FOGSCREEN A NEW GENERATION OF DISPLAY

by Niyan Omer

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ABSTRACT

The technology of immaterial projection systems are in constant development and will be more applicable on the market in the future. Therefore, there is a need for color management to improve the image reproduction on these displays, as they are more complex to manage than normal fixed screens. The FogScreen® projection screen produces a thin curtain of "dry" fog that serves as a translucent projection screen, displaying images floating in the air.
This thesis aims to optimize the viewing experience by considering the technical aspect as well as the application aspect in order to reach reliable results, as they both have equal impact on the viewing experience. The technical approach is the characterization of the device in terms of color management and profile generation. Based on the device's characteristics, we are able to determine how the image projection can be optimized under given viewing conditions and installation settings. Furthermore, the application aspect is approached by designing innovative concepts for Norwegian companies. The concepts include consideration of location, the screen's functionality and purpose, media content management and business innovation.

Tittel	Fogscreen – En ny skjermgenerasjon
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Veiledere	Peter Nussbaum, Førsteamanuensis, PhD, Høgskolen i Gjøvik Jean-Baptiste Thomas, Førsteamanuensis, PhD
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SAMMENDRAG

Den teknologiske utviklingen innenfor immaterielle og transparente skjermer har ført til at implementering av den type skjermteknologi blir mer vanlig å se på markedet. På grunn av skjermenes karakteristikk som gjennomsiktighet og immaterielle overflate, blir fargestyringen mer komplekst ettersom det nå er flere faktorer å ta hensyn til enn vanlige skjermteknologier. Fogscreen er en projeksjonsteknologi som generer et tynt lag med ”tørr” tåke som legger til rette for å vise bildemateriale som “flyter” i luften. I denne avhandlingen forsøkes det å optimalisere seeropplevelsen ved å betrakte det tekniske aspektet, så vel som anvendelsesområdet for produktet. Ettersom det tekniske aspektet og anvendelsesområdet påvirker seeropplevelsen på en Fogscreen på samme nivå, er det særdeles viktig å vurdere begge aspektene likeverdige for å oppnå presise resultater. I den tekniske tilnærmelsen av fargemåling og fargestyring blir skjermen karakterisert og tilegnet utstyrsprofil. Basert på utstyrets karakteristikk og egenskaper kan vi fastslå metoder for å optimalisere bildegjengivelsen under gitte lysforhold og innstillinger. Anvendelsesperspektivet tilnærmet ved innovativ konseptutvikling for implementering av Fogscreen for norske bedrifter. Dette inkluderer vurdering av lokasjon, omgivelse, tiltenkt funksjonalitet og formål, håndtering av medieinnhold og forretningsmessige gevinster ved denne innovative implementeringen.

FOGSCREEN- A NEW GENERATION OF DISPLAY

BACHELOR THESIS

by NiYAN OMER

May 15th 2013

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During this project I have learned so much more than I expected, and it would not have been possible without the help and support from these people:

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Vitensenteret Innlandet in Gjøvik, represented by Petra Skoglund, has given me access to the Fogscreen-device and given me the opportunity to test it for hours; this thesis would not have been the same without this opportunity, and your contribution really helped me improve my project, thank you so much!
Some other names that should be mentioned: Costas Boletsis, Martine Stensrud Finholdt and Kennet Fredstie (Norwegian Opera House), thank you all for your contributions.
Lastly, I would like to especially thank my employer ColorLab, represented by Marius Pedersen, for the collaboration on this project.

Gjøvik, May 15th 2013

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Chapter 1
INTRODUCTION

1. INTRODUCTION

This chapter provides an introduction to the structure of the thesis and the delimitations that is made. Furthermore, a brief presentation of the employer and the supervisors is included in this chapter.

1.1 CHOICE OF TOPIC

The topic of this thesis was chosen based on a combination of my academic background as a Mediamanagement student, and a personal interest in color management and modern display systems. I find it very interesting to know the future within projection systems, and based on this curiosity I have chosen Fogscreen which is highly applicable at the moment as one of the few products in the market within the category of immaterial projection screens. Moreover, the research work of this thesis is approached from a technical aspect that I find interesting to learn more about, in combination with my professional skills in business, media and innovation that I have gained throughout the educational period at Gjøvik University College (GUC). Being the first person to write an academic paper about this product at GUC, perhaps even the first in the country, has been an excellent motivation factor. Since the Fogscreen is an exclusive product, my personal goal is to be one of the few people in Norway who is specialized in managing both technical and media content for this type of display. This kind of expertise will be a door opener for job opportunities in the future.

Besides my personal interest in the topic, there is a need for examination of the Fogscreen from the color reproduction and color management perspective. As such types of screen technologies rise and become more commonly use, the need for color management is needed in order to use the device properly. Immaterial, transparent, screens are much more complex to manage than regular fixed screens, hence the dedication to work in this particular research area.

1.2 DELIMITATIONS OF PROJECT

There are both benefits and downsides choosing a topic that is not well known for the majority of people. The benefit is that no one has done it before and therefore it is a more interesting research area. The downside is the lack of data that is needed, thus the pursuit of reliable information is at some degree more challenging to obtain than other well-known topics within projection systems.

1.2.1 DELIMITATION OF RESEARCH AREA

Fogscreen is a new topic at GUC, and there are so many elements and aspects to examine. However, some priorities must be made due to limited research time. As a Mediamanagement student, the thesis is intentionally approached from two major perspectives that suits by educational background; a sufficient technical aspect, in addition another aspect that focuses on application possibilities which includes media content management, business, and innovation. Due to my limited technical expertise, a set of selected elements of the Fogscreen is chosen to study in this thesis. The present study provides other students to follow up my research and continue the examination of the product at an advanced technical level for additional contribution in this field.

This thesis is mainly based on my previous course, Digital Image Reproduction and Color Management from the second year of the bachelor program for Mediamanagement at GUC. For that reason the outline is mostly based on the syllabus from this course, while the remaining parts are from subjects such as marketing, business innovation, and creative work methods.

1.2.2 ACCESS TO FOGSCREEN

From day one the most crucial point in this project has been to access the device in order to conduct and collect information about the unit. Because the product is very exclusive, only a few exists in Norway, whereas only one unit is installed permanently. Thus the master plan was to conduct the examination of the device in Finland at the manufacturer. To everyone's big surprise, we found out that an actual Fogscreen was installed at the Science Center (Vitensenteret Innlandet) in Gjøvik. The most critical element in this project turned out to be the easiest.

1.2.3 TIME SCHEDULE

The determination of the project started already in November 2012, though the official start was in January 2013. The Gantt-table shows the structure and requirement of the process from start to finish. Furthermore, the project was structured into five phases with some overlapping activities. Naturally, some deviation occurred during the process. For instance, phase 2 – measurements- took two weeks more than estimated, which led phase 3 – application possibilities - to be shortened with the same amount of time. Otherwise the process went smoothly and followed the main structure of the Gantt-table.

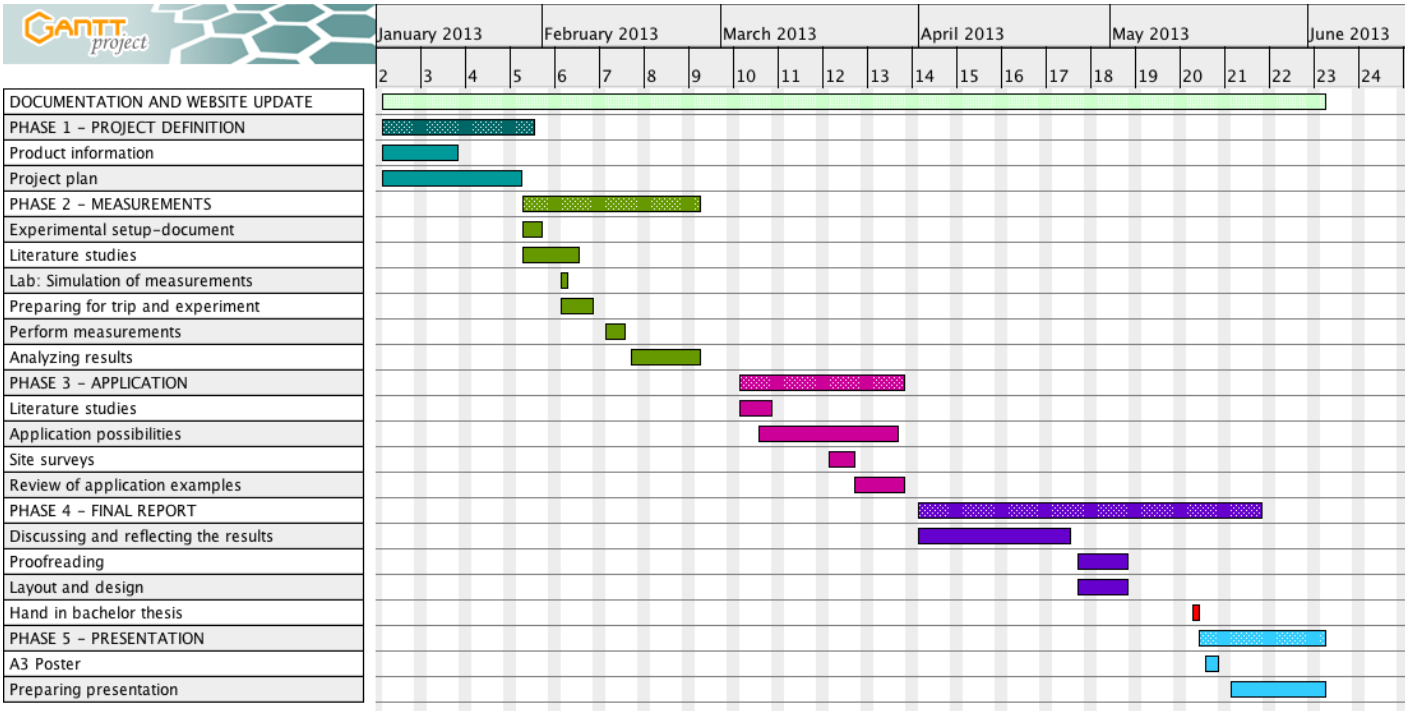

Figure 1.1 Gantt-table

1.3 THESIS STRUCTURE

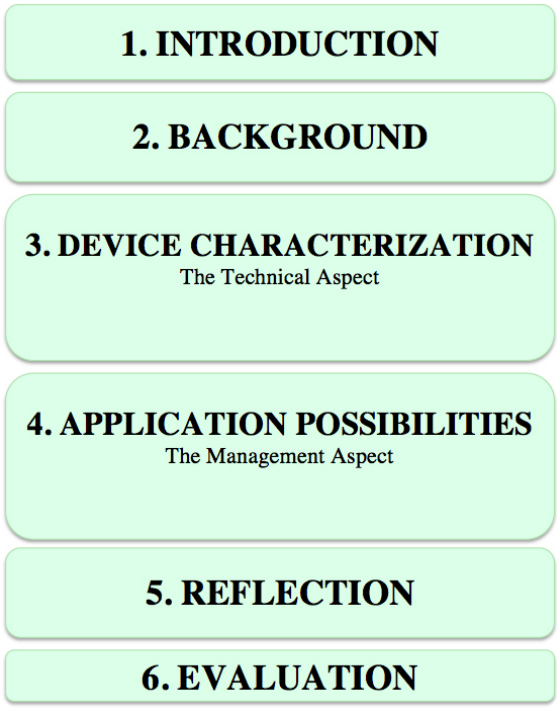

Figure 1.2 Overview of thesis outline

The thesis is divided into six chapters, whereas chapter 3 & 4 represent the main part and are emphasized equally. Chapter 1 – Introduction - serves the purpose of addressing primary information about the project's research area. In chapter 2 – Background – state of the art within new display technologies are presented and a brief introduction of the Fogscreen is given. Furthermore, chapter 3 –Device characterization – dig deeper into the technical aspect in the pursuit of characterizing the device's ability for color reproduction. Intentionally, this thesis emphasizes equally on the technical aspect and the application aspect in order to gain reliable data to answer the research question.
Chapter 4 – Application Possibilities – construct real-life examples of potential Fogscreen application for three selected Norwegian companies. The technical properties of the unit are taken into account while including other perspectives such as content management, business innovation, marketing, and creative application examples. In chapter 5 – Reflection – vital elements from previous chapters are brought up for further reflection and are processed with the conclusion of the research question in mind. Chapter 6 – Evaluation – evaluate the project work and determines the achievements of the thesis.

1.4 EMPLOYER AND COLLOBORATORS

1.4.1 THE NORWEGIAN COLOUR AND VISUAL COMPUTING LABORATORY

The official employer of this project is The Norwegian Colour and Visual Computing Laboratory facilitated at Gjøvik University College. The Norwegian Color Research Laboratory is a research group within the Faculty of Computer Science and Media Technology at Gjøvik University College. It was founded in the spring of 2001 to serve the rising needs for colour management solutions in the graphic arts industry. Since its foundation, the scope of interest has grown to cover colour science, colour imaging, and image processing in a broader sense, and their vision is to be one of the best research groups in this field (colorlab 2010).
Because this project is the first to me conducted within this type of display, the research work will build a solid foundation to further examination of similar units. Thus the project is very interesting for both parties.

1.4.2 FOGIO OY

Other collaborator for this project is the Finnish company named Fogio Oy.
Fogio is the only official manufacturer of FogScreen® projection screens. The original inventors of the technology and a team of business people and technicians run the company. Fogio own multiple patents on the product and also the trademark for FogScreen walk through magic® (Fogio 2012).
We contacted Fogio Oy in November 2012 to get information about the device and present the aim of this project. Since then, we have had frequent contact and received feedback on our suggestions for examination of the device. The ideal outcome of this project for the manufacturer would be ideas for new research approach concerning the color management perspective.

1.5 SUPERVISORS

The supervisors will help and contribute to this thesis with their expertise in the fields of color imaging, projection technology, and media management and innovation.

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Chapter 2
BACKGROUND

2. BACKGROUND

State of the art within projection technologies is presented to provide an overview of the new non-fixed display trend. Furthermore, the need for awareness of color reproduction on non-fixed displays is discussed. The purpose of this chapter is to introduce the Fogscreen technology and the background for such device before defining the research question.

2.1 STATE OF THE ART – NEW DISPLAY TREND

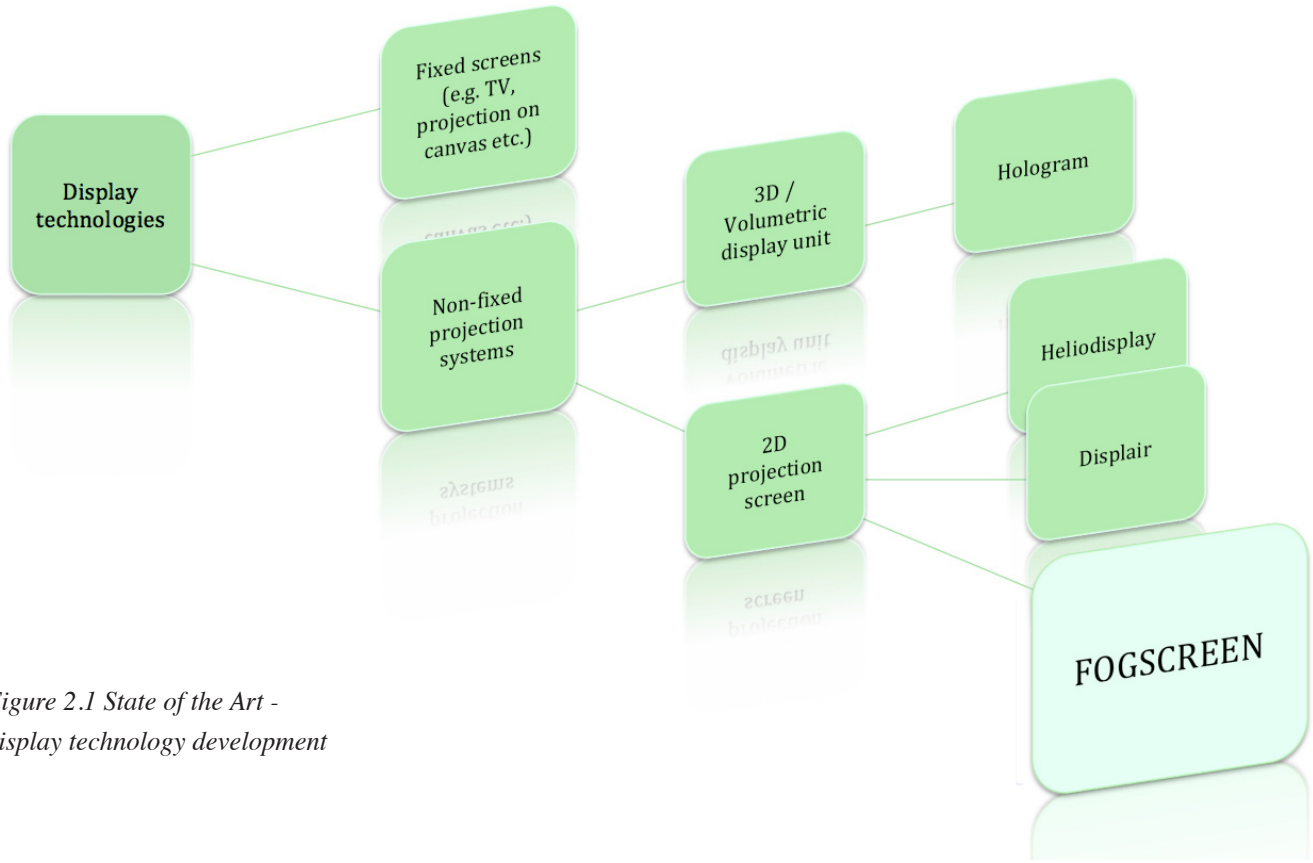


Figure 2.1 State of the Art - display technology development

As seen in figure 2.1, non-fixed screen technology is in constant development. Furthermore, the immaterial display systems are divided into 3-dimensional and 2-dimensional display technologies. Typical 3-dimensional (volumetric) display units are Hologram. This thesis focuses on the 2-dimensional screen technologies, such as Heliodisplay, Displair, and Fogscreen. The common drive for this trend in the market is to implement displays that are transparent, immaterial, and interactive "touch"-screens. These properties increase the application possibilities, which will lead to increased revenue for the consumer.

This trend is especially interesting when viewed from a commercialized perspective. Such display units demands for immediate attention, in addition also serve the purpose of functioning as an effective channel for information distribution whether its advertisement or informative communication. The rising trend of implementing immaterial screens is highly interesting from a business innovation point of view. Powerful visual effect, attention grabbers, and the immediate attraction of people-flow are vital properties in a commercialized market. And managing these assets will eventually lead to increased revenue.

2.2 AWARENESS OF COLOR REPRODUCTION FOR NON-FIXED DISPLAYS

Imagine this scenario: you have a picture on your laptop that you would like to print. In an ideal situation, the image you see on your laptop and the reproduction image printed on a piece of paper would be exactly the same. Well, that is not possible. Each device has a limited amount of colors they can produce. In this case, a printer is only capable of reproducing a certain amount of colors, which is usually less than a digital monitor. So why is color management important? The main purpose of color management is to achieve the best possible match between original image and the reproduction. Different technologies, processes, and physical device characteristics etc. sets a limit to how good a reproduction can be. By applying color management, the image reproduction may be more accurate and match the original image on a higher level.
The pursuit of complete match between the original image from input (laptop) and reproduction on a Fogscreen is impossible to obtain. The monitor (laptop) and the display (Fogscreen) employ differing imaging technologies and for that reason they have different color capabilities. However, by knowing the device's characteristics, an optimised reproduction can be achieved, though it never matches the original image one hundred percent.
A device's characterization is like a humans personality. Image reproduction will be more accurate if the device's personal characteristics are known to us. If we know the Fogscreen characteristics, we are more likely to have a more accurate reproduction, even though the range of colors is significantly poorer than a computer monitor.

When it comes to a product such as the Fogscreen, the intention of color management still remains; aiming for accurate image reproduction between input and output. The challenges with color management suddenly become more complex when it comes to screens that are transparent and immaterial. Usually the most significant issue regarding image reproduction is the gamut limit within the device. But with a translucent and immaterial screen, additional challenges appear. Factors such as ambient light, objects behind the screen, air flow in the room, temperature, and installation set-up are additional issues that must be managed when using a Fogscreen. These factors will directly affect the image reproduction and how the human eye will experience the final result. Thus image reproduction on such a device becomes more complex unlike a LCD display for instance. The most important factor is the viewing condition one perceives the contents in. That factor goes for all types of substrate. Managing the viewing conditions for this type of display requires even more considerations, as the complexity grows.

2.3 PRODUCT INFORMATION

In the following sections general information about the Fogscreen is presented in pupose of gaining knowledge about the technology the device operates with. Information about the three different product models, installation set-up and typical application sites are introduced.

Figure 2.2 Fogscreen at Avon Event by SCREENRENTAL, s.r.o.

2.3.1 FOGSCREEN TECHNOLOGY

Fogscreen is a patented display-technology based on projection of pictures and videos in mid air. The Fogscreen projection screen produces a thin curtain of “dry” fog that serves as a translucent projection screen, displaying images floating in the air. This allows people to walk through the screen without damaging the screen, or being exposed to any chemicals. By using ultrasonic technology, the water is vaporised to fog, and several fans “pushes” the fog downwards. As seen in Figure 2.3, the fog is sandwiched between two laminar air curtains, making the surface less turbulent by resisting wind pressure in most indoor conditions. The Fogscreen works well in almost all types of installation settings, however it is meant for indoor use only. The crucial factor to obtain best possible image quality requires low ambient light, or a stronger projector to compensate in brighter light conditions. This factor is deliberated in details in upcoming chapters.

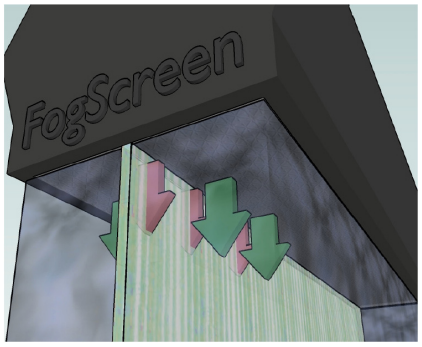


Figure 2.3 Layers of air and fog

Water is the only ingredient to make this device work. Pure water is filled in the tank, or a water line is connected to the device in case of permanent installation. The water consumption depends on the size of the screen. A 2.2 meter wide eMotion model consumes 6-10 liters per hour. Thus water line connection is recommended for permanent installation.

