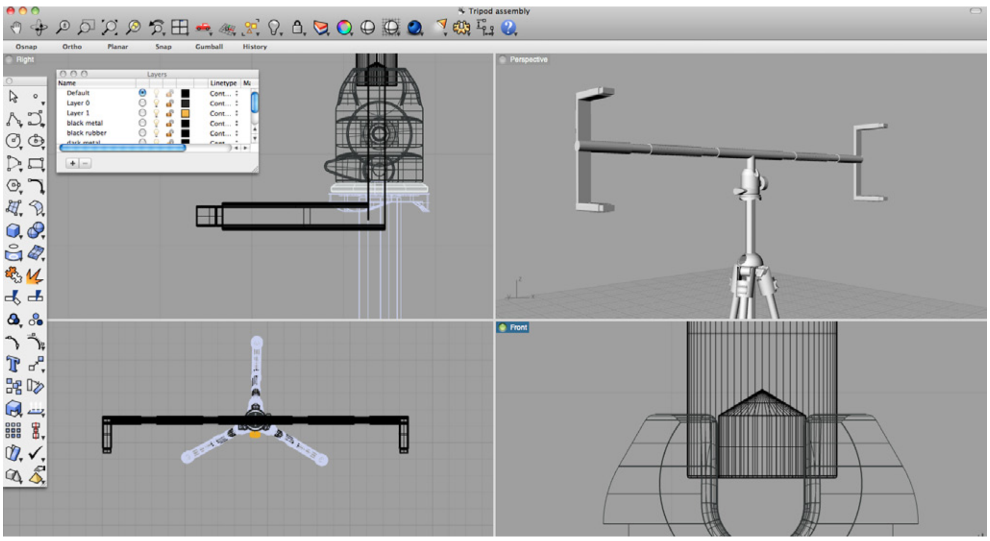


Figure 5.2.2 Screenshot from a CAD modelling session.

Mock-up models were also iteratively created during the concept development process in order to evaluate the designs as well as the functional principles that emerged.

The mock-up models were also used for evaluation purposes later on during the user focus group in the concept refinement phase.

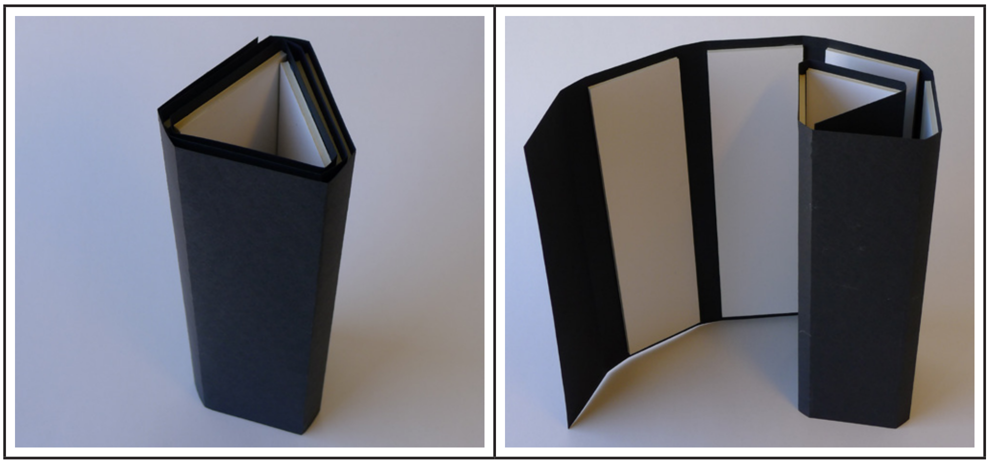


Figure 5.2.3 Mock-up of the rolling concept.

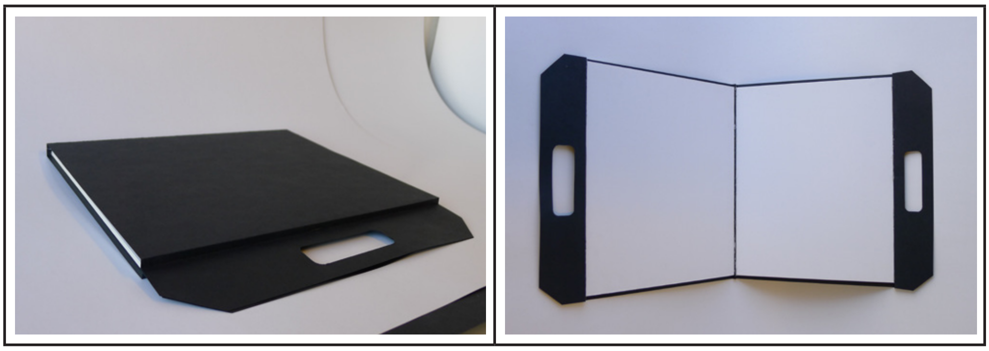


Figure 5.2.3 Mock-up of the book-folding concept.

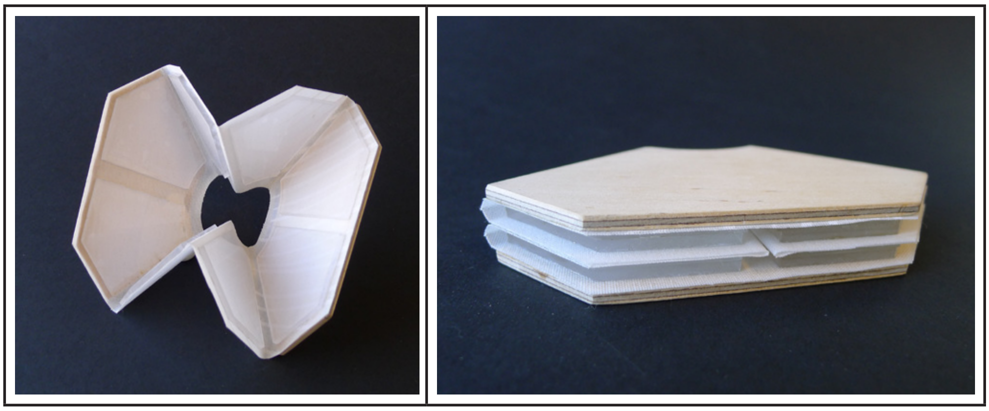


Figure 5.2.3 Mock-up of the map-folding concept.

5.3 DEVELOPED CONCEPTS

5.3.1 The rolling concept

The roll-up functionality has been further explored on variations of dimensions of the segments and the distance between each segment, as well as the placement and the arrangement.

One idea was to enlarge the distance of each segment in order to be rolled-up, while on the other hand, enlarge the width of each segment. Since the different dimension on the segment could cause some waste in manufacturing process, we decided to enlarge the distance in between instead of increasing the width of each segment.

The 47 inches (104cm x 58cm) LCD backlight has been chosen as a reference to divide the segments. Up to eleven segments could be divided in one 47 inch LCD backlight vertically and 6 segments could be divided horizontally for a comfortable holding size. The arrangement of the segments is also illustrated in Figure 5.3.1.1.

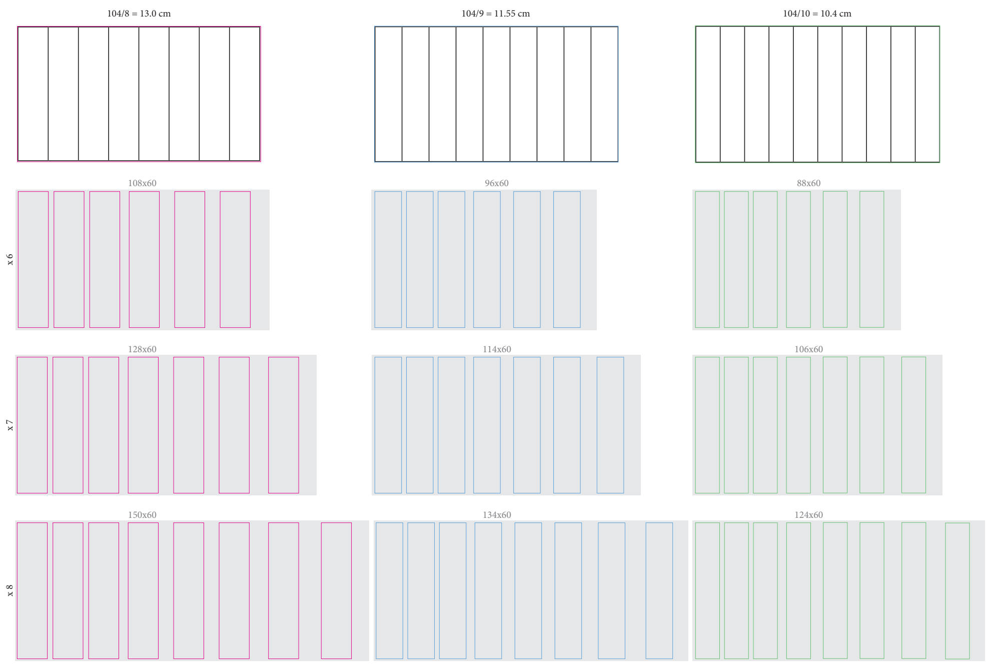


Figure 5.3.1.1 Variations of number of segments horizontally distributed.

The decision of how many segments that should be arranged in one piece is not only concerning the total length of those segments in an array, but also when rolled up, whether the size of the roll is possible to be hold.

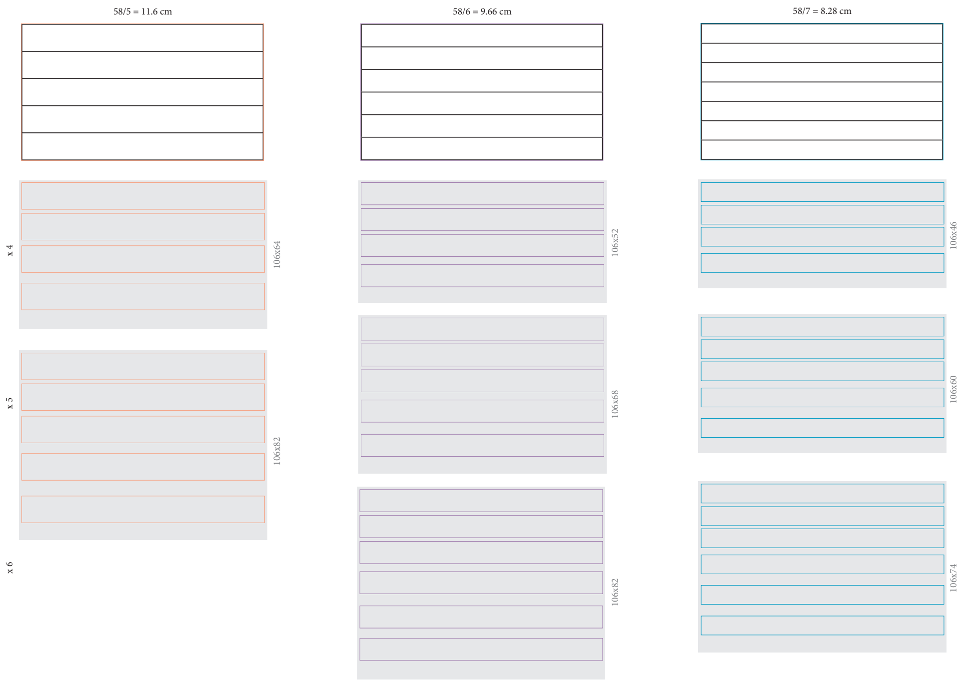


Figure 5.3.1.1 Variations of number of segments vertically distributed.

By carefully testing and comparing, a total amount of seven or eight segments divided vertically in one 47 inches LCD backlight is highly recommended (see appendix I).

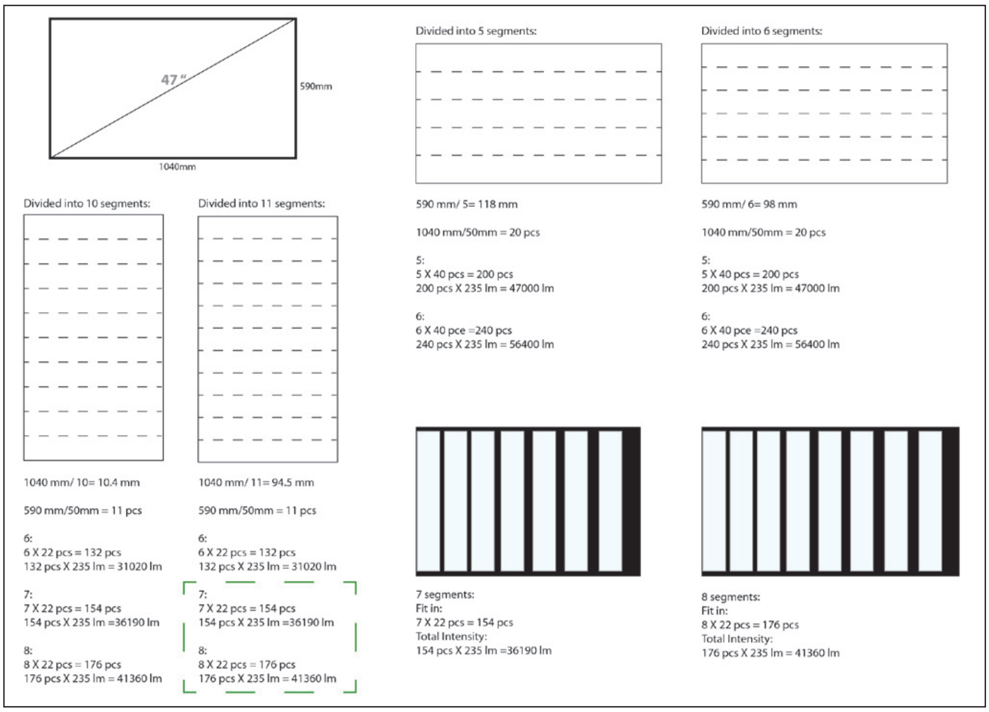


Figure 5.3.1.2 Variations of the rolling concept and the theoretical intensity output.

Modular segments or one piece:

At this stage two ideas had been developed regarding the rolling concept. The first one was to make each light guide segment a module of its own that could be connected to each other by hinges. Each segment should be possible to use alone or connected in a row. The second idea was to decide on a number of light guides to be connected into one single segment without the possibility to disconnect any modules.

The advantage of making the segments modular is that is makes each module easier to be replaced when one is out of function. However, the shortage is that it is difficult to produce the connecting hinges since they are in different dimensions, and moreover, it is quite confusing for the user to assemble them due to the large quantity of sub-pieces.

To make it one piece will not give the user the freedom of customisation, it however will improve the user experience since it is much easier for the user to operate. Moreover, easier to manufacture is also a superior advantage; if the light guide is modularized, the connection needs to be made in at least seven different widths in order to be possible to roll up, which will increased the manufacturing cost.

Materials:

Due to the folding function, the material for the backside should be flexible as a hinge while still be stiff when it is unfolded. Meanwhile, the backside material should also protect the light guides and the LED lights. A suitable material for this purpose is a polymer. Polymer is a large molecule composed of repeating structural units, which makes it has an extraordinary family range.

A highly resilient, flexible and durable synthetic material is polyurethane. Though there may be other material qualifications that need to be considered, polyurethane could be a suitable material for this concept as well as the book folding concept.

The light guide frame is framing the LED lights, and should therefor be able to dissipate the heat that the LEDs produce. Since aluminum has excellent thermal conductivity as well as it is stiff and strong it is ideal to use as light guide frame material. Furthermore, due to the shape and construction of the light guide frame, extrusion could be used as manufacturing method which is able to produce very complex cross-sections and provide an excellent surface finish. EDM (Electrical discharge machining) could also be an alternative machining method. This method is as well accurate and could also provide a fine finish.

Detail design:

Several suggestions for a backside design was created. The patterns were created in two dimensional illustration in the beginning in order to see how a single pattern look like and how the patterns were arranged on several segments as well.

A dark color for the backside was chosen because a color contrast of the front and back side was preferred in order not to reflect light on the backside. To use a matt surface was also decided since a matt surface is less reflective as well (a bright, shiny surface would reflect the light too much and disturb the studio environment). For the backside, a dark grey matt surface with bright aluminum frame makes a great combination. Dark grey also gives a more caring and protective feeling together with the matt surface finish.

In order to unite the design language of each details in this concept, the corner of the backside is designed chamfered, representing the crystal and diamond form matching the backside pattern.

Tripod and remote:

A tripod is necessary for professional luminaires in terms of providing better usability and user experience. Yet, where to place the tripod connection with the rolling concept and how is the tripod mount controlled and adjusted are issues to further consider.

The remote control could provide a huge mobility to adjust the light intensity. Based on the former interviews and observations, a conclusion is that it is crucial to have a remote control at hand in motion picture shooting environment. The lights are always quite far away from the shooting object and it is not easy and convenient to adjust the light by coming close to the light. Therefore, what features that the remote control obtain need to be further examined.

5.3.2 The book-folding concept

A large quantity of different ideas was created for this folding principle where the objective was to minimise the gap between the two light guide segments.

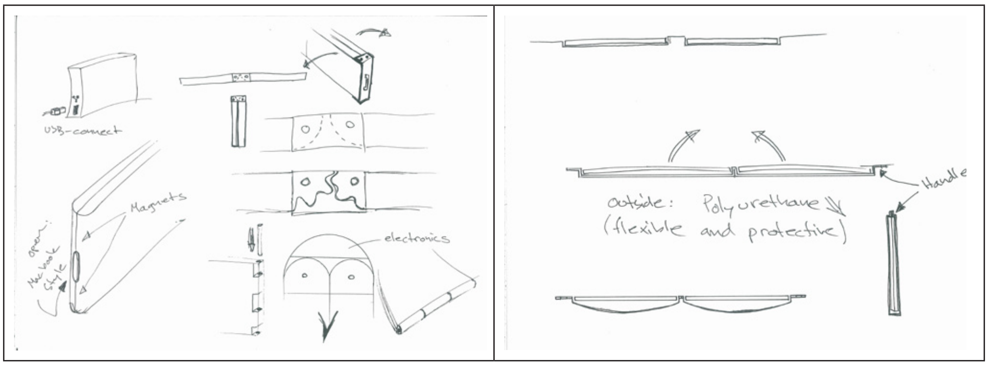


Figure 5.3.2.1 Variations of hinge solution in order to minimise the gap.

Since the aim was to design a product family, the material selection, light guide frame design as well as manufacturing method is recommended to be the same for all the different concepts. The pattern on the other side, should be similar, but could be developed further due to the different size of the rolling concept segment.

The basic form of the book folding concept are the same as the rolling concept, as well as the basic functionality. If combined with a modular connection solution an infinite number of screens can be connected to each other for a preferred size light source.

5.3.3 The map-folding concept

Instead of the original Turkish map fold, a circular shape was first developed and replaced the square shape. Later an octagon shape was discovered to be more efficient in the way of folding and reducing unnecessary material waste.

The center was cut into a hole to be placed around the camera lens in order to create a ring light or macro light. Rubber cushions were also placed around the hole for a better attachment to the camera lens.

The variations of this concept are mainly on the different shapes of the light guide and the distance between each of them (see appendix J1-J4).

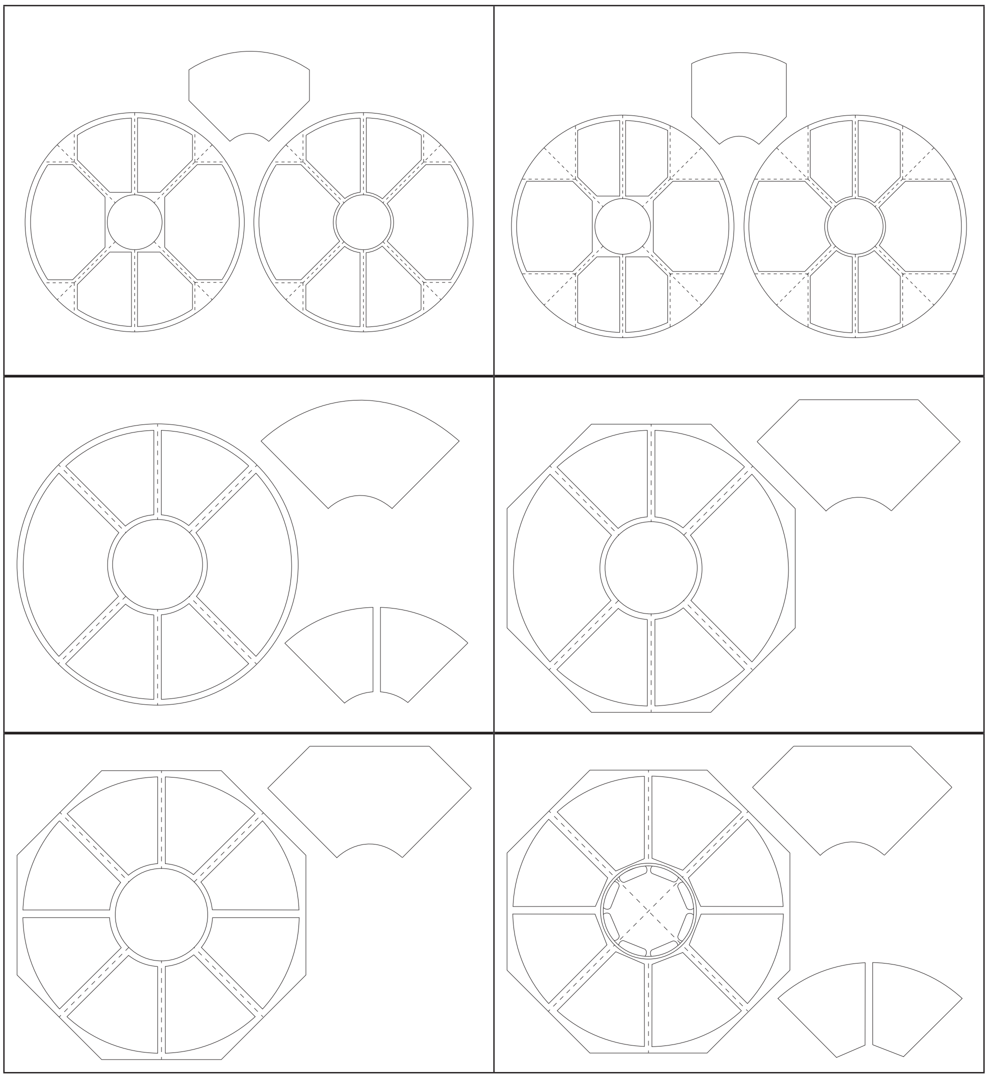


Figure 5.3.3.1 Variations on the map-folding concept.

5.4 DISCUSSION

Each of the three concepts showed potential for different segment sizes and shapes within the photo and motion picture industry. The different solution characteristics was taken advantage of for optimizing its usefulness in the segment and a product family was constructed. The benefit of a product family is to show the diversity and usefulness of the technology used in the concepts.

Issues to consider further on in the concept refinement phase are mainly functional aspects for optimal light quality and usability for the end user. Further research on optimization also has to be made regarding alternative solutions for each principle, choice of materials and technical solutions.

6 CONCEPT REFINEMENT

6 CONCEPT REFINEMENT

In the Concept Refinement phase, the selected concepts have been taken from initial ideas and been refined to be realistic representations of products we hope to create, several necessary changes involving functions, aesthetic appearance (form, color and interaction), technical aspects including material selection, LED selection and manufacturing are discussed and made accordingly in this stage. This helps to ensure the final design maintains a particular aesthetics, using proper and reachable materials, and in the meantime can be manufactured efficiently.

The Concept Refinement phase is considered very important in this thesis project. Not only every detail have been considered that will affect the overall outcome of the final design, but also this is the stage at which the design becomes realized.

While refining some of the measurements and dimensions, we made full size mock-ups to test and evaluate the concepts. Advanced CAD software were also used to define and validate the models.

6.1 USER FOCUS GROUP

Focus groups were conducted in order to elicit more quality information about the opinion of the sought functionality and attributes of the concepts among the users. In a focus group, a small number of people get together to discuss a given topic, in this case usability of the concepts (Osvalder, 2009).

Several focus groups were held together with professionals within each category of profession; both photographers and motion picture producers as well as experts on lighting. The groups mainly consisted of previously interviewed persons but also a few new contacts without any preconceived ideas about the product. In this way both thought through reflections as well as new open-minded thoughts could be extracted. The age-spread among the participants reached from 25 to 50, both female and male.

