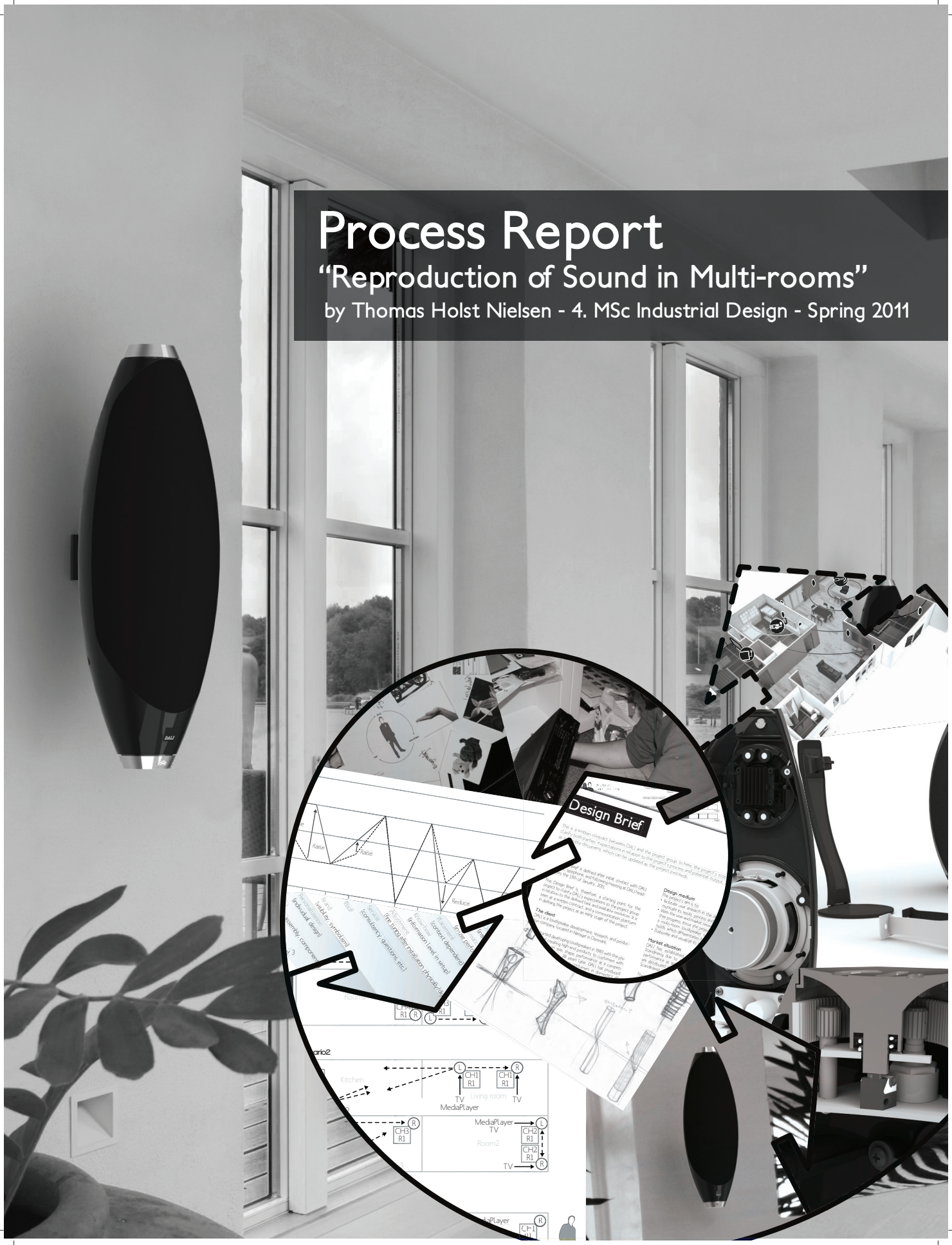
Process Report

"Reproduction of Sound in Multi-rooms"

by Thomas Holst Nielsen - 4. MSc Industrial Design - Spring 2011



Title Page

Title:
"Reproduction of Sound in Multi-rooms".

Study unit:
4. MSc project at Industrial Design,
Institute of Architecture, Design and Media Technology,
Aalborg University (AAU).

In collaboration with DALI (Danish Audiophile Loudspeaker Industry).

Project period:
17th of January to 31st of May, 2011.

Examination:
20th of June, 2011.

Language:
English.

Supervisor:
Søren Bolvig Poulsen, Assistant Professor.

Product Report pages: 12
Process Report pages: 110
Appendix pages: 88
Editions of reports: 5

Thomas Holst Nielsen

Front page description:
The background image is a context picture of the final product proposal. The illustration in the bottom right corner is an excerpt of the overall iterative development process of a multi-room loudspeaker with pictures from main events throughout the project.

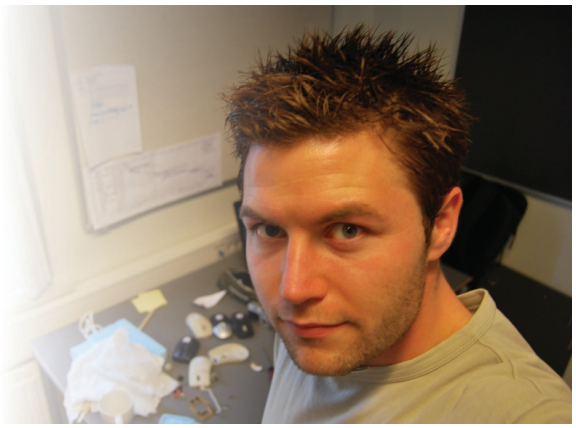


Figure 1: Author.

Resume

This master project in Industrial Design at Aalborg University (AAU) is exploring the field within reproduction of sound in multiple rooms in Danish households with basis in user-centred design, and hereby exploring users' musical behaviour and use of product with an open and different perspective. The outcome of the project is a wireless music streaming multi-room system solution where users are interacting with the loudspeaker itself, which includes source and volume control. The product proposal integrates technological and functional parameters into one, unified whole resulting in a new and unseen loudspeaker suitable for placement in multiple contexts in Danish households.

Reading Guidance

The reading guidance informs the reader about how the reports are structured.

Product Report

The Product Report is targeted potential users, and is produced as marketing material for advertising in interior and furniture retail stores and additionally as material for Hi-fi Klubben. It is a product catalogue with information about the loudspeaker and its in-build functionality in different contexts of use. It can therefore be read without reading the Process Report.

Process Report

The Process Report is targeted DALI, censor, and supervisor associated this master project at Industrial Design. It is providing information and documentation of decisions affecting the design process of a multi-room loudspeaker for the Danish market in collaboration with DALI.

Throughout the entire project, 5 phases are completed in finalizing the product proposal:

- Phase 0: Program
- Phase 1: Problem Definition
- Phase 2: Concept Development
- Phase 3: Concept Detailing
- Phase 4: Marketing & Implementation

In every phase of the project, a colour is used in the upper right corner including the phase number to inform at which stage of the documentation the reader is. In general, the Process Report is kept as short and precise as possible with references to additionally documentation found in literature and attached on the DVD. Each chapter which is found less necessary in understanding the complete process of the project is moved to Appendix located on the DVD. The Appendix must be read for a complete and full understanding of the whole process. Every time a chapter is supported with an Appendix or data located on the DVD, a symbol is represented with indication of its placement in the list of reference. Example:
(see Appendix 1: Process Logbook, DVD)

At every transition in-between phases of the project, an illustration is made in getting a quick overview about what the upcoming phase encompasses.

Formalities

The Harvard Method is used for references of all sources in form of Internet web-pages, books, articles, interviews, and meetings. All the references are indicated with brackets like: *(Ulrich & Eppinger, 2008)* whereas the name indicate the author(-s), and the number is the year of publication. All references can be found in a complete list in the end of this Process Report.

All illustrations and pictures are listed by: *Figure "number of illustration": "Figure text"* (without the quotation marks). In the end of the Process Report, a full list of illustrations and their sources can be found.

DVD

The attached DVD in the back of the Process Report is used throughout the documentation of the project with references to articles, interviews, and Appendix chapters. The DVD consists of the following data:

- User research data (mp3- and video files)
- Articles which are used as references (if possible)
- Full Appendix Report
- PDF of Process and Product Reports
- Gantt Chart
- 3D CAD files
- 3D CAD eDrawing
- eDrawing installation file

Table of Content

Introduction

A brief introduction of the purpose of the master project at AAU entitled "Reproduction of Sound in Multi-rooms".

Denmark has a great tradition in researching and developing innovative acoustical technologies and products. Many companies have gained solid recognition for their admirable work within acoustics, transducer technologies, and digital signal processing (DSP). Sound technologies are not only reserved the loudspeaker industry, but also sound measurement equipment, hearing aids, acoustic damping materials and many other specific industries are derived from the same passion of creating innovative products with implementation of new, break-through technology *(kulkom.dk, 2011)*.

Several Danish companies are more visual dominant in Medias than others. Bang & Olufsen (B&O) is among others a powerful brand, which started its adventure in 1925. B&O still continues to develop unseen products, and has gained great appreciation all over the world for the technology, its reliability, quality, and of cause, its performance. In the field of loudspeakers for instance Jamo, Dantax, Audionord, Dynaudio, DALI, Lyngdorf Audio are also present illustrating that Denmark is among the leading countries within music reproduction and sound technology *(kulkom.dk, 2011)*.

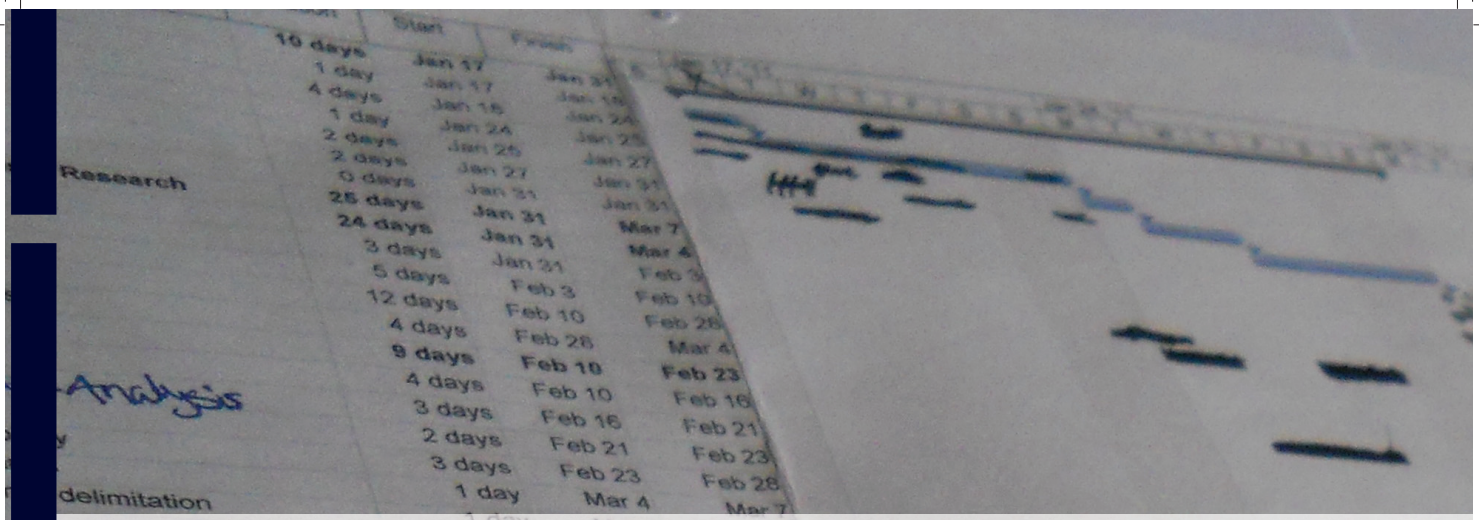
The author's interest in sound is with respect to the mechanical, electronic, and acoustical construction of a loudspeaker, and the passion in creating the best possible outcome whether it is a product, service or technology.

Prior to the project start, the author has done internship at audio technology and loudspeaker manufacture, Lyngdorf Audio in 2008, which helped in founding a solid interest in sound technologies and loudspeaker construction. Afterwards a bachelor of engineering was finalized at the University of Southern Denmark (SDU) in Integrated Design followed by the master programme in Industrial Design. In here, it is possible to explore new methods, new theory, and specialize the education towards a professional career. Therefore it was a natural choice to contact DALI in defining a master project.

Collaboration with DALI

Initial contact was made with DALI resulting in collaboration with the Danish loudspeaker manufacture. As part of communication in-between the project group (the author is from this point of departure referred to as "the project group") and associated DALI staffs, a Process Logbook is made where the project's process is illustrated in a weekly picture. This logbook is sent to DALI each Friday with the purpose of informing the project's progress in a quick, illustrative way.

The logbook can be found in Appendix on the attached DVD *(see Appendix 1: Process Logbook, DVD)*.



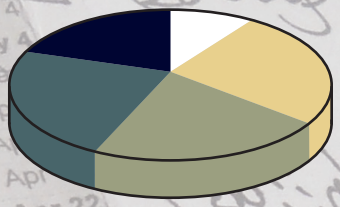
Project group

Initial meeting with Mads Møller and Kim Kristensen from DALI

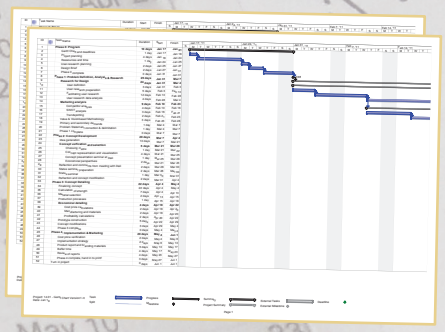
Initial ideas

Expectations

Opportunities



Time planning

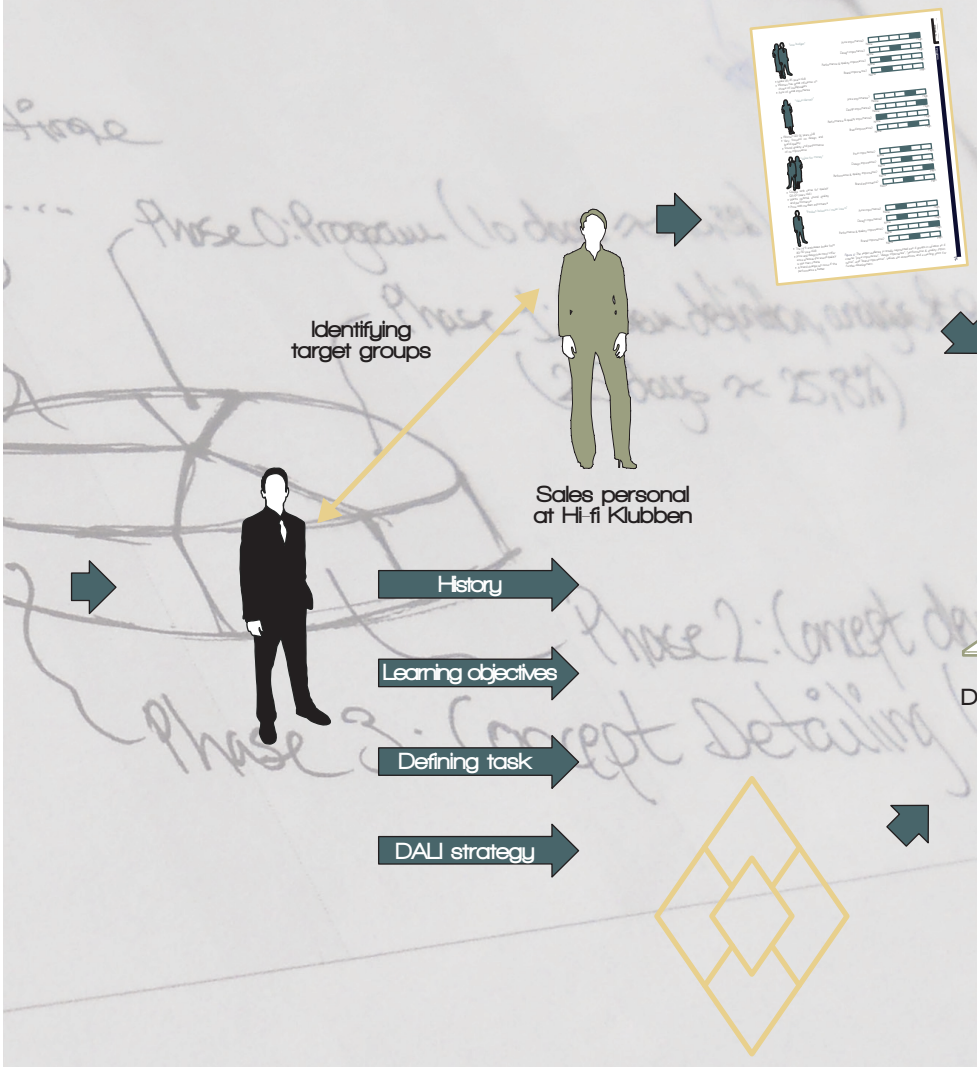


Gantt Chart creation and task planning

Output

- Collaboration with DALI
- Time management
- Resources disposition

Phase 0: Program



Output

- Target groups
- Strategic perspectives
- Design Brief

Design Brief

Figure 2: Phase 0 overview.

Project Planning

Resources, time and initial process overview are planned in order to structure the framework for the project.

Throughout the Program chapter, several important aspects are defined with purpose of structuring the project process with greater overview as output.

Project Planning deals with structuring, systemizing, and planning time and resources available in the one-man project group.

It is planned with experience from similar projects facilitated at Integrated Design at SDU, and from Industrial Design at AAU.

Furthermore, the resources available are planned with regard to the Study Guide.

The general allocation of time in the project period can be seen in the figure below. It is divided into 5 phases going from a project structuring phase, Program, to Concept Detailing and marketing perspectives in the end of the project (see next page for further detailed overview).

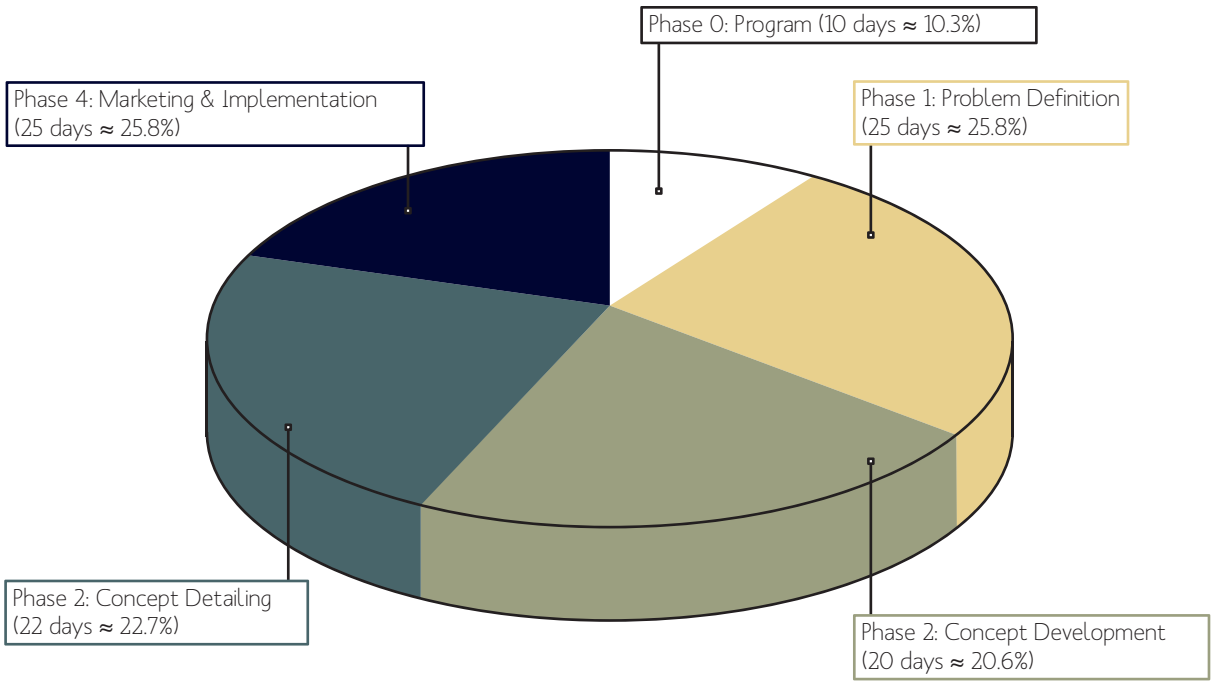


Figure 3: Allocation of time in the project period.

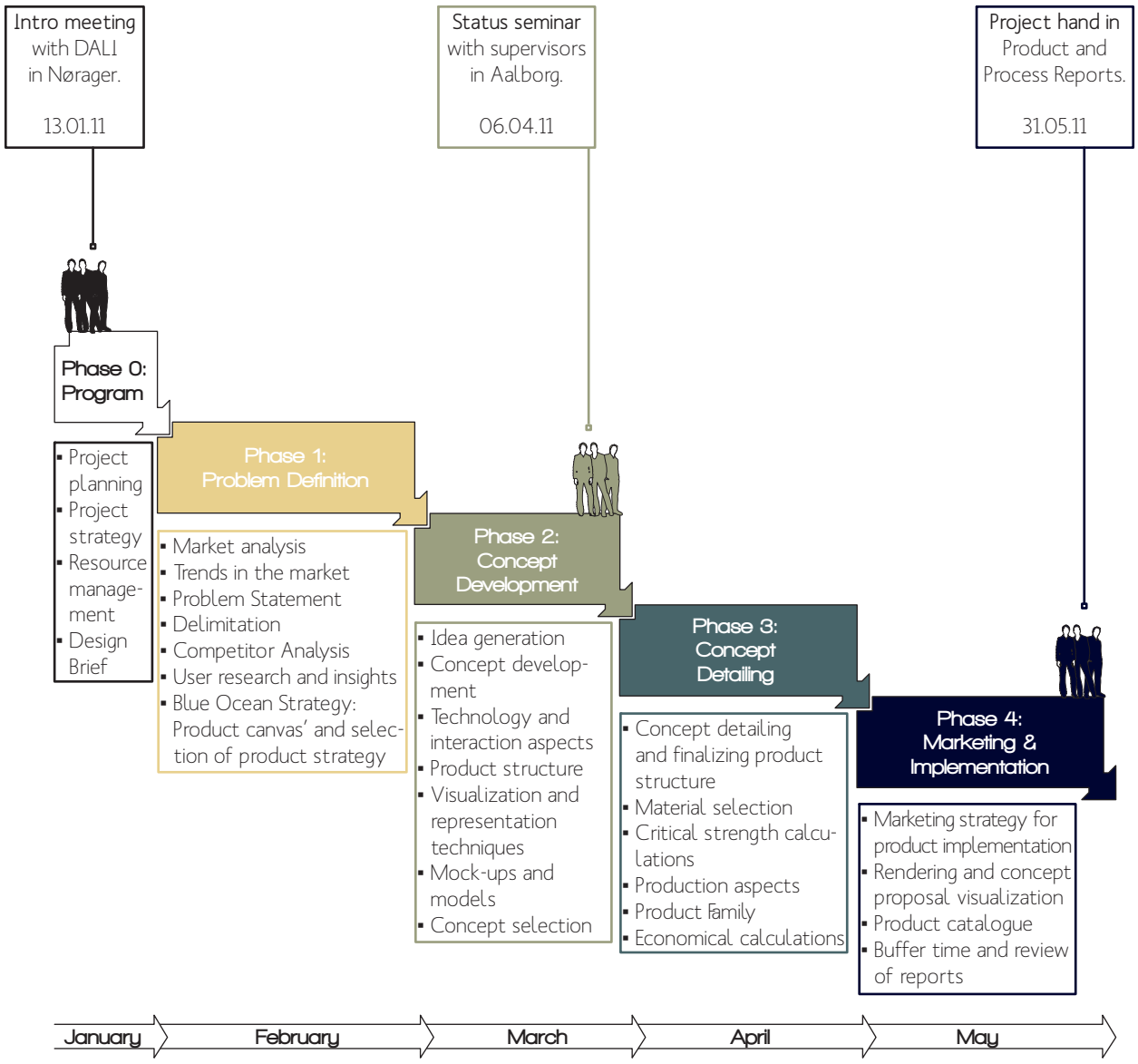


Figure 4: Process overview including 5 phases and listings of main events and dates.

Gantt Chart

Further process exploration is made by detailing the phases into tasks which need to be executed in fulfilling the scope of the project. Some tasks are linked together before further process can be made.

In the figure above, main events and dates are listed in an initial process overview. At the end of the project, the process is evaluated in the Reflection chapter.

Full Gantt Chart can be found on the attached DVD with all tasks and events defined *(see GanttChart.pdf, DVD)*.

The chosen structure of the project is planned with reference to Ulrich & Eppingers "Product Design and Development" literature *(Ulrich & Eppinger, 2008)*.

Design Brief

This is a written contract between DALI and the project group. In here, the project's scope is defined in order to clarify both parties' expectations in relation to the project's process and potential output. The Design Brief is seen as a flexible document, which can be updated as the project proceeds.

Introduction

The Design Brief is defined after initial contact with DALI by e-mail, telephone, and following meeting at DALI headquarters the 13th of January, 2011.

This Design Brief is, therefore, a starting point for the project to clarify DALI's expectations to the project group in relation to the defined task and available resources. It is seen as a written contract, and a communication platform in defining the project at an early stage of the project.

The client

DALI is a loudspeaker development, research, and production company located in Nørager in Denmark.

DALI started developing loudspeakers in 1983 with the philosophy of creating high-end products to customers with primary focus on size, shape, performance at a competitive price level. Now, 28 years later, DALI has produced over 1 mio. loudspeakers to costumers in domestics all over the World. The company's slogan is "in admiration of music", and its product series has gained appreciation from costumers as well as awards from magazines and listening tests *(dali-speakers.com, 2011)*.

The company is an offspring of Scandinavia's major, and leading audio retail chain, Hi-fi Klubben, which is located all over Scandinavia with over 70 stores + 3 additional national webshops, and founded by the Danish sound pioneer Peter Lyngdorf *(hifiklubben.com, 2011)*. He started Hi-fi Klubben, DALI, and also Lyngdorf Audio among other audio manufacture and production companies.

Task

The task is defined in collaboration with DALI, and is formulated as:

> *"Designing a multi-room loudspeaker solution with a user-oriented approach to Danish households. The system deals with the integration of technical aspects as sound sources, speakers and control units in one, intelligent user-friendly solution. The solution is not only focusing on speaker design, but researching in music systems in households from a holistic user-oriented perspective with integration of DALI's core values."*

Design medium

The project's aim is to:

- Facilitate user research in the defined market, and communicate its result, process and outcome
- With the user and market research as foundation for further progress, focus the project towards conceptualizing a multi-room loudspeaker solution for Danish households, which differentiates itself from other designs
- Elaborate and visualize its market potential

Market situation

DALI has established a solid and respected brand in Scandinavia due to its products' quality, reliability and performance at an acceptable price level. The products are distributed throughout Hi-fi Klubben in Denmark (and Scandinavia) which has a central role in DALI's success.

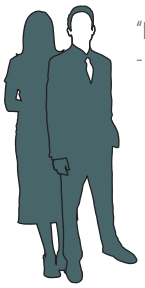
The project is focusing on the Danish market in order to facilitate user research within the limited project period. The research is also a part of defining the exact market for later implementation in correlation with a market analysis.

The market within quality loudspeakers is a relatively conservative and high competitive market. Therefore, user research and market analysis are used to identify a product differentiation and market opportunity. The targeted market cannot be specified in depth at the present moment.

Target audience

Within the market of loudspeakers sold in Hi-fi Klubben, target groups are defined in order to specify what the final product proposal is aiming at. 4 groups are identified with use of 4 criteria: "price", "design", "performance & quality", and "brand". Criteria and target groups are defined in collaboration with a sale personal from Hi-fi Klubben *(see Appendix 2: Interview with Sales Personal, DVD)*

Demographic segmentation is not seen as a main criteria at the present time.
Instead, is the first group entitled "low budget". In here, the price has the most influence on what is bought, and is typically a couple with the need of background music with minor focus on the loudspeaker's quality and performance. The target group size is minor compared to other groups.

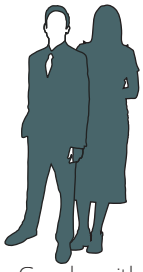


"Low budget"
- minor target group

- Male (35-45 years old)
- Woman has great influence on choice of loudspeakers
- Price of great importance

"Value identity"
- medium sized target group

- Woman (20-35 years old)
- Very focused on design and brand quality
- Sound quality and performance of no importance



"Value for money"
- huge target group

- Couple with sense for quality (25-50 years old.)
- Wants optimal sound quality and performance
- Price with medium importance

"Product believers / music lovers"
- minor target group

- The Hi-fi enthusiast (male from 40-50 year old)
- Price and design has minor influence whereas the sound quality is the main criteria
- A brand change can occur if the performance is better

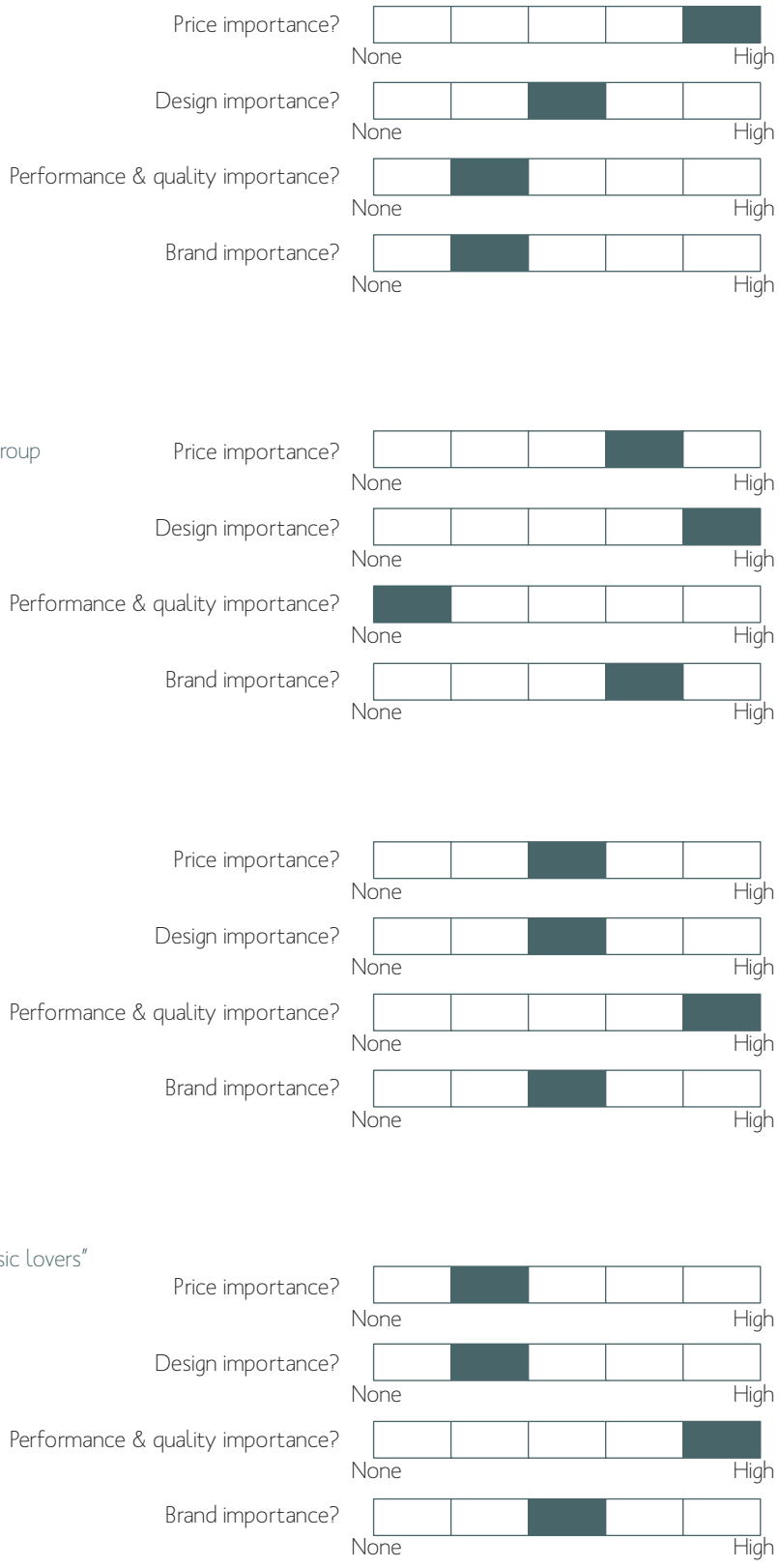


Figure 5: The target audience is initially segmented into 4 groups in relation to 4 criteria: "price importance", "design importance", "performance & quality importance", and "brand importance". Values are estimations made by a sales personal at Hi-fi Klubben and a starting point for further development.

Group no. 2, "value identity" is cost focussed but highly interested in the product's design, values, brand, and symbolism in relation to the user's own personality. Performance and quality parameters are of almost no importance. The size of the group is evaluated as of medium size.

Group 3, "value for money" is focussing on achieving the highest value possible in terms of performance and quality in a loudspeaker with the use of acceptable amount of money. The design and brand are at a medium level of importance, and are expected to be at a suitable standard in relation to the money spent. This group is the primary costumers in Hi-fi Klubben and therefore of greatest size.

The last group, "product believers / music lovers", is characterized by a little group of hi-fi enthusiasts who only want the best product quality and performance with minor regards to its costs. The design is estimated being at a medium to low level of importance. In this project, the primary target groups are "value identity" and "value for money" groups, which are estimated the groups with greatest potential in relation to DALI's core values of product quality and performance plus the potential market size.

"Product believers / music lovers" is a niche group where DALI is already offering products like the Megaline with supreme performance. "Low budget" can be a potential target group, but at the present time this group is evaluated being in conflict with DALI's core values.

Economical Perspectives

Products from DALI are sold in Hi-fi Klubben at very different price levels. From the lowest price for Concept 1 at DKK 749.- each to Megaline at a price of around DKK 130,000.- each *(hifiklubben.dk, 2011)*.

The new multi-room speaker must be at a competitive price level in accordance to incorporated features, performance, quality and the fact that this product is targeted multi-room installation in users' households. Therefore, the speaker must not be targeted the highest price level in DALI's product series hence to the total cost when installing multiple speakers in a system solution.

Business objectives

The business objectives are defined in order to make the project realistic because no specific objectives are defined by DALI's economical department or board of directors. These are estimations, and cannot be measured after completion of the project. The objectives are as follows:

- Aim to achieve a market share of 40% in Denmark within the first 2 years of implementation within sales of more than 2 speakers at the time
- Aim to achieve 50% costumer awareness of the new multi-room product within the target groups
- Aim to strengthen the costumers' awareness of DALI's values by focusing on users throughout the product development process, and implementing these values into the multi-room speaker design

Technical and practical constrains

DALI has a wide range of professional knowledge in loudspeaker development and production. This knowledge is available for the project group in terms of supervision from Design Manager Mads Møller, and R&D Manager Kim Kristiansen, who are associated with this master project.