2.3.2 PRODUCT MODELS

At present time, Fogio Oy offers three different Fogscreen models that serve all type of installation purposes; eZ, eMotion, and Pro.

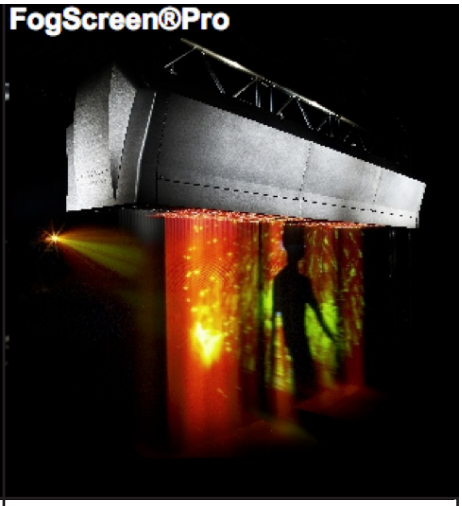
FogScreen®eZ	FogScreen®eMotion	FogScreen®Pro
		
Fogscreen **eZ** is a compact plug-and-play screen that is applicable for smaller installation solutions. Projection surface: 80 cm wide	Fogscreen **eMotion** is also a compact plug-and-play model, and might be more suitable for bigger installations. Projection surface: 2.2 m wide	Fogscreeen **Pro** is a linkable one-meter-wide screen, which allows larger set-ups. This model perform in more challenging environments and withstands frequent road use.

Figure 2.4 Fogscreen models eZ, eMotion, and Pro. Screenshots from fogscreen.com/products

2.3.3 INSTALLATION GUIDE

Fogscreen is a rear-projection screen, which means the particles of water are not very reflective (only about 5%to 10% bounce back(FogioOy 2004), but they transmit light forward very well – creating the illusion of a floating images in the mid air. A projector with suitable lumen is needed to display the images. There are no particular brands of projector that work best on Fogscreen, however, brighter light condition in the room claim for a stronger projector, this is discussed in chapter 4.

Positioning: The projector is normally mounted above the Fogscreen projection screen and angled downwards to avoid creating a bright hotspot on the viewer's eyes. In most installations, the screen is mounted so the bottom of the generator is about 2.2 m above the ground. In this case the projector is normally about 3 – 3.5 m back from the screen and 3 m in the air. The projector is angled downwards and keystone correction is used to fix the resulting trapezoidal image. The distance can be shortened to less than 2 m by using a wide-angle lens (FogioOy 2004).

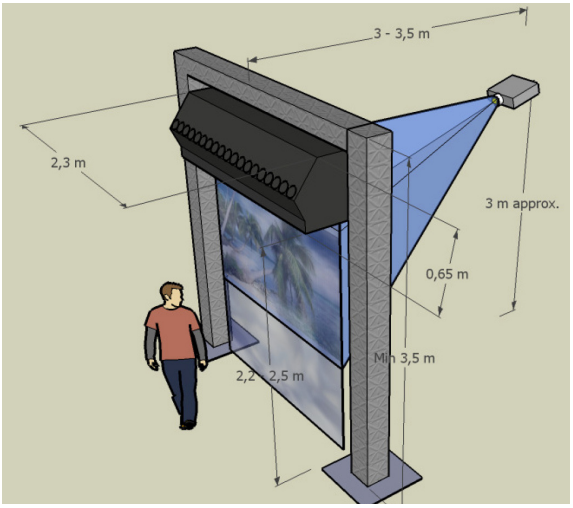


Figure 2.5 Installation set-up (FogioOy 2004)

2.3.4 TYPICAL APPLICATION SITES

This kind of display gives endless application possibilities as it can be used for commercialized approaches to an audience, as an information board or for entertainment purposes.
The typical application sites for a permanent installation would be:

- Amusement parks
- Nightclubs
- Museums
- Science Centres
- Hotels and casinos
- Scenographical effect on stage

Permanent installation is not always suitable, in which case temporary rental set-up is a good alternative. These temporary installations are typically event-based set-ups as:

- Product launch
- Fashion shows
- Concerts
- Exhibitions
- Other types of events

Fogscreen is an exclusive product and has been used by some of the world's most well-known brands such as: Mercedes, Coca Cola, Absolut, Adidas, Cirque de Soleil, Nokia, and Pepsi just to name a few.

Figure 2.6 Examples of application - Photo: Absolute Vodka event by Skyreklam and Mercedes event by Fogtech

2.3.5 FOGSCREEN IN NORWAY

Besides the Fogscreen-device installed at the Science Centre in Gjøvik, there is only one other permanent installation in Norway. The Norwegian Cruise Line, Epic Vessel has a Fogscreen installed at Bliss nightclub. Other than permanent installation, Fogscreen can be temporary installed for events. Conventor AS, based in Stavanger and Oslo, is the official Norwegian rental company for such device.

2.4 RESEARCH QUESTION

By knowing the background of the device including advantages and limitations, and the constant need for color management as these types of screens becomes more applicable, it is time to review the research question.

Research question:
How can we optimize the viewing experience when both technology and application are considered?

The first approach to this question is to perform a general review of the device, which has been presented in previous sections in this chapter.

Definition of terminology
For the purpose of this document the definition of terminology is used as follow.

The technology aspect consists of examining the device's characteristics.
Characterization refers to defining the device's ability for color reproduction. The amount of colors it can produce is given by a numeric volume, which is also known as a device's color gamut. A color gamut is defined as the range of colors a device can produce (Sharma 2004, p. 30)

Application
The term application means how and where the Fogscreen is used.
Application in this thesis refers to the environmental setting at installation spot, the purpose, and the function of the Fogscreen. Light conditions are one of the most significant factors in the term application.

Viewer experience
For a non-fixed screen, image quality would be a common term. In this case, the Fogscreen adds more attributes to the actual experience, that the term viewing experience is much more suitable. Image quality is a complex term consisting of several attributes that defines quality.
Viewing experience covers the total human experience of the Fogscreen; perception of images, walking through the screen, and interaction with the content. Viewing experience is dominated by the subjective perception and experience of the display.

Optimization
Optimizing the viewing experience based on technology and application means how the subjective perception of image projection and the experience can be improved from a given standard setting. The term refers to how we can adjust and facilitate the technical calibration of the device, and the conditions in the room to achieve a better image projection.

Delimitation of research area
Due to limited resources, the research area is narrowed down to focus on two important aspects of the device; a sufficient technology perspective and an application perspective to reveal the product's potential in the Norwegian market. The intention was to combine these to very important aspects equally, as they both affect each other. A full technical review is not useful if realistic application possibilities are not taken into account, and the other way around.

Chapter 3
DEVICE CHARACTERIZATION

3. INTRODUCTION

In order to answer the research question the technical aspect must be approached by characterizing the device. A measurement experiment is set up to characterize and determine the screens performance. The experiment is divided into an objective color measurement and a subjective image evaluation for the purpose of including all factors in the overall evaluation. Furthermore, this chapter presents the theory, methodology, the experiment set-up, results and analysis.

3.1 THEORY – COLOR FUNDAMENTALS

This thesis will in the following section present basic theory about color fundamental which includes human perception, color attributes, device characteristics, calibration, characterization, conversion, monitor profile, and device gamut.

3.1.1 HUMAN PERCEPTION

Understanding the principle of color perception and the human observer is one of the most essential perspectives in color management. Put in a few words, color management is about understanding how we perceive color imaging in order to control and predict colors.

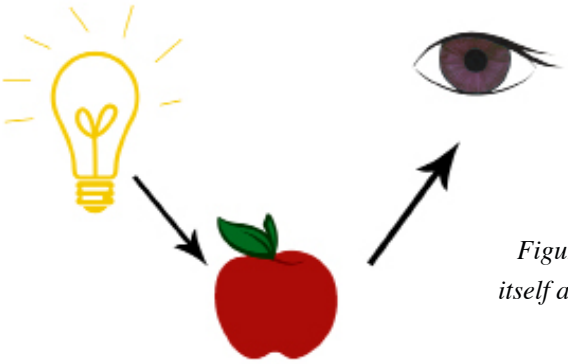


Figure 3.1 Perception of colors by light source, the object itself and the human observer. Ilustrated after Figure 2-1 in (Sharma 2004, p. 50)

The principle of color appearance is simple; there are three things that affect the color on an object (Sharma 2004, p.50). First is the light source, like natural source as daylight or artificial as different types of lamps. And there is the object itself that reflect some parts of the incident light and absorbs the other parts of the illumination. The imprinted color of the object, in this case the red apple, appears as a result of the transmitted and the reflected parts of the incident light source. Then the eyes perceive this data and the brain interpreters the color as “red”.

Viewing condition is one of the most vital factors to consider in the field of color management. The term viewing condition refers to the illumination state a color/sample is viewed in. In previous section we acknowledged that colors are perceived by three things; the light source, the object itself, and the human observer. The incident illumination can be retrieved from natural sources such as daylight, or from artificial sources. It is important to be aware of what type of light source that is used, as different light sources operate with different color temperatures. When the color temperature of the light source is known to us, we can adjust the white balance to obtain accurate color appearance.

The measurement experiment presented later in this chapter uses three different viewing conditions to determine how they affect the image projection. The viewing conditions are adjusted to normal/full light, low light, and no light.

3.1.2 COLOR ATTRIBUTES

There are three attributes of color: hue, saturation, and lightnes (Sharma 2004, p.77). Figure 3.2 shows the relation between hue(H), saturation(S) and lightness(L). The vertical axis is corresponding to the lightness that goes from black towards white. In between the top and the bottom of the axis, is a scope of grey shades. In the center of the sphere are the desaturated, neutral colors. But moving from the center and outward are the saturated, pure colors. And lastly, by moving around the circumference of the sphere the color changes its hue. For example starting with blue and moving to the right of the circumference will change the color to green, or yellow by moving even further around the loop.

Figure 3.2 Color Attributes - Hue, Saturation, and Lightness. Image retrieved from (Bunting 1998)

3.1.3 COLOR MANAGEMENT – THE THREE Cs

The essential concern with color imaging is that each device has different characteristics for how they behave and perform in terms of color reproduction. For that reason color management is needed to pursue accurate color reproduction considering the fact that each device has its own limits. Abhay Sharma describe color management in terms of The Three Cs; calibration, characterization and conversion (Sharma 2004, p. 34)

Calibration

Calibration means establishing a fixed, repeatable condition for a device based on certain parameters for that particular device. For a monitor it is typically adjusting contrast, brightness, and gamma (white point). On a Foscreen-device, calibrating consists of adjusting parameters for light condition, projector luminance, fog density and fog flow. After calibration, the device's characteristics and behaviour are studied in a process known as *characterization*.

Characterization

In terms of color management, characterization refers to the process of generating a device profile that contains information about the device's typical response and behaviour to reproduce colors. The study of a device's behaviour consists of sending a set of reasonable color patches to the device and record its response. The response is then stored in the device's *profile* that contains information about the device's characteristic, behaviour, and gamut. To record the device's response, a *spectrophotometer* is used with its corresponding software to store the data.

Spectrophotometer is a measurement instrument used for measuring the color patches displayed on the Fogscreen and the white canvas for reference data. The spectrophotometer measures the sample and reports the transmittance back to the software on the computer. Spectrum is the most complete description of a color, and it can be used to calculate all other metrics, such as XYZ and LAB (Sharma 2004, p.111), even though for this purpose XYZ/LAB are enough to generate a profile. Usually the spectrophotometer measures the center of a sample. However, due to the lack of uniformity on the Fogscreen, a *diffuser* was placed in front of the head in order to capture the average transmittance from the whole surface area of the color patch.

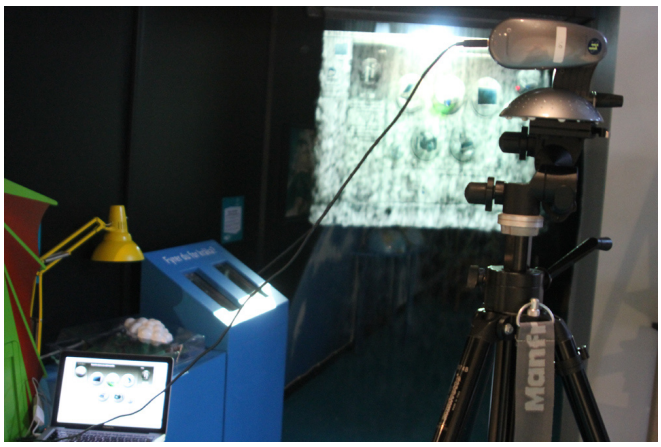


Figure 3.3 Eye One Pro Spectrophotometer connected to laptop for the characterization process. Photo: Niyan Omer

Conversion

Finally, conversion is a process where images are converted from one color space to another.
Conversion is also known as *rendering intent* or *gamut mapping*, a strategy used by color management system to deal with the differences between device gamuts (Bunting 1998).

3.1.4 MONITOR PROFILE

As already mentioned, a device profile contains data representing color reproduction characteristics and response of a device. A screen profile contains CIELAB values that are needed to define the color gamut of the device.

3.1.5 DEVICE GAMUT

A device gamut is the range of colors that a device is able to produce, and is defined as a part of the profiling process. Every device has different *gamut* and their limited ability to reproduce colors are one of the fundamental issues in color management.

ICC3D

Former students at GUC developed the software ICC3D. In this thesis ICC3D is used to visualize the color gamuts that is presented later in this chapter. The first step to generate the visualization of the color gamuts is to create a text document consisting of the RGB input data in addition to CIELAB and XYZ data taken from the profile. The text document is then brought up in ICC3D and visualized as color gamuts. There are two methods for gamut visualization: Convex Hull and Segment Maxima. For this purpose, Convex Hull was used. The ICC3D then calculates the gamut volume, and the size is presented as numeric unit.

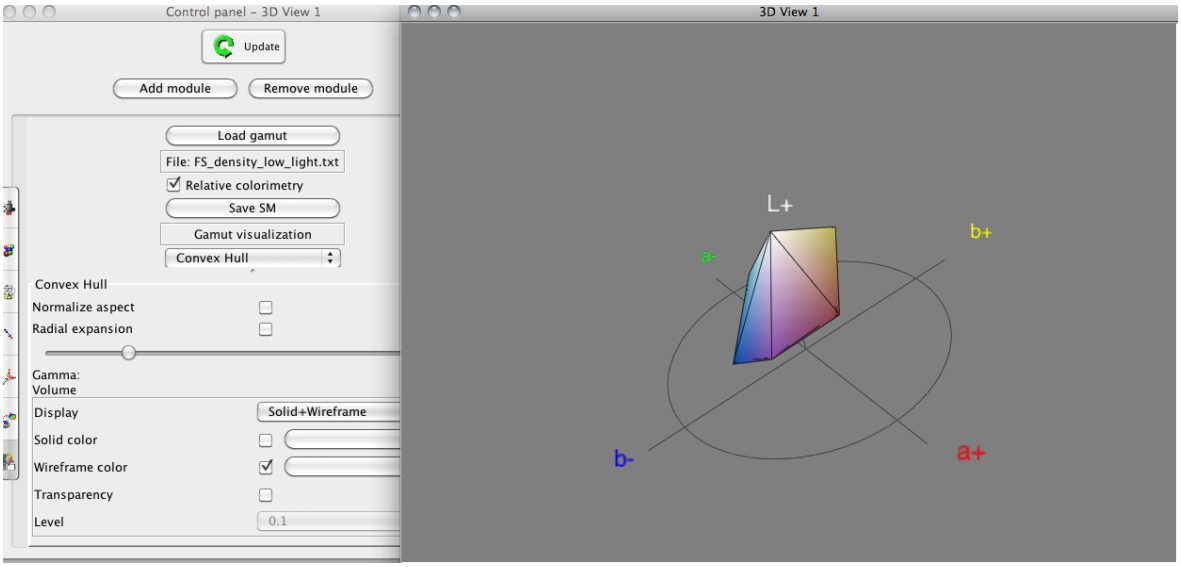


Figure 3.4
ICC3D- Screenshot from gamut visualization

3.2 METHODOLOGY

The method of approach for the technical part of the thesis consists of literature survey, experiment set-up and analysis of the results. The main purpose is to gain information about the device's characteristic for image reproduction.

Literature survey

Literature and information from the product manual is studied in advance of the experiment to gain as much information as possible about the device and the technology it operates with. Due to a patented confidentiality principle, detailed information about the device is not available, which means we can only work with the data that is available at this moment.

Experiment set-up

The structure of the measurement experiment is defined to approach both an objective and a subjective evaluation. Preparation for the experiment consisted of a simulated trial at the Colorlab at GUC to test the software and insert correct input data. The final experiment was conducted 24th of February 2013 at the Science Center in Gjøvik.

Analysis and discussion

The results from both objective and subjective measurements are analysed and discussed in the pursuit of revealing the setting that provides best possible image projection on a Fogscreen under different calibration settings.

3.3 EXPERIMENT SET-UP

The color measurement experiment and the subjective image assessment is an approach to determine the device's ability of image reproduction under different calibration settings. Certain software programs and hardware units are used to gain necessary data for the characterization process and the image assessment. An overview of equipment is presented in Figure 3.5.

Hardware	
Projector	Optoma EP780 DLP Image brightness: 4000 ANSI lumens
Spectrophotometer	Eye One Pro
SLR camera	Canon 1000D
Laptop	MacBook Pro
Reference screen	White canvas
Fogscreen Inia	Fogscreen 80cm wide
Software	
Eye One Match	Creating profiles
ColorSync	Reading profile information
Microsoft Excel	Organizing results (RGB – XYZ - LAB)
ICC3D	Visualizing color gamut

Figure 3.5 Equipment overview for the experiment.

Determining what properties of the Fogscreen to examine in the experiment has been challenging since everything about the device seemed to be interesting to learn about. However, in collaboration with my supervisors, a few aspects were chosen for this experiment. Due to the research question, the following factors are emphasized: examining the screen's ability to display colors under different light conditions, in addition approach the subjective perspective by evaluating complex images in comparison to reference. Hence it was decided to conduct the measurements in front of the Fogscreen under different light and device calibrations, and on a reflective canvas to obtain a reference to compare the data to later.

3.3.1 PROCEDURE

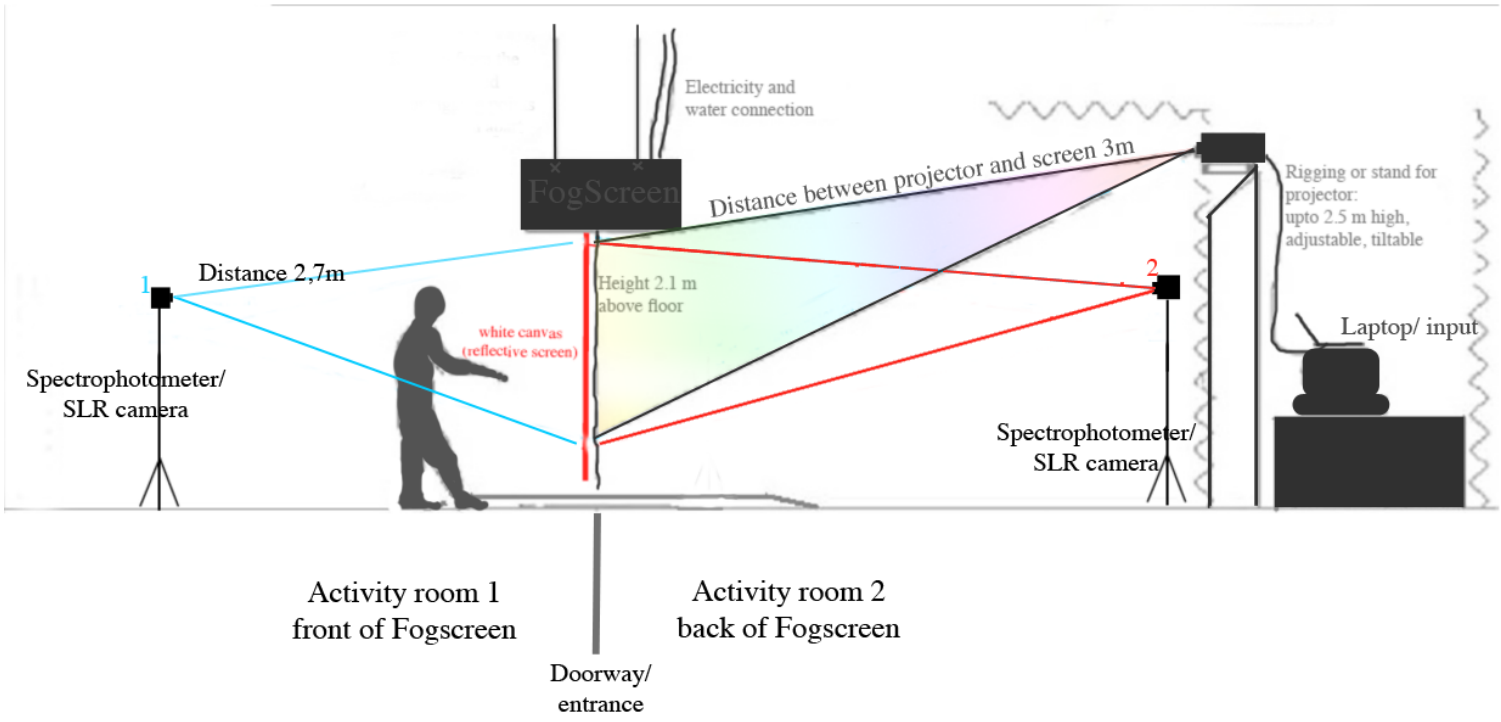


Figure 3.6 Experiment set-up for objective color measurements and subjective image evaluation. Illustrated after model from (PSCoRental 2004)

I Objective Color Measurement

Colour measuring instrument	Eye One Pro including ambient head	Procedure: 2 measurement tasks 1. Use the spectrophotometer and measure the displayed color patches in front of the Fogscreen. (Blue mark-up in Figure 3.6) 2. Proceed with the same measurements, now with a reflective screen. Because it's a reflective screen, the spectrophotometer has to be placed on the other side, under the projector. (Red mark-up) Calibration set up Parameter for: A. Environment (viewing conditions) - no-light condition - low-light condition - high-light condition B. FogScreen - increased fog flow - increased fog density The intention of the calibration is to see how these settings will affect the viewing experience.
Equipment setup	Standard installation	
Test graphic	36 colour patches: R: 0, 32, 64, 96, 128, 160, 192, 224, 255 G: 0, 32, 64, 96, 128, 160, 192, 224, 255 B: 0, 32, 64, 96, 128, 160, 192, 224, 255 Gray: 0, 32, 64, 96, 128, 160, 192, 224, 255 The color patches represent - Primary colors - White - Black - And color combinations	

II Subjective Image Evaluation

Measuring unit	SLR camera + visual assessment	Visualisation of complex images (test images) for subjective evaluation in comparison with the objective measurements. Procedure: Basically the same procedure as task 1, but now we are replacing the Eye One Pro spectrophotometer with SLR camera. The camera will then capture the test images from following positions: 1. In front of the fogscreen 2. In front of a normal reflective screen as reference (positioned below the projector).
Equipment setup	Standard installation	
Test graphic	Complex test images - Low contrasted image - Optimal image - People/facial area - Color vs. black/white image - Text	

III Measuring Deviation

The closest alternative to such projection set-up as a Fogscreen is a normal reflective canvas; therefore this reflective screen is used as reference data to evaluate the difference between such projection solutions. There is one significant issue due to the reference data; because of different technologies between a Fogscreen (rear-projection that transmit the light forward) and a reflective canvas (that reflect the light) an inaccuracy occurs because of different ambient light in the two different rooms. For the Fogscreen measurements, the spectrophotometer is located in front of the Fogscreen (activity room 1) while measuring the reflective canvas, the spectrophotometer is located underneath the projector (activity room 2). The problem is that the ambient light conditions are different in those two rooms. In room 1, the light condition is much brighter because of daylight coming in from the windows, whilst room 2 are sheltered from daylight. This factor was taken into account during the experiment, consequently the calibration for light conditions were adjusted to achieve approximately same variables for the three ambient calibrations.