The focus groups were presented with full size mock-ups of the three concepts with sought proportions and folding mechanism, as well as renderings of the sought design. The discussions were focused on to what extent the products would be used in the daily work among the users and in what way the products would be used.

The functionality of the light including light quality, intensity and dimmability was unfortunately not possible to communicate during these sessions, but is an important aspect that should be evaluated at a later stage in the development process.

The common opinion among the users was that all concepts would be greatly appreciated in the daily work and used on a daily basis. The largest benefit is the portability aspects and the innovative ways of folding the concepts together. The functionality of the folding principles together with the new technology of LED-light could create a trend within the industry and become something fashionable to use. A risk however is that the trend is short-lived if the usability is not convinced, the usability and light quality will always be the main factors when deciding on a product. A decisive factor is also the diversity of the product; if there is a narrow scope of possible uses the product will not be used at all unless its function is unique. With a unique function the aspect of portability is lost since it will become yet another piece of equipment to bring with.

In the photo and motion picture industry the common agreement among the users is that one light cannot fit all purposes. The concepts presented during the focus groups however have large potential to replace a large segment of products within a specific field of the industry. To be focused on a segment is important in order to convince the benefits with the products and should be clearly communicated.

6.2 FUNCTION

6.2.1 Mode

The selected modes of the light are flash and constant light. On flash mode, before shooting, the user turns on this mode to sculpt the light. The light intensity can be dimmable from zero up to one hundred percent where the lower intensity is used for sculpturing the light. When the light is sculptured and the user is about to shoot and the shutter is pressed, the light intensity increases immediately to a set level of intensity as a flash. On constant light mode, the user can dim the light from zero to one hundred percent of the full power to set the light in any angle and perspective.

The reason for the user to use the flash function is that it requires much less energy as well as lowers the heat generation. If used as a constant light, the electricity consumption will increase resulting in a shorter time for usage on battery power and lower the aspect of mobility and portability. The products also aim to considerably decrease the energy consumption compared to existing products and convince an environmental awareness.

6.2.2 Operating

In order to roll up the light and lock it in a rolled up position as well as stabilizing the handle for when holding it or when mounted on a tripod, the solution is to embed thin magnet stripes inside the backside sheet. Since aluminum is not a ferrous metal, the magnets should be placed on one end handle as well as the place where the end handle attaches when rolled up. The second handle can be fitted with an aluminum stripe.

When the user wants to use the folded up light, simply open it resisting the magnetic pull. When the light is rolled out and ready to be rolled up, fold the first handle till the last inward and the last handle will be attached on the backside of the light automatically locking it in place.

The handles on the concepts are for operating the light without being mounted on a tripod. A person can hold the light or it can be hung onto any object e.g. a nail in the wall or a tree branch. The handled on the book folding concept can also be used for transporting the light in closed position just like a regular briefcase.

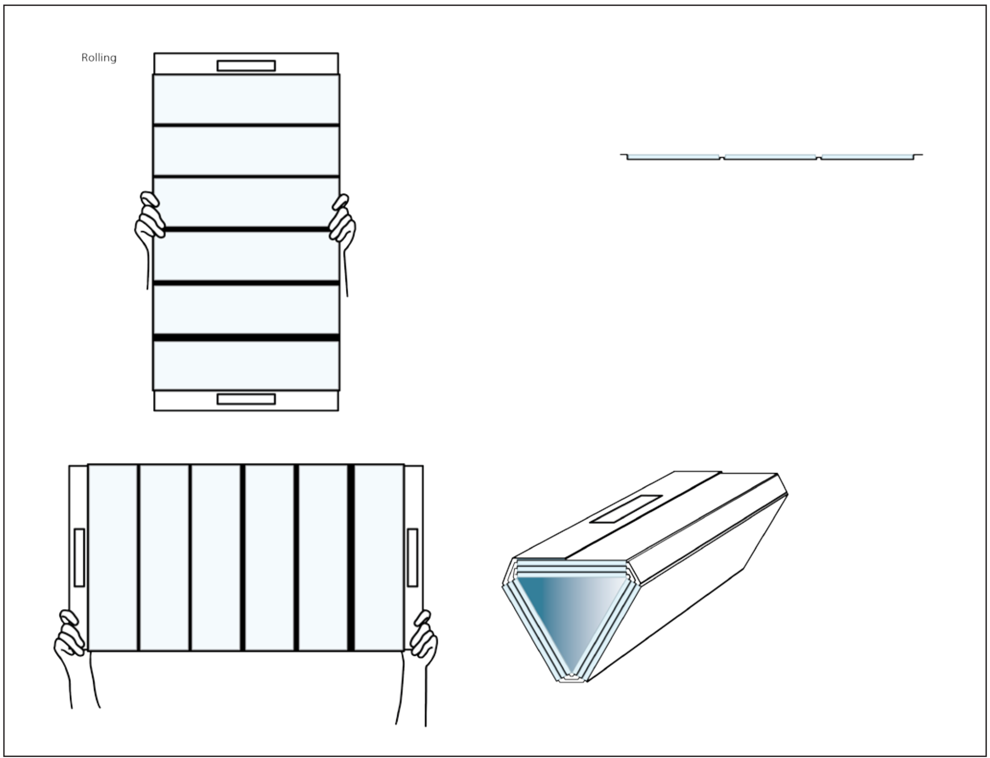


Figure 6.2.2.1 Illustration of holding the rolling concept

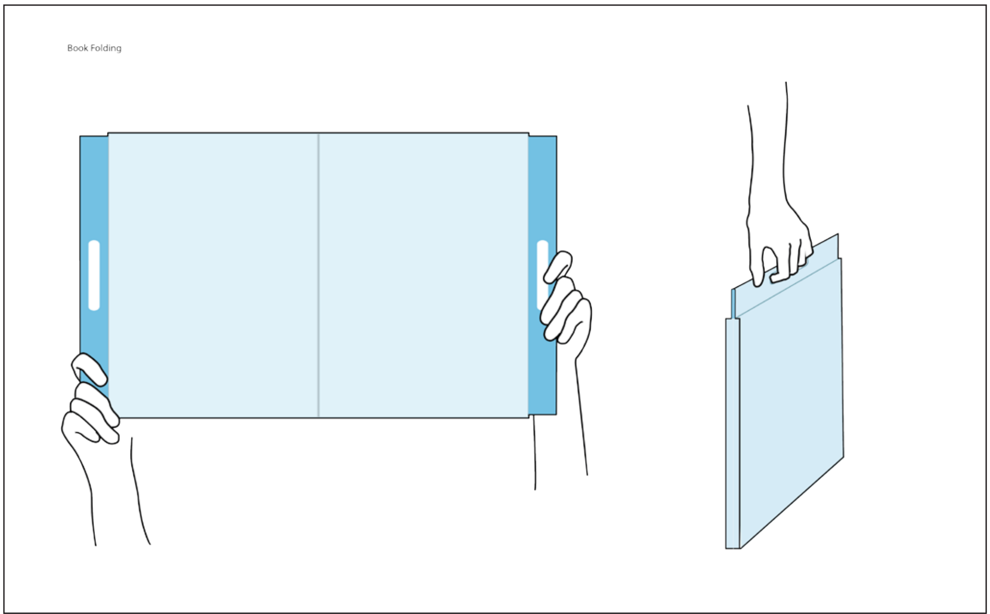


Figure 6.2.2.2 Illustration of holding the rolling concept

6.2.3 Films

As mentioned in the pre-study section, a high efficient reflector behind the light guide is required to minimize the loss of intensity as a result from multiple reflections. The reflector film which reflects up to 98% of the light, allowing it to go outward through the diffuse film and prism films, is a necessity in this project.

Based on the previous research on LCD panels, the conclusion is that diffuser films and prism films are required to enhance the light intensity. Theoretically, the diffuser film evens the light out over the surface making it homogenous and two prism films together guide the light in a perpendicular direction. To focus the light perpendicularly increases the light intensity in one direction instead of spreading it over a larger area. However, more films added in front of the light guide will decrease the over all intensity. Unfortunately, whether or not to use two prism films or one could not be tested during this thesis project. Further investigation regarding this is recommended.

The conclusion is that the reflector film is a necessity and should be placed underneath the light guide. A diffuser film will be used and placed directly above the light guide. Regarding the prism films; the design of the light guide frames allows the user to add or remove the films depending on the users own preferences. In this way the light can be focused or spread out depending on the situation and a higher level of usability is created.

6.2.4 Tripod mount

In order to be able to mount the concepts onto a conventional tripod but at the same time have a larger degree of possible adjustments, a tripod mount was constructed specifically for the final concepts. The tripod mount is using a ball-connection to connect to the tripod and four bars to be inserted in equivalent slots on the light concepts. By rotating parts of the horizontal bars of the tripod mount, the length of the bars can be adjusted resulting in an angular change of the light. The light can in this way be more or less focused. The ball-connection enables the light to be rotated in any angle.

6.2.5 Remote

The remote is merely conceptual. Due to delimitations of the thesis and time limitations the design and functionality of the remote is on a basic level. The user study however shows for a need and wish of a remote and is therefore included as a part of the final concepts.

The function of the remote is to simultaneously control several light at the same time or to control a light that is placed inaccessible e.g. in the ceiling. Adjustments can also be made to the lights without physical interaction resulting in a better workflow for the users not having to change position for adjustments. This is particularly good when working alone or operating several lights at once.

Adjustments that can be made from the remote includes on/off, intensity level of sculpting light, intensity level of flash, intensity level of constant light and flash test.

6.3 VISUAL APPEARANCE

6.3.1 Form

Since the basic shape of the lights is quite thin and flat, and the functionality of the folding principles being an important part of the design, the visual appearance was decided to be kept as simple as possible. The front side of the lights is intended to be consumed entirely of the illuminating light guides and the hinges required for the folding function. Minimum distances between the light guides is a requirement for an homogeneous light and is therefore kept as smooth and thin as possible without any decoration. The front side design desires for pureness, simplicity and reduction of form in order to be able to concentrate on the essential function.

In order to convey our value words from the earlier design phases; cool, diamond and robust, a facet surface was designed to decorate the backside. A great quantity of variations of the 2D patterns were created (see appendix K1-K5) and some were selected, evaluated and finally one was picked out that to a high extent express balance, elegant and strength. The pattern is inspired by the Delaunay Triangulation Algorithm invented by Boris Delaunay in 1934 (see figure 6.3.1.1).

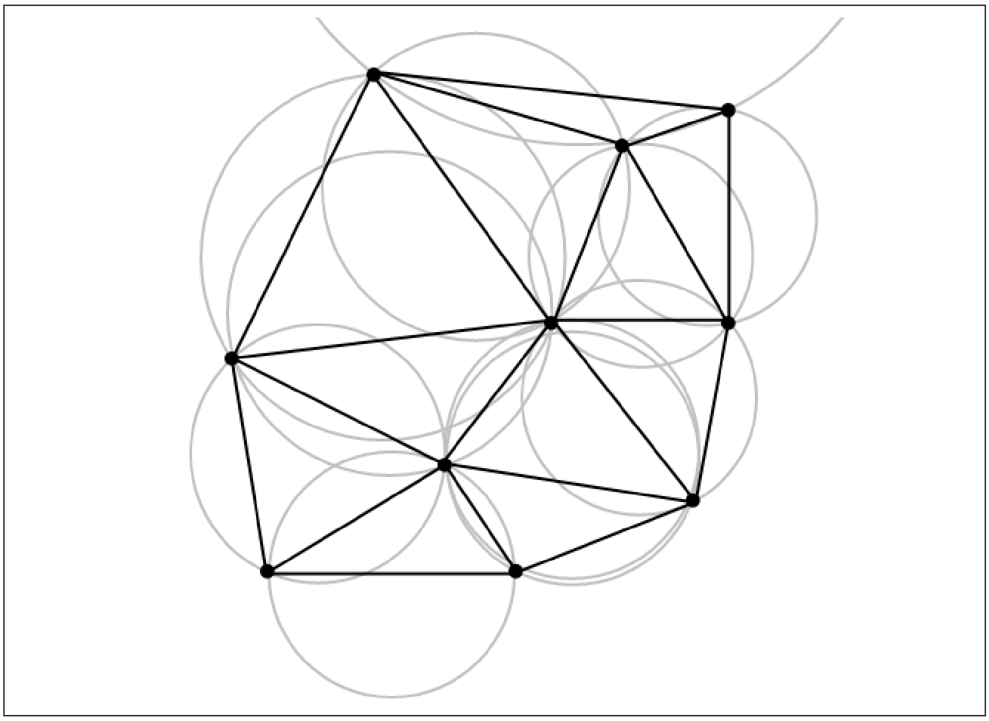


Figure 6.3.1.1 Delaunay Triangulation Algorithm

3D software was used to realize and visualize the pattern into a realistic visual three dimensional representation. The surface is not totally flat but has small axial variations that can be seen depending on view angle or light conditions.

6.3.2 Light guide frames

The light guide modules including the LED lights, reflector, diffuser and prism films are positioned and held in place by an aluminum frame which in turn is mounted on the backside. The frame is designed to have minimal construction towards the front side in order to have as little disturbance as possible on the light. The edges of the frame are chamfered for a slimmer over all visual experience while the excessive material functions as a heat conductor. The frame also allows for different films to be placed and replaced on the front side of the light guide depending on the users preferences on the light properties.

6.3.3 Light guide covers

In order to secure the light guide and the different films inside the light guide frames, a cover is placed on respective side of the frame that follows the contour of the frame.

The cover consists of two plates and two screws. The bottom plate is single-cultured either in black or a characteristic (trademark) color. The upper plate is a hollow shape patterned in a framework-like design, also inspired by the Delaunay Triangulation Algorithm (see figure 6.3.1.1), following the same design principle as the backside pattern. In combination the two plates give the impression of ventilation for the light guide frames conveying a sensation of coolness and efficiency (see appendix L).

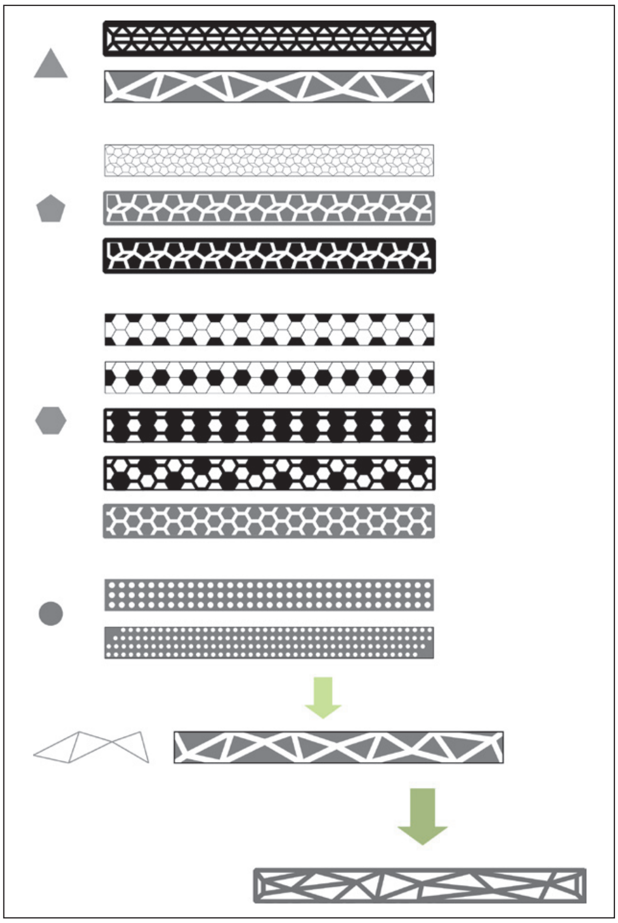


Figure 6.3.3.1 Variations of the light guide cover

6.3.4 Color selection

The front side of the concepts has a bright reflective color for a unified and seamless transition between the light guide segments conveying the front side to be one solid element. The reflective color enables the reflection of the light segments on to the object in front of the light to be less distinct. Since the light source in itself consist of divided smaller elements the reflection e.g. in an eye or on a shiny surface will reflect the same shapes. If the transitions between the light source elements are less distinct, the reflected transition will be less distinct and more homogeneous.

Figure 6.3.4.1 Reflective front side color

The backside of the concepts has a dark grey matt surface as described in section X. This is due to the non-reflective properties. The dark grey color gives a contrast to the bright shiny front side at the same time as it conveys a sense of robustness. The surface finish of the backside is slightly roughed to further enhance robustness.

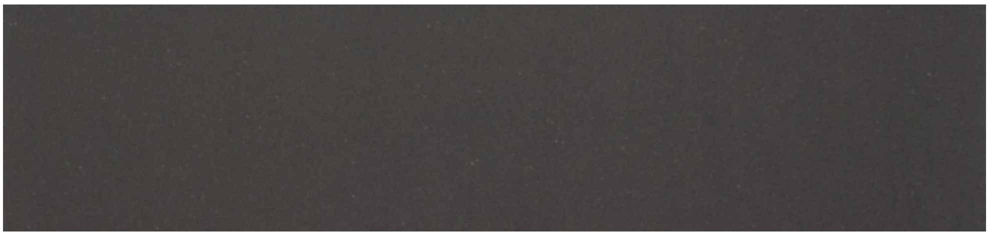


Figure 6.3.4.2 Matt dark grey back side color

A vivid color is selected for specific details of the product, such as the bottom plate of the light guide covers and the locking mechanism of the tripod mount. As green is a symbolic color of environmentalism, and the basic element of the product comes from reused material, it is truly a proper color to represent the product. The vivid color is used as a trademark throughout all concepts and can be applied onto different parts of the different concepts. It should however be represented in some way on each product for recognition and branding purposes.

Figure 6.3.4.3 Vivid colorful detail color

The visual appearance of the tripod mount and the remote follows the same design attributes as the backside of the light concepts. The color is dark gray and the same roughed matt surface as the backside is used in order to carry on the design language as well as not to reflect the surroundings.

6.3.5 Material selection

The material selection of the backside part is based on three major criteria. First of all the ability for the material to be thermally conductive is important in order to dissipate the heat generated by the LED arrays. If the heat is not dispersed away from the sensitive LED diodes the quality of the light will more quickly deteriorate and the life time will be reduced.

Secondly the function of the backside is to work as a hinge for respective folding principle. In this sense the material needs to be flexible enough but still durable for an extensive number of folds without deteriorating the function.

The third criterion is for the material to be protective and durable in everyday usage. The texture and tactile sense should satisfy the need for security in an unsettled environment conveying robustness and protection and the user should be able to handle the equipment without care.

In order to incorporate all three criteria into one material the choice fell on a flexible polymer material called CoolPoly. The rubberlike properties ensure flexibility and elasticity as well as a non-fragile surface finish without compromising the thermal conductivity (CoolPolymers, 2011).

Cool Polymers, Inc. manufactures thermally conductive plastics and heat transfer solutions. Its family of thermally conductive plastics known as CoolPoly is available in a variety of base resins and ranges in thermal conductivity from 2 W/mK (similar to glass) to 100 W/mK (similar to cast aluminum). Meanwhile, the material is still bendable. This material is ideal for this thesis project and is available today. Detail properties of the recommended materials see Appendix I.

For the light guide segments where there is no need for a flexible functionality, the chosen material is aluminum. When dispersing heat from LED diodes, aluminum is most commonly recommended.

Aluminum has a high thermal conductivity and is at the same time strong and light. The low weight of aluminum results in a low over all weight of the product which enhances the level of portability.

There is no additional cooling system for the design since the selected materials are intended to dissipate a great amount of heat naturally due to the material properties. The aluminum light guide frame can radiate some heat to the air on the front and side of the product while the rest will be transferred through the aluminum and via the backside material to the air on the backside.

6.4 MANUFACTURING AND PROCESS

6.4.1 Backside

The chosen manufacturing method for the backside part is injection molding or alternatively casting. Because of time limitations the final method has not been decided since it requires further discussion with manufacturing companies and material producers.

The backside of the rolling concept consists of two polymer parts, two magnet plates and one aluminum plate (see appendix M).

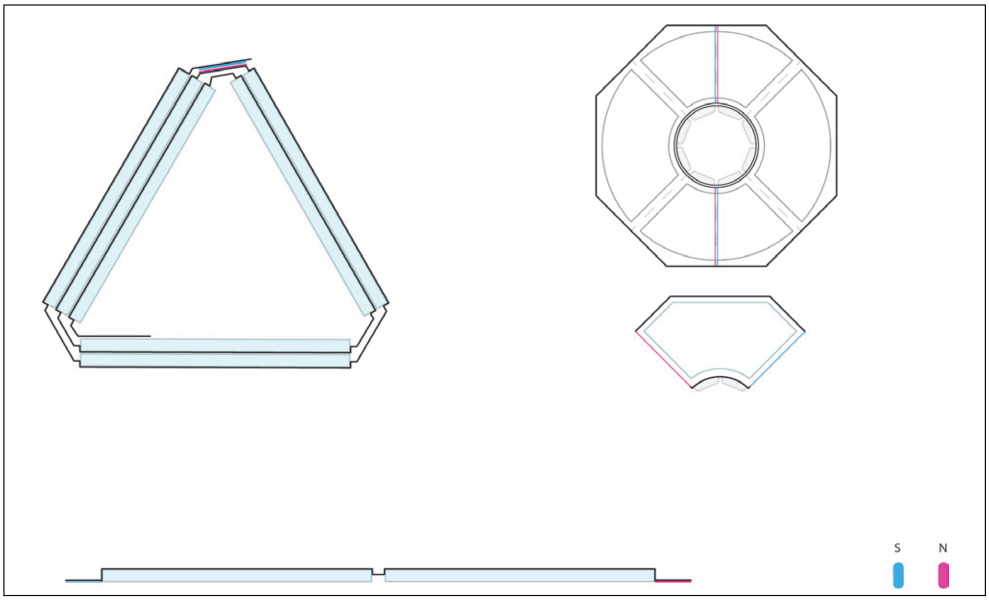


Figure 6.4.1.1 Magnet placement

One magnet plate and the aluminum plate function as stiffeners of the handles while the second magnet plate work as an attractive counterpart of the first magnet. All the plates should be places between the two polymer parts. The backside of the book folding concept only consists of the two polymer parts and two magnet plates placed in between the handle segments. For the map folding concept, the magnets are placed on the edges of the light guide segments so that they attract each other and lock in position in both open and folded state (see figure 6.4.1.1).

6.4.2 Light guide

The light guide components including the light guide and the films are reused components from recycled LCD television sets. In order to form the light guides into the wanted shape and size they are laser cut. By laser cutting the light guides a high quality cut surface can be ensured, necessary for an effective utilization of the LED lights (see appendix N1-N2).

6.4.3 Light guide frame

The light guide frames made of aluminum are manufactured by extrusion. The segments have a two dimensional design ideal for extrusion with no further post processing requirements except cutting the segments in appropriate lengths and drilling the holes for the cover screws. With this method a large quantity of segments can be produced during a short period of time with high accuracy and quality.

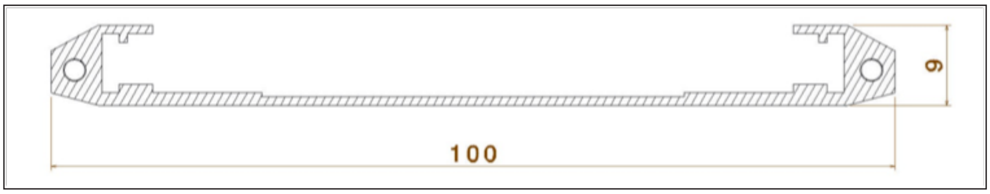


Figure 6.4.3.1 Illustrations of cross section of light guide frame

6.4.4 LED construction

The LED arrays are made up from smaller LED segments connected in a row onto an aluminum stripe. The LED stripes are then slid along the long sides into the light guide frame and hold in place by the covers. The LED segments are glued on to the stripe by an adhesive with good thermal conductivity specially made for LED diodes.

7 FINAL CONCEPT

7 FINAL CONCEPTS

The final design is presented in Figure 7.1.1-7.5.2, which shows the full scale of the products and detailed renderings.

7.1 ROLLING CONCEPT

Figure 7.1.1 Rolling concept

The rolling concept is the largest of the concepts and consists of seven light guide segments that together produce a very high intensity light. In order for the light to still be portable despite its size, the user can easily roll the light up by simply folding the segments one by one into a triangular shape. The rolled up light in this way becomes handy to carry with.