The following aspects are DALI's main competencies:

- Transducer technology
- Speaker units research
- Mechanical loudspeaker construction
- Acoustics
- Testing and calibration
- Craftsmanship
- Production processes (mainly wood)
- Prototyping
- Packaging
- Marketing and advertising

The project group has no profound development budget, which simplifies the level of resources available. DALI has accepted to put resources, supervision hours and prototype materials at the group's disposal throughout the project. It will benefit the realism and overall output of the final product proposal.

Time and resources

The project is facilitated in a one-man group which is challenging in project structuring, and resources available. A project plan is generated, and can be found on the attached DVD. *(see GanttChart, DVD)*

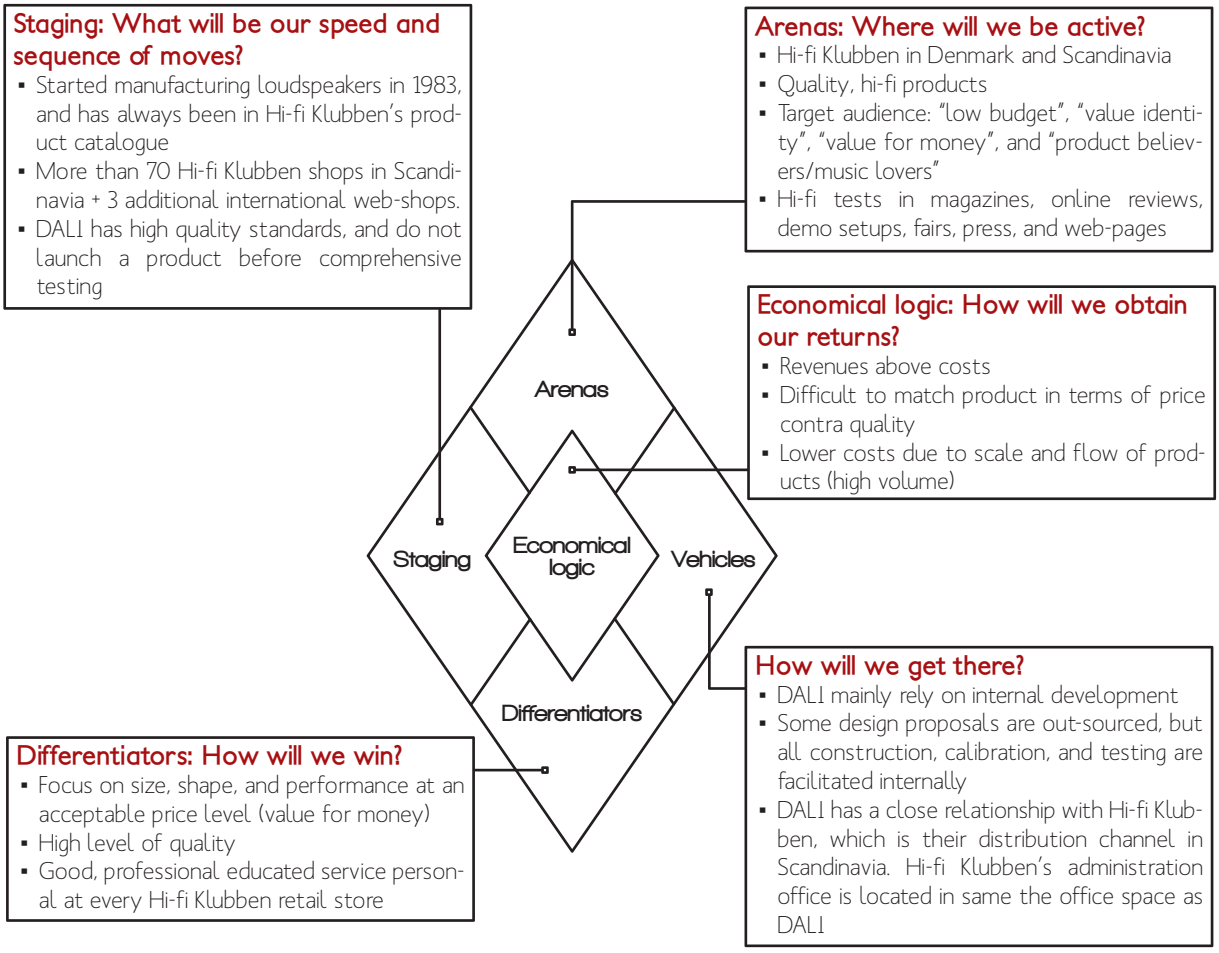


Figure 6: The Strategy Diamond summarizing the content of the Design Brief with illustration of the 5 major elements in a strategy. The diamond is conducted by initial research and meeting with DALI at project beginning.

Learning objectives

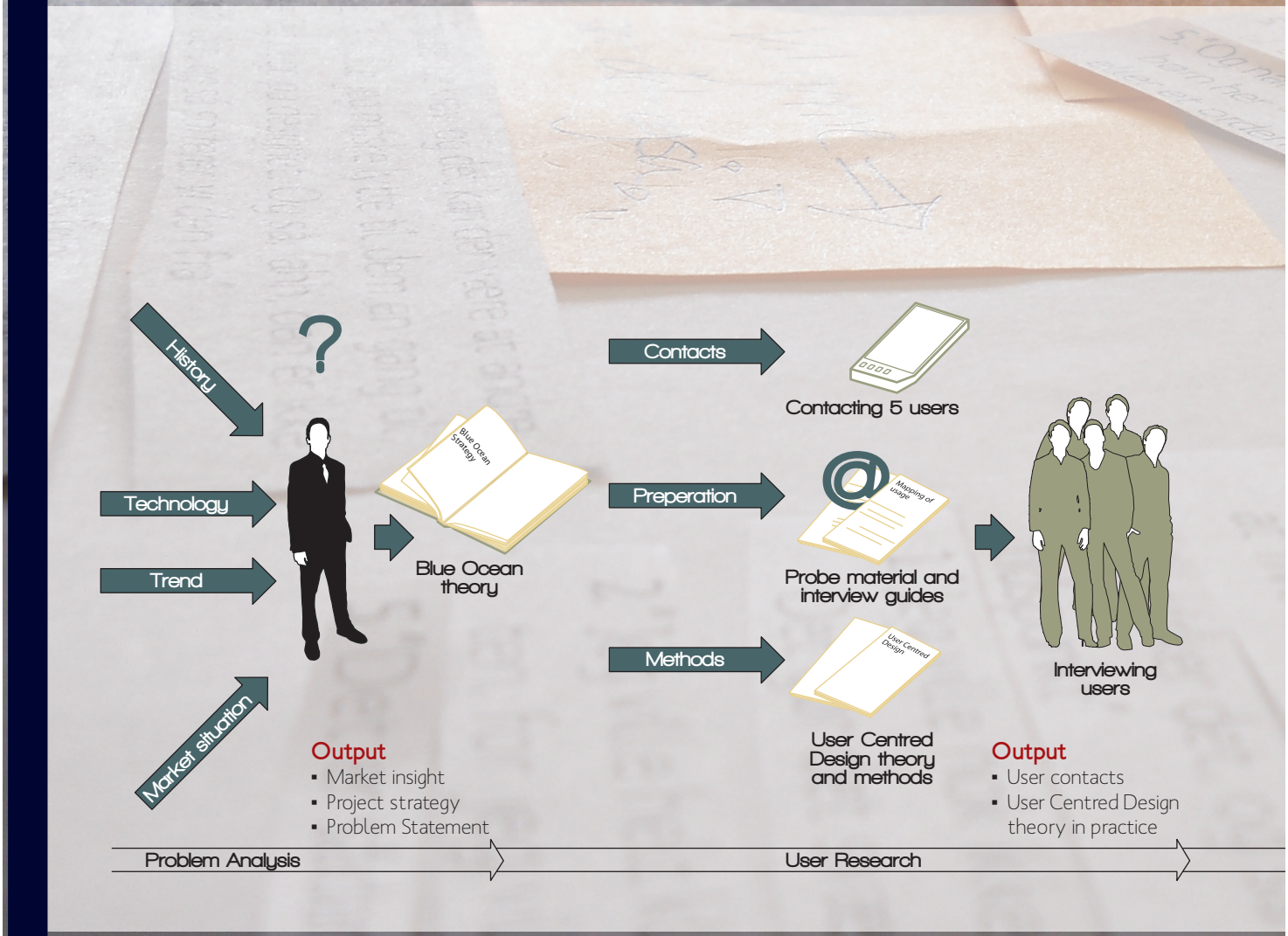
The project group's learning objectives are as follows:

- Structuring and facilitating a project in a one-man group
- Working as an extern consultant to DALI, and hereby structuring and communicating results in a easy and appropriate way
- Facilitating user research and data extraction in a systematic manner
- Knowledge about loudspeaker construction detailing, and issues in relation to loudspeaker's performance and quality

Strategy diamond

In the illustration above a strategy diamond *(Hambrick & Fredrickson, 2005)* for DALI's overall market position is conducted, which summarizes the Design Brief into 5 major elements of a strategy.

In Phase 4: Marketing & Implementation, the strategy diamond will be evaluated at a product level indicating which elements are influenced and challenged by the introduction of the new product.


History
Technology
Trend
Market situation
?
Blue Ocean Strategy
Blue Ocean theory
Contacts
Contacting 5 users
Preperation
Mapping of usage
Probe material and interview guides
Methods
User Centred Design
User Centred Design theory and methods
Interviewing users
Output
Market insight
Project strategy
Problem Statement
Output
User contacts
User Centred Design theory in practice
Problem Analysis
User Research

Phase 1: Problem Definition

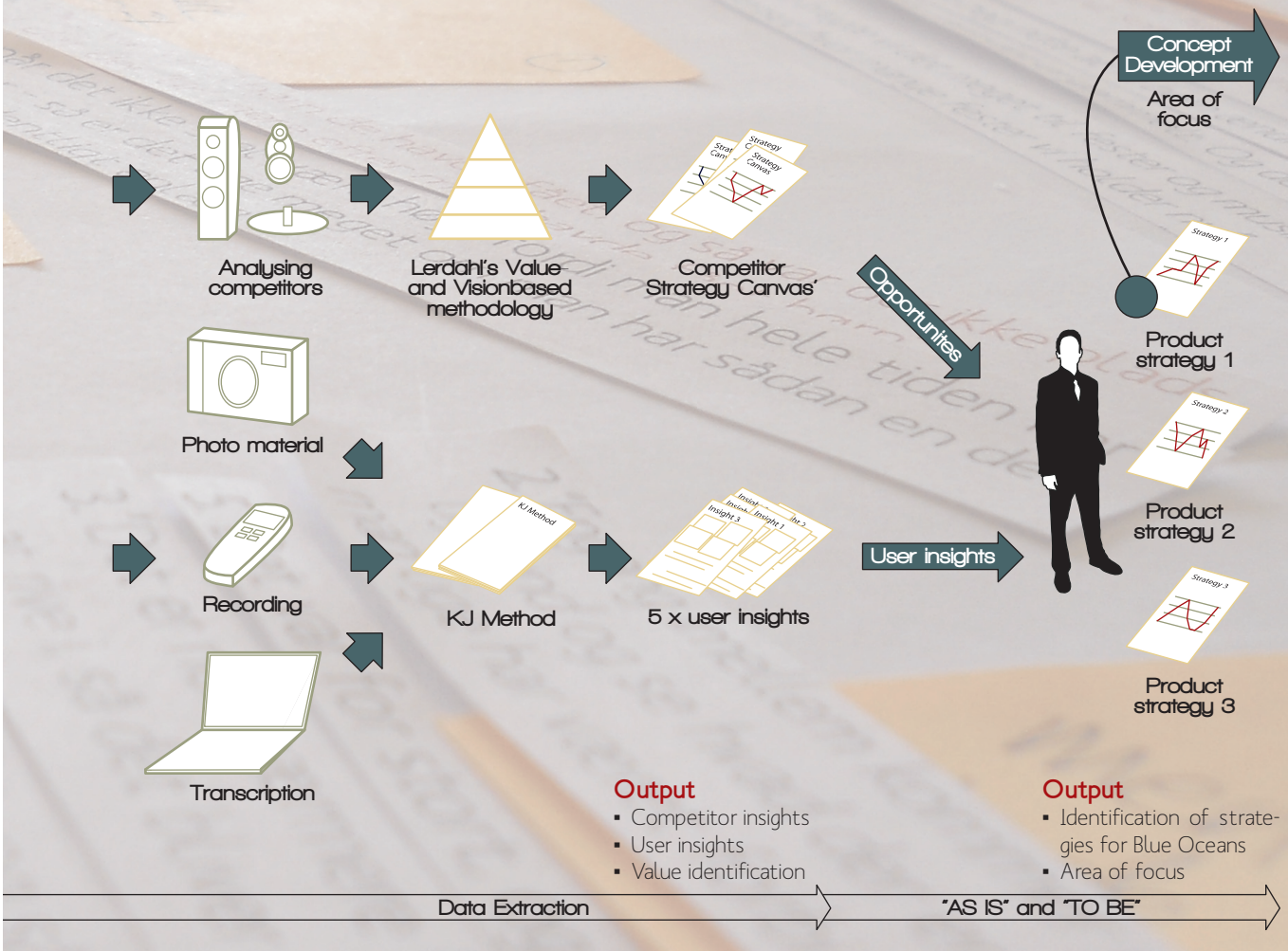


Figure 7: Phase 1 overview.

Problem Analysis

A Problem Analysis chapter is made to explore which challenges the project group confront when starting a project concerning developing of a multi-room loudspeaker for the Danish market. An overall Blue Ocean strategy is used with implementation of a user-centred design approach to get new user insights and inspiration.

Introduction

Music plays a role in every people's daily life. For some people music is a minor part - and in contrast - musicians their whole existence of life; economically, socially, mentally and physically.

Throughout history, music has grounds of existence in every known culture, and has been used in generations for different purposes. Technology has made it possible to reproduce a music tune, speech or song, and hereby regenerate an experience which triggers human emotions, feelings, or even actions.

Music is not only used as comforting background tunes, but as means for healing and other psychological purposes. In general, music is used for multiple purposes and has been so throughout generations *(wikipedia.org, 2011)*.

Technology advancement and development, trends in the market, global economy, human and social behaviour, etc., have all influenced how people play and interact with music in today's world.

In this Problem Analysis chapter, these topics will be explored in analysing the project's area of focus with point of departure in the defined task described in the Design Brief.

After initial market analysis, a Problem Statement is defined in order to frame the project for further progress.

Technology advancement

The development of the "modern" loudspeaker is a relatively new invention. It has its origin in California where the Danish engineer Peter L. Jensen and Edwin Pridham in 1915 developed the product Magnavox. Due to difficulty in selling their invention to telephone companies, they changed strategy and revealed their invention to the citizens of San Francisco by broadcasting a musical play at the city counsil balcony *(ing.dk, 2001)*.

A modern loudspeaker design is the concept of how today's loudspeakers technically and functionally are produced. Loudspeaker inventions were made before 1915, but the Magnavox was the first modern build loudspeaker in the world.

It is a moving coil driver (also named dynamic and hereby modern) principle which in general generates sound waves by a vibrating membrane attached to the coil. The coil is moving back and forth due to electrical current, and hereby is it possible to transform electrical signals into sound waves audible to people *(wikipedia.org, 2011)*.

The first loudspeakers manufactured are technically and functionally incomparable with today's products in quality, performance, and production, but the main principle concerning a moving coil driver is generally the same.

Going from invention to high quality products

Product optimizations were constantly made, and with the beginning of the industrial revolution, the term "hi-fi" became relevant. Hi-fi is a terminology used by audiophiles/audio enthusiasts and audio equipment manufactures referring to the equipment's quality as being of a "high fidelity" in contrast to inexpensive, low quality reproduction equipment (also named "low fidelity").

The term has its roots in the 1950s with the introduction of revolutionary home audio equipment as; reel-to-reel audio tape recording, vinyl records, FM radio broadcasting and better amplifier designs *(wikipedia.org, 2011)*.

Figure 8: Looking into the horizon to get inspiration from history, and organise one's thought before making action.

The market

Concurrently with the technological improvements and rising interest in reproduction of sound and music by private people, lots of hi-fi manufactures and loudspeaker companies appeared in the market. For a very long period of time, hi-fi equipment has been reserved for people with special interest in this area, who also possess knowledge about equipment and technology plus a disposable income due to its typically high price level.

DALI has seen this opportunity for differentiation by offering higher quality loudspeakers than low fidelity products at a acceptable price level, and gained great market profit from this market position.

DALI has not made radical loudspeaker innovation but has instead improved its designs and performance over time. This can be categorized as incremental innovation, and is a common objectively picture for many loudspeaker manufactures. Material refinement, production standardisation, improvements in component design quality, digital analysis tools, CAD animated cabinet designs, etc. are some examples of incremental innovations from the introduction of the first modern loudspeakers ever made.

In contrary, value innovation within this market occur when technology, market opportunities, and new user insights are combined with economical responsibility in a new and valuable way beneficial for both the manufacture and users.

In the figure below, the major influences for loudspeaker design are listed including a mapping of loudspeaker competitors to DALI in Denmark. Many competitors are seen, and it gives a picture of a very competitive market situation.

On the next page, inspirational examples are described to exemplify the role of other actors than the loudspeaker market's actors themselves.

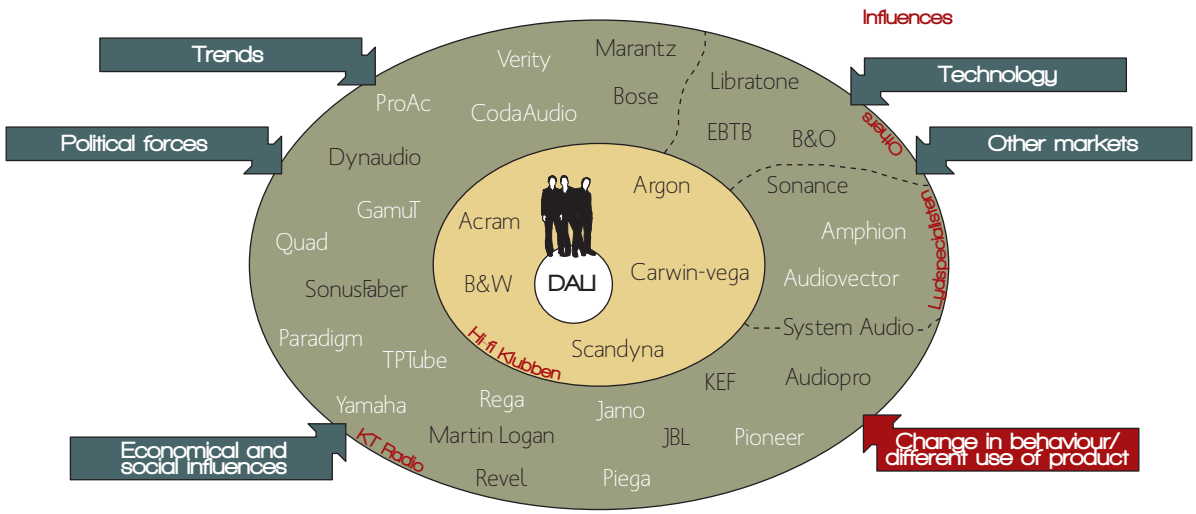


Figure 9: Map of DALI's competitors in Denmark. The first ring is indicating competitors within the same distributor (Hi-fi Klubben). The following ring is other competitors within the market of loudspeakers (KT-Radio, Lydspecialisten, and others). The last ring indicates parameters with influence on what kind of loudspeakers the market develops. "Change in behaviour/different use of product" is one of the most interesting parameters which has great connection to creating value innovation.

Black text = competitors with multi-room products available in their product series. By multi-room speaker means in-wall/on-wall or compact/satellite speakers with potential of being used for multi-room purposes.

White text = competitors without multi-room products available at the moment.

Development of loudspeakers due to new products, technology or trends in other markets

- **Introduction of flat screen TV's.** New digital technologies made it possible to reduce the TV's depth, and improve its resolution. It resulted in a need of a better loudspeaker instead of low quality, in-build speakers in flat screens. The result is a sleek, elegant, flat loudspeaker which can be wall mounted next to the flat screen TV to fit the TV's design and idiom.
- **The digital portable music revolution**, where users transport their entire music library in small intelligent products. If the product, at all, has a loudspeaker included, it typically performs badly. The portable music player resulted in a need for easy connection to external loudspeakers, and i.e. docking stations were born to fulfil that need. These docking stations are both produced in stationary or movable versions.
- **Digital music storage** in PCs, laptops, network hard drives, or other multifunctional music storage devices. They all need a user-friendly interaction which has the functionality of connecting existing music systems in the household to new digital applications and Internet streaming services. Media centres, SONOS and other digital music applications were born to fulfil the need of easy accessibility, functionality and interaction with an intangible music library. This has resulted in CD players and receivers which are not that interactively important anymore for some users. The interaction is replaced by a remote control, a smart phone application or other portable devices.
- **Interior design, a trend of minimalism** where everything is stripped down to its most fundamental. This is also seen in loudspeaker designs as they are build in-walls, on-walls and made very sleek and elegant. *(epn.dk, 2009)* The huge, heavy and boxy look is not as welcome in the households anymore like it used to. With improved loudspeaker performance in minor chassis, drivers can perform almost with same quality as bigger loudspeakers *(epn.dk, 2010)*.
- **Loudspeakers as furniture design.** Loudspeakers can be a very dominating element in a room, and, therefore, some loudspeaker manufactures have made loudspeaker design width great inspiration from furniture design values and symbolism. It can be seen in atypical loudspeaker designs which do not look like a loudspeaker at first glance. An example is Scandyna's "bubble"-loudspeakers which looks very different than ordinary loudspeakers found in Hi-fi Klubbens product range, or the newly introduced, movable wireless Libratone Beat speaker.

Figure 10: Flat screen TV with DALI's Motif speaker wall mounted.

Figure 11: Internet radio stations and music streaming services are available for everyone in a large amount of services.

Figure 12: Digital music and the iPod has revolutionized the music industry.

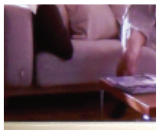


Figure 13: Heavy, boxy loudspeakers are replaced with small, elegant solutions like in-wall speakers.

Figure 14: Easy interaction and accessibility by using SONOS.

Figure 15: The Libratone Beat is a movable, wireless loudspeaker but just as much a design furniture.

Products in the Market

Browsing multi-room loudspeakers from Hi-fi Klubben and mapping their price levels.

Figure 16: Scandyna.

Figure 20: Argon

Figure 19: ARCAM.

Figure 18: B&W.

Figure 17: B&W.

Figure 21: DALI and CAMBRIDGE.

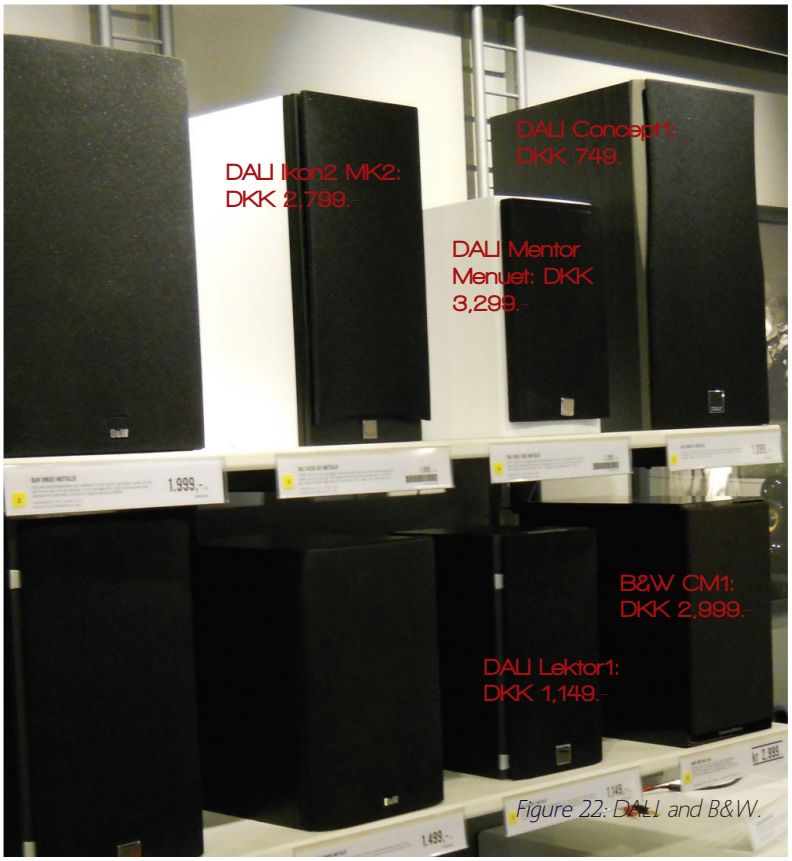


Figure 22: DALI and B&W.

Value innovation

Value innovation is a term used in Blue Ocean strategy theory *(Kim & Mauborgne, 2005)* about how to differentiate a product/service or a company's overall strategy within a rigid market of competitors (red ocean), and hereby create a new, unexplored market with no competitors (a blue ocean). Value innovation is created by reducing/eliminating costs and by raising/adding value to the product or service at the same time (see figure to the right) *(Kim & Mauborgne, 2005)*.

Blue Ocean strategy's project outcome

Blue Ocean theory is interesting in this project because of its different view on product innovation within a rigid market (a red ocean like the Danish market objectively is being evaluated as; high supply/low demand ratio. See page to the left for a quick overview of products in Hi-fi Klubben where DALI is represented with several compact loudspeakers).

The Blue Ocean theory is used in seeking inspiration on how to systematically create a differential advantage compared to close competitors in the market, and making them irrelevant due to added value and cost reduction.

It is done by analysing your own and the competitors' products in relation to its values and product characteristics. In this project interesting competitor's products are analysed by using Lerdahl's model for value- and vision based methodology to explore a minor selection of hi-fi equipment which differentiates itself, and hereby creates value innovation.

Also, Strategy Canvas' are made to give a snapshot of the market situation, and to give inspiration for further development. A Strategy Canvas gives you the opportunity of understanding your competitors present product characteristics, and which values the market is addressing at the present moment in a quick and illustrative way *(Kim & Mauborgne, 2005)*.

User insights

A user-centred design approach is facilitated in getting new user insights, and hereby inspiration on how to create value innovation in this market. The user research planning, theory, extraction and results are explained in the following chapters in this phase.

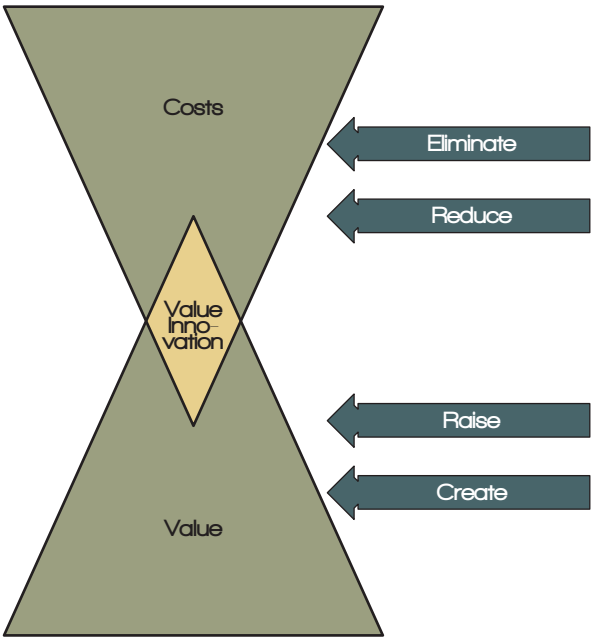


Figure 23: The value innovation pyramid. By reducing or eliminating costs and raising or creating value can value innovation be made. This is the main principle in Blue Ocean strategy.

Sum up

- None radical loudspeaker innovation has been made in many years, and mainly incremental innovation is seen from loudspeaker manufactures in terms of technology advancement, component design optimization, construction effectiveness, assembly lines, manufacturing processes, CAD optimization, etc.
- The intensity of rivalry within the market of loudspeakers in Denmark is very high with many manufactures (red ocean)
- Many products are competing in characteristics as: product specifications, design, performance/quality, brand value, and price level
- Price levels on hi-fi equipment differ highly
- A Blue Ocean strategy is evaluated as a plausible principle for the project to explore the Danish loudspeaker market, and focus the project towards creating value innovation for users
- A user-centred design approach is used to get new insights from users with a following data analysis to get ideas on how to differentiate a new multi-room loudspeaker from competitors

Competitor Analysis

In the following pages a Competitor Analysis is conducted. Its purpose is to explore the competitive area within loudspeakers and hi-fi equipment with focus on relevant competitors using the Value- and Visionbased methodology. The chosen competitors have all made products which differentiate themselves from other products in the market.

Libratone Beat

Libratone is a small, newly started Danish hi-fi company with 5 people full-time employed and expanding. In less than a year, the company has developed and produced a new active (amplifier included), stand-alone loudspeaker which can be wireless connected to iPods, iPads, iMacs and PCs. Libratone participated in the world's most famous user electronic fair, CES2011, with great outcome and media exposure *(Berlingske Tidende, 2011)*.

Libratone Beat is available in 130 stores in Denmark, Finland, Germany, Italy, the Netherlands, Norway, Sweden, Switzerland, and additional online stores. The greatest, and maybe most important step, is their newly collaboration with Apple stores, which encounters around 130 stores world-wide *(libratone.com, 2011)*.

The following analysis is carried out with inspiration from Lerdahl's Value- and Visionbased methodology *(Lerdahl, 2001)*.

Libratone Beat inspiration

- Libratone has found a niche by integrating state-of-the-art technology, quality materials and drivers, a movable loudspeaker with integrated amplifier and user-friendly interaction by wireless technology
- High quality Loudspeakers are normally stationary, but this can physically, be moved around the household or from one place to another
- Converted their values into a product concept by using quality materials, technology and a unique design
- Using distribution channels which are unusual by hi-fi manufactures: design stores, fashion houses and Appte stores

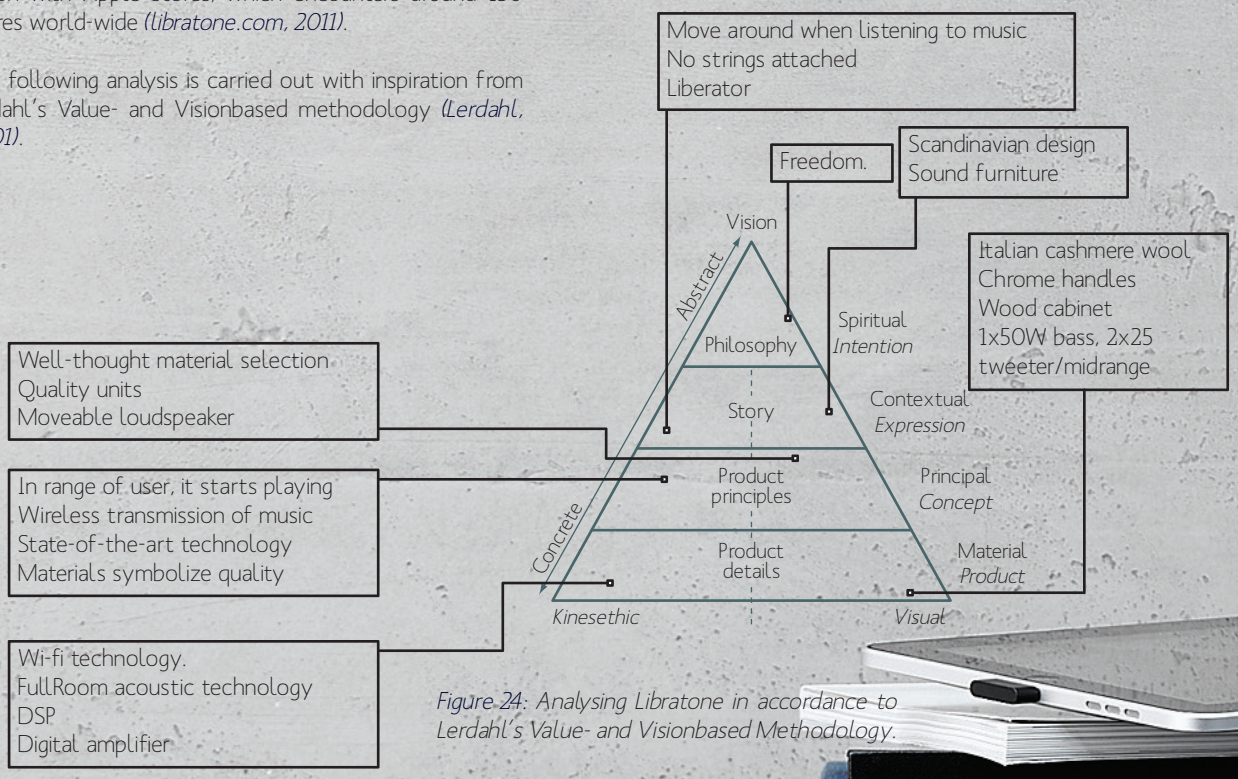


Figure 24: Analysing Libratone in accordance to Lerdahl's Value- and Visionbased Methodology.

Figure 25: All photos are free press material located on web-page (libratone.com, 2011).

Imagine a world without wires and cables. A world where you can play anything anywhere – perfectly. This is our vision.

Quote from *(libratone.dk, 2011)* about their vision.

B&W Zeppelin

B&W is a well-respected tradition-bounded hi-fi developer, researcher and hi-fi manufacture. It all started in 1965 in England, and has rapidly grown into one of the world's major loudspeaker manufacturer well-known world-wide.

Their passion, willingness, perfection and collaboration with great recording studios have made B&W a majority in loudspeaker production. In 1981 John Bowers founded Steyning Research Establishment, also called "University of Sound", with the intention of seeking for perfection by researching in sound technology *(bowers-wilkins.com, 2011)*.

B&W produces a wide range of loudspeaker product series, and has also made headphones, car audio, iPod docks, and computer speakers. One great milestone for B&W was the introduction of the Zeppelin where the finest drivers, best technologies, acoustical knowledge and digital signal processing and amplification all are merged into one stand-alone product. They raised the bar for the "music on the move market" - meaning users' movable, digital music libraries, and many replicates can now be found on the market.

B&W Zeppelin inspiration

- B&W used their knowledge in loudspeakers and technology to do vertical integration (not only focusing on loudspeakers but also amplification, digital technology, etc.), and to follow the trends in the market concerning users' portable, digital music.
- B&W is using the story about Bowers & Wilkins and its related values as branding for new products like the Zeppelin. Its idiom, design and functionality are radically different from their former product series, but manufactured with foundation in the same cores values B&W represent.
- B&W was one of the front movers within the market for iPod docking stations with focus on design, quality, performance and quality at the same time and hereby made a unique product niche.