3.4 RESULTS - OBJECTIVE COLOR MEASUREMENTS

The objective color measurements serve the purpose of providing data about the device's characteristics. There are several elements within a device characterization. However, for this thesis the device profiles are generated to find the gamut volume, which then will be used to indicate how the calibration settings affect the viewing experience of the images displayed on the Fogscreen. The color gamuts for the Fogscreen are compared to the reference data (reflective screen) as well as different illumination and Fogscreen's properties as fog density and fog flow. In this thesis, the optimization of viewing experience relies on factors that are adjustable for the user, such as light condition and device calibrations as fog density and fog flow. Based on that acknowledgement, the measurement results are analysed in a way that indicates which calibration setting that will provide the optimal viewing experience.

Definition of light calibration settings:

Normal-light: normal ambient light used on daily basis (except from the spotlights in front and behind the Fogscreen). The experiment location in room 1 was exposed to daylight from the windows.

Low-light: All spotlights in the room behind the screen were turned off.

No-light: All lights turned off. Only light source was from the windows in room 1.

Fogscreen calibration settings:

Fog density: this function allows you to increase the amount of fog produced.
The manufacturer has given clear guidelines for the standard amount of density. Still it will be interesting to see the impact on the viewing experience by increasing the fog density.

Fog flow: with this function you can change the speed of the fans that pushes the fog downwards. Increased fog flow will make the fog fall faster. There is also a guideline for this function. However, we are interested in the objective values the spectrophotometer will record.

3.4.1 RESULT OVERVIEW

The twelve calibration settings from the objective color measurements resulted in twelve ICC profiles. ICC3D was used to visualize the gamut volume for each profile. The numeric volume is shown in the blue mark-up for each calibration setting

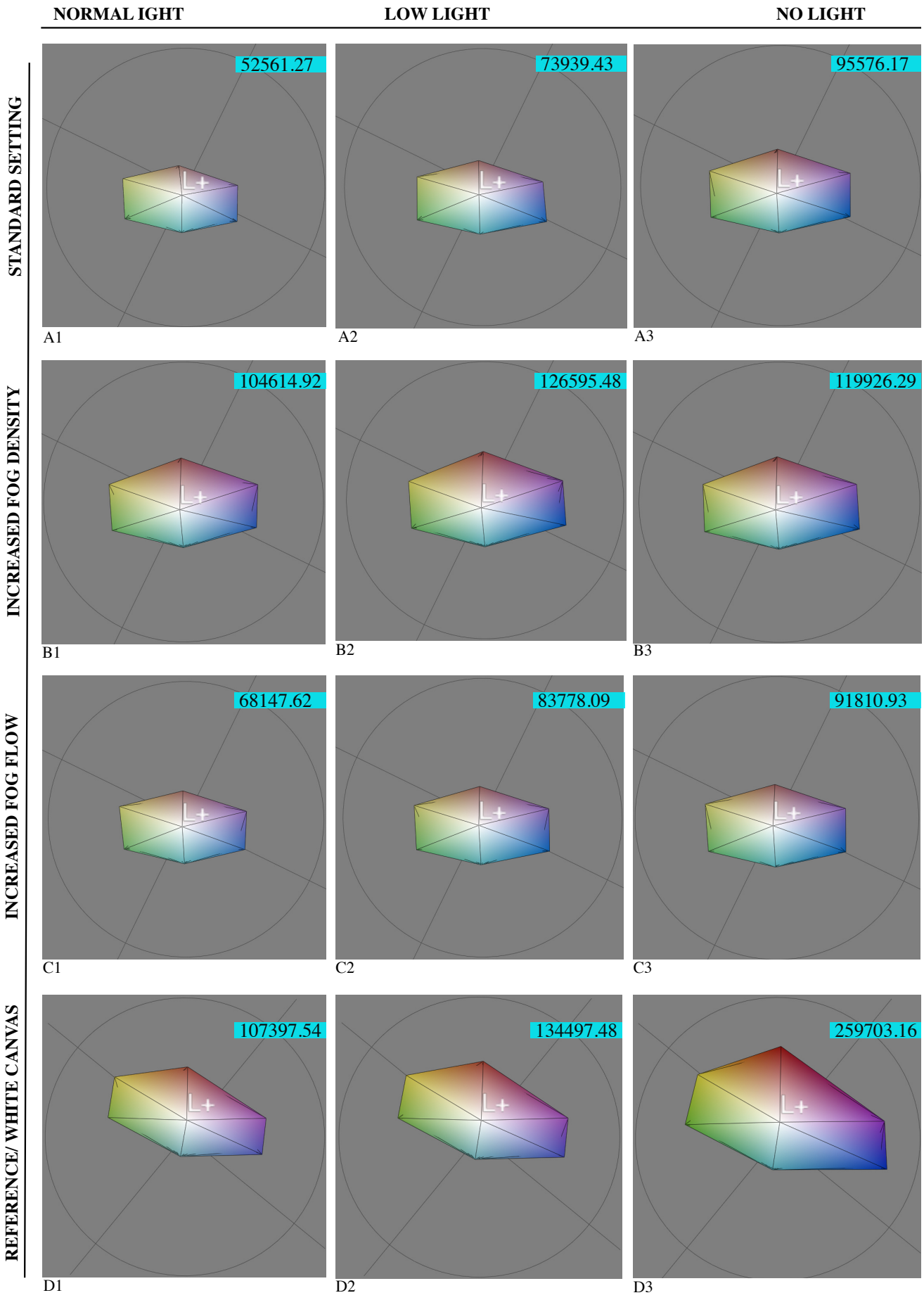


Figure 3.7 Result overview of color gamuts

3.4.2 ANALYSES AND DISCUSSION

By viewing the gamut volumes for all calibration settings in an array provides an instant indication of which type of parameters provides the highest volume. For instance, the gamut volume for standard setting under no-light condition is almost twice as much when compared to normal-light condition. This means the darker light condition, the better color appearance, which is no big surprise in terms of light transmittance.

Normal light

While looking at the gamut volumes for standard setting(A1), fog density(B1), fog flow(C1) and the reference(D1), one can't help noticing that increased fog density and the reference gamut has the highest rates. In fact, there is only a slight deviation between those two calibration settings, which means denser fog structure result in larger gamut volume. The calibration for standard setting(A1) has the lowest volume, whilst increased fog flow(C1) result in a marginally improved gamut volume. However, the difference between A1 and C1 is not at any significant level. The volume size for all calibration settings seem to increases proportionally as darker the ambient gets, with the exception of B3. Somehow the volume for increased fog density decreases under no-light condition, compared to B2.
The deviation might have occurred due to a measurement error.

Increased fog density

Fog density is one of three setting that controls the screen's performance. Increasing this dial will significantly increase the amount of fog produced. As the objective color measurement clearly states (B1-B3), increased density result in larger gamut volume. However, though thicker fog may increase the gamut volume, it leads to several disadvantages such as increased dripping and poorer resolution (FogioOy 2004). By creating a denser screen, the surface becomes turbulent for the light to project through. Still, increased fog density might be preferred for some application settings to create a certain visual effect.

3.4.3 REFERENCE COMPARISON

The main purpose of this comparison is to provide an indication on the relation between Fogscreen's color gamut and the closest alternative, a reflective canvas screen. Yet, a justified comparison at higher level would not be appropriate because of significant differences between the two projection displays. The figures below shows color gamut for the standard Fogscreen settings (solid figure) compared to the reflective screen as reference data (transparent figure).

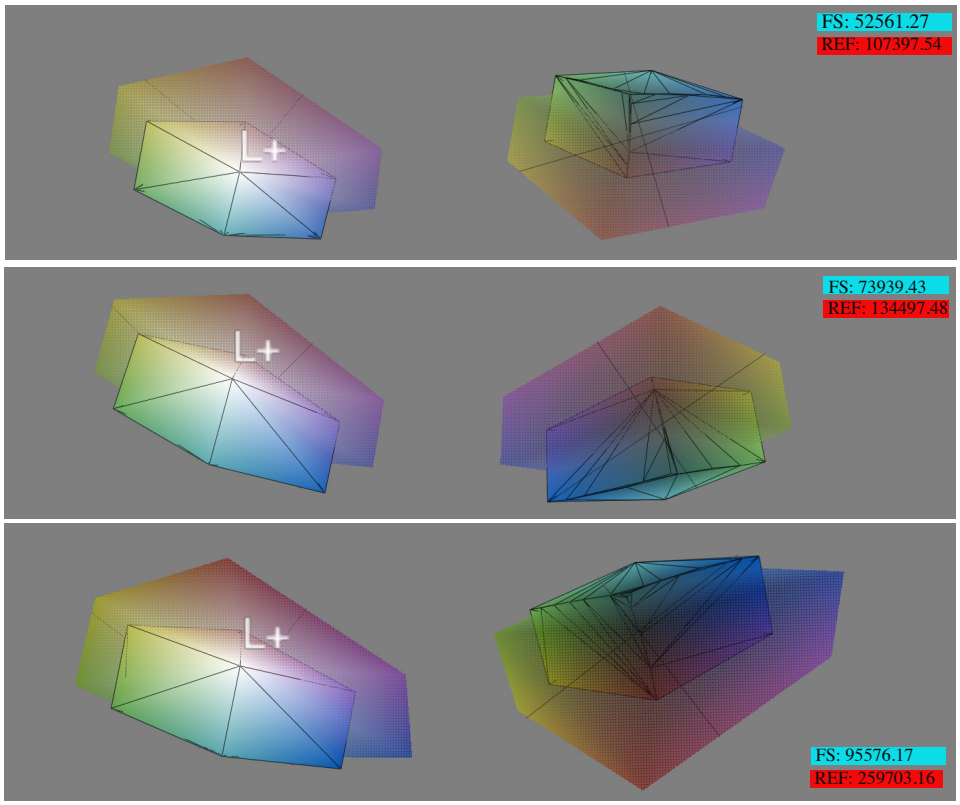


Figure 3.8 Device gamut comparison between Fogscreen and reflective screen (reference)

Gamut Shift

As seen in Figure 3.8, a shift of the color space towards the blue region can be identified. In order to explain that particular shift in details, further investigations and analysis needs to be done. However, potential factors affecting the shape of the color space can be considered such as the geometric setup of the projector and the fog screen. Furthermore, the characteristic of the Fogscreen with its translucent projection properties influences the light transmission and reflection. Finally, the appropriate light and color measurement technology for measuring the Fogscreen and color appearance model to analyze and compare the color data needs to be discussed.

3.4.4 LIGHT CONDITION COMPARISON

For this comparison, the three light conditions are presented in the same figure to demonstrate the difference of volume sizes. The light condition comparison is based on the standard Fogscreen setting. The 3-dimensional gamut volume is displayed from different angles: from top, in profile and from the bottom.

Visual presentation of figures:
Normal-light: *black wireframe*
Low-light: *solid*
No-light: *transparent*

The background for this measurement was to state which light condition provides the highest gamut volume. The ambient light is adjustable and has a major impact on the image reproduction.

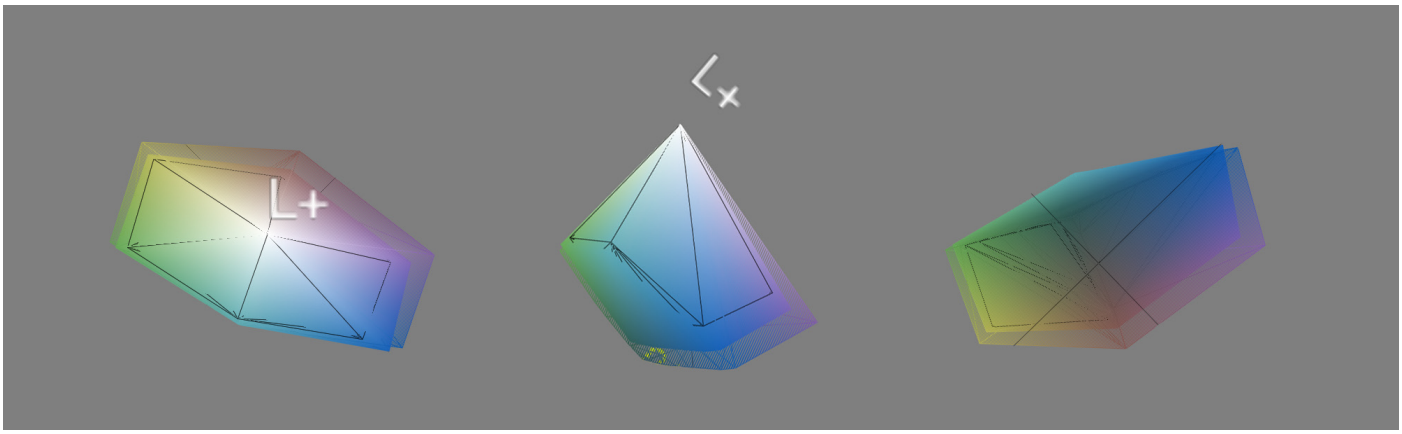


Figure 3.9 Light condition comparison: normal-light, low-light and no-light

Advantages of Dark Surroundings

The size of the volume increases proportionally as the light conditions turns darker, which means no-light will provide the best result. However, it does not mean better viewing experience is simply accomplished by turning off all lights. Other factors must be taken into account when ambient light is considered as a solution for optimizing viewing experience. For instance, no-light condition was achieved by turning off all light sources in both rooms at the Science Center. But in reality, the light sources are needed for other activities in the rooms.

Advantages of Bright Surroundings

Even though dark surroundings are preferred in many cases, bright ambient condition has its own advantages in the terms of using the Fogscreen as a visual effect. One of many effects that can be created with the Fogscreen is the illusion of an object “floating in the mid air”. This illusion can be made by displaying an image with one object in centre, on black background to make it completely transparent, so the object in center is given free space around. In this case, normal or low light is preferred to maintain the illusion. This topic is discussed further in the subjective image evaluation. In conclusion, darker surroundings are preferred for better color appearance, but in some cases, brighter surroundings contribute to create visual effects.

3.4.5 DEVICE CALIBRATION COMPARISON

Fog density and fog flow are two of three Fogscreen settings that can change the screen's performance. The intention of this comparison was to see which one of the device calibration settings gives the highest gamut volume.

Visual presentation of figures:
Standard setting: *white wireframe*
Increased fog flow: *solid*
Increased fog density: *transparent*

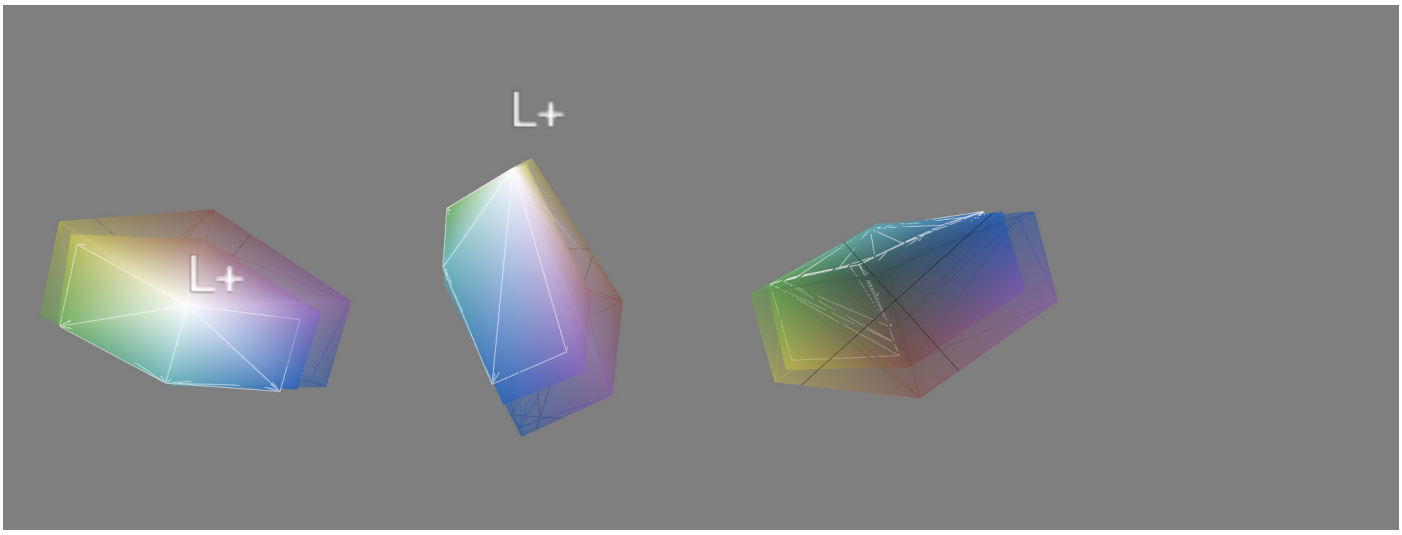


Figure 3.10 Device Calibration Comparison for increased fog density and fog flow

Increased fog density(transparent) result in a much higher gamut volume than standard setting(whit wireframe) and increased fog flow(solid). However, increased fog density will also increase the dripping because the amount of fog is amplified. As discussed initially in section 2.8.1, denser screen will not necessary mean improved resolution.
Fog flow is another device setting that controls the screens performance. Fog flow controls the speed of the fans inside the panel that blows into the tank to force the fog out of the generator. Increased fog flow makes the screen fall faster. Subjectively assessing, increased fog flow appeared disturbing for the eye because of the fast fall-speed of the fog. Increased fog flows also causes higher amount of dripping, which is a big disadvantage.

3.5 SUBJECTIVE IMAGE ASSESSMENT

This section focuses on the subjective aspect of the image appearance. Objective metrics are one way to evaluate and characterize the device, but the subjective evaluation is equally important in order to find out in what way image appearance can be optimized. Some factors about the screen can only be revealed by testing complex images and record its response. The subjective evaluation will describe the objective findings with a practical significance, in the term of viewing experience.
For this analysis the environment light conditions are narrowed down into two settings; normal-light and no-light condition. The images are compared to the appearance on a reflective screen that serves the purpose of reference data. One important point relating to color management and color assessment is that the human eye is least sensitive to changes in lightness, more sensitive to changes is saturation, and most sensitive to a difference in hue (Sharma 2004, p.80).

3.5.1 LOW COLOR CONTRAST & SMALL DETAILS

Figure 3.11 Subjective image evaluation - low color contrast

This image was chosen to test the Fogscreen's limits for reproducing small details such as the paintings on the wall, windows, and trees. In addition, the image has low color contrasts and is dominated by low-saturated colors.
Under normal-light condition, the image reproduced on the Fogscreen is basically useless, as the details disappear and the transparency becomes a significant issue. Due to transparency, objects in the room behind the screen blend in with the display and result in a much disturbed image projection. The image appearance is somehow improved under darker surrounding. Under no-light condition the details in the picture are much more visible, and transparency is no longer an issue. Still, this type of image composition is not preferred for the Fogscreen.