The rolling solution shows great potential for larger light guides where a large size light source can be created but with great folding capabilities. The solution will be built up from light guides that are cut length wise in thinner segments and placed with short distances between one another. Cutting the light guides to an appropriate shape solves the problem of using different kinds and sizes of light guides in the same product, utilizing the most of what is available from the recycling stations. Cutting the light guides also increase the possible light intensity due to that more LEDs can be fitted around the light guide. The light can easily be focused or scattered just by bending the module edges inwards or outwards.

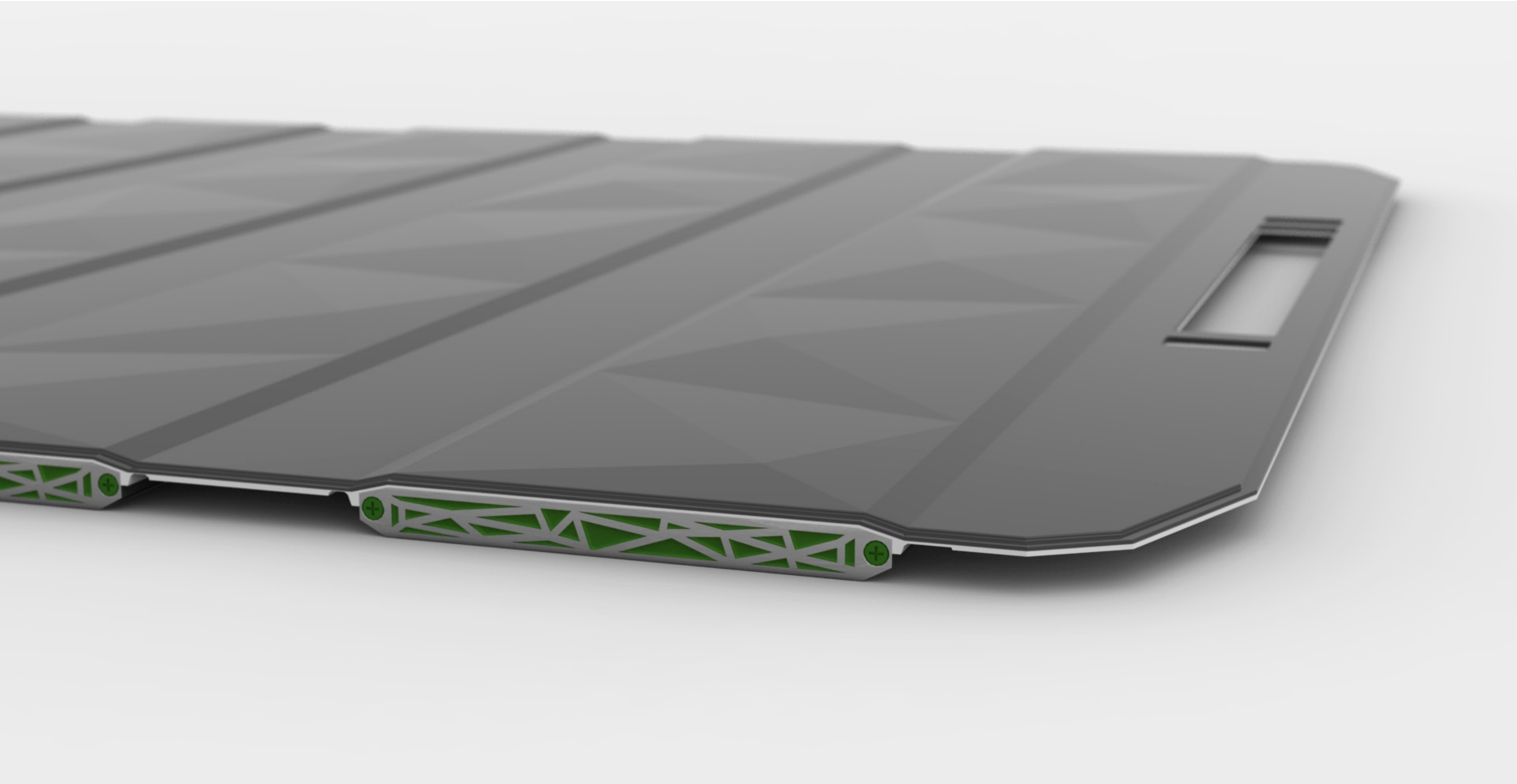


Figure 7.1.2 Rolling concept

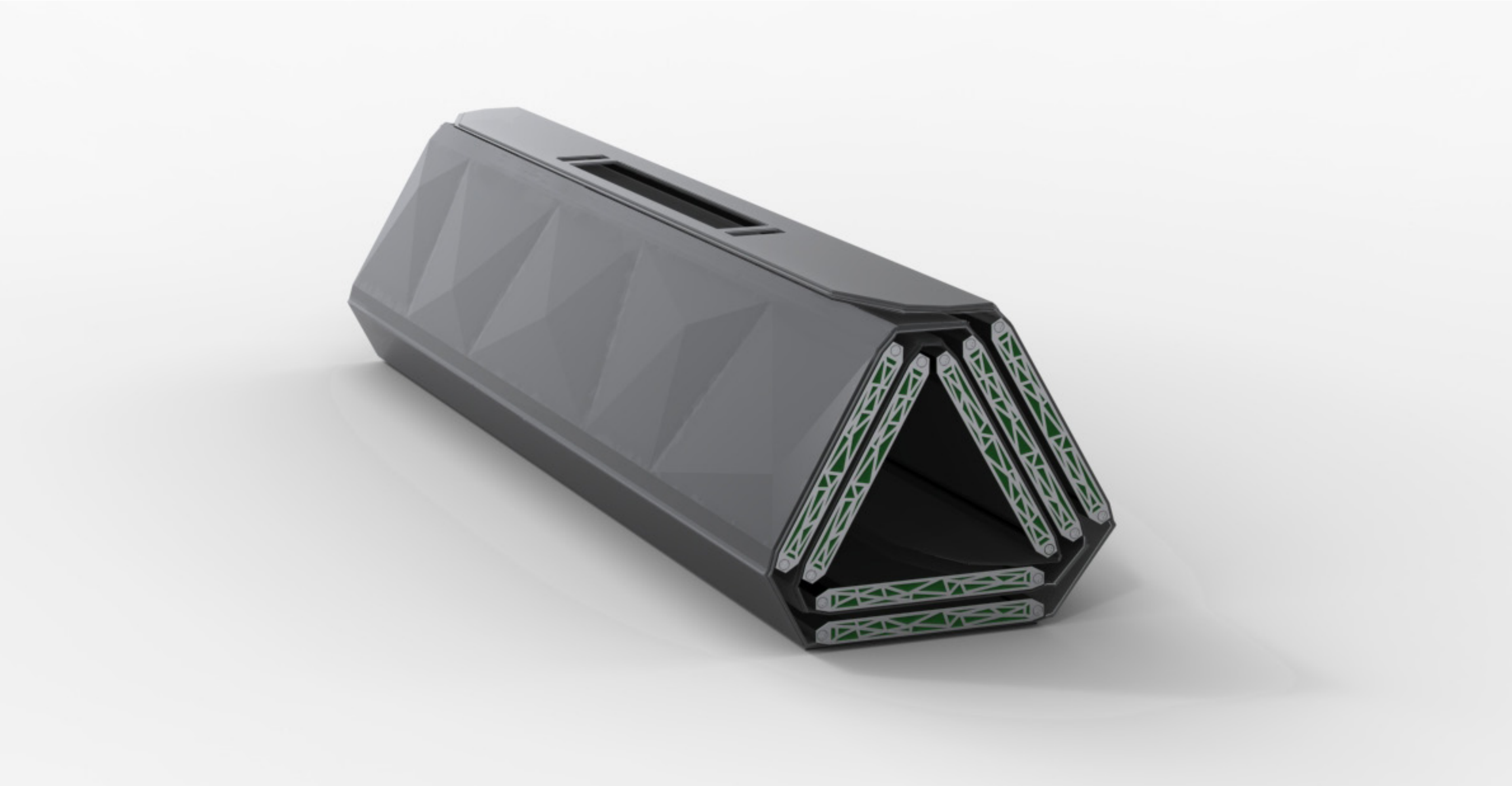


Figure 7.1.3 Rolling concept

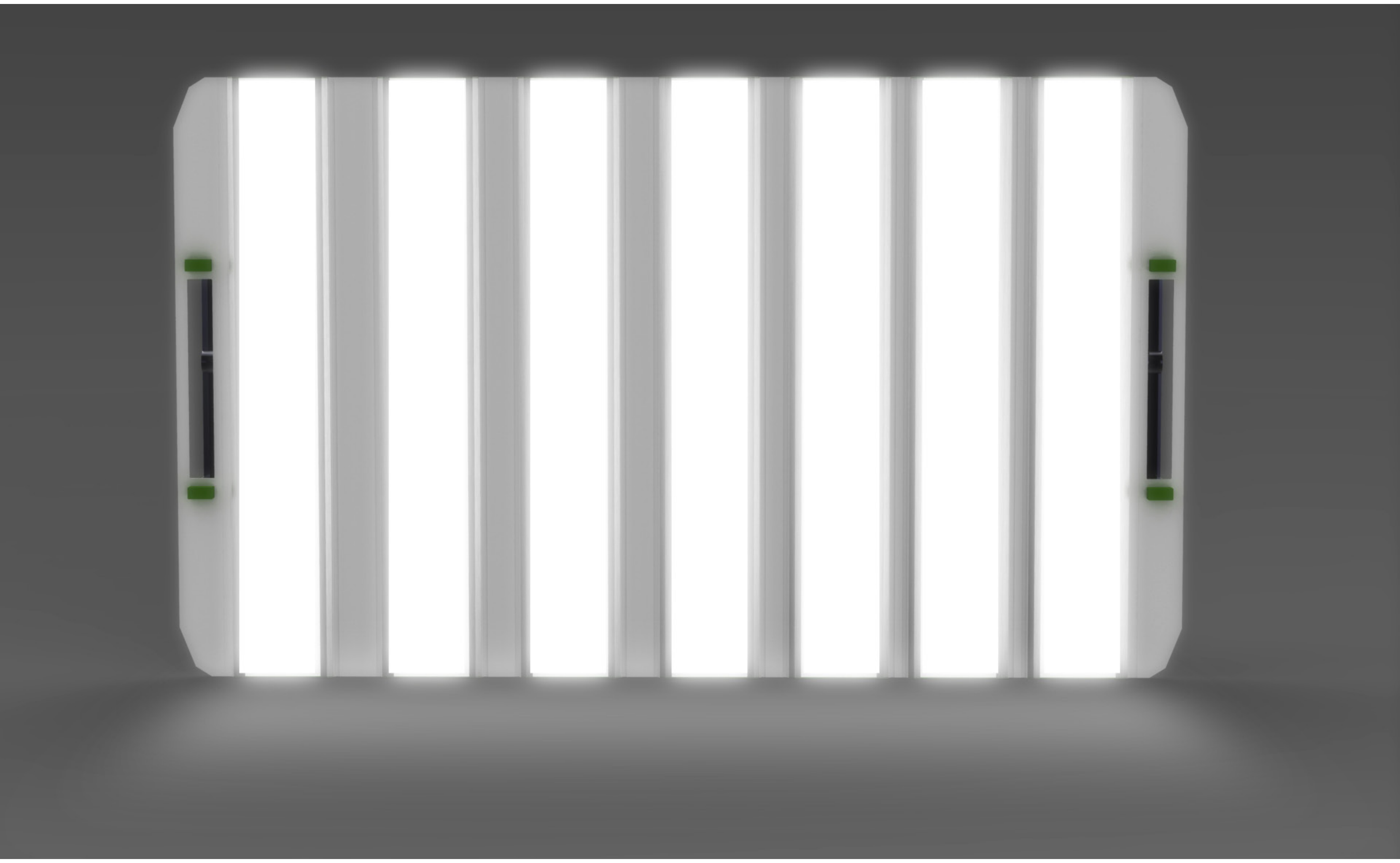


Figure 7.1.4 Rolling concept

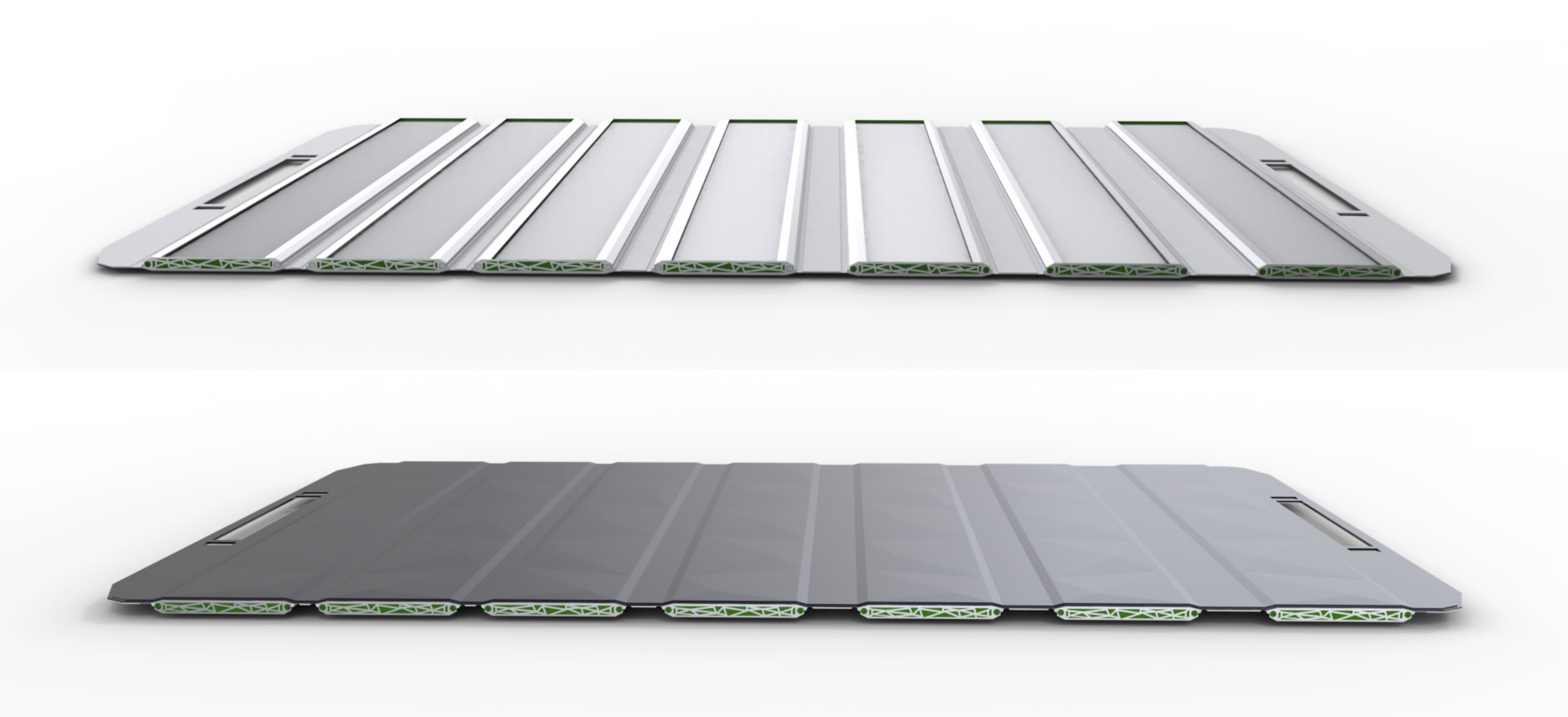


Figure 7.1.5 Rolling concept

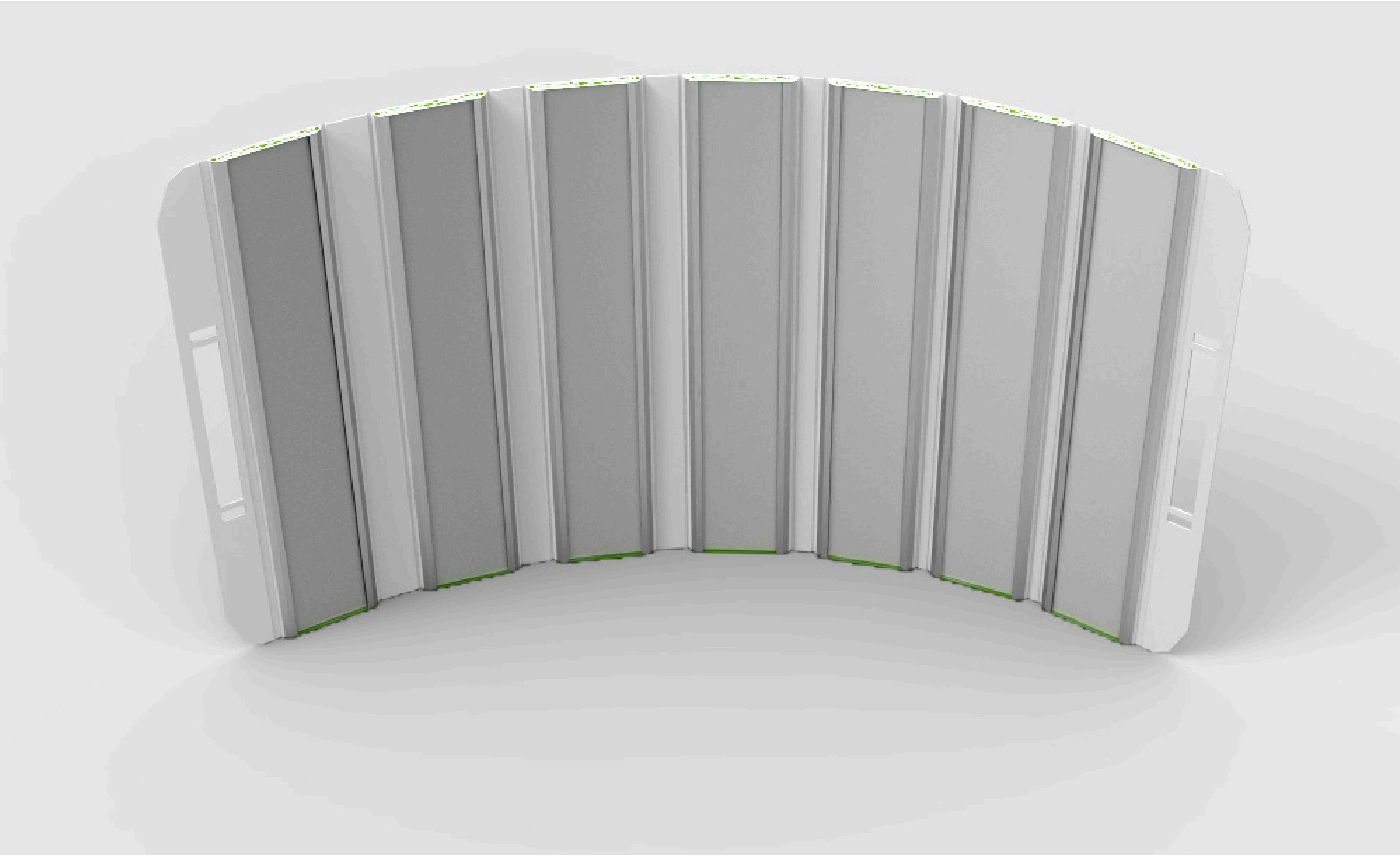


Figure 7.1.6 Rolling concept

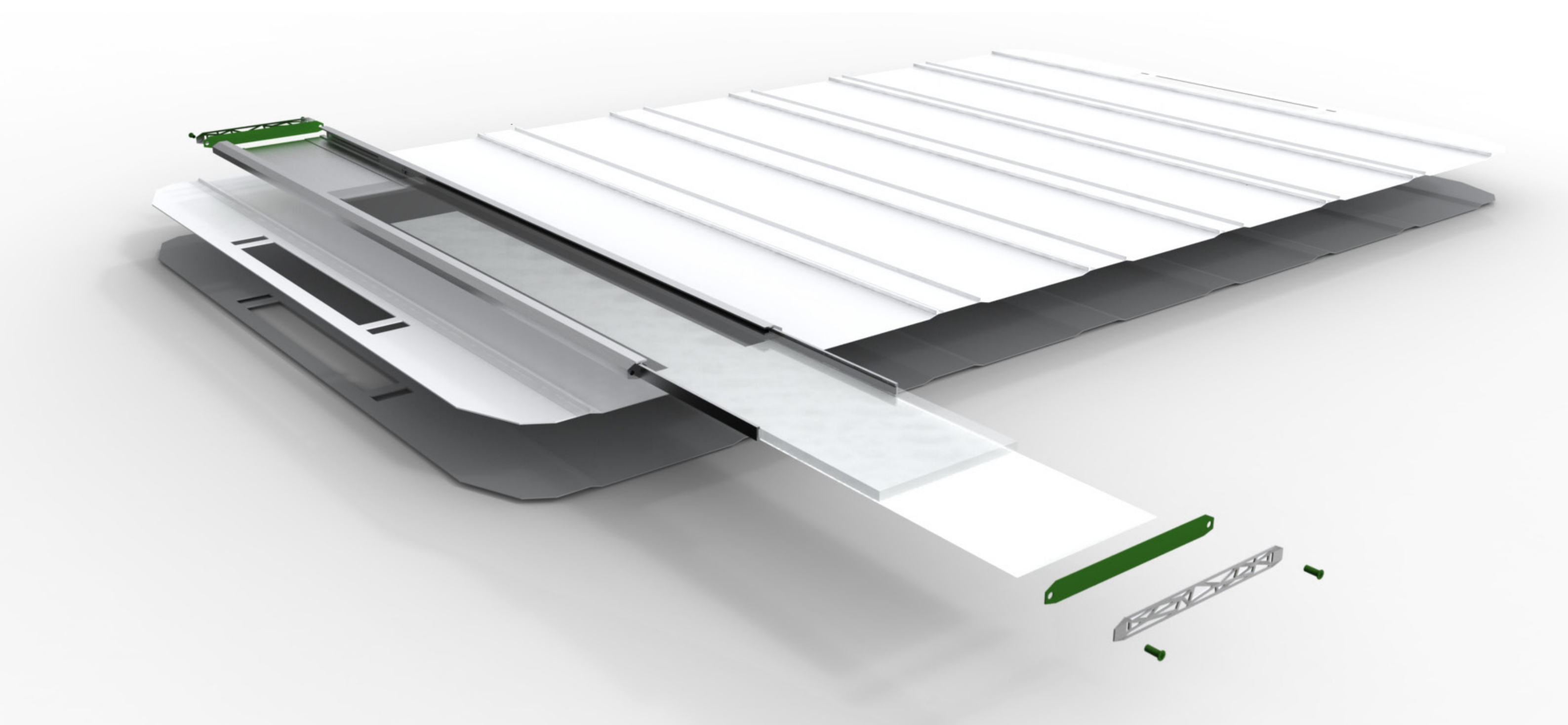


Figure 7.1.7 Rolling concept

7.2 BOOK FOLDING CONCEPT

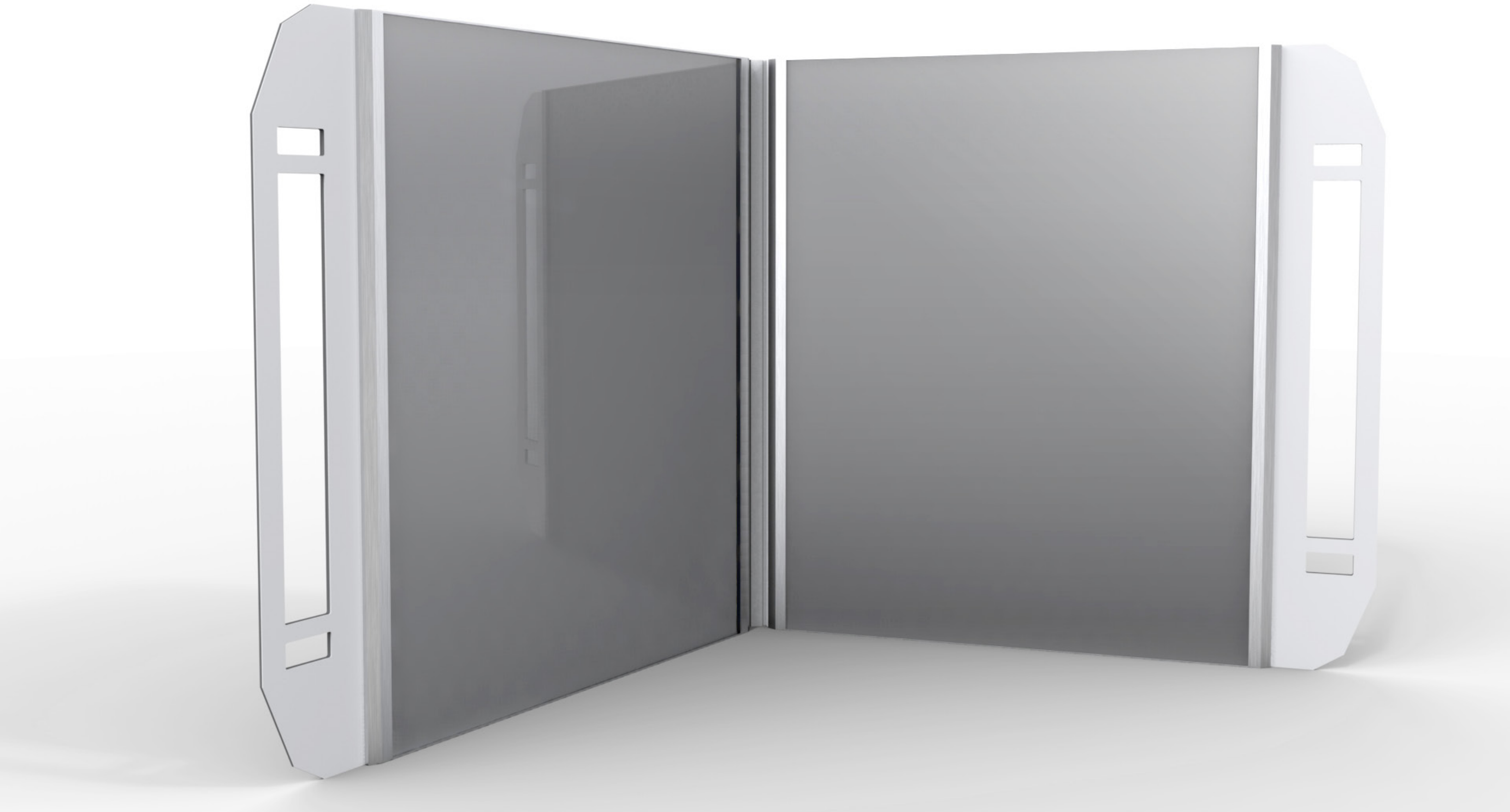


Figure 7.2.1 Book folding concept

The book folding solution shows great potential for smaller or medium size light guides where two light guides can be folded together like a book or briefcase in an instant for immediate change of location. The light guides will be protected on the inside of the collapsed module and safe from scratches and breakage. The casing can be used for housing the technical parts as well as function as a tool for carrying excluding the need for additional cases. The light can easily be focused or scattered by adjusting the angle between the two screens.

