Summary

_Projekt opsummering.

Dette projekt er udviklet i samarbejde med Martin Professional Århus, Danmark og omhandler optimering af et af deres eksisterende produkter. Valget er faldet på en scanner, da denne produktkategori er meget benyttet på natklubber, diskoteker, bowlingcentre m.fl.
Optimeringen af scanneren sker som led i et forsøg på at re-brande netop dette produkt, da realiteten kan siges at være løbet fra produktet.
Fra Martin Professional er det gjort klart, at de gennem de sidste år har mistet mange kunder fra dette marked fordi markedet er blevet overtaget af billigere produkter med samme funktionalitet som Martins produkter. De billige modeller er som ofte produceret i Kina, hvor prisen er den væsentligste faktor og dermed eksistensberettigelse for disse produkter.
Gennem brugerinterview af både klubejere og teknikkere/installatører af dynamisk lys er antagelserne fra Martin Professional blevet bekræftet, hvilket har ført til en undersøgelse af mulighederne inden for markeder med høj priskonkurrence.

Ved brug af forskellige forretningsanalyser, heriblandt S.W.O.T, er det klargjort hvordan det ikke umiddelbart er hensigtsmæssigt for Martin Professional udelukkende at konkurrere på pris da dette vil forringe kvalitet til en niveau, der ikke umiddelbart er foreneligt med Martins brand. For at omgås denne problemstilling kræver det, at scanneren får tilført ekstra funktionalitet for at tilføre anden eksistensberettigelse og for derved at kunne styrke Martins konkurrenceevne på markedet.

Gennem research og teknologiundersøgelser er det tilstræbt at finde en eller flere metoder at øge produktets funktionalitet eller ydeevne for derved at skabe et produkt, som har mulighed for at differentiere sig fra andre, eksisterende produkter.

Gennem konceptfasen er det forsøgt at inkorporere disse forskellige teknologier på bedst vis. Dette er primært ved skitsering og 3D modellering, som er bakket op af teknisk viden om, hvordan disse teknologier fungere og har indflydelse på brugen af scanneren. Fra koncept fasen fremkommer tre muligheder der muliggør funktionsforøgelse af scanneren. Disse tre koncepter bliver vurderet mod hinanden ud fra et sæt vægtede krav, som produktet bør opfylde.

Det valgte koncept bliver gennem detaljeringsfasen detaljeret frem mod et endeligt produkt forslag, hvor der blandet andet er lagt vægt på at de udformede plastemner kan produceres med simple udtræk for at holde prisen på disse nede. Der er herforuden også anvendt FEM analyser, med det formål at sikre at produktet ville kunne holde.

Det endelige produkt er præsenteret i produktrapporten

Preface

_Preface

This project is conducted on the 4th and final semester of the Master of Industrial Design at Architecture, Design and Planning, Aalborg University.
The project period is from 1st of February to May 23rd.

The project is documented and in two reports; a process report communicating the process from first analysis to final product including research, strategy and concept leading to the final product proposal.
The final product proposal is communicated in the product report illustrating the final product.

_Title

FLX

_Project theme

Master thesis

_By

Lasse Qvistgaard Nielsen
Industrial Design
Architecture & Design
Aalborg University

_Project duration

1st of February to 23rd of May 2012

_Supervisor

Finn Schou

_Number of reports

4

_Pages

121

Formalities

_Synopsis

Product optimization is the core theme for this master thesis. The project revolves around creating and redesigning a scanner for Martin Professional. The project uses different analysis methods for verifying statement from initial meeting at Martin Professional.
Based on these finding the research phase provides a set of optimization option that are compared with findings from the analysis. This leads to a concept phase where they are merged and a final concept is determined. The concept is detailed in throughout the detailing phase. The main focus in the project has been about adapting optical fibers to add a larger degree of flexibility and usability to a scanner.

_Foreword

This process report is written by Lasse Qvistgaard Nielsen at Industrial Design, Architecture & Design, Aalborg University as Master Thesis project 2012

The main theme for this report is product optimization in cooperation with Martin Professional, Aarhus.

I would like to thank all participants for their cooperation during the master thesis with regard to user interviews, knowledge sharing and for providing me with products for testing and use.
I would especially like to thank Henrik Sørensen from Martin Professional, Aarhus for being my contact person at Martin Professional.

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Initiation

- Project description
- Project management
- Martin Professional
- Motivation

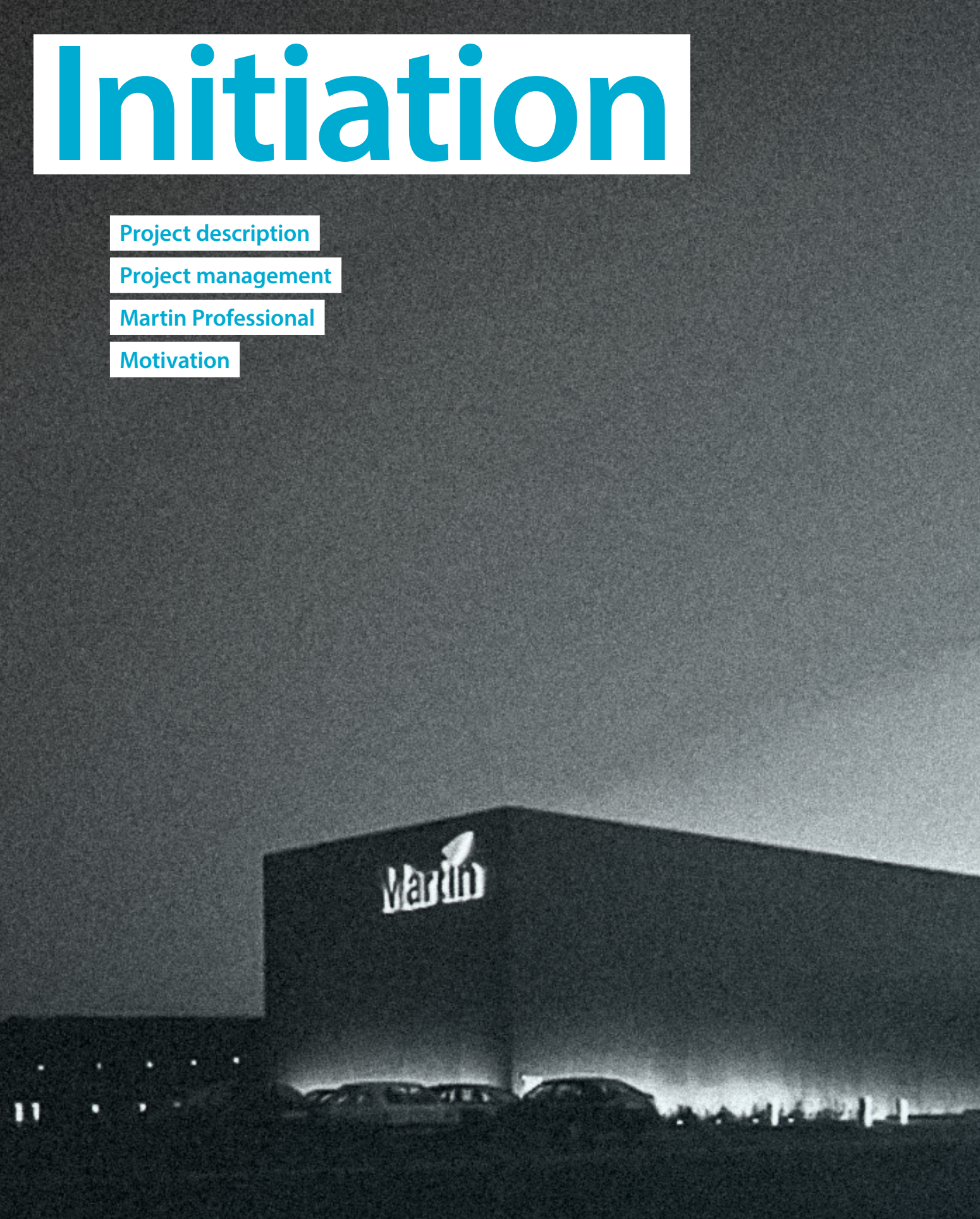


Figure 001 - Martin Factory, Frederikshavn

Project description

_Project description

This semester is the master thesis and the aim of this semester is to enable the students to demonstrate their key competencies in this final project. At this semester it is chosen to cooperate with Martin Professional, Aarhus, one of the worlds leading manufactures of lighting equipment for the entertainment industry and architectural lighting.

_Learning objectives

In order to ensure a certain level of the master thesis the student must therefore possess the following:

Knowledge

- Must be able to account for the relevant design related knowledge and identify design relevant problems within the chosen subject
- Must account for the appropriate research-based knowledge in the design process
- Must demonstrate a high degree of awareness regarding the main experiments, tests, proposals and evaluations affecting the decision-making in the design process
- Must demonstrate a high degree of awareness regarding the main critical issues in the design proposal and the appropriate course of action to amend these
- Must be able to thoroughly account for the scientific validity of test, investigations and other type of data used in the design process

Skills

- Must demonstrate the ability to independently create design proposals of a high standard, integrating selective aspects
- Must demonstrate the ability to frame the design assignment using professional tools and methods
- Must demonstrate the ability to generate a design proposal based on clearly defined values, user needs and/or business plan
- Must demonstrate the ability to select and use the appropriate method, techniques and tools for analyzing problems, users, technologies, constructions, competitors, markets, products, strategies, companies and own design proposals
- Must demonstrate the ability to select and use the appropriate method, technique and tools for carrying out experiments and synthesizing design proposals, including physical form, 2 and 3 dimensional documentation in both analogue and digital form
- Must demonstrate the ability to navigate a design process, by continuously drive the design process forward by focusing

on the most relevant part of the project and delimit the scope accordingly
- Must demonstrate the ability to communicate design and design proposals in a professional manner
- Must be able to design and construct a design proposal that meets predefined criteria, target values and cost range

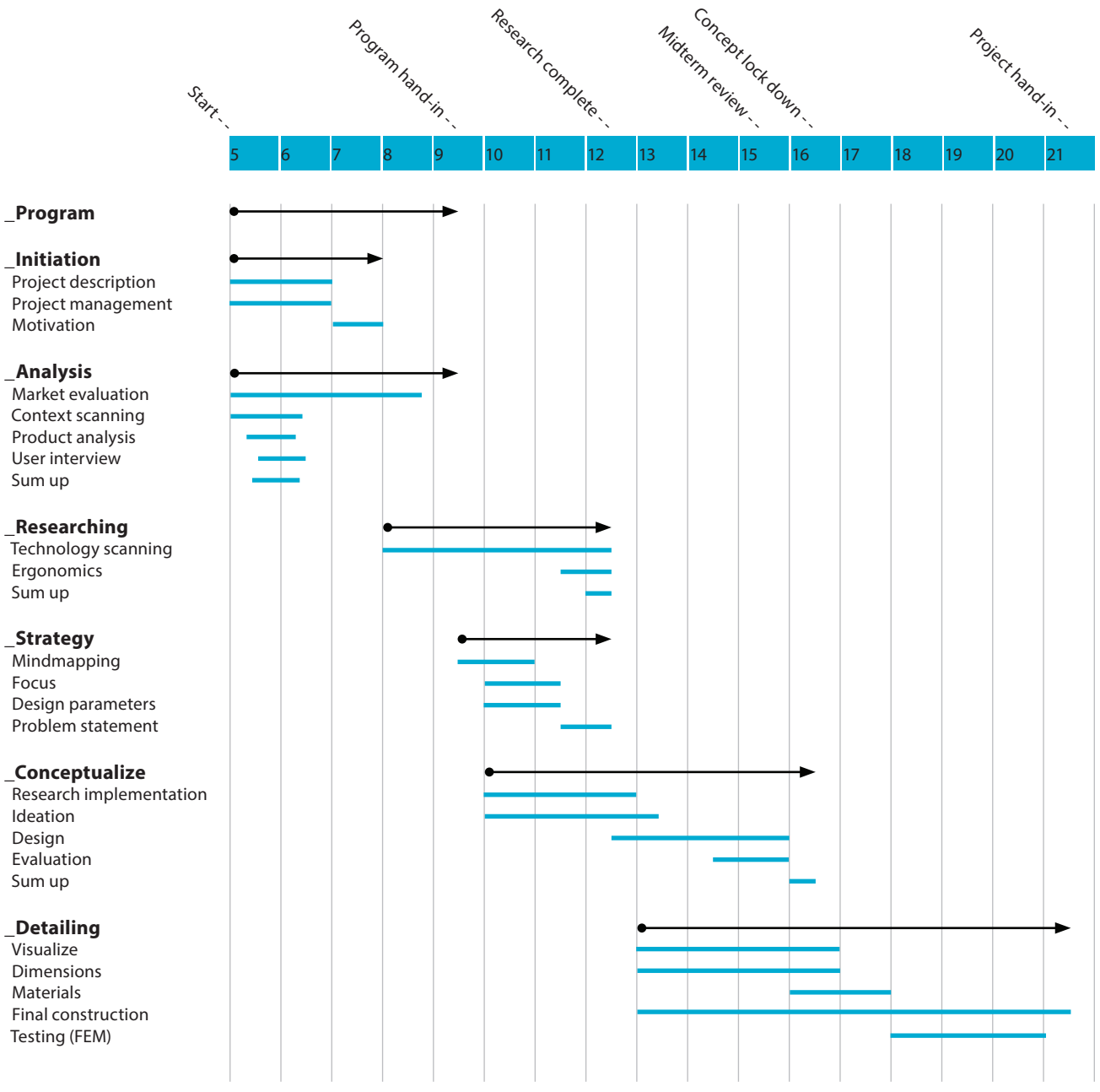
Competencies
- Must achieve a high degree of integration of appropriate aspects of the subject of choice, (design and technical aspects as a minimum), in a coherent proposal for a solution within the broad field of design
- Must be able to plan, conduct, communicate and reflect on processes connected with the design of a subject of their own choice using a wide range of theories, methods and tools
- Must be able to evaluate and perspective the final proposal in relation to its feasibility, market potential and further development

[Studieweb, 2012]

_Management

In order to manage and control the time of this project as well as the learning objectives a time schedule conducted. The time schedule divides the project up into phases for better overview. The time schedule is illustrated on the following spread. In order to complete each phase a set of tools will provide the required knowledge. These tools are outline in the project management chart on the following spread.

Time schedule



Project management

Initiation & Analysis	Researching	Strategy	Conceptualize	Detailing
In this phase a plan for the project is conducted. Also the assignment is outlined based on product and market insight gained by researching the exiting products.	In this phase all the required research is conducted. This includes technology scanning.	In this phase the strategy for the concept is outlined in order to create a frame for the further processes.	During this phase the concept is brought from initial brainstorm to concept lock down.	This phase is the final phase taking the concept lock down towards realization.
_Tools › Gantt chart › Daily agendas › Company analysis › S.W.O.T analysis › Competitor analysis › User analysis › Product analysis › Market analysis	**_Tools** › Technology scanning › Acquire additional knowledge regarding the analysis phase	**_Tools** › Mindmapping › Brainstorm › Focus › Design parameters › Problem statement › Demands and wishes › QFD	**_Tools** › Brainstorm › Sketching › CAD modeling › Concept matrix › Function diagram › Mock-ups	**_Tools** › CAD modeling › Material selection › Renderings

Martin Professional

_Who is Martin professional?

Martin Professional is one of the largest manufacturer and distributor of dynamic lighting solutions and smoke machines among other products for the entertainment industry. Martin Professional also creates lighting solutions for architectural and commercial use.

Martin Professional was founded in 1987 and was initially producing simple fog machines and a small selection of disco lights and has throughout the years grown to a company producing state-of-the art fog machines, controllers for lighting, speaker systems and dynamic lighting.

Martin Professional operates in nearly 100 countries distributing their products to DJs, famous artists and bands, clubs and theaters around the world where Europe, North America and Asia are their core markets.

It is important for Martin Professional to inspire their customers to be creative with lighting environments as well as pushing themselves in order to be the preferred choice in the industry leading the following statements of Martin Professional.

_Mission

"Our mission is to understand, inspire and enable our customers to develop attractive environments and create excitement through the use of dynamic light and visual effects"

_Vision

"We strive to be the obvious choice for the global professional lighting market. We add value through superior quality, industry-leading competencies, full accountability and die-hard dedication to our customers."

[Martin.com, 2012]

Figure 002 - Martin factory, Frederikshavn

Motivation

_Motivation

Martin Professional has grown from manufacturing simple dynamic lighting products to being the leading manufacturer of lighting equipment for the entertainment industry as well as for outdoor and architectural lighting.

The key value of Martin Professional of today is superior quality aiming at the top of the market.

During the transformation to the top position Martin Professional has lost market shares in its market of origin and over the years the market for low-cost, mid-range products have grown larger and Martin Professional seeks to reclaim this market to part of it again.

By extending the Martin brand with a sub brand, probably Basic by Martin, Martin Professional seeks to create a new product line up specifically for this market.

The motivation for this project is therefore how to create a product that is optimized for the market of mid-range products while at the same time trying to keep true to some of the key values of Martin Professional. Since Martin Professional manufactures a wide variety, this project will focus solely on the scanner, like the MX-1 illustrated below, and how to optimize a scanner.

Figure 003 - Martin MX-1

Analysis

- S.W.O.T analysis
- Porter's five
- Market evaluation
- Competitors
- Context scanning
- Product architecture
- Product comparison
- User interviews
- Design experience
- Phase summary

Figure 004 - Martin Showroom, Aarhus

S.W.O.T analysis

_The S.W.O.T analysis

The S.W.O.T analysis is a simple and quick method for analyzing and outlining the strengths, weaknesses, opportunities and threats of a company or organization or a part thereof.

By outlining the threats and weakness it gives the opportunity and awareness to cope or reduce threats before they catch up and becomes real dangers. By analyzing the strengths it can help to better understand the core competencies of a company and thereby help regain or optimize the focus of the company. The opportunities might reveal new possible territories for a company to explore.

By avoiding threats and weaknesses and at the same time sharpening the company focus the S.W.O.T analyzing can help a company distinguish and expose their business on the market. [Quickmba.com, 2012] The S.W.O.T analysis for Martin professional is illustrated on the next page.

	_Helpful	_Harmful
_Internal	**_Strengths** › Martin Professional has focus on high quality in order to be the leading manufacturer of light equipment › Service is part of Martin Professional securing smooth and fast maintenance in case of problems › Martin has been in the market for 25 years. During this time period Martin Professional has acquired a lot of know how in the profession › Due to the above Martin Professional is a strong brand in the business.	**_Weaknesses** › The price range of Martins products is high due to quality control and service minded on the rental market. The rental market requires low maintenance and high quality. The entertainment industry (pubs and night clubs) have a higher focus on prices forcing them to look at the competitors.
_External	**_Opportunities** › With the quality and service provided by Martin Professional the product line up is aimed at customers for whom durability is highly rated. By re-focusing on simpler market such as night clubs, Martin Professional has the ability to expand their position in the lighting industry › Martin Professional is at the moment undergoing some changes in the supply chain. By outsourcing the supply chain to other manufacturers Martin Professional can focus on R&D › Martin Professional is a strong brand. Martin has the opportunity to use their brand to their advantage in the reclaim of the midrange market and introduction of Basic by Martin.	**_Threats** › Since Martin Professional started their business in 1987 the competitors have catch up with regard to quality, service and prices which is a threat to Martin Professional.

Porters's five

_Market forces

The porter's five forces is a model that allows for examining the micro environment close to a company or close to the industry in which it operates. The model can help examine the competition in a market and thus gives a great overview

The porter's five model is a micro environment method and does not take macro environments into account meaning that the forces needs to be updated according to the changes of the macro environment thus yielding that the Porter's five is a static model. The model is illustrated on #figure 005#.

[Competitive strategy, 1980]

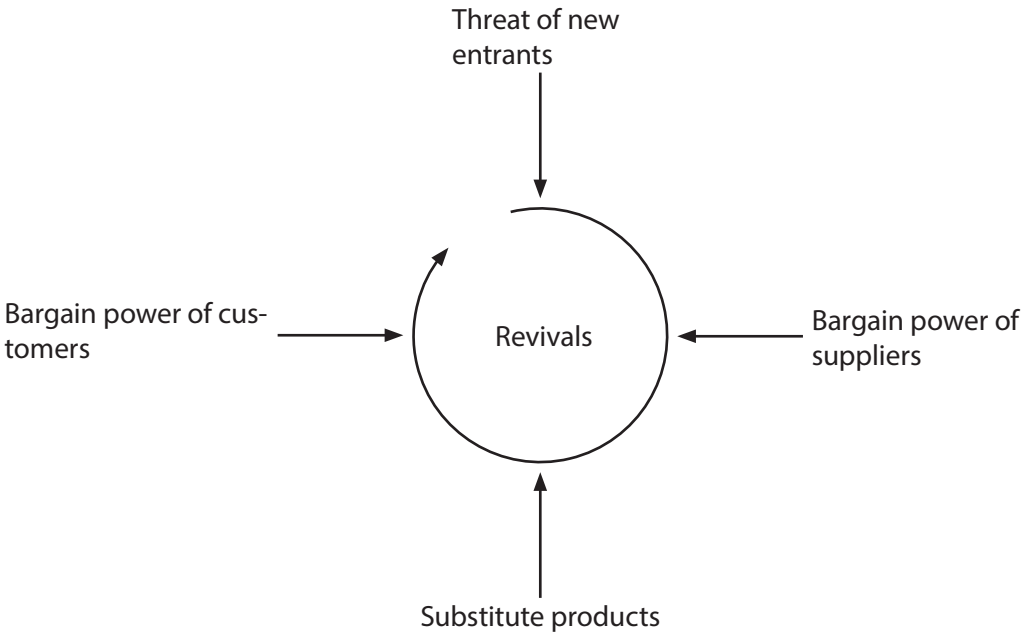


Figure 005 - Porter's five forces

_Vertical forces

New entries

The barriers for entering this market are estimated to be medium. Martin Professional has a high level of customer royalties due to their superior quality but this comes with high costs that force some customers to change supplier thus opening the door for new entrants focusing primarily on prices.