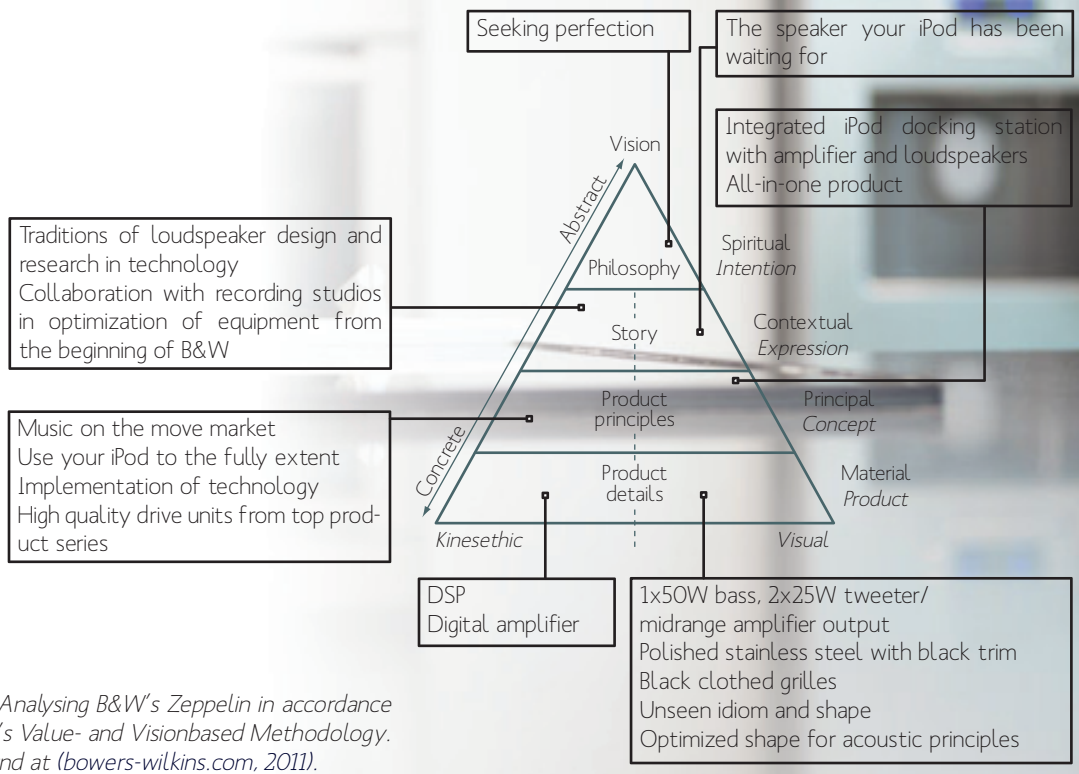
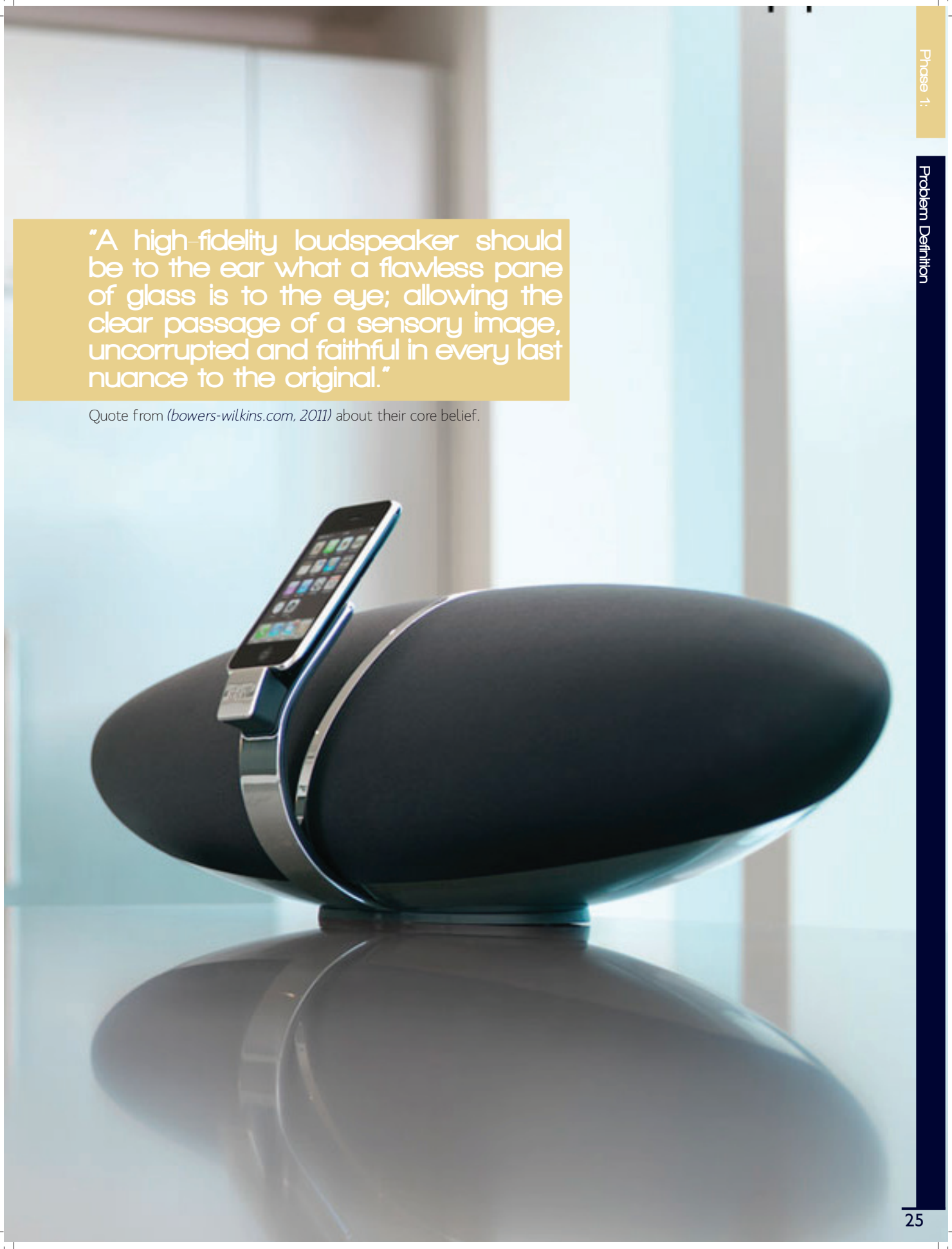


Figure 26: Analysing B&W's Zeppelin in accordance to Lerdahl's Value- and Visionbased Methodology. Info is found at (bowers-wilkins.com, 2011).

"A high-fidelity loudspeaker should be to the ear what a flawless pane of glass is to the eye; allowing the clear passage of a sensory image, uncorrupted and faithful in every last nuance to the original."

Quote from *(bowers-wilkins.com, 2011)* about their core belief.



All our efforts are committed to one single goal: to design and manufacture first class products which to please both the eyes and ears.

Quote from *(everything-but-the-box.com, 2011)* about EBTB's philosophy.

Figure 27: EBTB Venus speaker in a dual setup. Press material found at (everything-but-the-box.com, 2011).

EBTB Venus

Everything But The Box (EBTB) manufactures, develops and distributes handcrafted loudspeakers which are "everything but the box". The product series is highly different than traditionally loudspeaker designs in shape and finish.

The Bulgarian company started in 1991 with distribution and installation to major pro audio end-users in Bulgaria (radio stations, recording studios, etc.) before EBTB was founded. EBTB started in 2003, and from this point on, EBTB started developing its own series with focus on optimal acoustic design and loudspeaker idiom, shape, and design.

Venus is a satellite loudspeaker consisting of an midrange driver and a dome tweeter. It can be mounted on-wall by a bracket or hanging in wires from the ceiling.

The Venus loudspeaker is produced in the costumer's favourite colour, and can be supported by x-number of additional extra Venus speakers mounted in the same line (2 Venus' is visualized in the picture). Hereby the costumer can create a line-source speaker setup, which is more powerful than a single one *(everything-but-the-box.com, 2011)*.

The loudspeaker can also turn 90 degrees to fine adjust the setting after installation (up and downwards). It is developed to fit into multiple contexts with many opportunities for individual customization.

EBTB Venus inspiration

- EBTB has developed a loudspeaker which is easy to modify in colour, and has many opportunities for multiple installations
- One loudspeaker can also be used in a system of loudspeakers, meaning that several Venus loudspeakers can be merged into one, more powerful line-source loudspeaker for different user needs and preferences
- Created a provocative design by thinking differently, and made it with focus on every detail in the design (not designing a box)
- It is developed for stereo, and surround setups in single or multi-rooms. It can also be used in public areas

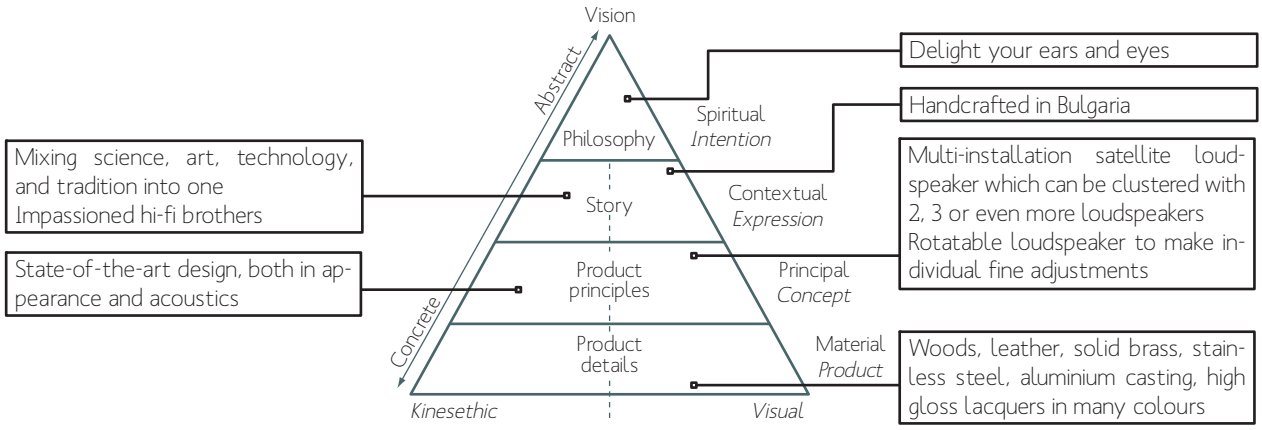
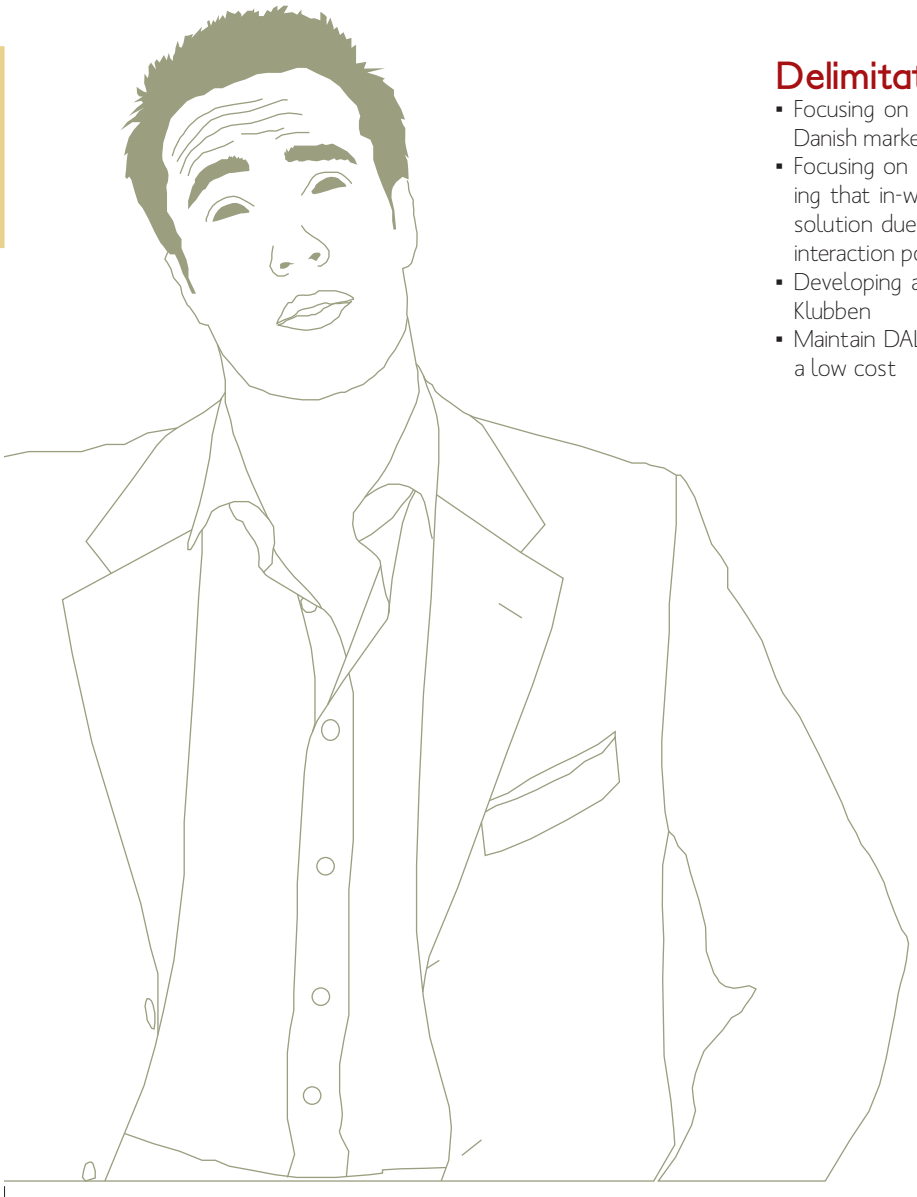


Figure 28: Analysing EBTB's Venus loudspeaker in accordance to Lerdahl's Value- and Visionbased Methodology. Info is found at (everything-but-the-box.com, 2011).

Problem Statement

The Problem Statement and delimitation are defined with point of departure in the Design Brief and preliminary market analysis.

"How can a loudspeaker be designed to fit into multiple contexts in a Danish household, and hereby merging the loudspeakers and household's music system into one user-friendly solution?"



Delimitation

- Focusing on developing a loudspeaker solution for the Danish market
- Focusing on the design of a visible loudspeaker, meaning that in-wall loudspeakers are not seen as plausible solution due to its invisibility, and lack of user-friendly interaction possibilities
- Developing a product with market introduction in Hi-fi Klubben
- Maintain DALI's core values of quality, performance at a low cost

User Research

User research is facilitated in the beginning of the project period for getting user insights. These insights provide inspiration for the following Concept Development Phase by identifying values important to users.

Planning

The point of departure is the defined Design Brief, market analysis, and Problem Statement. It is seen in previous projects that a user-centred design approach can provide new insights and knowledge about in-use situations, interactions and user-behaviour *(Chayutsahakij, 2003)*.

The research is executed with a practical output in mind, and can by Alain Findeli et al., 2008, be defined as "researching for design" within design research methodology. This means that a specific practical problem area is researched with a targeted output in mind which can be applied in this project, alone *(Alain Findeli et al., 2008)*.

In relation to this project, the output contributes to new insights in the field of design regarding music systems in Danish households. In the following chapter, theory, methods, key questions, and user contacts are presented for further systemic collection of user data.

Method for user research

Several methods can be used in conducting user research in practice. With inspiration from Chayutsahakij, 2003, the research is focusing on different innovation situations. These situations are divided into categories regarding new/known technology and new/known market situation *(Chayutsahakij, 2003)*.

The scope of the project is development of a new multi-room loudspeaker to Danish households, which is evaluated as a new market situation for DALI. DALI is producing in-wall, on-wall and on-floor speakers for multiple system solutions, which can function as a multi-room loudspeaker system, but none are directly targeted a multi-room solution.

Therefore, this innovation is situation KT-NM (known technology in a new market). The most suitable investigations models in KT-NM are defined as; activity, artifact, physical, and cultural. Common for all these are that it is an open-ended approach, which captures the users' experience and life style.

Innovation Situation	NT-NM	NT-KM	KT-NM	KT-KM	
				Utility	Design Language
Investigation models	Flow Activity Physical Cultural	Flow Sequence	Activity Artifact Physical Cultural	Sequence Ergonomic Physical model	Activity Artifact Physical Cultural
Phase of application	Predesign	Predesign During-design	Predesign During-design	Predesign Post-design	During-design Post-design
Research aim	Generative	Somewhat generative	Generative	Evaluative	Somewhat generative
Research structure	Unstructured	Semi-structured	Unstructured	Semi-structured	Semi-structured
Analytic perspective	Somewhat conceptual	Procedural	Conceptual	Procedural	Conceptual
Generalization	Cultural level	Social level	Cultural level	Social level	Social level
Mode of collection	Immerse Observe Listen	Immerse Observe Listen	Participate Observe Listen	Observe Listen	Observe Listen
Media of delivery	Visual Verbal Tactile Experience	Visual Verbal Experience	Visual Verbal Tactile	Visual Verbal Experience	Visual Verbal

Figure 29: User research for different innovation situations regarding technology and market. In this project the focus is put upon KT-NM (Chayutsahakij, 2003).

Mode of collection

The mode of collection is by Chayutsahakij, 2003, defined by participating, observing, and listening. This can be done by exploring the users' environment, and how the present technology is used in the known market situation.

It provides insights and knowledge about users' behaviour, reasons for actions, the meaning behind actions, emotional perspectives, and motivation.

The starting point is defining key questions which all are important to explore by using several different practival methods. They key questions are summarized into 3 main subjects:

- Users' behaviour in the context of use
- The interaction with product and system
- Present music system setup, and future system

The key questions are listed to the right with sub-questions with purpose of exploring each key questions in-depth.

Key questions

1) Users' behaviour in context of use:

- What is the household's music listening pattern, and why?
  - When do users listen to music?
  - Who is listening to music?
  - Why do users listen to music?
  - What music is the user listening to at what time of day/week?
  - Is it a supporting activity when users are doing another task or activity?
  - Is it a single-user activity or do users listen to music together?

2) User interaction with product and system:

- How is the users' interaction with the system?
  - Who is using the system?
  - With which part of the system is the user interacting with?
  - Is it possible to interact differently?
  - What is the most suitable interaction?

3) Present music system setup, and future system:

- How is the music system connected and placed in the household, and with what purpose?
  - How many systems are installed?
  - Who has installed the system?
  - What kind of system is it?
  - When will the system be replaced with a new one, and why (if any)?
  - What is the motivation for buying additional or/and new components for the system?
  - Who has the ownership of the system?

Establishing user contact

In the Design Brief it states that the targeted user groups are defined as "value identity" and "value for money" users. Even though, the facilitated user research is using all types of users. This is done due to difficulty in establishing user contact to one specific group, but mainly because of the opportunity for inspiration and input from professional users, "product believers / music lovers", and also the group "low budget".

Users are contacted by e-mail from a personal network in Denmark. The chosen users are not close friends or family because it can conflict in the validity of the data. Users are friends of friends or family co-workers.

The introduction e-mail sent to possible users can be seen in Appendix 2 on the attached DVD. *(see Appendix 2: User Research Templates: Cultural Probe interviewguide , DVD)*

Materials for data collection

The following tools and methods are used for the user research:

- Digital Cultural Probe (probe material sent by e-mail to users which needs to be printed and completed by user)
- Situated interview (recorded)
- Participatory picture cards (value and symbolism)
- Picture documentation (system setups)

In the scheme below, the tools are listed in relation to their task, purpose, and estimated duration of task.

Tools	Task	Purpose	Duration
Digital Cultural Probe	Mapping of how the music system is installed and connected in the household. Rating of users' preferences regarding price, design and quality/performance. Logging of users' interaction with music system, and by whom at what time.	Deeper understanding of how systems can be installed and connected in different context. Identifying target groups. Observation of interaction patterns.	10 min. of mapping/ rating, and 1 week of logging by multiple users.
Interview	A following interview in users' context with further in-depth questions regarding the Cultural Probe material. Understanding of users' behavioural pattern concerning music and music systems. Understanding of the household's economical and demographic situation, and motivations for buying new components or equipment.	Deeper understanding of users, in-use scenarios, and behavioural issues. Roles in the household, and decisions regarding the system and usage.	40 min. interview with one or multiple users.
Participatory picture cards	Using picture cards to symbolize values in relation to their present and future loudspeakers.	Debating and get insight in users' emotional point of view regarding loudspeakers by the use of values. Also define what effect these values have at a personal level.	10 min. of debating, discussion and defining values.
Picture	Observation and documentation of in-use scenarios by questioning the users' action. Installation and connection issues are discussed and documented by pictures.	Users' interaction with music system, and documentation. Identifying preliminary issues in systems and context constrains.	20 min. of picture documentation.

Figure 30: 4 different tools are used to collect user data. The tasks are defined with the purpose of answering 3 key questions from previous page with use of minimal time. Hereby is it possible to collect more empirical data in less time.

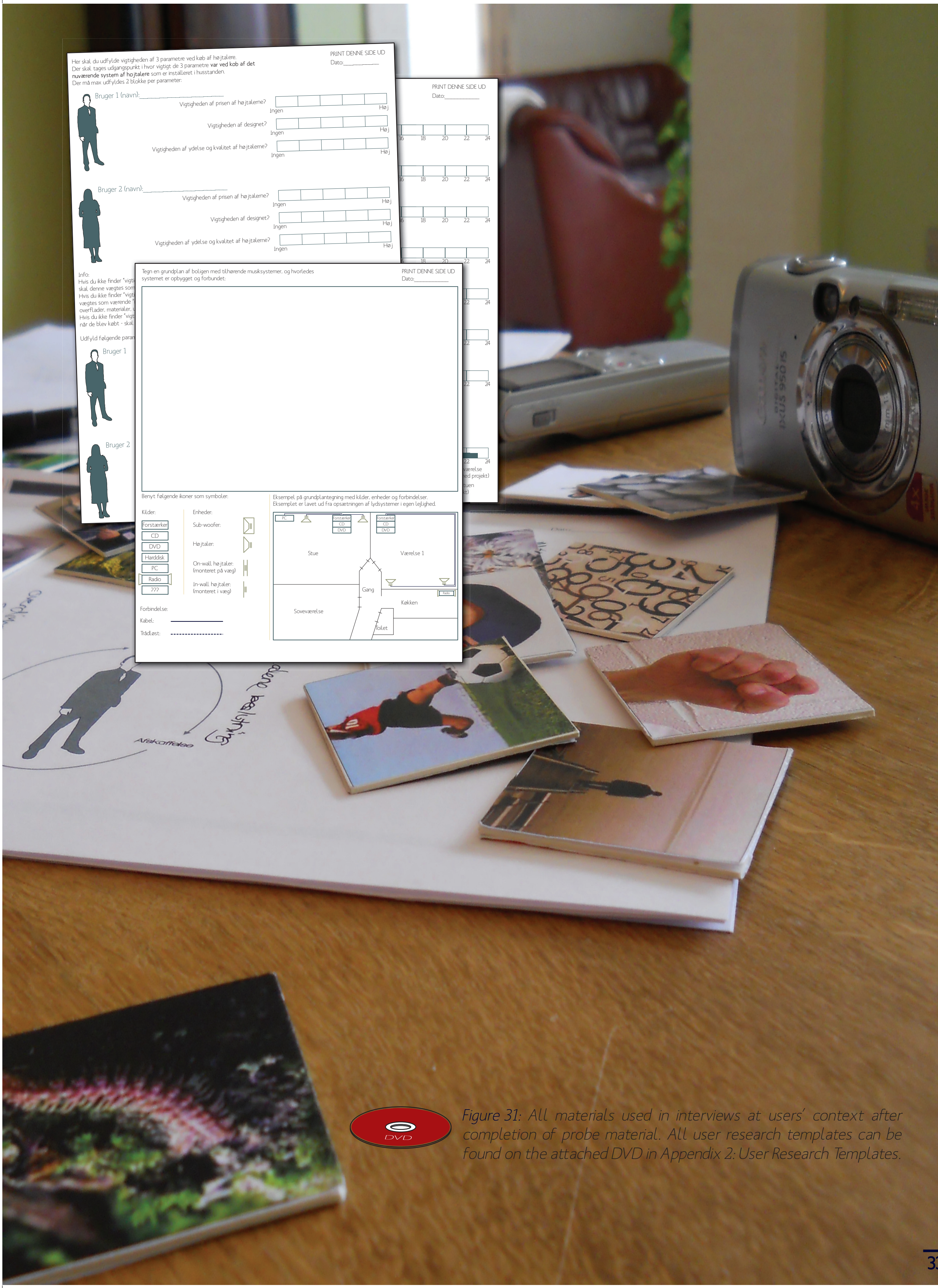


Figure 31: All materials used in interviews at users' context after completion of probe material. All user research templates can be found on the attached DVD in Appendix 2: User Research Templates.

Data Extraction

The user research data is all processed with use of the KJ Method *(Scupin, 1997)*. In this chapter, the data is extracted resulting in 5 user insights which both gives inspiration, and identifies values of importance to users. The insights are used for creation of new Strategy Canvas' for the Danish loudspeaker market.

The empirical data from the user research is used to get inspiration and user insights about users' music behaviour, interaction and present/future music system setup. By doing these interviews it is possible to "be surprised" by opinions, meanings, setups, etc.

The data is consisting of voice recordings, and picture documentation from 5 different users. It can all be found in Appendix 3 on the attached DVD.
(see Appendix 3: User research Data: Interview 1, interview 2, interview 3, interview 4, and interview 5, DVD)

Target group considerations

The chosen target group for the user research is a small representative cross section of the target group population in Denmark, and is not further explored due to limited time and resources. For a broader selection of user data, a wider range of users need to be consulted (greater diversity in gender, age, personal interests, demographics, etc.).

In this project, the user research is carried out on the island of Funen in Denmark with participation of man and women in the age range of 30-40 years. They are all married with children, and living in single family houses. This target group was not specifically chosen to fit these criteria, but contacted because of easy networking and accessibility.

KJ Method

The data extraction is facilitated using the KJ Method *(Scupin, 1997)* which originally is a research technique for analysing empirical ethnographical data in a systemized approach. It has its roots in Japan, and is widely used in many areas of science and applications.

The method's appliance

The KJ Method is used to organize the empirical user research data into groups with same characteristics, and afterwards extract essential user insights. These insights give inspiration in how to create value innovation to users illustrated by Strategy Canvases in the end of this phase. The method is also used for brainstorming during data extraction.

In the following, the method is explained with descriptions of how the method is used. The method consists of 4 main steps *(Scupin, 1997)*:

1. Label making. Information based upon observations and /or quotes relevant to the problem is written on note cards containing only one statement at the time. Labels are noted on a computer with use of the recorded interview. The first interviewed person has labelled "1." in front of every quote, and the quote is in red if it is said by the woman in the household. Interview no. 2 is labelled "2" and etc. This is done to make it easier for the facilitator to remember the exact quote, and the meaning behind that statement.
2. Grouping. Randomizing the concepts or thoughts (quotes) by shuffling labels and then grouping the labels into "team families". Preconceived thoughts must not motivate one's choices, but feelings should dominate logic in grouping the labels together. Team families are assigned with a title, and afterwards teams within the team family are grouped and assigned with a title. Relations, contradictions, similarities, etc. between teams are mapped initiating a brainstorming while working.
3. Chart making. Generation of a chart including a new team family consisting of teams from other existing team families. The new team family chart is describing an user insight, and brainstorming is mapped directly onto the chart. The insight is assigned with a suitable title.
4. Explanation. To communicate the results logically, the chart must be explained verbally and in writing short and concise. Its purpose is to reduce the chart's complexity, and to express in detail the relationships of teams which are represented in the chart. The communication is done by pictures, quotes, team Post-its, and by a short descriptive text.

To the right, the method's progress is explained step-by-step.

1. Label making

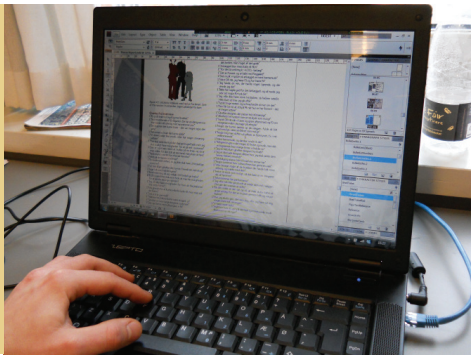


Figure 32: Typing quotes into computer.

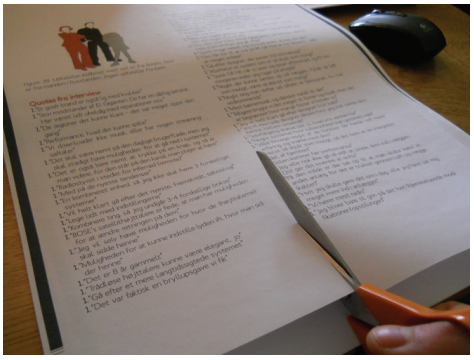


Figure 33: Clipping note cards.

2. Grouping

Figure 34: Grouping into team families.

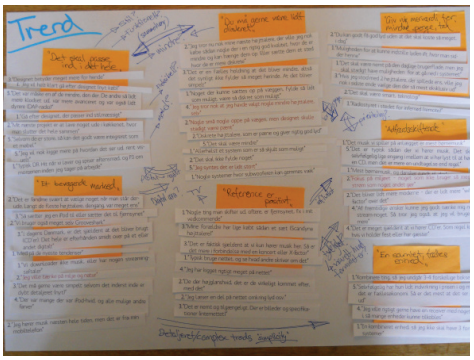


Figure 35: Creating teams within the team family.

3. Chart making

Figure 36: Exploring all team families and teams.

Figure 37: Creating new team families by "stealing" teams from existing team families, and title the new team family.

4. Explanation

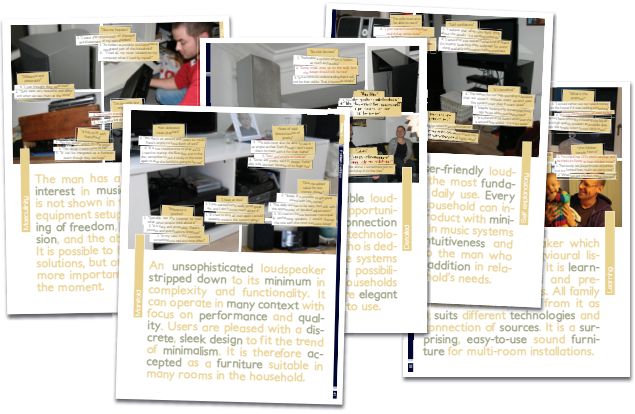


Figure 38: The new team family's chart is explained using pictures, team Post-its, and quotes from the user research emphasizing what this insight describes. Additional text is explaining this insight into words. The 5 charts can be found in Appendix 4 on the attached DVD (see Appendix 4: User Insights, DVD)

"AS IS" and "TO BE"

All the analysis' and insights are summarized into Strategy Canvas' in an "AS IS" situation (present/competitors), and a "TO BE" situation (upcoming/future product). Products are evaluated in values identified via user research.

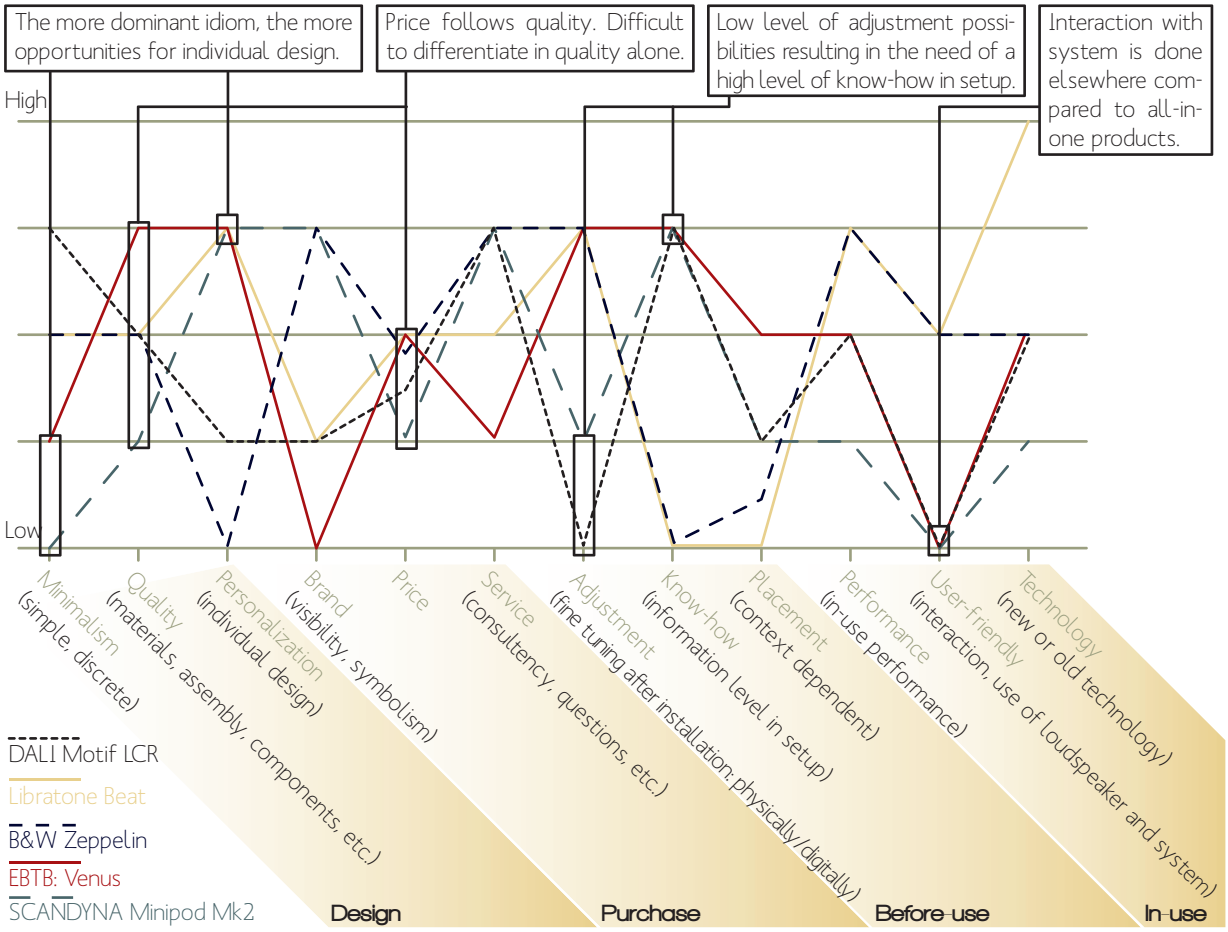


Figure 39: A competitor Strategy Canvas. This canvas maps identified values from user research insights, and evaluating the values with competitor products found in Hi-fi Klubben, and interesting products from other distributors. Values are evaluated by the project group, and executed with knowledge from visits in Hi-fi Klubben, user research insights, and desk research.