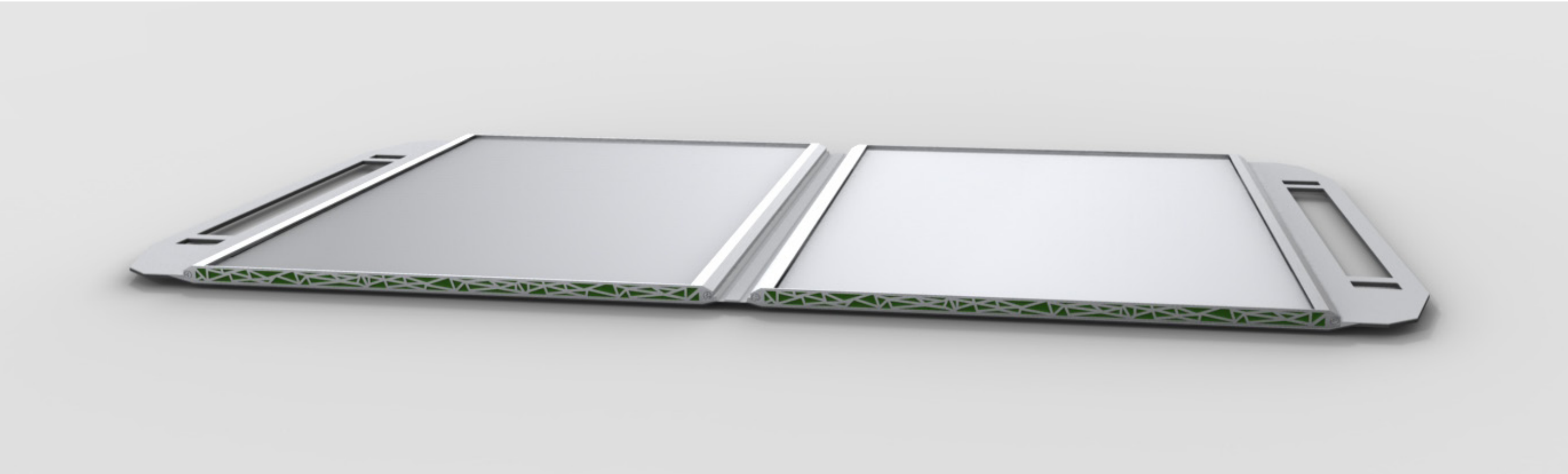


Figure 7.2.2 Book folding concept

Figure 7.2.3 Book folding concept

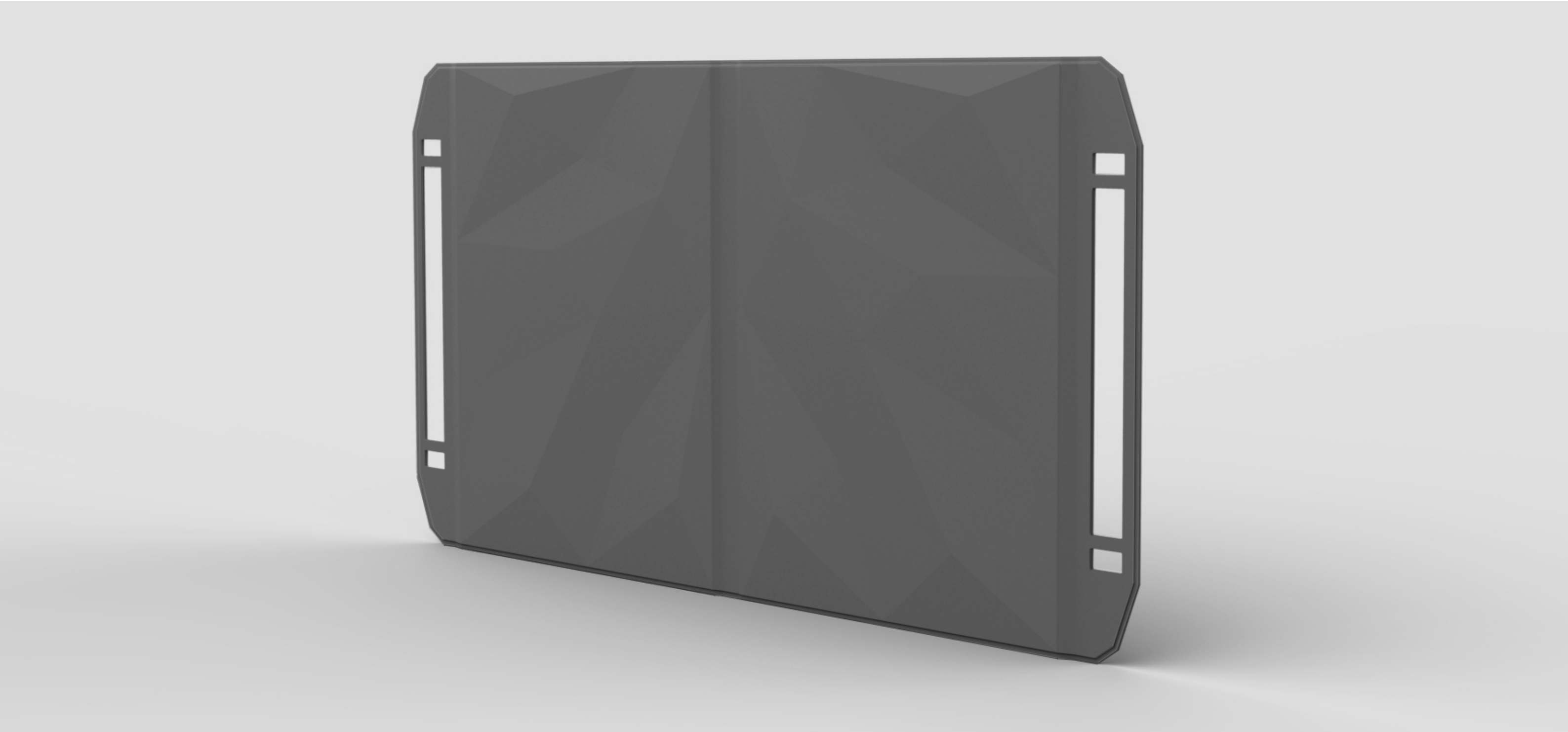


Figure 7.2.4 Book folding concept

7.3 MAP FOLDING CONCEPT

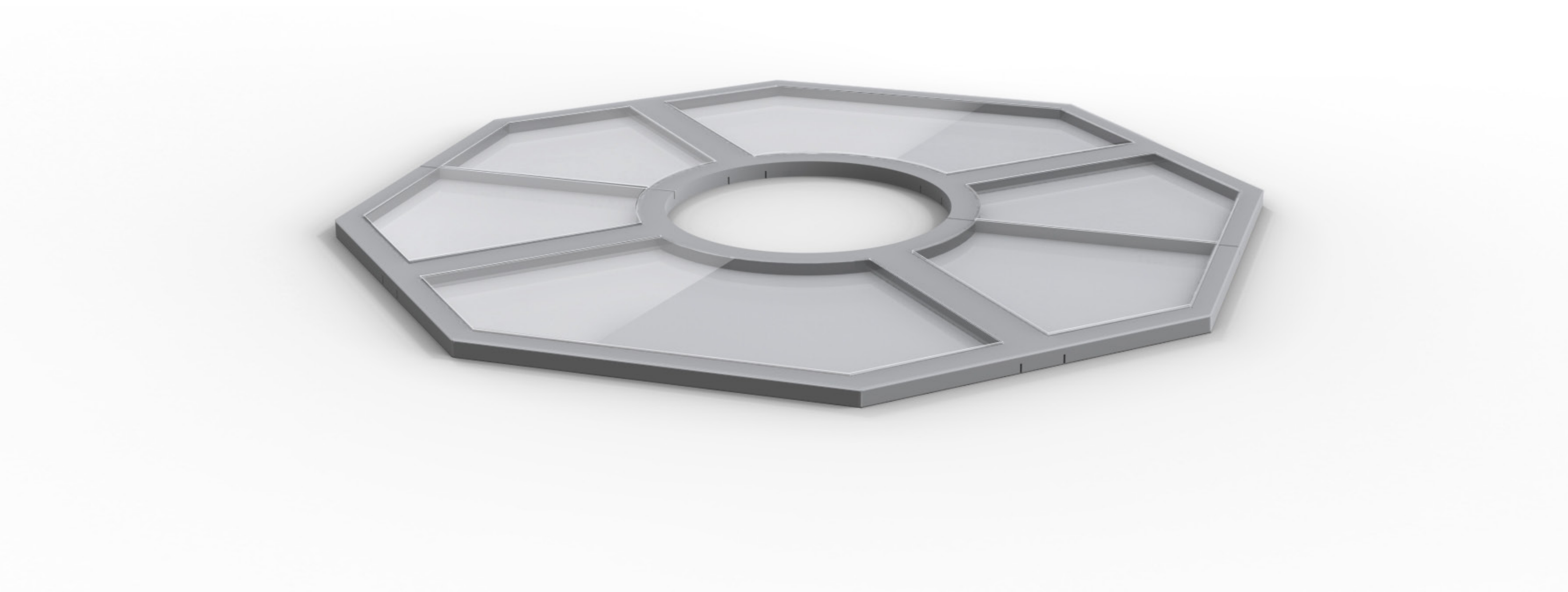


Figure 7.3.1 Map folding concept

The map folding concept is a small pocket size ring light to be mounted directly onto the lens of the camera.

The map folding solution shows great potential for either very large or very small light guides. The basic folding principle in unfolded state creates a ring light functionality with a hole in the centre where the camera can be attached for macro-photography. The map folding principle is unconventional and innovative for use as foldable light.

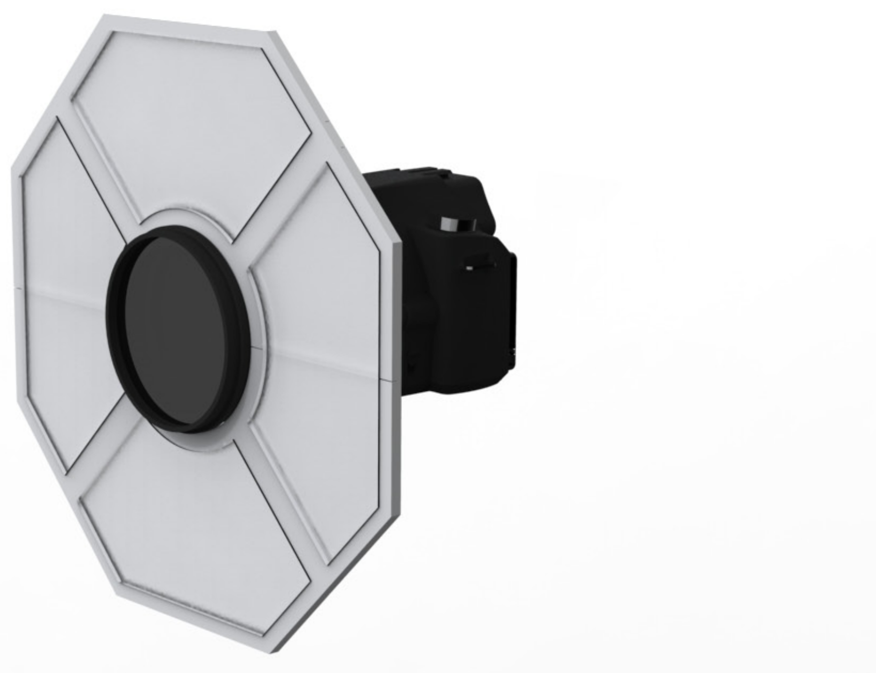


Figure 7.3.2 Map folding concept

7.4 TRIPOD MOUNT

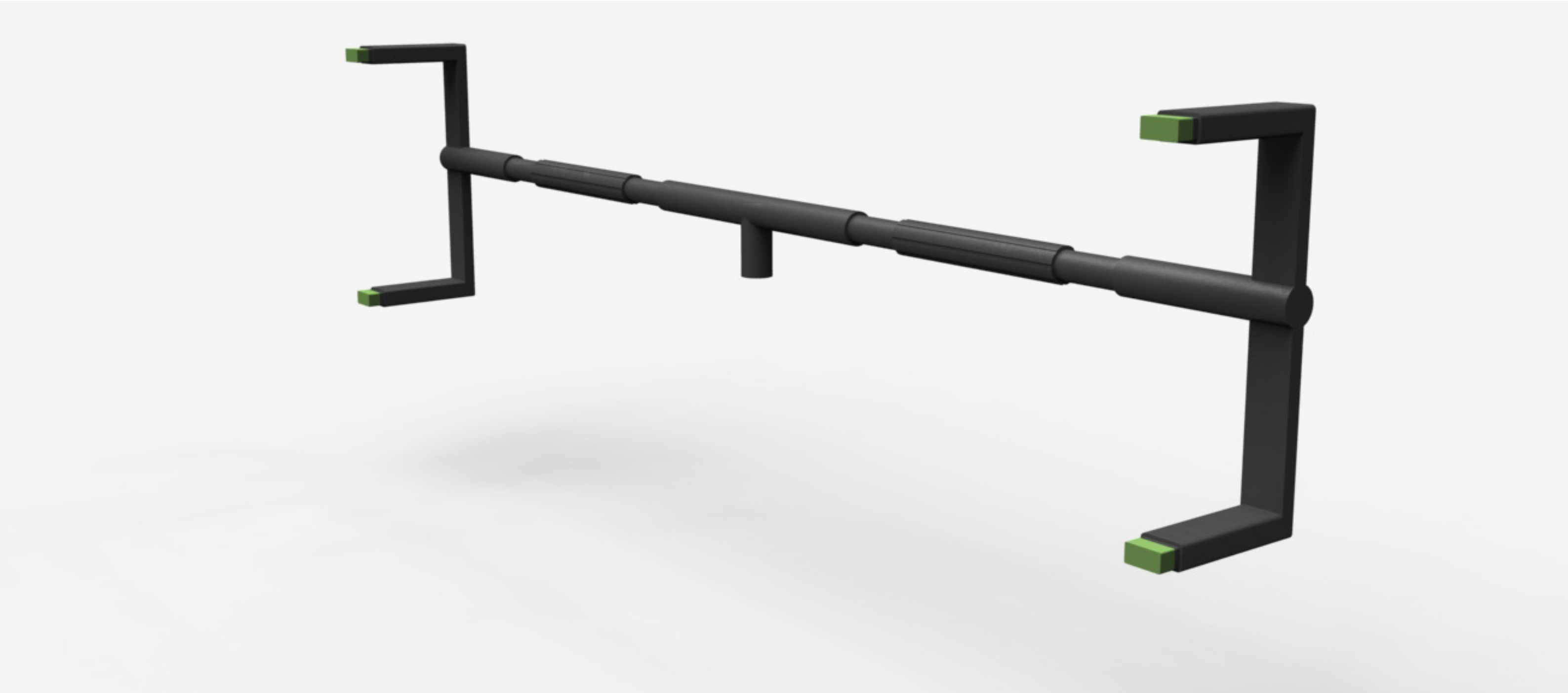


Figure 7.4.1 Tripod mount

The tripod mound can be used to place the lights stationary directly on the floor or hung from the ceiling but still with a high level of adjustability. The light is attached by sliding it on to the four bars and secured by rotating the knobs 90 degrees on the edges of the bars. The ball-connection connecting the tripod mount on to the tripod can be rotated and angled in all directions.

Figure 7.4.2 Tripod mount

Figure 7.4.3 Tripod mount

Figure 7.4.4 Tripod mount

7.5 REMOTE

Figure 7.5.1 Remote

The remote enables the user to make several different adjustments to the lights individually from a distance or to several lights at once.

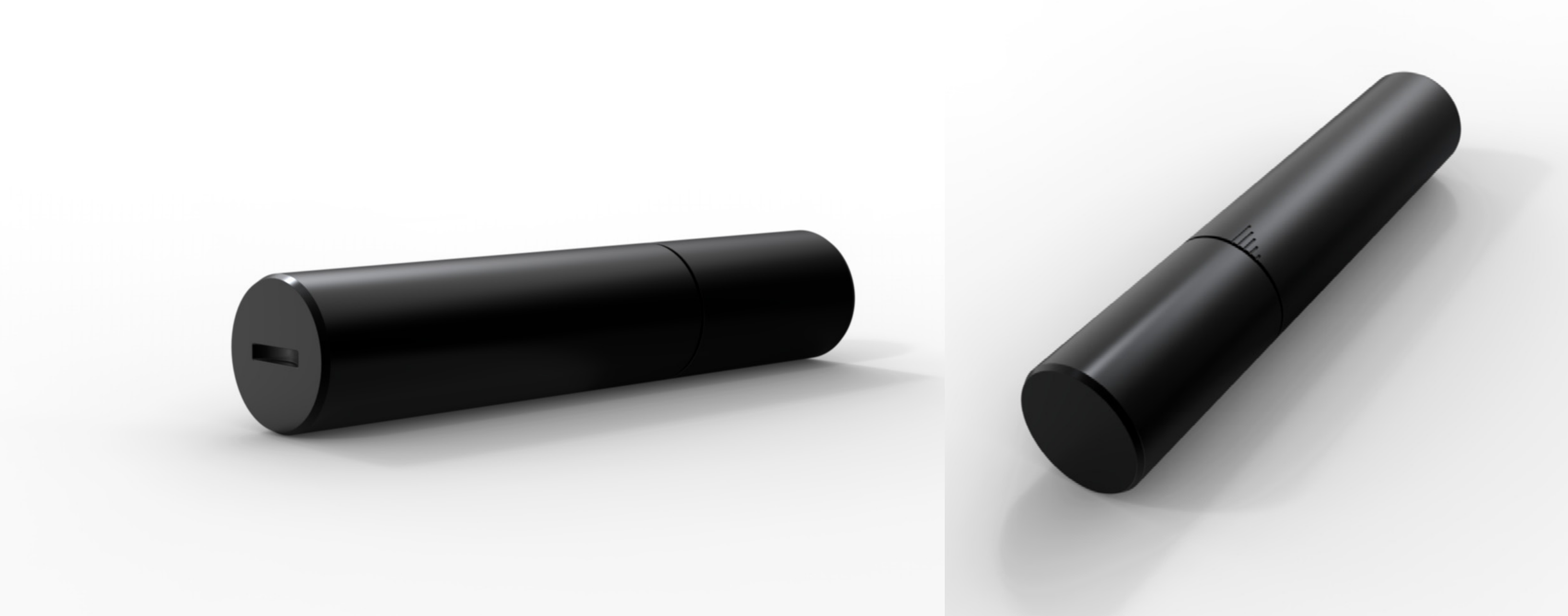


Figure 7.5.2 Remote

7.6 PROTOTYPE

As a result of this masters thesis project a prototype was manufactured. The ambition was to show design and functionality of the rolling concept with a high level of accuracy in order to evaluate the technology, functionality and usability among actual end users.

The light guides were provided by Recycling Development in appropriate sizes and the light guide frames were manufactured in aluminum. Since extrusion of aluminum is very expensive for a low number of parts, the chosen method for manufacturing was Electrical Discharge Machining (EDM).

The backside piece was manufactured by molding and the material used was Polyurethane, a resilient, flexible and durable manufacturing material for this model. Polyurethane is however a thermoplastic material with poor thermal conductivity. The solution was to incorporate the flash functionality in the prototype so that the aluminium light guide frames by themselves can dissipate the heat generated from the LEDs. A burst of light can however be released with the push of a button or via flash sensors.

Due to restrictions in size when molding a large but thin surface, the size of the prototype had to be reduced. Instead of making the concept half the original size it was decided to make it with only three light guide segments instead of seven since the light guides could not be scaled in thickness. By doing this the proportions of the backside and the light guide segments as well as the functionality of the folding principle could be preserved.

The backside could also only be molded in one piece resulting in that the frontside surface is the same dark grey and matt color as the backside surface, instead of having a light and reflective color.

Figure 7.6.1 CAD model of the prototype.

8 DISCUSSION

8 DISCUSSION

The aim of this master thesis project included the design of a new generation of lighting product for photographers and motion picture producers, as well as to provide the best user experience possible. At the same time the latest technology of LED and reused material from recycled LCD panels was essential to use as basic components. Except for these aspects, the project was undefined and the result should mainly be based on the outcome from the user study.

Based on the user study, the light quality is the most important aspect together with the light intensity. The light temperature is also important but can be regulated through additional films. The LED technology however is still relatively young and the development has been slow. Because of this, much time during this thesis went in to finding a suitable LED based on the users requirements.

The LED chosen for the prototype is from Citizen CL-L103 series, with a Ra value of at least 90 and color temperature of 5000K. This light fulfils all the set requirements for the product. It however generates a lot of heat, especially in the quantity used in order for the concepts to have sufficient intensity. The problematics with this lead to further difficulties in finding a suitable material for the backside part of the products without using an additional cooling system.

Aluminum is considered to be the most effective and widely used material for heat dissipation. This property together with the low weight of the material was the reason why it was chosen for the light guide- and LED- frame. It is however not a flexible material and hence this not suitable for the backside part.

Much time went in to research about a material that is both flexible like a polymer, and have a high thermal conductivity like a metal. The result is a material called metal-polymer composite. This material combines the advantages of both materials and is available today. It is however very expensive due to a small demand for such material and the small quantity needed in this project.

In order to still be able to use a polymer for the backside material, it was decided to incorporate the flash functionality in the products. In this way the benefits with a constant light can still be utilized while the heat generation can be kept to a minimum when the intensity is not needed. Another advantage with this is that the energy consumption will be lowered.

By observing and interviewing the users during the user study it was concluded that one light can not fit all situations. It became clear that it is necessary and valuable to design several products in order to satisfy all the users needs and it was decided to create a product family with a common design language.