Substitute products

The amount of substitute products for dynamic lighting is estimated to be low. A substitute product would be neon tubes and other colorful lighting. The dynamic lighting effect is almost non-existing in such products thus lowering its functionality value. The service and warranty on substitutes is very limited

Revivals

The amount of competitors in this market is quite high and they are represented at all levels with regard to quality, prices and service.

Many competitors in the market compete on prices, which is an often used method. Since the competitors quickly follow the new pricing the market is devaluated in terms of profit.

Competing on price level is still relevant, but other position strengthening methods must be considered in order to keep a certain level of profit

_Horizontal forces

Bargain power of customers

The bargain power of customers is high. Many entrants are represented at different levels in terms of quality, service and prices and the customers can choose freely in order to achieve the best deal.

Bargain power of suppliers

With own production the bargain power consist of suppliers of raw materials and components. Since many providers exist it is easy to switch one supplier at a time if necessary thus limiting the bargain power.

Market evaluation

_The market

If simplified, the market for dynamic and visual lighting can be but a business one on one graph with a quality axis and a market placement axis and is illustrated on #figure 006#.

The quality axis covers terms such as product durability, lifespan and included services.

In terms of market placement the market is divided into an install market and a rental market. The install market covers night clubs, bars, and bowling alleys etc. where the product would be installed permanently. The rental market covers touring band and the like where the product would be installed and afterward taken down and transported to a new place. The center of the rental-install axis represents placement in both markets.

Since it is chosen to only focus on scanners, only manufactures creating scanners are represented with a picture whereas manufactures without pictures are not represented in this market.

_Placement

Martin Professional has since 2001 been the leading manufacturer of superior quality product and therefore Martin Professional belongs to the top level. At this level quality, innovation and service are some of the main aspects for competition.

Over the past years the mid-range market has progressed in quality and size and has now reached a considerable standard capturing the attention of Martin Professional wanting to be part of this market again. In order to ensure a distinction between the two markets a sub brand of Martin Professional, Basic by Martin, is going to be the competitor on the mid-range market.

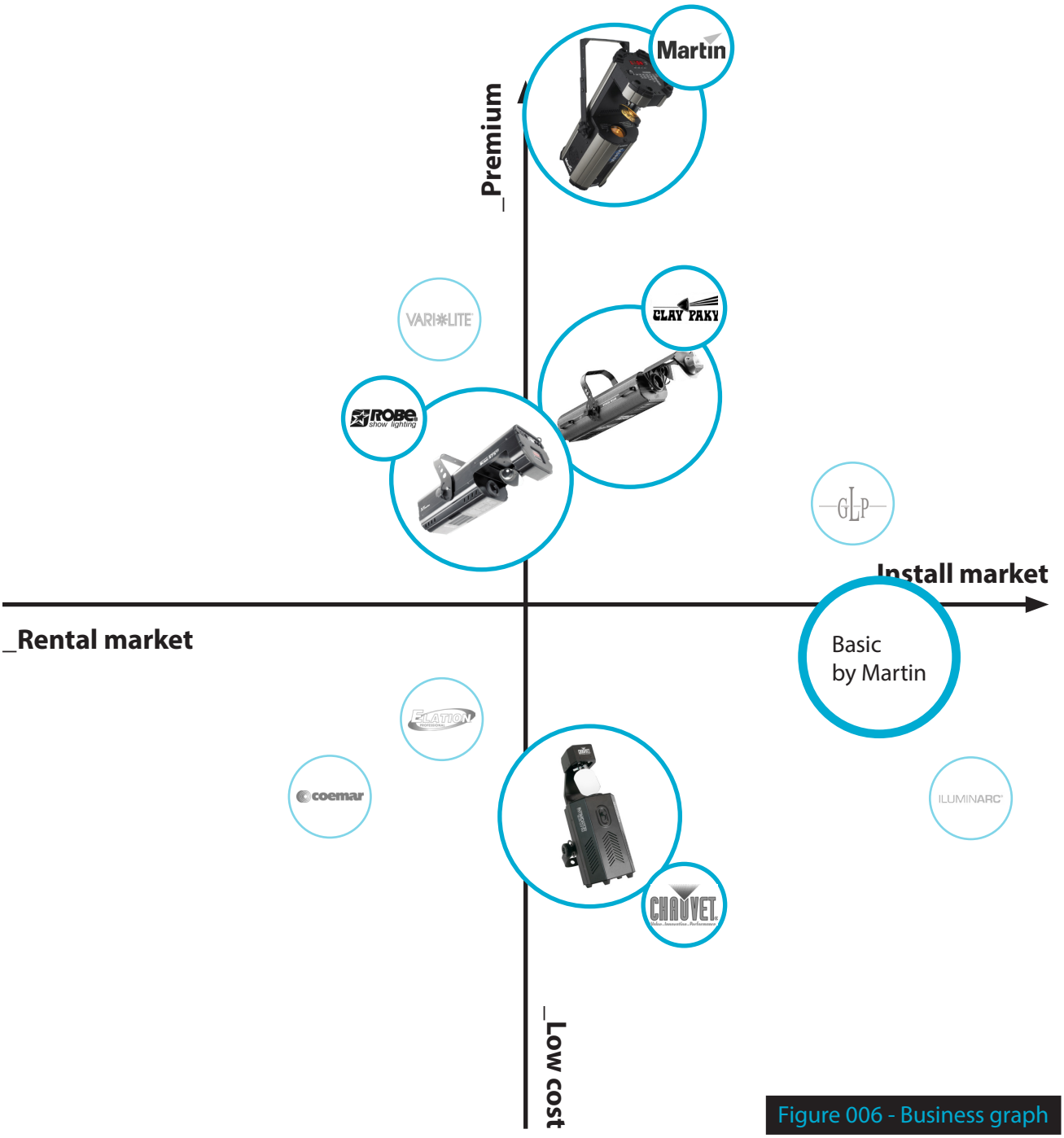


Figure 006 - Business graph

Competitors

_Product lineup

The competitors are analyzed by outlining their product lineup in order to evaluate where the competition is hardest and where opportunities might lie. The product line up is illustrated on #figure 007#
The diagram illustrates that the market for moving heads is quite saturated; also it is worth noticing that Martin Professional has a high interest in this market for their professional equipment.
Looking at the market for scanners it is noticeable that primarily the premium market are dealing with this product category thereby leaving it open as a possible blue ocean.

_Blue ocean strategy

The blue ocean strategy states that there are basically two kinds of markets, which is labeled as blue oceans and red oceans. The red oceans are known markets with many entrants forcing high competition on service, quality and prices. In a red ocean the profit is very low due to the high bargain power of customers calling for the best service and quality for the lowest price.
Blue oceans on the other hand are new markets with limited or no competition. The limited or non-exiting competition implies higher market shares and hence higher profits.
The key to a blue ocean is value innovation. Value innovation embrace adding new values to a product or service that goes beyond the set of values determined by the competition of red oceans.
[Blue Ocean Strategy, 2005]

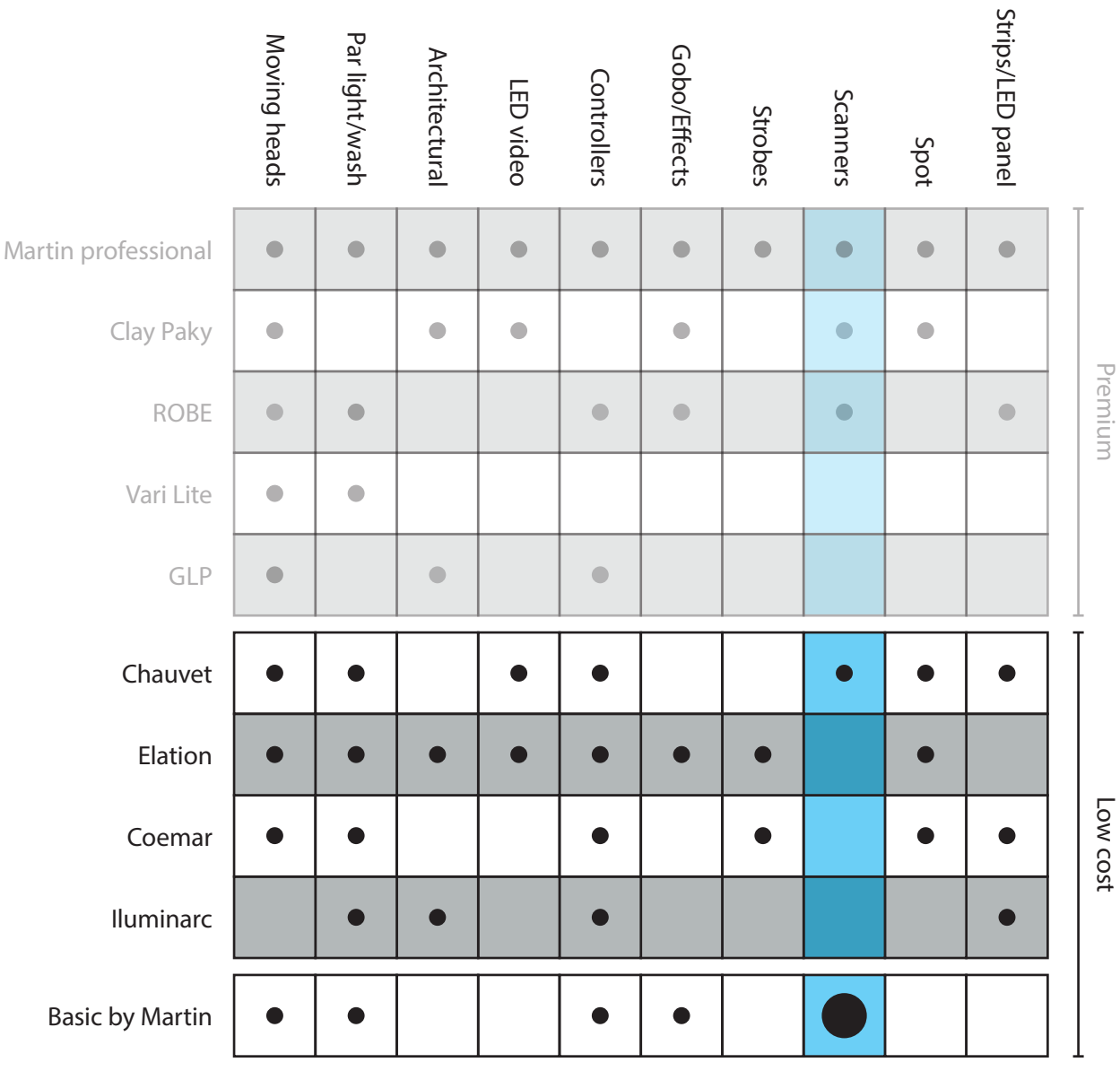


Figure 007 - Competitor mapping

Context scanning

_Context

In order to determine where a scanner is used a context scanning is conducted. The scanning will provide information about usage, advantages and disadvantages

As illustrated in #figure 009# it is clear that the scanner is a very common product in night clubs and the like. The scanners function is to create colorful lighting effects with high movement in order to create an energetic atmosphere on for instance dance floors. The scanners ability to create a colorful energetic atmosphere is thus its prime advantage. Another advantage of the scanners is its price tag compared to moving heads. A disadvantage for the scanner is the environment, which is hot and often dusty giving the scanner poor operation conditions. Therefore cooling and cleaning are important issues to deal with. Another disadvantage is its limited operation area compared to moving heads, which therefore yields that more scanners is needed to achieve the full desired effect.

_Opportunities

Is it clear that the market for scanners still exists and it is therefore a market of great value. This statement is supported by quotes, from users of dynamic lighting gathered by Martin Professional.

"Why has it taken Martin this long to realize they lost something they owned?"
- Felicia Newbury, Magnum Companies

"I'd go after this market immediately"
- Rory Goldstein, Shoreview Distribution

With regard to scanners, Martin products are marked with a triangle in the figure. These Martin products are often discontinued products such as the MX-1. Martin Professional has therefore still a rather large opportunity to regain old customers when they choose to upgrade in near future.

Figure 008 - Club Black, Herning

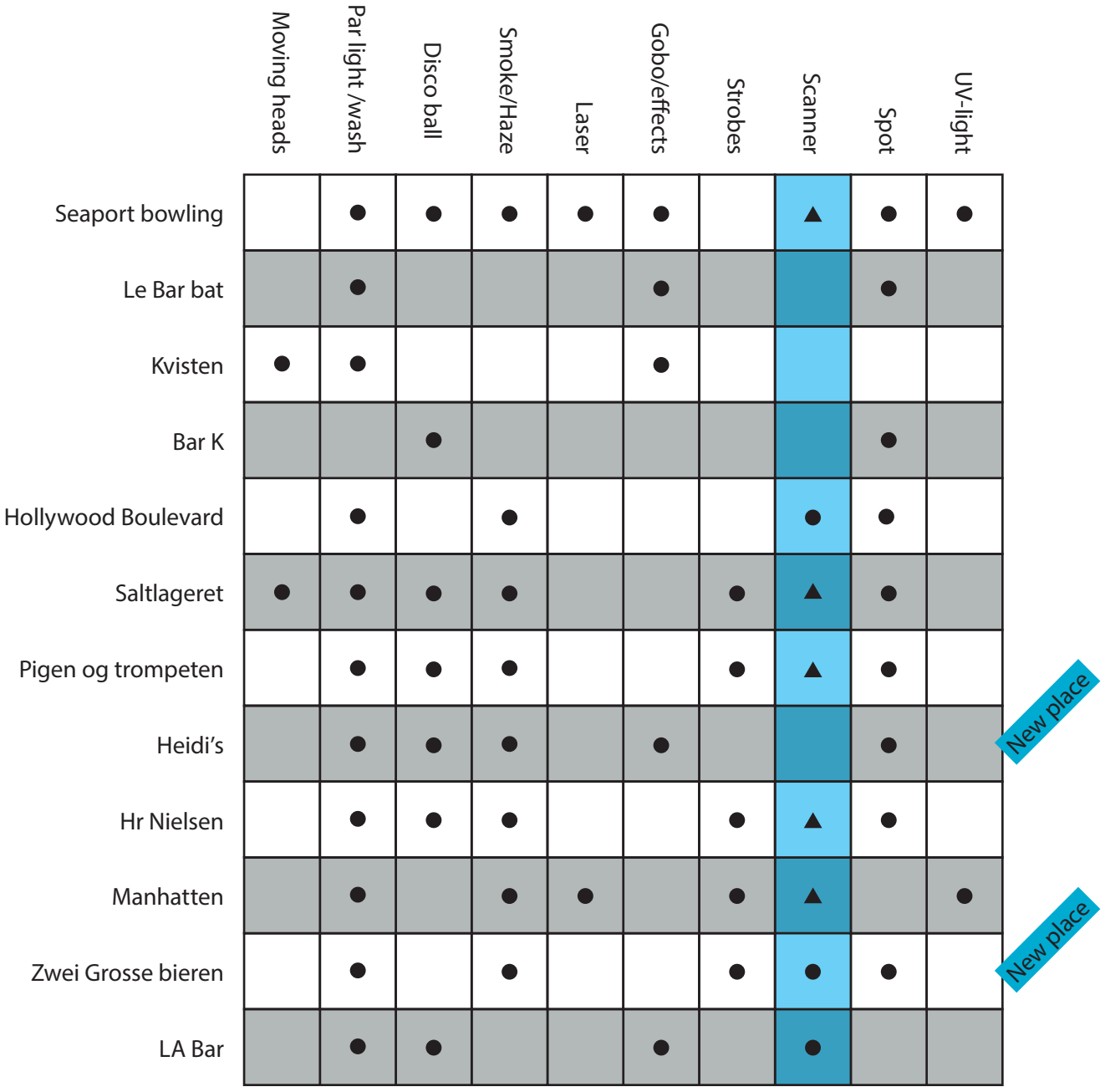


Figure 009 - Context mapping

Product architecture

_Product architecture

In order to be able to modernize and optimize the scanner it is mandatory to understand the inner workings of it. Since the basic concept of a scanner is basically the same on newer and older models, the product architecture is based on analyzing the MX-1 from Martin professional and Acme Dragon Scan.

_How it works

A scanner is a simple product for creating dynamic lighting, and is often used in nightclubs, pubs and bowling alleys as illustrated on #figure 009# on the previous page. The scanner basically consists of a powerful light source that is focused into light beam using simple optics. Colors and effects are added to the light using a gobo wheel and a color wheel, which sometimes is combined into one single wheel. The principal is illustrated below.

In order to create the dynamic light effect the light is reflected on to walls or floors using a moving mirror. The mirrors movement can be controlled by the build in microphone which synchronizes the light effect to the beat of music. Otherwise the mirror can be controlled by using the DMX system in order to create predefined pattern for the mirror. A third option is for the dynamic light effect to be created randomly by the scanners circuit boards.

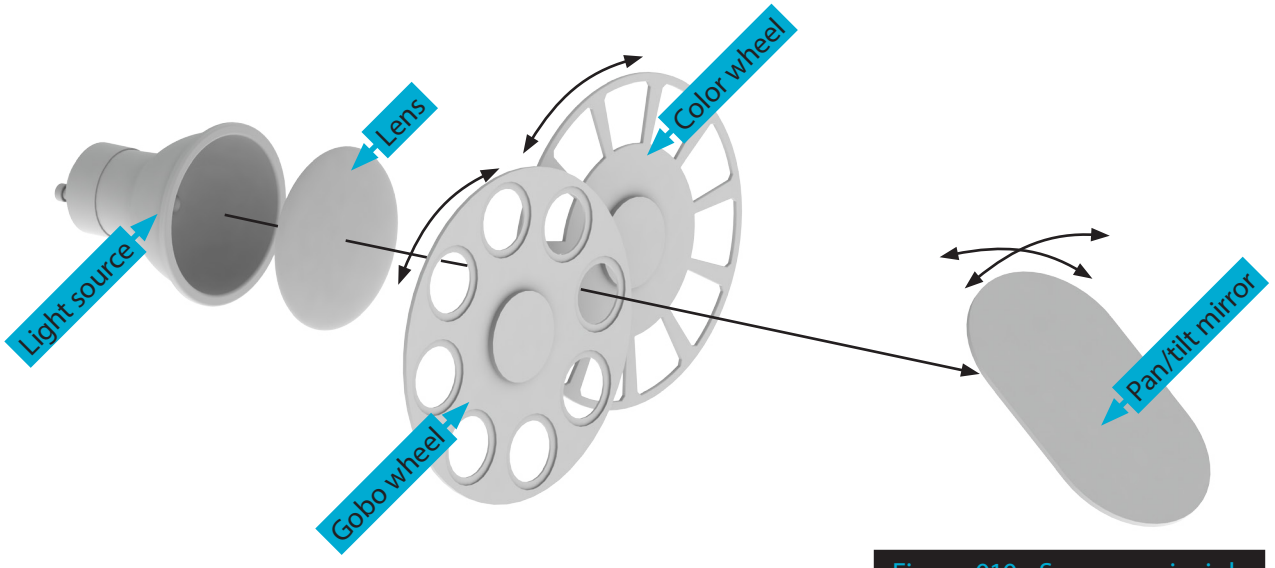


Figure 010 - Scanner principle

_Internal architecture

As illustrated on the previous pages, the structure of the scanner is very fixed because the lens, both wheels, and the mirror need to be in permanent relation to the light source. The mirror is not only fixed in terms of position with regard to the light source, but also in it area of operation since the front plane of the mirror must face the light source at all time. This permanent relation seams to points to a limitation in design and optimization of functionality, which is verified by the many scanners on the market today that looks the same in terms of configuration.

Build upon the main structure are the motors and the cooling system which is illustrated below on #figure 011#. The cooling system must be applied near the LED in order to work thus limiting the configuration possibilities. The same is true for the motors, since these must be applied to the tilt, pan and rotation of the mirror and the wheels.

A reconfiguration of the structure or the components is thus necessary if a better operation area is to be achieved. Reconfiguration options will be discussed in the later in the process.