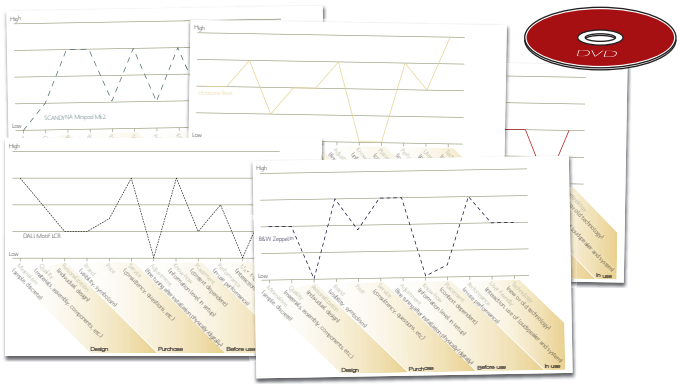


Figure 40: Competitors Strategy Canvas' can be found in Appendix with detailed explanation about each value's rating. (see Appendix 5: Competitors Strategy Canvas', DVD)

"AS IS" situation

The Strategy Canvas above is a merging of 5 canvas' which is seen as competitors in a multi-room installation.

Some of the major unique selling propositions in loudspeakers are quality, price, performance, and technology. Viewing isolated on the loudspeakers' Strategy Canvas' (Motif LCR, Venus, and Minipod Mk2), only, is it shown that the curves are very much alike with minor diversity in some values. The biggest diversity is seen when comparing all-in-one products (Beat and Zeppelin) with loudspeakers. The Beat and Zeppelin are easier to adjust and place in a household because of their mobility. They are a bit more expensive than a single, passive loudspeaker.

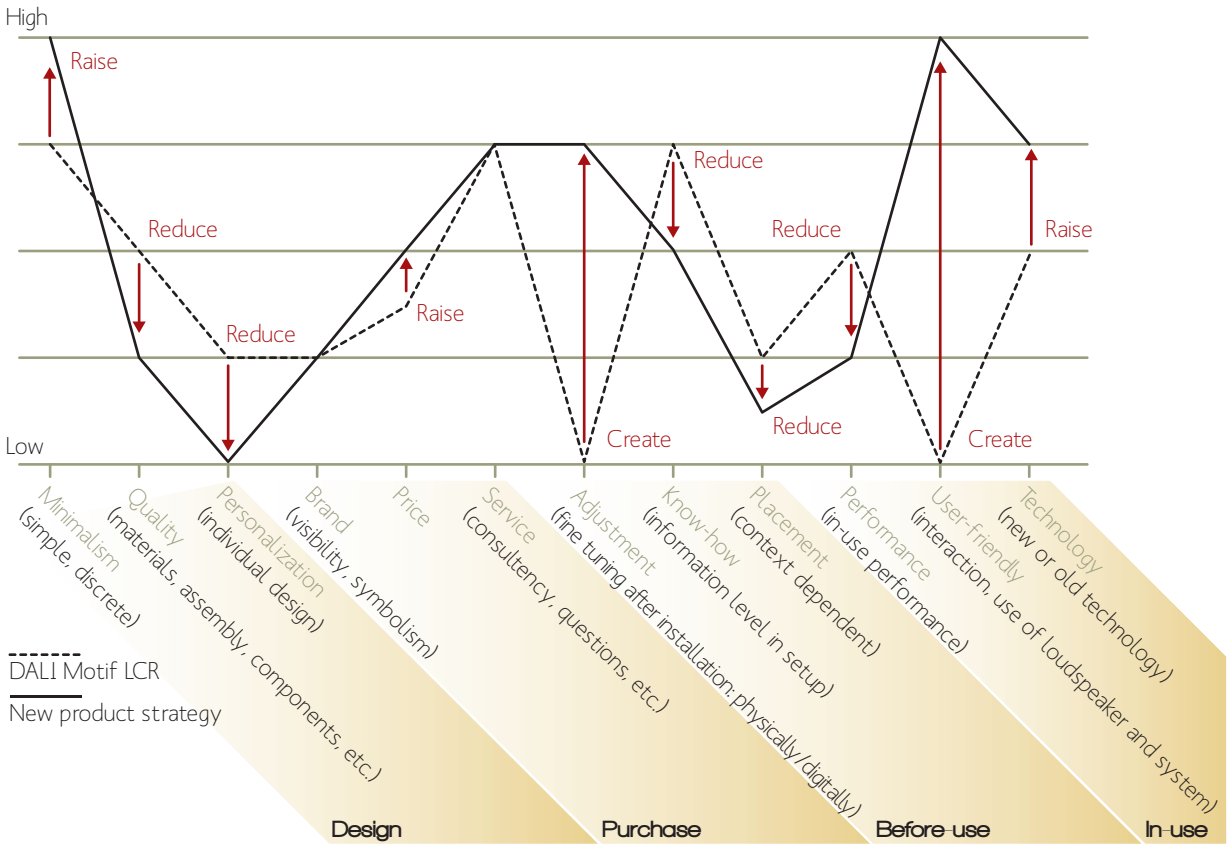


Figure 41: Strategy canvas for the "TO BE"-situation. This canvas summarizes the Problem Definition phase by visualizing what values the project is aiming in the following Concept Developing Phase. The canvas synthesises what is evaluated as the most suitable project strategy for creating a Blue Ocean. Evaluation is based on analysis' throughout this phase of the project.

"TO BE" situation

The "TO BE" situation is illustrated on the Strategy Canvas above including DALI's newest product Motif LCR. In here, indications are made where values are reduced, maintained, raised or created. The canvas is made with point of departure in theory about Blue Ocean Strategy *(Kim & Mauborgne, 2005)*, market analysis, and by extracting valuable user insights from previous chapter.

Especially, the user insights labelled "Self-explanatory" and "Detailed" are used in creating the new Strategy Canvas, and can be seen in Appendix 4.

The chosen strategy is evaluated as the most potential strategy regarding the creation of value innovation. It reduce values where it is seen possible, and creates beneficial value addition in unseen areas within stand-alone loudspeakers. 2 additional discarded Strategy Canvas' can be seen in the Appendix on the attached DVD.
(see Appendix 6: Strategy Canvas 2 & 3, DVD)

Value proposition

- Making an even more minimalistic loudspeaker which is a trend in the market, and also do user insights emphasises this point of view
- Reducing quality, personalization, and performance values to compensate for potential increasing economical costs
- Raising the price level due to the possibility of introducing new components/technology to the loudspeaker
- Creating opportunity for physically adjustment after installation of loudspeaker in the household
- Reducing the level of know-how when installing to attract more users in purchasing the product
- Reducing the level of context dependency by making a more minimalistic design or/and movable product
- Moving the interaction from the music system to the stand-alone loudspeaker, and hereby opportunity of product differentiation
- Raising the level of technology due to new interaction

Phase 1 Reflection

Reflections are made after each phase of the project concerning used theory, methods, project process, and project outcome.

Problem analysis

The Problem Analysis chapter is the starting point of the project definition carried out in this phase of the project. It quickly became clear that high fidelity music equipment has a solid history with many manufactures, and just as many individual opinions about what good equipment is. Therefore, a brief introduction is made about loudspeakers history and how they in generally work. It could have been beneficial to have made a detailed description on how a loudspeaker's drivers are working for achieving a better understanding of its functionality and principles. It is not seen crucial at the time, and will be explored later in the project if seen applicable.

Market

The loudspeaker market is huge and a mixture of enthusiastic manufactures, which all have products that differentiate themselves some way or another. It is therefore difficult to figure out what is with greater importance for users, and what values to emphasize in the analysis. The market is explored with an open mind and with focus on values, and how competitors are expressing their values throughout the products. It is not only passive loudspeakers, which have been analysed, but also all-in-one products. Again, it gives great inspiration about market trends by looking at different solutions to the same overall need of music playback instead of product specifications only.

The Value- and Visionbased methodology is used, and has given inspiration on how the values are expressed. At that state of the project, user research was not facilitated and hereby important values identified by users unknown to the project group. The Competitor Analysis could have been even sharper and more precise if it was carried out after the user research with a more focused result as outcome.

Problem Statement

The defined Problem Statement is an outcome of the first analysis made in the beginning of the project period. It is focusing on how to create a multi-room loudspeaker suitable for many Danish contexts merging the household's music system into one user-friendly solution.

During user research and market analysis it is found interesting to re-think how users are interacting with their music systems. Many solutions have in-built interaction possibilities, but are all mainly expensive, and typically the interaction is an add-on feature to the system. It is seen very likely to develop an unseen product which integrate technology, interaction, and design into one unified whole, and hereby creating value innovation to users.

User research

The defined task in the Design Brief is a very open assignment, and was defined in collaboration with DALI. From the beginning of the project, one of the personal learning objectives was to plan and execute user research, and it has been a very beneficial experience in many levels. The greatest outcome in relation to the project has been the verification of ideas and problem areas which beforehand were seen plausible for product optimization.

Before starting the project, it was known that the loudspeaker market situation is very rigid, and hereby difficult to differentiate a new product. Therefore, a user-centred design approach is used to get new user insights to inspire the development of a new product.

Establishing user contacts has been a challenge, but with use of personal network it was possible to find users with interest in participating in interviews. Several pages of material were sent to users with, for instance, a task of mapping their listening pattern and music behaviour. An interesting outcome of this was that users had thought and reflected upon their music behaviour because of one week of mapping before facilitating the interview. When questioning, it was observed that they all had very qualitative answers which is seen unlikely if random situated interviews were conducted without sending the probe materials.

A bigger diversity of users could have given the project a greater output, but is delimitated due to limited time and resources. Even though only 5 users were interviewed, the interviews did provide great user insights and inspiration to the creation of new product canvas'.

KJ Method and data extraction

The KJ Method is used to extract the data. By questioning the probe material and mapping in the following interviews, all materials were discussed and quotes used on note cards. It is found very efficient to make note cards from quotes instead of observing picture and video material.

The method has been a very beneficial tool for analysing user material. The most surprising element is the fact that you automatically brainstorm when allocating note cards, creating families, and team families. Relations and contradictions between families have also been used to inspire and get new ideas. It is seen very plausible that this method can be used in many contexts, and other projects to come.

The method describes that it should be executed in a group for greater outcome. It is seen very likely that a higher level of user insight is possible if i.e. the method was executed with participation of representative from DALI or other Industrial Design students at AAU. It can also be used as a tool for better communication and common project discussion in-between the company and project group.

Blue Ocean theory

Blue Ocean theory is an interesting way of looking at the market, and how to differentiate a company or product by creating value innovation. The theory is used on a general level, and suitable tools and methods are used in the project i.e. the development of Strategy Canvas'.

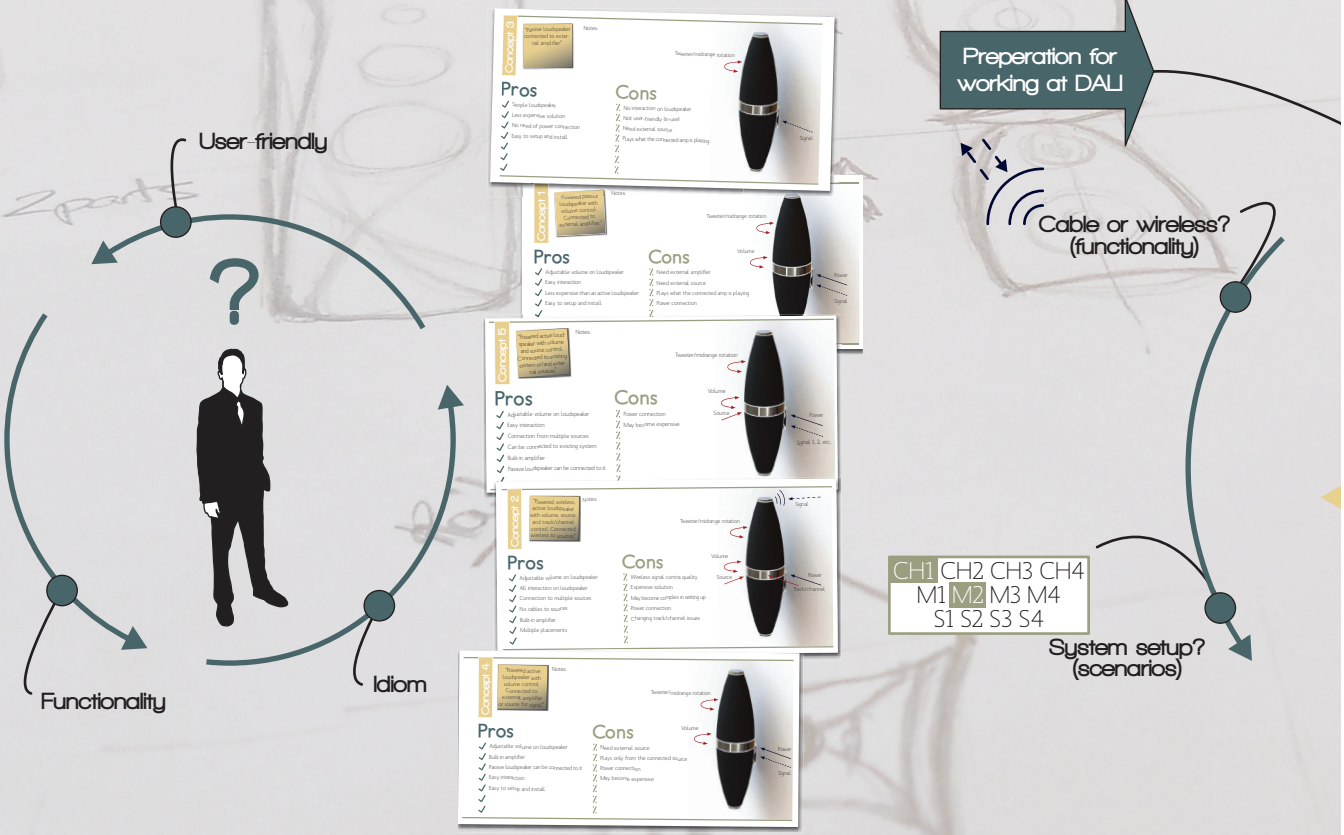
If Blue Ocean theory must truly be integrated at DALI, the whole company must follow the main principles of the theory. It is not seen possible nor the purpose for the project group to affect DALI's administration in this way.

The theory has helped transforming market and user insights into a structured, illustrative platform of communication about what the project is aiming at developing. In the end, it hopefully gives inspiration to DALI in how a product's characteristics and values can be evaluated in relation to competitors and existing products.

Strategy Canvas

The most beneficial outcome of Blue Ocean strategy is the creation of Strategy Canvas'. It truly helped the project group to easily illustrate how and where to differentiate a new product with use of market and user insights.

It is a very communicative way of explaining what this project is aiming, and it will be evaluated in the "Point of Perspective" chapter if accomplished or not. It is seen very plausible that the Blue Ocean theory and methods can be used in other projects with great outcome as result.

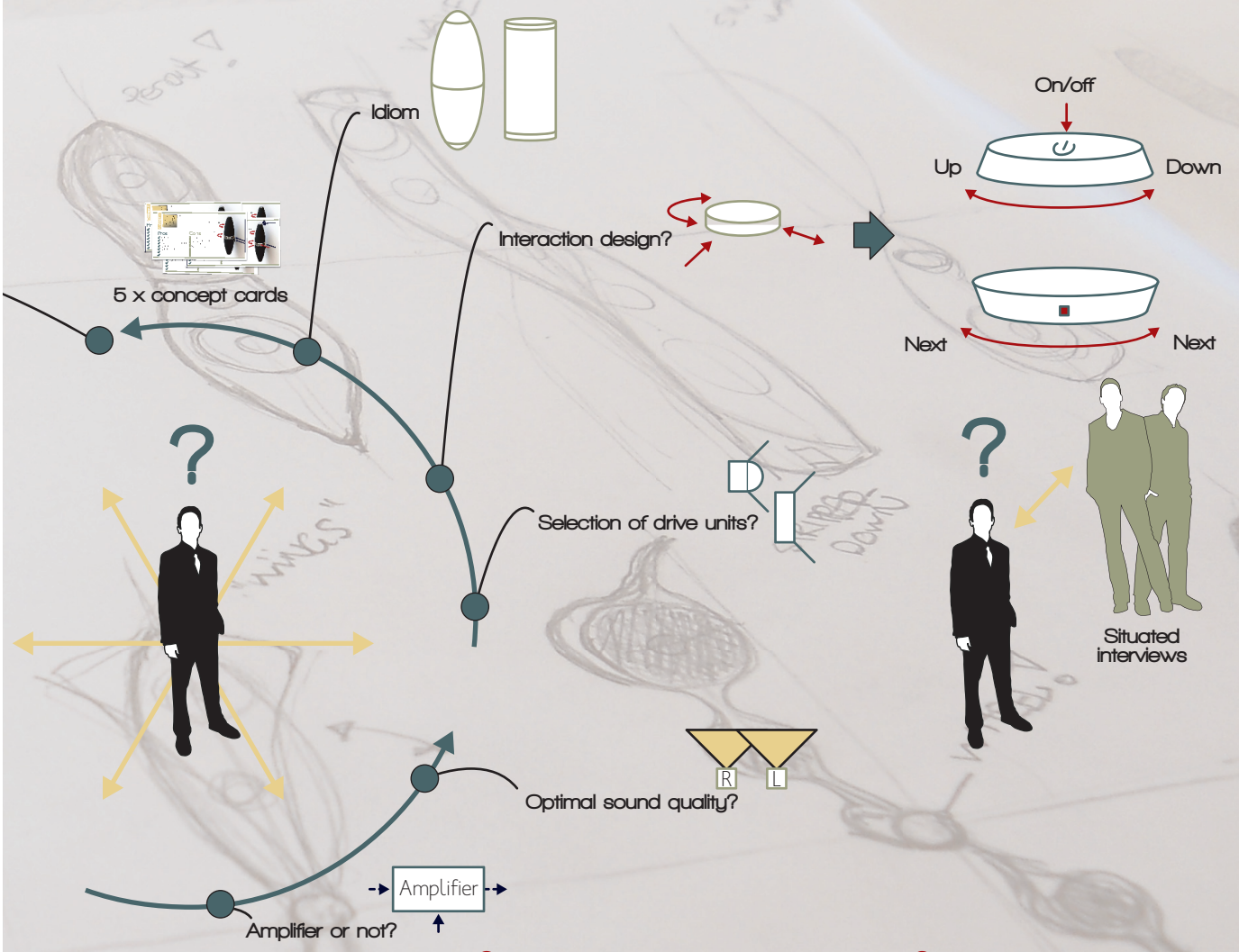


Output

- Initial concept ideas
- Material for discussion with employees at DALI

Initial concept development

Phase 2: Concept Development



Output

- Loudspeaker knowledge and professional consultancy by DALI
- Loudspeaker functionality

Output

- Determine interaction principles
- Situated interviews facilitation

Working at DALI in Nørager → Interaction design

Figure 42: Phase 2 overview.

Functionality

The Concept Development Phase is among others a result of a three-day visit at DALI in Nørager with consultancy by employees with different competencies within loudspeaker construction and technology. Decisions are made in collaboration with DALI, and in the following chapters the choices made throughout the phase are elaborated.

Interaction

Present loudspeakers do not need any interface if they are passive (without amplifier included). This is what DALI normally is manufacturing, and is also more simple and hereby cheaper in production and developing (DALI manufactures active subwoofers in some product series).

It is seen possible to integrate functions into the new loudspeaker, and hereby create the possibility of easy interaction because of:

- A multi-room installation will have loudspeakers in many different positions and placements
- Changing volume, source, track, radio channel, etc. are a possibility of interaction when music is playing in many rooms instead of using a multi-room solution like SONOS. When a multi-room solution like SONOS is not installed, all interaction is done at the source
- Creating an all-in-one product where users can interact with a more discreet and minimalistic stereo setup instead of big boxy amplifier and sources

5 different concept cards with focus on different interaction and functional possibilities are made before visiting DALI. These cards are printed in hard copy to discuss issues and opportunities with employees at DALI who all have different expertise within loudspeaker construction, production, acoustics, and technology. The 5 concept cards can be found in Appendix on the attached DVD *(see Appendix 7: Concept Cards, DVD)*.

By discussion and consultancy with employees at DALI, it quickly became clear that it is very difficult to create an interface with a track and channel (radio) option. In order to integrate these functions, the loudspeaker needs to be able to communicate with the source (for instance wireless connected Mp3-player like Apples AirPlay wireless module). These functions are not seen plausible, and therefore not chosen.

In contrary, it is seen possible to integrate the opportunity of adjusting volume and selecting sources, which will be further elaborated in the chapter "Interaction Design". These functions are also seen in external amplifiers like the Argon DA1 Digital USB-Amplifier, which directly can be connected to passive loudspeakers *(hifiklubben.dk, 2011)*.

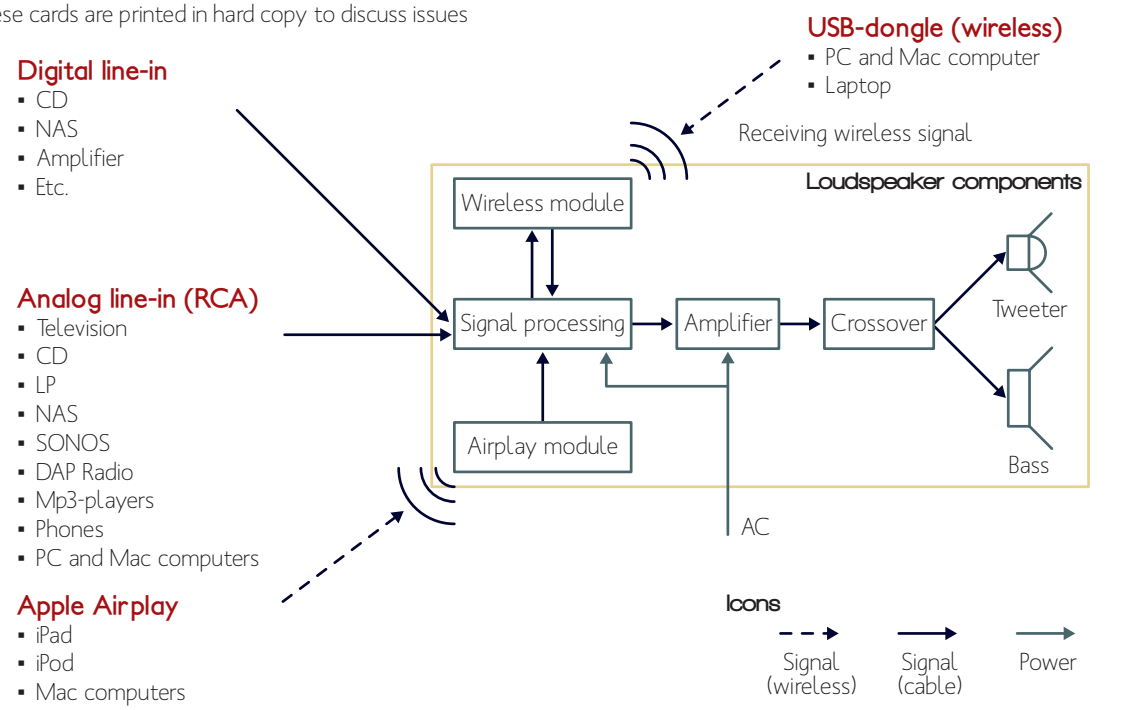


Figure 43: Mapping of internal components of a loudspeaker for a multi-room solution in relation to which sources the loudspeaker can be connected to. In this mapping an amplifier is included in order to make an all-in-one solution.

A mapping of available sources, loudspeaker components, and external wireless modules can be seen at the bottom left figure. It is not possible to develop a loudspeaker which can play every single source, and therefore a selection is made in respect to cost price addition, technological constrains, and plausible features (see figure at the bottom for the selected sources and components).

Connected sources

Criteria of selection with respect to users' existing sources in their households derived from user interviews:

- Opportunity of connection to existing sources in the household like CD-players, LP-players, MiniDisc, etc.
- Opportunity of connecting a DAP Radio
- Opportunity of connecting phones, computers or other Mp3-players
- Television connection without delay (DALI employees explain that wireless audio streaming has an in-built buffer which compensates for loss of signal. Therefore, the signal is not streamed instantly (real time), and cannot be used for television at the moment. Technology is progressing fast, and is evaluated as a possibility in near future)

A totally wireless loudspeaker would be beneficial for users due to installation of many cables when several loudspeakers are connected together in a multi-room solution, and hereby playing from the same source.

Constrains

By discussing the concept cards with DALI employees, it became clear that a wireless loudspeaker is possible but challenging due to the following issues:

- Selection of wireless technology
- Update and maintenance of the technology
- User interface programming
- Cost price addition (technology/components)
- Power connection (when a wireless module is integrated into a passive loudspeaker, it needs an amplifier to process the signal (amplify it)

Area of focus

In the figure below, the chosen setup of components is illustrated. A wireless module is integrated into the loudspeaker with the purpose of transmitting and receiving music in-between loudspeakers in a multi-room setup to eliminate cables. Analogue RCA inputs are used in securing that users' existing sources and TV can easily be connected to the system. In addition a wireless USB-dongle is seen plausible to introduce, which can transmit music to every loudspeaker due the loudspeakers' in-build wireless technology. Apple Airplay wireless streaming is only an option if dedicated partnership is made with Apple. DALI's greatest competitor, B&W, has a collaboration with Apple (Zeppelin product), and is therefore not seen plausible.

The wireless technology is evaluated plausible and seen in a similar product from etc. Audio Pro, which uses a dedicated internal wireless network in-between transmitter and receiver on 2.4 GHz frequency *(audiopro.com, 2011)*. This secures stability in the streaming of music.

USB-dongle (wireless)

- PC and Mac computers
- Laptop

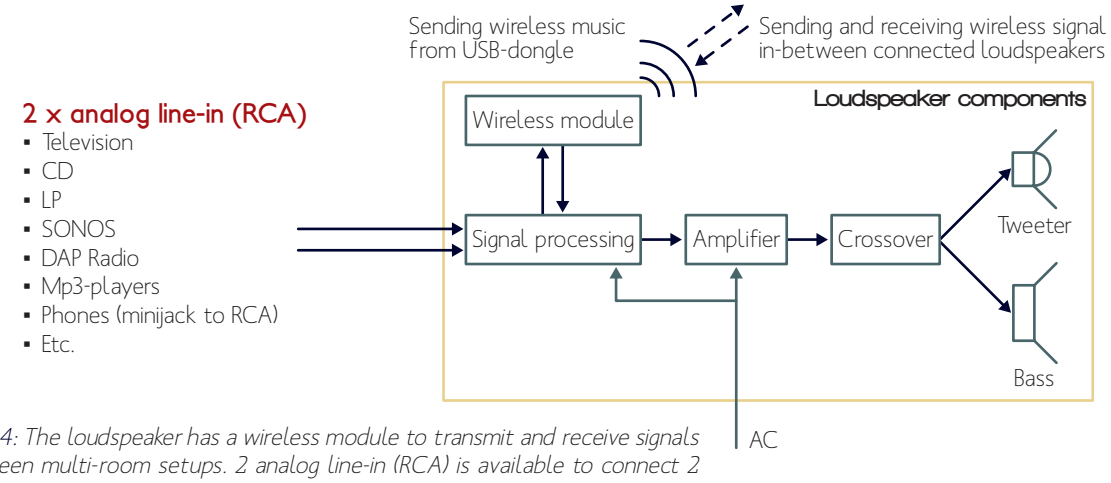


Figure 44: The loudspeaker has a wireless module to transmit and receive signals in-between multi-room setups. 2 analog line-in (RCA) is available to connect 2 different sources plus the option of transmitting wireless music by USB-dongle.

System Setup

This chapter describes different setups of loudspeakers in multi-room installations. The loudspeaker's functionality is closely developed with respect to the system's flexibility in placements in its context of use. However, the system architecture is seen as guidelines on how it can be designed in practice.

Each loudspeaker's incorporated components and functions are designed to create a multi-room loudspeaker which can fit into as many contexts as possible in a Danish household. By integrating wireless transmitting and receiving in-between loudspeakers, cables are spared and other loudspeakers in the household are merged into the same zone of music in any constellation the user desires. This means that it is possible to use only one channel for music in the entire household, which results in one music tune playing instead of several different music tunes. In another scenario, it is possible to create 4 different zones of music (see scenario 1 in the illustration to the right).

Left and right loudspeakers

In respect to DALI's sound quality standards, a stereo setup of 2 loudspeakers is chosen as the most suitable in any given context. An alternative is to develop a soundbar including both a left and a right loudspeaker for creating true stereo perspective. This aspect is further elaborated later in the "Sound Quality" chapter. In the scenario description to the right, the left and right loudspeakers are illustrated with "L" and "R". The user must select which loudspeaker is left and right when presetting the system.

Selecting channels

Before installing every loudspeaker, the user must preset to which channel (musical zone) it is connected. If the user wants to merge the living room and kitchen together, the same channel is chosen (CH1 is selected.: see scenario 2). By doing this, the user has chosen that whatever the loudspeakers in the living room are playing (transmitting), is available in the kitchen when the source selection is set to "wireless" (receiving) on kitchen loudspeakers. In scenario 2, rooms 1 and 2 are connected to 2 independent channels, and hereby playing individual music. The selection of channels can at all time be changed after setup.

Room selection

When the channel is selected, the user must preset in which room (indicated with an "R" in the box) the loudspeakers are placed. The loudspeaker setup in scenario 2 is in the kitchen selected as room 2 (R2), and in the living room as room 1 (R1). - both on channel 1 (CH1). This means that whatever music is playing in the living room is transmitted to the loudspeakers in the kitchen. Additionally, a radio is connected to the left loudspeaker in the kitchen in scenario 2, which is using the same wireless channel as the living room. The kitchen setup will play the radio tune even if the living room is playing music due to the selection of room (R2). It is caused by the room selection which is a dedicated selection in-between the 2 loudspeakers (left and right) and hereby of higher priority than the living room transmission of music. When the user wants to listen to the living room's connected source again, the radio is turned off, and the kitchen setup automatically detects that music is being transmitted on channel 1 (CH1) when the "wireless" source is selected. Another option is to select "wireless" on the living room loudspeakers resulting in the kitchen radio being transmitted to the living room. Whenever the user is installing a setup in different rooms, which is not a part of the multi-room installation, the room selection parameter is not important (like in scenario 1).

Volume control

In scenario 3, both the living room and kitchen are connected to the same channel with individual room selection. This is beneficial if the user wants different volume in each room. Therefore, the room selection is also dedicated to interconnected volume adjustment in-between loudspeakers in a setup. Volume adjustment are facilitated using the incorporated wireless network.

USB-dongle

With the integration of wireless technology in every loudspeaker, it is possible to use the same technology in a USB-dongle for streaming music from computers and laptops. The USB-dongle needs to have an integrated channel selector (see scenario 2 and 3, room 1) in being operational. The loudspeakers in room 1/scenario 3, have both selected "wireless" as source which results in wireless streaming of music from a USB-dongle. A radio is also cable connected to the left loudspeaker, and therefore transmitting music to the right loudspeaker whenever the radio is selected as source.

Technological issues and delimitation

The integration of wireless technology is competencies which DALI has to in-source before getting a fully functional product or, as an alternative, by incorporating a fully functional wireless module. The system architecture is seen as overall guidelines on how the wireless communication and setup in-between loudspeakers could function in practice. It is evaluated possible to buy a functional module with the described functionality with additionally programming of its system setup functionality by electronic engineers. Consequently, it sets up demands for testing and quality assurance. The wireless communication is from this point of departure delimited due to limited knowledge about implementation of the module and further technical issues.

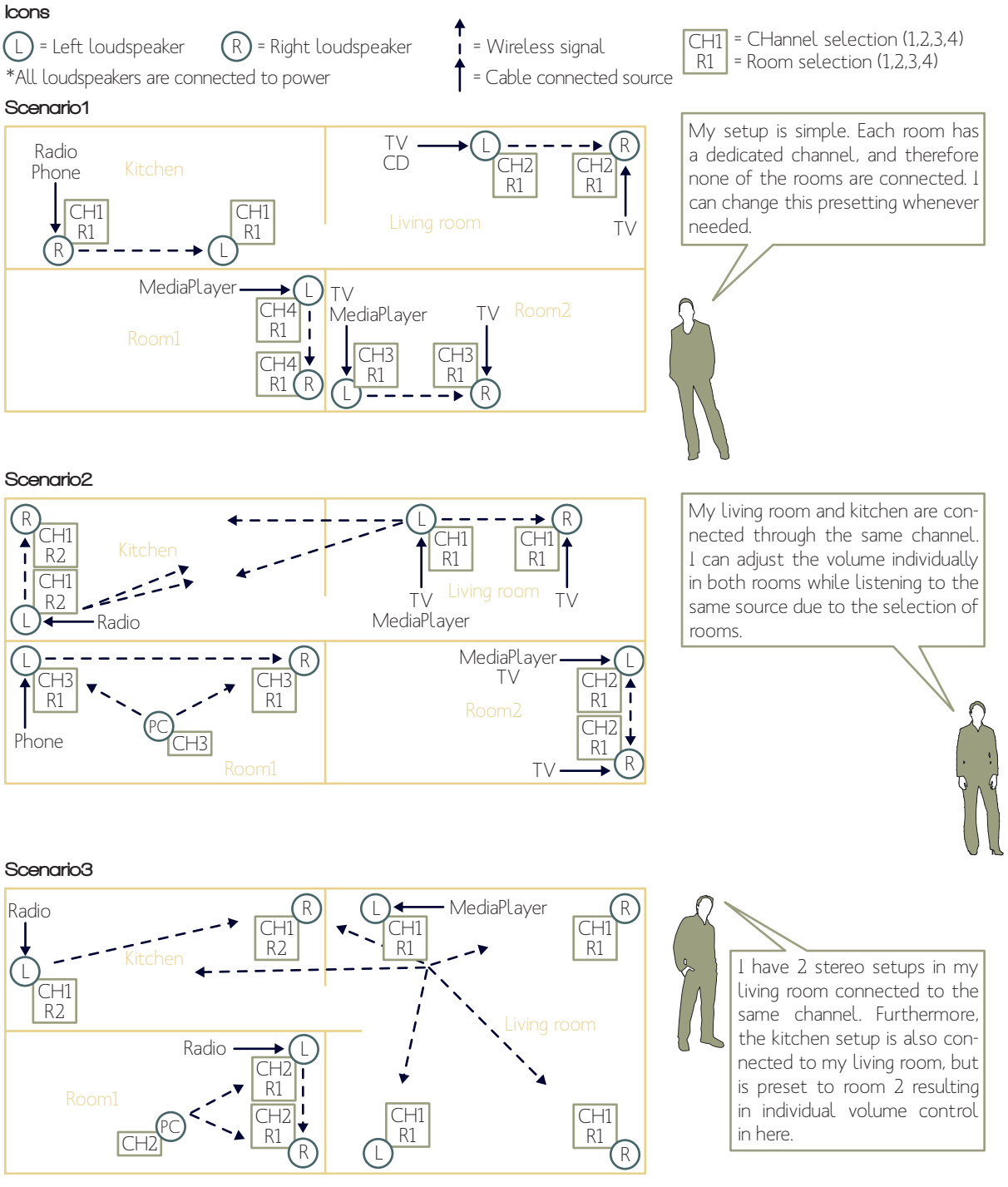


Figure 45: 3 different scenarios of system setups with elaborated comments of its use.