The rolling concept and book folding concept are the main concepts, designed to a level not far from production-ready. The map folding concept on the other hand, is considered as a conceptual design but with great potential to be further developed.

The technology used in the three concepts are intended to improve the user experience. Since current products are usually bulky and heavy, the use of reused light guides and efficient LED results in a more portable and energy efficient light solution. The innovative design allow for new ways of using illumination, and the diversity of the product family can meet a wide range of needs.

9 FURTHER RECOMMENDATIONS

9 FURTHER RECOMMENDATIONS

This project has been considered to be achieved in a complete process from scratch sketching and paper folding into prototype making, and further considered the manufacture possibilities.

Though, due to the limited time and budget, we only make the rolling concept into the real functional prototype; also, the final rolling prototype has only three segments instead of seven in the original design.

In the beginning, the target user group were photographers and motion picture producers which are quite similar though difference industries. The three final concepts are designed for both industries, however, more possibilities could be investigated in either of these industries. By enlarge both the quantity of the design and the category of the target user, a product family could be made more diversity and practical.

And as mentioned in the previous chapters, the map folding concept is a conceptual design, so for the further development, more advanced technology is needed to accomplish the design (smaller size LEDs, thinner light guide, etc.).

As it is important that the aim of this thesis project is to reuse the material that is not easy to recycle, it is also recommended to further consider how to deal with these new disposal in a sustainable way of thinking, though it might have a better way to recycle the LEDs or light guide in the short future.

In this project, though we have done a user focus group interview after the three concepts have been developed, for the product evaluation phase, it is also recommended to take another round of interview on how the interviewees reflect the functional prototype.

Some technical problems such as how to connect the electric cable, what is the dimension of the cable have not been considered into this project due to the limited communication with the technician and our related knowledge. Though this could be accomplished by cooperate more with professional person.

10 REFERENCES

10 REFERENCES

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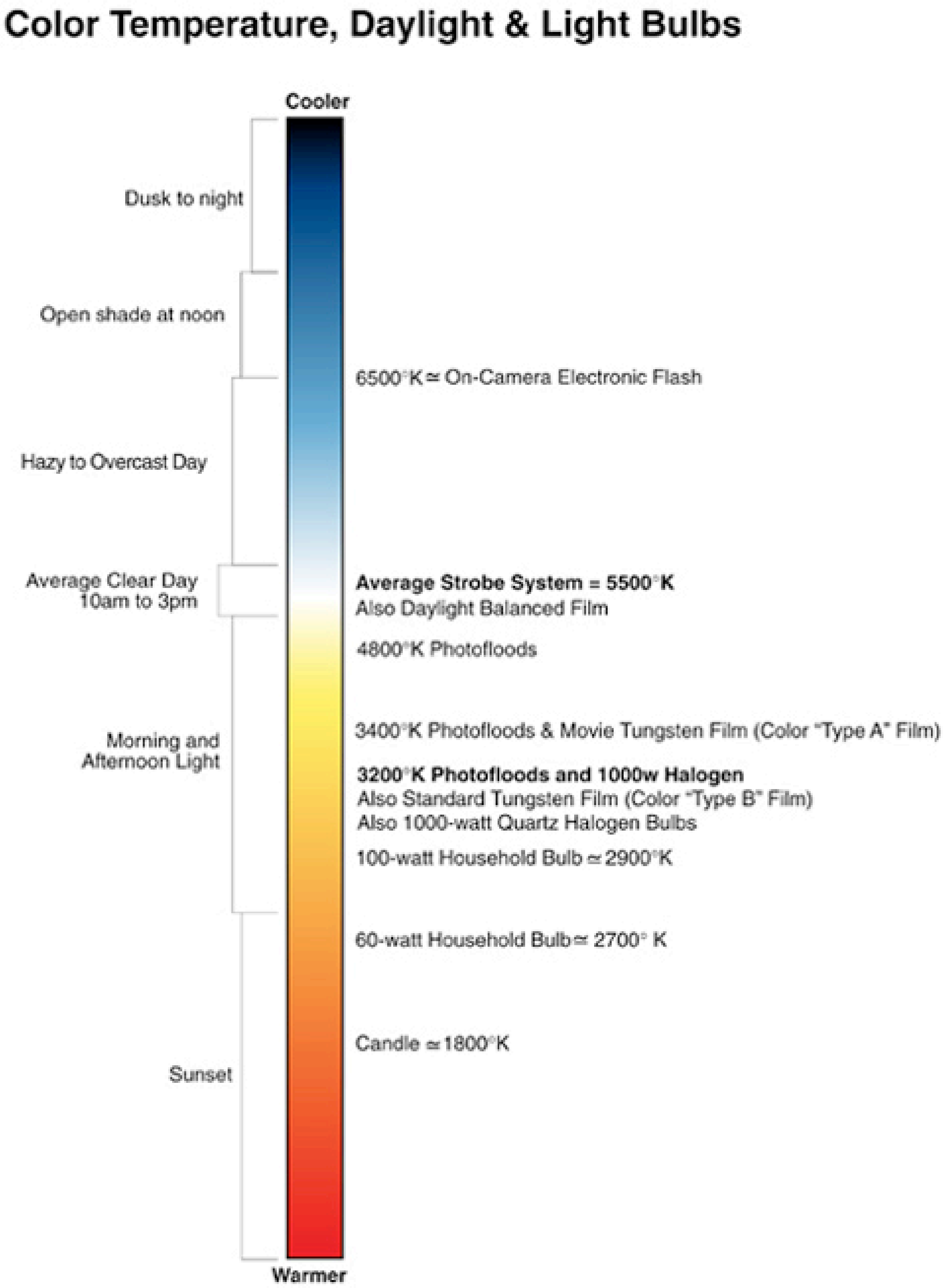
11 APPENDIXES

Appendix A
Time planning

Tasks / Week, Date begins	4 01.24	5 01.31	6 02.07	7 02.14	8 02.21	9 02.28	10 03.07	11 03.14	12 03.21	13 03.28	14 04.04	15 04.11	16 04.18	17 04.25	18 05.02	19 05.09	20 05.16	21 05.23	22 05.30	23 06.06	24 06.13	25-35 06.20-08.31
Start-up scheduling, meeting,etc																						
Pre study 1. Technology studies; 2. Exsiting products research.																						
Interview & User study 1. Interview photographers and movie-makers' needs; 2. Document how they work, analyse how the exsiting products work,light quality, usabilities in reality.																						
Idea generation Concept development 1. Generating ideas; 2. Further developing concepts.																						
Mid-presentation 1. Presenting all the user, product studies and initial concepts; 2. Collecting suggestions and advices; 3. Summarising and analyzing.																						
Concept validation computer aided design visualisations																						
Prototype 1. Making mock-ups(idea generation); 2. Making prototype for final design.																						
Report 1. Daily-weekly summaries 2. Final report																						
Final Presentation																						
Buffer																						

Appendix B
Color temperatures



Appendix C1
DFA-existing lights

D F A

Photo light concept

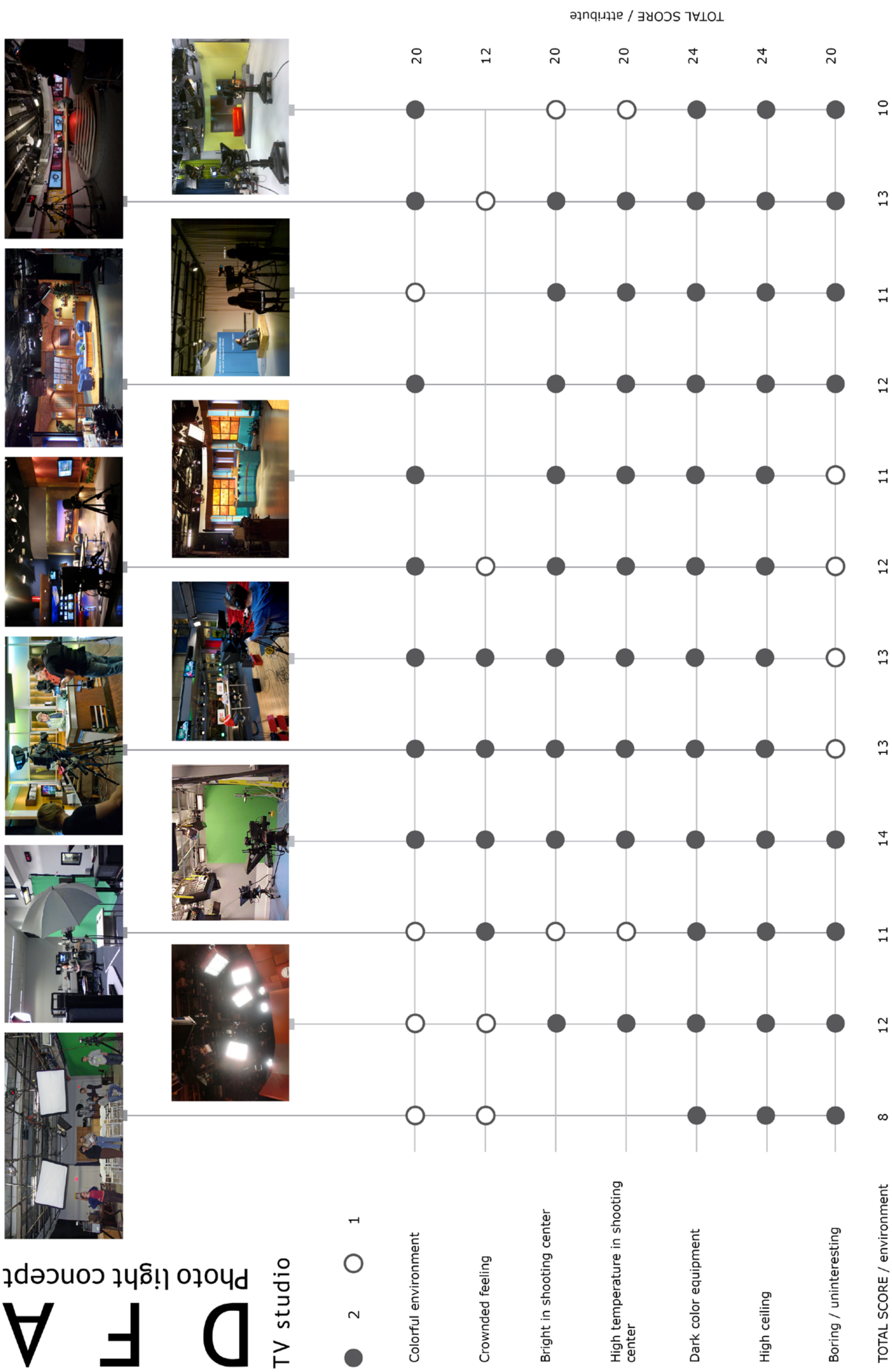
existing lights

Black outside surface	●	●	●	●	●	●	●	●	●	●	●	22
White inside surface			○		○					●		4
Silver inside surface						●	●		●			6
Square shape		●	●	○	●	●		●	●		○	14
Round shape	●	○		○			●			●		8
Metal	●	●	●	●		●	●	●	●	●	●	20
Fabric				●	●							4
Industrial look	●	●	●	●	●	●	●	●	●	○	●	21
Bulky/Heavy	●	●	○	●	●	○	○	○	○	●	●	17
Total score / product	10	11	10	12	11	11	11	9	11	11	9	