3.5.2 OPTIMAL IMAGE

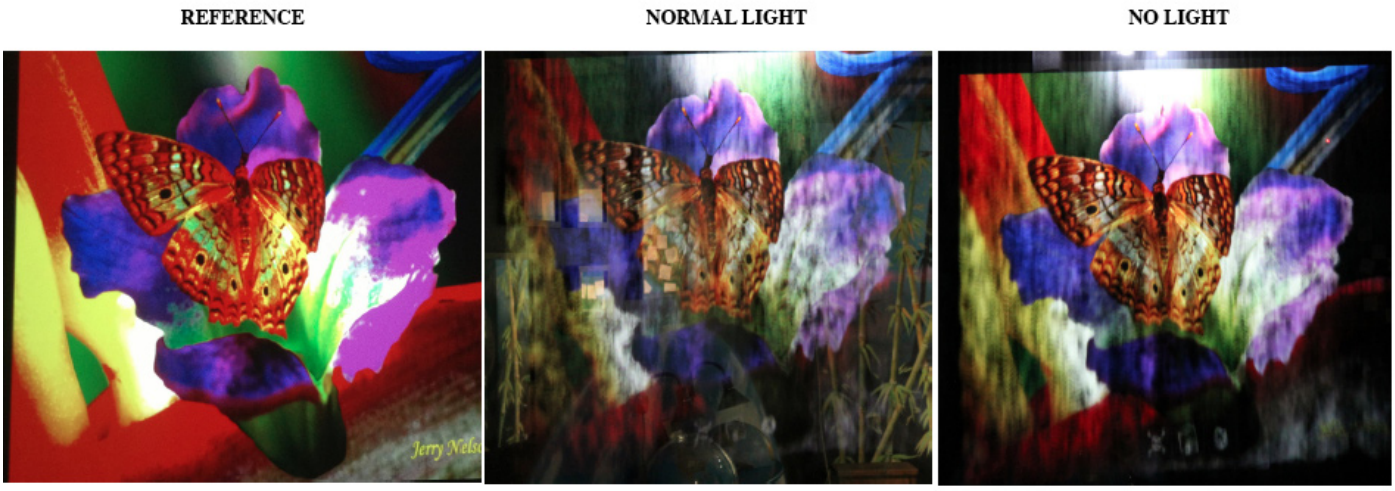


Figure 3.12 Subjective image evaluation - optimal image

Based on the guidelines from the manufacturer about optimal content creation, this image was chosen to prove how easy optimal image projection could be created by using an appropriate image composition. In this picture one large object is centred on high-contrasted background. The color contrasts highlight the important areas of the image, and for that reason the viewing experience is much better. Under normal-light condition, the small details still appears because of the strong color contrasts, but the transparency becomes an issue as the objects behind the screen blend visually with the image projection. Under no-light condition, the projection is immediately improved as colors and structure appears clearly. Compared to the reference, the image projected under dark surroundings is a very close match, and pleasing for the eye. It is impressive to see the dark spots on the butterfly wings appear with such visibility.

Attributes for optimal image

Several attributes related to the image composition contribute to optimize the image projection.

1) High color contrast between the objects in the picture.
2) Reasonable composition by centring the main object in the upper area of the screen to achieve best possible resolution. The best resolution quality on a Fogscreen is at the top of the screen, and degrades as the screen falls. Thus small graphic details should be placed at the upper area of the screen.

3.5.3 FACIAL AREA

Figure 3.13 Subjective image evaluation - facial area

One of the crucial factors when projecting images of people is to have an accurate view of the facial area. Usually this is not a problem when projecting images on fixed screens. The Fogscreen on the other hand operates with another projection technology, which makes the surface turbulent because of the flutter-effect. The face is a sensitive area of the human body. With the flutter-effect on the Fogscreen, unfortunate facial expression might appear. For that reason, this image was tested to see how the facial area appears on such device, whether if the result is acceptable or unfortunate.

Normal light
During normal-light condition, this image appears transparent, as certain areas of the image fades. The arms are almost invisible for the viewer. Under bright surrounding, the black dress appears transparent and exposes the objects behind the screen to the viewer. The image composition in this case is unfortunate, thus not recommended under bright ambient light.

No light
The same image viewed in darker surroundings provides a better result in terms of stronger visibility, since transparency is not an issue. However, the grainy surface is at some dregree disturbing in the facial area. Nonetheless, considering the total viewing experience from a subjective point of view, the appearance of the facial is at an acceptable level. In live projection, the viewers will adapt their perception of the screen, and the brain will compensate for the lack of accuracy (as long a reference images is not put next to the screen).

3.5.4 COLOR vs. BLACK/WHITE

The intention of these test images has been to see how well a black/white image appears, compared to a normal colored image.

Figure 3.14 Subjective image evaluation - color image vs. black/white image

Comparing the two images displayed on the Fogscreen during normal-light condition shows that colored images withhold the details in much better sense than the black/white image does. The reason for that is simple; during normal-light condition, the Fogscreen is much more translucent than darker surroundings. Furthermore, black and other dark colors have a tendency to appear transparent on a Fogscreen. By displaying black and white images, the dark area becomes transparent, which means objects behind the screen are exposed to the viewer. This results in an image projection with fewer details than a colored image would do under same light condition.

However, during darker surroundings the appearance of the black/white image is pretty adequate, as transparency is no longer an issue. Though the black/white image appears just fine, the colored image is a much better fit for a Fogscreen. Then again, it all depends on the context the images are displayed. For some application settings, black/white image is better suited than colored image. The conclusion that can be drawn from this example is that black/white images are best viewed in dark ambient light.

3.5.5 TEXT

Figure 3.15 Subjective image evaluation -text size and background

Text is one of the main types of content that is displayed on a Fogscreen. In the pursuit of finding the best possible calibration for text projection, positive and negative appearance of text is displayed on the Fogscreen. From earlier we know that the Fogscreen is not uniform. The upper area of the screen has the best resolution, and it degrades as the screen falls. Hence the smaller text size is placed in the upper part as the size increases the lower it is placed. By doing so, every text line are assured visibility and is readable for the observer.

White Background vs. Black Background

As mentioned in previous section, black appears transparent on a Fogscreen. Under normal-light condition the black background generates transparency and causes the letters to “float in the air”. During no-light condition, the letters are projected optimum. With white background on the other hand, the letters are less visible and less reader-friendly because of the high amount of grain. The white area in the picture highlights the fog structure, which causes higher amount of grain/noise. Under no-light condition, the letters are someway better projected. Still, black background is preferred for both bright and dark surroundings for this particular venue.

3.6 JUSTIFICATION FOR LIVE PERCEPTION OF THE FOGSCREEN

The way we perceive images on the Fogscreen in live projection is different than what we see in a picture of the screen captured with a camera. In reality, the structure of the screen is in constant movement, meaning that the eyes perceive a correct version of the image within a short moment.The unfortunate flutter/curtain-effect causes a turbulent surface where small details come and go. Still, the human observer will get the sense of a complete image because the brain compensates for the lack of the details as they come and go frequently, giving you the impression of a complete image. However, taking pictures of the display with a camera, only one screen structure is captured. This means the image previewed later have missing details. Though the subjective assessment in this thesis is based on captured images from the measurement experiment, the images does not really present a justified reference compared to the actual viewing experience.

Chapter 4
APPLICATION POSSIBILITIES

4. APPLICATION POSSIBILITIES

This part of the thesis approaches the management aspect of the research area. Having the technical aspect deliberated in the previous chapter, the focus here lies within potential application possibilities. Common key words to describe this chapter are business innovation, media management, concept design, marketing and creativity.

The sole purpose of this chapter is to bring the results from the previous chapter into a practical understanding by designing realistic application concepts for selected companies in the Norwegian market. Designing these concepts provides a realistic overview of what kind of media content that is best suited in that particular setting and environment. The Fogscreen can be utilized to its full potential only if both technical and application are considered equally. Consequently, elements such as media management, marketing and business innovation are involved in this chapter, in addition to the results from previous chapter.

4.1 THEORY

The topic *business innovation* has been introduced to Mediamanagement students as part of the bachelor programme to raise awareness of the need for innovation within the area of media and communication.
This chapter cast a perspective in the area of innovation by considering application concepts of the Fogscreen as a media channel. This thesis approaches the innovation aspect by designing three application concepts for Norwegian companies based on their needs for implementing such product.

4.1.1 BUSINESS INNOVATION

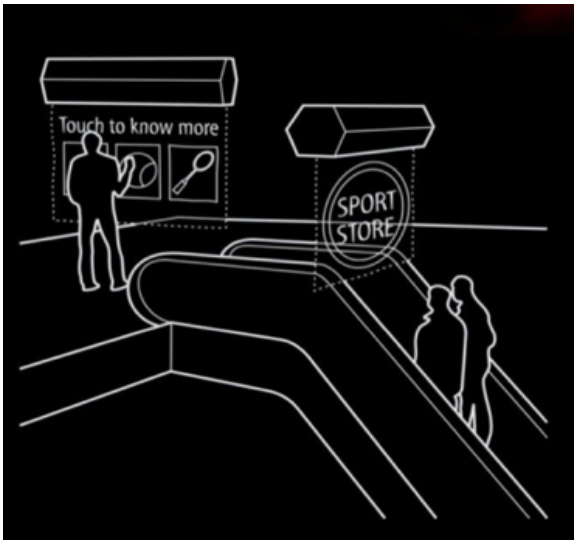
Innovation is defined by OECD as:

> *"An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations." (OECD 2005)*

In this thesis innovation is used as an implementation of an existing product in a new marketing method. The actual product is not new, but the combination of using a Fogscreen as a part of the organization's everyday activities is innovation. Implementation of Fogscreen could be a part of a marketing strategy to increase the companies' revenue, profiling or gain publicity and public attention.

4.1.2 AN EFFECTIVE COMMUNICATION CHANNEL

The fundamental purpose of advertisement is to grab the audience's attention. At crowded public places, digital information boards are used to display advertisement or information towards the audience. For instance, digital information boards from JC Decaux are a common sight at Oslo Central Station or other well-visited places. The essential purpose of the screens is to catch people's attention with the information it offers. The disadvantage of this type of distribution channel is that people in hurry has developed a self-generated ignorance. Human brain is exposed to all sorts of information, eventually the mind filter the information flow down to perceiving only the most significant elements they need, also known as stimulus selection (Kaufmann and Kaufmann 2009, p.150).



This is where the Fogscreen has its greatest advantage. Because of the screen's exclusivity, the product is new to the people. Fogscreen is not only a digital display, but also a strong visual effect that attract the audience's immediate attention. Thus the content that is displayed reaches out to the people since they cannot ignore this type of extraordinary device. The unusual characteristics of the device make the Fogscreen an effective communication channel.

Figure 4.1 Illustration by (FogioOy 2004) - example of Fogscreen application at a shopping mall

4.1.3 DIFFERENTIATION STRATEGY

With the constant development of technology trends, companies work hard to find innovative strategies that can give them an edge in the market they operate in by standing out. As mentioned above, Fogscreen is an excellent channel to reach out to a large group of people. At present time, only two Norwegian companies have permanent installation of the Fogscreen-device. For that reason, any other companies that implement such product will make them stand out from competitors. Differentiation is an important part of the marketing strategy for every company that seeks to gain competitive advantage in the market (Kotler and Fredriksen 2005, p.265). In this thesis implementation of Fogscreen is used as a differentiation strategy for all three companies to stand out from the competitors that operate in the same market. Companies can achieve differentiation based strategically use of channels and image building to state their position in the market. Implementing a Fogscreen will associate the company of being innovative and technology-orientated, which then will lead to image building and branding the company name. The assumption is that the company conduct the implementation *now* because the product is new and exclusive, not in a few years when the trend has passed on.

4.2 METHODOLOGY

Method of Approach:
Based on the theory and results from the measurements in previous chapter, this thesis will design suitable concepts for three application sites, where every aspect of the product is considered in order to optimize the total viewing experience.

The methodology used in this chapter:

- Concept design
- Creativity and innovation (finding application possibilities)
- Using available resources and connections at GUC
- Using data from chapter 3 – device characterization – to design application concepts considering both technology and application.
- Site surveys – observe the environment and the light conditions. Based on this information it will be possible to custom design application concepts suitable to Fogscreen-devices.

4.3 FOGSCREEN APPLICATION

In section 2.3.4, typical application sites were presented for both permanent and temporary installation set-ups. As already mentioned, the application possibilities are endless with the Fogscreen. However, it is important to be aware of the risk if the only purpose of the device is to attract an audience. Though the device will demand immediate attention, the *wow-factor* will eventually pass, especially with permanent installations. Because of that, it is significantly important to assign a practical function to the screen, besides being an attraction and a visual effect. By assigning a practical function, the risk of losing the wow-factor will not affect the value of the product, as it will always serve its practical purpose.

The typical application purposes are (FogioOy 2004):

- Information board
    - Interactive touch screen
- Entertainment
- Attraction
- Stage/ scenography effect
- Marketing channel/ screen - for promotion and commercials

4.4 FOGSCREEN MANAGEMENT SYSTEM

Fogscreen Management System is designed for this thesis to provide guidelines for optimal utilization of the product. The importance of managing both technical and application aspects has been addressed earlier in the thesis. These guidelines present the requirements that is needed to manage the following aspects:

- **The technical perspective** – limits and potentials.
- **Content management** – creating images, text, graphics, and videos that is customized for such device under given environment.
- **Application site (concept)** – strategically placement of the screen to obtain desired feedback from the audience/target group.
- **Functionality** – Creative and innovative approach to build an application concept that increases the efficiency of information distribution (reach more people), as well as optimizing the total viewing experience for the audience by adding special features.

4.5 POTENTIAL APPLICATION CONCEPTS

The three different application concepts are chosen to give a broad variation of the possibilities that can be achieved with a Fogscreen. The application concepts are assigned to The Norwegian Opera House, Ballroom, and Vitensenteret Innlandet Gjøvik (Science Center).

These are the common factors deliberated for the application examples and serves the purpose of optimizing the viewing experience:

- Company context
- Environment and light conditions
- Functionality of the screen
- Content management
- Special features
- Installation
- The economy aspect

4.5.1 THE NORWEGIAN OPERA HOUSE

Figure 4.2 The Norwegian Opera House. Photo: Erik Berg/operaen.no

The Norwegian Opera & Ballet, located in Oslo, is the largest performing arts institution in the country to present opera, ballet and concerts (DNO&B 2013). The Opera House is well known for its extraordinary architecture, and it is considered a landmark. The Opera House has a high rate of visitors and tourists. People visiting the Opera House expect attraction, fine architecture and entertainment of the highest quality. Implementing an exclusive product as the Fogscreen in such a special building seems to be a very suitable application concept. The Fogscreen is known for its ability to catch the crowds' attention. For that reason, placing the Fogscreen in the Opera House, a well-visited building, will immediately attract attention and enchant the audience.

CONSIDERATIONS OF FOGSCREEN INSTALLATION

Installing a Fogscreen-device in the Opera House enquires certain considerations regarding the environment at the location. As a result of observation from the site survey, the following elements should be taken into account in advance of implementation.

Brightness

At daytime there will be some challenges to the display because of the open architecture and the brightness in the room. This factor must be taken into account when a projector model is considered. In such a bright environment as the Opera House there is need for strong projectors.

Airflow From Entrance

It is crucial to place the screen in a spot not too close to any entrances because the airflow will disturb the fog structure. It will result in a more turbulent surface, which will make it more challenging to display clear pictures.

PRESENTATION OF CONCEPT

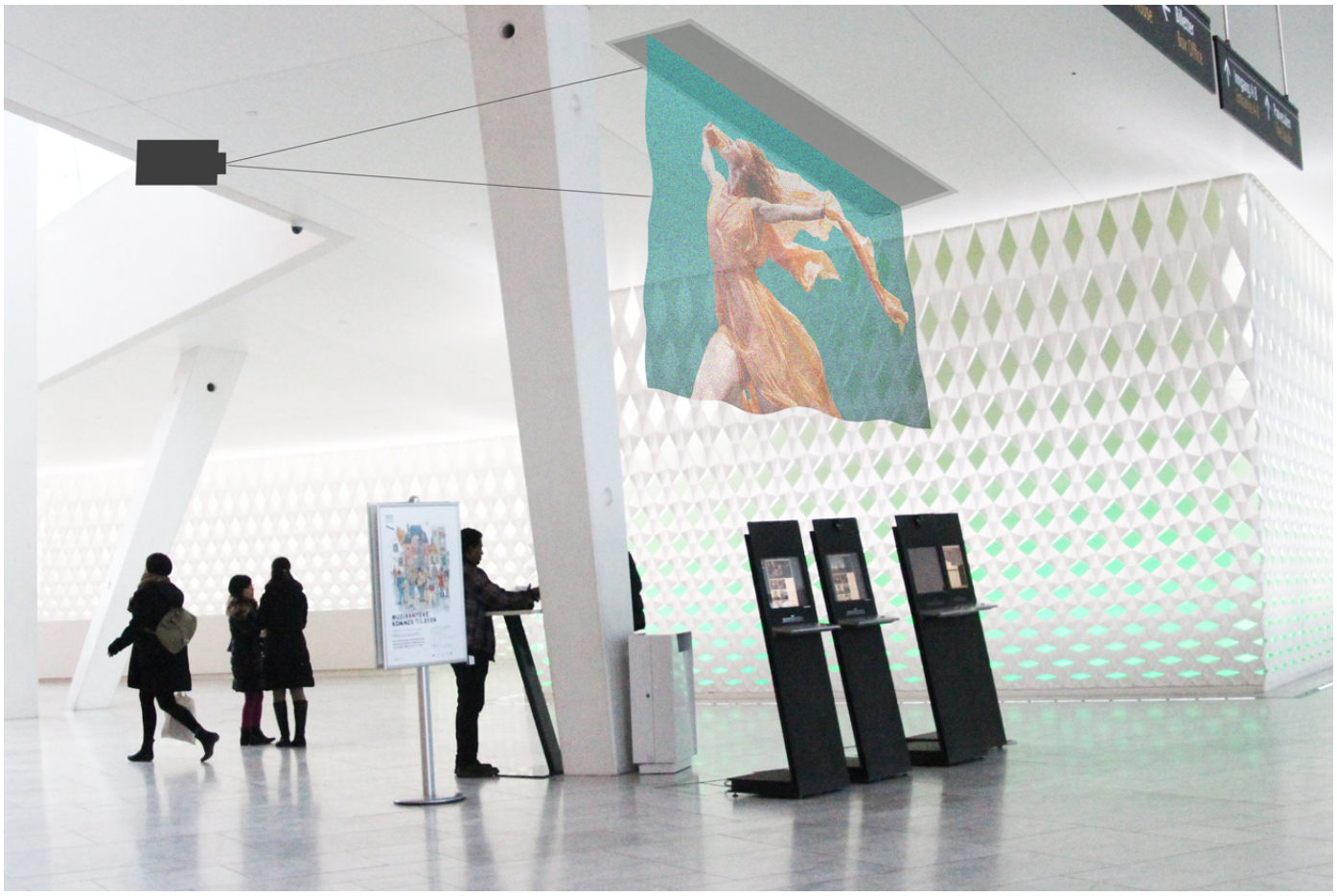


Figure 4.3 Simulation of Fogscreen implementation. Photo: Niyan Omer

FOGSCREEN IN THE FOYER

The concept of placing a Fogscreen in the Opera House is to find a central spot that makes the screen visible to the visitors. Installing the screen in the ceiling in the middle of the foyer is the optimal spot. For this application, Fogio eMotion 2.2m is the perfect Fogscreen model. Any smaller model could easily get lost in the open space. Other alternatives could be 4x 1.1m linkable Fogio Pro model. However, a bigger screen will result in increased acquisition cost, and the dripping would increase significantly.

FUNCTION AND PURPOSE

The main function of the Fogscreen could be to use it as a digital information board. No information board exist at present time. Thus using a Fogscreen as a media channel to distribute information seems like an appropriate purpose. Such digital board will capture the crowd's attention, so whatever information is displayed will get through to them easily. Beside its function as an information board, it will also be an attraction for visitors/tourists by day, and spectators in the evening.

Due to increased dripping when it is used over a longer period, it is recommended to use the screen a few hours on daytime for the tourists and regular visitors, and before and after showtime in the evening.

TYPE OF MEDIA CONTENT

Due to the screen's function and purpose, image, text and video would be suitable media content for this application site. For instants, using campaign images and text for upcoming shows would be a good way to promote a show.

CONSIDERATIONS FOR OPTIMAL VIEWING EXPERIENCE

Now that a couple of elements of the application concept are stated, it is time to consider the option for an optimized viewing experience.

INSTALLATION SET-UP

This application set-up requires a permanent installation in the ceiling with a direct water line connection. Since the ceiling is higher than normal in the foyer, the walk-through effect will not be possible, however, having displayed images soaring above the viewer's head will call for even more positive attention.
Having the projector placed so high above the viewer's head solves the problem of having the projector light shining directly into people's eyes. This is a crucial factor, and having it removed clearly increases the viewing experience in a positive way.

DRIPPING ISSUE

Even though the fog is "dry", some dripping will occur eventually. It is estimated between 1 and 2 drops per minute (FogioOy 2004). When the device has been operating for a couple of hours, there will be some water spills on the floor which can cause slithering issues for the visitors. To avoid this problem a carpet underneath the screen is highly recommended.

ENVIRONMENTAL LIGHT CONDITIONS

One of the major concerns regarding this application site is the level of brightness in the foyer, especially during the day. This light condition will make it challenging to display images at an acceptable accuracy. In a worst case scenario, the viewer will not be able to see the image that is displayed on the Fogscreen. There are a few solutions that will optimize the image reproduction considering this light condition.

Projector

For starters, the projector has to be one of the "strongest". A projector with 7500 ANSI lumens will optimize the color reproduction. The term ANSI lumen is a measurement by light output of a projector, which has been standardized by the American National Standards Institute (PCmag.com 2013).
The projector used for the measurements in chapter 3 was operating with 4000 ANSI lumens. According to the manufacturer, an application site similar to the Opera House, which has an open installation, should have a projector with minimum 7500 ANSI lumens.

MEDIA CONTENT MANAGEMENT

The main purpose of the Fogscreen is to distribute information. Considering the application site and the bright surroundings, the media content should be chosen very carefully. For instance, dark colors at this application site would be a total failure, as it would appear transparent. In the following are suggestions for media content based on general guidelines from the manufacturer and the measurements in chapter 3.

Images

Pictures with high contrasted colors and motives are highly recommended. The image should not have to many small details, and it should have one or two large objects in the center. The colors should be high-saturated colors, as we discovered these colors are the most visible on a Fogscreen. To demonstrate these statements, two images are chosen to represent a good and a bad example.

Bad Example
A large scale of dark area dominates the image, and there are too many and too small details, which prevents a good image projection. The dark area would appear as transparent on the screen, so the dancer's legs would blend in with the background.

Figure 4.4 Bad example. Photo: Rahi Rezvani/Operaen.no

Good Example
This image is much better suited for a Fogscreen. The clear background consists of one color which highlights the front object. The color contrast between the background and foreground makes the person stands out as the main focus. The image composition is also very good. We must consider the lack of uniformity of the screen surface. In this case, having the face placed in the upper part of the picture is definitely an advantage. If this picture was a campaign for an upcoming show, the empty area on the top of the image could be used as a text area.