Active or Passive Loudspeaker

Setting up 3 different scenarios regarding integration of an amplifier in the multi-room loudspeaker.

One of the major decisions with great influence on every single part of the loudspeaker construction and functionality is the question regarding integration of an amplifier or not (passive/active loudspeaker). In here, three scenarios are seen as options with individual pros and cons. Examples of the 3 solutions can be seen in the figure to the right.

Solution 1 (no amplifier)

If a passive loudspeaker is chosen, an external amplifier physically needs to be connected to each loudspeaker in order to perform. Some TV's have an in-built amplifier, and loudspeakers like the Motif LCR can therefore directly be connected to the TV. All other sources need the signal processed throughout an amplifier.

If solution 1 is chosen, cables are needed to every single loudspeaker directly connected from the external amplifier and source. Furthermore, additional cables are needed for multi-room and interaction purposes with integration of additional multi-room control units like SONOS. This solution is not merging the household's music system into one, intelligent solution, and therefore it is not seen as an option.

Solution 2 (amplifier in one loudspeaker)

Another possibility is to integrate an amplifier into one of the loudspeakers in a stereo setup, and cable connect the left/right loudspeaker. It has its benefits in only using one amplifier (instead of both loudspeakers being active), and the signal being cable connected eliminating wireless connection between the left/right loudspeaker. The wireless communication is needed in between every stereo setups in the household creating a more simple multi-room solution compared to cable setups in-between every room.

Solution 3 (amplifier in both loudspeakers)

Solution 3 is the most flexible and seen as the option which fits a multi-room installation the most due to the following aspects:

- Every loudspeaker can have all functions integrated which gives the user the possibility of selecting sources and volume on every single product
- Both loudspeakers in a stereo setup can be connected to external sources. This doubles the opportunity source connectivity and hereby increases flexibility
- No cables need to be connected in between a left/right stereo setup because of wireless streaming of music reducing overall installment of cables (only power cable an if a TV is connected)
- The loudspeakers are identically produced resulting in less comprehensive production and assembly

Integrating amplifiers and wireless modules in every loudspeaker has the following cons:

- Increasing the cost price
- Increasing complexity in setting up due to channel, room, and selection of left/right
- Programming and development costs
- Maintenance of wireless system (updating)

Demands

Solution 3 is selected as the most suitable setup due to its flexibility in setup in multiple contexts and in-use scenarios. By selecting a solution with integrated amplifier in all loudspeakers, a set of demands for the amplifier can be listed:

- 2 x RCA line-in in each loudspeaker (2 analogue line-in connections are evaluated as acceptable due to the opportunity of connecting 2 sources to each loudspeaker in a stereo setup resulting in 4 sources in total)
- 2 x 50 Watt output (by integrating an amplifier it is possible to boost the bass driver resulting in greater depth in bass frequencies. It reduces the need of an external subwoofer, which also is an important issue conducted via user research)
- Availability of source selection
- Availability of volume adjustment
- Integration of a power supply resulting in no visible external adapter. A visible adapter can conflict with the overall idea of creating a discreet loudspeaker

Selected amplifier

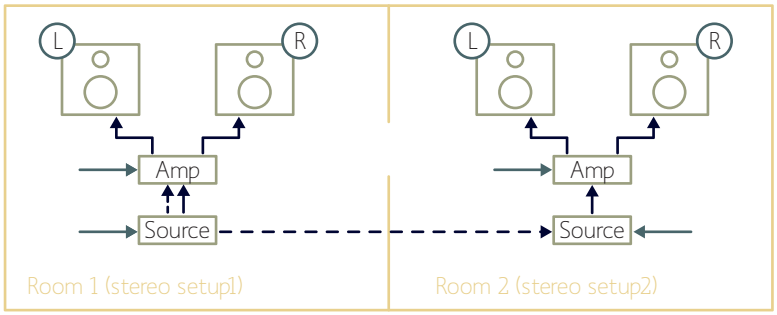
The selected amplifier is an ICEpower50ASX2, which is a high quality amplifier with integrated power supply, line-in availability, and 2 x 50 Watt output. By consultancy at DALI it is evaluated plausible to integrate a less expensive amplifier with same functionality. The ICEpower50ASX2 is an expensive solution and will have a major influence on the overall cost price *(icepower.bang-olufsen.com, 2011)*.

From this point of departure, the selection of amplifier is not further elaborated due to limited knowledge in amplification technologies and focus of project. It is evaluated as an important part of the project in buying, testing, and calibrating the amplifier for optimal performance. The ICEpower50ASX2's dimensions are 110mm x 80mm x 35mm and is used in further 3D modelling of the loudspeaker *(icepower.bang-olufsen.com, 2011)*.

Icons

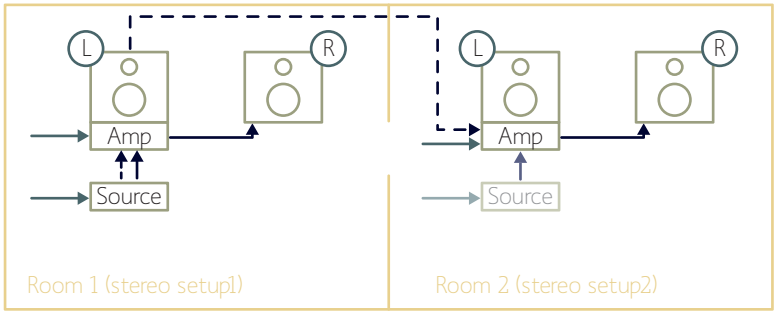
L = Left loudspeaker R = Right loudspeaker Signal (wireless) Signal (cable) Power Amp = amplifier Source = source

Solution 1 (no amplifier)



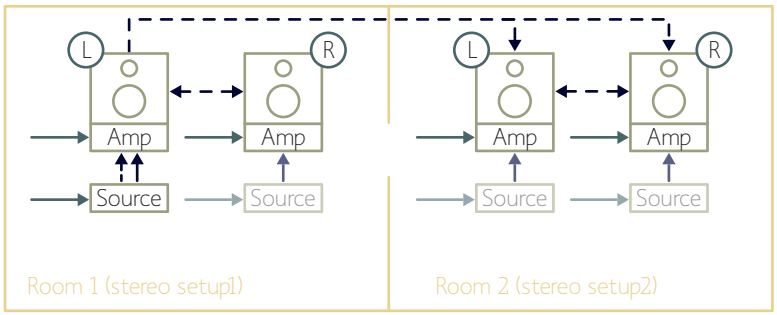
This multi-room solution is wireless connected with use of i.e. SONOS. SONOS can be bought without amplifier (illustrated in diagram), with an amplifier included, and also as an all-in-one solution with loudspeakers. In a SONOS multi-room instalment users easily connect all zones together and interact with the system by a SONOS remote or using an iPad/iPhone/iPod Touch/PC/Mac. For fully functional SONOS, a NAS (Network-Attached Storage) can be connected to a wireless network.

Solution 2 (amplifier in one loudspeaker)



In this multi-room solution, the musical zones are connected via an internal wireless network in-between the left loudspeakers. In each room, the right loudspeaker is cable connected which has its strength in only using one amplifier. Additional sources can be connected in room2 (faded source in diagram).

Solution 3 (amplifier in both loudspeaker)



The last multi-room solution is with an amplifier integrated in each loudspeaker. Every loudspeaker is wireless connected together in a normal stereo setup, and can transmit music to other rooms. It is a highly flexible solution with many opportunities for different instalments in many contexts. It is also the most expensive solution. Source and volume interaction is done at the loudspeaker without the need of using a digital multi-room solutions like SONOS.

Figure 46: 3 solutions are illustrated with and without use of active loudspeakers in creating a multi-room solution. The selected solution is no. 3 because of its flexibility and opportunity of integrating interaction design directly onto the loudspeaker differentiating itself by being user-friendly without use of complicated technological systems. SONOS systems are also very user-friendly, but needs i.e. a NAS for fully functional multi-room music system.

Sound Quality

DALI's slogan is "in admiration of music" and manufactures loudspeakers with focus on quality materials and technology calibrated for best sound quality. In this chapter, DALI's sound quality principles are in general described with focus on selecting drivers and what kind of stereo setup to use for the multi-room loudspeaker.

With the creation of a new DALI product, several aspects have great importance in relation to optimal sound quality. DALI is a relatively new loudspeaker developer and manufacture compared to other "giants" like Bowers & Wilkins. Even tough, DALI has developed quality loudspeakers by researching in new technologies which can be integrated into its product series.

DALI's sound quality standards

DALI's main sound principles are 3D Audio, amplifier optimized loudspeakers, hand crafted products, time coherence calibrated drivers, wide dispersion technology, and low resonance cabinets *(dali-speakers.com, 2011)*. These principles are what makes a DALI loudspeaker of high quality in performance.

Wide Dispersion Technology

The Wide Dispersion Technology is a principle which simply fill a wide area of the room with sound from the loudspeakers' drivers. The loudspeakers' construction, drivers, and crossover are optimized for optimal frequency response. This means that the sound pressure is consistent regardless of frequency. For true stereo perspective, the listener needs to be located in the centre (see illustration to the right). The Wide Dispersion Technology also spreads the sound smoothy in other directions of the room optimizing off-center listening position (also with the use of wall reflections) *(dali-speakers.com, 2011)*.

Figure 47: The existing Lektor 1 which driver's are used in the new loudspeaker.

DALI drivers

DALI put great effort in ensuring that its drivers are manufactured in quality materials with repeatedly standardized production processes.

The selected drivers for this project are already in production in other product series. It simplifies the process of selection plus the drivers are covered by DALI's quality standards.

The selected drivers are from DALI's existing product series, Lektor 1, which is a compact quality loudspeaker. The drivers are chosen due to the following aspects:

- Lektor 1 has drivers of fine quality
- Lektor 1 is a compact loudspeaker with use of minimum volume (4 litres) for reproducing great sound including 2 bass ports (not a closed cabinet for greater bass depth)
- A relatively less expensive model (DKK 1,149.- in Hi-fi Klubben, each) *(dali-speakers.com, 2011)* which is needed due implementation of new components (cost price increase)

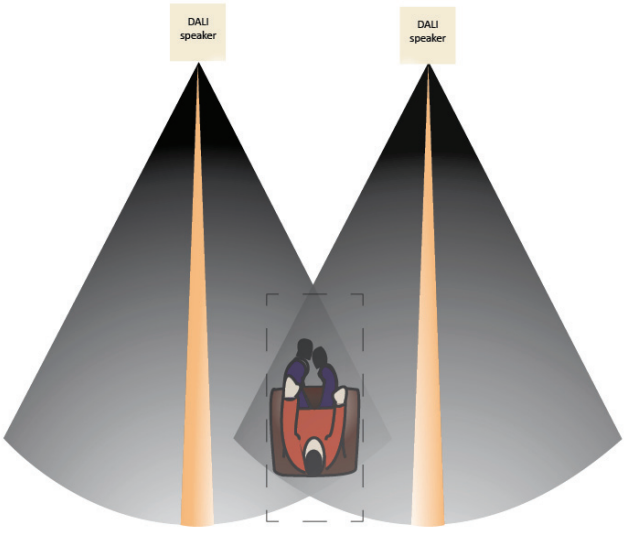


Figure 48: Illustration about the Wide Dispersion Technology incorporated in DALI's loudspeakers. This principle is also valid for the Lektor 1, which driver's is the selected ones for the new loudspeaker. In the centre position, true stereo perspective is achieved.

Stereo setups

By consultancy by DALI's acoustical engineer, 2 types of stereo setups are evaluated possible in creating a true stereo perspective. A mono loudspeaker setup is not seen as an option due to conflict with DALI's sound quality standards.

Stereo setup 1 (left/right loudspeaker)

The first stereo setup is a typical loudspeaker scenario. A left and right speaker is installed and sound is filled in the room with use of DALI's sound principles.

This setup is highly flexible in terms of placement opportunities. The loudspeakers are not merged into one soundbar, and are hereby physically less dominant. The negative aspect is that users can install the loudspeakers in many different scenarios with no respect to i.e. Wide Dispersion and true stereo perspective (like illustrated in pictures from user research *(see Appendix 3: User Research Data)*).
It is highly difficult to predict the width between the left and right loudspeaker which has great influence on the loudspeakers' performance in terms of true stereo perspective. Furthermore, it is possible to turn the loudspeakers 90 degrees which enhances placement opportunities.

Stereo setup 2 (soundbar)

The secondary stereo setup is by merging the left and right loudspeaker into one soundbar. A major positive effect is that the drivers are fixed and cannot be moved resulting in ensuring true stereo perspective.

On the contrary, the soundbar cannot be rotated 90 degrees. When rotated, the sound is being heard as a mono signal because stereo occurs when the left and right ears receive different sounds.

Project output

A stereo setup including both a separated left and right loudspeaker is chosen due to the following:

- Lektor 1 drivers needs a volume of 4 litres which makes a total of 8 litres in a soundbar setup. It results in a physically dominating loudspeaker which is in conflict with a minimalistic design and compact loudspeaker (see next chapter "Idiom" where the loudspeaker's size is evaluated by using 3D modelling and 1:1 2D paper models)
- A left/right stereo setup enhances flexibility in placement opportunity for users

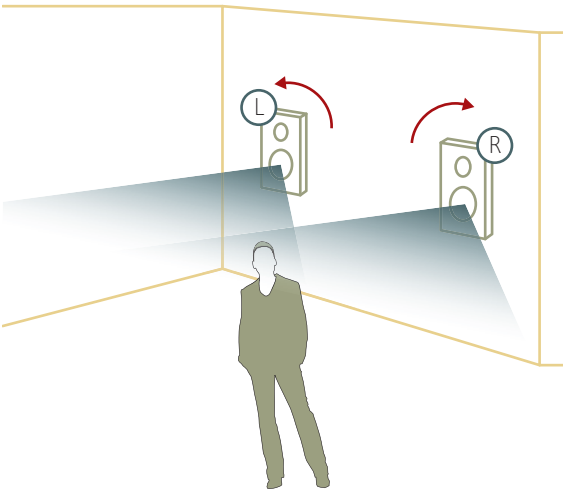


Figure 49: A left and right stereo setup. Both loudspeakers can be rotated 90 degrees enhancing multiple placements.

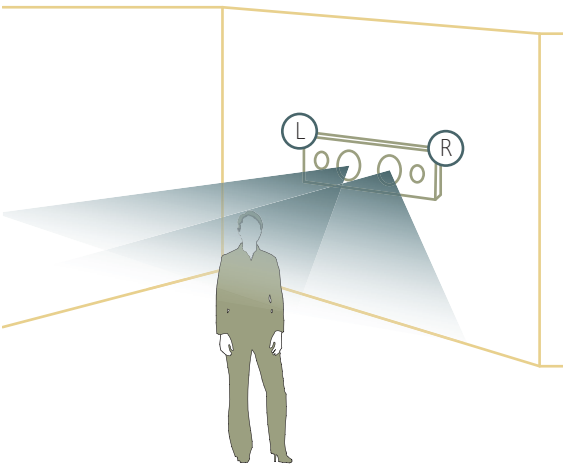


Figure 50: A soundbar stereo setup. The left and right loudspeakers are merged into one bar filling the room with sound.

Idiom

The idiom and styling of the loudspeaker is an on-going process throughout the Concept Development Phase. The illustration below shows a funnel with point of departure in demands defined in Phase 1. The process is also used as a brainstorm where main statements are posted into the funnel.

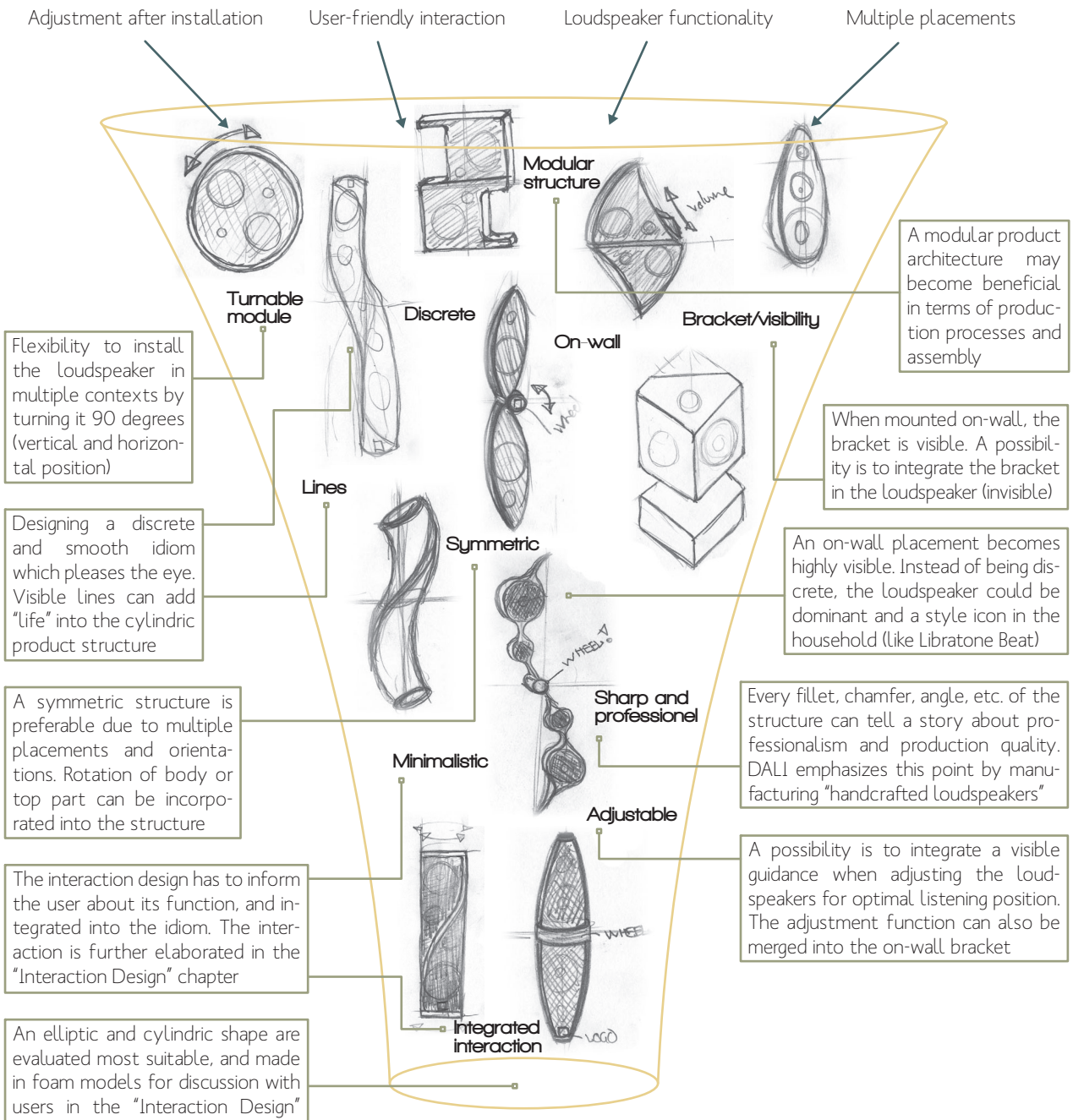


Figure 51: The idiom of the loudspeaker is an ongoing iterative process where choices regarding its functionality has mayor impact on the final styling. The result of the idiom in the Concept Development Phase is a cylindric and elliptic shape, which is further discussed in interviews in the "Interaction Design" chapter.

The process of choosing an overall idiom has been influenced by many factors such as:

- The loudspeaker's functionality and components (amplifier, crossover, drivers, system setup, etc.)
- Driver selection and hereby needed volume (litres)
- On-wall, on-floor or other placements possibilities
- Placement in many different contexts in Danish households (different rooms)
- Horizontal and vertical placement opportunity for greater flexibility
- Adjustment possibility after installation (optimal sound quality)
- Integration of components for interaction/functions
- Economical aspects (cost price and productional processes)

In this phase, sketching on paper has been the starting point. All sketches can be found in Appendix *(see Appendix 8: Sketches, DVD)*.

Further on, 2D paper models are taped to the wall and used in collaboration with 3D modelling program, SolidWorks, in visualizing the needed volume contra size (see illustration below). The result has been very positive by using several different platforms in generating ideas and sketches.

The end result is a symmetric, minimalistic, cylindric or elliptic idiom due to:

- A minimalistic, compact idiom is evaluated being more acceptable by many users, and can be placed in multiple contexts
- A symmetric design is selected because of its horizontal and vertical placement opportunity. Hereby, the idiom is not in conflict with other installed setups in the household, which supports a consistent and strong idiom

Figure 52: D = diameter, H = height, and L = litres. 2D paper models were taped to the wall in order to quickly visualize a rough sketch of the loudspeaker's size (outline). SolidWorks is used to calculate the volume and trying out different shapes.

Interaction Design

The interaction design is a crucial part of the multi-room loudspeaker. Therefore, situated interviews with 2 users are facilitated in order to discuss different interaction options.

Preparation

This analysis has the purpose of analysing several critical issues regarding the interaction with the loudspeaker's main functionality. It is done by involving users in situated interviews in the context of use including foam models as tools for communication. The selection of channel, room, and left/right presetting are not taken into account in this interaction analysis due to previous delimitation.

Key questions

The following questions are of high importance, and can with a user-centred design approach provide insights for further concept detailing:

1) Design and idiom
- How can an intuitive volume interaction be integrated into the design of a loudspeaker?
- How can an intuitive source control interaction be integrated into the design of a loudspeaker?
- How are the different shapes perceived by the users?

2) Interaction and functionality
- How can users adjust the volume and source when the loudspeaker is horizontal placed?
- How can users adjust the volume and source when they physically are far away from the loudspeaker?
- How can users turn the loudspeakers on and off?
- How do users install the loudspeakers in relation to most optimal stereo perspective?

Model making

2 models are made in foam with different idiom and interaction. Both models have volume up and down functionality, but the source control is not integrated. This aspect is also open for discussion in the interviews closely related to the issue regarding turning the loudspeaker on and off.

The cylindric loudspeaker is coloured entirely black, and the elliptic one with a glossy chrome colour in top and bottom (also the wheel for adjusting volume). It is done with the purpose of discussing colours and styling with the users. At last, the models are covered with black cloth indicating where the drivers are located. It benefits to the realism of the models, and will help when tasks are facilitated with users.

Contacting users

All users from the previous interviews are contacted, but only 2 had the opportunity of participating.

Facilitating interviews

The interviews are carried out as singles instead of a focus group. A focus group is preferred because of a more intense discussion and dynamic in-between users, but not an option due to the users' personal agendas in this time of the project.

Setup and materials

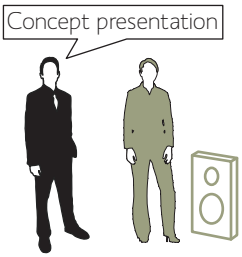
The setup of models and music system is done in a Danish household in the northern part of Odense located on Funen closely located to the participating users.

Interview guide

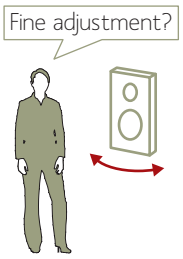
The interview's form is semi-structured, and therefore not strictly following an interview guide. Although, this guide is made securing that all key questions are elaborated and discussed with users. The flow of sequences can be seen in the illustration to the right. 4 setups are made with the purpose of discussing differences, potential issues, and interaction possibilities.

Setup 1 (vertical orientation)

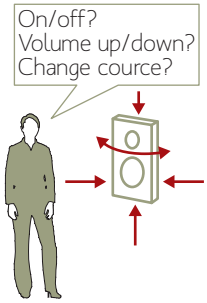
- User is introduced to the concept of a multi-room loudspeaker with the ability of volume adjustment, source control plus rotation of loudspeaker for optimal stereo perspective



- The user places the loudspeaker in the room, and fine adjust the loudspeaker's orientation for most optimal stereo perspective

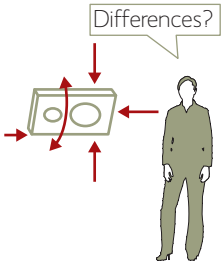


- The user turn on/off the loudspeakers
- The user interact with the loudspeaker by turning up and down the volume
- Afterwards, the user is changing source



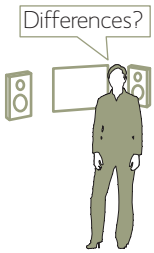
Setup 2 (horizontal orientation)

- The user interacts with the loudspeaker like previous tasks. In here, the user elaborate on differences and critical issues identified during the exercise



Setup 3 (TV/far away)

- The user is watching TV and seated far away in a chair. In here, the user changes volume, and discusses differences in this setup



Setup 4 (table discussion)

- The user and facilitator discuss thoughts and ideas from the exercises about the interaction with the loudspeaker. Model materials are available for fast model making

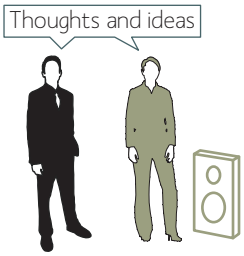


Figure 53: Flow of sequences in the interview guide about interaction design.

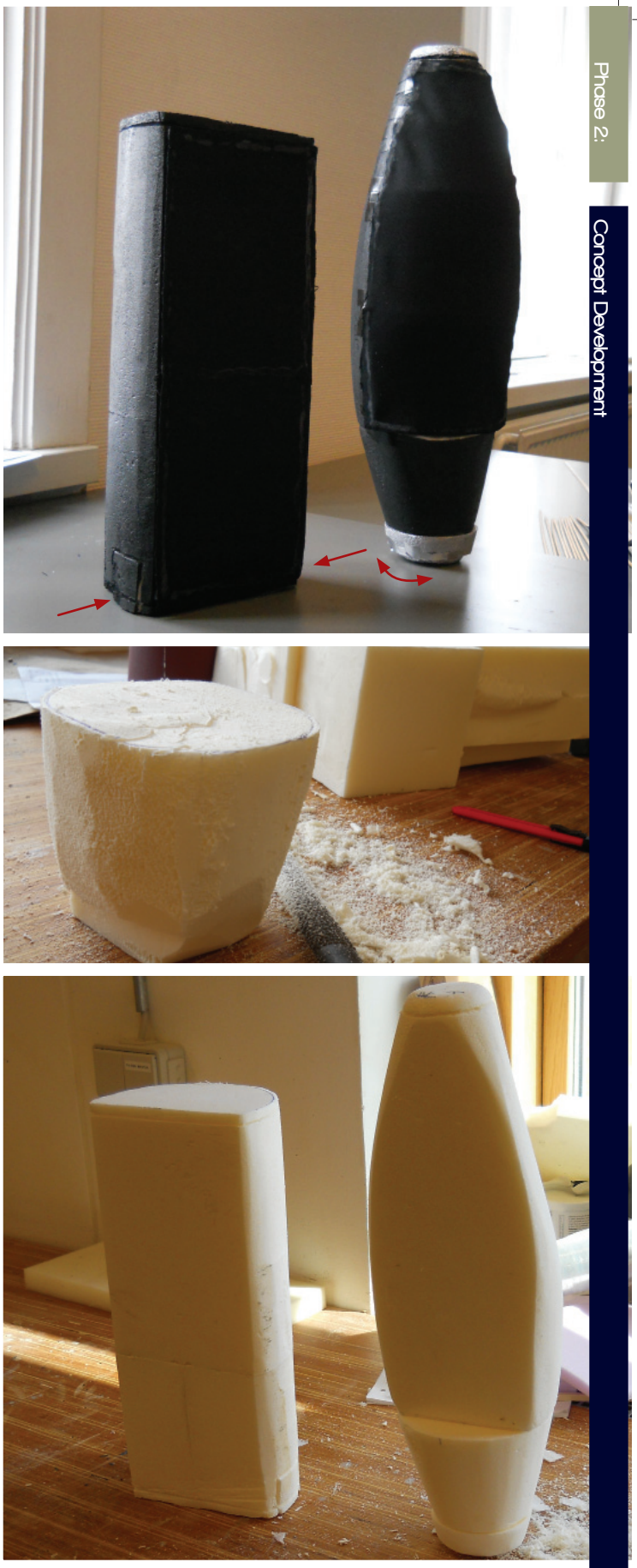


Figure 54: 2 different foam models are made. A cylindric and elliptic idiom with different interaction possibilities.

User 1

Design and idiom
- "It could easily stand on a shelf or hang many different places"
- "It could be a "furniture" placed on a table or shelf"
- "The design justify visual appearance"
- "I might buy it in a red colour even though I have no red furniture at home"

Fine adjustment
- "If I knew that the loudspeaker should not directly be pointed at you, then I might place it correctly. It is very context dependent"
- "It can almost be turned all around without notice because of its design"

Interaction
- "It must be an integrated part of the loudspeaker"
- "A potentiometer is banned because it is normally pointing outwards perpendicular to the loudspeaker"
- "It would be a shame to put buttons along the side of the loudspeaker"
- "An LED-light could be on when the loudspeaker is on"

Functionality
- "If there is not any opportunity of connecting an external subwoofer, it would be reason for me, personally, for not buying"
- "Maybe I would create an on-wall bracket for my iPod right next to the loudspeaker"

Observations
- The user almost only interacted with the elliptic loudspeaker and its top wheel for volume because he found it most interesting (all quotes are therefore only about the elliptic model). When the loudspeaker was turned on and off, the user pushed a button in the bottom part. The wheel was very intuitive and needed no explanation before use. The source button was pushed at the top of the model at any height
- The user did not interact that much with the cylindrical loudspeaker. It was found boxy and not that exciting. In here, the buttons were not understood at first sight and needed explanation

Figure 55: User 1 discussing horizontal orientation.

User 2

Observations
- The loudspeaker is placed in a corner in the kitchen minimizing the loudspeaker's appearance
- The user is most pleased about the cylindrical loudspeaker because it symbolizes performance instead of being a design object
- The user wants some kind of augmented feedback when interacting with the product
- The loudspeaker can be placed incorrectly when it has a symmetric idiom (up-side-down)

Design and idiom
- "If it is totally plain you can wipe the dust away"
- "The elliptic one would I place horizontal"
- "A wheel is preferable because it doesn't interfere with the idiom"
- "It could be cool if the interaction was integrated into one side of the product"
- "The cylindrical model is very classic whereas the elliptic one is more iPhone/design-like and more special"
- It is a pity to interfere with the design by adding buttons pointing outwards"

Fine adjustment
- "It could be done by mounting an arm which also is a bracket. Just like my TV"
- "I would fixate the loudspeaker because the direction doesn't matter in such a small room (kitchen)"
- "The direction is only important when watching TV where picture is synchronized with video"

Figure 56: User 2 discussing interaction with elliptic loudspeaker.

Interaction
- "Touch control is cool, which is integrated into the phones I operate at work"
- "The volume adjustment could be by touch"
- "In the elliptic model, all interaction could be integrated into one end of the product"
- "The wheel looks like something you turn up and down with"
- "I would not use touch in an elliptic form"
- "Fainted light could be cool when the loudspeaker is turned off and only visible during night. The light could be red when turned on"
- The placement of the buttons must be easy accessible"
- "Make a visible icon indicating if you are connected to RCA or wireless sources"

Functionality
- "I would place the loudspeaker somewhere easy accessible to cable connection"
- "The models are very similar, and therefore possible to turn it up-side-down"
- "I choose performance rather than design"
- "I would use a remote control when I'm sitting from a distance"
- "It is annoying with many remote controls"

Data collection

The user interviews provided profitable insights in how to interact with the product. Furthermore, the loudspeakers' idiom and styling were discussed by using the foam models.

Important quotes from both users are noted in the illustration to the left. Additional observation from the facilitator is noted after review of video material from each interview. In the following chapter, the issues regarding idiom and interaction design are elaborated.

Idiom

One of the purposes of making 2 different idioms in foam was to discuss advantages and disadvantages with users. It quickly became obvious during the interviews which loudspeaker the users most likely wanted installed in their household.

The selected idiom is the elliptic on the basis of facilitated interviews and conducted material throughout the Concept Development Phase:

- Evaluated as the loudspeaker with most minimalistic and discreet idiom (with influence of user comments)
- Greatest potential regarding placement flexibility in many scenarios
- The interaction can be merged into one or both ends of the shape merging the idiom and interaction together into one elegant and integrated solution
- User 1 found the idiom very exciting, and could easily see it being installed in his household (even in a provocative colour)
- User 2's preference is the cylindrical one because he rates performance more important than design. In his opinion, the cylindrical loudspeaker's idiom and shape are closely related to traditional loudspeakers found in the market today, and hereby not something new and exciting

Interaction ideas

Several different interaction setups were tested and further discussed during the interviews. The cylindrical foam model has a volume up and down button located on the left and right side. The users did not find it intuitive to use the buttons, and tried to adjust the volume by sliding their fingers along the surface (touch panel).

At the elliptic model, both users adjusted the volume by turning the upper wheel instead of the incorporated wheel in the bottom, which was a surprising observation.
Other observations regarding power on/off and source selection:

- The users pushed the power button on the top part of both models
- Both users had difficulties in selecting sources because of no visible display or augmented feedback
- The source selection can be located in the top or bottom part of the loudspeaker, and not in the middle section because it is evaluated by the users as a disturbing element in the loudspeaker's idiom
- Touch panels can be integrated, but need augmented feedback in terms of display, light, vibration or sound
- Both users concerned about being able to switch the power on/off and selecting sources when the buttons are not visible to the user due to its placement
- The users prefer to use a remote control when they are physically far away from the loudspeaker

Interaction iteration

The interviews provided new insights which triggered another iteration of sketching and quick foam/clay modelling. Additional sketches can be seen in Appendix *(see Appendix 9: Interaction Sketches, DVD)*. The focus is also on how to incorporate intuitive feedback and feedforward information to the user. 2 main ideas for interaction are elaborated below.

One wheel

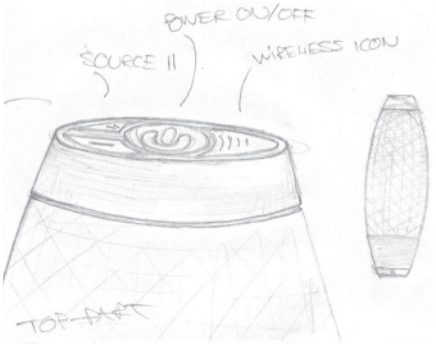


Figure 57: Merging of volume adjustment (wheel), power on/off (button), and source selection (buttons) into one end of the product

Power/volume wheel and source selection wheel

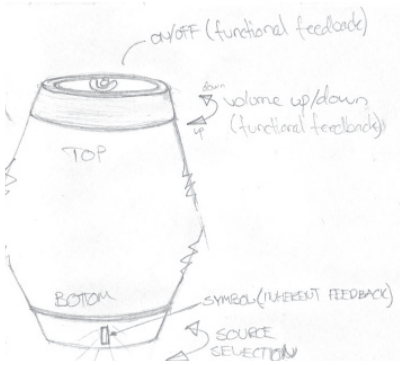


Figure 58: Merging of volume adjustment (wheel) and power on/off (button) into the upper end, and source selection (wheel) in the bottom part

Project outcome

Both interaction principles were quickly tested by fellow students regarding its intuitiveness. In the pictures to the right are several different principles tested.