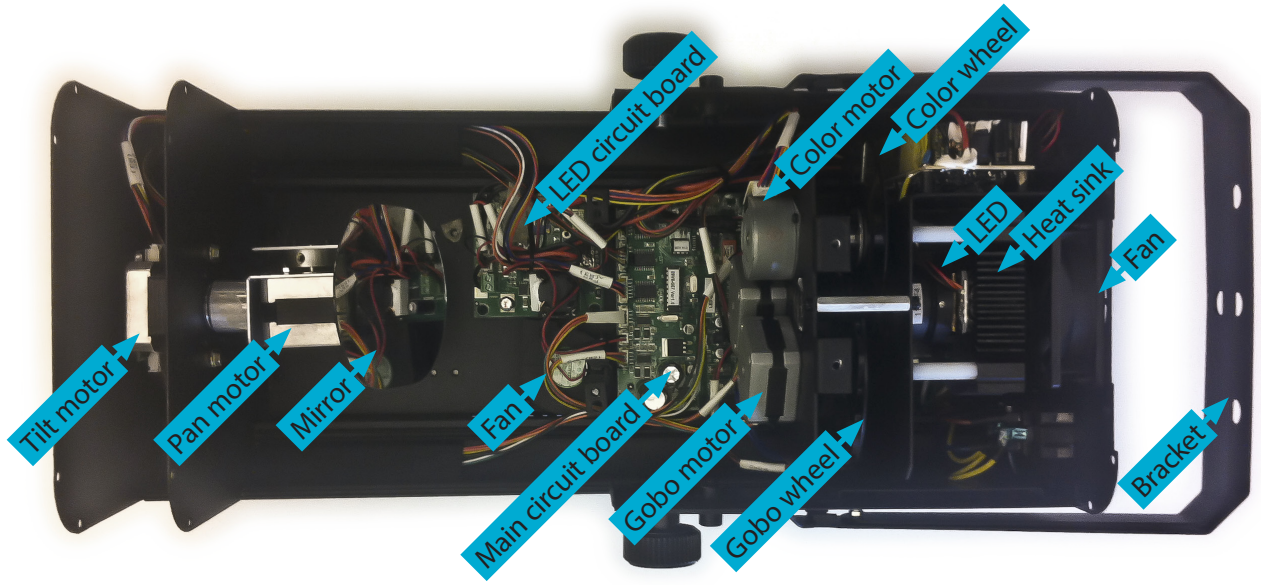


Figure 011 - Internal architecture

Product comparison

_Scanners & Moving heads

Before the introduction of moving heads in 1997 with the MAC 500, scanners were the primary product for dynamic lighting effects. Since the introduction of moving heads, a lot of resources have gone into developing the moving head leaving behind the scanner although new scanners was produced and sold after 1997.

The increased popularity of the moving heads since their lunch in 1997 indicates supremacy in terms of functionality, which also is confirmed by their technical specifications

Due to their supremacy and popularity, the two product categories are compared to see what qualities that make the moving head so popular and if these can be transferred to the scanner. [Martin.com, 2012]

From the comparison chart the most noticeable differences is the lumens or the effect of the product, the area of operation being significantly larger and also the use of CMY color system in some moving heads creating more colors then the predefined color wheel.

_Specification	_Scanner	_Moving head	
Lumens	500-4.100 lumens	4.100-33.900 lumens	Better
Watt	150W -250W	150W - 1500W	
Pan	198 degrees	540 degrees	Better
Tilt	72 degrees	257 degrees	Better
Focus	Manuel	Auto	
Color wheel	Yes	Some	
Wheel colors	8-12	8-12	
CMY color mixing	No	Some	Better

User interviews

_The technician

It was only possible to get an interview with two technicians; Jørgen Lund from Martin Pro Shop Nord Aps and Bo Villumsen from StandLux Aps.
Bo Villumsen answered a questionnaire from where data was collected. Jørgen Lund participated in analyzing the Acme Dragon Scan in a video interview. Though the data collected was insufficient in terms of verification, it still provided a general idea about the conditions the technicians deal with and what problems they encounter.

_Cleaning and maintenance

"The most common problem is dust. Usually the problems are not detected in time causing more problems to occur." – Bo Villumsen

"There has never been a dust filter in previous models. People do not change these it will then turn ugly and it [the product] will overheat"- Jørgen Lund

"With regard to maintenance it often just dusts removal. Sometime the mirror needs to be replaced – Bo Villumsen

Based on the above statements, it can be said that club owners presumably don't clean their product regularly and thus cleaning is the prime objective with regard to maintenance.
Combined with the statement below it is clear that the scanner should be simple to open and easy to clean.

"Why not create a solid lid instead of assembled part [it is easier] when you need to open the product for service. It's simply not working" (it takes a lot of time to disassemble the product due to amount of screws). – Jørgen Lund, said about the Acme Dragon Scan.

_Quality and pricing

"The problems are the placement of the circuit boards, the use of 2 fans, and the quality of the assembly methods. And use proper screw, use prober screws, use prober screws" (One screw needed to be drilled out in order to disassemble the product during the interview) – Jørgen Lund; said about Acme Dragon Scan.

"Martin professional is my preferred brand. A lot of thoughtfulness is put into the product. They are service friendly, whereas cheap china models are one time use only and afterwards they just for the garbage can." – Bo Villumsen

"It is absolutely shit. It must be so that this can made in a smarter way"– Jørgen Lund; about ventilation in the Acme Dragon Scan

"Problems occurs more often when the product is too cheap" – Bo Villumsen

The cheaper models are apparently focusing solely on price at the expense of service possibilities, lifespan and quality. It conflicts with the DNA of Martin Professional. Martin professional should not compete merely on prices. Other measures like quality, effect, output or functionality must be added.

_Service and installation

"The use of more circuit boards is very problematic. By combining them into one a lot of wiring can be spared and decrease the risk of failure. Prober wiring is a must" – Jørgen Lund; said about the Dragon Scan

"If the product is too cheap, the bracket is usually shitty and difficult to install" – Bo Villumsen

"When the bracket is installed [separately] you can mount the scanner [on the bracket] and then you do not need to hold the product while tightening the screws" (This was not possible with the Acme Dragon Scan) – Jørgen Lund; said about Martin products.

"They are easy to install" – Bo Villumsen; said about scanners in general

In terms of service and installation it is important that it is easy to install the product. The easier the product is to install, the less time is spend balancing on a ladder causing problems for the technician.

_The owner

A questionnaire was conducted with questions about prices, functionality and trends with regards to buying and installing dynamic lighting in night clubs.

The questionnaire was conducted as an interview with Carsten Juhl part owner of Café Saltlageret and Zwei Grosse Bieren in Jomfru Ane Gade, Aalborg.

_Cleaning and maintenance

""The ability to clean the product is also quite important because of dust and grease from smoke machines" – Carsten Juhl, said about what he looks for when buying new products

"You need to remove 6-8 screws. It could be could be easier and is probably the reason why we don't always clean the products as prescribed." Carsten Juhl; said about maintenance on his products.

"A proper lid allows for better access to maintenance"

From these statements it can be confirmed that some issues with cleaning do exist as proclaimed by the technician. Carsten Juhl directly implies the need for a proper lid for easy maintenance as stated by the user interview conducted with technician.

_Quality and pricing

"The price, LED (because of the life span) or the use of cheap light bulbs are important factors when I buy new products" – Carsten Juhl, said about what he looks for when buying new products.

"Prices of maximum 10-15% more than Future Scan would probably make me buy a Martin product next time. A 20% price raise would make me back out of the deal" Carsten Juhl; said about what would make him consider buying a Martin Professional product next time.

"The scanner is my primary product, the price is the only reason I don't by a moving head" Carsten Juhl; said about scanners in general.

"Moving heads due to their effect and area of operation, but I don't buy them because they are way too expensive" Carsten Juhl; said about where he seek inspiration for new products.

From the statements above it is worth noticing the wish for moving heads because of the effect and operation area, but that the price tag is a to important factor forcing the club owner to stick with scanners.

_Install and service

"I didn't hear any complaints during installation (from the technicians) Carsten Juhl; said about the installation of Future Scan in Zwei Grosse Bieren.

Design experience

_Confirm interview

Due to the low participants in the user interview, it was chosen to send the final user interviews to Martin Professional in order for them to match their user experience with the finding from the user interview.

"This [the user interview] is a 100% repetition of my own experience as leader of the DJ/Club development department. These statements confirm the direction Martin is following. If we, in terms of business, choose this path we are maybe compelled to lower our "service mindedness" and it might conflict with the conception of the Martin Brand. But we will still be completive"

- Claus hansen, Martin Professional, Aarhus

From this statement it is chosen to relay on the user interviews as a valid source for the further development.

_Design experience

From the many designs and product produced by Martin Professional a lot of experience has been gathered both in terms of god and bad designs. The most important bullets are outlined below. For more details see #Appendix B#

The list will act as a guideline in the following phases.

- Must be able to replace the mirror
- The mirror, the lens and the light source is fixed
- The more open the more range of movement
- Fixtures for grip and transportation
- Easy to clean cooling system
- Easy to clean lens, color glass and gobo
- Power and data connection to be placed near bracket
- Protect the cables, for instance by cable tray
- Prober security for safety wire
- Fixture bracket must be placed at the center of gravity
- Ability to place the scanner as close to a surface as possible, for instance ceiling
- Ensure the microphone and the cooling system do not interfere

Analysis summary

_Analysis

The analysis phase gave a good insight into the market aspect of Martin Professional and their competitors as well as their product line up. Also the analysis phase gave insight in what should be the position of the new scanner by Martin Professional.

Regarding competitor product line up a more thorough evaluation could have given a deeper insight, though a more in-depth analysis would have required access to competitor products which was only the case with the Acme Dragon Scan. Also use case scenarios with competitor products would have been valuable to the analysis phase.

With regard to the context scanning a more wide spread analysis could have pointed out a different picture in terms of how different products are represented in the market. The similarity of night clubs in Jomfru Ane Gade, Aalborg was very consistent.

The analysis did provide general and useful information about the inner workings of a scanner based on research conducted on Martin Professional MX-1 and Acme Dragon Scan. This part of the analysis was considered fully examined due to the high resemblance between the two products and scanners in general.

The user interview was based on only a few participants and a more thorough approach could have revealed more or other relevant problems regard dynamic lighting and especially the scanner as well as whishes and demands. The user interview was though confirmed by Martin Professional and was thus considered a reliable source.

Research

- Technology scanning
- Light emitting diode (LED)
- Optical fibers
- Cooling
- Lens optics
- Handle&Ergonomics
- Phase summary

Figure 012 -Martin document folder

Technology scanning

_More knowledge is required

The purpose of this phase is to outline and examine existing and possible technologies in order to implement them into the product with the aim of improving the product and the use of it.

From the knowledge gathered during the previous phases it has become clear that the product has some drawbacks as well as some opportunities with regard to construction, technologies and handling. The gathered knowledge will set some requirement for the concept development phase and can as well be used as possible design parameters.

_Technology scanning

The currently used technologies will be studied in order to outline how they are implemented and how they work. The knowledge gathered from this study can help determine if the implementation of these technologies can be optimized or replaced by better technology thus adding value to the product.

Alternative technologies will as well be studied in order to gather information about that limitations and potentials. The alternative technologies have to add value to the product either by extending the use of the product or improve currently used technologies before they can be considered.

Light emitting diode (LED)

_Why LED?

The use of LED has become very popular over the last couple of years. This is due to the many advantages the LED possesses compared to other light sources like halogen lamps or incandescent bulb.

One of the advantages is the lifespan. An LED has an average lifespan of 35.000 to 50.000 hour but some LED manufactures claim lifespan of up to 100.000 hours. In comparison a halogen spot has only a lifespan of up to 4000 hours [U.S department of energy, 2009].

Another benefit of the LED is the size. LEDs can be very small and they are therefore ideal for use in small spaces or on circuit boards where other light source would simply not be able to fit in.

_Light emitting diodes (LED)

A LED is a semiconductor that is able to emit light ranging from infrared to ultraviolet thus also the ability to produce visible light.

The semiconductor is basically divided into two parts where negatively and positively charged impurities are added to the semiconductor in order create an n-part and a p-part. When voltage is added the positive and negative charges are forced to move against each other. When two charges meet energy is released as a photon also known as light.

In order to obtain as much light as possible, the semiconductor is placed in a reflective cavity that redirects into a beam of light.

In some cases almost 20% of the energy is lost as heat leaving only 80% light. Since the lifespan of an LED can be severely reduced due to heat cooling is needed on high powered LED as them used in a scanner.

_White light and colors

Under normal circumstances the LED produces a light in a certain color depending on the material used for the semiconductor. Since white light is a combination of all colors the LED itself is not able to produce white light.

There are currently two methods that will allow the LED to produce white light. One method is the RGB LED, which consists of a red, green and blue LED. By combining these three colors approximate white light is produced. Since the RGB LED is based on

Figure 013 - Simple LED

the combination of three LED spots the intensity of the white light is therefore very high.
Another method for creating white light is coating the small lens of a blue or ultra violet high powered LED (HPLED) with phosphor. The phosphor slows down parts of the blue spectra creating wavelengths in green and red spectra. Since blue is the dominant color in this system the approximate white light has a blue glow to it. Some efficiency is lost due to the use of wavelength conversion process. The phosphor bases LED is the most common used method due the being the least expensive method of creating white light.

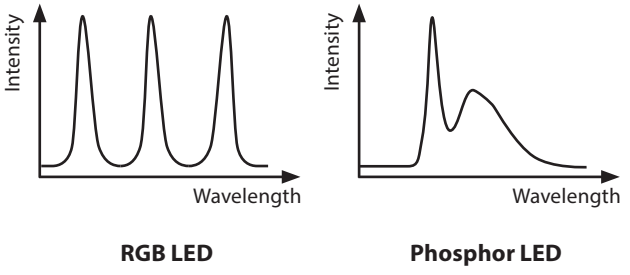


Figure 014 - White LED

_Bi-color LED

LED having the ability to emit two colors us fairly common. For instance LED indicators with ability to emit a red and a green light are often used in electronics. The ability to create LED with more colors is thus also an option.

_Possibilities

The use of LED is already in use in today's scanners due to price, long lifespan and small size. The LED primarily used in scanners today are based phosphor covered LED to create a white light source, which is then colored by the color wheel. The method is inexpensive since the components are cheap and the configuration is easily built.
By implementing a system using the RGB LED method a huge variety of colors can be created by the LED thus eliminating the need of a color wheel which takes up a lot of space in the existing configurations.

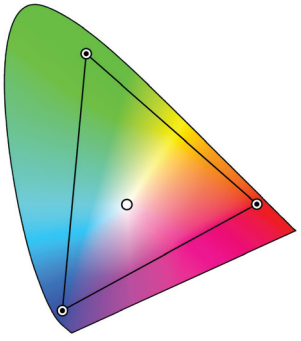


Figure 015 - RGB color spectrum

A disadvantages of implementing RGB LED is the additional heat created due to this system running on three LED compared to one causing the need for more effective cooling.

Optical fibers

_Optical fibers

Optical fibers are coated glass or plastic fibers with the ability to transfer light over great distances or in situations where light needs to be wired through narrow space. These abilities give the optical fibers great usability in many situations.

_The structure

An optical fiber consists of three layers as illustrated on #figure 016#. The fiber cable consists of a core made of either plastic or glass through which the light is conducted. The surface of the core is covered with a cladding which acts as a mirror keeping the light inside the core. The optical fiber is protected from external damages by a coating which also gives the fiber its mechanical structure as known from normal wires.

The core and the cladding are both see through,

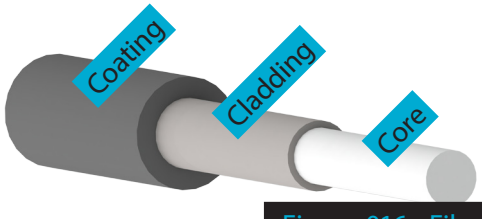


Figure 016 - Fiber cable

but the two materials have different densities or refraction indexes which changes the velocity of a light waves. As a result hereof almost all light is reflected back into the core and thus kept in the core throughout the cable length [Process Control and optimization, 2012], [Fiberdk.dk, 2012]

_Drawbacks

In order to discuss the drawbacks of optical fibers the principle behind needs to be explained.

An optical fiber relays on refraction. When light travels through the fiber, light rays will hit the surface between the core and the cladding at a certain angel as illustrated on #figure 017#.

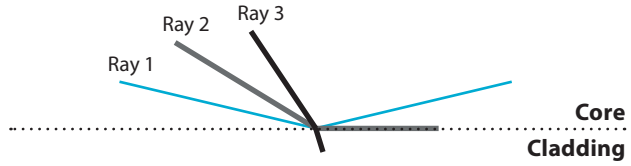


Figure 017 - Refraction

If the light rays are within acceptance, represented by Ray 1 on #figure 017#, the light will be reflected into the core and thus conducted through the cable. Light rays at the critical angel or rays outside this angle represented by Ray 2 and Ray 3 respectively will not be reflected but instead enter the cladding and eventually be lost. The loss due to light escaping is normally estimated to be about 4%. Impurities in the fiber are accountable for another 4% loss giving a total of 8% loss per meter.

[Practical Fiber Optics, 2003]

When light goes from traveling in one material to another, refractions is also a concern. When light enters the fibers, it goes from traveling in air to the material of the fiber; either glass of plastic. In this situation the light must enter the fiber within the

cone of acceptance as illustrated on #figure 018#. If this is not the case, the light will instead enter the cladding and become lost. With use of lenses it is possible to change the cone of light from a light source in order to make it fit within the cone of acceptance. If the lenses is optimized the loss of light can be minimized to 5-10% loss.
[Practical Fiber Optics, 2003]

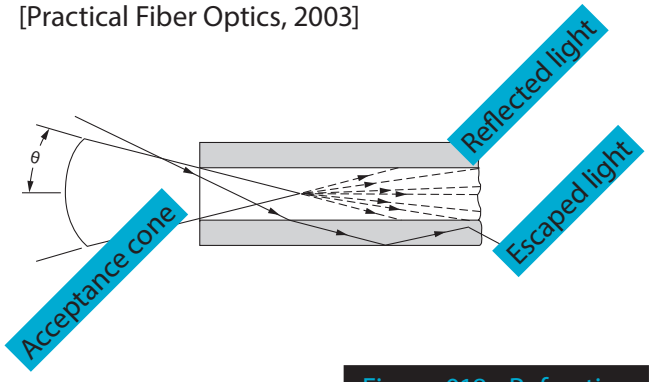


Figure 018 - Refraction

Despite having high usability some limitations in flexibility do exist. The flexibility is depending on different factors.
When determining the flexibility and thus the minimum bending radius of a fiber there are two instances being single core fibers and multi core fibers. With single core fibers the minimal bending radius is determined to be no less than 20 times of the diameter of the cable.
In a multi core fiber the flexibility is depending on how bendable the single fiber is. In general the bending radius of a multi core fiber is determined to be no less the 10-15 times the diameter of cable.

_Possibilities

Despite some of the drawbacks in the optical fibers, the cable is still able to transfer up to 82% of the original light from the source and at the same time giving more usability to an else what fixed construction.
With the use of optical fibers it should be possible to obtain a 360 degree pan and 180 degree tilt thus giving a much greater area of operation compared to the use of a mirror. The optical fiber will be used in the concept development due to its flexibility and possibilities.

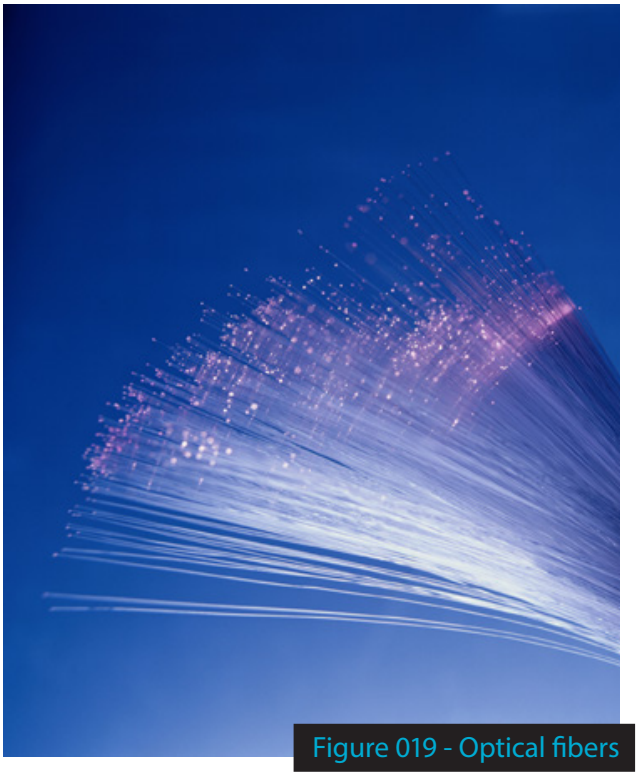


Figure 019 - Optical fibers

Cooling

_Environment and product

Due to the hot environment in which the scanner operates heat is an issue. Also the LED and other electronics create heat which in worst case can cause damage leading to failure. Heat dissipation is therefore an important part in designing dynamic lighting.

From the video interview with Jørgen Lund it was learned that some problems with cooling exists. The limited air flow in the Acme Dragon Scan proposed for a second fan, which due to its size has a high risk of failure. A better cooling system is therefore desired.

By upgrading the scanner to RGB LED will mean the use of three LEDs instead of one which will likewise increase heat thus also entails better cooling.

_Cooling

In terms of cooling many methods are available like for instance laser cooling and other advanced systems. Due to the limitations of this project more conventional methods of cooling will be examined. These are passive cooling, liquid cooling and air cooling.