Figure 4.5 Good example. Photo: Jörg Wiesner/Operaen.no

Video
Now, lets keep imagining the setting where this is a commercial for an upcoming ballet show. Wouldn't it be much better if this was a film teaser where the dancer performs some dance moves? The optimal solution for a film teaser would have a similar composition where the contrast between background and foreground/object is just like this picture.

Text
In addition to images, text is another way of distributing information to visitors. The text line could be a part of an image, or independently displayed on the screen. The screen's limit of uniformity, where as the best quality projection surface starts from the top of the screen and ends about 1.5 below the top, calls for awareness especially when projecting text.
As demonstrated in the subjective evaluation in section 3.5.5, the text lines should increase the lower it is placed on the screen. Considering the bright environmental light conditions in the foyer, the text should be placed on a dark background, which will generate transparency, with white letters to obtain high contrast that lead to better visibility.

THE ECONOMIC ASPECT

There is no point in presenting potential application examples without considering the economic aspects. However, due to delimitation of the research area the economic perspective is not a major focus in this thesis, and for that reason it will only be a sufficient topic.

Acquisition Cost

As mentioned initially, business innovation is about implementing a new way of doing what you always do. Bringing a Fogscreen into the Opera House will be a new way of distributing information. These innovative solutions have a price. To give a pointer on how much this implementation would cost, an estimated acquisition cost follows here. The numbers are obtained from The Norwegian Opera House and Fogio Oy.

Product	kr. 194 400
External projector	kr. 15 000
Shipping	kr. 6 634
VAT	kr. 48 600
Operator education	kr. 15 000
Installation in the foyer	kr. 25 000
TOTAL COST	kr. 304 634

RETURN ON INVEST AND COST AVOIDANCE

Even though the numbers above may seem scary to begin with, there are several methods to reach break-even, and even increase revenue over time.

Cost savings and cost avoidance

At present time, the Opera House does not have a large digital information board. They use lots of resources on posters, season books/ programs and other print media to distribute information about upcoming events. Using print media for each new event is cost-inefficient over time. By decreasing the amount of print media, and rather use a digital information board as the Fogscreen, will reduce costs. The print media such as posters, flyers etc. are for one-time use only, and will eventually be thrown in the garbage. But using digital board will be a much more attractive way of distributing information and it will not be consumed, since new events can be added whenever. At some point the amount of cost saving money will be enough to cover the acquisition cost, and break-even is reached. It is most likely that the Fogscreen will be still in use after the break-even. In which case, the Opera House should start to increase their revenue by using a digital information board, in addition to a lower amount of printed media.

Revenue Without A Price Tag

There are several benefits to draw from this implantation than just revenue by numbers. For instance, the Opera House will benefit this innovative act as a way of company profiling and image-building in the market they operate in. Using a product that allows a total viewing experience for the visitor will benefit the Opera House in terms of increased satisfied costumer experience.When looking at the total picture, suddenly the acquisition cost doesn't sound that bad anyway.

4.5.2 BALLROOM

Figure 4.6 Ballroom - Photo: (BallroomAS 2013)

The Oslo based event house, Ballroom, provides a flexible location for all types of events, from weddings, conferences, product launches, dinnershows, concerts, and nightclub parties (BallroomAS 2013). Beautiful pillars, creating arched entrances all around the hall, characterizes the main hall. People coming here have lots of energy and are in a good mood. In order to stand out as an event house in a tough market, it is important to provide the costumer with something extra. Ballroom has a very nice location with special characteristics like elegance and exclusivity. To complement these features, a Fogscreen should be implemented. In a place where entertainment, theatre smoke and spotlights are natural elements, a Fogscreen would be a natural fit.

CONSIDERATIONS FOR FOGSCREEN INSTALLATION

Unfortunately it was not possible to conduct site survey at this application site, which means that the considerations are based on pictures seen from the location. Neither has it been possible to gain enough information to estimate calculation for implementation costs.

New Events

Ballroom is a flexible event house, which makes the content management part more challenging and complex. The type of media content changes within every new event.

Colored Spotlights

Several colored spotlights are used in the room to create a certain atmosphere.
This will have an impact on the viewing condition.

Installation

Permanent installation requires a water line connection. A certain amount of resources is needed to conduct this installation. At a location like Ballroom, the placement possibilities are many. The Fogscreen can be used as part of the scenography on stage, in the foyer/entrance hall, or in the main room.

PRESENTATION OF CONCEPT

Figure 4.7 Simulation of Fogscreen implementation at Ballroom - Photo: (BallroomAS 2013)

FOGSCREEN ENTRANCE

At a location like Ballroom, the choices are many to place such screen. However, placing the screen somewhere close to the main hall is crucial to obtain visibility and availability, hence to grab the crowd's attention. The best solution is to place the Fogscreen between to pillars that creates an entrance to the main hall. This way, the screen will be visible and serve its purpose. Due to the spot of the Fogscreen between the pillars, a Fogio eMotion 2.2m wide Fogscreen is recommended. The size of the device is a perfect match for this application concept.

FUNCTION AND PURPOSE

The Fogscreen will be a natural attraction element in the room, and the screen itself could easily entertain a curious-minded audience. Locating the device as an entrance is good way to make people walk through it and by that take advantage of the Fogscreen's most characterised benefit. This will also be a solid opportunity to increase the total viewing experience of the product. The Fogscreen has more potential than being just a sight to see. It's very important to use the device for a more functional purpose, such as an information board or as advertisement and media channel. Taken into account the potential events at Ballroom like product launches, concerts or conferences, the screen would serve its purpose as a way of promoting brands, companies, products etc.

The screen's function and purpose depends on the type and the theme of the event. For instance, an event such as a product launch would call for a display that shows the company's logo or the product that is launched that evening. This would definitely be an exclusive way of promotion and advertisement. If the companies' logo were displayed, it would immediately have an increased visibility because everybody will notice the Fogscreen.

TYPE OF MEDIA CONTENT

Typical type of content for such application would be images, text and logo.

CONSIDERATIONS FOR OPTIMAL VIEWING EXPERIENCE

A few factors that will be considered for optimizing the viewing experience in the following.

INSTALLATION SET-UP

As the previous application example at the Opera House, a permanent installation is also required at Ballroom. There should be a direct water line connection as well. The dripping issue is crucial to manage, either by carpeting or creating a drainage system on the floor.

SPEACIAL FEATURE - TWO-SIDED PROJECTION SCREEN

Without further due, it is time to present the first special feature that can be assigned to this application concept. Fogscreen is a rear-projection screen, which means the particles of water are more efficient light transmitters than they are reflecting light. Only 5-10% of the light projected onto the water particles bounce back (FogioOy 2004).
In a practical understanding, using one projector in front, and another in the back transforms the Fogscreen into a two-sided projection display. By doing so, we can display two different images on each side of the Fogscreen.

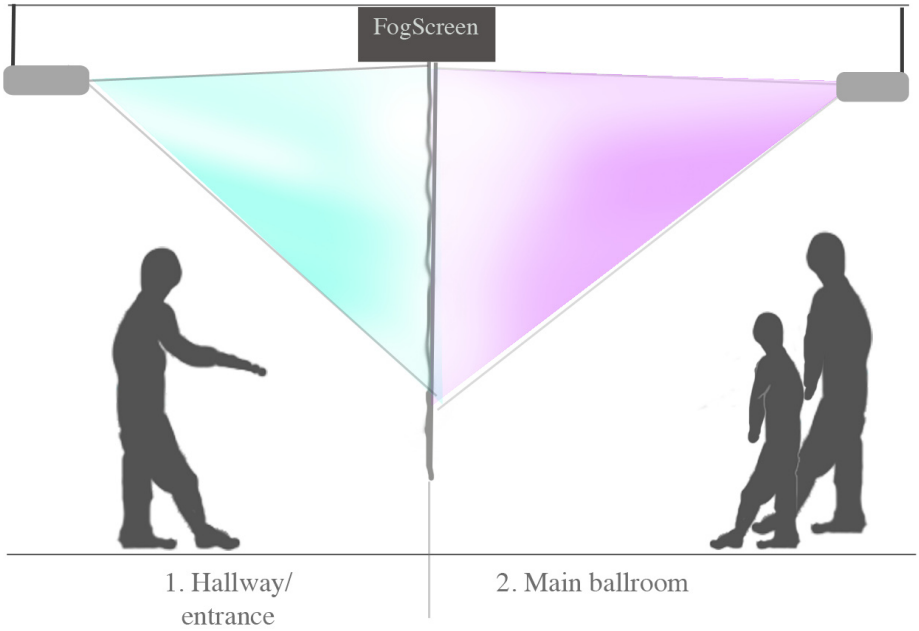


Figure 4.8
Two-sided projection screen

The two-sided projection screen concept is suitable for locations when there are people on both sides of the screen. In this case, the Fogscreen is placed between the hallway and the main hall, which means people will observe the screen from both sides. The two-sided projection display would also fit the Opera House, but because the brightness in the room it wouldn't be as efficient as it is for Ballroom.

ENVIRONMENTAL LIGHT CONDITIONS

During the events at Ballroom, the light conditions are lower than at the Opera House. Based on the images, the light conditions during events, correspond to the low-light condition from the measurements in chapter 3. With darker light conditions, better image reproduction will be achieved. However, it is recommended to turn off any light sources close to the screen for an even better projection.

Colored Spotlights

Several colored spotlights are used to obtain a certain mood. If these colored spotlights are pointed directly towards the screen, it will have an unfortunate impact on the displayed image. Avoiding this scenario will easily solve the problem. In fact, a stronger visual effect is created by having these colored spotlights next to or beneath the screen, as long as the colors doesn't have any direct impact on the Fogscreen.

PROJECTOR

A Fogscreen located at Ballroom is sheltered from windows and daylight, and because of the low light condition, unlike the Opera House, it requires a less strong projector than the previous example. A projector operating with minimum 5000 ANSI lumens is recommended. Even though any stronger projector would increase the image reproduction, 5000 ANSI lumens is acceptable for this application site (FogioOy 2004).

MEDIA CONTENT MANAGEMENT

It is important to remember that Fogscreen projection screen first and foremost is an effect screen, not a high-resolution display (FogioOy 2004). A much better image projection can be achieved by following the recommendations that are given here. These recommendations are based on guidelines from the manufacturer and the measurement results in chapter 3. To present the recommendations, a fictive product launch example is constructed.
Let us assume there is a product launch and the typical media content is logo, text and pictures.
To optimize the viewing experience, two projectors are sat up on each side of the screen to create a two-sided projection display.

Text and Logo

The company's logo and text is displayed on the front side of the screen (viewed from the hallway before entering the main hall). For the best possible result, the logo should be in white or a very bright color on black background. The dark background would appear transparent; creating an illusion of the logo floating in mid air. The same principle goes for normal text as well. As seen in the subjective evaluation of text creation in section 3.5.5, bright text on dark background gives the best visibility, rather than dark text on bright background.

Image

On the other side of the screen, viewed from the main ballroom, an image of the product can be displayed. The object in the picture should be composed in the upper part of the screen due to uniformity issue caused by the fluttering effect on the lower part of the screen. The main object in the picture that is placed at the upper area and about 1m down will give the best image quality. As for colors in the picture, high saturation and significant color contrasts are recommended. Static images are not as interesting a moving 3D object would be. Because of the screen's strong visual effect, interactive pictures should be considered for a more fascinating and entertaining viewing experience. It is a shame if the Fogscreen and its strong visual effect are not used for its full potential.

4.5.3 VITENSENTERET INNLANDET GJØVIK (SCIENCE CENTER)

Figure 4.9 The Science Center - Photo: Vitensenteret Innlandet Gjøvik (VitensenteretInnlandet 2013)

The Science Center is an exciting, fun, and interesting environment packed with activities and experiments in natural science, technique and mathematics for people in any age (VitensenteretInnlandet 2013). The Science Center is a place for everybody who are playful, curious and willing to learn in a new and fun way. The most common visitors are kindergartens, schools, businesses, teams, organizations, and families, making it a place for everyone.
As one of the very first companies to invest in this product, the science centre purchased a 80cm wide Fogscreen Inia in 2007. Unfortunately, the device has been out of service for over a year now. The problem has been increased dripping issues because of a damaged sensor inside the panel that controls the water levelling. Even though it is out of service for daily use, the device worked well enough during the measurement experiment.

CURRENT SITUATION AND SET-UP

Currently a Fogscreen Inia model is placed in the doorway between two activity rooms. The Fogscreen is permanently installed in the ceiling and has direct waterline connection. Unlike the previous application examples, certain elements are already settled with the Fogscreen application in the science centre. For that reason, there will be more focus on the actual content and the device's function.
For this application concept, the Fogscreen will be used for entertainment and educational purpose. By involving the viewer in the interaction feature of the display, the learning process will be much more interesting and entertaining. Suitable media content are images, text, graphic motion, games, and sound effects.

CONSIDERATIONS FOR OPTIMAL VIEWING EXPERIENCE

INSTALLATION SET-UP

There have been some ideas about moving the Fogscreen to another spot where it is more sheltered from light sources. It is definitely a good idea to raise some sort of walls to create a completely dark room behind the screen. However, these considerations are based on the current installation.

Dripping issue

The error is reported to the manufacturer and the spare part that is needed can be obtained. If the sensor is replaced with a new one, the increased dripping issue will be fixed. Some dripping will occur regardless, but it will be a decreased amount, and can be fixed by carpeting, or a more permanent solution: drainage system. At the moment, the drainage solution is the best alternative. Since the device has been operating for 6 years, we cannot expect that there will be less dripping compared to the new products that have been produces in the last years. The risk for this particular device to be more exposed to the dripping problem is high; therefore a drainage system would be the best solution.

ENVIRONMENTAL LIGHT CONDITION

Because of the measurement experiment we have good record of the light conditions at the Science Center, thus the recommendations are based on the results from the objective and subjective measurements in chapter 3. The image reproduction is at its best during low-light or no-light conditions. During no-light conditions, all light sources are turned off. This is not practicable as the light sources are needed for other activities in the rooms. However, turning off the light bulbs just behind and in front of the screen will optimize the image display for the observer.

PROJECTOR

The projector currently used operates with 4000 ANSI lumens. The image quality would be significantly improved if a projector with minimum 5000 or 7500 ANSI lumens was used instead. It is highly recommended to replace the current projector with a stronger one in order to obtain immediate improved image projection.

MEDIA CONTENT MANAGEMENT

The focus of this application concept is implementing interactive educational games to engange the audience. This thesis proposes to integrate an interactive feature to the Fogscreen by using Kinect for Windows.

Kinect

Since Fogscreen can easily be connected to the computer, theoretically, one could display everything that can be displayed on a computer. Kinect for Windows gives computers eyes, ears, and the capacity to use them (MicrosoftCorporation 2013). This device allows people to interact with computers by gesturing and speaking. The Kinect device senses a person's gesture by using skeleton recognition technology. This means that the content that is displayed on the screen can be manipulated by the tip of the finger, gestures with other body parts, or even by spoken command. The idea of applying Kinect technology onto the Fogscreen was presented to me by Costas Boletsis, PhD student at GUC. The concept of using interactive games on the Fogscreen at the Science Centre was a result of collaboration with Mr. Boletsis. Several ideas for games have been suggested, which will be presented in the following.

Figure 4.10 Kinect for Windows - Photo: Microsoft Corporation/microsoft.com

THE BASIC STEP OF APPLICATION DEVELOPMENT

To examine if the application idea is possible to execute, we started with the basic step: run the images that is most likely to result in interactive games, and determine if the image quality is good enough, before using resources on the actual game developing process.

THE MAZE GAME

Figure 4.11 The Maze Game - Photo: Niyan Omer

The Maze Game is an example of a simple game that could potentially be played on an immaterial screen by using you fingertip to command the action. The important outcome of this image assessment was to decide if these images would present an acceptable result. The conclusion is positive, this could be a potential game application that could be developed for this purpose.

Transparency, contrast and high-saturated colors are common factors that describe composition of the images that are used in order to obtain the best possible quality. This is a concrete solution for an optimized viewing experience, combining the quality of the image reproduction and the actual, physical experience the viewer will have.

THE TRADTIONAL TETRIS GAME

Figure 4.12 The Traditional Tetris Game - Photo: Niyan Omer

Tetris is a traditional game which has been played by many people, but it has most likely never been played interactively on a Fogscreen before. Kinect has been used to play Tetris on other devices. *Kinetris* (Chen 2011) is a video that shows how a person manipulates the Tetris-objects with his hand.
The risk of displaying games is the amount of objects in the pictures. In order to display clear images, the objects (in this case the blocks) have to be in a proper size and in significant contrast to the background. In this example, blue-colored blocks are used on black background to create the illusion of the elements floating in the air. The benefit of Tetris displayed on a Fogscreen is the fact that the blocks fall downwards, which is an advantage considering the best resolution is found in the upper area of the screen.

WALK-THROUGH WALL

The ultimate feature of the Fogscreen is walking through the screen. This example is designed to serve that particular purpose. Inspired by the show game on television, Hole in the Wall, this game sets an example for how the walk-through feature can be used for a reasonable purpose.

Figure 4.13 Walk-Through Wall - Photo: Niyan Omer

Unlike the original game, the Fogscreen doesn't move towards the player, the players have to walk towards the screen. Because of this challenge the figure they walk through has to be limited to the upper half of the body, as they need to walk freely on their feet. A simple score system can be made to keep track of the competition. This image has been an easy composition to generate. Based on the principles of creating the illusion of objects floating in the air, and the subjective evaluation of text-display in section 3.5.5, a silhouette of a body is displayed on black background creates a satisfying contrast.

Figure 4.14 Hole in the Wall Game Show - Photo: (About.com 2013)

TRAVELING AROUND WITH GOOGLE EARTH

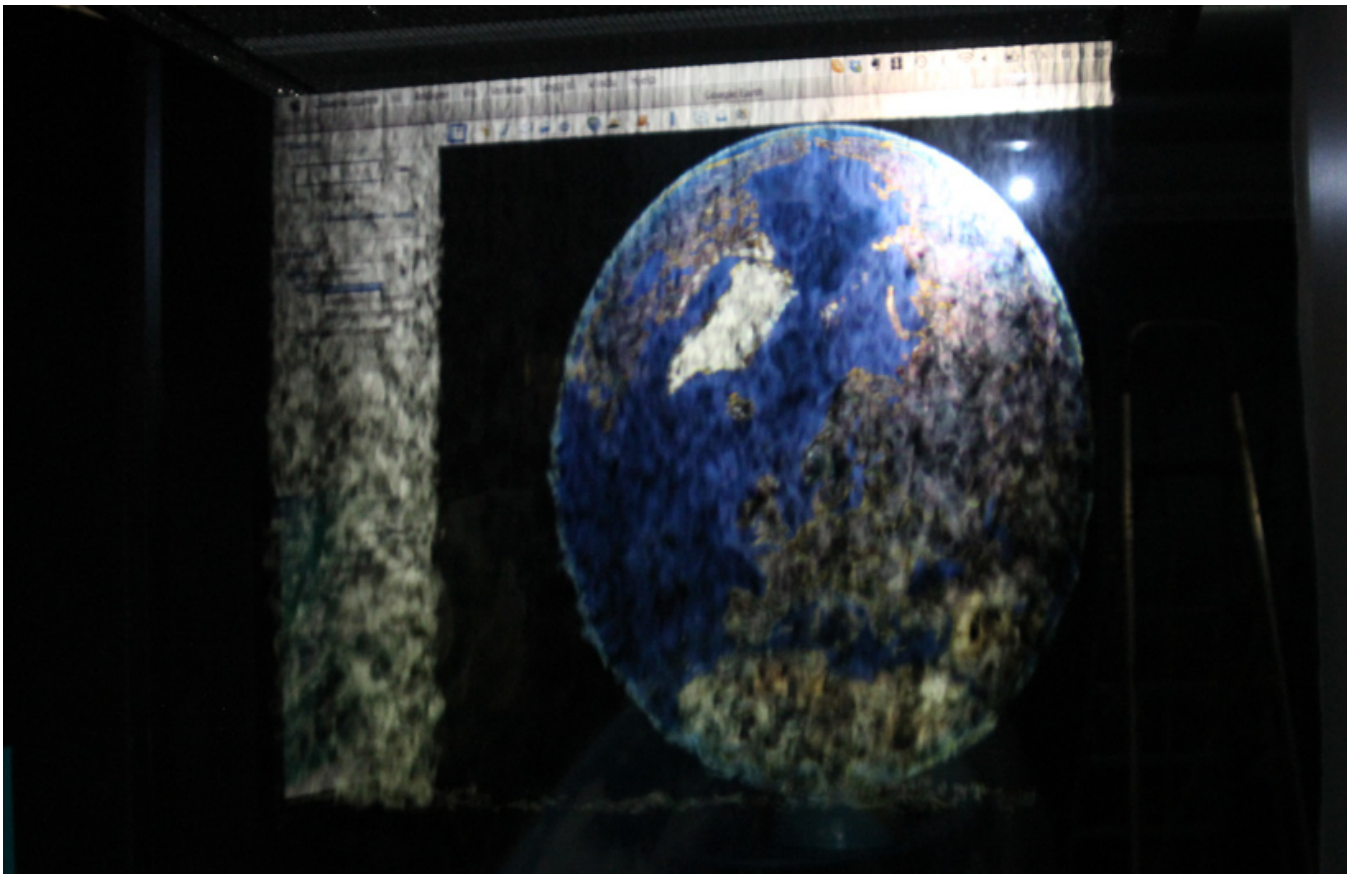


Figure 4.15 Google Earrth displayed on Fogscreen - Photo: Niyan Omer

Imagine traveling around the world and (literally) walking through the streets of Milan, Paris or New York, simply by moving the tip of your finger. This concept is based on the idea of using Google Earth and the Kinect device to navigate around by gesticulating or voice control.
Similar applications has been done with Kinect on a normal reflective canvas. The video 'Kinect + Google Earth!' (Lambremuse 2011) shows an example of how a person simply navigates around Google Earth by using his hands in different positions to generate the commanding acts. In addition to commanding by gesticulation, one could also use the speech recognition that Kinect is equipped with to make command. There are benefits and disadvantages of using Google Earth on a Fogscreen. The benefit is definitely the experience of navigating by gesticulation. The downside is the poor image resolution.