The tests are fast and rough, and provided valuable insight in what interaction principles to choose.

Chosen interaction design

The chosen interaction design is with a power button and volume wheel at the upper end, and source selection wheel in the bottom. Further scenario elaboration can be seen on the next page. These interaction principles are seen most intuitive in the scenarios of use.

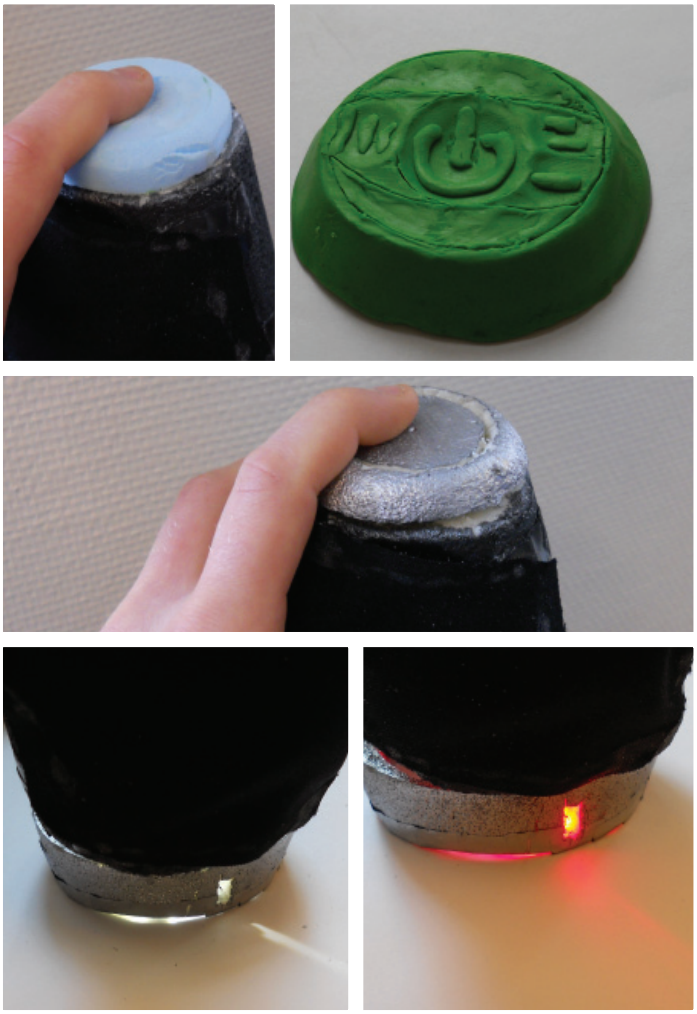
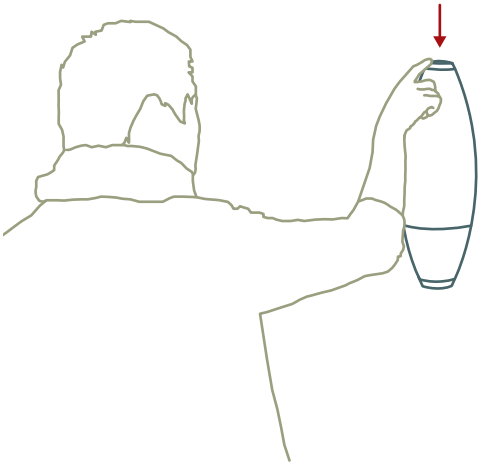
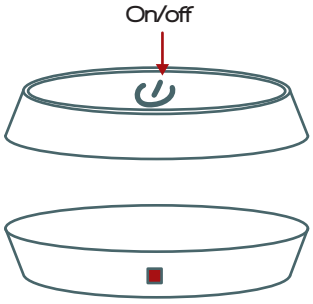


Figure 59: Testing interaction principles with different feedback to users.

Scenarios of use

1) Turning the loudspeaker on and off

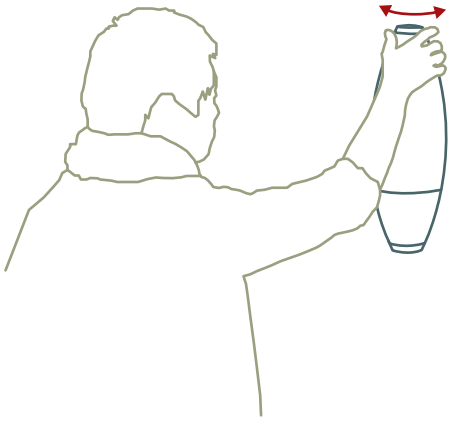


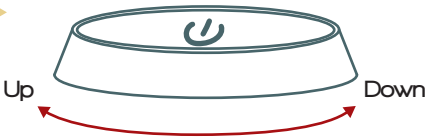


- Soft white when standby
- Red when turned on

- On/off button on top of loudspeaker with functional feedback when loudspeaker starts playing
- The button itself gives inherent feedback by its movement and feeling of being pushed down
- Augmented feedback when loudspeaker is on by LED changing from soft white to red colour

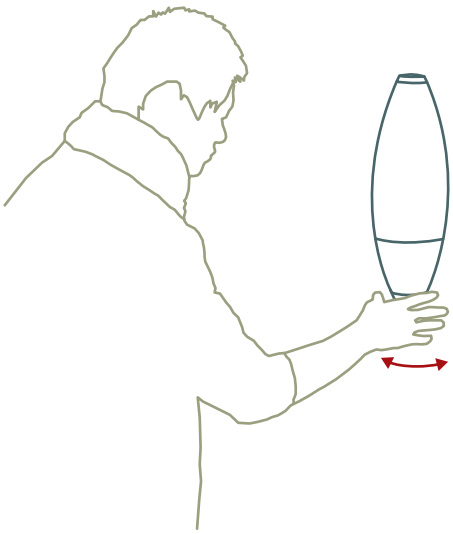
2) Adjusting volume

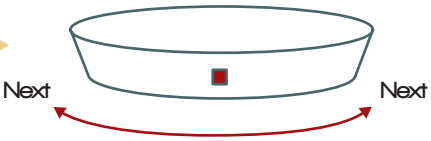




- Volume adjustment feedforward by wheel closely attached to on/off button like in many other amplifiers
- Functional feedback when increasing or decreasing volume by turning left or right. Increasing volume is clockwise, and counter-clockwise decreasing the volume

3) Selecting sources





- Functional feedback when the source is selected and playing throughout the stereo setup
- LED light and icons are augmented feedback in selecting source. The 3 selections are fixed in grooves which is an inherent feedback securing the source is selected

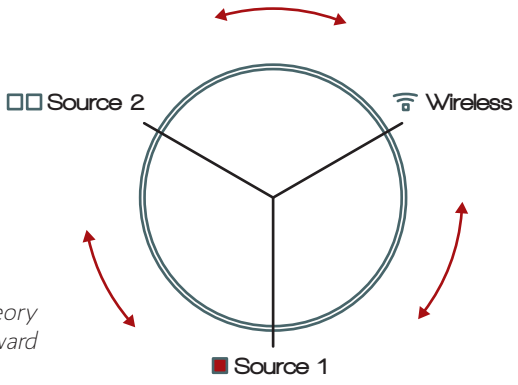


Figure 60: 3 different interactions with the loudspeaker. Theory about functional, augmented, and inherent feedback/feedforward is from (S. A. G. Wensveen et al, 2004).

Placement Flexibility

The loudspeaker's placement flexibility is highly dependent on its idiom. Furthermore, the bracket is in correlation with the loudspeaker's placement mobility found as an important issue to explore.

3 types of placement flexibility are seen plausible, and are elaborated in this chapter.

Fixed placement
By fixating the loudspeaker to its bracket, it cannot be moved to other locations in the household.

Semi-fixed placement
A semi-fixed solution adds additional value to the user who can move the loudspeakers into other rooms or even outdoors when needed. This requires an additional stand to fixate the loudspeaker when placed on the floor.

Mobile loudspeaker
A mobile loudspeaker is very similar to iPod-docking stations, which can be carried around in the household when needed. An entirely mobile solution is not the aim of the multi-room loudspeaker. The purpose is to install several stereo setups in multiple rooms, and hereby connect these setups together. The merging of the households stereo setups is in direct conflict with a completely mobile version.

Project outcome (bracket)
It is seen plausible to develop a bracket which is functional on-wall, with a secondary function of on-floor fixation with help of an additional stand.

The loudspeaker is not aimed being mobile, but has the opportunity of being moved easily into another bracket.

Additional sketching can be found in Appendix on the attached DVD *(see Appendix 10: Bracket Sketches, DVD)*.

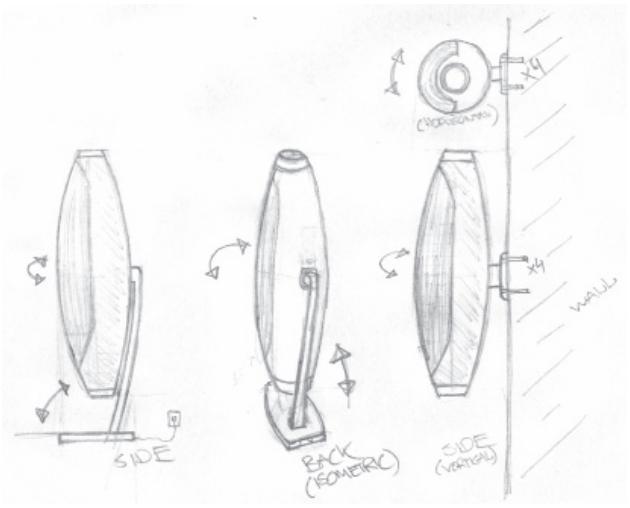
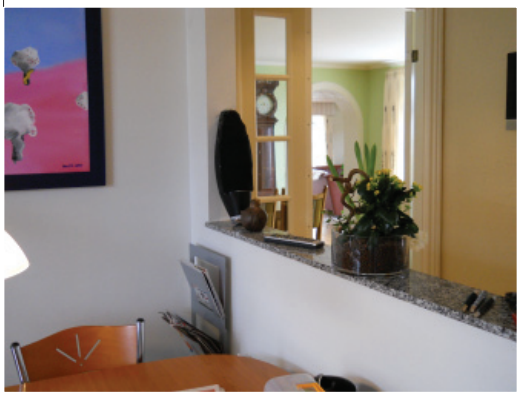


Figure 61: On-floor and on-wall brackets.

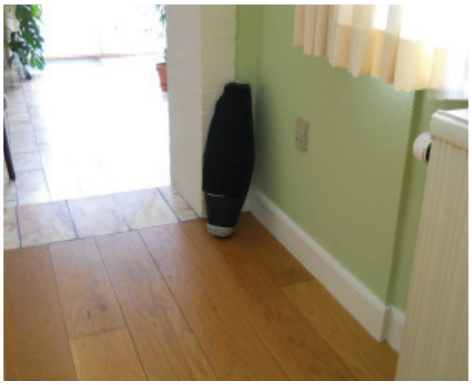
Throughout sketching and idea generation, the following demands can be listed for further concept detailing of the bracket:

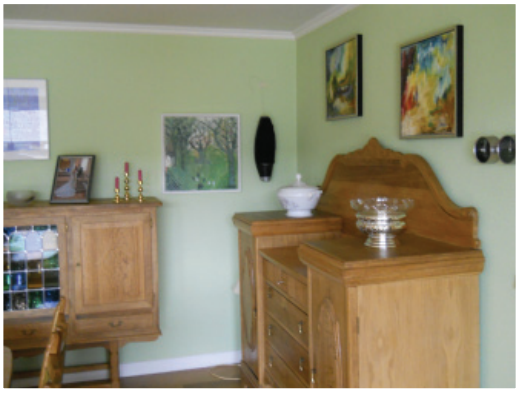
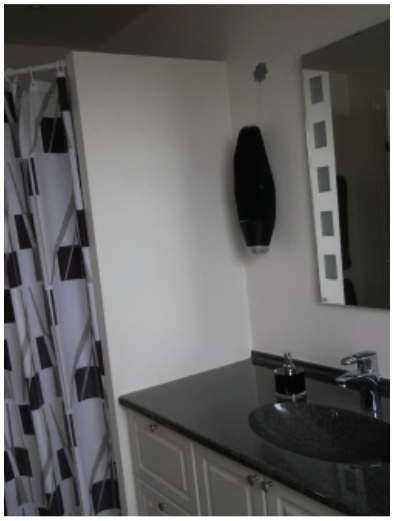
- The loudspeaker must be able to rotate 45° from its centre axis in both direction. It gives the user the opportunity of fine adjusting the loudspeaker when wall mounted (45° is estimated acceptable in order to rotate the loudspeaker to a desired position when wall mounted)
- The loudspeaker must easily be placed and removed from the bracket without the use of screws and other additional locking devices
- The locking mechanism integrated into the bracket must stabilize and fixate the loudspeaker both when horizontal and vertical installed

With use of the elliptic foam model, the loudspeakers were placed in many different placements in a Danish household. Pictures can be seen to the right.









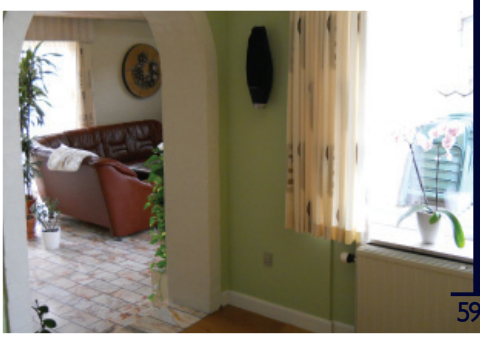



Figure 62: Placing the elliptic foam model in many contexts in a Danish household.

Economical Perspectives

DALI's distribution channel in Denmark is taken into account when calculating the target cost price from a market price perspective (top-down calculation). The target cost price is a crucial parameter influencing final production processes, material selection, and further construction detailing.

The target cost price is calculated in generating an overview about the links in the chain of actors in terms of this product's economical profit throughout distribution. The chain with included calculations is seen in the illustration to the right (price calculation for one loudspeaker).

Market price estimation

The loudspeaker's functionality and added value sets the parameter in evaluating the market price. The market price is an estimated price with point of departure in similar products found in Hi-fi Klubben's product catalogue, and competitors with similar characteristics.

Competitors with similar characteristics are for instance:

- Libratone Beat costing DKK 3,999.- *(eplehuset.dk, 2011)*
- Scandyna's Smallpot Active loudspeaker system costing DKK 4,499.- *(hifiklubben.dk, 2011)*
- The B&W Zeppelin system costing DKK 3,799.- *(hifiklubben.dk, 2011)*

The product's market price is evaluated due to the following aspects which adds value to the product justifying the estimated market price at DKK 3,000.- each resulting in DKK 6,000.- for a stereo setup:

- The loudspeaker is an all-in-one product with integrated amplifier meaning users do not need to buy an additional amplifier for a stereo setup
- The music is streamed wireless in-between the left and right loudspeakers resulting in fewer cables
- Ability of wireless transmitting of music from another stereo setup, and hereby ability of playing the same source in many rooms (stereo setups are connected together by selecting same wireless channel)
- Integrated volume and source control into a sleek, minimalistic design
- High quality DALI drivers from the Lektor 1 series with incorporated sound quality principles from DALI
- Ability of connecting multiple sources both by RCA cable and with use of USB-dongle (wireless streaming)
- Opportunity for multiple placements in many contexts

Target cost price calculation

The target cost price is estimated with basis in the chosen market price by calculating from a top-down perspective. This means that the calculation is backwards with a starting point in the market price with included VAT (Value Added Taxes), and profits throughout the distribution channel which include:

- DALI A/S with an estimated contribution margin of 40%
- HI-fi Klubben A/S corporation with an estimated profit of 10%
- Hi-fi Klubben shop with an estimated profit of 35%
- 25% VAT

The target cost price is calculated being DKK 1,154.- for one loudspeaker, which will be used in the Concept Detailing Phase when calculating a detailed economical cost price.

Target cost price considerations

As stated, the cost price is an estimate which cannot be further detailed before the product is accepted for market introduction. DALI's economical department will from this point of departure calculate the exact cost and market price in order to generate a profitable revenue stream.

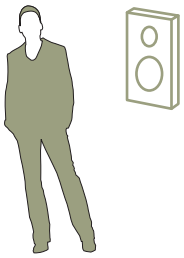
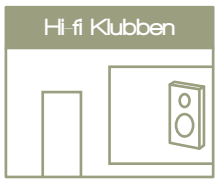
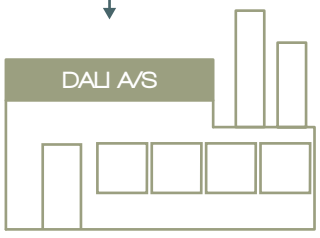
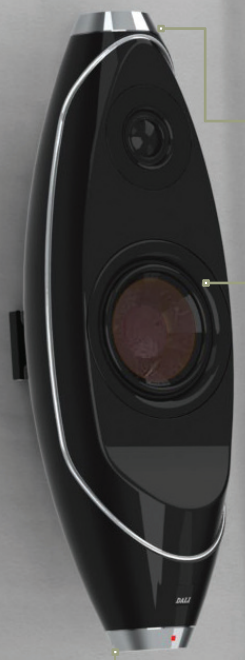
Price calculation	Flow of sequences	Explanation
Market price: DKK 3,000.- VAT (25%): 3,000/1.25 = 2,400 VAT (25%) in DKK: 3,000 - 2,400 = 600		User is buying one loudspeaker for DKK 3,000.- at a local Hi-fi Klubben shop (B2C). 25% VAT is included in the market price.
Hi-fi Klubben shop sales price: DKK 2,400.- Profit (35%): 2,400/1.35 = 1,778 Profit (35%) in DKK: 2,400 - 1,778 = 622		Hi-fi Klubben shop buys the loudspeaker from Hi-fi Klubben A/S for DKK 1,778.- (B2B). Hi-fi Klubben shop wants a 35% profit earning kr. 622.- at each sale.
Hi-fi Klubben A/S sales price: DKK 1,778.- Profit (10%): 1,778/1.10 = 1,616 Profit (10%) in DKK: 1,778 - 1,616 = 162		Hi-fi Klubben A/S buys the loudspeaker from DALI A/S for DKK 1,616.- (B2B). Hi-fi Klubben A/S wants a 10% profit earning DKK 162.- at each sale.
DALI A/S sales price: DKK 1.616,- Target cost price (40% contribution margin): 1,616/1.40 = 1,154 Contribution margin in DKK: 1,616 - 1,154 = 462		DALI A/S manufactures the loudspeaker for DKK 1,154.- and wants a 40% contribution margin. DALI A/S's profit is hereby DKK 462.- for each sale to Hi-fi Klubben A/S (B2B).

Figure 63: Calculating the target cost price by doing a top-down analysis. The market price is estimated being DKK 3,000.- for each loudspeaker, and hereby is it possible to calculate downwards resulting in a target cost price at DKK 1,154.-

Concept Presentation

The following material summarizes the Concept Development phase by presenting a spread including the concept proposal with descriptions of its principles in illustrations and text. This concept is the basis for further concept detailing in the next phase of the project.



Volume wheel and power button.

On-wall multi-room loudspeaker with DALI Lektor 1 drivers with removable front cloth.

Wireless transmit the source signal to right loudspeaker, and additional stereo setups in the household which are connected to same channel.

Source selection wheel. Users' existing sources can be connected by 2 x RCA cable or wireless streaming of music from a PC or Mac computer by USB-dongle.

Unique Selling Propositions

- Multi-room solution by wireless streaming of music to any loudspeaker in the household with easy, user-friendly interaction directly integrated into the loudspeaker
- Easy, mechanical source and volume adjustment by interacting with integrated wheels located in top and bottom
- All-in-one product with included amplifier creating a plug & play stereo setup for multiple placements in the household
- Turnable loudspeaker for most optimal stereo perspective in many different scenarios of use
- Multiple connectivity of sources with RCA plugs (2x), and wireless streaming of music from a computer by USB-dongle
- Minimalistic, Scandinavian design with many possibilities of placements (including removable front cloth)
- Easy removal and installment of loudspeaker into on-wall or on-floor stand with no use of screws
- Quality DALI drivers with integration of supreme acoustic and electro-acoustic principles securing optimal performance in multiple setups

Demands

Functional

- Volume adjustment (integration of i.e. potentiometer)
- Source control (selection between RCA1, RCA2, and wireless receiving of source signal from other loudspeaker's cable connected sources or USB-dongle with use of internal wireless network)
- 90° turnable bracket for most optimal sound perspective
- Loudspeaker presettings: channel (1 to 4), room (1 to 4), and left/right loudspeaker
- Integration of ICEpower50ASX2 amplifier
- Integration of wireless transmitting/receiving module
- AC power connection (230V)

Structural

- Internal loudspeaker volume at 4 litres
- DALI Lektor 1 high- and low frequencies drivers
- DALI Lektor 1 crossover unit
- 450mm total height and 150mm diameter at maximum
- Integrated bracket for on-wall and additional on-floor stand

Idiom and interaction

- Minimalistic and discrete design
- Symmetric idiom due to horizontal and vertical placement in different contexts
- Power and volume adjustment integrated into the top wheel
- Source selection integrated into bottom wheel

Economics

- Aimed market price at DKK 3,000.-
- Aimed target cost price at DKK 1,154.-
- Same sales channel as DALI in Denmark (Hi-fi Klubben)

Wireless streaming of music from a PC or Mac computer by a USB-dongle. It has an in-build option in selecting which channel to stream music by turning the small front wheel (1, 2, 3, or 4).

On-wall placement with front cloth.

Stand for floor placement.

On the back of the loudspeaker, the user can select channel (1-4), select room, left/right, connect 2 sources (RCA), and power.

Source 1, source 2, and wireless receiving.

90° turnable bracket and easy instalment.

Phase 2 Reflection

This Phase 2 reflection is used to discuss the essence of the developed concept in relation to the defined target group, Problem Statement, and Strategy Canvas from Phase 1. Also, the discussion from status seminar is included.

With point of departure in the defined Strategy Canvas in Phase 1, the Concept Development Phase became an interesting mixture of consultancy from DALI personal, concept development, and user-centred interaction design study with users.

Concept of the loudspeaker

In the Design Brief it is stated that the project aims to develop a product for the target groups defined as "value for money" and "value identity". The process of the project has not changed this perception, but a merging of both groups is seen highly plausible. The argumentation for this merging is with basis in the loudspeaker's idiom, integrated interaction, and in-build features in relation to its market price. Potential buyers can be very focused on the design or/and the loudspeaker's functionality contra money spend. This is evaluated highly interesting to hit both target groups at once, which also boosts the loudspeaker's potential sales volume due to a greater market size.

Problem Statement

The Problem Statement addresses the issue about being user-friendly, and the terminology can be perceived in many ways. By doing multiple user interviews and following data extraction, it became clear that user-friendliness is of top priority. In this project, the focus of the user-friendliness' is within how to mount, adjust, connect sources, and most important at all, how to interact with the loudspeaker.

Especially, the interaction design study is facilitated with a user-centred design approach meaning that users provided valuable insights on how it is seen most intuitive to interact with this type of product and its in-build functions when integrated into a loudspeaker. With use of a focus group, the discussion in-between users could have strengthen the discussion added additional value to the interaction design analysis.

The loudspeaker's opportunity of being placed in multiple positions is a direct result of the concept development, and has been an area of focus throughout this phase of the project because of a multi-room loudspeaker can be placed in many different rooms, and is therefore not dedicated to one specific scenario of use.

Strategy Canvas and developed concept

The product's Strategy Canvas shortly explain the overall aim of the product without being too specific in the ratings. The 3 main values which are being addressed are; minimalistic and discreet design, adjustment after instalment, and user-friendly interaction. All issues are integrated in the product proposal, and will further be evaluated in a final product reflection ending the project.

Another additional offspring of the concept development phase is the flexibility of the loudspeaker in mobility. The loudspeaker can easily be removed and placed in an on-floor/shelf stand for placement in another room or even for outdoor purposes. Its context dependency is hereby reduced to a minimum level, which is adding another dimension to the flexibility of placement and use.

Working at DALI

DALI has offered in letting the project group physically work at DALI whenever needed. It resulted in a three-day day stay with purpose of discussing the product's functionality, delimitations, and opportunity within technological and structural frames. With basis in user insights and initial concept iteration, concept cards with different incorporated functionality were used as a platform for communication with DALI engineers and acoustic professionals.

The outcome was very beneficial both professionally and personally, and is a repeating activity in the "Concept Detailing" Phase if the project group has the needed time available in discussing constructional details with DALI acoustical and mechanical engineers.

In-build functionality

The option of selecting sources and adjusting the volume directly on the loudspeaker are an outcome of functionality discussion with DALI personal and initial user research. The initial idea was to integrate track and radio channel selection, but is evaluated difficult due to the communication in-between sources placed in users households. In contrary, the integration of additional interaction possibilities would create a far more complex and demanding interaction design. Furthermore, the multi-room system architecture (system setup) is developed with the demand of user-friendliness in mind. It must be further tested with involvement of users in order to make improvements in functionality. Another issue to discuss is if users need to be able to adjust the treble and bass directly on the loudspeaker.

In many stationary amplifier designs, the user can directly make changes by turning an outpointing potentiometer.

Economics
The loudspeaker's market price is targeted a price level at DKK 3,000.- each resulting in a stereo setup price at DKK 6,000.-. The market price is evaluated with point of departure in similar products, and by evaluation of added value. The target cost price is an estimation, which will be further elaborated when the loudspeaker's construction is detailed. Ideally, the market price can be estimated by DALI's economical department with greater insight in the overall market price level in relation to the market situation.

When detailing the product and its target cost price, the market price will be challenged due to integration of amplifier, wi-fi module and additional components from the interaction functionality. The economical issue is addressed in this state of the project to give basis of communication with DALI plus a guiding line for the project group in what to aim at.

Status seminar
On the 6th and 7th of April 2011, the status seminar was facilitated which gives each student the opportunity of presenting their process and project status. The project group prepared a process walk-through presentation with final elaboration of the developed concept including context pictures presented in the "Concept Presentation" chapter. The overall comments were positive in regards to multi-room connection, and the merging of a music system into a more minimalistic and discreet all-in-one product suitable for many contexts.

Connection of sources
One of the main USP's is that the users can easily plug and play multiple sources, and/or use an USB-dongle to wireless stream music. In the context pictures, no sources are shown, and it misleads the audience with concerns about the physical placement of sources.

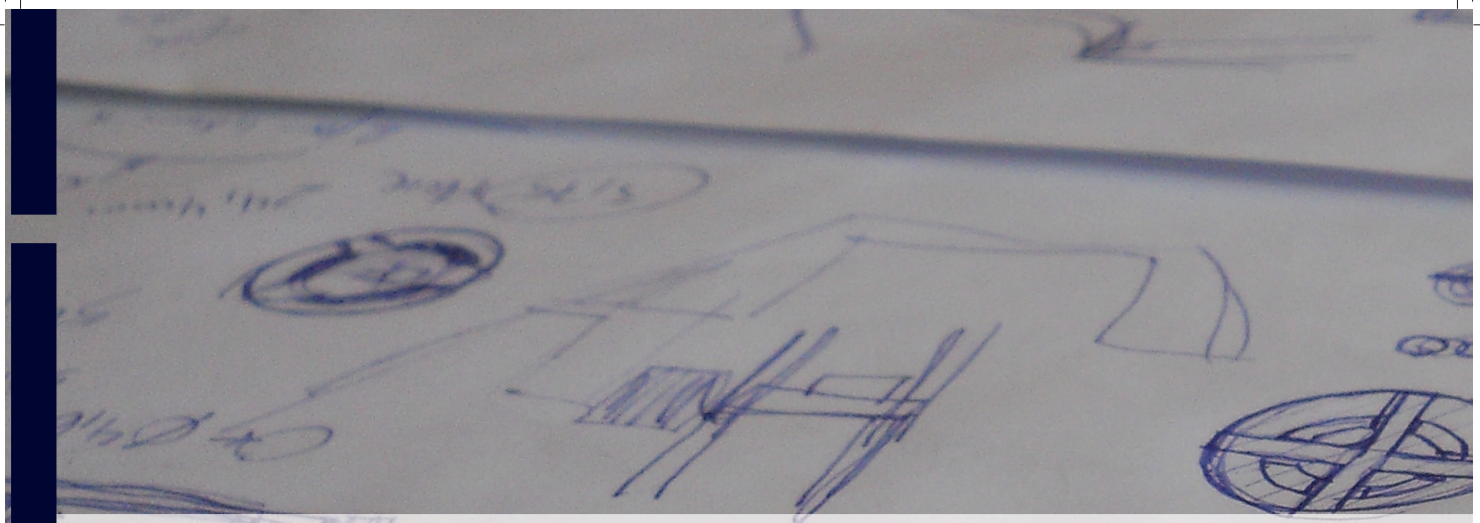
CD, LP, TV and other stationary sources cannot be integrated into the loudspeaker's stand or bracket for easy accessibility. Instead it is seen as an opportunity to integrate a holder for mobile devices (smart phones, mp3-players, etc.) into the wall bracket or loudspeaker cabinet. This issue has been addressed in the "Placement Flexibility" chapter, but needs to be elaborated in the "Concept Detailing" Phase.

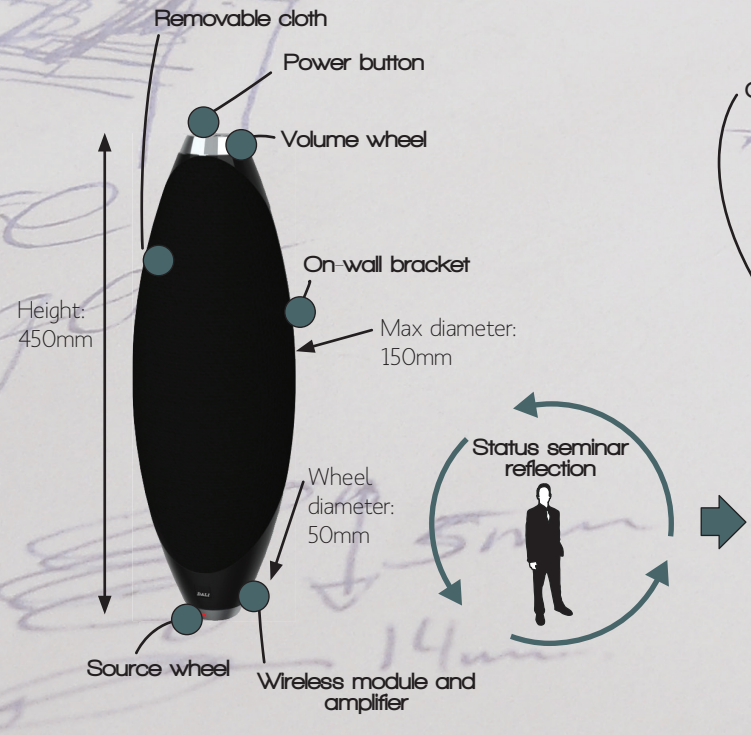
Floor stand
The floor stand's idiom was up for debate about its physical expression. The reason for making a floor stand must be perfectly clear, and can at the moment be questioned due to interaction difficulties when it is placed on the floor. If a floor stand is a part of the Product Family, it must be levelled into a reachable position for the listeners, or another interaction option must be available (etc. a remote control). In here, the flexibility of the loudspeaker in placements leads to questioning the need of a remote control. Those issues have also been discussed with users in the interaction design analysis, which confirms the potential need of a remote control as a part of the Product Family.

Product Family
Several different additional products can be added to the Product Family with the purpose of addressing multiple needs in many contexts of use. In user interviews, users have stated that a subwoofer can support the need of greater depth in the lower frequencies. Also, it is seen likely to have a more powerful stereo setup in the main listening area.

A remote control, subwoofer, a more powerful stereo setup, and the USB-dongle are all opportunities that will be explored in the "Concept Detailing" Phase as accessories available when purchasing the loudspeaker. It is not the aim of the project to fully detail these products, and therefore delimited from this point of departure in regards to constructional, productional, and economical detailing. This is done because of the defined learning objectives regarding loudspeaker construction and detailing. Although, it is important to develop a product platform, which do not exclude other products being developed after the ending of this project, and visualize the potential of the Product Family.

Graphical design
In giving augmented feedback about source selection, graphical icons have been made on the source wheel. The icons are of great importance, and the graphical design is made with focus on intuitive interaction and easy understanding. The graphic design is made as understandable as possible by one square is symbolizing "source 1", and 2 squares "source 2" whereas the wireless receiving channel is symbolized by 3 curves like other wireless graphics seen in wireless networks or smart phones. The graphical design is not further elaborated in the upcoming phase.