For passive cooling to work properly some requirement must be met. Initially the heat from the internal components must be transferred to the surface area of the product. To better dispose the transferred heat, a very large surface area is required to distribute the heat away from the product. An example is illustrated on #figure 020# Finally the passive cooling is dependent on its environment to create natural convection for cooling the system. Due to the intense temperatures in night clubs,

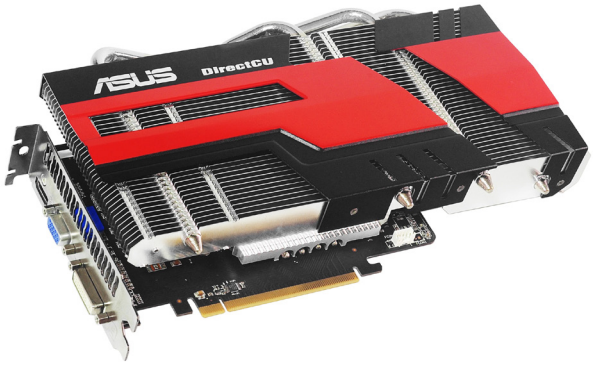


Figure 020 - Graphic card with passive cooling

Figure 021 - Computer with air cooling

passive cooling is therefore skipped.
Liquid cooling often uses water to transport the heat away. For the system to work, a water pump is needed to create flow in the water. The hot water is cooled off by using a heat sink. The high density of water allows for better heat disposal. Due to extensive safety precautions and higher price tag, liquid cooling is also skipped.
Due to air cooling being the simplest and cheapest methods of cooling it is the chosen method. To give air cooling the best terms of condition it is chosen to briefly examine aerodynamics in order to achieve a form that will allows for better airflow compared to existing design. An example on air cooling can be seen in #figure 021#

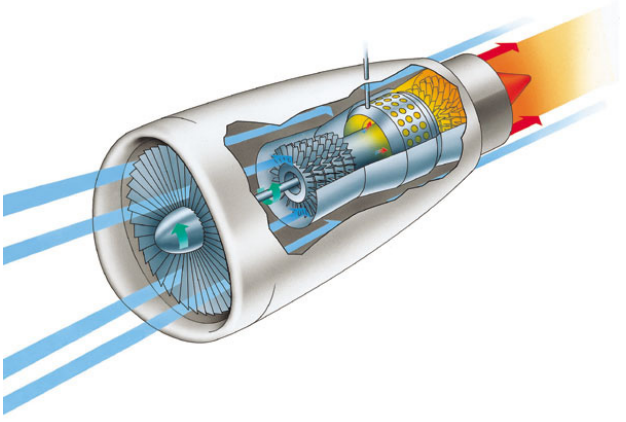


Figure 022 - Example of internal aerodynamics

_Aerodynamics

Aerodynamics is the study of airflow in interaction with solid objects and is quite similar to fluid dynamics being the study of fluids. The two sciences share some of the same basic ideas and theories.
The motion of air outside an object is called external aerodynamics and is concerning phenomenon such as lift and drag often in connection to cars, buildings, planes etc. The motion of air inside an object is called internal aerodynamics and is concerning flow properties in closed space and is often applied in regard to ventilation pipes and jet engines. Internal aerodynamics is thus the branch of aerodynamics related to the mentioned need for optimized air flow.
[Aerodynamics, 2012]

Lens optics

_Optics

In terms of lenses there are two kinds. Concave lenses that diverge and diffuse the light and convex lenses that converge and concentrate light. In terms of scanners only convex lenses are interesting since they have the ability to focus the light which is desired.

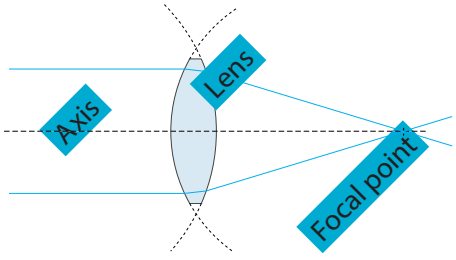


Figure 023 - Convex lens

The lens works in both directions. Going from left to right, in theory, all parallel light rays hitting a convex lens will be concentrated at the focal point of the lens as illustrated on #figure 023#. From right to left the lens will, in theory, act as a collimating lens, creating parallel light rays. Thus using minimum two lenses will give the ability to reverse the light cone from a light source as illustrated on #figure 024#

_Light cone

A LED light source produces a diffuse light cone of which the outer periphery has undesirable glow to it. The width of the cone can vary extensively, but normally the light cone is within 90-110 degree, 45-55 degrees on each side of the axis. The undesirable light must be filtered.

The undesirable light is easily filtered by simply blocking the light mechanically. The useful, but defuse, light is converted into a spot using an optic focus lens. During the conversion from diffuse light to spot light the angle of the cone is changed to about 60 degree.

Since a 60 degree angle is a wide angle in terms of scanners another set of lenses have the purpose of change the angle to a more desired one, where collimated light (parallel light rays) is preferred.

_Optical fibers

In terms of optical fibers, the light from the light source must be narrowed down to fit the cone of acceptance as discussed in the chapter regarding optical fibers. Thus instead of spreading out, the light must be narrowed down.

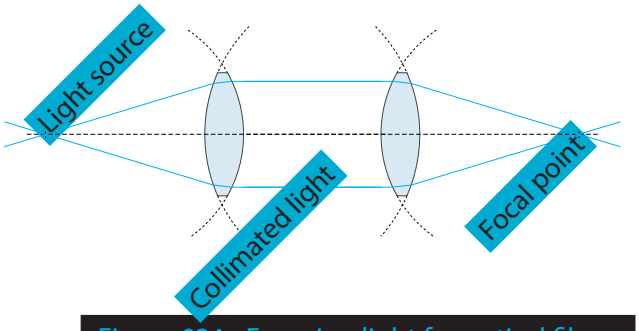


Figure 024 - Focusing light for optical fibers

_Equations

The basic equation for optics is called the lens maker's equation. This equation will determine the focal point of a lens in air, which is the case when calculating lenses for scanners. The equation for convex lenses is as follows

$$\frac{1}{f} = (n-1)(\frac{1}{R_1} - \frac{1}{R_2} + \frac{(n-1)d}{nR_1R_2})$$

Where f is focal length, n is refraction index of the lens, R are the radius of curvature of the lens and d is the thickness of the lens.
The radius of the curvature does not need to be equal on both sides of the axis, which is the reason for the 1 and 2 notations. For ease, the curvature will be equal hence

$$R_1 = -R_2$$

An approximation of the lens is achieved by leaving out the lens thickness, since it value is very small. The equation is thus.

$$\frac{1}{f} = (n-1)(\frac{1}{R_1} - \frac{1}{R_2})$$

Since we have set the curvature to be equal the final equation is hence

$$\frac{1}{f} = (n-1)(\frac{1}{R_1} + \frac{1}{R_1}) = (n-1)\frac{2}{R_1} = \frac{2n-2}{R_1}$$

_Calculations

Further calculations, as well as calculation on focal length and lens curvature are in the #appendix A#

Handle & ergonomic

_Handle and weight

During maintenance and installation some lifting is required. Since scanners can become quite heavy, ergonomic considerations are necessary in terms of use and handling. If the product is lacking a prober method of handling, inappropriate handling could in worst case cause back injuries.

The load a person is able to lift without causing back pains or other injuries is varying from person to person, but some general lifting rules is set up as illustrated in #figure 024#. The further away from the body a load is carried the more of a burden it is to the body in accordance with physical principle of torque.

The chart below illustrates the maximum burden at three different distances from the body.

[Arbejdstilsynet.dk, 2012]

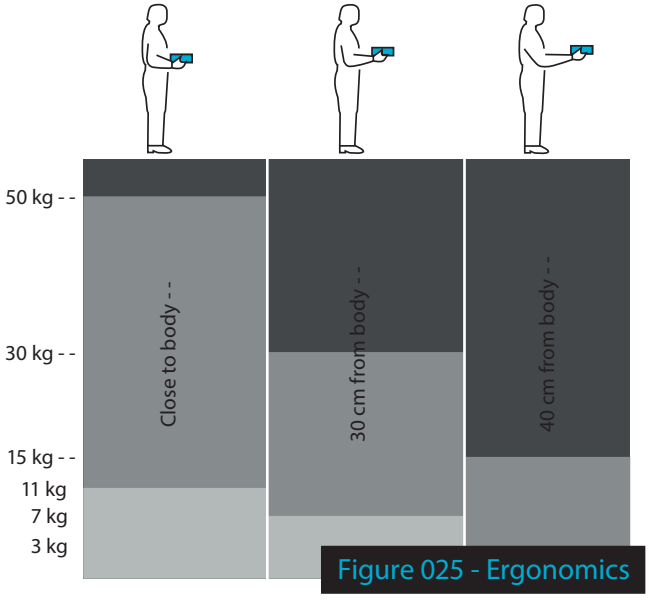


Figure 025 - Ergonomics

_Dark grey

Lifting and carrying in this position is considered unhealthy and should be avoided at all times due to the high strains.

_Grey

When carring at this distance from the body up to 30 kg can be carried before it is concidered unhealthy

_Light grey

Lifting close to the body is considered the healthiest and should be endeavored. Carrying in this position allows for longer lifts than the grey and dark grey area.

Research summary

_Phase reflection

The research conducted during this phase has revealed a lot of potentials and possibilities for the further design process. Besides providing a lot of new options, the technologies also have limitations that need to be accounted for in the design phase.

The prime objective for the research phase was to find a technology that could break with the static layout of the scanner as revealed in the product architecture chapter. This was achieved using optical fibers which can easily be incorporated into the scanner since the optical fibers only relays on lens optics which is a technology already used in scanners today.

From the LED research it was learned that different methods for creating white light is available, including RGB LED. The implementation of RGB LED would allow for better output in terms of lumens, since the color wheel is no longer necessary. Besides a higher output, some components can be removed from product thus possibly making it smaller. The RGB system would also provide a much larger color spectrum in comparison to the color wheel since the RGB would be able to create almost every color, whereas the color wheel has fixed colors

In terms of cooling, various technologies were explored, but none of them was found to be beneficial when safety, efficiency and price were taken into consideration. This lead back to the use of simple air cooling as already implemented in scanners today. In order to aid the use of air cooling, aerodynamics was briefly examined and can possibly be implemented in the design phase to create better airflow for optimized cooling.

Strategy

Focus & values

Mindmapping & brainstorm

Design parameters

QFD

Problem statement

Figure 026 - Strategy post-it

Focus & values

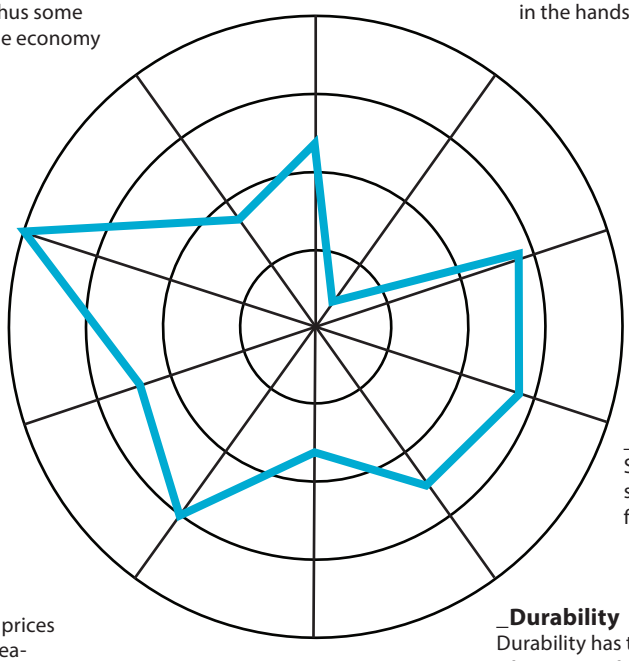
_Values

In order to narrow down the design process a set of values is defined based on the previous phases. These values will thus act as the value mission for the further design process and the final product. Some of the values are based on creating value Martin Professional in terms of production as well as not being in conflict with the image of Martin Professional. The values is as well based on creating value for the user to whom the product is intended. The diagram illustrates the different aspects that would be covered during the design process. The diagram is a beacon and it may not illustrates the final product.

_User friendly & easy handling
User friendliness is lacking in some midrange products compared to Martin products. User friendliness would add product value

_Economy
Price is an issue due to the competition and thus some focus is put into the economy

_Marketing
Branding of Basic by Martin is primarily in the hands of Martin Professional.



_Functionality
More or better functionality should preferably be added to the product thus creating more value for the customer.

_Production
The product must not be to advanced, which will slow down production and increasing the price. High production volume is preferred

_Maintenance
From the user interview it was learned that service can be an issue, therefore service is also in focus.

_Value & usability
Scanners today are very fixed in construction which limits the use. A more flexible solution is desired.

_Innovation
Martin cannot compete on prices only which requires new measures. Focus will be on innovation in order to add value the product.

_Durability
Durability has to be high to match the image of Martin Professional, but does not necessarily the same level as existing products

_Perfomance
In order regain market shares the scanner must out perform the competitors.

Mindmap & brainstorm

_Mindmap

Based on all the findings from the previous phases, a mindmap is conducted in order to initiate the ideation phase. The mindmap will act as an overview to of all the findings and possibilities gained from the different technologies that have been evaluated.

The mindmap is illustrated on #figure 026#

_Mood board

A mood board is conducted as well to provoke the concept phase. The mood board will be based on finding from the technology scanning as well as some of the issues gathered from the previous phase. Pictures are found matching the mindmap and the issues. The mood board is illustrated on # figure 027#

The mood board and mindmap are available in full size on the CD

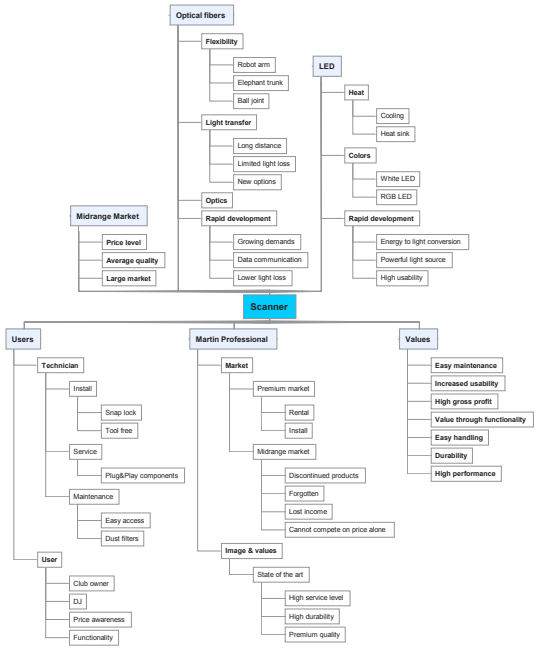


Figure 027 - Mindmap

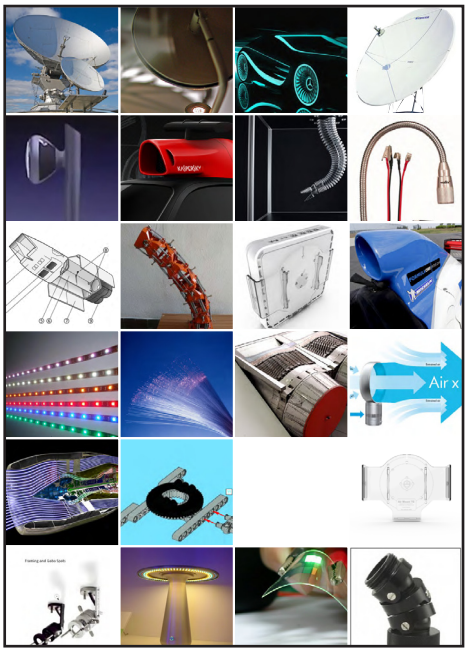


Figure 028 - Moodboard

Design parameters

_Maintenance

From the user interview it was learned that dust is the most common problem with regard to maintenance. According to the technicians a dust filter is not an option in terms of keeping the scanner clean, easy access to the components is preferred feature.

_Install

As indicated by the technician a scanners are often easy to install, but if the bracket is not constructed correctly it is rather difficult. In order to minimize the need for tools during install as well as the time on the ladder a prober install method is a need.

_Handle

Lifting heavy products can be an issue if they cannot be handled correctly. The technicians also have to handle the products while balancing on a ladder thus magnifying the importance of prober handling. Prober handling is therefore a must

_Effect

An easy and often used method for product comparison is the effect outcome. It is thus important for Martin Professional to have a product where the effect is at the same level or can out match the competitors.

_Economy

Martin professional cannot compete solely on prices since this will compromise their image. Price level is an important factor since the product still has to compete on this factor among competitors. Cost effective prices is necessary.

_Durability

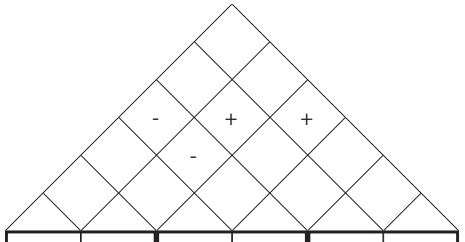
Martin professional has indicated a lifespan of about 3 years is to be expected. However durability should be as high as possible thus signifying high quality and durability.

QFD

_QFD

The house of quality is a tool that helps transform subjective wishes into something more measurable or objective. By transforming subjectivity into objectivity it is easier to measure the improvement and thus whether the wishes or demands have been met to sufficiently.

The vertical listing represents the subjective terms, whereas the horizontal listing represent the measurable tools to fulfill the wishes.



	What / How	↑	↑	↓	↓	↑	↓
		Performance		Range		Details	
		_Strength	**_Output**	**_number of parts**	**_Price**	**_Pan/tilt**	**_Required tools**
Use	**_Easy handling**	+					+
Use	**_Usability**		+			+	
Use	**_Maintenance**			-			+
Use	**_Functionality**		+			+	
Design	**_High performance**					+	
Design	**_High durability**	+					
Production	**_Simple production**			+	+		
Production	**_Economy**			+	+		

Problem statement

_Problem statement

How to create a scanner for Martin Professional that through product optimization and value innovation can compete on a more price aware market in order to help Martin Professional regain lost market areas due competition from midrange products.

Conceptualize

- Internal concept
- Color effects
- Internal concept
- Sketching&Ideation
- Design proposals
- Concept evaluation
- House of Quality

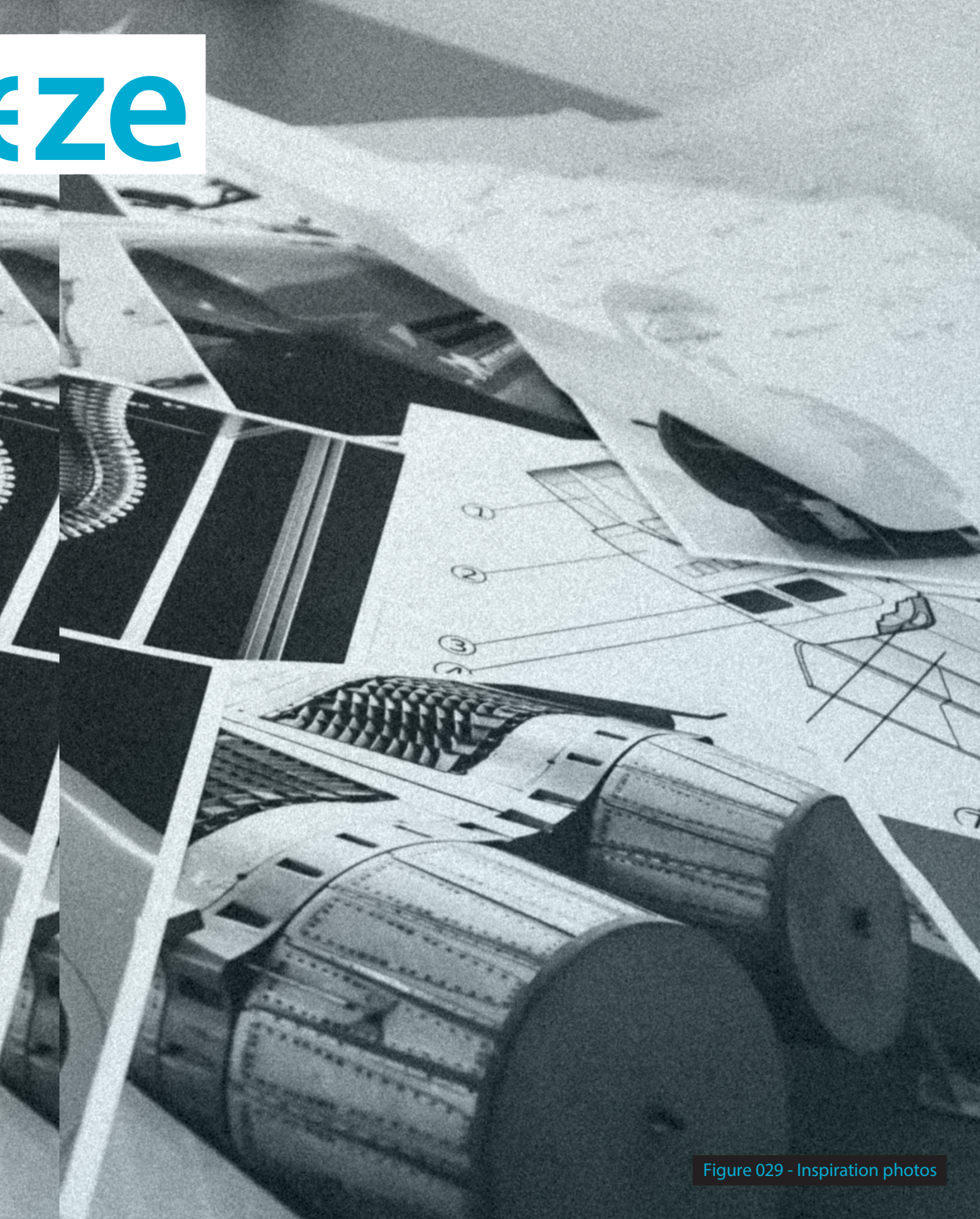


Figure 029 - Inspiration photos

Internal concept

_Internal concept phase

The concept phase will be split into parts covering different aspects. A lot of options and possibilities have been provided by the technology scanning from previous chapter and hence the need for an internal concept phase. Because the internal structure will be the base for the outer design and outer structure the internal components and construction will be prearranged first.