Google Street View
One of the most interesting elements of Google Earth is Street View and its quest of providing detailed images from all over the world. Unfortunately, the Fogscreen correspond badly to detailed images. Google Earth works excellent on a standard canvas, or any fixed-screens. The Fogscreen is not a high-resolution display, thus not an optimal display for such detailed images. The typical Street View images are dominated by natural colors, and desaturated colors. The Street View images have a lot of small details that would be challenging for a Fogscreen to display properly. All in all, Street View images are horror example for such screen. But there is one major factor to consider before tossing away the idea. Though the image quality is poor, the overall experience, both mentally and physically, is quite rich considering the fact that you are navigating around the world with the palm of your hands on an immaterial screen. By looking at it from this perspective, perhaps people are willing to sacrifice some amount of quality in return for an extraordinary experience that is more entertaining and fascinating than a normal screen could ever be, regardless of the high image resolution.

THE ECONOMIC ASPECT

In this application example, the situation is different than the Norwegian Opera House and Ballroom. The Science Center already owns a Fogscreen that is well installed, thus there will not be any acquisition costs. However, if the Science Center wants a “renovation”, there are some costs related to application development and facilitating the environment for the device.

Acquisition Cost

Projector	kr. 12 000
Kinect device	kr. 1 500
Game application development	kr. 10 000
Spare part (sensor)	kr. X
TOTAL COST	kr. 23 500+

REVENUE

If the Science Centrer succeeds in developing this application concept, they will be the only company in Norway to possess an interactive Fogscreen. Other immaterial screens on the market are Heliodisplay and Displair (prototype), and none of them has come to Norway yet. The Science Center in Gjøvik would also be able set an example for other science centers in the country and internationally.

4.5.4 SUMMARY OVERVIEW FOR APPLICATION POSSIBILITIES

The topics deliberated for each application site can be summarized in an array table for the purpose of seeing the overall picture and see the interaction between the elements for each application concept.

APPLICATION SITE	FUNCTION (Purpose)	ENVIRONMENT (Light condition)	CONTENT	SPECIAL FEATURE	INSTALLATION
OPERA HOUSE	Attraction Information distribution/ information board	High light condition (daylight/bright surroundings, open installation)	Information, text, images, video teaser, advertisement		Permanent installation in the foyer
BALL-ROOM	Attraction, entertainment, entrance Promotion, branding, advertisement, marketing, product launch, exclusivity	Medium light condition (evening/ colored light effects)	Visual effects, text/logo, graphic, 3D simulation, image, video	Two-sided projection display	Permanent installation, but content and context changes for each event.
SCIENCE CENTER	Entertainment, gaming, educational purpose, practical function	Medium/ no light condition (dark room)	Text, graphic, illustration Game alternatives: “Walk-through-wall” “Google Earth navigation”	Interactive touch screen by using Kinect technology.	Permanent installation

Figure 4.16 Summary overview for application possibilites

Chapter 5
REFLECTION

5. REFLECTION

Now that the device has been characterized and some examples of application possibilities have been presented, it is necessary to reflect on some factors from both a technical and an application perspective.
This section focuses on the findings from previous chapters and provides awareness on important issues concerning the viewing experience of a Fogscreen.

5.1 SUMMARY OF THE TECHNICAL AND THE APPLICATION ASPECT

The relation between the results from the measurements is considered due to the application aspect. The results of this summary are arranged in this table for an overview of the most significant factors that have an impact on the viewing experience on a Fogscreen. Additionally, the content is reflected in detail in the following section.

	Technical Limits					
	Installation	Dripping	Device Gamut	Light Conditions	Transparency	Uniformity
Application Considerations	Adjust set-up to avoid direct eye contact with projector light	Use carpet on the floor beneath the screen or build drainage system for more permanently result.	Customized content creation - consider the limited gamut volume for output device.	If possible adjust light source, or use a projector with higher luminance.	Use this as a visual effect by creating illusion of objects floating in the air, or avoid transparency by using high-saturated colors.	Locate detailed objects in the upper area of the screen to obtain higher resolution.

Figure 5.1 Array overview for technical limits and corresponding application considerations

5.1.1 INSTALLATION SET-UP

As seen in section 1.6, there is a general guideline for the installation requirements. At this moment, this thesis has no foundation for recommending other set-up methods for improvement. However, there is one factor that improves the viewing experience for the human observer. Because the Fogscreen technology is based on a rear-projection system, the projection light behind the screen is aimed directly towards the observer's eyes, causing irritation for the eyes. This problem can be solved by angling the projector in a certain degree, depending on the location and type of installation, to avoid hot spot to the observer's eyes. This way the Fogscreen will be much more viewer-friendly.

5.1.2 LIGHT CONDITIONS

Three different light conditions were tested in the measurement experiment in order to determine how they affect the image projection. Not surprisingly, the appearance of color is much better with darker surroundings. If the environment allows it, the surroundings should be darkened to obtain better image appearance. Facilitating the viewing condition for the Fogscreen depends entirely on the application site. In some cases the light conditions are easily adjusted, and in other places other activities in the room depend on a certain, challenging the display. Although darker light conditions provides a better image projection, there are settings where brighter surrounding can be an advantage, for instance when creating visual illusions of floating objects.

5.1.3 PROJECTOR ILLUMINATION

The projector type used in the Fogscreen set-up is a crucial element. There are application sites where the light conditions cannot be adjusted, in which case, a "stronger" projector must be used to compensate for the bright surroundings. These are the recommendations from the manufacturer for the projector's luminance (FogioOy 2004).
For no/minimum light conditions, the minimum recommendation is 3,500 ANSI lumens.
Low light conditions such as Ballroom, stages, or sheltered installation at trade shows requires minimum 5,000 ANSI lumens. For high-light conditions such as the Opera House, minimum 7,500 ANSI lumens is required. It is important to note that the strongest projector will give the best image projection. However, stronger projectors are more expensive.

5.1.4 TRANCPARANCY

Because of the thin layer of fog, the display appears completely transparent from distance. It is only when standing right next to the screen that you will see the fog. In a practical understanding, this means that the transparency is a curse and a blessing. The disadvantages of the transparency were discussed in the subjective assessment in chapter 3. The transparency occurs when the displayed image has dark colors and the light conditions are bright. The areas of the image that withholds dark colors appear transparent, allowing objects behind the screen to blend in. The result might seem disturbing. Then again, there are examples of application cases when transparency is preferred to create certain visual effects. The illusion of objects floating in the air is one of the advantages of transparency. The illusion is created by using an image with objects on a black background. The black area of the picture generates the transparency, while the main object in the image is highlighted.In conclusion, the transparency provides both advantages and disadvantages. The disadvantages can be avoided by selecting proper content that suits the specific location and environment.

5.1.5 THE OPTIMAL IMAGE

Based on the findings from the experiment in chapter 3, we have acknowledged that a set of elements can optimize the image projection. These elements are divided into *image composition* and *image attributes*.

I Image Composition

Due to a lack of uniformity on the screen, detailed graphics and the main object of the image should be placed in the upper area of the screen where the best resolution is found. For instance, the facial area of a person should be orientated towards the upper area. It is very important that the main object(s) in the picture has a certain size to obtain clear visibility. There should only be a few large objects in focus and not too many small details in the picture.

II Image Attributes

For an optimal image projection, the following attributes should be used as a checklist before selecting or creating content for a Fogscreen-device.

- **Contrast** – the image should have well-defined contrasts.
- **Saturated colors** – bright, high-saturated colors give the best appearance, while desaturated and dark colors are less visible for the observer.
- **Color contrast** – There is a need for significant color contrasts between the objects in the image in order to increase the visibility, as seen in section 3.5.2 for optimal image.
- **Sharpness** – because of the turbulent projection surface, it is important that the original image is sharp, and the object in it has well-defined edges.

III Text

As discussed in section 3.5.5, there are guidelines for presenting text on a Fogscreen. Due to uniformity issues on the screen, it is very important that the size of the letters increase the further down they are placed.

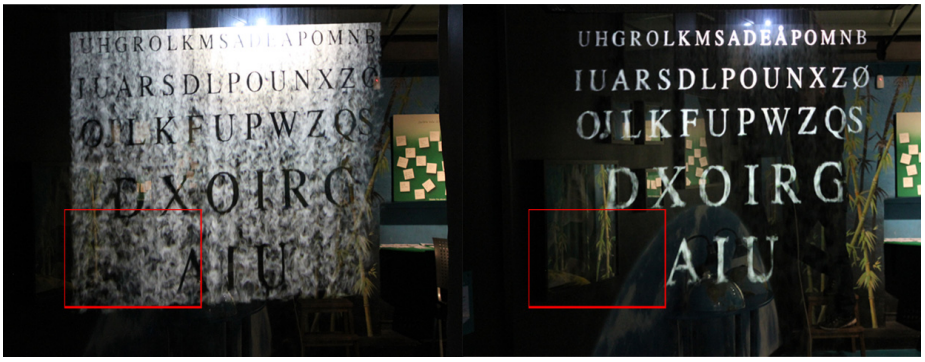


Figure 5.2 Difference between black and white background. White background highlight the grainy surface, while black generates transparancy

A display of white color highlights the fog structure as it falls down at the grainy surface. By placing text on white background it will reduce the visibility of the letters, as the content becomes difficult to read. On the contrary, white letters placed on a black (or dark colored) background results in better visibility and is more reader-friendly for the viewer. The same principle goes for displaying logos.

IV Context Consideration

Considering the context and environment in which an image is displayed is significantly important. Though some image compositions may look poor at one application site, it might be an excellent choice for another application concept. For instance, white background was determined to be a bad choice in the previous paragraph, but for another application concept, white background provides outstanding visual effect.

As seen in Figure 5.3, a Fogscreen is used as the entrance for the players in the opening ceremony of a hockey game. Using white background over the ice creates a powerful visual effect; therefore, a white background in this case is preferred instead of black background. In conclusion, an optimized viewing experience depends on the environment at the application site. Some image compositions might work excellent at certain locations, but function poorly in other places. The subjective evaluations in the process of designing application concepts are important when considering optimal image projection.

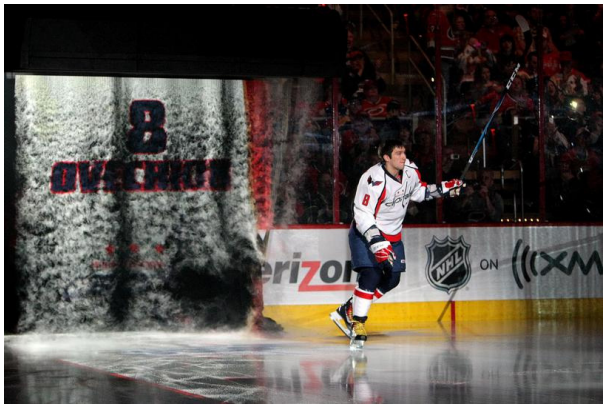


Figure 5.3 Fogscreen at NHL All Stars 2011 - Photo: (FogScreen 2011)

V Special Features - Optimizing the Experience

In this thesis two special features were presented as an act of optimizing the experience for the viewer.
The application possibilities of Fogscreen are countless, and special features can be added to optimize the viewer's experience. The Fogscreen can be used as a two-sided projection screen by placing projectors on both sides of the screen to display different contents on each side. The purpose of a two-sided projection screen is to utilize both sides in situations where people have access to both sides of the screen. This way the screen gains efficiency in terms of content display. The other special feature presented in this thesis is connecting Kinect for Windows to interact with the content. This feature increases the application possibilities even further. At present time, the smart TV trend is rising. The Samsung smart TV operates by gesticulation to manipulate the content (Samsung 2013), not so different from the example presented in section 4.5.3 for the Science Center. Though the principle is basically the same for both smart TV's and an interactive Fogscreen, the main difference is that the Fogscreen addresses to a larger group of people, and the viewer can walk through the screen. Both special features that are presented in the thesis improve the viewer experience by increasing efficiency of the display, and involving the viewer to interact with the content.

5.2 IMPROVEMENT OF FOGSCREEN MANAGEMENT SYSYTEM

A proposed system of Fogscreen management was constructed in this thesis for the purpose of improving the viewing experience. The scheme consists of managing the following aspects of a Fogscreen device; technical, content, application concept and the functionality/usability. The system was constructed with the research question in mind, and therefore has the potential of improvement by adding further elements.

5.3 COMPLETING THE COLOR MANAGEMENT LOOP

Initially, this thesis presented The Three Cs of color management in section 3.1.3, consisting of calibration, characterization and conversion as seen in Figure 5.4. During the measurement experiment, the Fogscreen device was calibrated by adjusting parameters for light conditions, fog density and fog flow, which led to the characterization part. A set of color samples were sent to the device and the spectrophotometer recorded the response. The information of the device's behaviour was stored in the profile. In this thesis twelve profiles were generated, whereas three of them was used as reference data. Each profile belongs to a certain calibration setting. Conversion is the final step in order to complete the color management pyramid. As the objective measurement results showed us in section 3.4.3, the color gamut volume for a normal reflective canvas is almost twice as a Fogscreen gamut volume. In practice understanding, conversion is about moving one color space (e.g. AdobeRGB from input) to one of the Fogscreen color spaces (e.g. Fogscreen low-light profile). By converting the input color gamut into the output/destination color space, we are able to predict the color appearance and take necessary action to increase the accuracy of the color reproduction on the destination device.

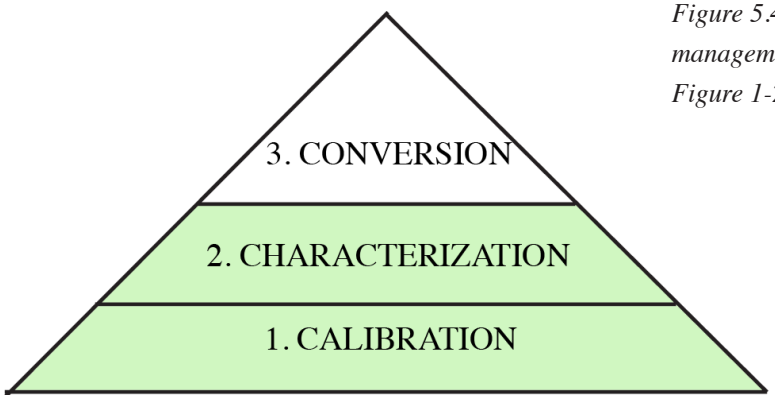


Figure 5.4 – The three steps of color management. Figure created after Figure 1-21 in (Sharma 2004)

Soft proofing is used for digital printing to predict how the print media viewed on a digital monitor will look like on paper. Assigning the printer's profile to the image in Adobe Photoshop or Adobe InDesign easily simulate the print media. Instead of the printer, soft proofing can also be made for the Fogscreen as a destination source before the actual conversion. An image can be soft proofed for a Fogscreen device by assigning one of the profiles that is already made to simulate the destination color space. This way, the color appearance is in some degree predicted. The critical point in soft proofing images for the Fogscreen on a digital computer monitor is that factors such as transparency, uniformity and fog structure will not show, thus an accurate soft proofing can never be achieve

5.4 IMAGE QUALITY

The definition of image quality is complex since several attributes are included.
Some of the attributes included in image quality are sharpness, contrast, noise/grain, exposure accuracy, and color accuracy. This thesis does not go into this field of study of image quality because of the delimited research area, however, some literature work can be recommended for those interested;

- Z. Wang and A. Bovik, Modern Image Quality Assessment (Z. Wang and A. Bovik 2006)
- J. Y. Hardeberg and S. Skarsbø, Comparing Color Image Quality of Four Digital Presses (J. Y. Hardeberg and S.Skarsbø 2002)
- S. Yendrikhovskij, Image Quality: Between Science and Fiction (S. Yendrikhovskij 1999)
- M. Pedersen, Image Quality Metrics for the Evaluation of Printing Workflows (M.Pedersen 2011)

Image quality is a way of measuring the characteristics of an image based on a set of attributes and is usually measured by comparing the selected image to a reference or an ideal image. There are two methods for image quality evaluation.

1) **Objective metric-based approach** – calculating numeric deviation between a selected image and an ideal reference. (M. Pedersen 2012)
2) **Subjective assessment** – using a psychophysical evaluation approach. (M.Pedersen 2012)

It is no surprise that both the objective color measurements and the subjective image assessment showed that the image appearance on the Fogscreen is poorer than on the reflective screen. Taken into account that the images are displayed on fog, we must acknowledge that HD quality can never be achieved because the Fogscreen is first and foremost an effect-screen, not a high-resolution display. Therefore, the aim of this thesis has not been to improve the image quality, but rather to adjust and facilitate the elements in the environment to improve the viewing experience based on the device's basic performance and characteristics.

5.4.1 IMAGE QUALITY VS. VIEWERS' EXPERIENCE

Once we have acknowledged the limits of image quality, it is important to point out that a Fogscreen provides application features beyond what a normal fixed screen does. The Fogscreen is exclusive and therefore an excellent product that catches the audience's immediate attention. Viewing content on a Fogscreen compared to on a normal screen is different because the Fogscreen address to the observer's emotions, and makes them feel curious, excited, enthusiastic, and captivated. The subjective perception will, to some degree, remove the self-generated expectation of high image quality. In other words, the special features that are assigned to the Fogscreen will compensate for the lack of image quality when we compare to normal fixed screens.

5.5 BUSINESS MATTERS

The business aspect is a crucial topic, although it has not been presented in details because of the delimitated research area in this thesis. Fogscreen implementation is not possible if the business aspect is not considered properly. With 'the business aspect' we mean costs that are related to the implementation process, and the potential income as a result of the investment. Ideally, a business model should have been a part of the application concepts presented in chapter 4, but this thesis focuses on the viewing experience and less on the implementation process, thus business model is not included. However, a sufficient calculation of acquisition cost and potential revenue as a result of the act has been included in the application examples for the Opera House and the Science Center.

Fogscreen products are suitable for companies who have the investment capital, and in addition are innovation-orientated with an eye for detecting revenue as a result of implementing innovative solutions. Implementing a Fogscreen requires a lot of money, time and human resources. Therefore, the companies must strategically plan for how they can achieve increased revenue by implementing such innovative product in their business (Osterwalder 2008). For some companies, revenue as a result of innovative implementation is obtained in terms of cash flow, return on invest, and cost avoidance. In some cases, revenue is a result of an act that has led to profiling the company, image building, increasing their market value, or gained attention in the media (which leads to increased visibility in the public). Even though it has not been focused much on the economical perspective in this thesis, it is important to know that the business aspect is vital in connection with the Fogscreen and its application possibilities.

5.6 CONCLUSION

In the thesis we have worked to find reliable answers to this research question:

How can we optimize the viewing experience when both technology and application are considered?

Fogscreen is first and foremost an effect-screen, not a high-resolution display. Although we acknowledge that image appearance on a Fogscreen is poorer than on a normal fixed screen, a set of activities can optimize the viewing experience based on considerations of the technology and the application aspect.

Technology: The characterization of the device has resulted in defining the screen's performance during different viewing conditions. Facilitating and adjusting the environmental light conditions can optimize the screen's performance. Projector and installation set-up can be customized for a particular location in order to obtain improved image projection.

Application: Where technology sets limits to the screen's performance, creative application concepts can be used to compensate for the lack of image quality. Adding special features, like integrating Kinect-technology to obtain an interactive display where people can walk through the screen, will optimize the viewer's experience.

By knowing all the sensational factors a Fogscreen provides compared to a normal fixed screen, people might be willing to sacrifice some amount of image quality in return for an extraordinaire visual experience.

5.7 FURTHER RESEARCH

It is the first time an academic paper has been written about the Fogscreen at GUC, which is why this thesis has been focusing on the general aspects of the device and not gone into minor details. Because of the limited research area, there are still many questions and elements that would be interesting for examination. In hope of engaging other student's interest in this field, a list of suggested areas are presented for further research.

Connecting Kinect-device to Fogscreen

The application concept for the Science Center in section 4.5.3, this thesis presented the initial steps of integrating a Kinect-device to the Fogscreen in order to generate an interactive screen. The basic steps of testing content for such an application provided successful results in terms of acceptable image projection. The next steps of this process would be to connect a Kinect-device to the Fogscreen and generate the actual interaction. The ideal outcome is that the Science Center will possess an interactive Fogscreen, as one of the first companies in Norway.

Future Display Technologies

Initially, in section 2.1, overviews of 2-dimensional non-fixed screens were presented consisting of Heliodisplay and Displair. For those who are especially interested in the topic of new display technologies, Displair (Displair 2013), Heliodisplay (iO2Technology 2013) and HoloDesk (Nosowitz 2011) are additional products to be aware of, as they will become more applicable in the market in the years to come.

Application of Modern Displays in the Norwegian Market

Due to the limited research area, additional survey regarding the market potential for such products has not been done. Still, there is a need for an investigation to figure out why only a few companies in Norway are aware of these display products. A market survey could provide reasonable answers to this question. It is important to discuss whether there is a need for such innovative device. The business and economic aspects should in addition be studied and discussed in order to strengthen the arguments concerning the research results.

Chapter 6
EVALUATION

6. EVALUATION

This evaluation reflects on the execution of the project and points out important elements of the process. The evaluation serves the purpose of determining whether the goal achievement is reached.

6.1 PROJECT WORK

The topic of this thesis was a continuation of a previous project that I worked on last semester, therefore, the topic has been known to me since October 2012. In a period of 7 months I have studied the Fogscreen-device both theoretically and in practice. The fact that I was given access to the device at the Science Center in Gjøvik gave me the benefit of exploring the device to a greater extent than I had anticipated in the beginning of the project. Consequently, this thesis has been able to cover the topic in a wide scope. Still, the thesis has focused on general aspects which makes is possible for other students to continue the research and even be able to dig deeper into details. This thesis can only serve the purpose as a foundation to further research if it is easily accessible, thus a proper website has been created to present the topic in an attractive way.