Total score / attribute

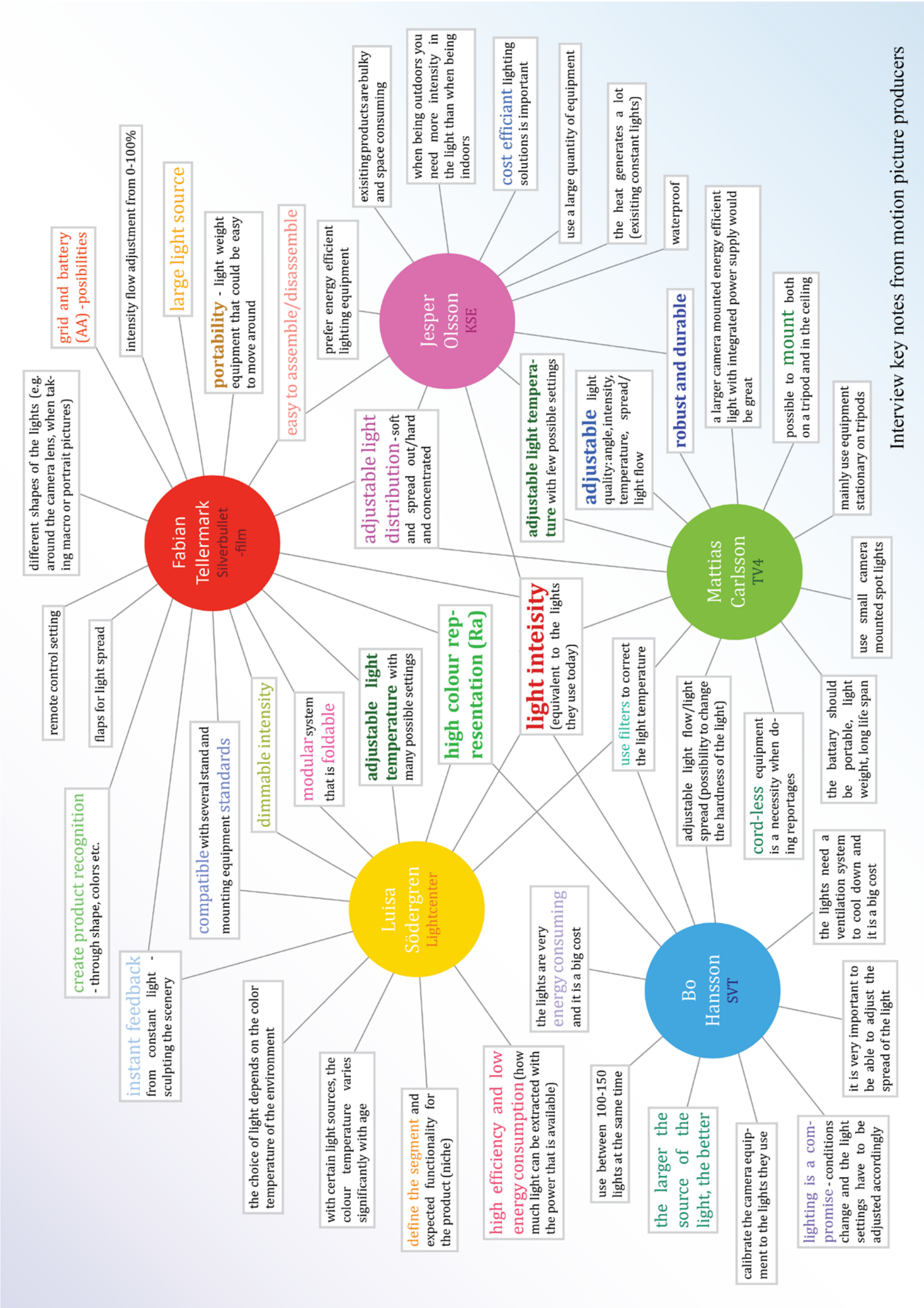
Appendix C2
DFA-photo studio

Appendix C3
DFA-TV studio

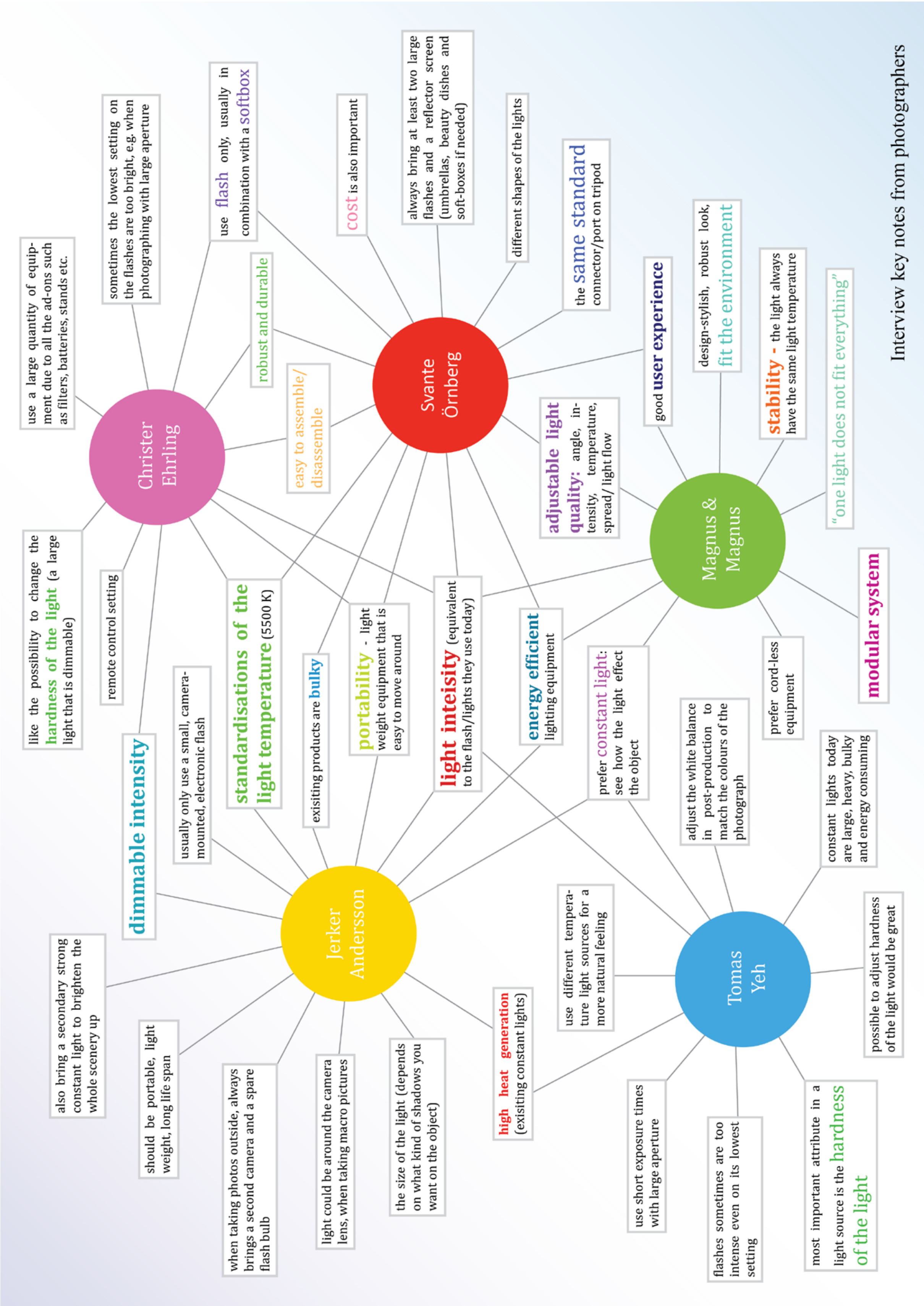


Appendix D1

Summary of interviews with motion picture producers



Appendix D2
Summary of interviews with photographers

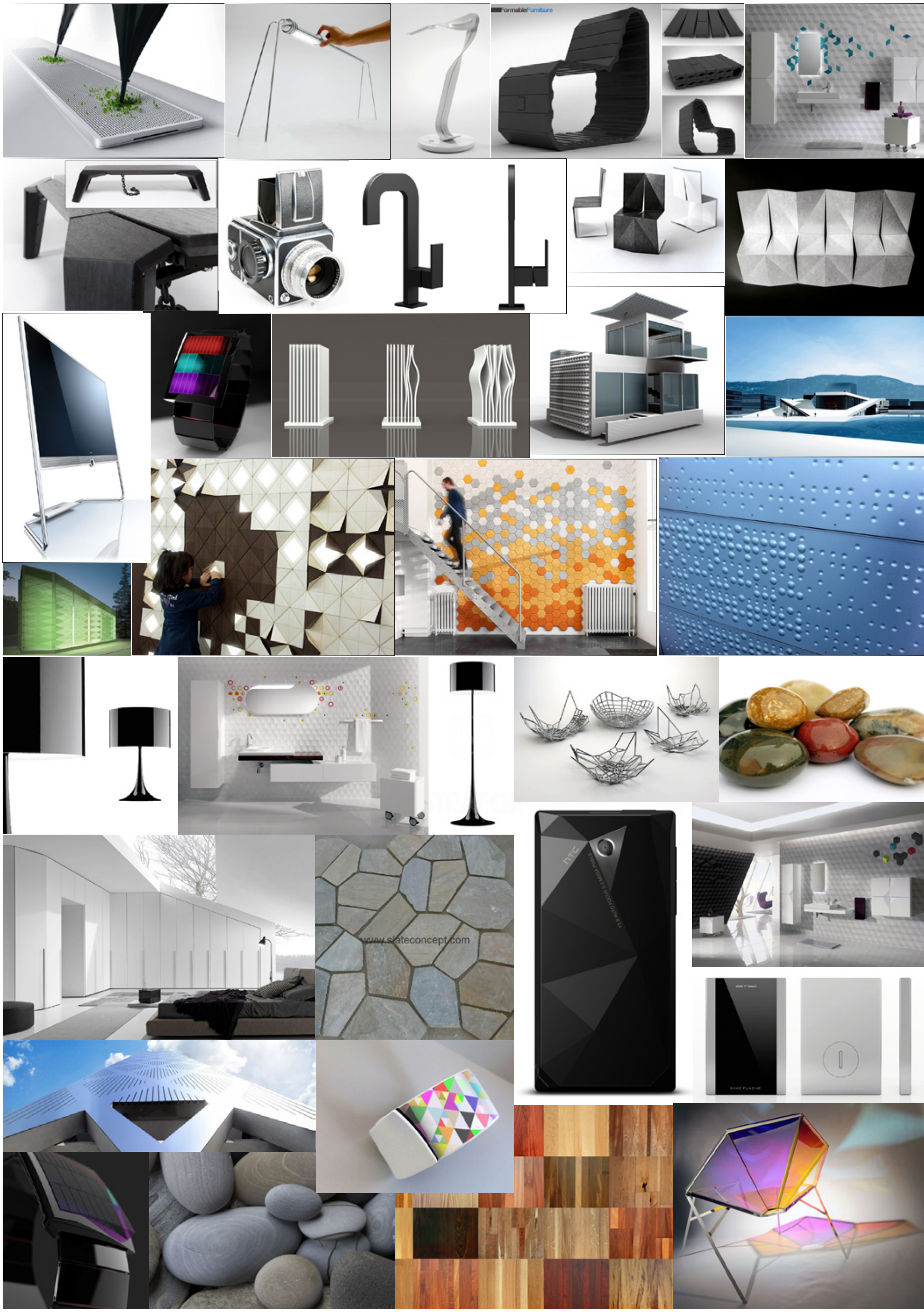


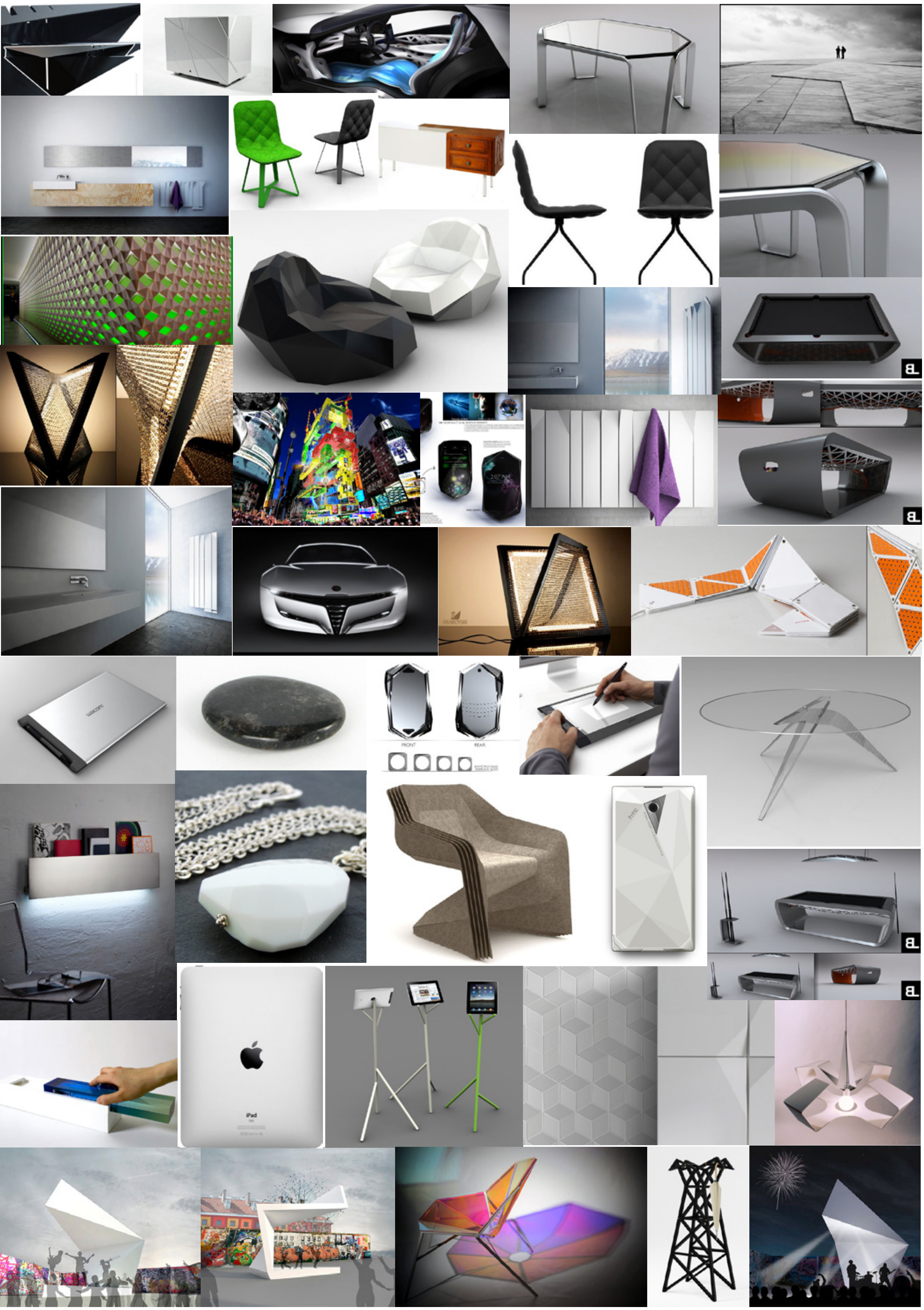
Appendix E
Demand specification

Function	Requirement	Design criteria	Priority value (1-3)	Notes
Quality:	High light quality	Sufficient light intensity	3	(LUX > 500 at a distance of 3meters from light source)
		Sufficient CRI-value	3	(CRI > 90)
		High light stability	3	Little or no color variations due to temperature or age
		Standard light color	2	Light color of daylight (5500K)
	Durable	Stable light quality	3	
		Robust	3	Trustful material selection, do not easy to break
		Waterproof	1	In order to withstand rough outdoor environments
Adoptability	Adjustable	Adjustable light intensity	3	Dimable in steps or from 0-100%
		Adjustable light spread	2	From scattered to focused by filters or flaps
		Adjustable positioning	2	Ability to adjust the height, pitch and direction of the light
		Adjustable light color	1	Either by using RGB LED or filters
		Adjustable light temperature	1	Either by using RGB LED or filters
		Ball connection	1	To be able to swivel freely for adjusting the direction of the light
	Controllable	Remote control adjustability	1	
Mobility:	Portable	Light weight	2	
		Easy to assemble/disassemble	3	
		Easy to carry when being disassembled	3	Either incorporated in the casing of the light itself or in specially made cases for all parts of the equipment
		Battery power as well as grid power possibilities	2	
		Integrated battery-pack in body	1	
		Foldable	3	Possible to fold together as a modular solution
		Tripod as well as ceiling mounting	2	
	Modular	Possible to adjust size by connecting several screens together	2	
Standardization:	DC power supply	230 volt grid power connection	3	
	Standard conjunction	16 mm thread screw connection	3	
		Compatible with today's standard equipment	3	
Design:	Strong visual recognition		3	Through a complete design language and colors
	Simple	Simple shapes – slim and light	3	
		Intuitive design	3	Easy-to-use and intuitive, Good HMI (Human-Machine Interaction)
	Innovative	New	3	
		Exciting	3	
		Interesting	3	
		Appealing	3	
	Express environmentally friendly	Based on recycled LCD-screens	3	
		Energy efficient	3	
		No hazardous materials	2	
		Possible to recycle	2	
	High-qualitative and detailed		3	
	Self-expression		3	Be a part of the environment where it belongs
Cost:	Low cost		1	
	Long lifespan of parts		3	

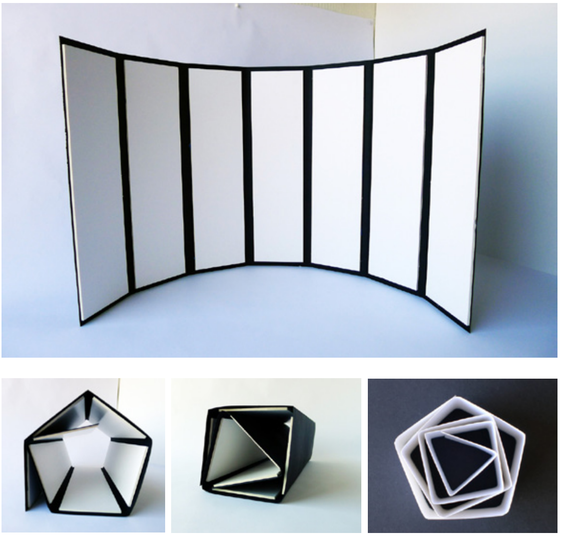
Appendix F
Image board

Appendix G
Inspiration board





Appendix H1
PMI tables



Rolling

Pros:

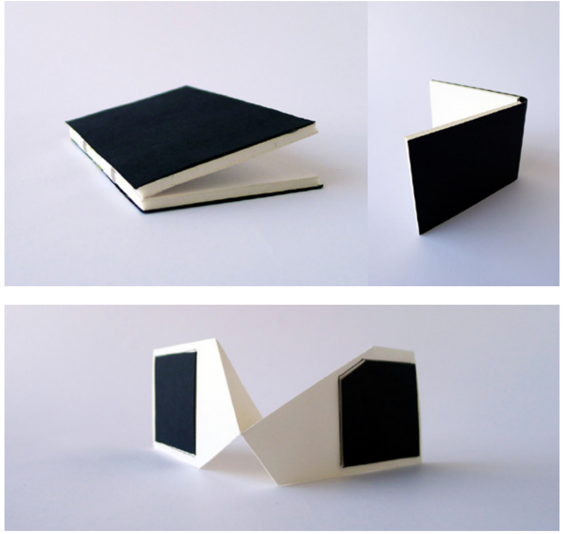
- Good for all size screens.
- Nice shape when rolled up.
- High innovation.
- Higher intensity (more LEDs fixed).
- Esay to carry/pack (less space occupied).
- Spread out/ focus the light.
- Could be mounted on the wall/ceiling and tripod.

Cons:

- The diffusing could be a problem /Gap in between each screen could affect the light.
- Need to laser cut the screens (could result in high manufacturing cost).
- In order to roll up in a triangular shape, either the gaps/screens need to grow in size.

Possibilities:

- Different kinds of rolling methods are possible.
- Explore different shapes for rolled up state.



Book Folding

Pros:

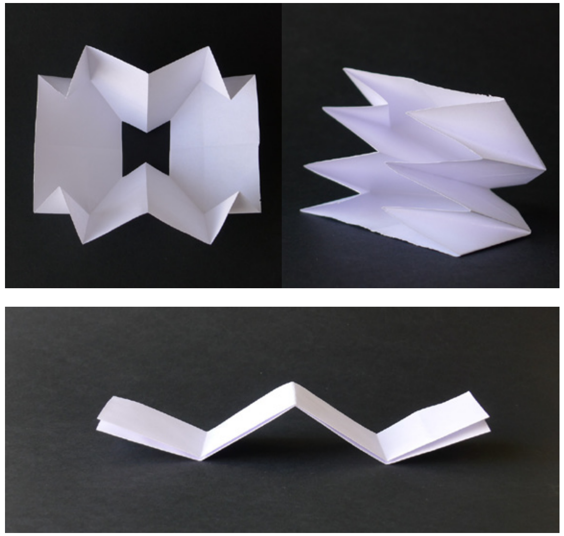
- Screens are protected when folded up.
- Easy and effective solution for assemble/disassemble (no connection mechanism).
- Spread out/ focus the light.
- Thin thickness remained even when folded.
- Easy to carry and operate.
- Possible to have more variations of folding/unfolding .
- Good for small size screens (hard to operate when too large).
- No need for extra processing of the light guides (laser cutting).

Cons:

- Conservative solution (however possible to develop it).
- Only fit two screens in one module.

Possibilities:

- High mobility, easy to carry and quick assemble/disassemble; good for professionals on the move or that have to change location fast.



Map Folding

Pros:

- Innovative.
- Easy to use as modules.
- Good for small size screens.
- Good for thin screens (conventional map fold).
- No need for extra processing of the light guides (conventional map fold).
- Camera can be placed in the centre (ring light), however only possible to have a square shape.
- “Integrated flaps”
- Could be a macro-photo solution as well.

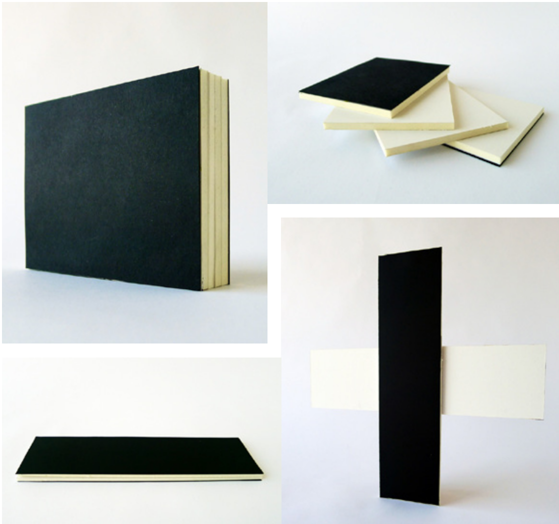
Cons:

- The gap in between each light source could be a problem.
- Conflict between material selection and structure stability for long term use (to be able to fold repeatedly and still have a stiff enough structure).
- Many screens can make the whole structure heavy and less portable.

Possibilities:

- Could use thin monitor light guides instead of the thick TV light guide.
- Possible to make it a round shape (with rectangular light guides)

Appendix H2
PMI tables



Fan (Spinning)

Pros:
- Innovative.
- Contemporary feeling.
- Close packing with one fourth of total size, (half of total size).
- High intensity light (200% increase).
- Could be applicable for both large and small screens.

Cons:
- Waste of material if cutting the screens square.
- At least one screen will be unprotected when folded.
- Weak construction point in connection.
- Maximum number of screens in a module is 4.

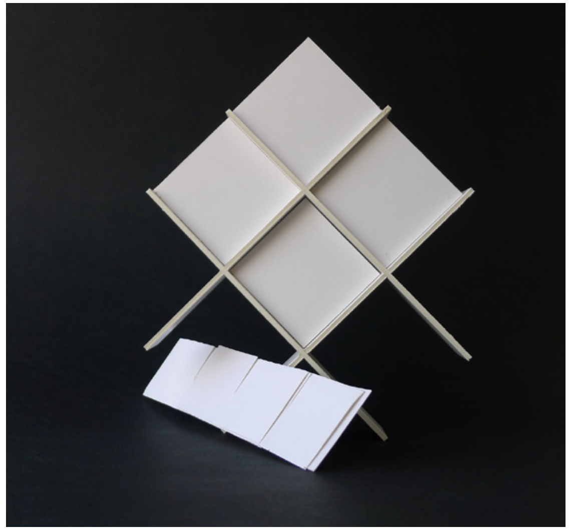
Possibilities:
- Use spring load to make the screens same level when folded out.

Pop-up

Pros:
- Integrated stand and handle.
- Portable.
- Fast to assemble/disassemble.
- Applicable both for large/small screens.
- No need for extra processing of the light guides.

Cons:
- Only one screen could be mounted.
- Low usability of the stand, few adjustment could be made.
- The screen is exposed without protection.
- Unbalanced and unstable structure.

Possibilities:
- Low budget, portable, less professional use.

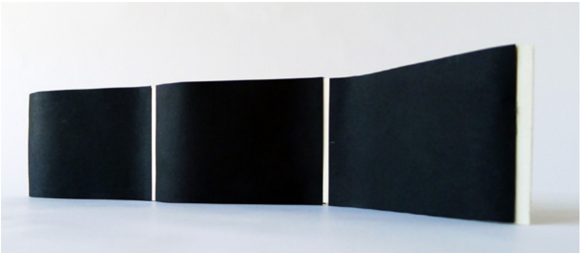


Intersecting (stand)

Pros:
- Highly foldable structure.
- High innovation.
- Possible to fit many screens on the stand instead of just one.

Cons:
- Unstable structure.
- Nonadjustable.
- Not standardised for compatibility with other brands/products.

Possibilities:
- Most applicable for common light.



Sliding (modular)

Pros:

- Possible to have individual screen as well as modular.
- Possible to connect endless amount of screens.
- Easy to assemble/disassemble.
- Close packing when disassembled.
- Possible to integrate the connections into the main body - low manufacturing cost.
- No need for extra processing of the light guide.

Cons:

- Could be difficult to make it stable when assembled because of the tolerences in manufacturing.
- May consume lots of time to assemble/disassemble .
- May need an extra case to transport screens.
- Each module needs individual cable connection.

Possibilities:

- Applicable for all size screens.

Sliding (fixed)

Pros:

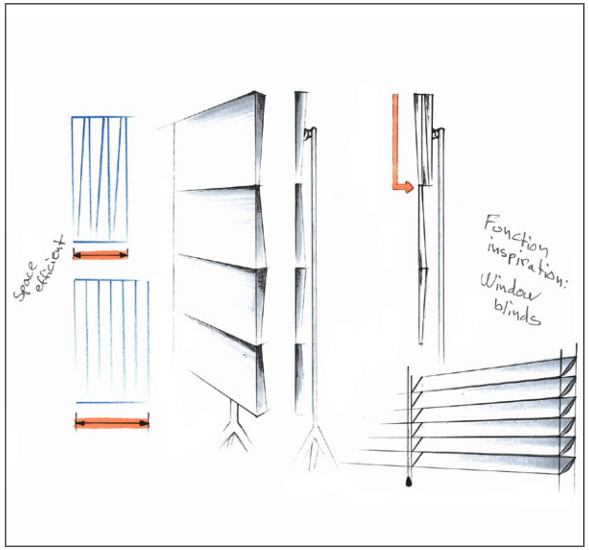
- Possibility to increase intensity or size.
- Portable and space effecient.
- Easy and fast to assemble/disassemble and set up.
- Use more than one kind of LCD screen (less waste).
- No need for extra processing of the light guide.

Cons:

- Difficult to make modular.
- Possible problems with the second reflector film.
- The mechanism for sliding is fragile if not kept simple.
- The limit in size of thin computer screens.
- Top screen will be unprotected.

Possibilities:

- Best applicable for small-medium size screens.
- Possible to make the sliding mechanism motorised.



Sliding (blinds)

Pros:

- Space efficient when folded together.
- Innovative.
- Easy and fast to assemble/disassemble and set up.
- Possble to adjust the size of the light source.
- Use more than one kind of LCD screen (less waste).
- Could be mounted on the wall/ceiling and on a tripod.

Cons:

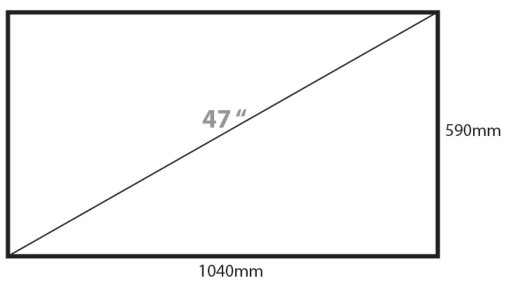
- Not possible to separate and use individually.
- The mechanism for sliding is fragile if not kept simple.
- At least one screen will be unprotected when folded.

Possibilities:

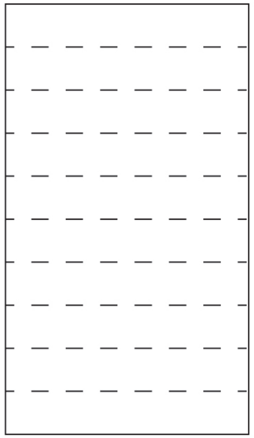
- Best applicable for small-medium size screens.
- Possible for common light as well.
- The string from the blinds could be used as an on/off switch, and other adjustments.

Appendix I

Variations of the rolling concept and the theoretical intensity output- divided vertically and horizontally



Divided into 10 segments:



1040 mm/ 10= 10.4 mm

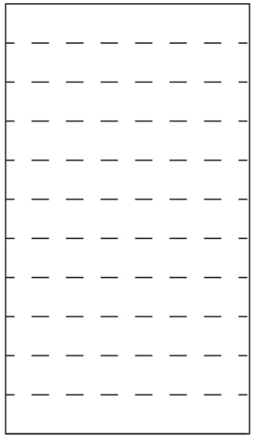
590 mm/50mm = 11 pcs

6:
6 X 22 pcs = 132 pcs
132 pcs X 235 lm = 31020 lm

7:
7 X 22 pcs = 154 pcs
154 pcs X 235 lm =36190 lm

8:
8 X 22 pcs = 176 pcs
176 pcs X 235 lm = 41360 lm

Divided into 11 segments:



1040 mm/ 11= 94.5 mm

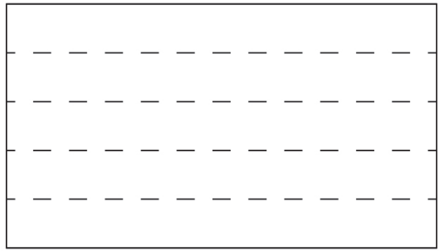
590 mm/50mm = 11 pcs

6:
6 X 22 pcs = 132 pcs
132 pcs X 235 lm = 31020 lm

7:
7 X 22 pcs = 154 pcs
154 pcs X 235 lm =36190 lm

8:
8 X 22 pcs = 176 pcs
176 pcs X 235 lm = 41360 lm

Divided into 5 segments:



590 mm/ 5= 118 mm

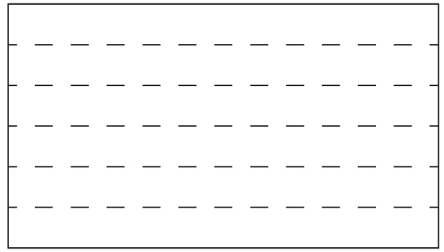
1040 mm/50mm = 20 pcs

5:
5 X 40 pcs = 200 pcs
200 pcs X 235 lm = 47000 lm

6:
6 X 40 pce =240 pcs
240 pcs X 235 lm = 56400 lm

7 segments:
Fit in:
7 X 22 pcs = 154 pcs
Total Intensity:
154 pcs X 235 lm =36190 lm

Divided into 6 segments:



590 mm/ 6= 98 mm

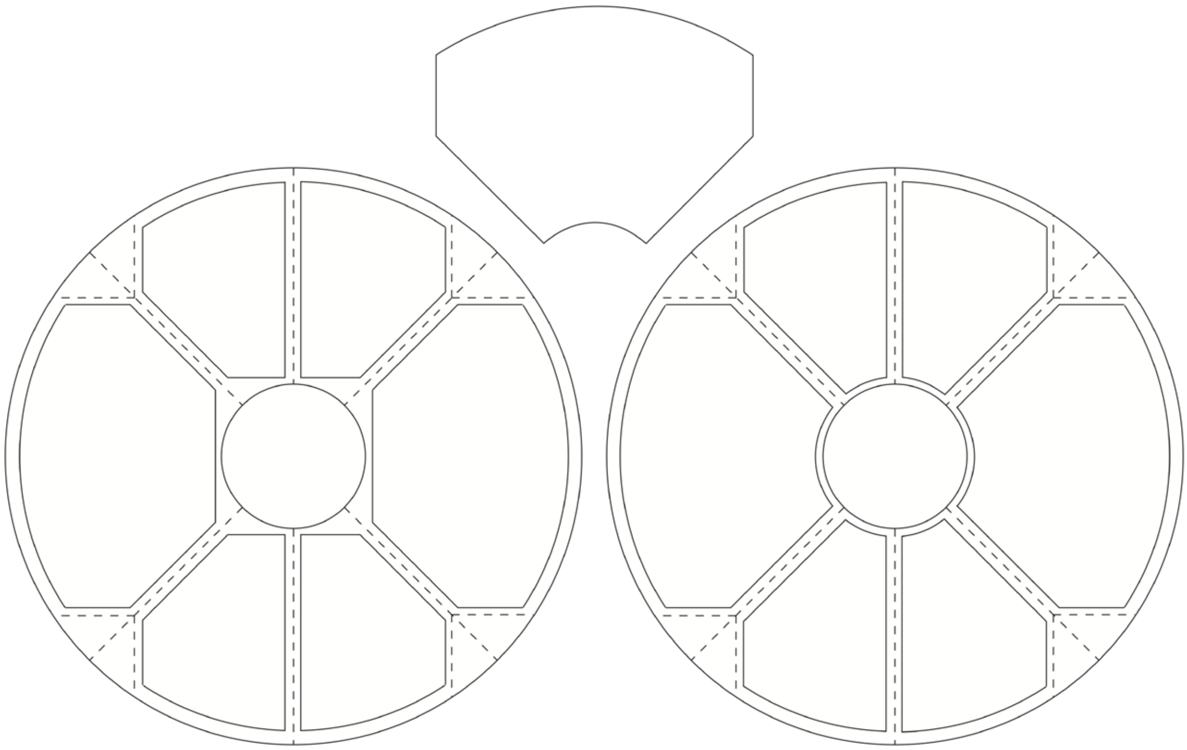
1040 mm/50mm = 20 pcs

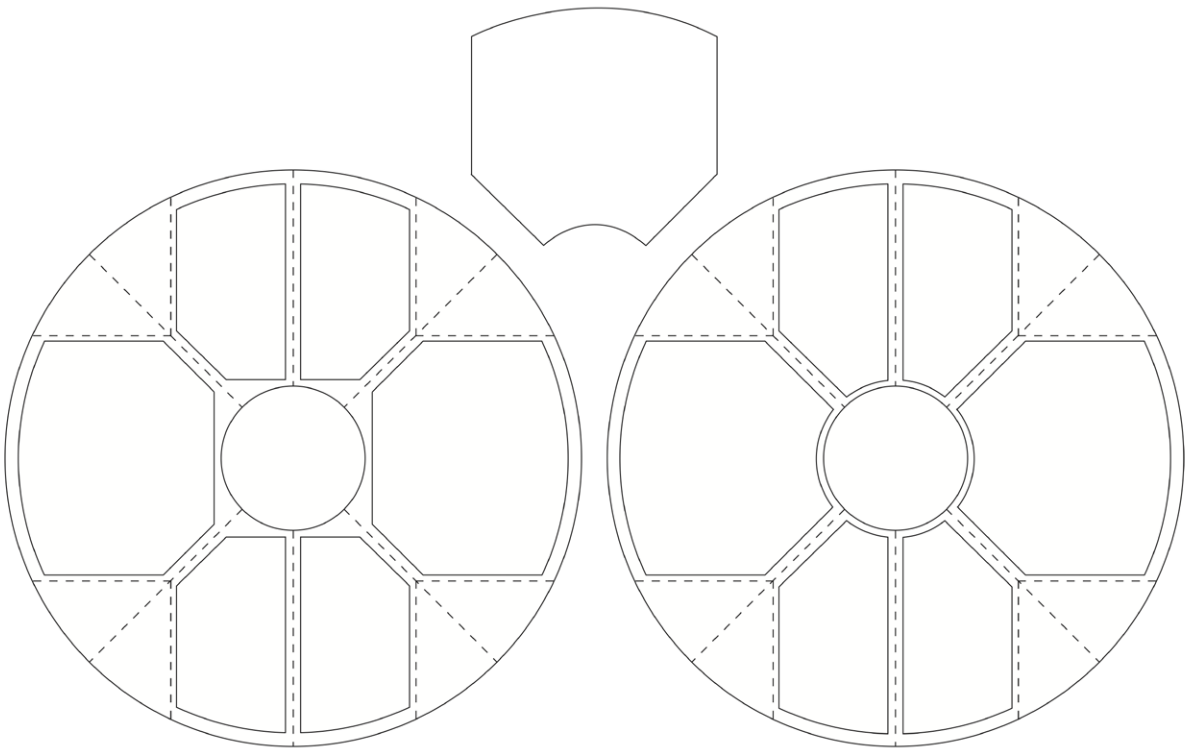
5:
5 X 40 pcs = 200 pcs
200 pcs X 235 lm = 47000 lm