Color effects

_Color effects

A color wheel is the most common method for creating color effects in scanners today for creating the necessary color effect.

LED is a technology in rapid development and has already replaced the use of halogen spots as light source, but the LED has other advantages than their size and high efficiency. From the previous chapters it was learned that LED can be used in a combination creating RGB LED, thus allow for a much richer color spectrum than the predefined color wheel.

In order to determine what system that should be used for further concept development a pro and con list is conduct and is illustrated below.

_Criteria

A criterion for designing a new scanner is to match or out match existing scanners and competitors. Based on this the multi-color LED is rejected due to it limitation on showing only on color at a time. The AmberRGB LED as well as the RGB LED has a higher color spectra compared to the existing color wheel, as a result the rejection of color wheel.

Due to problems with color rendering in the AmberRGB in situations with high output this is eliminated as well leaving the RGB LED as the preferred choice for further development.

_AmberRGB LED

_Pros
- Large color spectrum
- High color saturation
- Combined effect
- No effect loss

_Cons
- Heat accumulation
- Advanced control required
- Color rendering can be problematic

_RGB LED

_Pros
- Large color spectrum
- Cheaper then AmberRGB LED
- Combined effect
- No effect loss

_Cons
- Heat accumulation
- Advanced control required

Approved

_Multi color LED

_Pros
- Only one LED
- No effect loss

_Cons
- Advanced control required
- Can only display one color at a time
- Expensive

_Color wheel

_Pros
- Known system
- Cheap

_Cons
- Effect loss
- Limited colors
- Color wheel can become dirty

Internal structure

_Structure

From the product analysis knowledge about the internal structure was obtained. The primary problem with the existing structure is its rigidity in terms of component placement where the only variable is the placement in the axis of the light cone.

In order to break the rigid construction optical fibers was examined and proved to be possible solutions to this problem since it will allow much more flexibility. In order to determine what system to continue on a pro and con sum up list is conducted.

_Criteria

The criteria for the choice are the possibility to add value to the product in terms of functionality, design and other options like flexibility in terms of installation.

For the existing layout, the criterion for design is met but is highly dependable on the internal structure which can be a limitation thus limiting the further development to a styling project. In terms of functionality, the product can have added install options, but the true functionality improvement lies with the light source which is already covered.

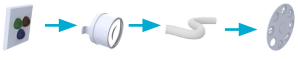
The introduction of optical fibers gives the needed flexibility because it can break the existing rigidity. Also the ability to separate the products into two part connected by the optical fibers is an option.

_Existing structure

_Pros
- Known system
- No loss due to optical fibers
- Easy upgradable with LED

_Cons
- Limited option for functionality upgrade
- Limited area of operation

_Optical structure



_Pros
- Highly flexible
- Option for larger area of operation
- Ability to separate light source

_Cons
- Loss due to optical fibers
- Life span on optical fibers when bending

Approved

_Combined structure

_Pros
- Known system
- Highly flexible
- Option for larger area of operation
- Ability to separate light source

_Cons
- Loss due to optical fibers

Approved

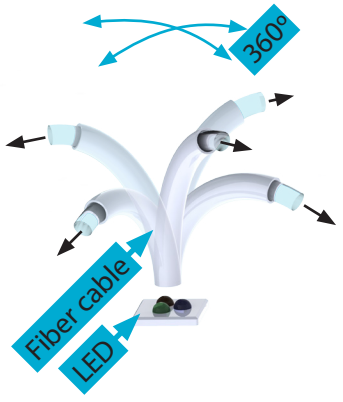
Initial concept

_Initial concept

In terms of structure two systems was chosen for further concept development. In order to make moving dynamic lighting effects, the *"optical structure"* uses no mirror in order to move the spot around and is thus dependent on the flexibility of the optical fibers. Bending the cable from side to side will create a 360 degree output as illustrated on the figure below.

The combined structure uses a mirror to reflect the spot light as known in today's system. The optical fiber in this setup will thus act as a mean of light transportation and is as well illustrated below.

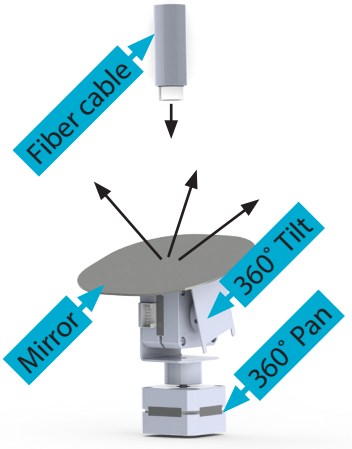
_Optical structure



_Elephant trunk

The elephant trunk has been an inspiration for this principle. It allow for flexibility in all directions thus out matching the area of operation in existing setup.
This principle relays mainly on the flexibility of the optical fibers.

_Combined structure



_Satellite dish

This mirror dependent system has been inspired by the satellite dish. Normally the signal is caught by the dish and reflected at the receiver. In this system the receiver is replaced with an optical fiber providing the light, and the mirror acts as the dish reflecting the light an all directions.

Sketching & Ideation

_Sketching & ideation

Two structures have been selected for further development and it is thus decided to do sketching based in these two concept ideas for generation of movement in optical fibers. The different proposals for generating movement will be evaluated as the last part of the concept phase.

Two additional matters are ideated on as well.

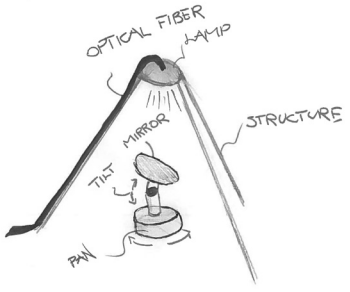
_Combined structure

The first part of the concept phase is sketching on the combined structure which is still uses the mirror. Since this is the system already in use today, the objective is to create a more open structure to allow for a greater pan and tilting which is equal to the area of operation.

A satellite dish is the primary source of inspiration and the objective is to create a slim yet highly durable structure

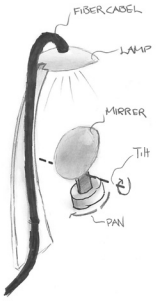
The *"satellite lamp"* is chosen for concept evaluation since it is the proposal with the most open structure.

Figure 030 - Satellite dish



_Satellite concept

This concept part is highly inspired by a satellite dish where the 3 legs support the lamp and the optical fiber. The lamp projects the light down on a mirror that due the re-configuration now has a much greater area of operation compared to existing design. The light is only limited by the lamp and the 3 legs.



_Satellite lamp

This concept has many similarities with Satellite concept, but is only supported by a single more solid leg to achieve an even higher area of operation.

_Optical structure

This part of the sketching phase is on the optical structure, where the flexibility of the optical fiber provides the movement of the dynamic lighting effect. The sketching is thus about creating ideas on how to mechanically flex the fibers in a 360 degree manner in order to create an optimized area of operation.

The inspiration for these concepts is the Festo Bionic Handling Assistand, having certain similarities to an elephant trunk.

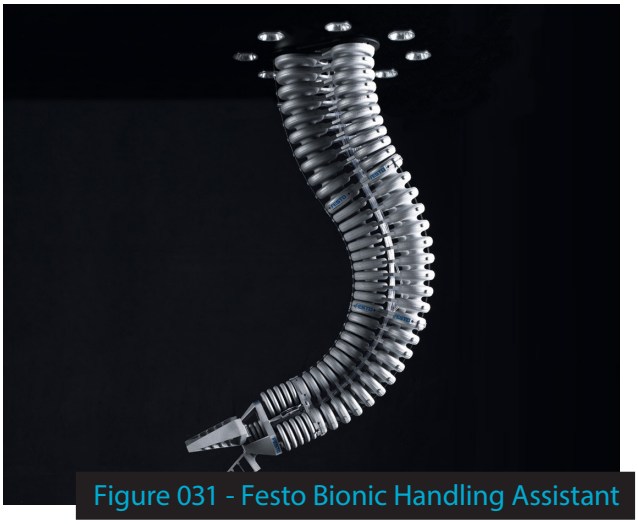
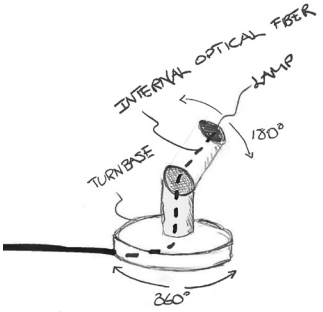
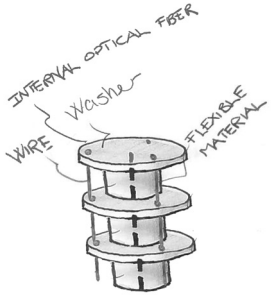


Figure 031 - Festo Bionic Handling Assistant



_Robot arm

The robot arm has en certain resemblance to the double motor system that is in use today. The base motor creates pan rotations and build on the base motor is a second motor creating the tilt. By attaching the optical fiber to this construction it is possible to flex the optical fibers in almost all directions



_Elephant trunk

This concept seeks inspiration from an elephant trunk since it is highly flexible. By combining a flexible material with a washer and pull in 3 axes a replication of the elephant trunk can be obtained.

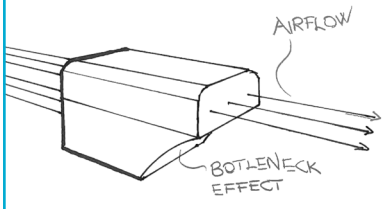
_Airflow

From the Acme Dragon Scan it was learned that an additional small fan was necessary to cool part of the circuit board due to a bad airflow caused by the internal framework.

The use of three more powerful LEDs also contributes to the need for cooling. Due to this it is decided to do some sketching outer shapes the will aid the airflow.

The bottleneck proposal is approved of the two concepts. The smaller neck causes more air to flow through at increased speed and is replaced faster which should result in better cooling.

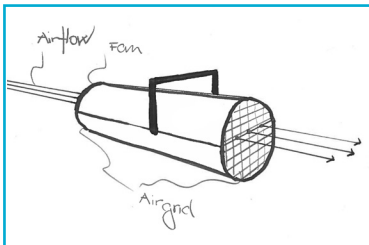
Figure 032 - Air intake, Ferrari F1



_Bottleneck

The idea is to create a bottle neck effect to accelerate to airflow in a certain area of the design. The accelerated airflow will increase the cooling effect in this region.

Approved



_Air duct

The idea of this airflow concept is to create a straight forward airflow as know from air duct. By having a grid in both ends the air is allowed to pas right through the cylinder thus cooling the components effectively.

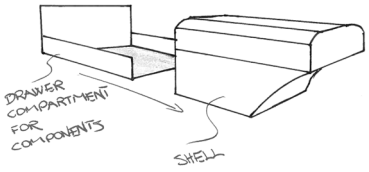
_Easy access

This part regards the option to easily access the scanner since maintenance is a requirement. The easier it is to access the easier it is to service.

In this sketching phase only two proposals were outlined as illustrated below.

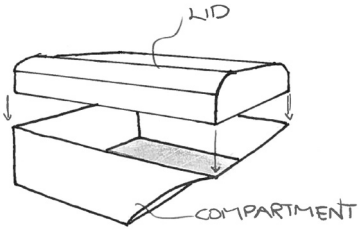
The lid concept is chosen among the two concepts due to extended need of materials and components in the drawer proposal. Additional plastic or metal is required to create the drawer and also the need for a sliding system results in increased bill of materials

Figure 033 - Maintenance on an ATM



_Drawer

This concept is based on a simple drawer system. The idea is to have all components and circuit boards fixed in the drawer which can be opened in order to service the product. A drawer system will allow for the possibility for a solid outer shell.



_Lid

The lid based system is a simple well known method. This system is used in the Acme Dragon Scan and the MX-1. In terms of the Acme Dragon Scan, the lid is too small.

This system is simpler compared to the drawer system because it does not need a sliding system.

Approved

Concept evaluation

_Selection matrix

In order to evaluate the concepts and to determine what concept to develop further the concepts are screened and evaluated in a matrix as illustrated below. All the concepts are evaluated based on their ability to satisfy the values set up in the value mission. The importance of the values is weighted in percentage according to their importance to this project.

Each concept can be awarded 0-5 point depending on how good they meet a given criterion. The score is afterward weighted accordingly. The summation will determine what concept to develop further and detail.

The selection criteria are listed on the vertical axis and the concepts on the horizontal axis.

		_Concept scoring					
		_Robot arm		**_Elephant trunk**		**_Satellite**	
_Criteria	**_Weight**	**_Rate**	**_Weighted score**	**_Rate**	**_Weighted score**	**_Rate**	**_Weighted score**
Handling&transportation	**_10%**	3	0,3	3	0,3	2	0,2
Ease of installation	**_10%**	4	0,3	4	0,4	2	0,2
Manufacturing	**_8%**	4	0,32	3	0,24	4	032
Performance	**_24%**	3	0,72	5	1,2	2	0,48
Maintenance	**_19%**	3	0,57	3	0,57	3	0,57
Durability	**_16%**	2	0,32	3	0,48	2	032
Functionality	**_13%**	4	0,52	4	0,52	3	0,39
_Total	**_100%**		3,15		3,71		2,48

Approved

Conceptualize summary

_Summary

The conceptualize phase gave a lot of good ideas and a lot of decisions were made in terms of possible technologies and their implementation in the coming product.

The conceptualization phase was divided into part focusing on one matter at a time thereby allowing for the decision making mentioned above.

Though some good sketches and good ideas have been generated another output could have been the case if the conceptualize phase have been conducted based on the integration of all ideas, technologies and so forth at once.

Also the conceptualization phase did not account for physical size and proportions and was merely created based on ideas on how to create a functional product.

During the concept phase almost no shape designs was conducted which is the reason why this part is not illustrated in this chapter.

The design of the out shell is primarily focused on physical attributes extracted from the shape and positioning of internal framework and components and is thus illustrated in the next chapter.

Detailing

- Initial detailing
- Lens optics
- Optical fiber lens
- Cooling
- Final Optics
- Connections
- Lens and connections
- Shell proportioning
- Shell features
- Shell detaling
- Front wall
- Core structure
- Assembling
- Bracket
- Final scanner
- Satellite lamp
- Flexing the fibers
- Choice of materials
- Manufacturing

Figure 034 - Modeling in Solid Works

Initial detailing

_Initial

From the previous phases some design proposals have been outlined. These proposals were made roughly in terms of size and proportions with regard to the internal components and their composition. In order to obtain guidelines for the size of the outer design the different components are detailed and placed best possible. From this composition the dimensions for the outer design are giving and afterwards the detailing of the outer shape can be made.

The detailing and optimization will be conducted with production in mind since this is quit essential. The final production detailing will be conducted later on.

Lens optics

_Light source

The most important part to the product is the light source and the lenses used to collimate and focusing the light in order to create sharp spot light. There for the light and lens system is detail first.

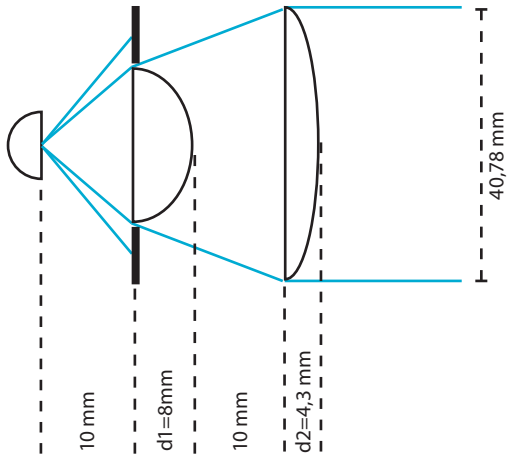


Figure 036 - Lens calculations

_Light filtering

In most cases high powered LED (HPLED) are wide beam angle LEDs and the spread often reaches approximately 90-110 degrees. The LED in the Acme Dragon scan is about 110 degree spread and the following size determination is based on the same spread. Before calculating on the collimating lens two issues need to be dealt with in advanced.

The first issue is the light quality. Most LED has a periphery of unwanted light due to its quality. This light is filtered mechanically by blocking the light. The second issue is the focus of the light. An LED produces a very defuse light spot and a focus lens is thus used to convert the defuse light into a sharper light sport. Since the spread is considered the same as the Acme Dragon Scan the same focus lens is used. The focus lens transforms the light to a 60 degree spread which is the base for the calculations of the collimating lens.

The setup is illustrated on #figure 036#

_Collimating lens

The distance from the focus lens to the LED light source is 10 mm at the Acme Dragon Scan which is equal to the focal point of the lens. The focal point is equal on both sides of the lens and therefor the collimating lens should be 10 mm from the focus lens. The total length of the lens system is 10+8+10+4,3 = 32,3 mm. The diameter is calculated to be 37,5 mm.

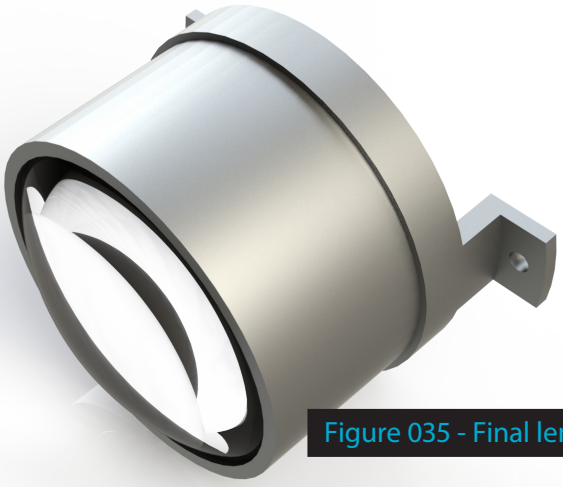


Figure 035 - Final lens

Optical fiber lens

_Cone of acceptance

The optical fiber has a cone of acceptance which the light needs to within in order to access the optical fibers. The cone of acceptance is dependable on the type of fiber; bit a rule of thumb is that the acceptance angle is approximately 25% in total.
The inner diameter of the 12 mm optical fiber is 9 mm causing the focal point to lie inside the optical fiber as illustrated on #figure 037#.

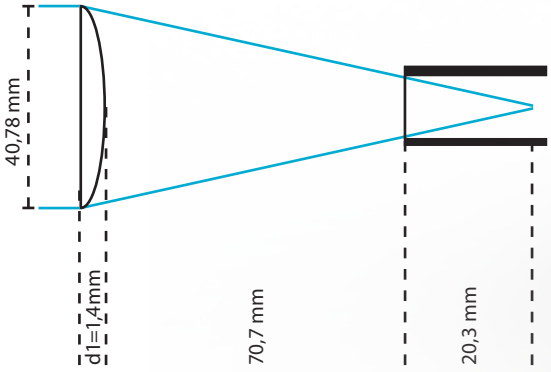


Figure 037 - Cone of acceptance

Since the light rays are parallel between the collimating lens and the optical fiber lens distance between the two lenses lens are in theory completely independent. In reality dust and other impurities in the air causes the light to loose output and should thus be kept at a minimum. Also the shorter the distance the shorter can the outer shell be

_The lens

The lens is based on the diameter of the collimated light. In the optical fiber lens only on lens is required since the light is already focused from the previous lens.

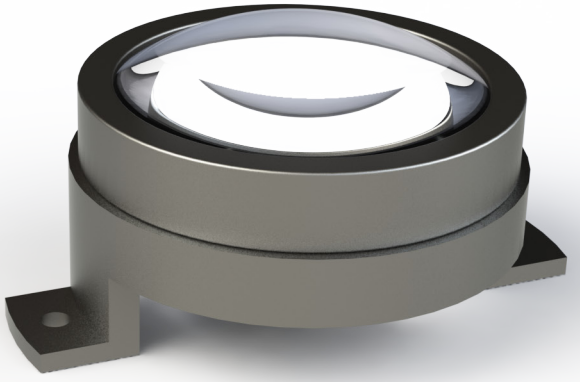


Figure 038 - Final lens

Cooling

_Heat Sink

The use of LED light causes the need for cooling and in order to improve the efficiency of air cooling a heat sink is used similar to the a heat sink found in the Acme Dragon Scan.

The Acme Dragon Scan uses a 50W LED of which up to 20% is converted to heat that via thermal conduction is transferred to the heat sink. The heat is removed using a fan.

At Martin professional a test have been conducted showing that the heat dissipation system found in the Acme Dragon was able to dissipate the heat emitted by a 75W LED. Based on these findings it is estimated that the heat sink is able to dissipate the heat emitted by the RGB LED system. The size of the heat sink is thus the equal to the one found in the Acme Dragon scan.

_Size

The heat sink is 22 mm think and has an outer diameter of 106 mm and is therefore a rather huge part of in the setup. The fan is a standard 80 mm fan measuring 80 mm on both sides. The thickness is 25 mm. To optimize the airflow around the heat sink the fan is placed 10 mm distance from the heat sink.

The total thickness is thus 22 + 23 + 10 mm = 55 mm.

Figure 039 - Final cooling system

Final optics

_The final optics

The final optics will be the base for the product since it will be the provider of light making the product functioning and is illustrated on #figure 040#.