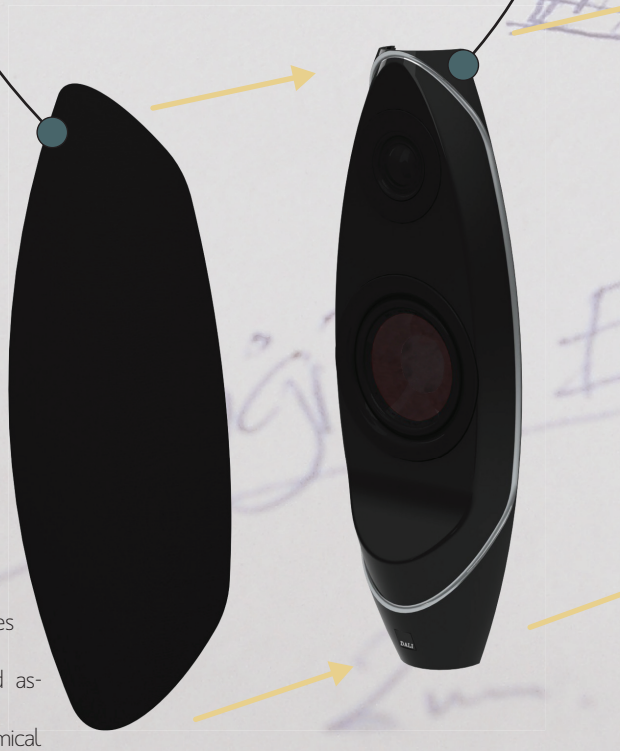




Status seminar reflection

Front body sub-assembly
- Front body
- Lektor 1 bass driver
- Lektor 1 tweeter panel
- Bass driver rim
- Tweeter panel rim
- DALI logo
- ICEpowerASX502 amplifier
- 3 x Ø8x2 ferrite magnet
- 3 x stickers
- 12 x M4x3 screw

Cloth sub-assembly
- Cloth frame
- Cloth
- 3 x Ø8x2 ferrite magnet
- 3 x stickers

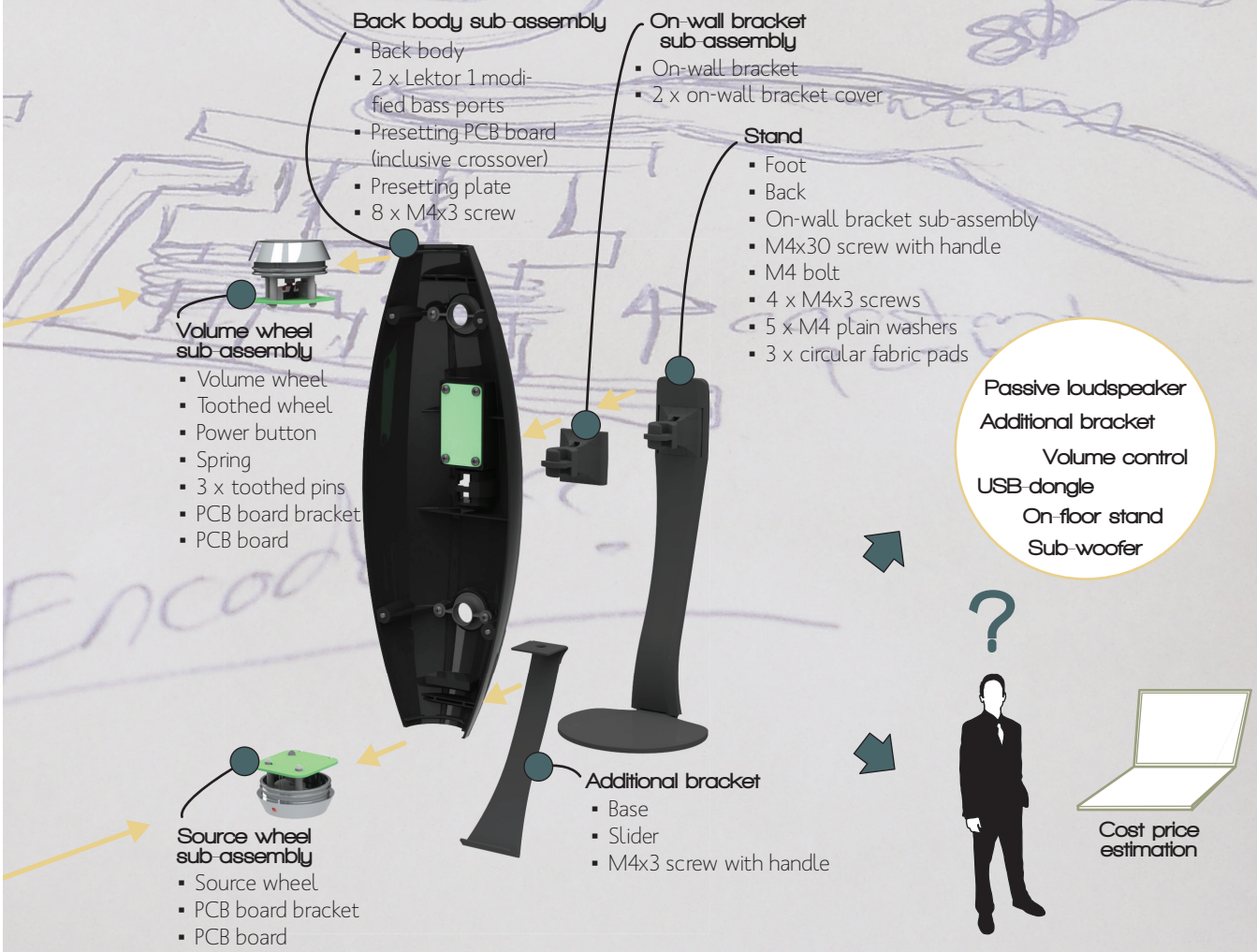


Project focus

- Placement of mobile sources
- Redesign of stand
- Construction detailing and assembly of loudspeaker
- Productional and economical perspectives
- Remote control and other Product family products?

Status seminar

Phase 3: Concept Detailing



Output
- Detailed construction and assembly
- Volume and dimension verification
- Redesign of stand
- New bracket (additional bracket)

Output
- Productional issues
- Cost price estimation
- Important costs and influences
- Product family

Concept detailing → Economical and productional perspectives

Figure 64: Phase 3 overview.

Brackets

In the Concept Detailing phase, the loudspeaker is detailed in CAD using SolidWorks. Additionally, productional, economical, and Product Family perspectives are taken into account ending this phase.

Additional bracket

At the status seminar, the placement of a cable connected portable music device was highly discussed, and has been a subject throughout the Concept Developing Phase. Preliminary, the idea was to place the device on a shelf or table closely to the loudspeaker. In some households, is this setup not available, and needs to be integrated into the loudspeaker without compromising the overall idiom and shape.

Many ideas and sketches have been visualized to verify the opportunity of placing the portable device into the on-wall bracket. This option is not seen plausible due to the need of easy accessibility to the device, and dimensional challenges. Sketches and 3D-modelling pictures of the additional bracket can be found in Appendix *(see Appendix 11: Additional Bracket Sketches, DVD).*

Bending, slim bracket

The additional bracket is designed following the lines of the loudspeaker, and hereby not compromising the overall idiom by being very slim and minimalistic. The user can easily access the portable device, and connect it by using a mini-jack plug directly connected to the loudspeaker. Furthermore, the bracket is designed being produced by simple processes and in less cost expensive material. The bracket can be removed completely or pushed upwards and fastened by a screw when not in use.

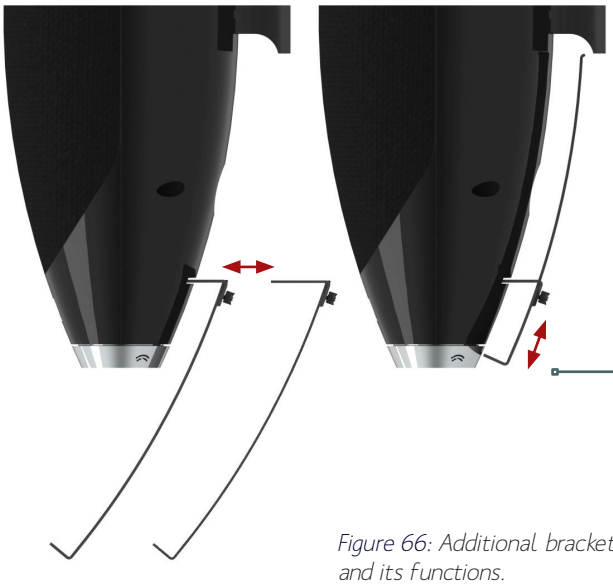


Figure 66: Additional bracket and its functions.

A smartphone, mp3-player or other portable music devices can be placed on the bracket, and play music by mini-jack connection.

Figure 65: The additional bracket seen in perspective with an iPhone connected by mini-jack plug.

Material and production

The bracket's two parts are laser-cut, 2mm steel plates which are bended in the top and bottom. Furthermore, the largest plate is bended smoothly fitting the elliptic shape of the loudspeaker from a side perspective, but also making the portable music device reachable for the user. The bracket's two parts are coated with TPE (thermoplastic elastomer) securing the device from slipping. The screw is a standard component, and all corners are rounded.

The additional bracket is mounted into a crack on the back of the loudspeaker. It can easily be removed when the bracket is not in use by sliding upwards for completely removal from the loudspeaker.

On-wall bracket

The purpose of the on-wall bracket is to easily mount and rotate the loudspeaker to its desired position. Furthermore, it must carry the loudspeaker's weight, which is evaluated being 3 kg. with basis in the original Lektor 1's dead weight *(dali-speakers.com, 2011)*. The stability of the bracket during long-time static loading is calculated and evaluated due to plastic material can creep under these conditions. The bracket has not changed radically in its design, but production issues have been taken into account like; equal wall-thickness, draft angle, direction of mould travel, parting line, fillets, etc. A dimensional drawing of the part can be seen in Appendix *(see DimensionalDrawings: On-wall bracket, DVD)*.

Material and production

The on-wall bracket is produced in SAN plastic material by injection moulding because of its many in-build functions and complex geometry. The maximum stress level of the part is calculated via FEA-analysis being 7.4 MPa including a factor of safety of 3. All calculations can be seen in Appendix *(see Appendix 12: Calculations of Strengths, DVD)*.

The calculations of maximum yield strength and creep module are used as criteria in selecting the plastic material using a systematic method. The material selection can be seen in Appendix *(see Appendix 13: Systematic Material Selection, DVD)*.

The on-wall bracket cover is an addition, and injection moulded using TPE as material due to its flexibility and ability of being easily cut creating room for guidance of cables on the back. It hides cables and screws. A dimensional drawing of the part can be seen in Appendix *(see DimensionalDrawings: On-wall bracket cover, DVD)*.

Cables

The loudspeaker can be connected with 2 RCA-plugs (a left and right channel plug each), and a power plug. These cables can be hidden inside the bracket, and guided downwards when vertical installed. A cable tray can be mounted below the bracket to minimize the cables visibility. However, the cable plugs will be visible if the loudspeaker is seen directly from a side perspective, and can only be hidden by moving the presetting plate deeper into the loudspeaker's construction resulting in a redesign of the loudspeaker's overall dimensions due to volume reduction below a total of 4 litres.

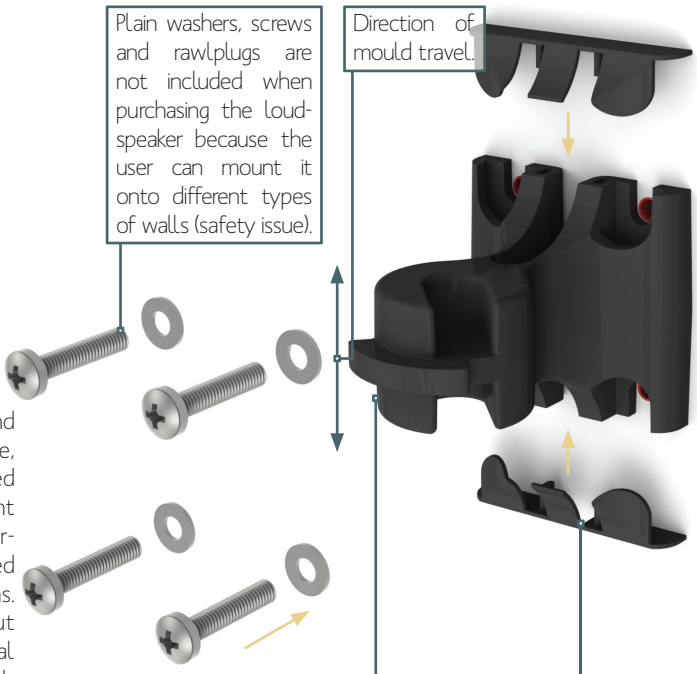


Figure 67: On-wall bracket with a rubber (TPE) cover.

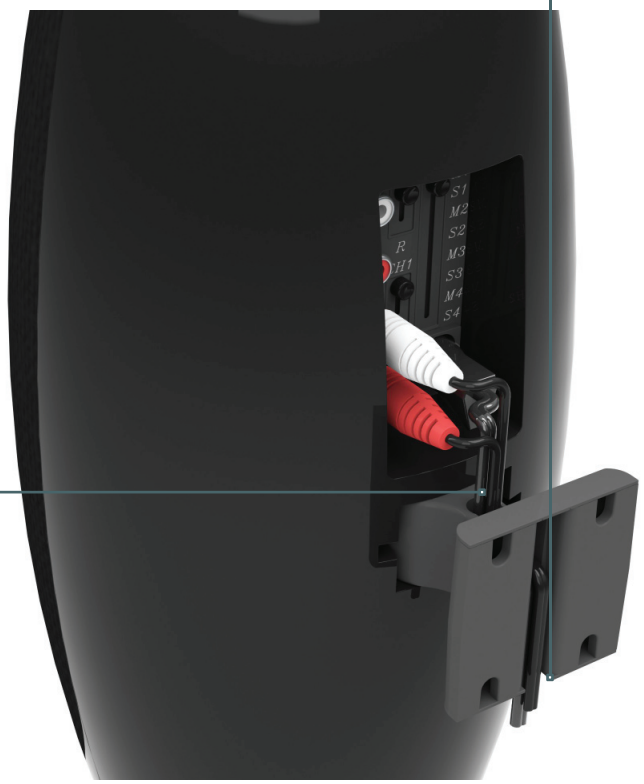


Figure 68: RCA and power connection with cables guided throughout the on-wall bracket.

Stand

As an accessory, the stand is detailed and redesigned making a suitable solutions for floor or shelf placement.

As a consequence of the status seminar discussion and further reflection, the stand is redesigned in creating a more anonymous expression. The shape of the stand's back is designed to fit the elliptic shape from a side perspective (front and back adjustment, see illustration below).

A new iteration of sketching resulted in a stand with a solid foot, which is simpler in its design compared to the first idea from the "Concept Presentation" chapter.

Other ideas and sketches can be found in Appendix *(see Appendix 14: Floor Stand Sketches, DVD)*.

The stand is manufactured in aluminium by casting resulting in a robust, solid stand. It is not manufactured in a plastic material due to plastic's lower density and signalling effect (also when touching the stand). A plastic stand would both be less stable and compromises the overall quality perception of the loudspeaker.

Accessory

The stand is not included when purchasing the product, and is therefore a part of the Product Family. It is being designed and detailed because it is seen plausible that the use of a stand is necessary in many scenarios. Furthermore, it is a relatively expensive stand to include in the total product package. The source interaction is not optimal when placed on a floor, but the stand is giving the product a much higher flexibility in placement, and therefore an option as an accessory to purchase.

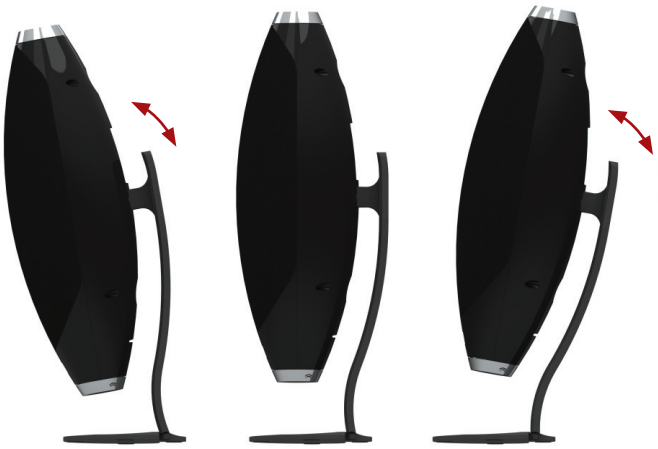
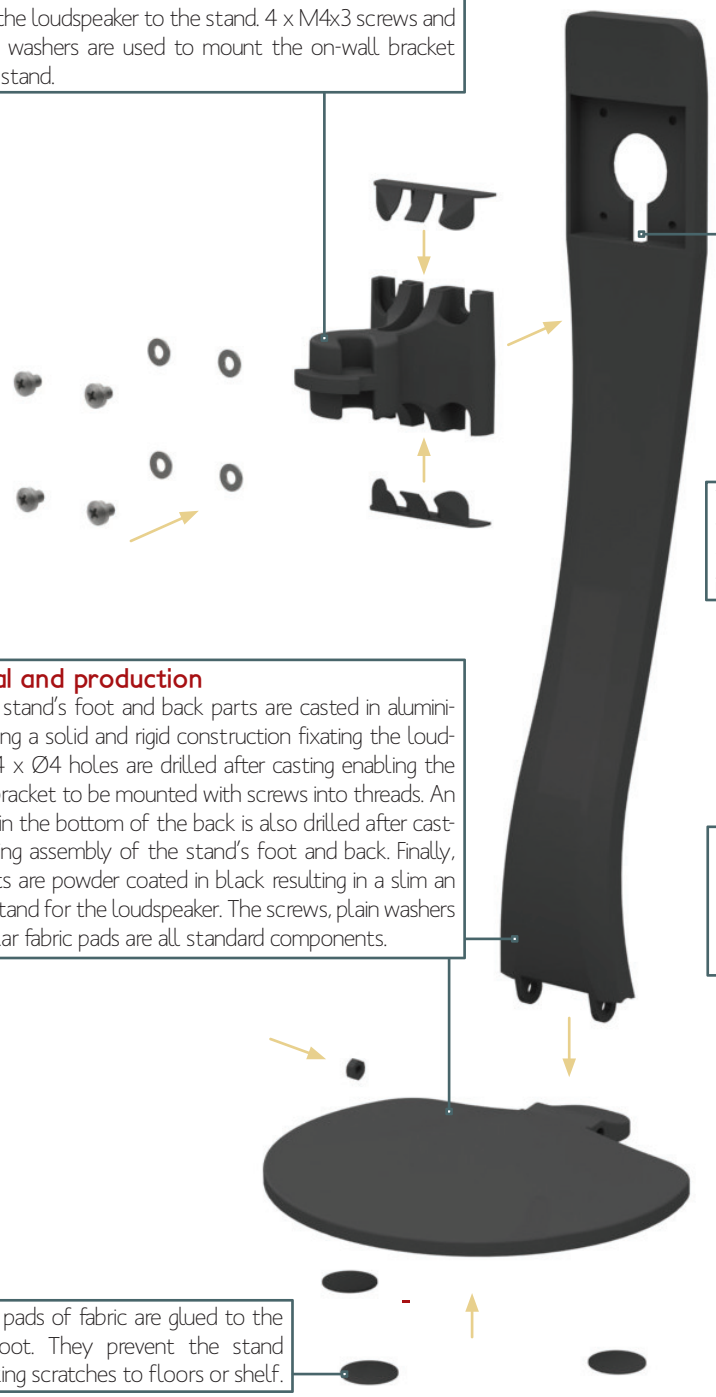


Figure 69: The stand can be adjusted 10 degrees back and forth making it adjustable in multiple directions for greater flexibility.

Figure 70: An aluminium shelf or floor stand which is very simple in its physical expression resulting in the loudspeaker being in focus.

The injection moulded on-wall bracket and covers are reused to fixate the loudspeaker to the stand. 4 x M4x3 screws and 4 x plain washers are used to mount the on-wall bracket onto the stand.



The cables are guided through the on-wall bracket and throughout a hole in the stand's back part. In here, a groove is made to guide the cables to the floor.

Material and production

Both the stand's foot and back parts are casted in aluminium creating a solid and rigid construction fixating the loudspeaker. 4 x Ø4 holes are drilled after casting enabling the on-wall bracket to be mounted with screws into threads. An Ø4 hole in the bottom of the back is also drilled after casting enabling assembly of the stand's foot and back. Finally, both parts are powder coated in black resulting in a slim an elegant stand for the loudspeaker. The screws, plain washers and circular fabric pads are all standard components.

A screw with integrated handle can tightening the stand's back in the user's desired angle. The stand can be angled 10 degrees from its vertical position both back and forth.

3 circular pads of fabric are glued to the stand's foot. They prevent the stand from making scratches to floors or shelf.

Figure 71: Exploded view of the stand's components. The yellow arrows indicates the travel of assembly.

Cloth

The user can easily remove the front cloth frame because of its in-build magnets. A very different expression occurs when the front cloth frame is removed, and the chrome line is designed being elegantly merged with the volume and source wheel. No mounting bosses are included in the front body, and instead replaced by hidden magnets.

The front cloth sub-assembly is consisting of 3 x Ø8 ferrite magnets, 3 x stickers, a cloth frame, and the cloth fabric. It is detailed with inspiration from DALI's existing loudspeaker, Motif LCR, which also can be removed easily by its in-build magnets.

3 additionally magnets are placed inside the front body part securing that the front cloth frame is fixated. The front body shape is also supporting its fixation, and the magnets ensure that it is mounted correctly and stays on the loudspeaker.

Cloth frame structure

The frame is constructed with a pentagonal structure minimizing the usage of plastic material, but also maximizing the drivers' opportunity for sound distribution throughout the cloth frame.

In the frame, slots are made for fixating magnets. The wall thickness of the frame is 3mm, which is also valid for the front and body parts.

Cloth

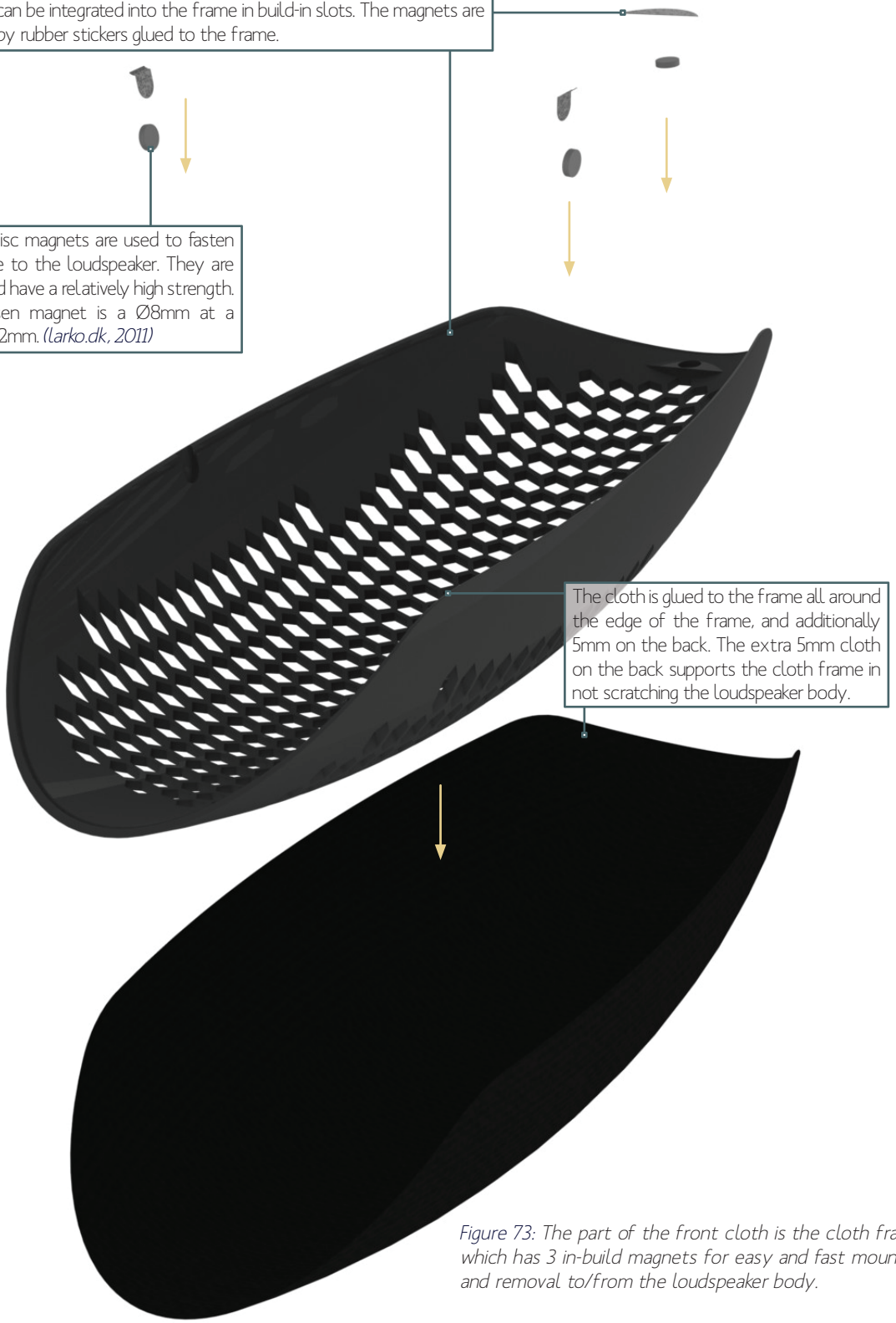
The selected cloth type is the same used by DALI in many of their other loudspeaker series. It is a very dark, black fabric with fine texture providing easy passage of sound waves, and hereby minimal sound absorption.

Figure 72: The cloth frame is attached to the loudspeaker by 3 magnets in the frame, and additionally 3 magnets inside the loudspeaker's front body part.

Material and production

The frame is curving due to the shape of the loudspeaker, and needs to support the cloth in a smooth, cylindrical shape. The frame is manufactured by injection moulding, and is optimized for a simple tool consisting of a cavity and core without side pulls. Consequently, the pentagonal structure in both left and right side of the frame is stretched because of the direction of the mould travel. By moulding in plastic, the mounting of the magnets can be integrated into the frame in build-in slots. The magnets are fastened by rubber stickers glued to the frame.

3 ferrite disc magnets are used to fasten the frame to the loudspeaker. They are cheap, and have a relatively high strength. The chosen magnet is a Ø8mm at a height of 2mm. *(larko.dk, 2011)*



The cloth is glued to the frame all around the edge of the frame, and additionally 5mm on the back. The extra 5mm cloth on the back supports the cloth frame in not scratching the loudspeaker body.

Figure 73: The part of the front cloth is the cloth frame, which has 3 in-build magnets for easy and fast mounting and removal to/from the loudspeaker body.

Front Body

The front body is a crucial part in the loudspeaker construction. Almost every component in the loudspeaker has influence on its final dimensioning. In this chapter, in-build functions are elaborated together with exploded-view pictures illustrating how to assembly this sub-assembly.

Several issues have been addressed during detailing of the front body part. The following functions are build into the injection moulded plastic part:

- An internally volume of 4 litres in total (front and back body parts)
- Mounting of tweeter panel and bass driver from the existing Lektor 1
- Mounting of tweeter and bass driver rims covering screws
- Logo fastening and ability of turning it 90 degrees when the loudspeaker is placed horizontally
- Placement of ICEpower50ASX2 amplifier with minimum 12mm of clearance around the component for safety and ventilations reasons *(icepower.bang-olufsen.com, 2011)*
- Integration of grooves for fast and easy mounting of source and volume wheel sub-assemblies without use of screws and fasteners
- Integration of flanges to guide the source and volume wheel
- Build-in slots to place magnets securing easy mounting and removal of the front cloth frame

With consultancy of Mads Møller from DALI, the wall thickness is decided being 3mm ensuring a rigid construction, and is used throughout the detailing of both the front and back body parts. The construction needs to be tested in a prototype if the body parts need additionally ribs inserted in creating an even more rigid structure.

DALI has not previously constructed loudspeakers in plastic material, and has therefore minimum know-how in plausible acoustical issues. Mads Møller also states that a final prototype of the loudspeaker in its defined plastic material can give acoustical engineers the opportunity of calibrating the crossover, which has great influence on the final performance. In addition, the amount of damping material inside the cabinet can be defined, which reduces potential acoustical issues. Acoustulux fabric is used, and is not illustrated on the step 2) back assembly illustration due to limited knowledge in how much and where it must be placed. A dimensional drawing of the part can be seen in Appendix *(see DimensionalDrawings: Front body, DVD)*.

Moulded-in inserts

IBB-M4-4 moulded-in threaded inserts from PennEngineering *(catalog.pemnet.com, 2011)* are used securing that components can be mounted with DALI's exiting custom-made M4x3 screw, which is used throughout its product series. The inserts also reduces the stress concentration in the body parts if parts are dismounted several times (i.e. repairing issues).

Material and production

The front body is manufactured by injection moulding in SAN plastic like the on-wall bracket. The outer wall thickness is 3mm, and additional extrusions internally are 1.5mm in accordance to standard dimensioning in plastic by injection moulding (half the outer wall thickness *(Ticona, 2000)*. The part is optimized for injection moulding without use of side pulls. Furthermore, all walls are constructed with a draft angle of 1.5° *(Ticona, 2000)*. It is coloured by mater batch in RAL 9005, which is the standard colour used by DALI for black parts. After moulding, an extra pad printing process is added colouring the chrome line around the part. The logo is an existing component from the DALI Motif loudspeaker.

Figure 74: Assemble of front and back sub-assemblies with 4 x M4x3 screws on the back of the loudspeaker finishing the total assembly of the product.

Step 1) Front assembly

The first step of assembling the front body is to mount the tweeter panel and bass driver followed by rims covering the screws. The screws are fastened into in-moulded M4x4 inserts. The logo is designed as a press fitting whereas it can be dismounted and rotated if the loudspeaker is mounted horizontally.

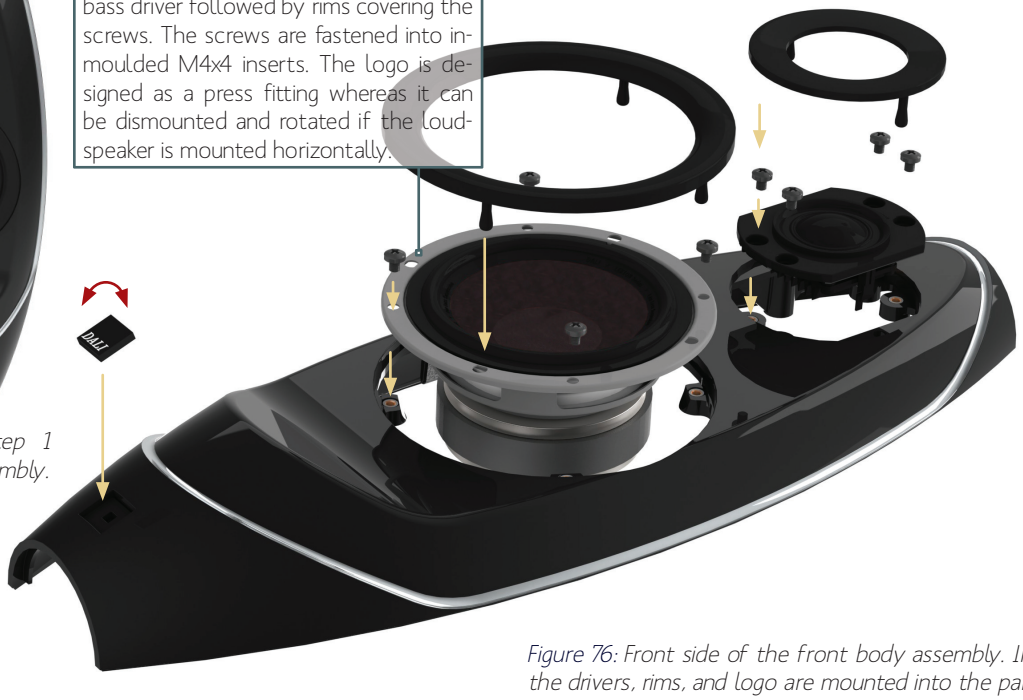
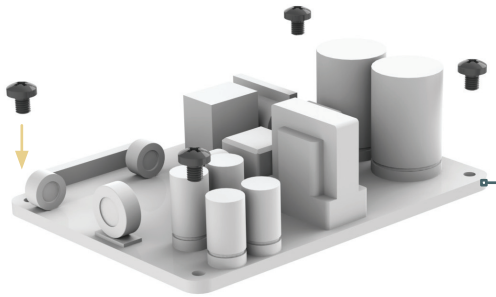


Figure 75: Step 1 finished assembly.

Figure 76: Front side of the front body assembly. In here, the drivers, rims, and logo are mounted into the part.

Step 2) Back assembly

In step 2, the front body is turned 180°, and the ICEpower50ASX2 amplifier can be mounted with 4 x M4x3 standard DALI screws. Furthermore is 3 x Ø8x2 ferrite magnets and stickers mounted. Cables from the tweeter panel and bass river are soldered together ready to be mounted to the presetting PCB board (not illustrated).



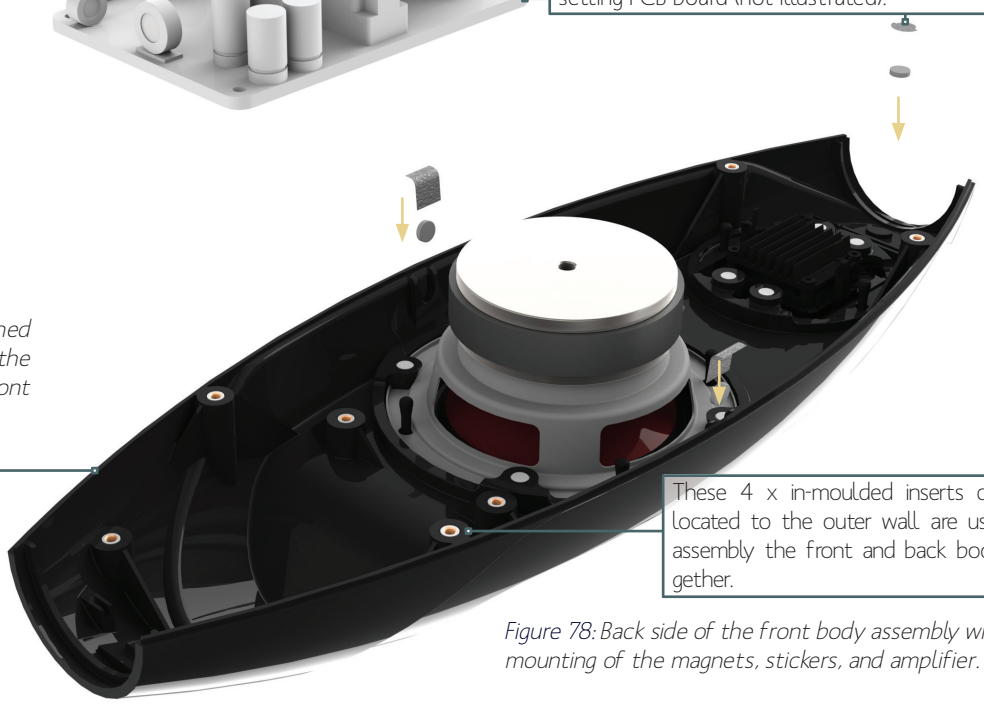


Figure 77: Step 2 finished assembly completing the assembly of the front body.

A groove is made all around the part to fixate the body parts when assembled in production.

These 4 x in-moulded inserts closely located to the outer wall are used to assembly the front and back body together.

Figure 78: Back side of the front body assembly with mounting of the magnets, stickers, and amplifier.

Back Body

The back body sub-assembly is less comprehensive than the front body by only mounting of the presetting plate, presetting PCB board, and 2 modified Lektor 1 bass ports.

The counterpart of the front body is named back body. Minor changes to the outer surfaces have been made as a result of detailing the construction. 4 holes suitable for 4 x M4x3 screws are visible when looking directly from the back. They are all cut into the back body minimizing its visibility of assembly with the front body part when seen from a front or side perspective. A dimensional drawing of the back body part can be seen in Appendix *(see DimensionalDrawings: Back body, DVD)*.

Lektor 1 bass ports

Bass ports are needed for the bass driver to fully perform at low frequencies, and result in more movement of air than etc. closed cabinets.

The bass ports mounted in the back body part are modified by integrating a bracket into the bass port part for easy mounting instead of introducing a completely new part to fixate it. Consequently, the existing injection moulding tool of the bass port is modified in producing both the original Lektor 1 bass port, and the newly designed bass port. It is facilitated by removing material from the core of the tool resulting in material addition to the new bass port (removing tool material = material addition in part).

2 different cores can be used to injection mould 2 types of bass ports. It is less expensive than producing a new injection moulding tool for the new bass port *(Ticona, 2000)*.