6:
6 X 40 pce =240 pcs
240 pcs X 235 lm = 56400 lm

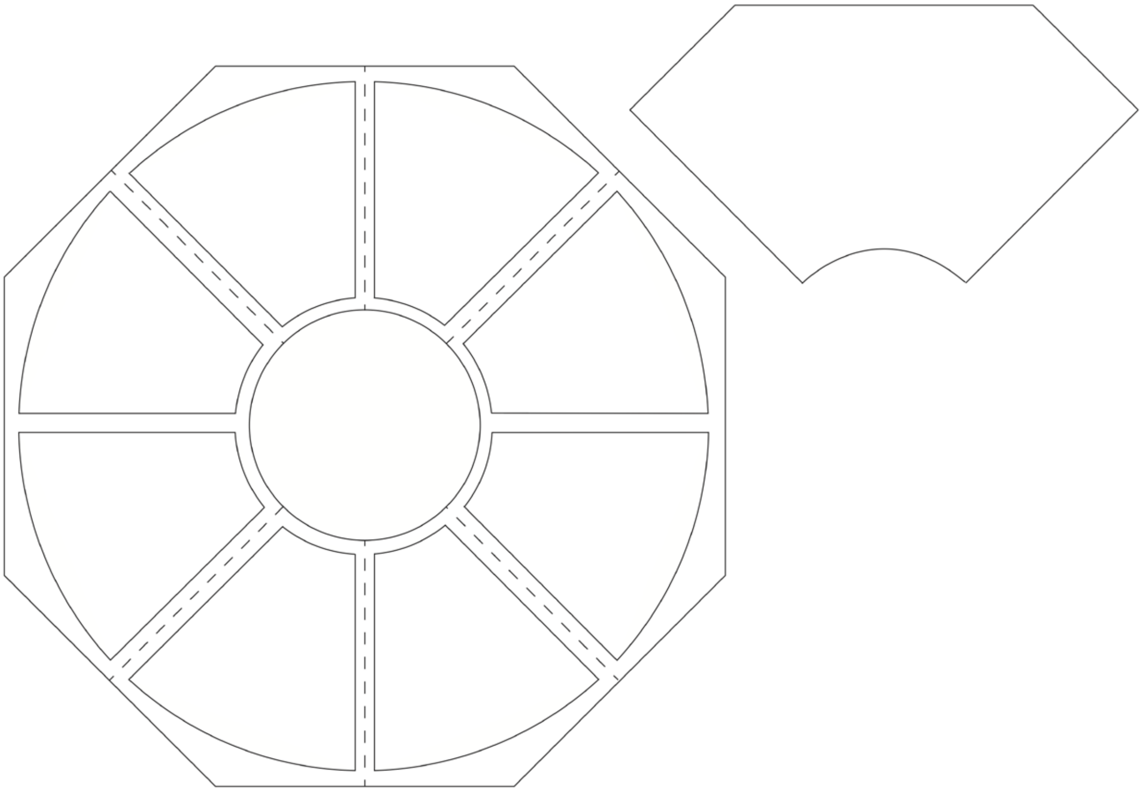
8 segments:
Fit in:
8 X 22 pcs = 176 pcs
Total Intensity:
176 pcs X 235 lm = 41360 lm

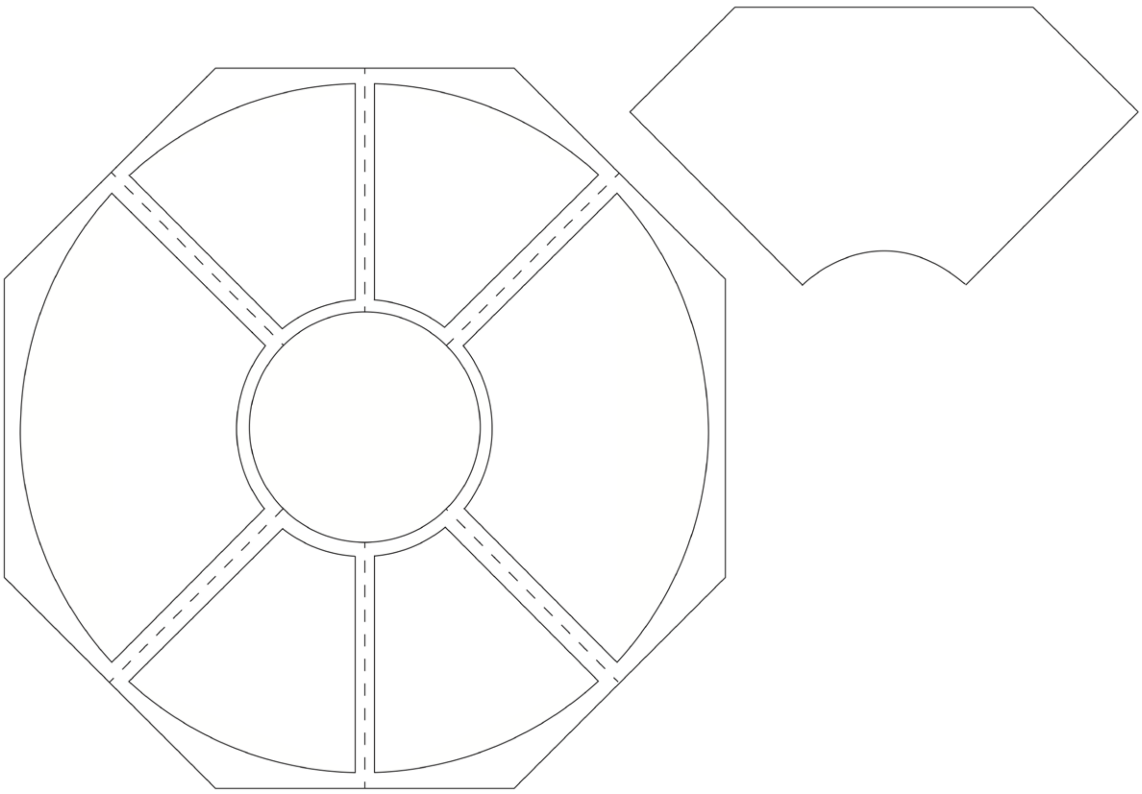
Appendix J1
Variations of the map-folding concept



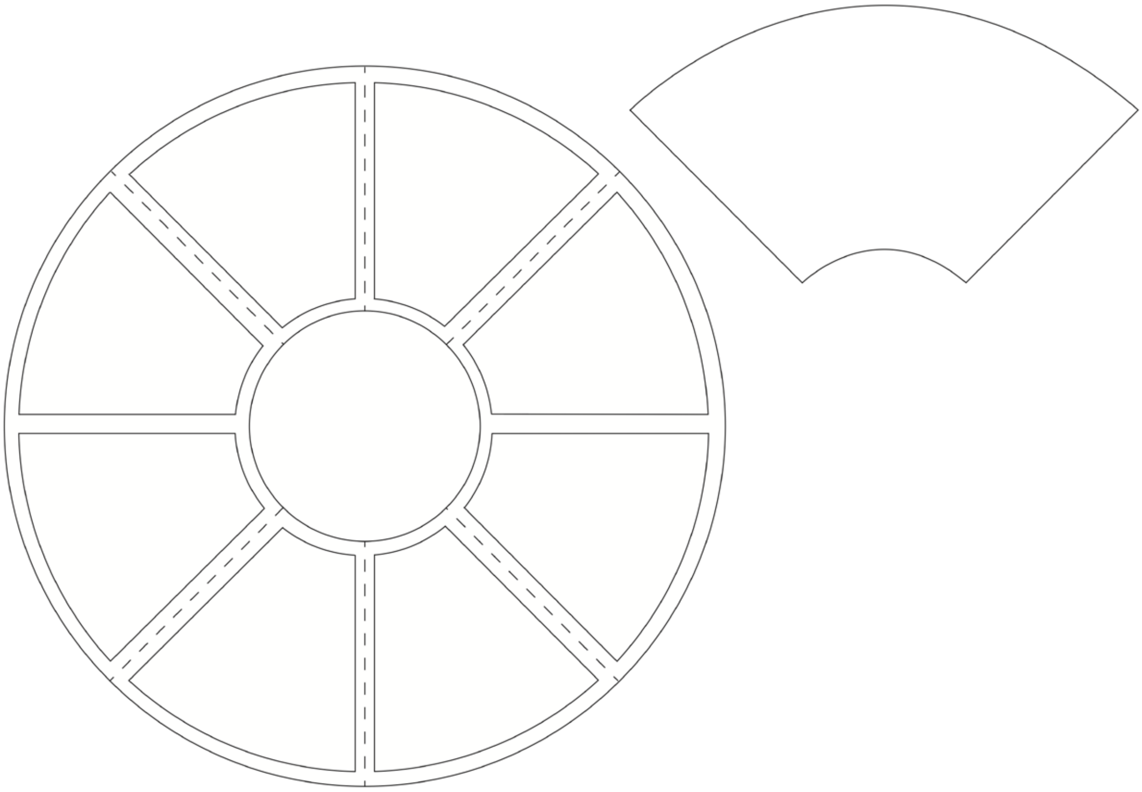


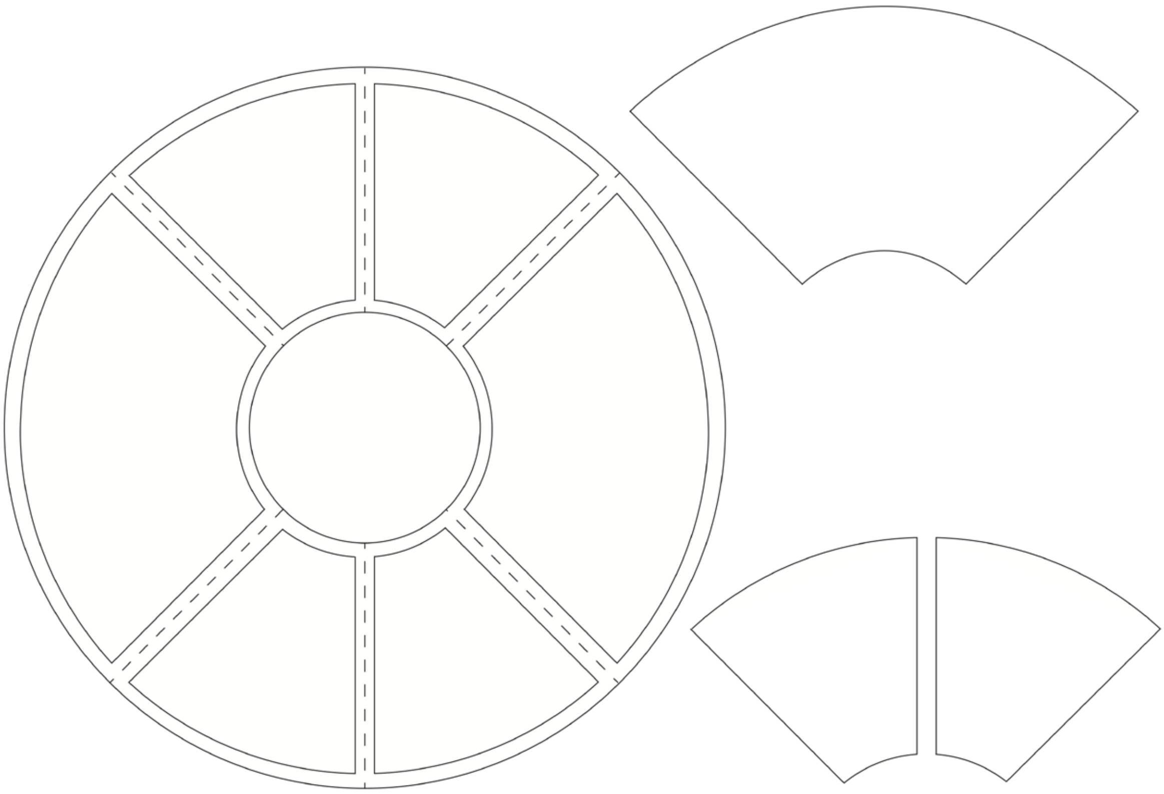
Appendix J2
Variations of the map-folding concept



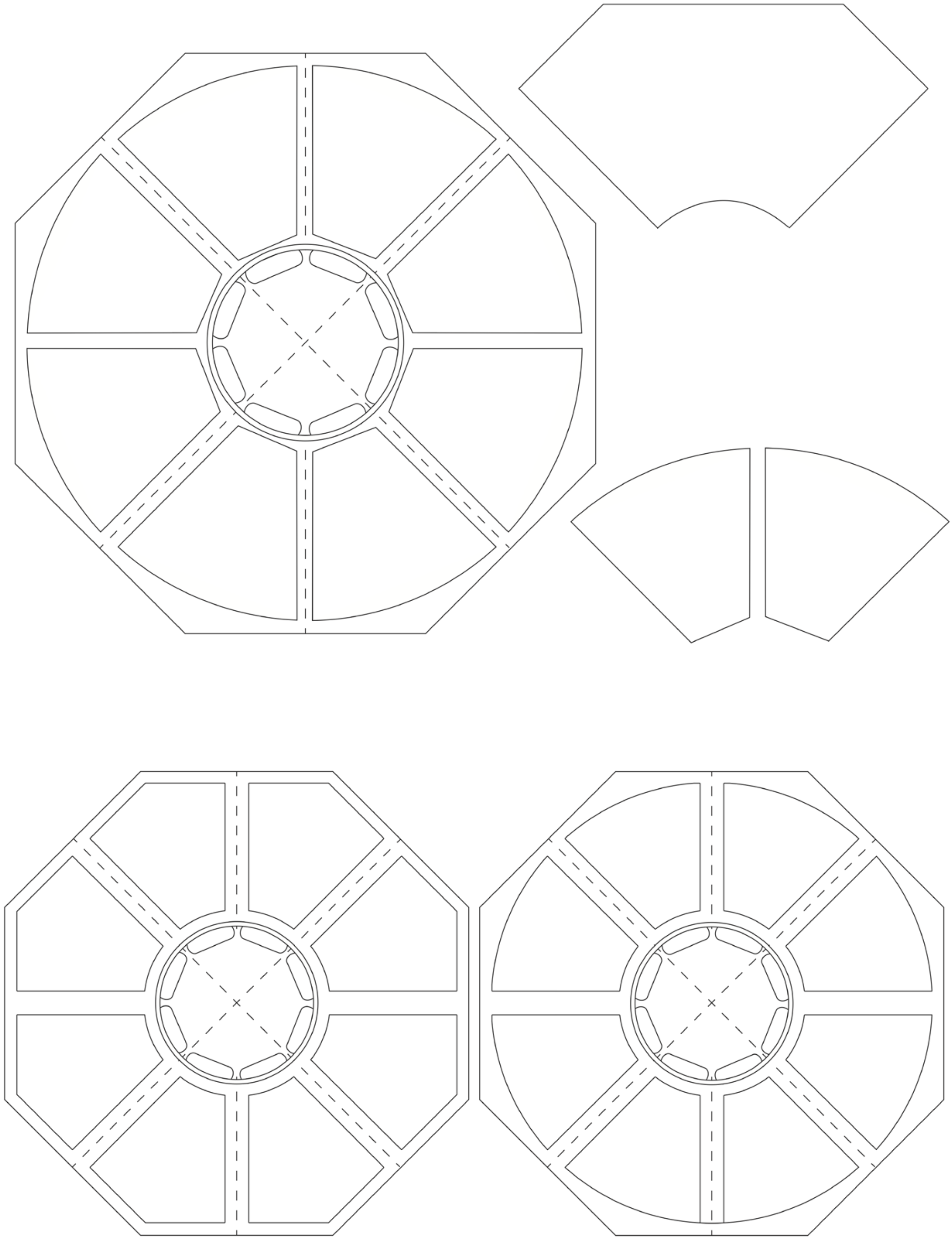


Appendix J3
Variations of the map-folding concept

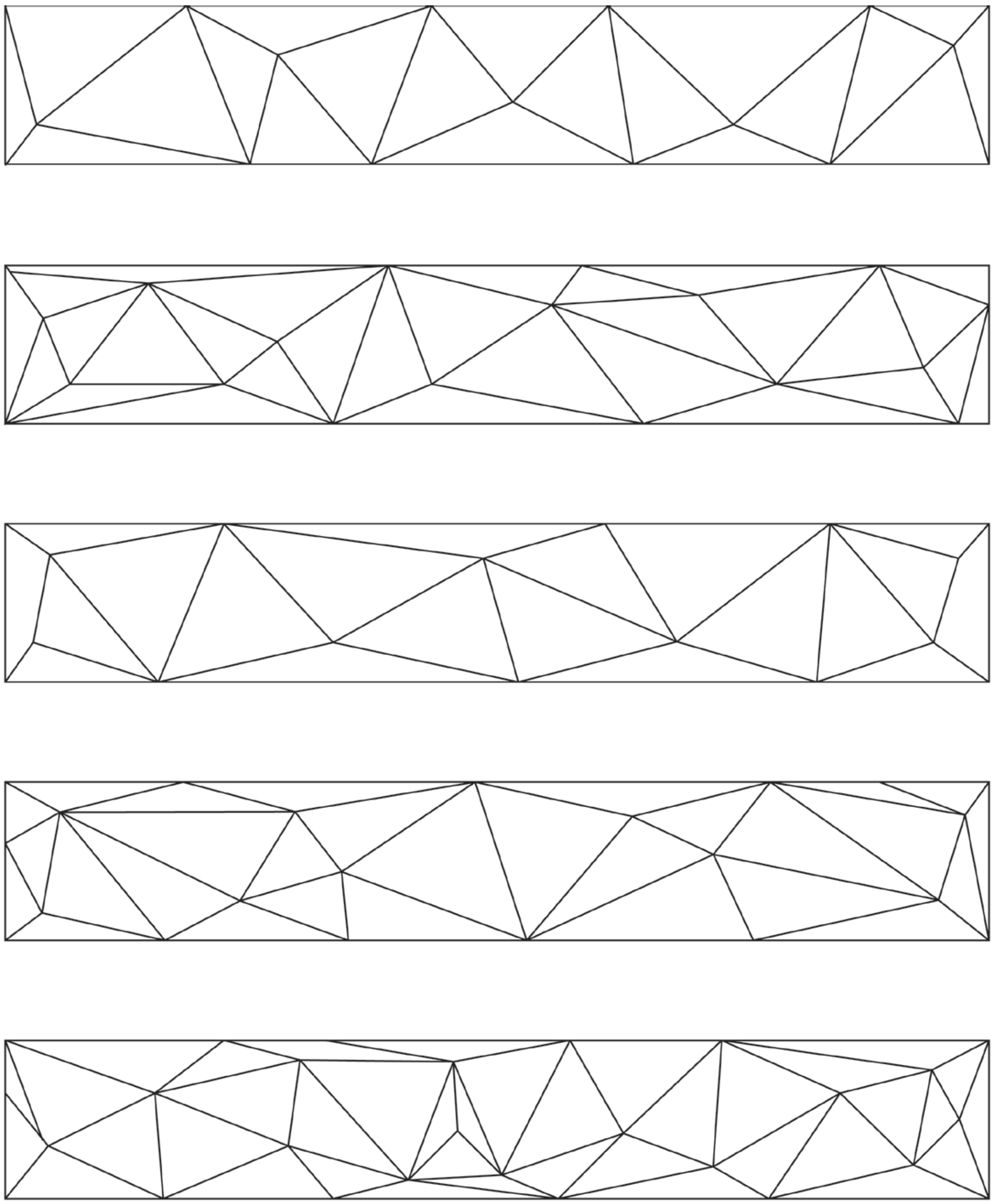




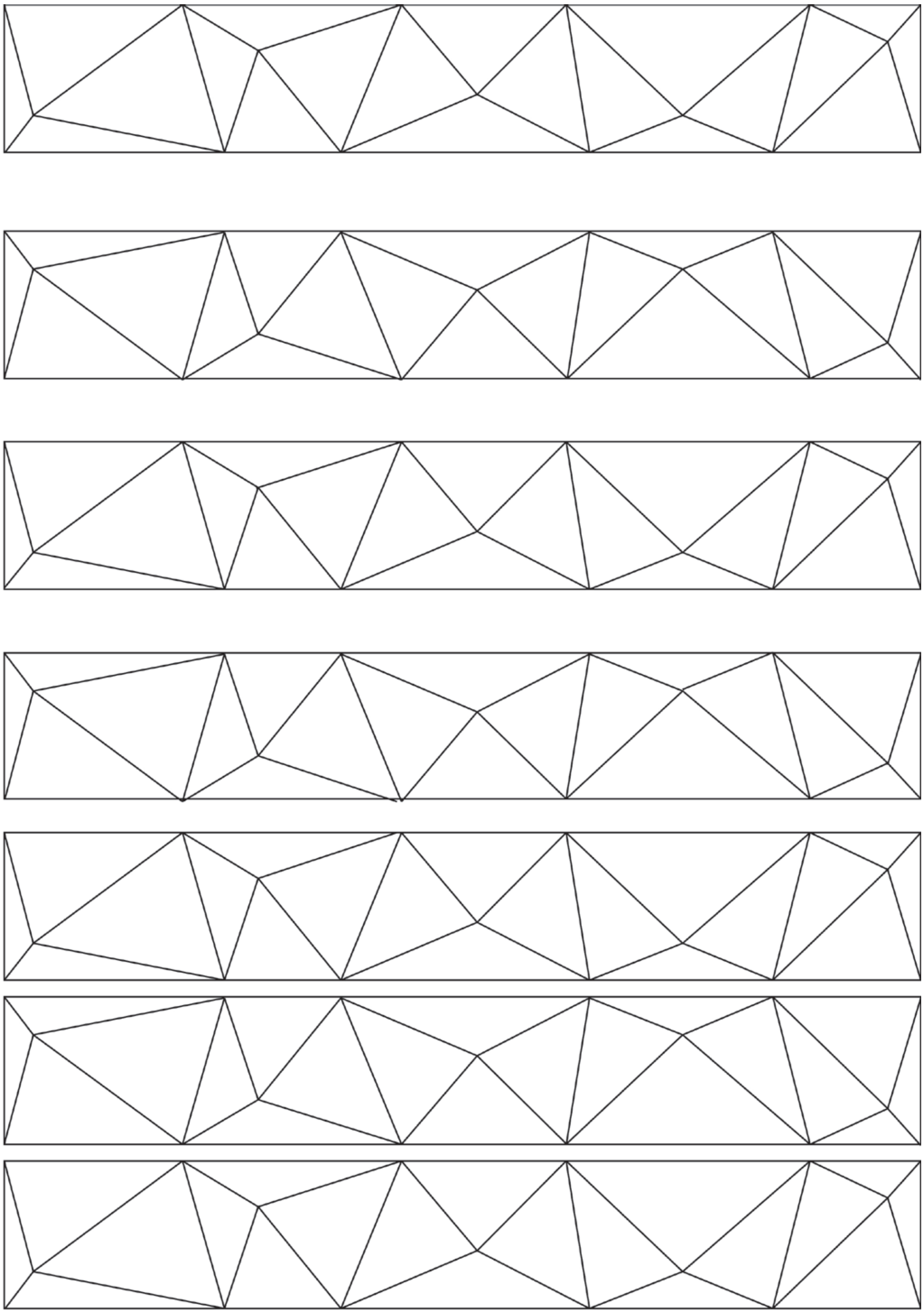
Appendix J4
Variations of the map-folding concept