The different measures of the optics have been defined throughput this process and have given the initial idea of the size of the outer shell.

The overall measures of the optical system are illustrated on the figure below on #figure 041#.

Figure 040 - Final lens

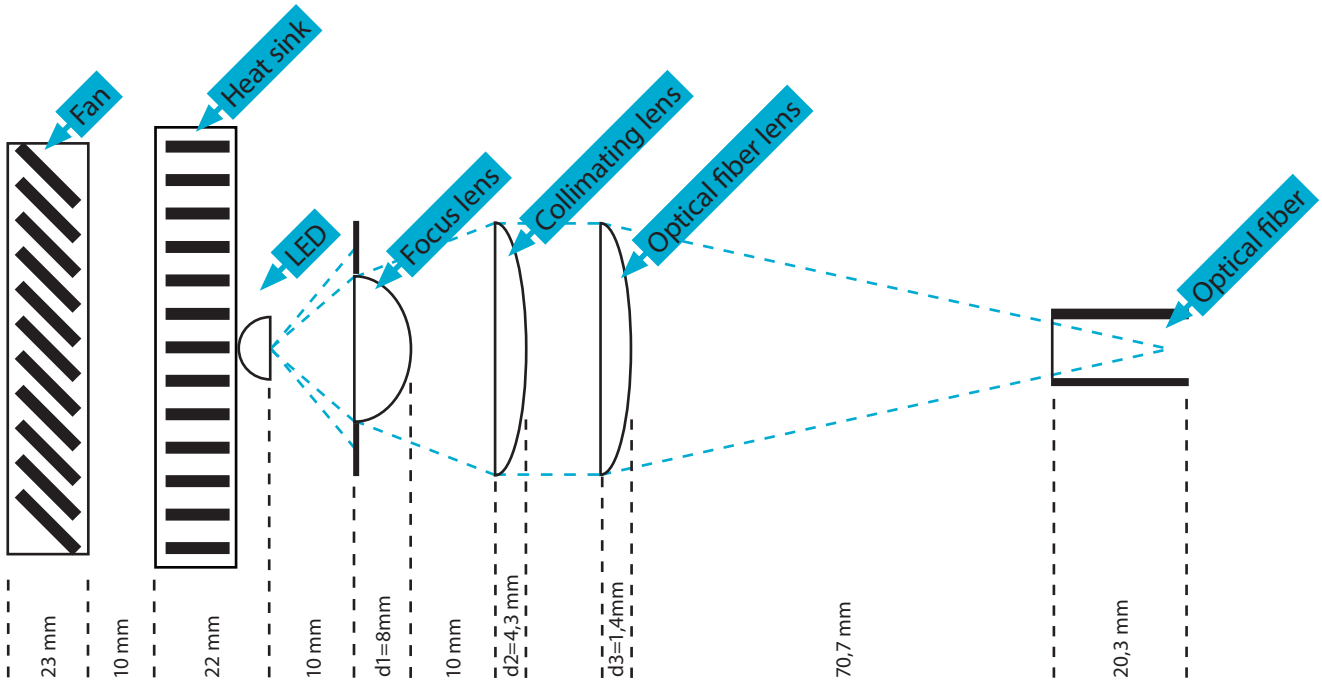


Figure 041 - Structure

Connections

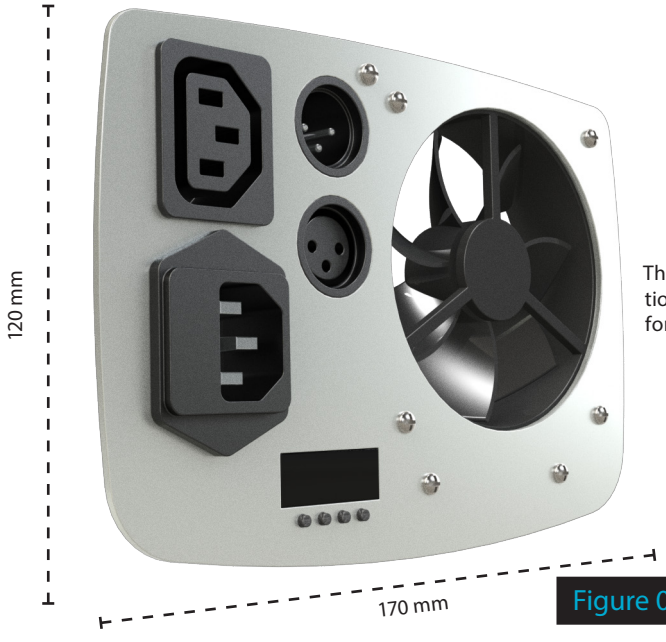
_Connections

In terms of placement of connections, there are several options. Due to the size of power cable and DMX plugs it is chosen not to place the connections in the top since it will create a huge gap between the ceiling and the product. Since light will exit in the front the wires might interfere with the light excluding the front as an option. The bottom is not an option, since it will reveal the wiring, leaving the back and the sides as options.

Due to the need for air flow in the direction of the fan, air intake or output is already causing modifications to the back and it is therefore chosen to place all connection at the back. It is chosen as well to place the connections side by side, in order to create the scanner as flat as possible to put it as close to the ceiling as possible.

The Fan is a standard 80mm fan and takes up most of the place. Martin Professional has proposed a wish for the option of serial linking the product being the reason for the DMX and power output.

The determined connection layout is illustrated below. From the measures below and the measures from the optics the outer shell can be no smaller than 170mm x 120mm x 180mm. Addition structure will cause to final product to larger, but the measure gives an idea of the product proportions.



The placement of the needed connections including the display and the fan for cooling the LED.

Figure 042 - Connection placement

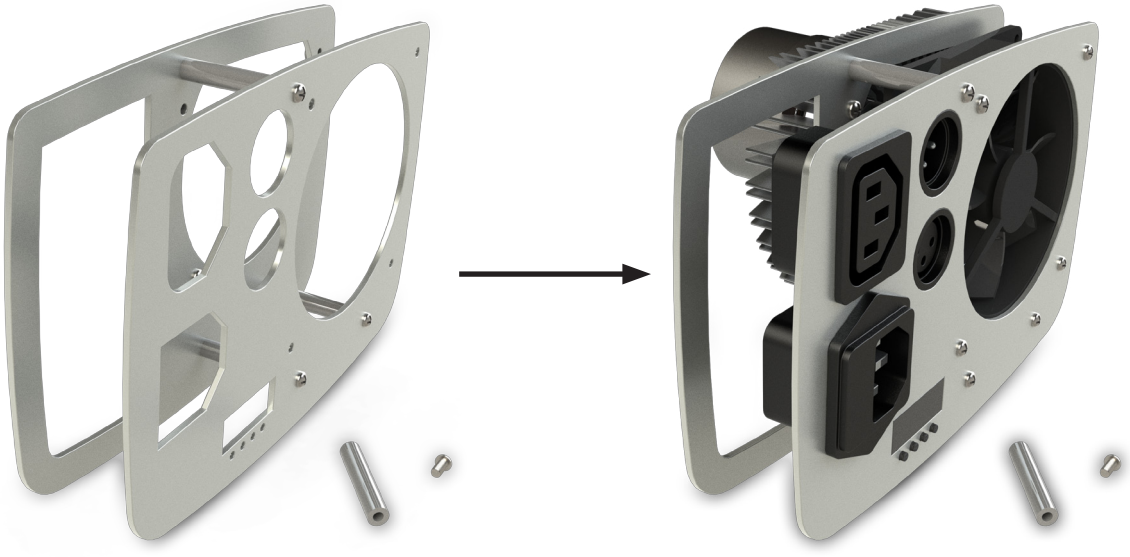
Lens and connections

_Bearing structure

The bearing structure consists of two parts of which one part support most of the internal components such as the LED and the lens and the other bearing structure supports the outer shell.

In order to create a strong internal structure the product relays on the interaction between sheet metals.

The structure bearing the internal components is held together with 3 cylindrical spacers as illustrated on #figure 043# with and without components



2x 2 mm thick steel profile fasten together with a spacer

Same profiles with components attached. The large square hole is for running cords to the circuit board

Figure 043 - Internal structure for components

Shell proportioning

_Proportions

As described previously the outer diameter of the product is no smaller the 170mm x 120mm x 180mm but due to spacing from other components the final product will be larger. Besides giving a general idea about the dimensions and proportions of the product, the configuration expresses a certain shape that is carried on in the detailing of the outer shape. The detail is illustrated on the figure below.

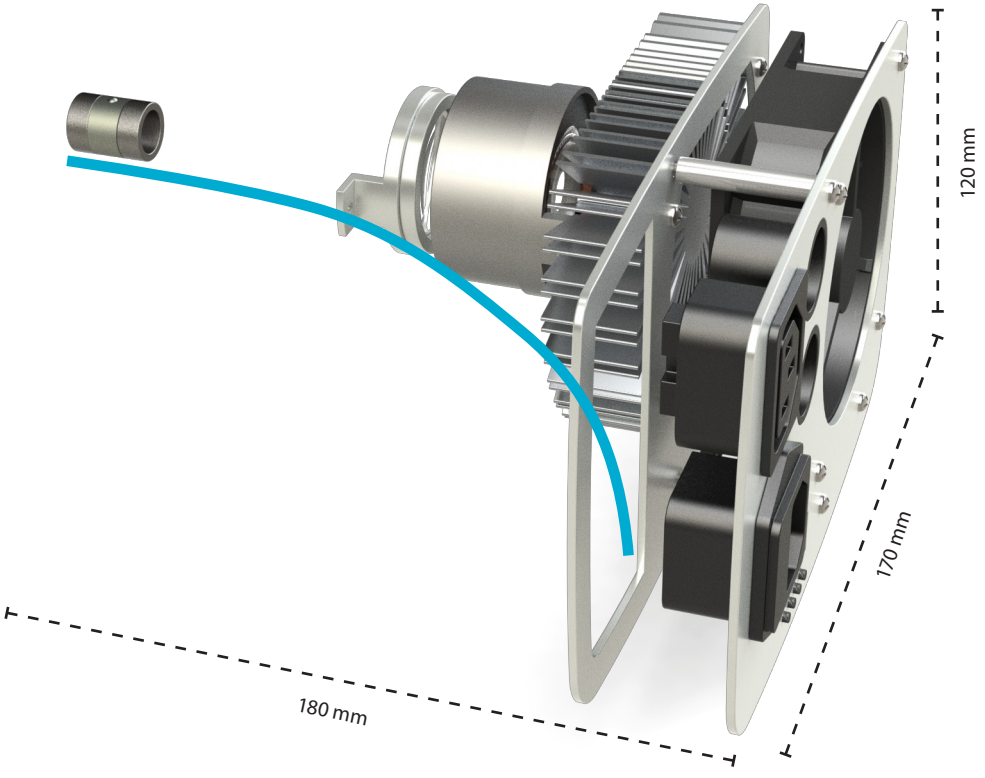
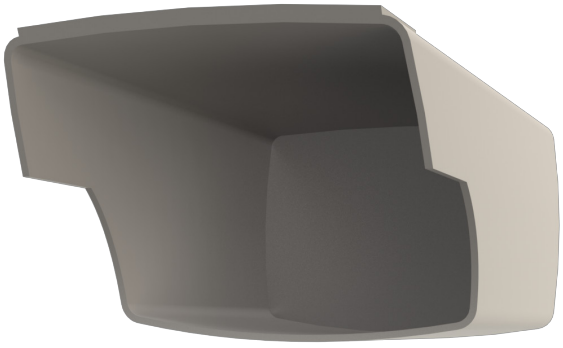


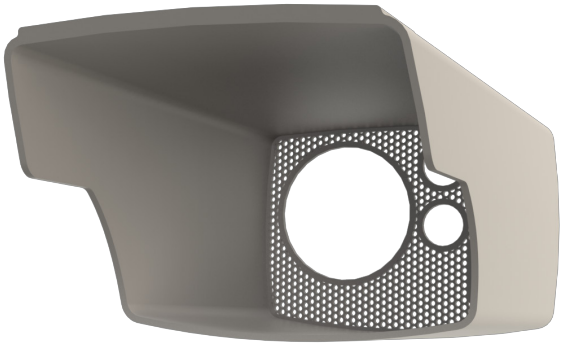
Figure 044 - Proportioning

Shell features



_Initial shape

The first shape was created by extruding the profile dictated by the connection layout as described previously. The extruded was extended to a size that was able to contain the internal configuration. The cut shape was copied from shape illustrated under shell proportioning

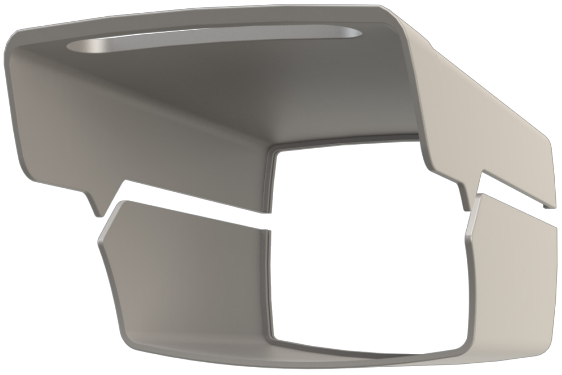


_Adding features

Initially the shape was thought of as a shell created in on piece in order to add stability and to avoid seams. A ventilation grid was added as well as holes for the connections and the fan.

_More features

By adding a handle to the shell it was sought to create better carrying and transportation possibilities. Pegs was added on the sides for mounting a bracket.



_Two part

Due to the extensive amount of features added to this single body, it was decided to split it in two part in order create a simplified molding process.
Furthermore it was decided not to have the end part molded as part of the body, but as a plate of sheet metal illustrated in the previous phase.

Shell detailing

Top shell

Bottom shell

_001 Ribs&Stability

Since the product is now split in two parts some stability has been lost. In order to regain stability in the product ribs are added on the inside as illustrated on the picture. The stability is tested using FEM analysis. The FEM analyses are featured on the CD.

_002 Mounting parts

In order to simplify the installing of the components it is chosen to create a system where the component assembly is slide into place. The slide is integrated as part of the ribs thus providing stability to the shell as well an easy assembly process.

_003 Snap fits

The pegs are shaped as snap fits which will allow for fastening the scanner in the bracket without the use of tool making it easy to install and take down when service is needed.

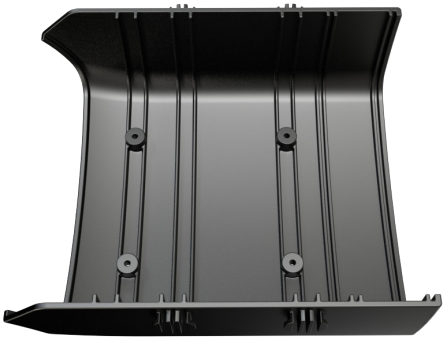
_004 Grooves and lips

In order to create a seamless connection between the two shell part grooves and lips are added to control the positioning the walls.

_005 Handle

A handle is added to the shell in order to create better options for carrying. To make space for the handle the body was extruded to a total of 295 mm in length

The FEM strength test is available on CD.



_006 Fastening

Extrusions are made in the top and bottom shell for fastening the shells. The extrusions allow for sub-merging assembly screws into the body so they are hidden

Front wall

_Front wall

The front wall sealing of the product was design to follow the cut from the initial shell proposal.
Holes are added to the front wall so that plugs can be attached and light can come out. The two large holes are for DMX cables, whereas the two smaller plugs are for the optical fiber.

_Air vent

In order for the product to cool air vents are added to the front of the product as illustrated on the model

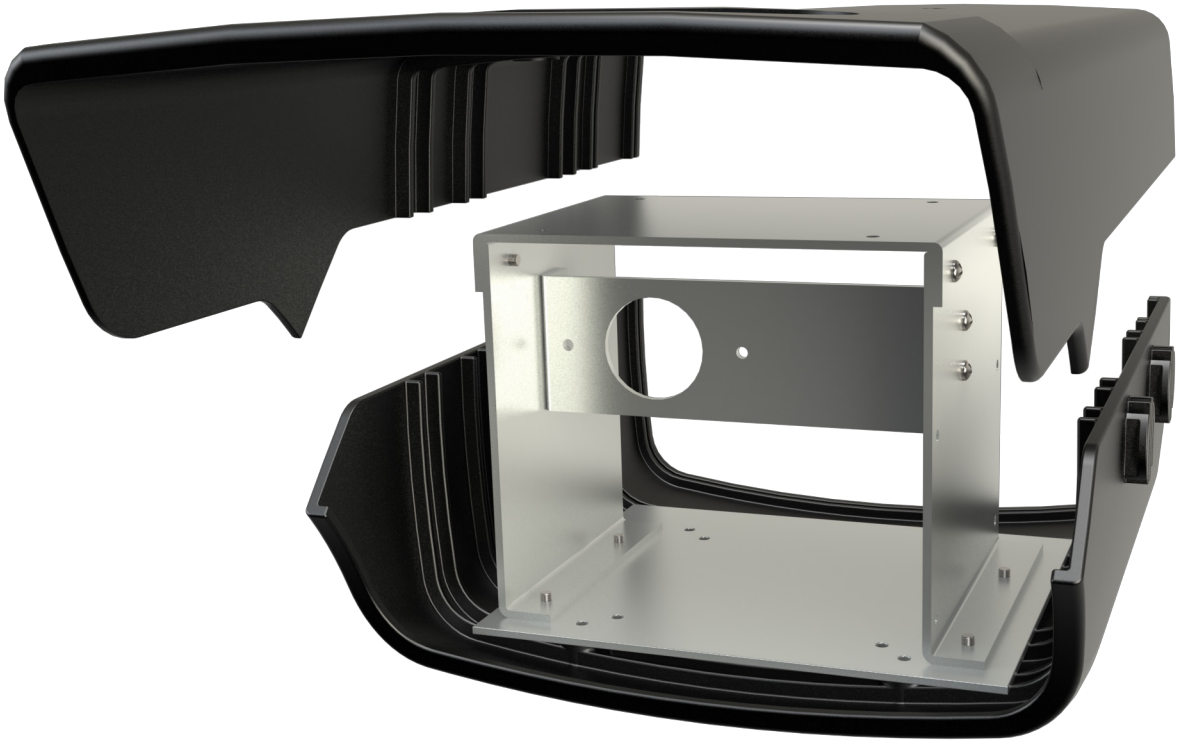
_Wedged

The gap between the front rib and the second rib is used to wedge the front wall.

Core structure

_Core structure

The core structure is a metal frame of bended sheet metal assembled by screws. The core structure acts as the method of assembling the two shells as well as providing additional stability to the shell. The stability is obtained through the stiffness between the walls. The core structure is created to mount the mount the circuit boards as well.

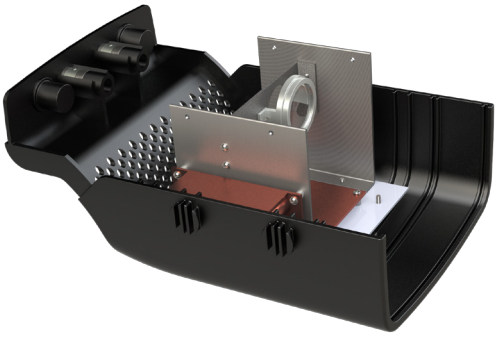


Assembling

_001

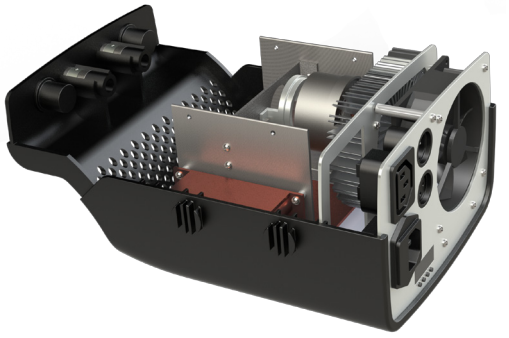
_002

The front is placed and firmly fitted between the first two ribs holding it in place.



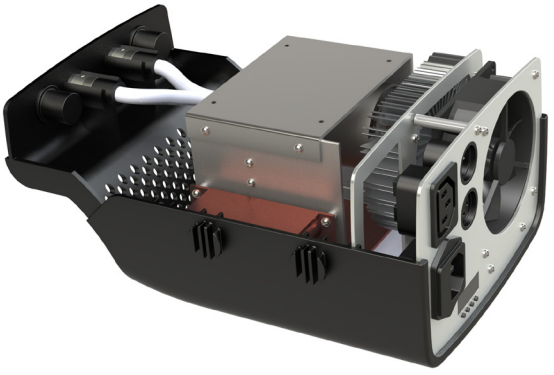
_003

The core structure is place on the bottom shell and fastened with 4 screws from underneath. The top part is removed from the core structure, to allow the components to be slide in place.
All circuit board are installed on the core structure



_004

The two walls carrying the components are slid into place. The wiring between the connections and the circuit board is conducted at this stage



_005

The optical fibers are installed leading the light from the last lens to the front connections is installed. The top plate is installed on the core structure.

_006

The lid is installed on top, keep everything locked. The lid is installed using for screws.

Bracket

_Bracket

The bracket for this product is molded in plastic as well. This is due to the flexibility in plastic compared to metal. Since the installation of this product is thought of as a snap fit solution it would require bending the bracket to release it from the snap fit. Extensive bending and flexing of metal could course metal fatigue and should thus be avoided at all cost. In order to achieve forces in the direction of gravity, the design is quite strict.