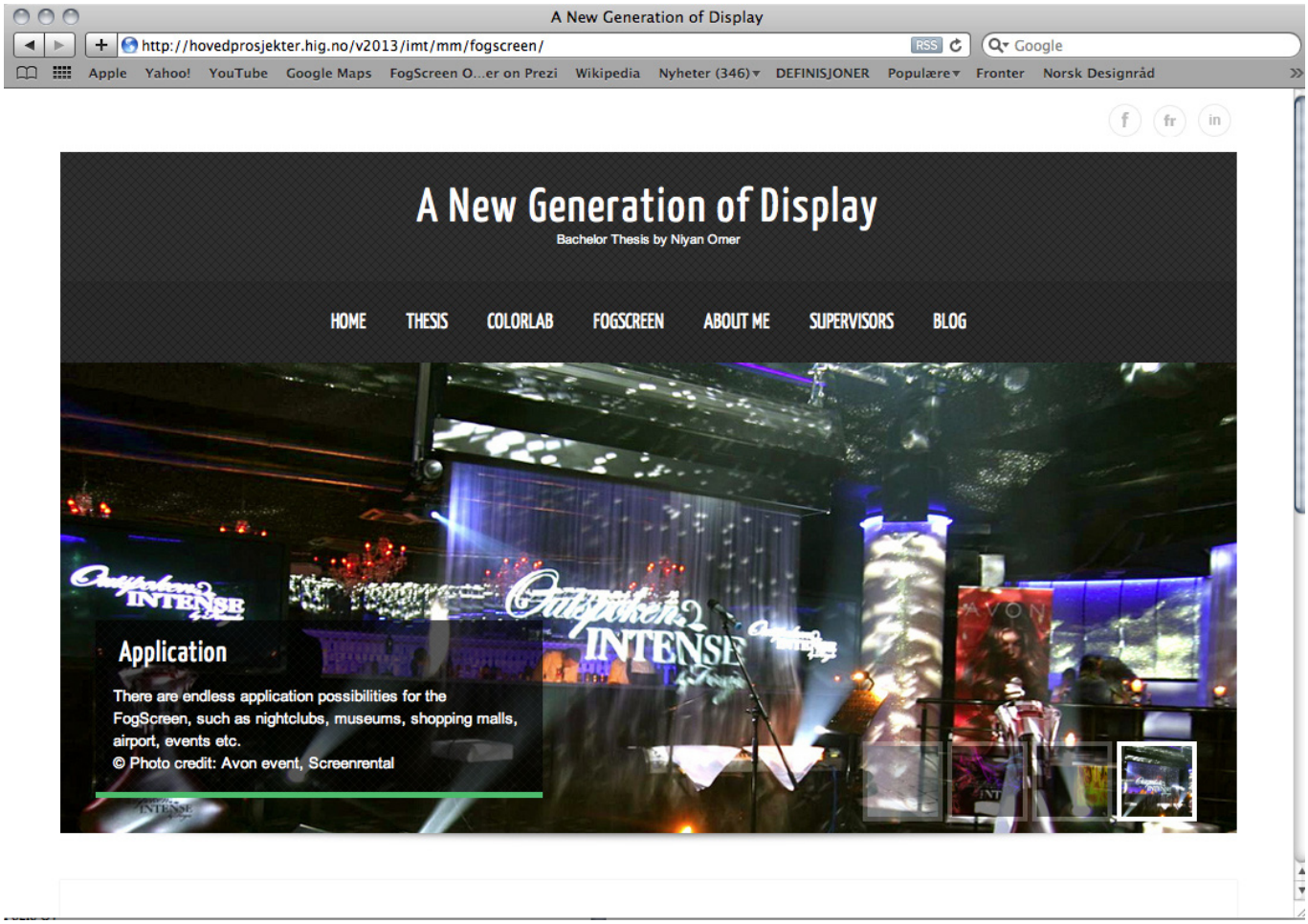


Figure 6.1 – Screenshot of website for the bachelor project

6.2 ACHIEVEMENTS

The goal with this project was to accomplish the following tasks by the end of the process:

- Define color gamut for the device based on objective color measurements
- Determine the factors that optimize the Fogscreen viewing experience
- Suggestions for innovative application possibilities for Norwegian companies, when both the technical aspect and the environment (application) are considered.

Now that the project has ended we can conclude that all of the three goals have been reached. Color gamuts for the calibration settings were defined in chapter 3 as a result of the measurement experiment. The thesis has provided concrete suggestions for optimizing the viewing experience. Finally, application concepts were designed for The Norwegian Opera House, Ballroom, and the Science Center based on the device's performance and consideration of the environment/ location.

The aim for the learning outcome has been to:

- Gain more expertise in the field of color management and modern display such as the Fogscreen.
- Improve my skills in writing academic papers.
- Use a combination of the skills I have gained during the courses in the bachelor program for Media management in order to succeed with this project.

It was a personal goal to gain expertise to manage both the technical and the business aspect of the Fogscreen. After processing this project I feel confident about managing the Fogscreen from a technical perspective and an application/ business perspective. This project has given me expertise in a specific field that will make me an important asset for those companies who desires to implement such products. Also, I am now more confident in writing academic papers than I was at the beginning of the project. The scope of the research area and the extent of the project made me dependent on knowledge from all the courses in my study program. The courses have been an important foundation for this project and its outcome.

6.3 COMMUNICATION AND FEEDBACK

Throughout this project I have had weekly supervision meetings. During the meetings current materials has been presented and then I have received feedback. To include both of my supervisors, Skype were used to connect with Jean-Baptiste Thomas in France, while Peter Nussbaum and myself were at GUC.
The supervision meetings were very helpful during the process and for the final outcome of the project.
There have not been many formal meetings with the employer. Since Peter Nussbaum is also a representative of the ColorLab, frequent meetings with employer haa not been necessary because of the regular supervision meetings during the whole process.

Fogio Oy, the manufacturer of Fogscreen located in Finland has been an important collaborator in this project as they have provided us with important information about the device. Esteban Carrizo, sales manager at Fogio was contacted in October 2012 and since we have had frequent contact via email. The project was formally presented to them during a telephone meeting whereas my supervisors and an addition member of ColorLab were involved.

6.3.1 DOCUMENTATION

Because I worked alone on this project, it was not necessary to log about every step of the way. Also because of the weekly supervision meetings, I didn't find it necessary to write a log book for this project. Instead I have written status reports once in a month, which is attached as appendix B. Still, documentation is very important for all type of projects, if not especially important to this bachelor project, since the aim of the thesis is to build a foundation to further research. Therefore I have bloged about interesting findings from the process on the project's website so it will be available for other people.

6.4 JUSTIFICATION

I was aware of the risk of choosing the structure of this thesis. Combining the two major aspects, technical and application, might seem very distanced and confusing for the reader. However, I sincerely believe that both aspects are equally important to consider, as they have significant impact on each other. Because of the research question, there was a need to combine both aspects in order to reach a credible conclusion. Now that the project has come to its end, I have no regrets with choosing this type of structure for the thesis. After all, a Media management student should know how to manage both aspects.

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APPENDIX

A.
PROJECT DESCRIPTION

FOGSCREEN- A NEW GENERATION OF DISPLAY

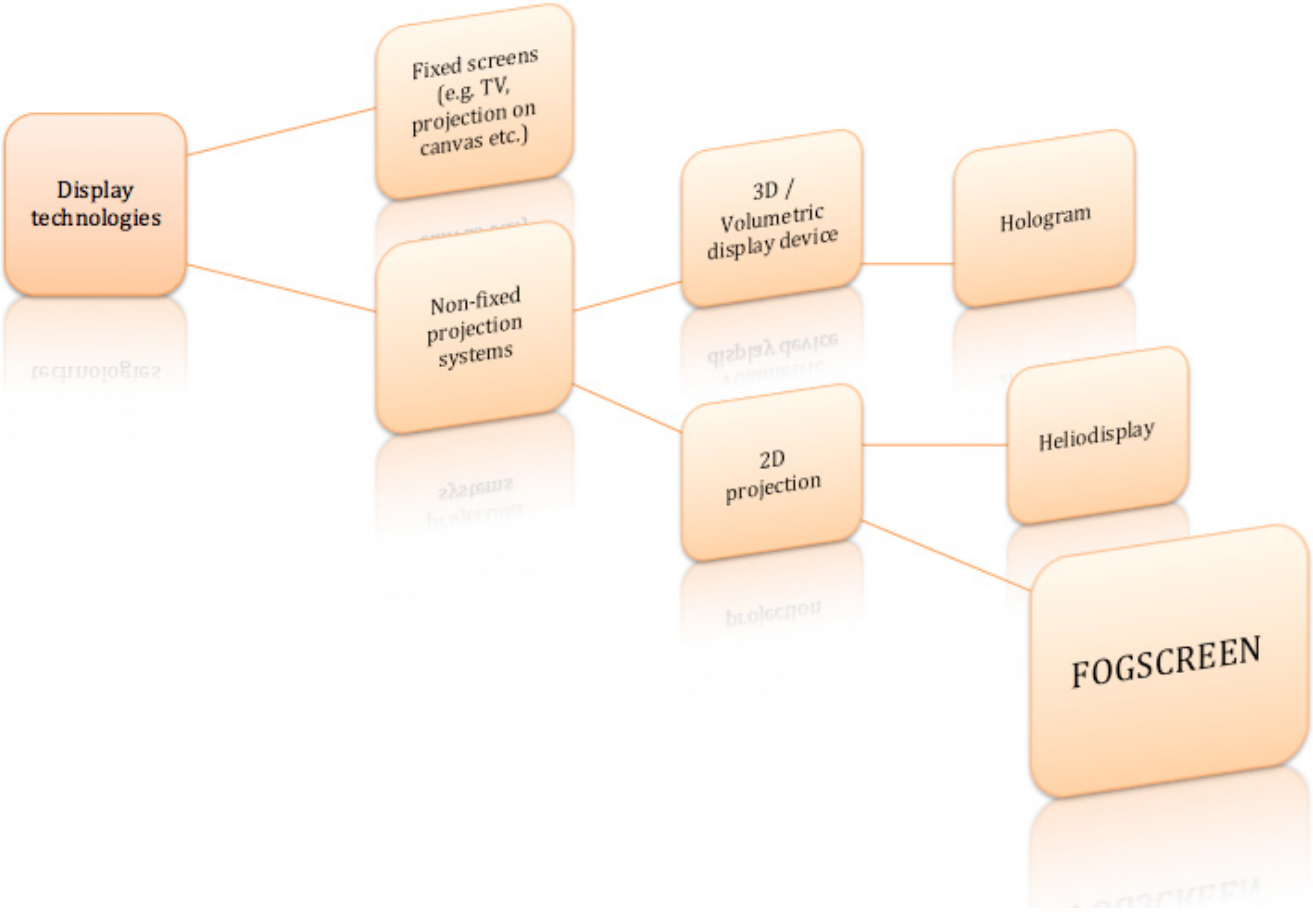
PROJECT DESCRIPTION

NIYAN OMER /100992
10HBMEMA
January 28th 2013

CONTENTS

INTRODUCTION

The topic for the bachelor project was mainly a choice based on my personal interest for modern display technologies. Development of display technologies has grown tremendously in recent years and it is always interesting to know what's next. From the perspective of a Mediamanagement student, it's even more interesting to see how the market acts as new technologies are continuously developed. There's almost no advantages in high-modern devices if people are not aware of its existence or if they can't use it properly.
I believe we are in a new technological trend where non-fixed screens will be more commonly used as medium channel. As this trend grows, and more people implement a more complicated type of screens, it's even more important to have knowledge about colour management for such devices. Colour management for non-fixed screens are more advanced because one has to take several factors into account for an optimized image projection.



EMPLOYER

The Norwegian Color Research Laboratory is a research group within the Faculty of Computer Science and Media Technology at Gjøvik University College. It was founded in the spring of 2001 to serve the rising needs for colour management solutions in the graphic arts industry. Since its foundation, the scope of interest has grown to cover colour science, colour imaging, and image processing in a broader sense, and their vision is to be one of the best research groups in this field(colorlab 2010).

COLLABORATOR

Other collaborator for this project is the Finnish company named Fogio Oy.
Fogio is the only official manufacturer of FogScreen® projection screens. The original inventors of the technology and a team of business people and technicians run the company. Fogio own multiple patents on the product and also the trade mark for FogScreen walk through magic® (Fogio 2012).
I've had regularly communication with company representatives for months, and so far the collaboration has been very good and helpful. I am looking forward to further collaboration.

PROJECT DESCRIPTION

FogScreen is a patented display-technology based on projection of pictures and videos in the mid air. This allows people to walk through the screen without damaging the screen, or being exposed to any chemicals. FogScreen creates a thin curtain of dry fog to project the images. This kind of displays gives endless opportunities for a commercialized approach towards audience in shopping malls, airports, museums, nightclubs etc.

Research question:
How can we optimize the viewing experience when both technology and application are considered?

METHOD OF APPROACH

The thesis is split in two main perspectives: a technical and an application review.

The technical aspect:

Literature studies on FogScreen, colour management and projection systems.
Research based on scientific measurements and subjective evaluation of image reproduction.
Quality of use/ viewing experience will be evaluated by measurement experiment.
Analysis of results will then give us an answer on how the viewing experience can be optimized. The important outcome of this analysis is to know how we can facilitate the conditions and the environment to obtain the best possible image reproduction.

The application and management aspect:

Literature studies on marketing, value of advertising and business innovation.
Reflecting on - market development/ market trend
- managing a modern media channel
Business innovation: proposal of FogScreen implementation to select companies/ venues.
Site surveys to consider the environment for placing the FogScreen in a particular room.

AIM FOR PROJECT'S RESULTS AND OUTCOME

The following should be accomplished by the end of the project:

- Generate color gamuts for the device based on objective measurements
- Determine the factors that optimize viewing experience on a FogScreen.
- Suggestions for innovative application possibilities for Norwegian companies, when both the technical and the economic aspects are considered.

Aim for the outcome in long term

- The bachelor thesis will be basis for further research by other students at GUC
- Hopefully this project will lead me to further collaboration with Fogio Oy.
- In present time there are no Norwegian companies who have implemented the FogScreen as a permanent installation. After this project I will gain solid knowledge in this field that could give me job opportunities with companies who consider investing in this product.

Learning outcomes

- Gain more expertise in the field of colour management and modern display systems
- Improve my skills in writing academic papers
- Use a combination of the skills I've gained during the course of studies to manage this project.

DELIMITATION OF THE PROJECT

FogScreen is a new topic at GUC, and there are so many elements that would be interesting to do research on, but some priorities must be made. I am a Mediamanagement-student and of course my perspective of the topic will be a combination of a sufficient technical-part and the other half will be based on application possibilities.
Due to limit of time and advanced technical knowledge, a selected set of elements of the FogScreen are chosen for research. Other major questions regarding the device may be solved if other students at GUC will continue the research.

STRUCTURE & ORGANIZATION

Individual project work

It was in the nature of the task, also my preference, to work individually with this project.
This means I'm solely responsible for conducting every part of the project.
Where others have group rules, I have unofficial policy for what I think is the best discipline for my own work methods. Working individually gives me more freedom in work methods and allows me to use my own work routines. I have experience working individually on several other major projects, therefore I am confident about the work structure for this project

Workspace

Because of overloaded workspace at GUC, my workstation will basically be at my home office, but also at group room and the library at GUC. For the sake of variation I plan to work in places such as Gjøvik's public library and NO3. It is important, especially when working individually, to talk about my project to fellow students to generate new inputs and ideas by revealing some of my findings. In this way I'll avoid losing sight of the bigger picture of the project, as people easily develop a selective perception of matters. Regular work days will be Mondays, Tuesdays, Thursdays and Fridays.

RESOURCES

Even though I am working individually, there are other parties involved in the project.

Key persons from Gjøvik University College

Supervisor - Peter Nussbaum, Associate professor, PhD

Supervisor - Jean-Baptiste Thomas, Associate professor, PhD

Jens Barland (Associate professor, PhD) will occasionally be my advisor in the field of media management and business innovation.

Representatives from Fogio Oy

Esteban Carrizo has been our contact person, especially in the field of sales and information.
Production Manager, Muntadar Altake, will be our contact person during the measuring experiment in Finland.

Trip to Finland

In order to solve the research question I must have access to the device. Due to that reason I must travel to the FogScreen manufacturer in Finland and conduct colour measurements of the device. This part of the project is the most cost-bearing activity, but also the most essential part.
An application for refund of the travel costs has been sent, but I must travel regardless of the outcome from the application.

Research trip to Fogio Oy in Helsinki, Finland	
Budget entry	**Price**
Flight	900 NOK
Hotel	2000 NOK
Transportation (bus and taxi)	1360 NOK
TOTAL	**4260 NOK**

DOCUMENTATION & BACK UP

Every activity should be documented from day one, such as text, pictures, web-links etc.
It's important to take as many notes as possible during the process and not wait with the writing till every test and measurement is finished. It will be easier to make good reviews when data is not forgotten. Besides personal notes, there are some documents to coordinate during the process.

Formal agreements:

- Project agreement between employer and student - must be signed by 28th of January.
- Publishing agreement between author and GUC/ library

Documentation during process

- Monthly status reports mainly for communication between supervisor and myself.
- The master file which contains all information and research during the process.
- Website – Blog regularly and share thoughts on current topic in the process and use image, videos and links for better communication. The purpose is for outsiders to keep up with my work during the process, and also after the project is ended people can look up and perhaps use it as reference to further research. The website should give a positive impression.

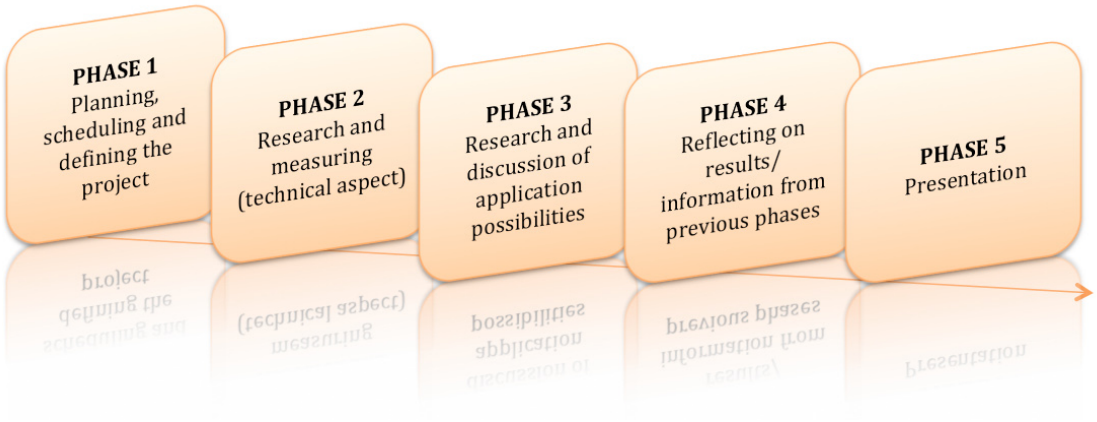
Structure for status reports

Status reports will be written at the end of each month to orientate the supervisor about the progress. The status reports will also be a tool for me to control that my progress is according to the schedule.

BACK UP SYSTEM

All content for the bachelor project are saved in common a folder and are directly linked to my Dropbox account. Meaning that every change I do to any of the files will be synchronized continuously and automatically. There are several advantages using this structure; firstly all of my files will be backed up online. Secondly, the files will be available to me on other devices (e.g. my iPad and cell phone), and I can easily share access to latest version of my documents to those who are going to follow up the process. Besides backing up online, I will weekly save all content on an external hard drive.

SCHEDULING



Phase 1. Planning, scheduling and defining the project

I have known the topic of the bachelor project since October 2012. Since then, I've already finished some of the planning and the delimitation regarding the project's content. There have been tasks such as:

- Planning the procedure of the project, such as detailed scheduling and budgeting.
- Sign necessary contracts and agreements (project agreement with GUC)
- Establish work structure and system.
- The project's website has to be uploaded during February.

Phase 2. The technical aspect - research and colour measurements

- Study and search for information about FogScreen.
- Create a plan for the measuring experiment.
- Do literature study in the area of colour management and projection systems.
- Lab-session with supervisor to exercise on the measurement procedure.
- Prepare test-contents for the measurements
- Plan a trip to Finland to run the tests and measurements.
- Analyse and discuss the results from the measurements.

Phase 3. The application aspect

- Do literature study for the management-part of the thesis such as: *marketing, advertisement, economy and management*.
- Search for application possibilities (e.g. Norwegian Opera House, hotels, malls). New and innovative application possibilities are preferable (e.g. using the interactive feature for gaming or drawing, as information board at airports, malls etc.).
- Site survey (if possible), visit places where it would be likely to install the FogScreen and consider the environmental settings.
- As a result of the site surveys and previous measurements, discuss how to optimize the viewing experience.
- Discussing implementation of a FogScreen applies not only to colour management, but factors such as economy and marketing value plays a huge role when companies consider investing in this product. Investment costs should therefore be seen in relation to the benefits the company will gain. These factors need to be included when we're reviewing application possibilities.