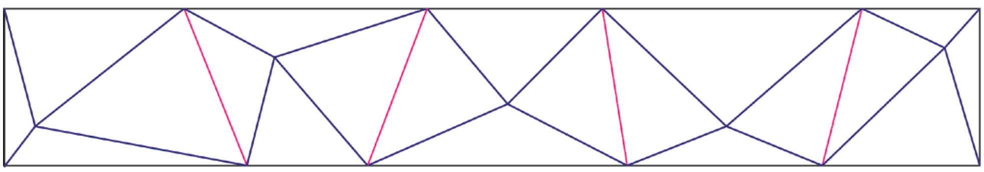


Appendix K1
Variations of the backside pattern



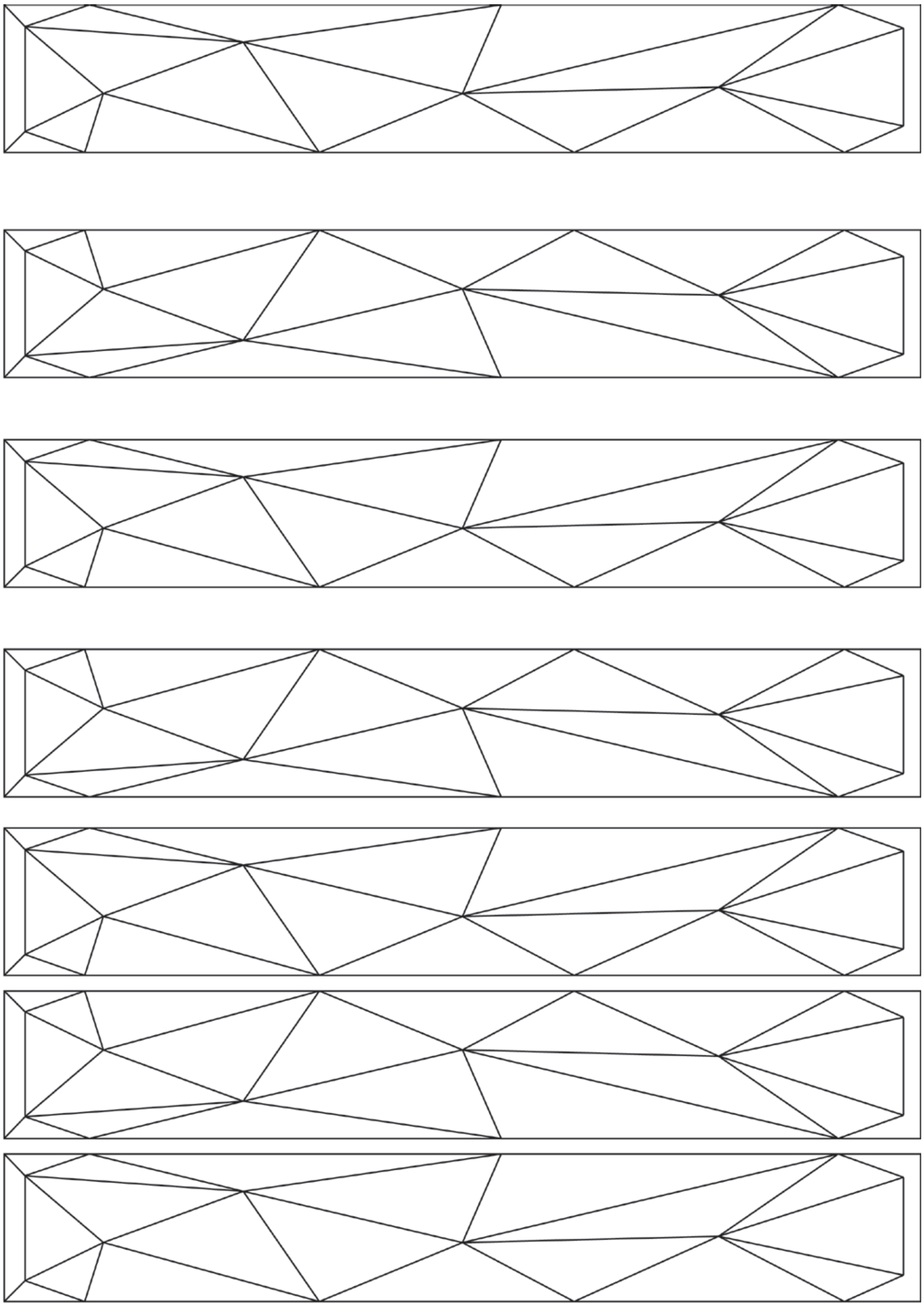
Appendix K2
Variations of the backside pattern

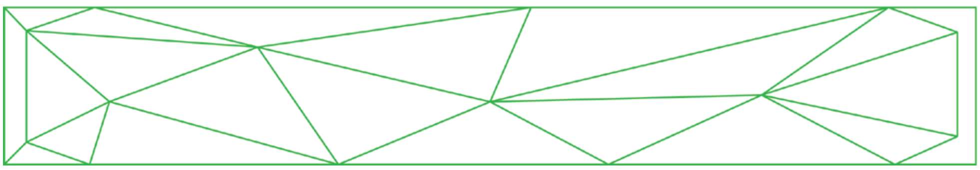




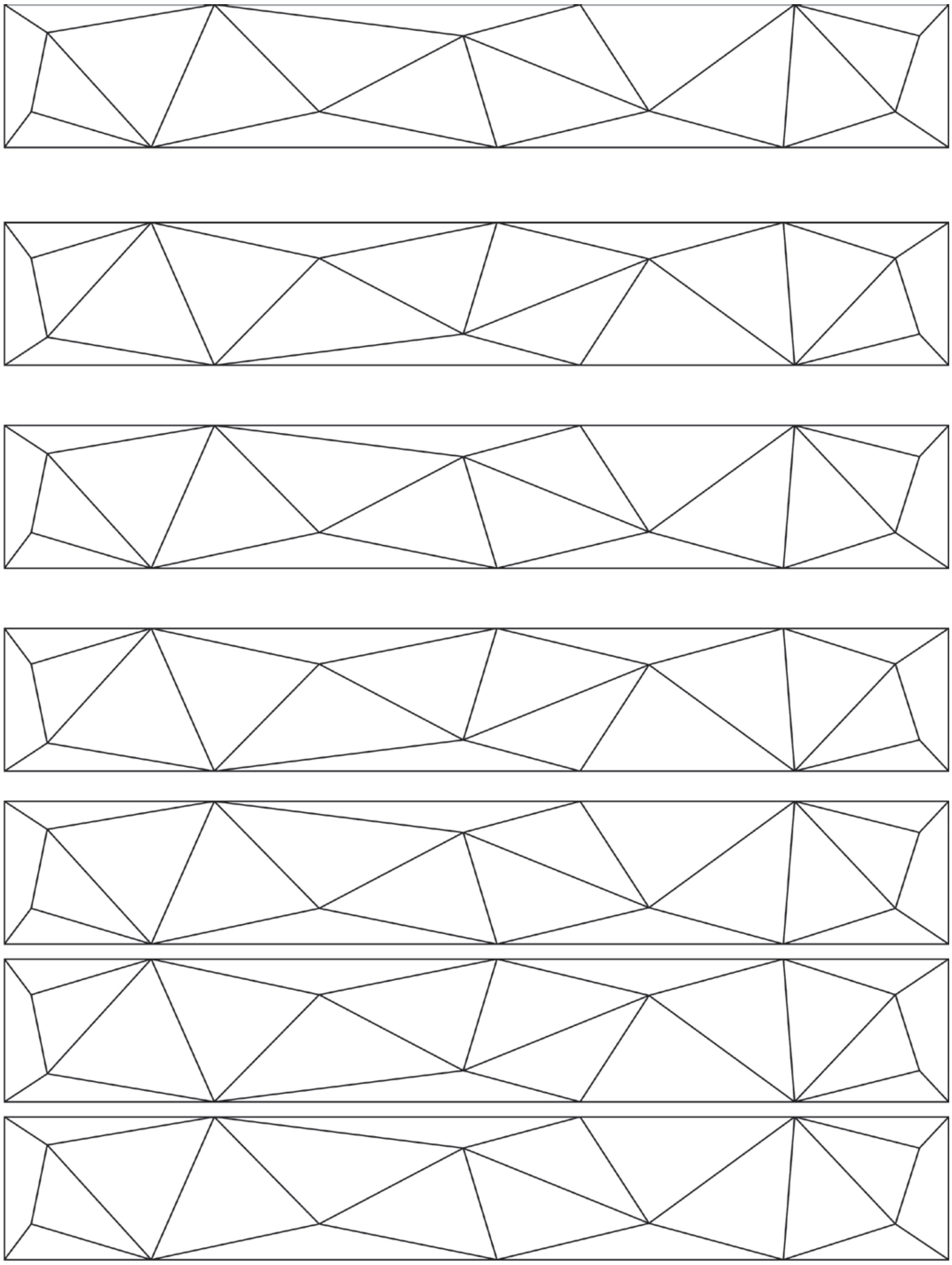
Appendix K3

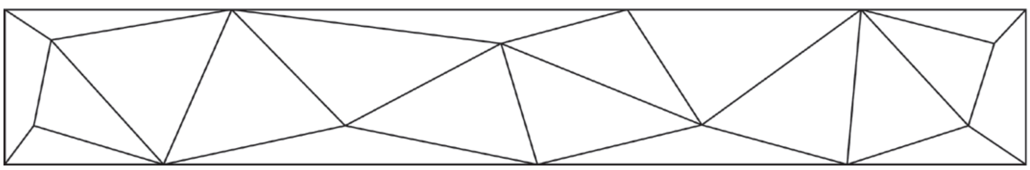
Variations of the backside pattern



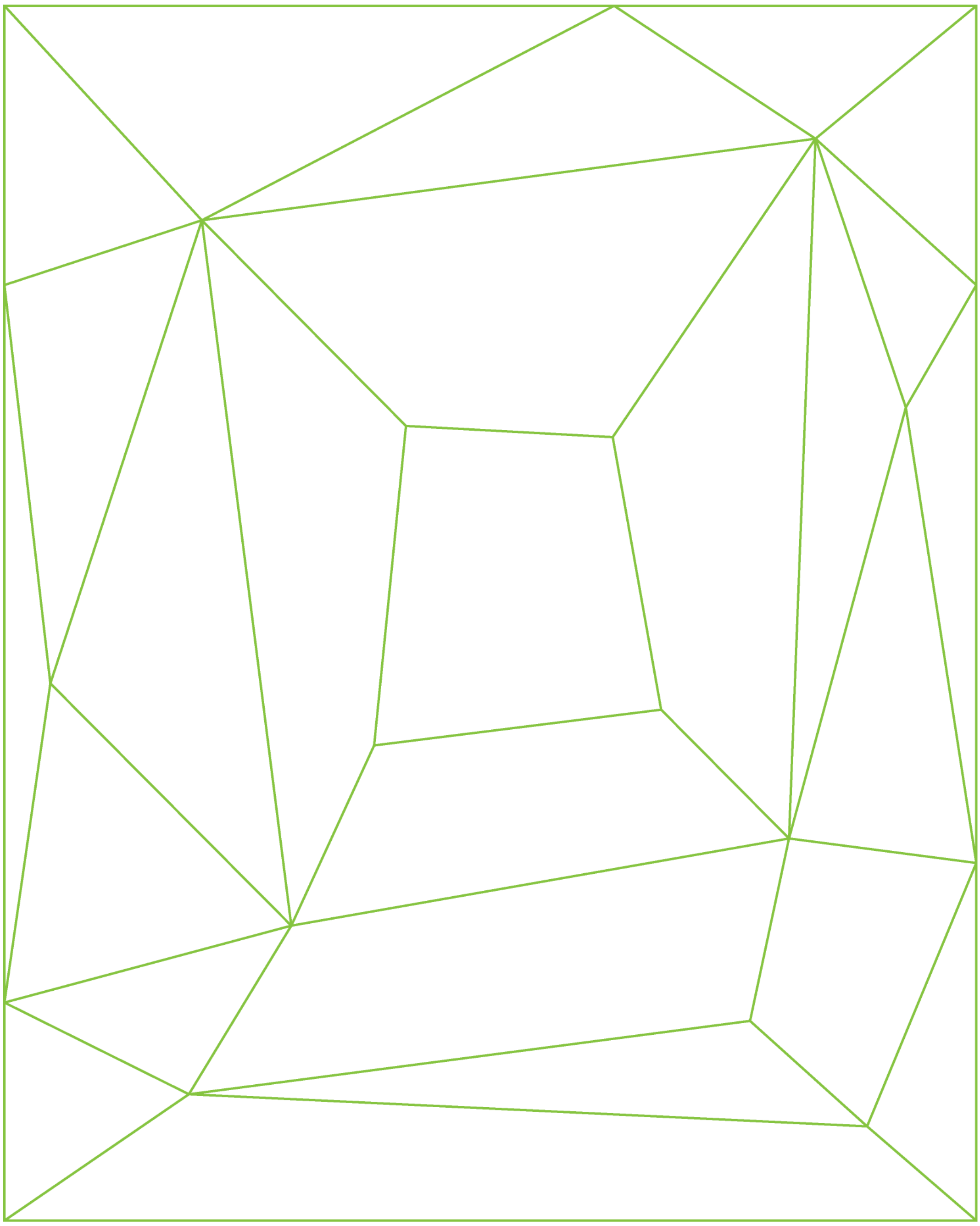


Appendix K4
Variations of the backside pattern



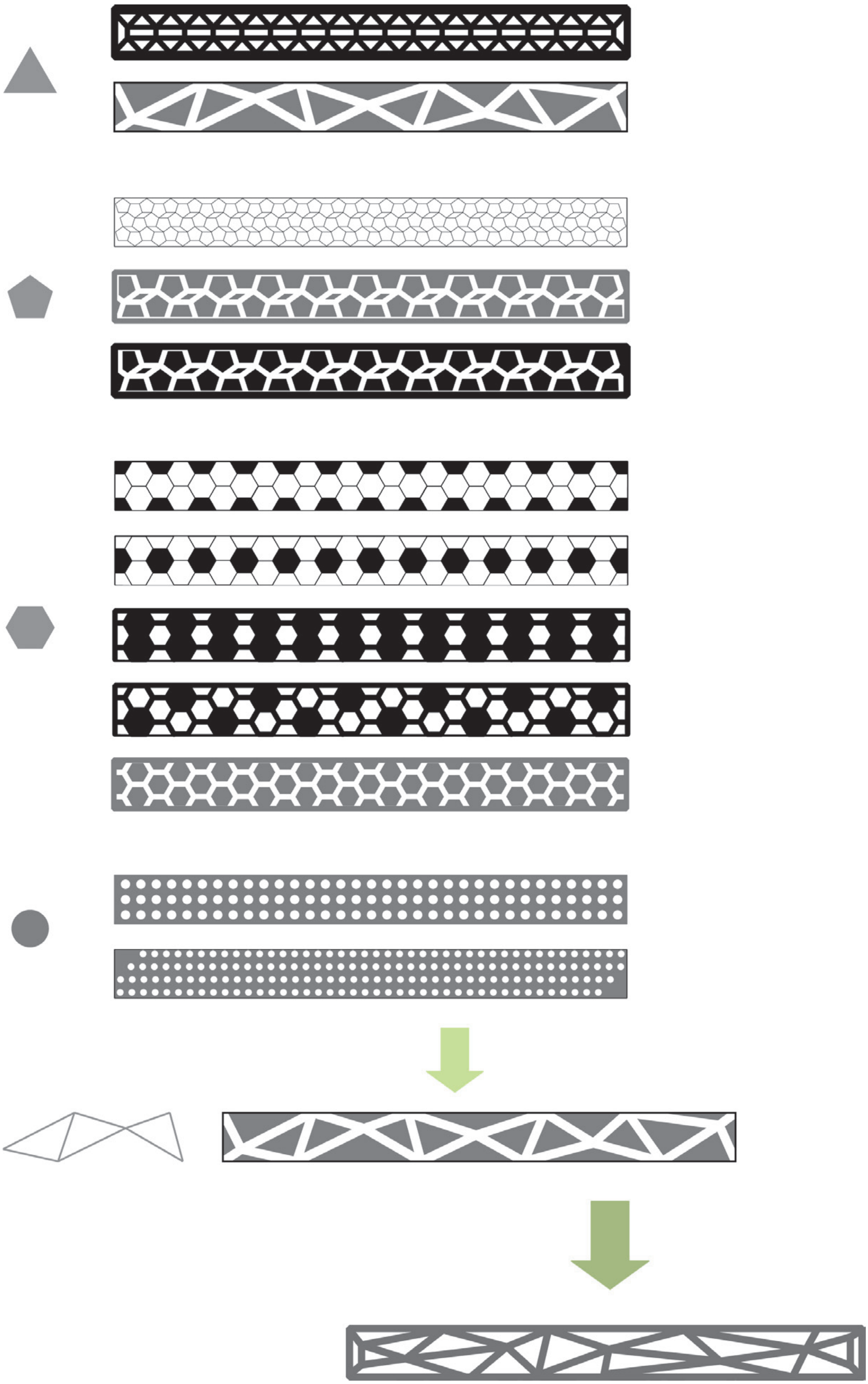


Appendix K5
Backside pattern of the book concept

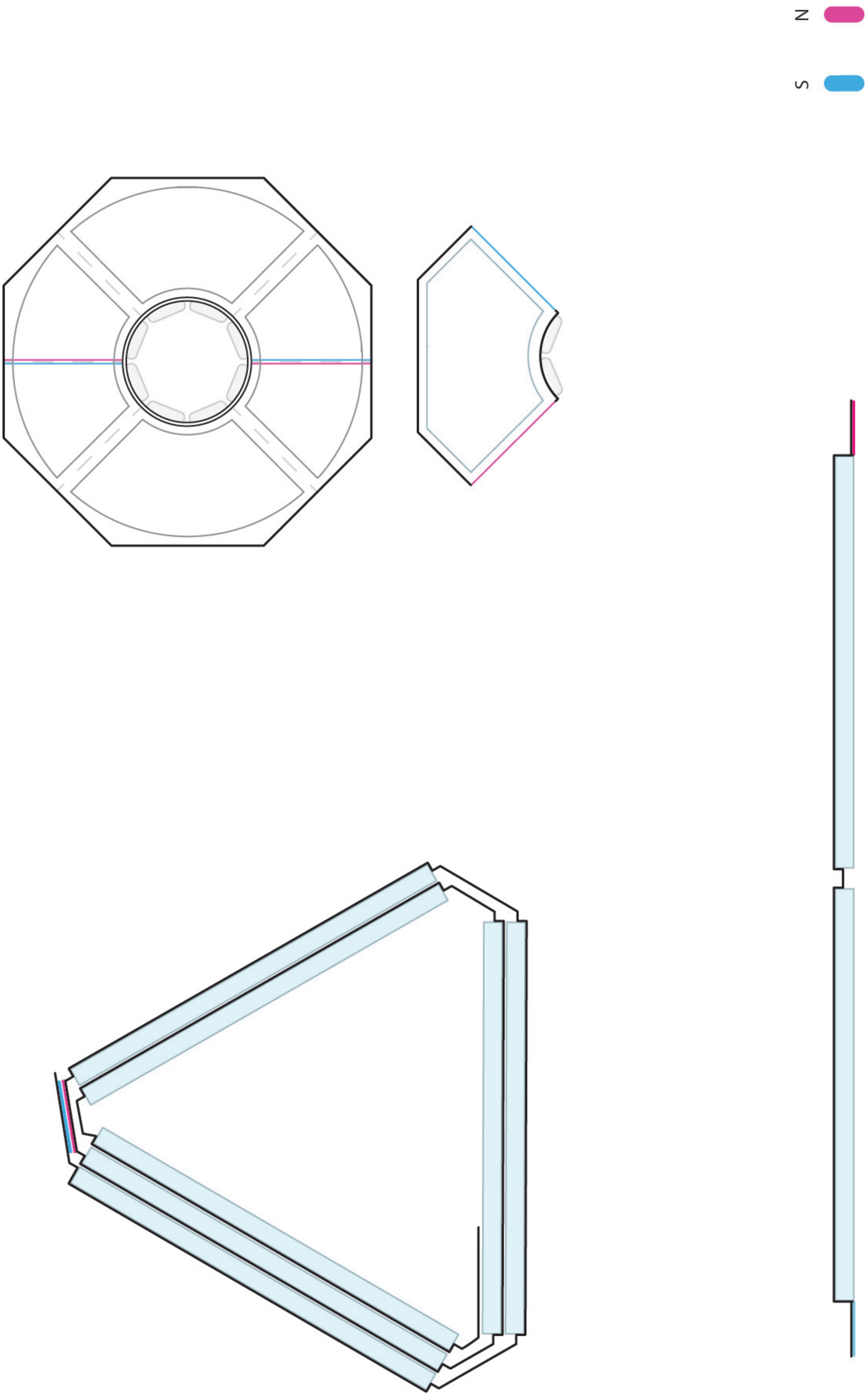


Appendix L

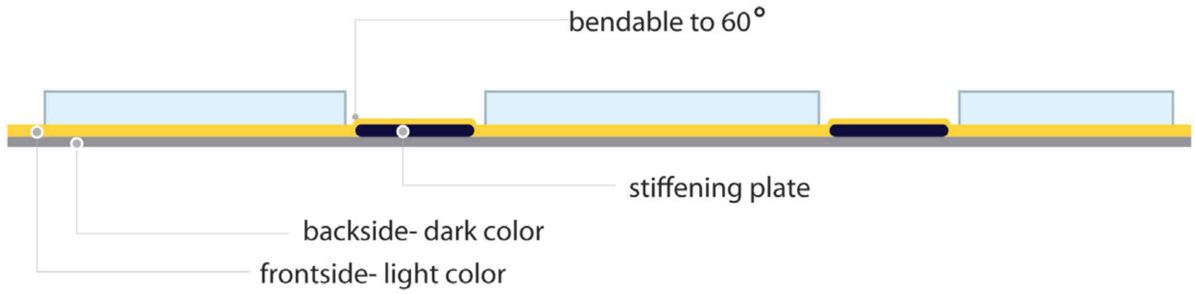
Variations of the light guide cover

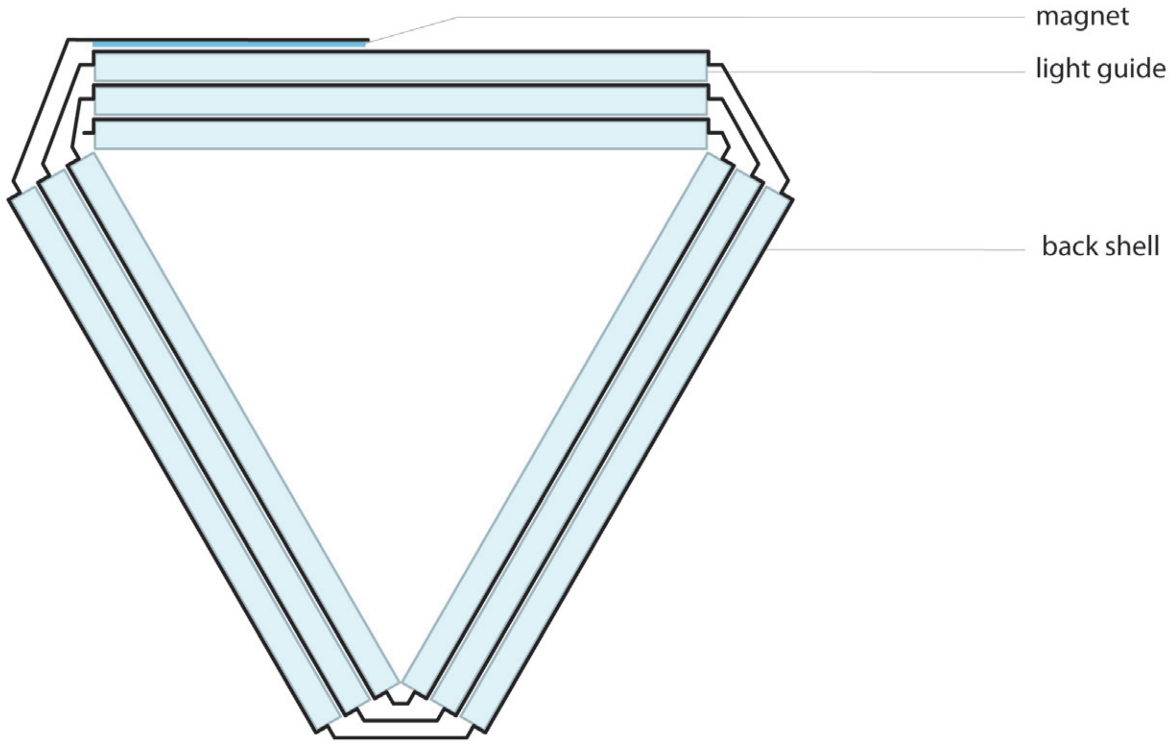


Appendix M
Magnet placement for the three concepts



Appendix N1
Construction of the rolling concept





Appendix N2

Construction of the rolling concept and the light guide