The FEM analysis for the bracket is available on the CD

Final scanner

Satellite lamp

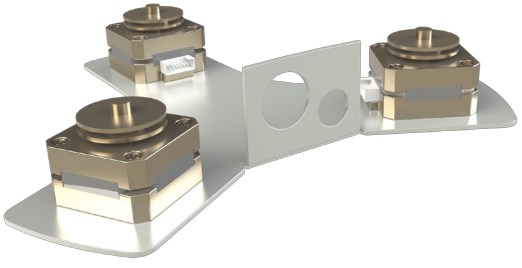
_Detailing the satellite lamp

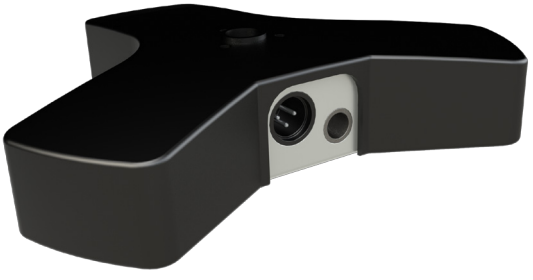
In order to pan and tilt the light as well as adding effects from a gobo a satellite lamp is designed in the concept of elephant trunk as chosen from the concept phase. The concept relies on pulling wires representing muscles in the elephant trunk. In order to make the concept flex in 360 degree pattern a minimum of three wires is required and is hence the starting point for the detailing of the satellite lamp.

The base structure for this satellite lamp is illustrated below

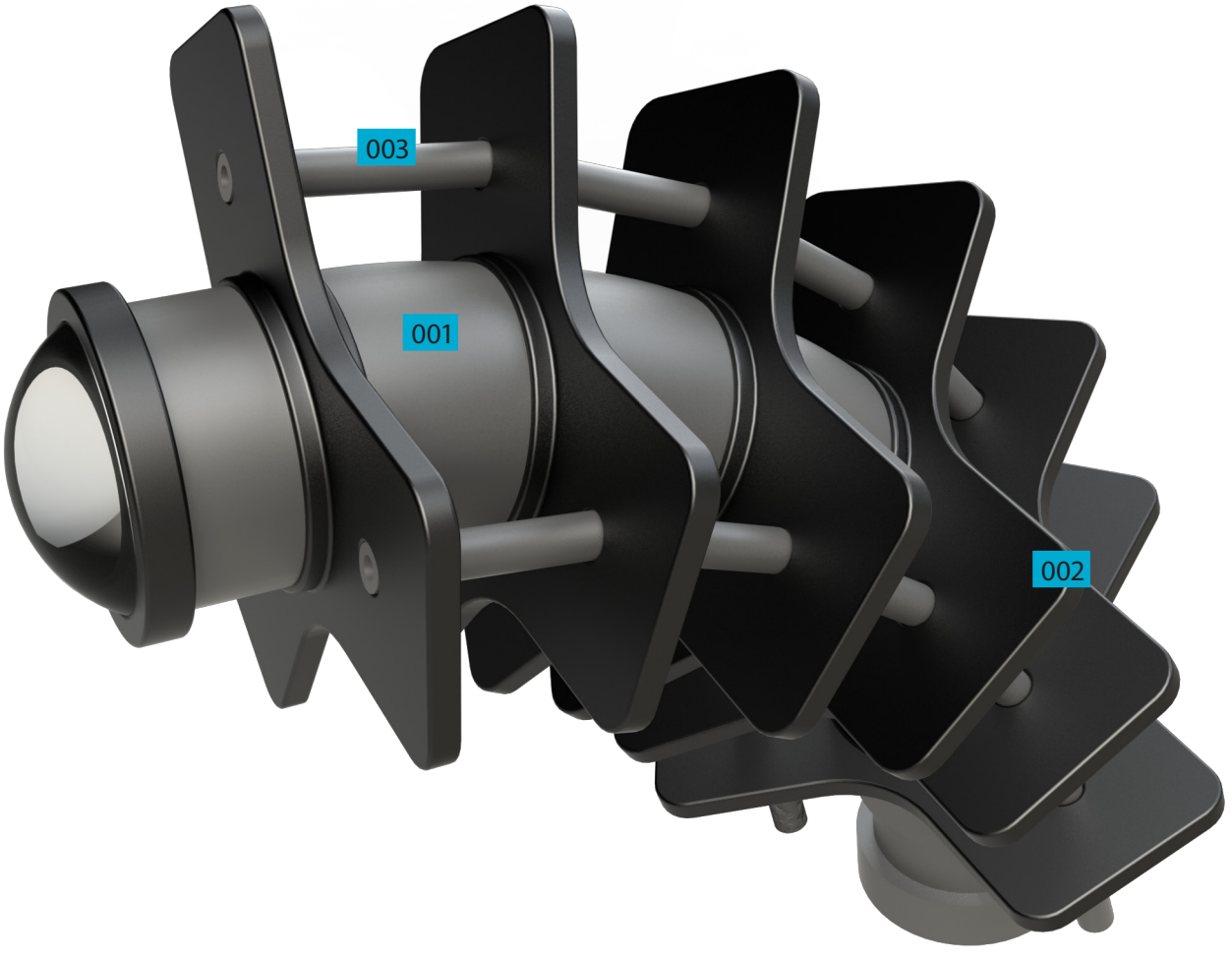
The three engines are installed on a base of sheet metal. The sheet metal is bended to create a wall for the connection. By cutting out two holes allows installation of connections.

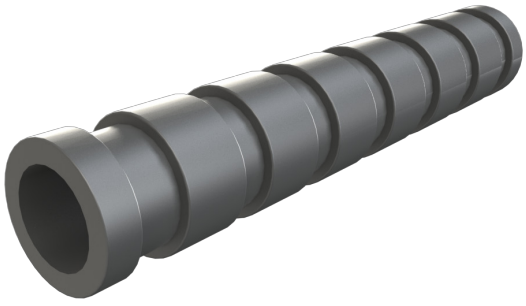
The bottom plate, the motors and connections creates the base for designing the plastic lid as illustrated.





Flexing details





_001 Rubber tube

The core of this flexing device is the rubber core containing the optical fiber. The rubber has grooves in it for mounting the spacers and mounting it in the plastic shell.

_002 Washers

The washers provide stability and control to the rubber tube. The washers also controls the direction of pull from the wires

_003 Rubber and wires

When pulled the wire creates contraction in the pulled direction creating the flexing movement desired. In order to limit the contraction as well as spare the wire from wear and tear.

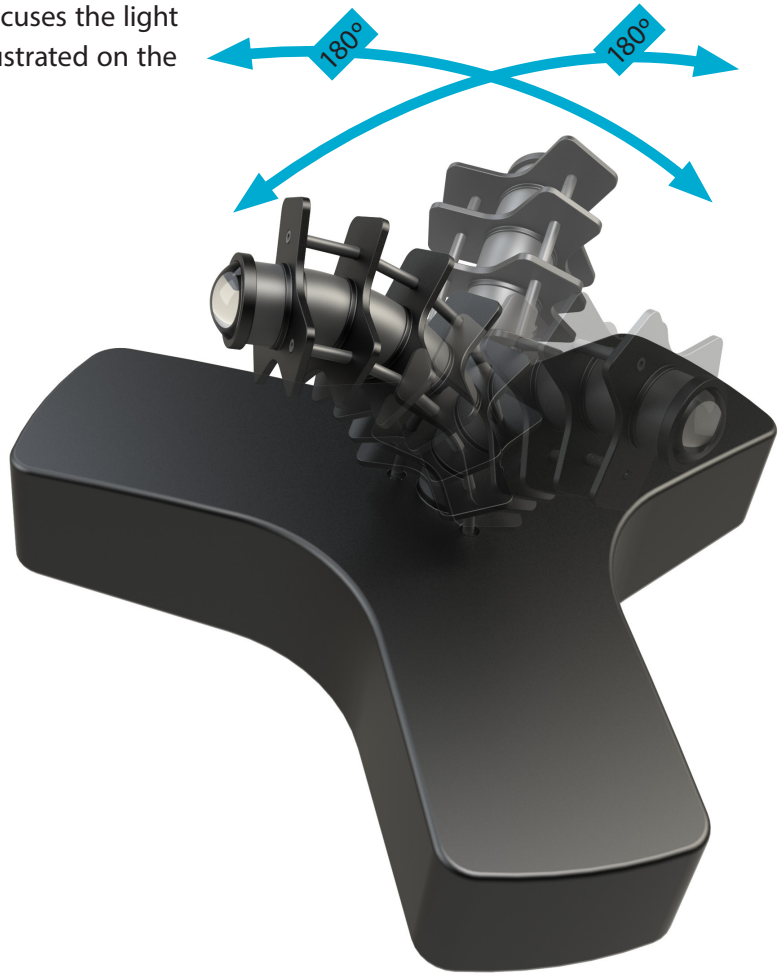
Flexing

_Flexing

When pulling or releasing the wire the optical fiber flexes allowing for an area of operation of 180° times 180°

_Light focus

The lens at the end of the tube refocuses the light before going through the gobo (illustrated on the next page)



Gobo effects

Choice of material

_Creating in plastic

When molding in plastic there is a lot of considerations to keep in mind in and it can thus be very difficult to choose the right material. Plastic comes in many forms and they have different technical specifications and sometimes trade-offs are made to increase certain specification like hardness. When hardness is increased the plastic material tends to get brittle, make the plastic weak in terms of fractures.

In order to choose the best material an initial research is conducted. The research is based on the plastics general use as described in *"En Verden af plast"* [En Verden af plast, 1999]. From these findings three plastic materials was chosen for further research. The plastic materials are PA6, ABS and PA due to their tensile strength as well as their use in electronics in general. The scheme below shows the criteria for choosing plastic and their ability to full these criteria. The ability to fulfill these criteria is defined as +1, 0 and -1. [holm-holm.dk, 2012]

_Concept scoring		
_ABS	_PC	_PA6

_Criteria	_Score	_Score	_Score
Impact strength	+1	+1	0
Hardness	+1	+1	+1
Surface resistance	0	-1	+1
Chemical resistance	+1	0	+1
Heat resistance	-1	+1	+1
Low water absorption	+1	+1	0
Static electrical resistance	+1	+1	+1
_Total	4	4	5

Approved

Manufacturing

_Methods

There are many different methods available when molding plastic parts like extrusion, co-injection molding and injection molding being some of the often used methods. Extrusion is a useful method when the plastic time has a profile shape and is thus only useful for creating simple shapes. Extrusion molding is hence rejected as a production method.
Co-injection molding is a method us for create plastic items with different plastic materials in on part. For instance when creating a wall with a core in a different and stronger material. The tooling for such molding is expensive and the combination of materials in one plastic body has no purpose in molding the proposed shapes and is hence rejected.
Injection molding uses only on type of plastic at a time, and can be used to create very complex shapes which is desired. The production when using injection molding can be automated and has a low cycle time which is desirable.

_Considerations

There are many aspects to keep in mind when using injection molding. The most noticeable aspects are draft angles, wall thickness as well as radii at corners and will be explained below.
Draft angles are important when opening the tool after finishing a plastic item since the plastic is injected into for form at high pressure creating vacuum at cavities. This vacuum can be avoided with draft angles. A rule of thumb is a minimum draft angle at 1*
Wall thickness is to be considered as well. If the wall thickness is created probably, a lot of material can be spared. Also an optimized and thinner wall will decrease the cooling time saving both time and money.
Corner radii are important since it can be difficult to pressing plastic into sharp corners due to limited flow at sharp edges. This can be avoided by proper use of fillets.

Discussion

Conclusion

Reflection - process

Reflection - product

Figure 045 - Optical fibers

Conclusion

_The process

During the project, different competencies have been obtained or improved. Mostly the competencies from previous semesters have been improved due to the high focus on every competence since tasks could not be outsourced to other group members.

Organizing and prioritizing was the competencies that required most attention due to the limited time available but was proper managed with the use of the time schedule conducted in the program.

Of new competencies business cooperation was most noticeable. Though business cooperation with Ergonomic Solutions was part of the 8th semester the collaboration was in a close cooperation due to highly defined terms as well as pre-defined demands and wishes in terms of functionality, production and materials.

During the cooperation with Martin Professional part of the task was managing meetings and gaining requested and required information from the contact person at Martin Professional, Henrik Sørensen, whose time schedule could conflict with the timing of the project forcing changes along the way. Other businesses, like Roblon, Frederikshavn, have been involved in this project. The situation was similar. This could have been limited if the request was more persistent, which could possibly have added more knowledge to the initial phases and hence a more solid foundation for the further development.

An important improvement, in terms of business cooperation compared to 8th semester was the essence of managing initial ideas and statement provided by Martin Professional with wishes and demands gained from interested parties such as club owners and technicians and creating a product that would suit all parties best possible.

The user interviews conducted revealed some incongruence between demand for cheaper prices and the demand for easy service and installations as well as the wish for moving heads because their functionality. This reflects the business findings regarding Martin Professional claiming that it would conflict with the DNA of martin professional whether to devaluate the standard in order to compete on prices or compete on functionality.

In terms of material choices, production and design a better cooperation with Martin Professional could have forced the project in a more business minded direction and created some boundaries in terms of cost prices and the like. This would have led to a project proposal being more fit for the market but was not obtained due to limited communication with Martin Professional. The importance of proper communication was proved to be very important.

_The product

In terms of creating a new scanner it was chosen to create a product with improved functionality instead of creating a product as cheap as possible. The key objective was hence to improve a scanner in terms of enhanced flexibility in order to add more

value to the product thus creating a product with improved sales basis for Martin Professional as well as creating a product category pulling the scanner towards the moving head but still has some of the qualities from the scanner.

The functionality of the scanner was improved and solved primarily with the optical fiber, but also the use of RGB LED added value to the product.

One of the primary value measurements of a standard scanner is the output measured in lumens. The extensive use of lenses as well as light loss in the optical fibers lovers the output compared to existing products as a compromise for the extended flexibility. This might indicate that the project proposal might not be ready for the market as of today, but probably will due to the extensive research on LEDs and optical fibers in other industries. The product proposal might hence obtain output improvements in near future making it more fit for the market.

As proclaimed above some qualities from existing scanners was found which have been used some extend explaining the similarities in terms of design and outer expression but also the construction of some internal components have certain similarities with the product proposal.

Throughout this project a key issue was how to create a product that was simple to produce in terms of BOM in order to fulfill a wish set by Martin Professional regarding a product for the midrange market but at the same time was true to some of the values of Martin Professional.

One of the issues was the wish for better maintenance in scanners witch was directly implied by the user interview. In the product proposal this was obtained using simple measures like creating a large lid for better access during maintenance and service.

Since the Martin MX-1 had very easy access to internal component due to the use of large plastic lid it was chosen to follow this and hence the use plastic. The use of plastic might increase the production price compared to the use sheet metal and extruded profiles but was considered a necessary move in order to obtain the lid as describes as well as higher esthetics. Due to the use of plastic molding was considered during the entire shell design.

Reflection - Process

_Reflection

This final part of this report will reflect on the various issues during the design process as well as the final product. The reflection will as well consider how the further development of the product proposal can be done and what issues there might lay.

_The process

In order to manage the process of this project it was controlled using Gantt chart, daily agendas and sometimes to-do lists were conducted to manage tasks. These time managing tools was helpful through the project since it help keep the project on track

In the beginning of the process a lot of considerations were put in researching the use of LED and their possibilities as well as a lot of research in optical fibers due to having limited knowledge in these two fields. The extensive research conducted on these two technologies as well as other technologies consumed extensive amount of time which distorted the time management extensively. This forced the project through the design phase at high pace which is clearly visible in the process report. In order to optimize the remaining time is was hence decided to let simple design proposals conducted follow the internal shape as much as possible, in order to give the design some guidelines.

The design of product proposal could thus have been better and designed smarter if more time have gone into the design phase of the project.

In order to have better managed the research time, are more detailed Gantt chart could have been use full. By splitting the research phase up into smaller part equal to the amount of things to research a better control could have been obtained. Also a plan specifying what was needed and how to obtain this knowledge could have focused and shortened the research.

_Market

In order to evaluate the statement provided by Martin Professional a market evaluation was conducted. The market evaluation covered market potentials, user, owners as well as the possible sales potion for Martin Professional.

The market scanning was conducted in Aalborg solely, as described in the analysis sum up, a different image could have emerged if a wider market have been analyzed. Furthermore could a user interview with every own have provided valuable information to the reason for the dynamic lighting setup.

The S.W.O.T, Blue oceans and Porter's five analyses all pointed in the direction of differentiation which somehow conflicted with idea of creating a cheaper product. It was chosen to follow the concept of differentiation. The output would have been very different if focus was more on prices.

_Technologies

In terms of creating a product in cooperation with a company it is necessary to understand the market

they possess and are trying to reach. In that connection much of the research was focused mainly on light relevant technologies which left out the possibilities for researching on themes like sheet metals, grips and hands or how to dust-prof the scanner. In terms of presenting for Martin Professional do objection were made in terms of theses choices.

_Working with a company

During this process Martin Professional was primarily used for their knowledge hence providing valuable knowledge during the project. Their expectations and ideas were outlined in the beginning of the project but cooperation agreement and design agreement was never conducted leaving the project as an open task.

Since the project was an open task there were no obligations in terms of presentations, status and the like. This was managed along the way, some times before or after certain deadlines in the Gantt chart making it difficult to manage. By creating a cooperation or project agreement deadlines could have been control point for the Gantt chart which would have led to a better experience both parts

Reflection - Product

_Reflection

In terms of product evaluation and reflection it is always possible to add more details to the product, conduct more tests, and create prototypes with the objective to test and prove the realization of the product. In relation hereto time is always an issue and the detailing must hence stop at some point in order finalize the project

From the value mission and the design parameters like functionality, performance and values were some of the keywords stated. The goal was to create a scanner with a higher area of operation in order to pull the scanner towards the moving head. This was achieved using optical fibers that are highly flexible in terms of length and also flexible in terms of bending. The introduction of optical fibers lowered the performance when it comes to output in lumens which was a necessary trade off to achieve the goal.

With the introduction of optical fibers as well as large plastic parts increases the bill of materials. The product thus have to be sold to a wide verity of markets in order to make it more profitable compared to a strip down version of a scanner, where gross profit is in focus.
The question is thus whether the product will only fit the market for night clubs and bowling alleys or it will have the necessary functionality to fit part of the professional markets. In order to achieve a product feasible to both market aspects it is probably necessary to reevaluate the use of plastic in order to lower the bill of materials thus making the product more feasible for club owners to whom price is the primary criterion when buy dynamic lighting. It would also be required to conduct extensive testing RGB LED in order to severely increase the output of the product which increases the feasibility of both market aspects.

_Further development

From the beginning of the project and throughout the process plastic has been a highly considered material due to design freedom compared to the existing use of sheet metals and extruded profiles. The further development of this product could thus be the use of extruded profiles and sheet metal in connection with cheap laboring in production countries e.g. China or the like as a tool for minimizing the production costs making the product more profitable.

The level of detailing to the lamp was higher than the level of detailing on the satellite lamp. More attention to the satellite lamp could have given the product proposal a more unified expression making it stand together as a packaged solution compared to the expression of two individual products as illustrated in the product report.

In terms of the satellite lamp, more detailing to the entire mechanical part might have yield for a

different expression. No calculation was conducted on the flexibility and maximum bending per washer which might increase the amount of joint in the flexing neck. Also the amount of torque in the 3 motor in the product proposal might be either smaller or greater than the standard motors used in product proposal. The size of the motor was used to dimension the satellite lamp. All in all recalibration and calculation on the satellite lamp will eventually dictate a much different expression compared to the proposed product.