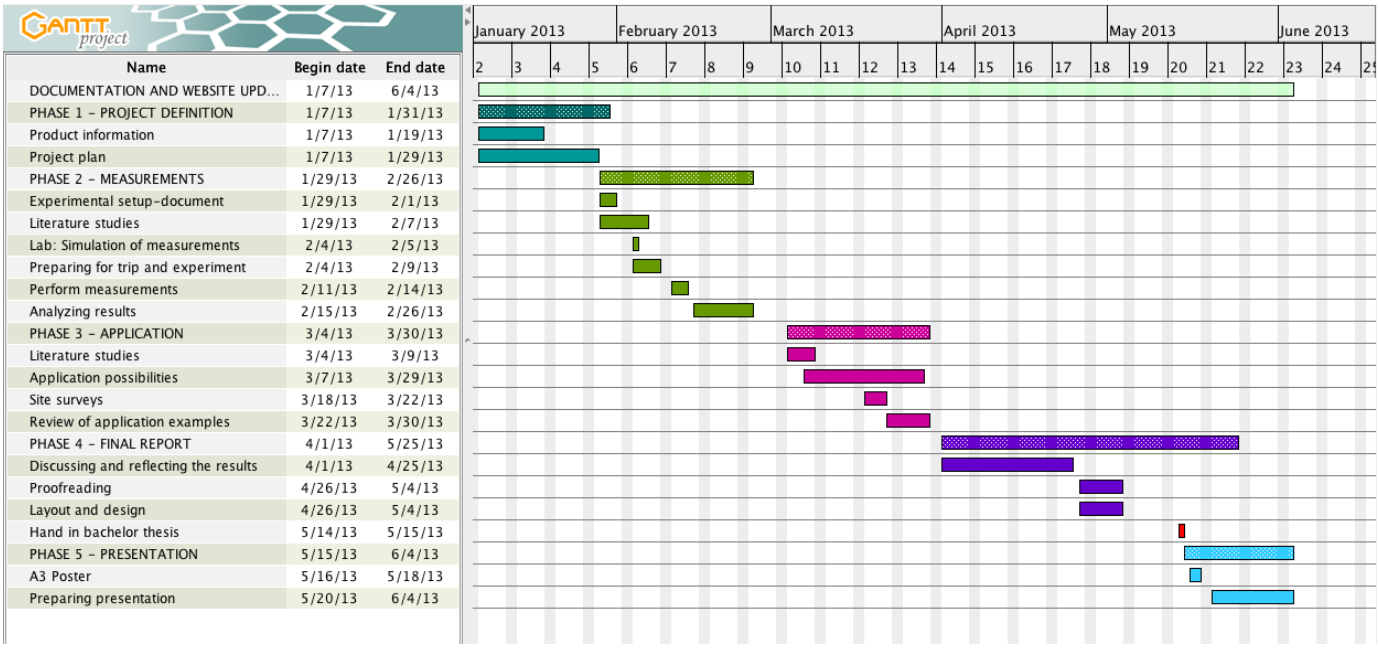
Phase 4. Writing the final report

- I'll reflect and discuss the results and thoughts from previous chapters on measurements and application possibilities. The intention is to work towards a conclusion and give a concrete answer to the research question.
- The first version of the thesis will be sent for proofreading.
- Create an attractive and interesting concept for layout and design for the PDF-file.

Phase 5. Presentation

- Design an A3 poster for the project. It should have the same design-concept as the report.
- Prepare for presentation.
- Invite guests for the presentation. The invitations should be sent 2 weeks in advance.

The phases and the tasks are summarized in the GANTT-form below.



Name	Begin date	End date
DOCUMENTATION AND WEBSITE UPD...	1/7/13	6/4/13
PHASE 1 - PROJECT DEFINITION	1/7/13	1/31/13
Product information	1/7/13	1/19/13
Project plan	1/7/13	1/29/13
PHASE 2 - MEASUREMENTS	1/29/13	2/26/13
Experimental setup-document	1/29/13	2/1/13
Literature studies	1/29/13	2/7/13
Lab: Simulation of measurements	2/4/13	2/5/13
Preparing for trip and experiment	2/4/13	2/9/13
Perform measurements	2/11/13	2/14/13
Analyzing results	2/15/13	2/26/13
PHASE 3 - APPLICATION	3/4/13	3/30/13
Literature studies	3/4/13	3/9/13
Application possibilities	3/7/13	3/29/13
Site surveys	3/18/13	3/22/13
Review of application examples	3/22/13	3/30/13
PHASE 4 - FINAL REPORT	4/1/13	5/25/13
Discussing and reflecting the results	4/1/13	4/25/13
Proofreading	4/26/13	5/4/13
Layout and design	4/26/13	5/4/13
Hand in bachelor thesis	5/14/13	5/15/13
PHASE 5 - PRESENTATION	5/15/13	6/4/13
A3 Poster	5/16/13	5/18/13
Preparing presentation	5/20/13	6/4/13

Overview of milestones

Milestones	
Deadline project plan	January 28th
Project agreement	January 28th
Trip to Finland	February
Create website	February 20th
Sending report for proofreading	April 25th
Deadline final report	Mai 15th
Presentation	June 4th/5th/6th

FOLLOW-UP

When one is working individually, it might be easier to postpone internal deadlines because of the huge amount of freedom one has. For that reason I will be stricter on monitoring the schedule and leave no room for delays during the process.

- On Sundays I will take 30 minutes to orient myself about the process to make sure I stay on schedule.

- In addition, once a week I'll consult with my supervisor on current status and follow up the process ahead. This will be a way to ascertain that I'm working according to schedule.

- At the end of each month (when a project phase ends), I will write a status report to summarize the progress for what is working good/bad, uncertainties or challenges. The status reports will also be a useful tool as a quality control for the work that is done.

RISK MANAGEMENT

Incident	Probability (1-10)	Consequence (1-10)	Measures
Lack of access to device	2	8 Lack of access to device will erase the measurement-part. The thesis's credibility will decrease.	In this case the research question needs to be reassessed. The thesis will be solely based on a subjective assessment and the technical section must be replaced with a chapter of financial perspective.
Wrong measurements / inadequate or incomplete results	5	7 The objective results will be almost useless, but I will still have the subjective evaluation based on personal experience.	Another trip to the manufacture and doing new measurements. This will be a very unfortunate scenario. Another opportunity is to cut off the section regarding measurements and replace that chapter.
Overworked software/ computer shuts down before saving or important data disappears from computer.	2	5 Loss of important information may double my work effort.	The project folder on the computer is directly synced to Dropbox so the content will continuously be backed up online. If the Dropbox fails, the entire folder will be backed up once a week on an external hard drive.
Scheduling: delay in progress	8	7 There is a huge potential for delay on particular tasks or phases because some tasks may require longer time than planned.	This situation can be avoided by being strict on monitoring the schedule and be self-disciplined in relation to my work effort during the entire process. I have a lot experience from this particular situation, but I have managed every time.
Sickness	5	2 The consequence depends entirely on how bad the illness is. A common cold will barely have any impact. A more serious illness can put me out of work for a short period of time.	Stay healthy, and if the illness causes delay in the progress I'd need to work harder to make up for the loss.

REFERENCES

Colorlab (2010). “The Norwegian Color Research Laboratory.” Retrieved 28.01.2013, 2013, from http://colorlab.no/.

Fogio (2012). “About Us.” Retrieved 28.01.2013, 2013, from http://www.fogio.fi/about-us/.

IMAGES

Page 2:
FogScreen (2011). FogScreen @ Spicarium in Bremen, http://www.flickr.com/photos/fogscreen/5683127329/in/photostream/.

FogScreen (2011). FogScreen at NHL All Stars 2011, http://www.flickr.com/photos/fogscreen/5471154230/in/photostream/.

FogScreen (2011). Pepsi event, http://www.flickr.com/photos/fogscreen/5412319919/in/photostream.

Cover:
UKFogscreen (2011). FogScreen Inia, http://ukfogscreen.com/gallery/.

B.
STATUS REPORTS

STATUS REPORT 1 JAN 21ST /2013 14.45

TYPE	Status report for the start phase of the project

PROJECT DESCRIPTION

DISCUSSION	Deadline is closing up. I intent to work on the Project Description/ Project Plan on Monday 21st, Tuesday, and Wednesday. I focus on finish the document before Thursday 24th and hand in to Peter for a review. The final version and the project agreement will be delivered to GUC Monday 28th.
CONCLUSION	It will be hectic period considering the short time to deadline; therefore this task is first priority.

TASKS	ATTENDEES	DEADLINES
Project Agreement	■	24th of January
Project Description	■	24th of January

WORKSHOP AT VITENSENTERET

DISCUSSION	Mail has been sent to Petra at Vitensenteret (Science Center), but still waiting for response though it's been a week now.
CONCLUSION	Have to obtain clarity as soon as possible regarding a potential workshop at the Science Center. Call within next week if the email is still not responded.

TASKS	ATTENDEES	DEADLINES
Contact Petra at the end of the week.	■	24th/25th of January

TRIP TO FINLAND TO CONDUCT THE MEASUREMENTS

DISCUSSION	For now it looks like I have to go to the trip regardless of any potential workshop to conduct the measurements I need. For the moment, it doesn't look like the travel-budget will be cover by GUC. I must plan the measurement experiment by looking into what kind of data that we need and how we plan to obtain this data. The experiment set-up will then be discussed with Product Manager at Fagia Oy before we get a clear signal that the experiment set-up approved. The Production Manager and I have been planning to find a suitable date(s) for the trip. Regarding the measurement experiment, I have begun to plan it. JB, Peter and I had Skype-meeting last week where we determined the experiment set-up. Then I found an installation guide for Pegasuren Inia, and that basically provides answers to our questions. For that reason the experiment set-up must be reconsidered, again.

WEBSIDE

TASKS	ATTENDEES	DEADLINES
I need to determine on content and layout. Then start the producing the website. Short name must be sent to Hilde Bakke as soon as possible.	■	Feb 1st 2013

LITTERATUR STUDIE

TASKS	ANSVARLIG	TIDSFRISTDATOER
As a part of the thesis, literature study is important. I have to review the Abbey Sharma's book about understanding Color Management. Most importantly I have to find literature study on similar projection screens.	■	January 28th →

STATUS REPORT 2 FRIDAY FEB 1ST /2013 12.00

TYPE	Status report for phase 1: Planning and scheduling

PROJECT PLAN

DISCUSSION	The project plan has been one of the main tasks during this phase. Finally it's done and delivered. I'm happy with the result. I think the project plan is a detailed tool for my progress and will keep me on track for the rest of the process. The project agreement was also delivered.
CONCLUSION	Satisfied with the results.

TRIP/ MEASUREMENT EXPERIMENT

DISCUSSION	Measurement experiment: Finally the experimental setup is verified and sent to the production manager in Finland to discuss further issues. I'm completely sure that we need to prepare for changes regarding the setup. But the ideal situation would be if the setup were correct. I'm still waiting for his response. To prepare for the experiment, we have decided to have a simulation setup in the lab with supervisor. I need to collect samples for the experiment such as test-images and determine what type of color patches I have to use. Trip As soon we have decided on a date with the production manager, I'll do the reservations. Hopefully I'll be able to do the measurements during the second or the third week in February. I'm still not sure if we'll do the measurements in Helsinki or Turku.
CONCLUSION	

TO DO/ TASKS	ATTENDEES	DEADLINES
Content for measurements	■	6-10th February
Simulation setup for measurements at the lab	■ and Peter	5th of February
Planning the trip: as soon prod.manager has agreed on a date.	■	20th February

WORKSHOP at The SCIENCE CENTER

DISCUSSION	Petra at Vitensenteret responded to our proposal for the workshop-idea. The exiting part is that they have a so-called "Tapsareen-device". What or how this device works we don't know yet. We have planned to meet them Monday the 4th and we'll finally know where they stand regarding the workshop-idea. Either way, it's very comforting for me to know that I am not depended on the workshop to do my measurements.

TO DO/ TASKS	ATTENDEES	DEADLINES
Meeting with the Science Center	■ and Peter	4th of February
Contact Convertor	■	5th February

WEBSITE

DISCUSSION	The next milestone is the website for the project. We won't have the domains until the 20th of February, but I have to find content for the page such as pictures, template, info etc.

TO DO/ TASKS	ATTENDEES	DEADLINES
Create content/ find information/ text	■	10th of February
Template	■	15th February
Take pictures	■	10th of February

STATUS REPORT 3 WEDNESDAY MARCH 6TH /2013 12.00

TYPE	Status report for phase 2: Measurement experiment

MEASUREMENT EXPERIMENT AT VITENSENTERET

DISCUSSION	To our big surprise, it turns out that the Science Center already has a Fogscreen installed!! I was very shocked and very happy that it turned out this way, because then I can be more relaxed about the measurement experiment. The measuring experiment was conducted 16th of February at Vitensenteret in Gjøvik. The process lasted for about 4 hours. I started first with the objective measurements, by running 42 patches on the fogscreen, and using Eye One Spectrophotometer to register the values. I did the same on a white canvas for reference. I had to vary between a couple of calibration settings: light conditions from normal light to no light, increased fog density and increased fog flow. In addition I also did a subjective evaluation by running a few selected complex images on the white canvas as reference and on the fogscreen. Then I used SLR camera (Canon 1DMIII) to take pictures from the same position as the spectrophotometer was placed. For the calibration settings I only used normal light and no light because of the closing hour at Vitensenteret. I tried a couple of after effect videos from Youtube to create fancy effects on the fogscreen. That part was fun!
CONCLUSION	I'm satisfied with the result, however, I need to conduct another measuring test due march. I need to take pictures of the color patches as they are displayed on the fogscreen. It would visualize the values I get from the profile.

TO DO/ TASKS	ATTENDEES	DEADLINES
New tests	M	March
Custom made content for the Fogscreen	M	March

PLANS FOR ANALYSIS

DISCUSSION	For the analysis part (objective) I'll use ICC3D to visualize the comparison of the color gamuts. Then I'll try to discuss the results, and most importantly how we can use this information to improve the image reproduction. For the subjective assessment I'll compare the images to point out the factors that impact whether if it's a good or bad reproduction.
CONCLUSION	Time is running out, I have to be done with this part by 8th of march!

TO DO/ TASKS	ATTENDEES	DEADLINES
Objective measurement analysis	M	7th of March
Subjective assessment	M	8th of March

Schedule

DISCUSSION	Because of external job these past 2 weeks; I've been behind schedule. For the moment I'm about 1 week of work behind. I need to wrap up the work for this phase before starting on the next about applications.

WEBSITE

DISCUSSION	The website is done! http://hovedprosjekter.hig.no/v2013/imt/mm/fogscreen/ Very satisfied with results. I think it makes a good first impression about the project. The blogging is working in a good way. I just need to remember posting continuously during the process.

TO DO/ TASKS	ATTENDEES	DEADLINES
Distribute link to involving parties	M	ASAP

STATUS REPORT 4 WEDNESDAY APRIL 3RD /2013 15.00

TYPE	Status report for phase 3: Application possibilities/ potential application sites

APPLICATION POSSIBILITIES WITH THE FOGSCREEN

DISCUSSION	For this part we are talking about application possibilities. There are endless opportunities to apply the fogscreen. To concretize I have chosen 3 application examples. The three examples are: The Norwegian Opera House (Oslo), Ballroom (Oslo) and Science Centre (Gjovik). These three companies are chosen to present a broad spectre of application possibilities. I think it was the right decision to pick only 3 examples and I'm very satisfied with the choice of the companies. Converter: To know more about the Norwegian market for implementing Fogscreen, I spoke with Even Isaahsen from Converter. Converter is the only Norwegian provider of Fogscreen rental. Talking with him made me realize how though the market is for such product. The market for Fogscreen rental is not so good because it's too expensive for smaller companies, and not many people are aware of the product. The conclusion I drew from that conversation was that permanent installation is the best option. For that reason all of the three examples I have chosen are based on permanent installation and not rental. Process: Unfortunately I had to weeks less to work on this part. Part A about measurements took longer time than expected. But I think I got the important materials I need for the application part.

TO DO/ TASKS	ATTENDEES	DEADLINES
Wrap up Application part	M	7th April
Visit the Science Centre again for new texts	M	15th April

WEBPAGE

DISCUSSION	There has been some trouble with the website lately because of permalink structure. It's not functional yet, but will hopefully be as soon as possible. And once it's fixed I need to start blogging again.
CONCLUSION	Get help to fix the permalink-structure.

TO DO/ TASKS	ATTENDEES	DEADLINES
Fix website and keep blogging	M	7th April

Prooess and further work

DISCUSSION	I do have nessessary materials for the application part, but I need access to the fogscreen again to complete this part. Literature survey: I have received a list of good literature work to study for both the measurement and application part. I need to start on that right away. Outline: For the next phase it's all about merging the materials I have collected till now, and make it complete. Writing a suggestion for outline is a good way to start that process.

TO DO/ TASKS	ATTENDEES	DEADLINES
Read literature	M	7th April
Outline	M	7th April

C.

PROJECT AGREEMENT

HØGSKOLEN I GJØVIK

PROJECT AGREEMENT

between Gjøvik University College (GUC) (education institution),

HiG - The Norwegian Colour and Visual Computing Laboratory (employer), and

Niyan Akbar Omer

(student(s))

The agreement specifies obligations of the contracting parties concerning the completion of the project and the rights to use the results that the project produces:

1. The student(s) shall complete the project in the period from 1. Februar 13 to 31. May 13.

   The students shall in this period follow a set schedule where GUC gives academic supervision. The employer contributes with project assistance as agreed upon at set times. The employer puts knowledge and materials at disposal necessary to complete the project. It is assumed that given problems in the project are adapted to a suitable level for the students' academic knowledge. It is the employer's duty to evaluate the project for free on enquiry from GUC.

2. The costs of completion of the project are covered as follows:
   - Employer covers completion of the project such as materials, phone/fax, travelling and necessary accommodation on places far from GUC. Students cover the expenses for printing and completion of the written assignment of the project.
   - The right of ownership to potential prototypes falls to those who have paid the components and materials and so on used to make the prototype. If it is necessary with larger or specific investments to complete the project, it has to be made an own agreement between parties about potential cost allocation and right of ownership.

3. GUC is no guarantor that what employer have ordered works after intentions, nor that the project will be completed. The project must be considered as an exam related assignment that will be evaluated by lecturer/supervisor and examiner. Nevertheless it is an obligation for the performer of the project to complete it according to specifications, function level and times as agreed upon.

4. The total assignment with drawings, models and apparatus as well as program listing, source codes and so on included as a part of or as an appendix to the assignment, is handed over as a copy to GUC who free of charge can use it in lessons and in research purpose. The assignment or appendix cannot be used by GUC for other purposes, and will not be handed over to an outsider without an agreement with the rest of the parties in this agreement. This applies as well to companies where employees at GUC and/or students have interests.

   Assignments with grade C or better are registered and placed at the school's library. An electronic project assignment without attachments will be placed on the library part of the school's website. This depends on that the students sign a separate agreement where they give the library rights to make their main project available both on print and on Internet (ck. The Copyright Act). Employer and supervisor accept this kind of disclosure when they sign this project agreement, and they must possibly give a written message to students and dean if they during the project period change view on this kind of disclosure.

5. The assignment's specifications and results can be used by the employer's own work. If the student(s) in its assignment or while working with it, makes a patentable invention, relations between employer and student(s) applies as described in *Act respecting the right to employees' inventions* of 17th of April 1970, §§ 4-10.

6. Beyond the publicising mentioned in item 4, the student(s) have no right to publicise his/hers/theirs assignment, fully or partly or as a part of another work, without consensus from the employer. Equivalent consent must be made between student(s) and lecturer/supervisor regarding the material placed at disposal by the lecturer/supervisor.

7. The students shall hand in the assignment with attachments electronic (PDF) in Fronter. In addition the students shall hand in a copy to the employer.

8. This agreement is drawn up with one copy to each party. On behalf of GUC it is dean/vice dean who approves the agreement.

9. In each case it is possible to enter separate agreement between employer, student(s) and GUC who closer regulate conditions regarding issues such as ownership, further use, confidentiality, cost coverage, and economic utilisation of the results.

   If employer and student(s) wish an additional or new agreement, this will occur without GUC as a party.

10. When GUC also act as employer, GUC accede to the agreement both as education institution and as employer.

11. Possible disagreements concerning understanding of this agreement are solved by negotiations between the parties. If consensus is not achieved, the parties agree that the disagreement is solved by arbitration, according to provision in Civil Procedure Act of 13th of August 1915, no 6, chapter 32.

12. Participants by project implementation:

GUCs supervisor (name): Peter Nussbaum, Jean-Baptiste Thomas

Employers contact person (name): ~~Peter Nussbaum~~ Marius Pedersen

Student(s) (signature): Nigan Ames date 24.01.2013

_____ date _____

_____ date _____

_____ date _____

for Marius Pedersen / Hilde Bakke

Employer (signature): _____ date 24. januar 2013

IMT Dean/Vice Dean (signature): _____ date 14/2-2013

D.
GUC PUBLISHING AGREEMENT

GJØVIK UNIVERSITY COLLEGE

Bachelor/ Master Thesis agreement

This agreement is a binding contract between Gjøvik University College (GUC) and the author(s) of the Bachelor/ Master Thesis.

Author's name	Niyan Omer
Course name (Bachelor/Master name)	Mediamanagement
Address:	
E-mail address:	niyanomer@empeia.no
Title of the thesis:	Fogscreen - A New Generation of Display

Fair use rights:

The author will hereby give GUC the right to make the author's thesis available (free) at the GUC library in electronic formats.

The author is aware of and accepts the extent of copyright laws and publishing on the Internet. This agreement must be signed by all parties (author(s) and a representative of GUC) to be valid.

GUC rights and responsibilities

GUC has decided that only bachelor theses graded C or better, and master theses graded A-E will be made available in electronic format. GUC library has the right to publish the thesis, but is not obligated to do so.
If GUC decides to publish a thesis, it must be published without changes as it was delivered to the GUC library. GUC is not responsible for proofreading or any control that the version handed in is accordance with earlier versions or drafts.

GUC has no beneficial rights of the thesis other than what is expressed in this agreement.

The author's rights and responsibilities

The author must at all times follow the publishing guidelines set forth by GUC library.

By a prospective agreement with other parties concerning publishing of the thesis, the author is responsible for ensuring GUCs rights by this agreement.

The author guarantees that he/she owns the intellectual property rights. This also applies for any material attached to or in another way connected to the thesis. Material/ documents obtained from other sources must be referred and the original authors must be given credit.

The author guarantees that the thesis contains material/documents that can be in violation of Norwegian law.

If GUC should be made liable to a third party due to a breach of this agreement by the author, the author is responsible for keeping GUC from suffering any losses.

Publishing

GUC has the right to publish the thesis on the Internet, to copy, to distribute and display the work.

Termination of the agreement

GUC has an unlimited right to discontinue the publishing of the thesis.

The author has the right to terminate this agreement he/ she is obliged to inform GUC in writing. GUC will remove the thesis from the Internet no later than 6 months after receiving the notice. GUC is obligated to remove the thesis sooner if the author gives good reasons for this.

This agreement shall be executed and signed in two counterparts, and the parties will keep one each.

Gjøvik, (date) 13/05-13	I have read and accepted this agreement GUC, (date) 13/05-13
HiG, 13.05.13 Ingvil Stavseth (Representing GUC)	(Author)
HØGSKOLEN I GJØVIK BIBLIOTEKET	(Author)
	(Author)