List of referen

Sources

Illustrations

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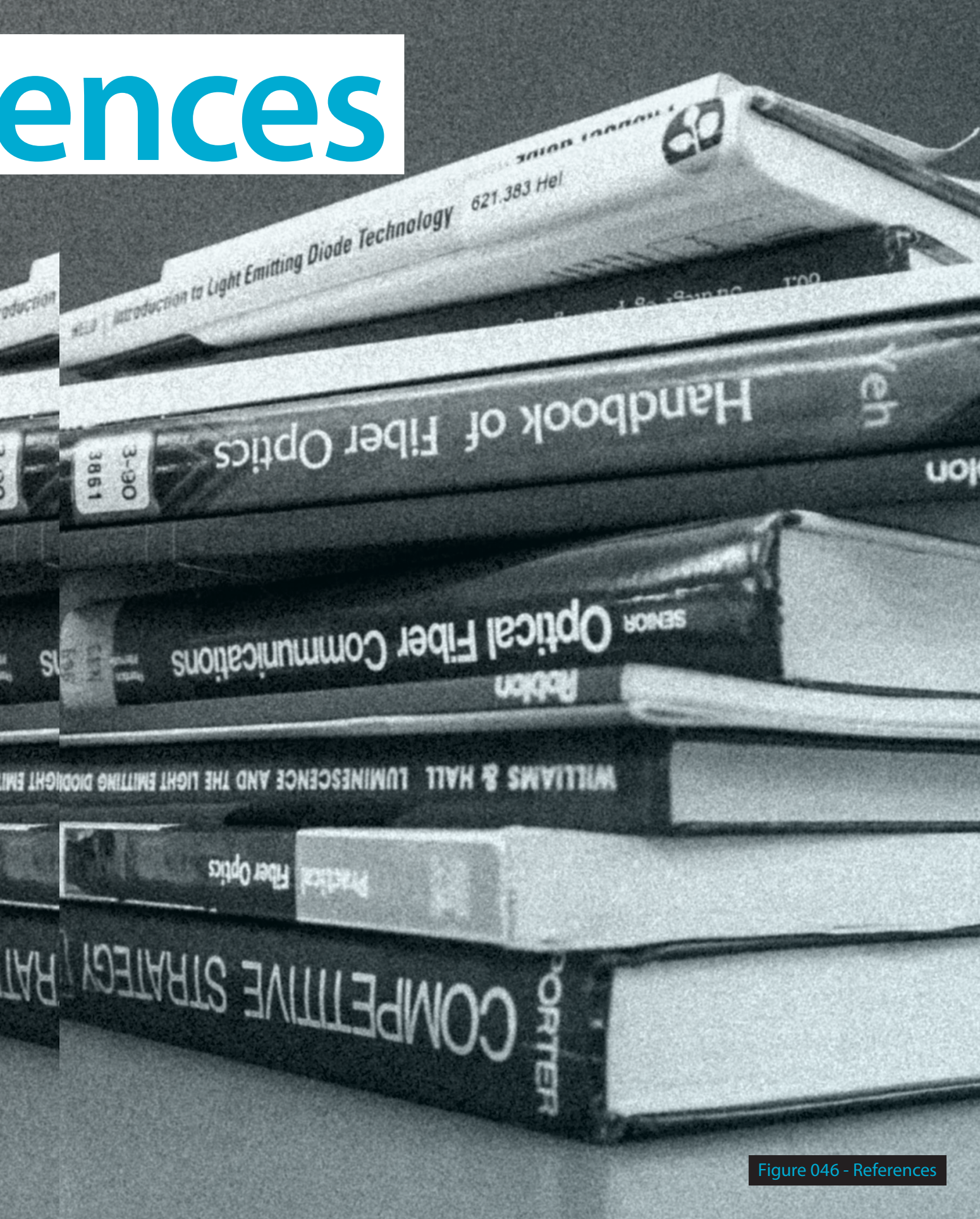

Figure 046 - References

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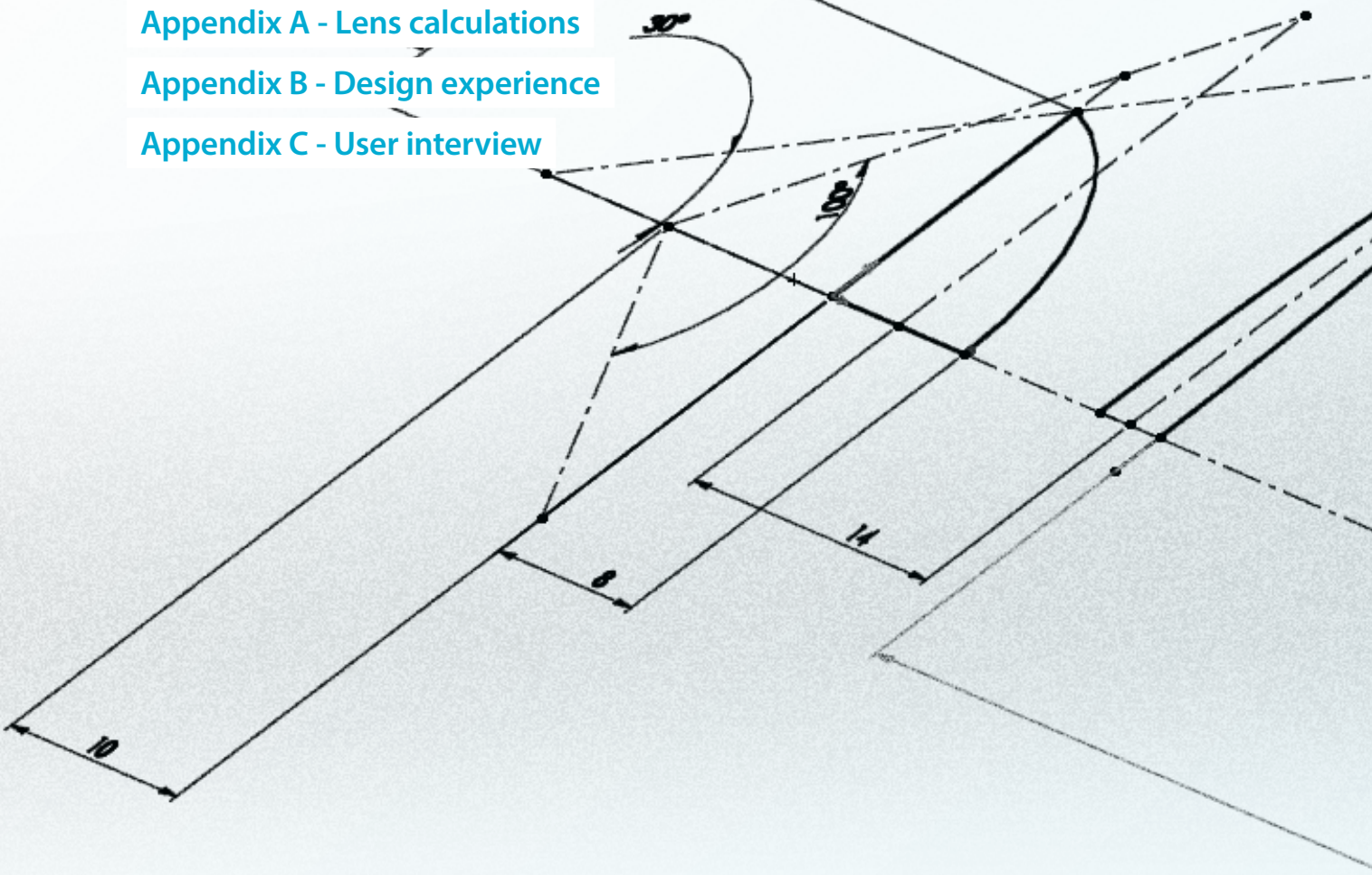
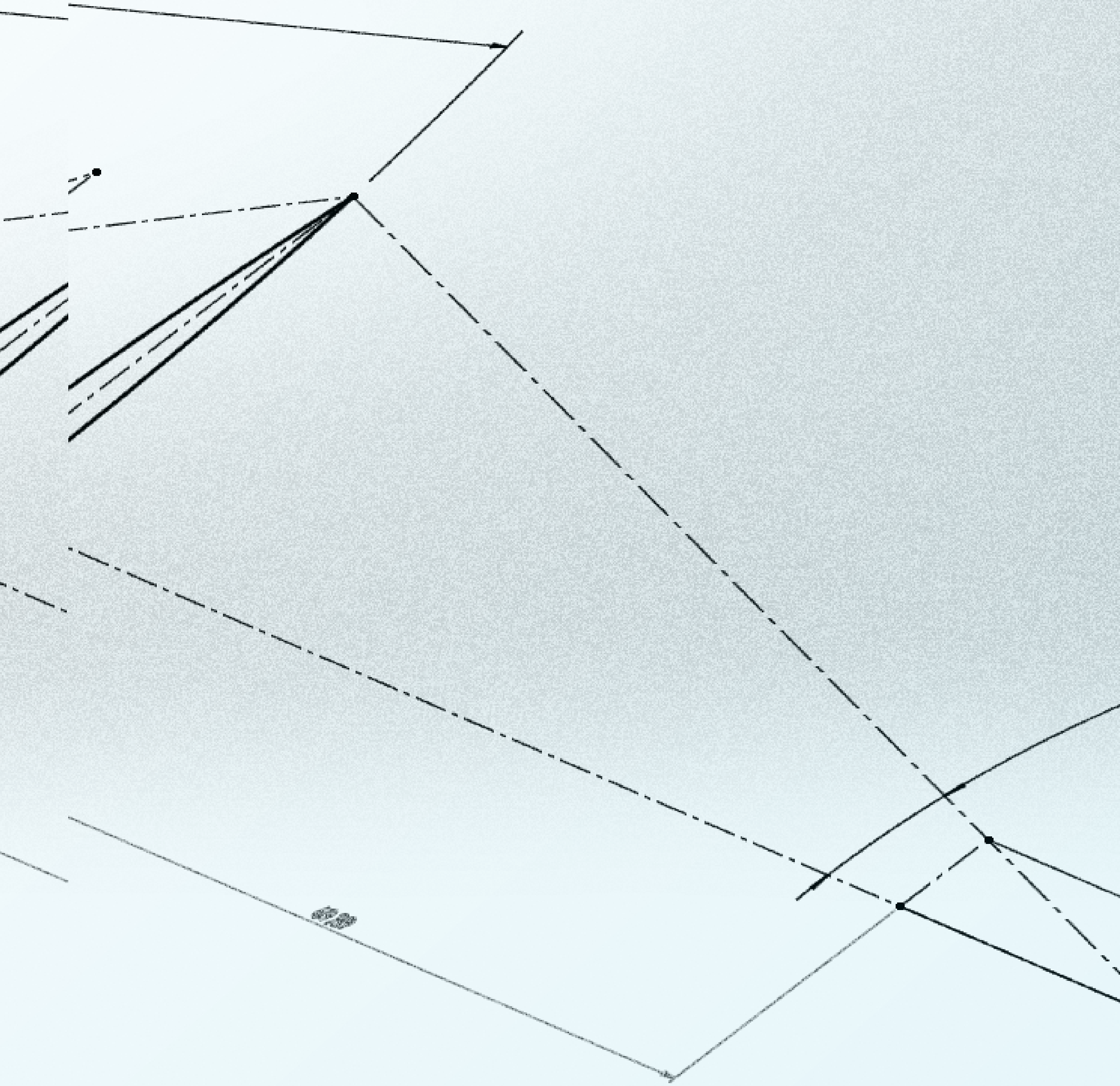
Figures

Figure not listed here are own photos

Appendix





Appendix A
Lens calculation

_Collimating lens calculations

On the Dragon Scan the first lens was a focus lens and this lens will be the base for the further calculations. The lens a was plano convex lens placed 10 mm distance from the LED light and has the following measures

$R_{focuslens} = 13mm$ $d_{focuslens} = 8mm$ $D_{focuslens} = 20mm$

Where R is the radius of curvature and d is the thickness of the lens and D is the circumference. Since the focal point is measured from the center of the lens thickness the focal point must hence be

$$f_{focuslens} = dist_{LED} + \frac{d}{2} = 10mm + 4mm = 14mm$$

From the Dragon Scan the following measures have been determined and will be transferred to this project and the further lens calculations.
The focus lens narrowed down the light cone from 110° to 60° as illustrated on #figure 021#.

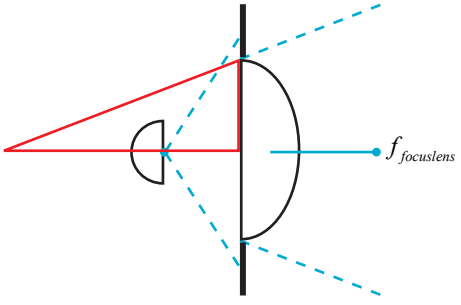
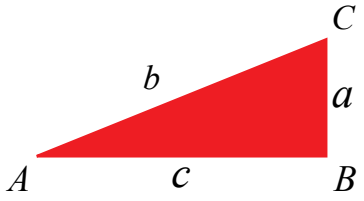


Figure 047 - Focal point



A is known to be half of 60° which is equal to 30° and c is half the diameter of the lens which is equal to 10mm Based on trigonometry the following calculations made

$$c = \frac{10mm}{\tan(30°)} = 17,32$$

The focal point of the collimating list can thus be calculated to be

$$f_{collimating} = 17,32mm + 8mm + 10mm = 35,32mm$$

The lens maker's equation is calculated using the following equation

$$\frac{1}{f} = (n-1)(\frac{1}{R_1} - \frac{1}{R_2} + \frac{(n-1)d}{nR_1R_2})$$

Where f is the focal point, n is the refraction index of the lens and R is the radii of curvature of the lens. In the equation the lens thickness can be excluded due to is small size small size in the equation

$$\frac{1}{f} \approx (n-1)(\frac{1}{R_1} - \frac{1}{R_2})$$

In this calculation the size of both radii is set to be equal

$$R_1 = -R_2$$

this gives us the final equation of

$$\frac{1}{f} = (n-1)\left(\frac{1}{R_1} + \frac{1}{R_1}\right) = (n-1)\frac{2}{R_1}$$

The refraction index of glass is 2,5

$$\frac{1}{35,32} = (2,5-1)\frac{2}{R_1} = \frac{3}{R_1}$$

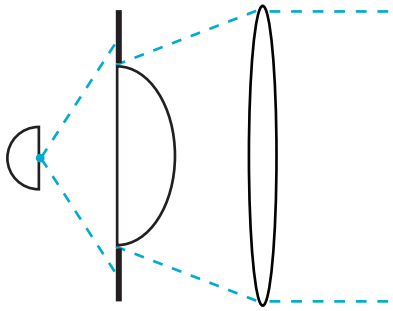
$$\Updownarrow$$

$$\frac{1}{35,32} = \frac{3}{R_1}$$

$$\Updownarrow$$

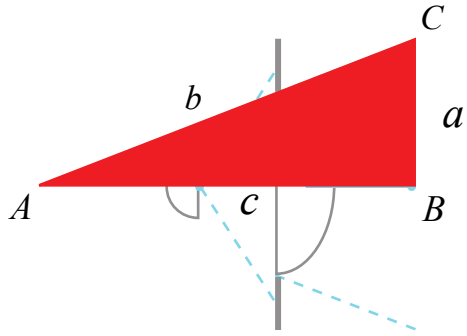
$$R_1 = 3 \cdot 35,32 = 105,96$$

The lens is illustrated below



_Diameter

The minimum diameter is calculated using the following information. A is still equal to 30 and the c is the focal point calculated to be 35,32mm



The diameter can is equal to

$$D = 2 \cdot a$$

and can be calculated as

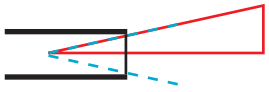
$$a = \tan(A) \cdot c = \tan(30°) \cdot 35,32 = 20,39mm$$

the minimum diameter is

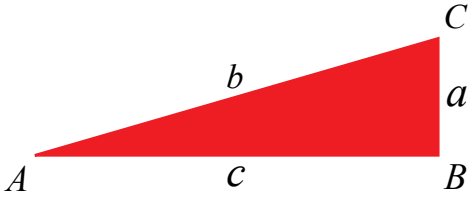
$$D = 2 \cdot 20,39mm = 40,78mm$$

_Optical fiber lens

In order to transfer as much light into the optical fiber as possible the light needs to be narrowed down to fit the cone of acceptance. The cone of acceptance is known to be 25°



The angle A is equal to half the acceptance cone, hence 12,5. From calculations on the collimating lens a was determined to be 22,38mm



The distance c can be calculated using trigonometry and is equal to the focal point of the optical fiber lens.

$$c = \frac{20,39}{\tan(12,5°)} = 91mm$$

$$\frac{1}{f} = (n-1)\frac{2}{R_1}$$

$$\Updownarrow$$

$$\frac{1}{91} = (2,5-1)\frac{2}{R_1}$$

$$\Updownarrow$$

$$\frac{1}{91} = \frac{3}{R_1}$$

$$\Updownarrow$$

$$91 = \frac{R_1}{3}$$

$$\Updownarrow$$

$$R_1 = 91 \cdot 3 = 273$$

The minimum lens diameter is the same as the collimating lens.

Appendix B
Design experience

Claus Hansen

Subject:	Møde med Lasse Q Nielsen - AUC
Location:	Gæstekantine 1
Start:	ma 05-03-2012 10:00
End:	ma 05-03-2012 11:30
Recurrence:	(none)
Meeting Status:	Accepted
Organizer:	Henrik Sørensen
Required Attendees:	Claus Hansen; Lasse Qvistgaard Nielsen (lqni07@student.aau.dk)

- Spejlets dimension er bestemt af lyskeglens diameter + afstanden fra frontlinsen + pan/tilt parametrenes yderpositioner. Jo større spejl, jo langsommere bevægelse, hvilket er scannerens eksistens berettigelse!
- Design udtrykket udfordres ofte ved at lyskegle skal have max. bevægelsesområde, men ved at "åbne op" i for stort et område, så kommer spejlet til at virke for udsat for mange brugere.
- Scanneren skal kunne rulles rundt uden at spejlet kan knække.
- Spejl skal være let-udskifteligt (f.eks MX-10)
- Jo større tilt vinkel, jo smallere skal scanner kroppen være for ikke at skære i lyset = mindre plads til interne effekter.
- Undervurdér ikke bære-metoden af scanneren – transporten fra papkassen til applikationen, 1 person op ad stiger og lignende. Håndtag eller lignende indbyggede funktioner er at foretrække. Ellers løfter kunden i hvad han finder passende!
- Nem adgang til rengøring af blæser.
- Nem adgang til rengøring af linser, farveglas og goboer.
- Alle mekaniske stop bør have gummi for at lyddæmpe reset.
- Hvis gummifødder eller lign. overvejes, så skal det sikres at de ikke kan ryge af ved at trække produktet sidelæns (f.eks fra bagerst på hylde).
- Undgå generelt gummi materiale, som efterlader sort footprint på linolium og andet.
- Sørg altid for at placere netbrønd og data stik i nærheden af ophængningsbøjle.
- Sørg altid for at netkabel og data stik ikke "klippes" i bøjlens bevægelsesområde.
- Sørg altid for at lave hul til korrekt størrelse sikkerhedswire.
- Ophængningspunktet **SKAL** være i balance og håndtag skal være lette at stramme og HOLDE positionen. Cruiseships installationer ryster og scannere hænger ofte med "hovedet" efter kort tid. Overvej optional permanent vinkelindstilling til faste installationer.
- Optimale design vil tilgodese at når produktets rygrad hænger f.eks tæt mod væg eller loft, så kan håndtag eller bolt hoved stadig spændes.
- Sørg altid for at optimere installationsmulighederne – i riggen, på gulvet, på væggen, indbygning osv, mens strøm og signal kabler ikke generer.
- Sørg altid for at blæser ikke forstyrrer / over-trigger printets mikrofon.
- Standardisering / modularisering foretrækkes så vidt muligt.

Appendix C
User interviews

Hvor søger du primært inspiration til produktkøb?

køber altid scannere pga pris og effekt

Hvad kigger du bestemt efter og hvorfor?

prisen er den væsentligste faktor
LED, rengøring pga støv og tæt fra røg. Låget = bedre adgang til vedligeholdelse

Er der nogle trends for tiden, som du forsøger at følge?

LED

Rangere disse efter vigtighed

1 - Pris
2 - Funktioner
4 - Levetid
3 - Kvalitet
5 - Garanti/service
6 - Andre ting?

Moving heads pga effekten og arbejds område, men køber ikke pga prisen.

Hvad er den maksimale pris du vil give for et produkt. Hvilke kriterier ligger til grund for dette?

Det kommer meget an på stk, men FutureScan = 3000

Har du ønsker til ændringer til eksisterende udbud af produkter?

Forskellige farver ind sort
Billiger udendørs belysning

Hvad er dit forhold til scannere?

Det er mit hovedprodukt

Pris?

Prisen er grunden til at det ikke er moving head

Kvalitet?

Kvaliteten på future scan er ringe og i nogen tilfælde

Vedligeholdelse?

6-8 skruer. Det kunne være nemmere

Output?

kunne godt være bedre

Funktionalitet?

Funktionen er ok. Det er primært

Installation?

for lys på gulvet så gobo'en er underordnet

brug og smid væk

egentlig ikke altid får gjort rent

Der var ikke noget brok under installation

Hvad skulle der til før du købte en Martin scanner fremfor en af konkurrenternes?

pris på max 10-15% mere. Alt over 20% og bakker ud.

Billigere moving head kunne have interesse

Hvilke produkter plejer du at installere? (Her tænkes typer og ikke mærker)

Moving Head , scanner , samt Led belysning

Hvilke produkttyper fortrækker du at installere (evt hvorfor) og hvilke er mindst at fortrække? (evt hvofor)

Led Belysning: hurtigst og den bedste avance.. ☺

Hvilke produkttyper fortrækker du at servicere (evt hvorfor) og hvilke er mindst at servicere? (evt hvofor)

Moving Head: mest service venlig

Kina Produkter : disse produkter er lavet til Køb og smid væk

Hvilke mærker arbejder primært med og hvilket er dit foretrukne? (begrund gerne hvorfor netop dette mærke er at fortrække)

Martin : lavet med omtanke og til at yde service på

Hvilke typer af steder installere du produkter?

Konferensen Center , messe center , cafe , samt diskoteker

Hvilke problemer oplever du med produkter, som du udfører services på? (her tænkes fx manglende vedligeholdelse, træng plads ved service, dårlige komponenter og lignende)

Det hyppigste problem er støv…. Samt at folk ikke opdager fejl… og at dette forsager

Flere problemer

Hvilke problemer oplever du når du installere et nyt produkt? (Her tænkes fx pladsmangle, dårlig håndtering af produkterog lignende)

Hvis produktet er for billigt…. Kan beslag være noget lort ☺

Installere du ofte scannere? Hvem er den typiske kunde?

Ja.. for loft højden på de danske diskoteker…. Er typisk 3m

Hvilke fordele og ulemper oplever du primært ved scannere?

- Installation? Nem at montere
- Brug? Billig i pære
- Vedligeholdse? Skal bare blæses og spejl tørres af
- Service? For det meste skal der bare nyt spejl
- Andre? Billig i anskaffelse

Andre bemærkninger?