On-wall bracket

The counterpart of the on-wall bracket is build into the back body, and is of high importance in relation to final dimensioning and tolerances. Draft angles and fillets are also important to include because it can have major influence on the functionality of the bracket. Tolerances are not calculated due to limited resources and time. It is an issue in further development and detailing of the loudspeaker, and must be solved with professional sparring from plastic engineers and tool makers.

Presetting and system setup electronics

The electronics of the presetting plate are not further detailed from the Concept Developing phase due to delimitation and limited know-how in selecting the suitable components. The crossover is in-build onto the presetting PCB-board, and not visualized to the right. It needs to be connected by cables to the tweeter panel and bass driver.

The RCA and power connection plugs are dimensioned after standard components providing a realistic rendering of its size and placement. Cables in-between the amplifier and presetting PCB board must also be taken into consideration, and are not visualized in illustrations to the right.

The placement and size of the presetting plate has major influence on the final construction of the back body part. Furthermore, the total size of the loudspeaker can be expanded (etc. the width) if the presetting plate needs to be moved further into the centre or widened in size suitable to all of its components and buttons.

This issue needs to be clarified before final production, and is a part of further concept detailing with collaboration of electronic engineers, system presetting detailing, and, finally, which components are selected as optimal for the electronics.

Back side of the part

Figure 79: Back side of the back body where screws are as hidden as possible.

Figure 80: Front side of the back body with mounted bass ports and presetting plate.

Material and production
The back body is also produced by injection moulding in SAN plastic. The wall thickness is 3mm, and internally additional walls are 1,5mm with a draft angle of 1.5° *(Ticona, 2000)*. It is coloured by master batch in RAL 9005.

4 holes are now visible when looking directly from a back perspective.

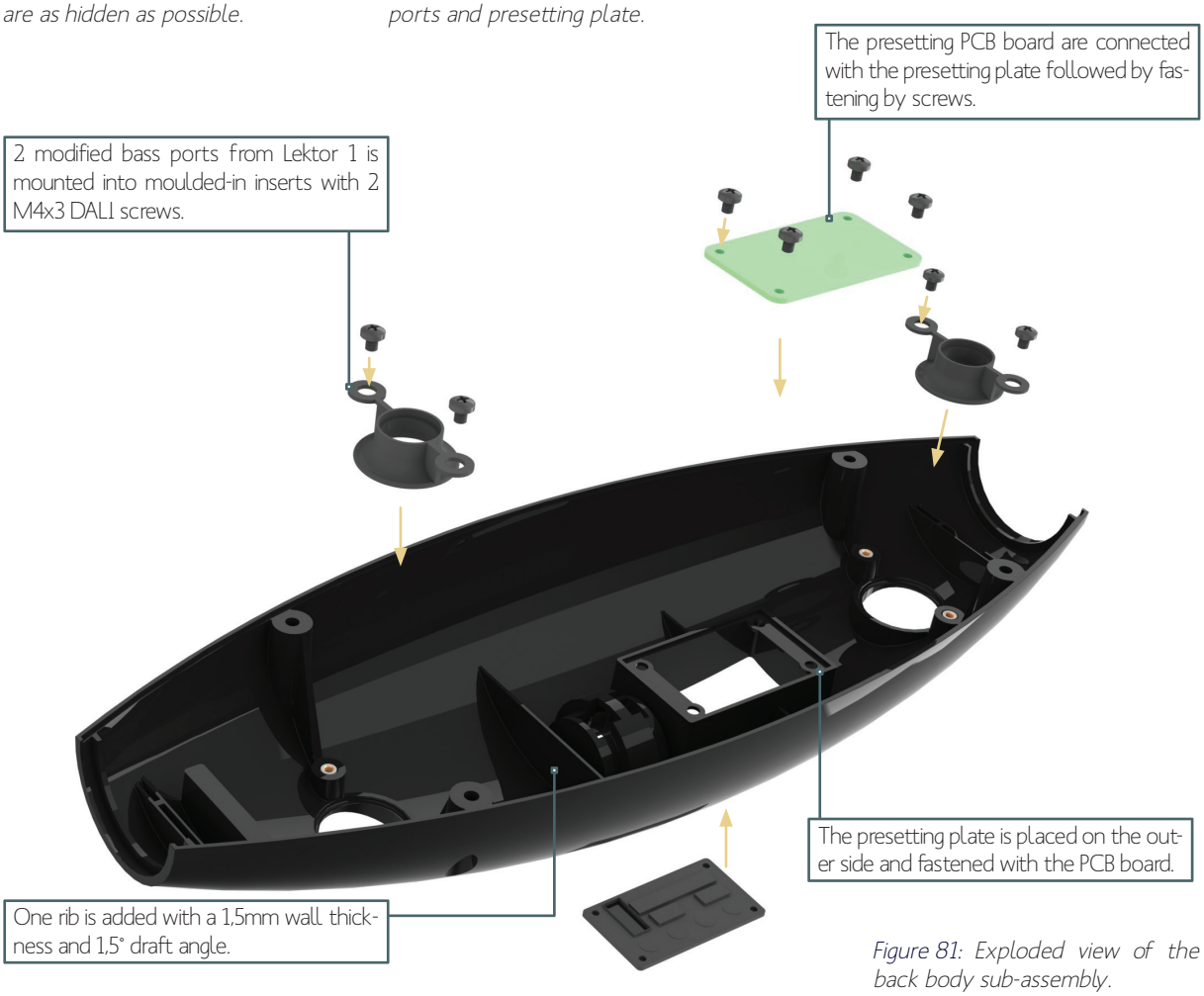


Figure 81: Exploded view of the back body sub-assembly.

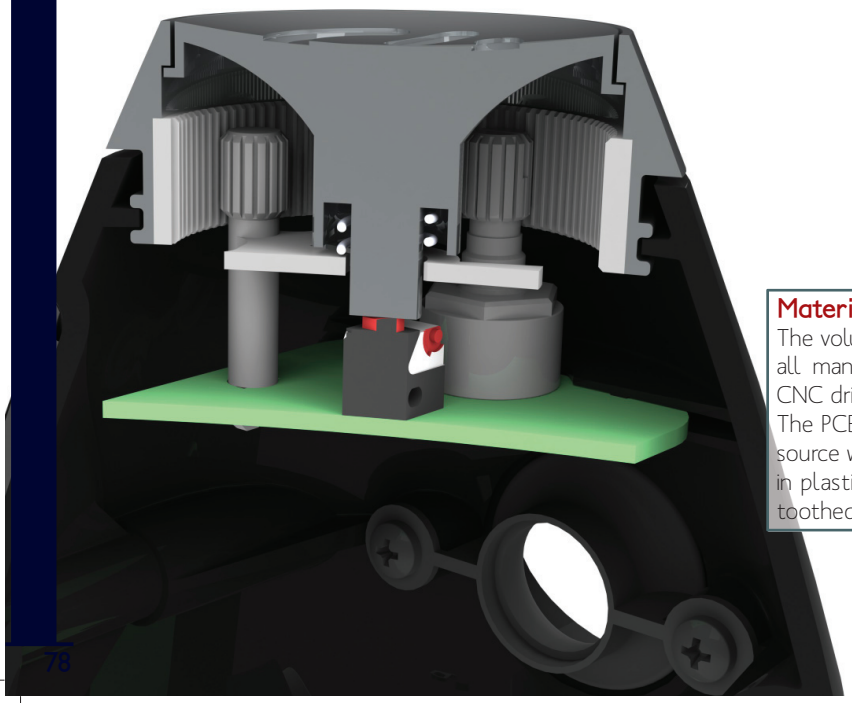
Source and Volume Wheel

The user has the opportunity of turning the loudspeaker on, adjusting the volume, and selecting source. The interaction is integrated into 2 wheels, which are elaborated in details how they are constructed.

Volume adjustment

All loudspeakers which are preset to the same room can adjust the volume on both loudspeakers by wireless connection in-between. Consequently, the volume wheel must not have any grooves or symbols indicating at which level the volume is set - unless the wheels automatically turn simultaneously when one loudspeaker is adjusted. This can be seen in some amplifier designs where a small step motor is integrated adjusting the volume wheel. It is an expensive additional component with less relevance to this product, and therefore not included.

The volume wheel is constructed with a potentiometer and 3 additional supporting wheels with the purpose of supporting a smooth movement. The potentiometer is dimensioned with use of a standard component *(bitechnologies.com, 2011)*. A ball bearing was seen as an option, but is adding additionally costs to the target cost price and therefore excluded. The PCB board and height of the power button is a direct outcome of the dimensions of the potentiometer. It must further be detailed which potentiometer is needed before final construction of the body parts. Dimensional drawings of the volume wheel, power button, and PCB board bracket can be seen in Appendix *(see DimensionalDrawings: Volume wheel, Power button, and PCB board bracket, DVD)*



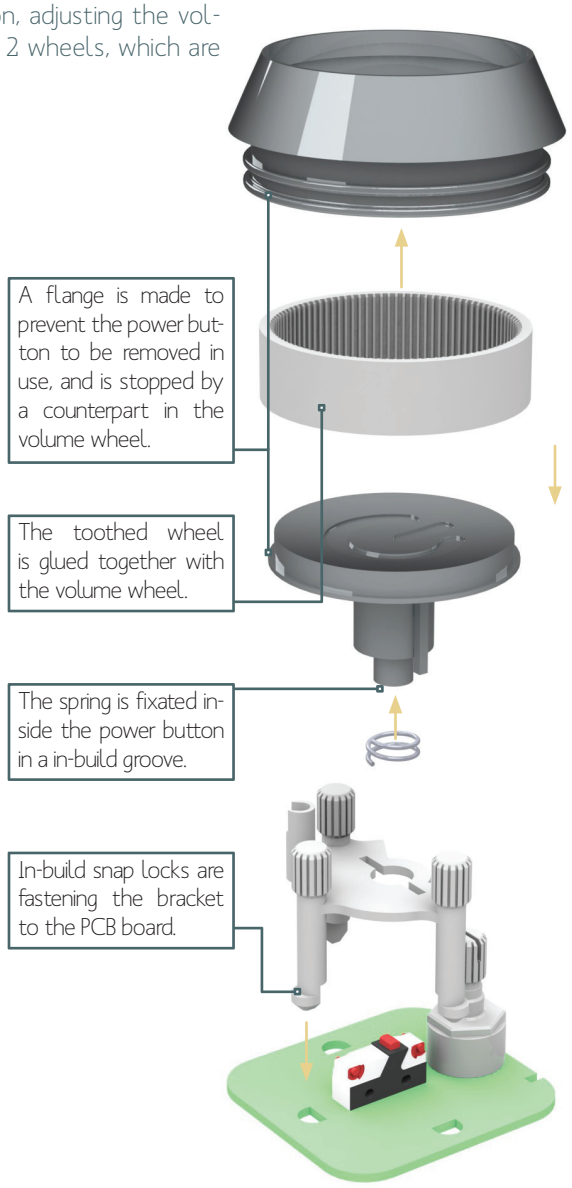


Figure 82: Exploded view of the volume wheel sub-assembly.

Material and production

The volume wheel, source wheel, and power button are all manufactured in aluminium by a multi-dimensional CNC drilling machine with a following polishing process. The PCB board bracket is used in both the volume and source wheel sub-assemblies, and are injection moulded in plastic. The spring, micro switch, potentiometer, and toothed wheels are all standard components.

Figure 83: Cut-through of the volume wheel when mounted into the loudspeaker.

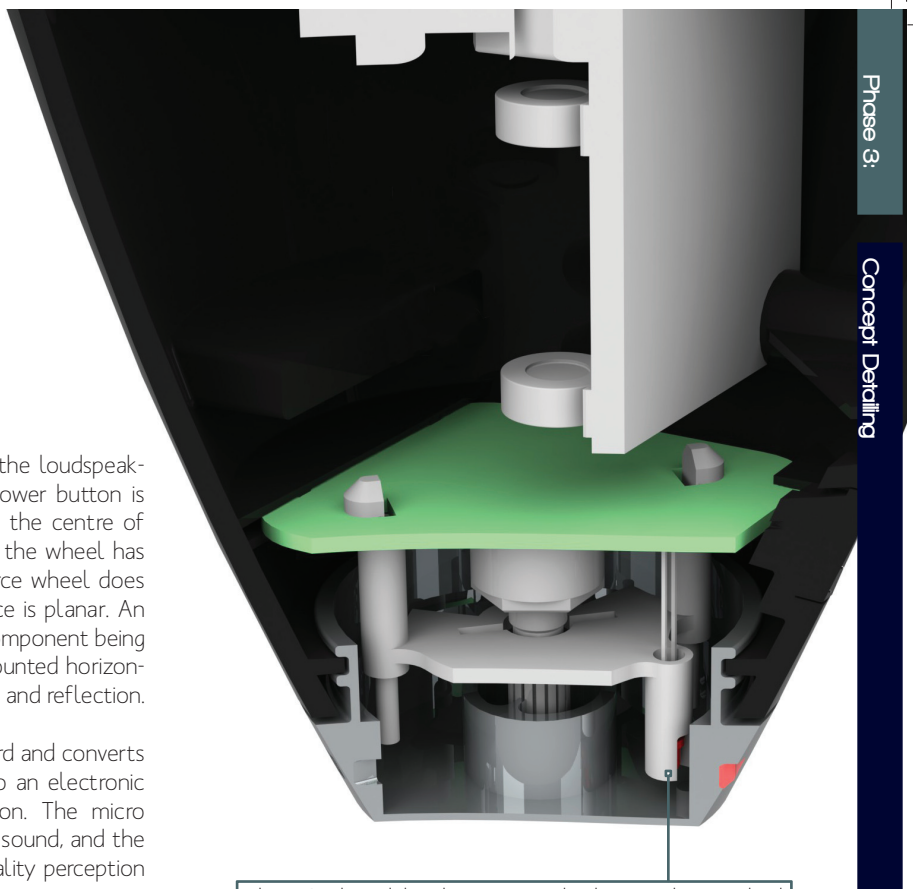
Power button

The power button cannot be seen when the loudspeaker is vertically mounted. Therefore, the power button is manufactured curving downwards towards the centre of the loudspeaker letting the user feel that the wheel has an integrated button. In contrast, the source wheel does not have a button, and this wheel's surface is planar. An icon for the power button is cut into the component being slightly visible when the loudspeaker is mounted horizontally or on shelf/floor dependent on lights and reflection.

A micro switch is attached to the PCB board and converts the pushing movement of the button into an electronic digitally signal turning the loudspeaker on. The micro switch itself produces a mechanical action sound, and the sound itself has great influence on the quality perception of the product *(Lyon, 2000)*.

If the button is rattling and produces jarring sounds, it will be in direct conflict with the product's quality perception and DALI's core values of quality produced products. The power button mechanism, volume and source wheel must be tested in a final prototype addressing these issues.

Figure 85: Exploded view of the source wheel with reuse of the PCB board bracket.



The PCB board bracket is reused whereas the toothed wheels are removed and not used in the source wheel subassembly. Instead, the LED light is guided downwards to the opening of the source wheel. The PCB board is fixated into grooves into both the front and back body.

Figure 84: Cut-through of the source wheel where the LED light is guided into the PCB board bracket.

Source selection

In the bottom of the loudspeaker, the source can be selected (source 1, source 2, and wireless receiving of music stream). When the loudspeaker is playing source 1 or 2, it automatically transmits music to every other loudspeaker connected to the same channel.

A potentiometer is also chosen to control this selection, and it differs from the volume adjustment potentiometer by being a three-step component (the 3 sources to select). The detailed construction is dimensioned using the same potentiometer. An LED light is furthermore connected to the PCB board indicating if the loudspeaker is on (lighting red throughout the cut whole in the source wheel), and white if it is on standby mode. If the wireless source is selected and none connection is available, the LED flashes.

The source wheel construction is simpler than the volume wheel due to no button. It results in the source wheel being directly attached to the potentiometer, and it will be fixated by the integrated grooves in the body parts.

Production

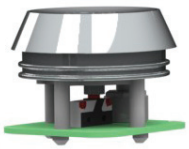
All sub-assemblies are listed into a scheme elaborating on how the parts are produced with appurtenant information to summarize which components are included when purchasing one loudspeaker. The stand, additional bracket and other products from the Product Family are not included.

Picture	Part	Quantity	Material	Process	After processing	Colouring
On-wall bracket						
	▪ On-wall bracket	▪ 1	▪ SAN	▪ Injection moulding	▪ None	▪ RAL9005 by master batch
	▪ On-wall bracket cover	▪ 2	▪ TPE	▪ Injection moulding	▪ None	▪ RAL9005 by master batch
Cloth						
	▪ Cloth frame	▪ 1	▪ SAN	▪ Injection moulding	▪ None	▪ RAL9005 by master batch
	▪ Cloth	▪ 1	▪ Fabric	▪ Standard component	▪ Cut and glued on cloth frame	▪ Black with texture (DALI cloth)
	▪ Ø8x2 ferrite magnet	▪ 3	▪ Ferrite	▪ Standard component	▪ None	▪ None
	▪ Stickers	▪ 3	▪ TPE	▪ Standard component	▪ Glued on cloth frame	▪ Black
Front body						
	▪ Front body	▪ 1	▪ SAN	▪ Injection moulding	▪ Pad printing edge in chrome	▪ RAL9005 by master batch
	▪ Lektor 1 bass driver	▪ 1	▪ Unknown	▪ Standard component	▪ Cable connection to crossover	▪ None
	▪ Lektor 1 tweeter panel	▪ 1	▪ Unknown	▪ Standard component	▪ Cable connection to crossover	▪ None
	▪ Bass driver rim	▪ 1	▪ Plastic	▪ Standard component	▪ None	▪ Black
	▪ Tweeter panel rim	▪ 1	▪ SAN	▪ Injection moulding	▪ None	▪ Black
	▪ DALI logo	▪ 1	▪ Plastic	▪ Standard component	▪ None	▪ RAL9005 (with DALI in chrome
	▪ ICEpowerASX502 amplifier	▪ 1	▪ Unknown	▪ OEM	▪ Cable connection to crossover	▪ None
	▪ Ø8x2 ferrite magnet	▪ 3	▪ Ferrite	▪ Standard component	▪ None	▪ None
	▪ Stickers	▪ 3	▪ TPE	▪ Standard component	▪ Glued to front body	▪ Black
	▪ M4x3 screw	▪ 12	▪ Unknown	▪ Standard component	▪ None	▪ Black

Back body

Picture	Part	Quantity	Material	Process	After processing	Colouring
	▪ Back body	▪ 1	▪ SAN	▪ Injection moulding	▪ None	▪ RAL9005 by master batch
	▪ Lektor 1 modified bass port	▪ 2	▪ Plastic	▪ Injection moulding	▪ None	▪ RAL9005 by master batch
	▪ Presetting PCB board (crossover)	▪ 1	▪ Unknown	▪ OEM	▪ Cable connection to drivers and amp	▪ None
	▪ Presetting plate	▪ 1	▪ Stainless steel	▪ Laser cut	▪ Powder coating and pad printing	▪ Black
	▪ M4x3 screw	▪ 8	▪ Unknown	▪ Standard component	▪ None	▪ Black

Volume wheel

Picture	Part	Quantity	Material	Process	After processing	Colouring
	▪ Volume wheel	▪ 1	▪ Aluminium	▪ CNC drilling	▪ Polishing	▪ None (polishing/ natural colour)
	▪ Toothed wheel	▪ 1	▪ Plastic	▪ Standard component	▪ None	▪ White
	▪ Power button	▪ 1	▪ Aluminium	▪ CNC drilling	▪ Polishing	▪ None (polishing/ natural colour)
	▪ Spring	▪ 1	▪ Spring steel	▪ Standard component	▪ None	▪ None
	▪ Toothed pins	▪ 2	▪ Plastic	▪ Standard component	▪ None	▪ White
	▪ PCB board bracket	▪ 1	▪ Plastic	▪ Injection moulding	▪ None	▪ White
	▪ PCB board (incl. potentiometer)	▪ 1	▪ Unknown	▪ OEM	▪ Cable connect to presetting and amp	▪ None

Source wheel

Picture	Part	Quantity	Material	Process	After processing	Colouring
	▪ Source wheel	▪ 1	▪ Aluminium	▪ CNC drilling	▪ Polishing	▪ None (polishing/ natural colour)
	▪ PCB board bracket	▪ 1	▪ Plastic	▪ Injection moulding	▪ None	▪ White
	▪ PCB board (incl. potentiometer)	▪ 1	▪ Unknown	▪ OEM	▪ Cable connect to presetting and amp	▪ None

Detailed Economics

With basis in literature and experience from previous projects, the detailed economical calculations are made to verify if the targeted cost price at DKK 1154.- in Phase 2 is feasible. The calculated cost price is a guesstimate meaning that many productional factors are unknown. Only parts from the "Production" chapter are included.

On-wall bracket

Part	Quantity	Tooling/part cost	After processing	Total price
▪ On-wall bracket	▪ 1	▪ IM [1]: DKK 75,000,- [2] / 15,000 parts [3] = DKK 5.-	▪ None	▪ DKK 5.-
▪ On-wall bracket cover	▪ 2	▪ IM: DKK 50,000,- [2] / 30,000 parts [4] = DKK 1.7.-	▪ None	▪ 2 x DKK 1.7.- = DKK 3.4.-

2 min. of manual assembly at DKK 400.- an hour: DKK 13.3.-

Front body sub-assemebly price: DKK 21.7.-

Notes

1. Injection moulding in SAN.
2. Estimated injection moulding tooling cost with basis in examples from *(Ulrich & Eppinger, 2008)*. The estimated cost price is including tooling operation costs, material consumption, and start-up costs.
3. 15,000 parts with estimated sales volume of 1000 parts within the first year followed by increased sales the following years (14,000 sets).
4. 30,000 parts due to the use of covers.

Cloth

Part	Quantity	Tooling/part cost	After processing	Total price
▪ Cloth frame	▪ 1	▪ IM: DKK 125,000,- [1] / 15,000 parts = DKK 8.3.-	▪ None	▪ DKK 8.3.-
▪ Cloth	▪ 1	▪ SC[2]: DKK 5.- [3]	▪ CG [6]: DKK 10.-	▪ DKK 5.- + DKK 10.- = DKK 15.-
▪ Ø8x2 ferrite magnet	▪ 3	▪ SC: DKK 2.- [4]	▪ None	▪ 3 x DKK 2.- = DKK 6.-
▪ Stickers	▪ 3	▪ SC: DKK 1.- [5]	▪ None	▪ 3 x DKK 1.- = DKK 3.-

5 min. of manual assembly at DKK 400.- an hour: DKK 33.3.-

Front body sub-assemebly price: DKK 65.6.-

Notes

1. Estimated injection moulding tooling cost with basis in examples from *(Ulrich & Eppinger, 2008)*. The tool is more complicated than the on-wall brakcet, and the estimated cost price is including tooling operation costs, material consumption, and start-up costs.
2. Standard Component from other DALI series.
3. Estimated part cost.
4. One Ø8x2 ferrite magnet's price is found at *(larko.dk, 2011)* costing DKK 1.95.- when purchasing 10,000.
5. Estimated cost price for stickers in TPE.
6. Cut and Glued on cloth frame by machinery/manual operation.

Front body

Part	Quantity	Tooling/part cost	After processing	Total price
Front body	1	IM: DKK 300,000,- [1] / 15,000 parts = DKK 20.-	PP [5]: DKK 5.- [6]	DKK 20.- + DKK 5.- = DKK 25.-
Lektor 1 bass driver	1	SC: DKK 63.5.- [2]	None	DKK 63.5.-
Lektor 1 tweeter panel	1	SC: DKK 63.5.- [2]	None	DKK 63.5.-
Bass driver rim	1	SC: DKK 21.1.- [2]	None	DK 21.1.-
Tweeter panel rim	1	IM: DKK 50,000,- [1] / 15,000 parts = DKK 3.3.-	None	DKK 3.3.-
DALI logo	1	SC: DKK 5.- [3]	None	DKK 5.-
ICEpowerASX502 amplifier	1	OEM[4]: DKK 400.-	None	DKK 400.-
Ø8x2 ferrite magnet	3	SC: DKK 2.-	None	3 x DKK 2.- = DKK 6.-
Stickers	3	SC: DKK 1.-	None	3 x DKK 1.- = DKK 3.-
M4x3 screw	12	SC: DKK 1.8.-	None	12 x DKK 1.8.- = DKK 21.6.-

10 min. of manual assembly at DKK 400.- an hour: DKK 66.7.-

Front body sub-assemebly price: DKK 678.7.-

Notes

1. Estimated injection moulding tooling cost, which is far more complex than the previous tools *(Ulrich & Eppinger, 2008)*. The estimated cost price is including tooling operation costs, material consumption, start-up costs, and moulded-in inserts.
2. Estimated part cost derived from cost price calculations on the existing Lektor 1 loudspeaker *(see Appendix 15: Lektor 1 Cost Price, DVD)*
3. Estimated cost price for existing DALI logo from the DALI Motif loudspeaker.
4. Original Equipment Manufacturer
5. Pad Printing
6. Estimated cost for pad printing the edge of the front body in chrome.

Back body

Part	Quantity	Tooling/part cost	After processing	Total price
Back body	1	IM: DKK 300,000,- [1] / 15,000 parts = DKK 20.-	None	DKK 20.-
Lektor 1 modified bass port	2	IM: DKK 75,000 / 30,000 parts = DKK 2.5.- [2]	None	2 x DKK 2.5.- = DKK 5.-
Presetting PCB board	1	OEM: DKK 50.- [3]	None	DKK 50.-
Presetting plate	1	LC [4]: DKK 10.- [5]	PC and PP: DKK 10.-	DKK 10.- + DKK 10.- = DK 20.-
M4x3 screw	8	SC: DKK 1.8.-	None	8 x DKK 1.8.- = DKK 14.4.-

10 min. of manual assembly at DKK 400.- an hour: DKK 66.7.-

Back body sub-assemebly price: DKK 176.1.-

Notes

1. Estimated injection moulding tooling cost with basis in examples from *(Ulrich & Eppinger, 2008)*. The estimated cost price is including tooling operation costs, material consumption, start-up costs, and moulded-in inserts.
2. Estimated injection moulding tooling cost when the core is modified moulding the new bass port with bracket. The cost price of the existing bass ports is calculated *(see Appendix 15: Lektor 1 Cost Price, DVD)*
3. Estimated part cost manufactured by sub-supplier including crossover and wi-fi module.
4. Laser Cut.
5. Estimated cost price for laser cutting a steel plate.

Volume wheel

Part	Quantity	Tooling/part cost	After processing	Total price
▪ Volume wheel	▪ 1	▪ CNC [1]: DKK 50.- [2]	▪ P: DKK 10.- [8]	▪ DKK 50.- + DKK 10.- = DKK 60.-
▪ Toothed wheel	▪ 1	▪ SC: DKK 5.- [3]	▪ None	▪ DKK 5.-
▪ Power button	▪ 1	▪ CNC: DKK 50.- [2]	▪ P: DKK 10.- [8]	▪ DKK 50.- + DKK 10.- = DKK 60.-
▪ Spring	▪ 1	▪ SC: DKK 2.- [4]	▪ None	▪ DK 2.-
▪ Toothed pins	▪ 2	▪ SC: DKK 1.- [4]	▪ None	▪ 2 x DKK 1.- = 2 DKK.-
▪ PCB board bracket	▪ 1	▪ IM: DKK 50,000,- [5] / 30,000 parts [6] = DKK 1.7.-	▪ None	▪ DK 1.7.-
▪ PCB board (incl. potentiometer)	▪ 1	▪ OEM: DKK 50.- [7]	▪ None	▪ DK 50.-

10 min. of manual assembly at DKK 400,- an hour: DKK 66.7.-

Volume wheel sub-assemebly price: DKK 247.4.-

Notes

1. Multi-dimensional CNC drilling machine operating in aluminium.
2. Estimated part cost including aluminium material, start-up cost, and programming.
3. Estimated part cost.
4. Estimated part cost when purchasing a large volume.
5. Estimated injection moulding tooling cost with basis in examples from *(Ulrich & Eppinger, 2008)*. The estimated cost price is including tooling operation costs, material consumption, and start-up costs. The tools are simple, and therefore not expensive.
6. The part is being used 2 times in each loudspeaker: both the volume and source wheel.
7. Estimated part cost manufactured by sub-supplier including potentiometer and micro switch.
8. Polishing of aluminium after CNC processing.

Source wheel

Part	Quantity	Tooling/part cost	After processing	Total price
▪ Source wheel	▪ 1	▪ CNC: DKK 50.- [1]	▪ P: DKK 10.-	▪ DKK 50.- + DKK 10.- = DKK 60.-
▪ PCB board bracket	▪ 1	▪ IM: = DKK 1.7.- [2]	▪ None	▪ DKK 1.7.-
▪ PCB board (incl. potetiometer)	▪ 1	▪ OEM: DKK 50.- [3]	▪ None	▪ DK 50.-

10 min. of manual assembly at DKK 400.- an hour: DKK 66.7.-

Source wheel sub-assemebly price: DKK 178.4.-

Notes

1. Estimated part cost including aluminium material, start-up cost, and programming.
2. The PCB board bracket is the same as in the volume wheel and the estimation is derived from the volume wheel sub-assembly.
3. Estimated part cost manufactured by sub-supplier including potentiometer.

Total cost price calculation

The calculated cost price of the loudspeaker is hereby:

- On-wall bracket sub-assembly = DKK 21.7.-
- Additional bracket sub-assembly = DKK 48.6.-
- Cloth sub-assembly = DKK 65.6.-
- Front body sub-assembly = DKK 678.7.-
- Back body sub-assembly = DKK 176.1.-
- Volume wheel sub-assembly = DKK 247.-
- Source wheel sub-assembly = DKK 178.4.-
- Total cost price = DKK 1,346.2.-
- Difference: DKK 1154,- - DKK 1346,2,- = DKK -192.2.-

Evaluation of cost price

The economical and production spreads are made to roughly calculate the target cost price of the loudspeaker in order to identify where there are economical challenges.

Even though the calculation is a guesstimate, it is highly relevant to identify where economical challenges are in order to make changes in another design optimization iteration of the detailed construction.

It is evaluated difficult to hit the target cost price at DKK 1,154.-. The difference of DKK -192.2.- is mainly because of the following factors of great importance:

- Introduction of 6 new injection moulding tools, which is an expensive start-up cost
- The body parts are also made by injection moulding, and the tools are complex and expensive to manufacture
- The cost price of the amplifier is an estimation, which is highly dependent on the quantity when purchasing. The amplifier does not specifically need to be an ICEpower-product, and can be purchased cheaper from another sub-supplier. The amplifier is chosen due to the following demands: in-build power adapter, minimal size, connection opportunity, and output/performance in watt in order to proceed in concept detailing. The estimated amplifier price level is at DKK 400.- and therefore a main part of the cost price. In addition, an amplifier cost of DKK 200.- would be applicable, and is targeted for further concept detailing

All prices are relatively high, and are evaluated plausible being manufactured cheaper. The main question about economical and productional issues are the amount of investment this loudspeaker needs in being produced contra sales volume. Also, there are strategically issues to discuss, which are closely connected to the economical logic of the project. These issues will be elaborated in the next phase to come.

If the parts of the loudspeaker could be manufactured cheaper without high investments, the project would have a higher chance of being introduced to the market faster, and with less economical risks. This aspect is exactly what Blue Ocean strategy is all about: creating value innovation by reducing/eliminating costs and risks.

Finally, the Product Family products must be taken into consideration when calculating the overall revenue stream of the loudspeaker. These products can support the revenue stream by having a higher profit ratio, and hereby directly support the economical logic of the product.

Product Family

The loudspeaker is part of a Product Family including the USB-dongle, stand, additional bracket (white or black), remote control, and a subwoofer. Furthermore, it is seen plausible to introduce a passive version of the loudspeaker for a traditional stereo setup with more powerful drivers.

USB-dongle

Users can purchase a dedicated DALI USB-dongle for wireless streaming of music from a PC or Mac computer. It is not included in the standard version of the loudspeaker because of the following:

- The loudspeaker is purchased one at a time
- More than 2 loudspeakers are installed in a multi-room installation, and thus the potential need of no more than one USB-dongle per household
- Target cost price increasing resulting in every loudspeaker being more expensive
- The USB-dongle can contribute to the revenue stream of the loudspeaker by having a higher profit ratio

Additional bracket

The additional bracket is an accessory to the loudspeaker, and hereby optional when purchasing the product. It is a less expensive component to manufacture, and can easily be modified in colour by powder coating. Users can choose which colour that suits their household the best (i.e. a white bracket is less dominant when mounted on a white wall).

On-floor and shelf stand

The construction of the stand and additional bracket are both detailed due to their potential influence on the rest of the loudspeaker construction and idiom. The stand is evaluated relatively expensive to manufacture because of start-up costs for die casting tools for both aluminium parts. An alternative process is to CNC drill the parts.

Remote control

The remote control is introduced as a result of the in-build interaction into the loudspeaker. It is thought as an accessory available when the loudspeaker is introduced to the market (like all the other products in the Product Family). The remote is reusing the volume wheel sub-assembly components from the existing loudspeaker. Furthermore, the remote must have in-build batteries and wireless transmitter module. The source selection cannot be integrated into the remote control due to the in-build potentiometer in the loudspeaker, which is controlled mechanically.

Subwoofer

The subwoofer shown on the illustration on the right is designed with basis in the elliptic loudspeaker. It is an outcome of the potential need of a subwoofer supporting the on-wall loudspeaker in the lower frequencies. Moreover, a user stated that the lack of opportunity of connecting a subwoofer could result in not buying the system (see "Interaction Design" chapter with situated interviews in Phase 2). The outer dimensions of the subwoofer are with basis in the Lektor-series subwoofer *(dali.dk, 2011)*: height = 315mm and maximum diameter = 310.

A final option is to develop a passive and more powerful, floor standing loudspeaker for existing amplifiers and stereo setups. This option is not illustrated because it needs dedicated attention in terms of design and construction.

Figure 86: The Product Family with multiple additional products suitable for many different scenarios of use.

Phase 3 Reflection

Throughout the Construction Detailing Phase, many productional and technical reflection have been made, and they are summarized into this chapter.

Loudspeaker construction

The overall dimensions of the product are derived from the need of 4 litres volume in DALI's existing Lektor 1 loudspeaker. Another demand is that the construction must be rigid in obtaining vibrations made by mainly the bass driver, and in signalling quality to end-users. DALI has not developed plastic cabinets prior to this product, and has therefore limited knowledge in potential construction issues the result of limited professional sparring available. If the construction is not rigid enough, ribs can easily be added to the injection moulding tool resulting in a more stiff body when assembled and performing in use.

With consultancy by Mads Møller from DALI, the wall-thickness is defined being 3mm, which is evaluated by Mads Møller as a minimum. The evaluation is done with experience in aluminium cabinets from DALI's Motif series and previous projects.

A prototype in the chosen plastic material can provide valuable insight about the loudspeaker's stiffness, and can identify potential acoustic issues. etc. the final calibration of the crossover, and where and how much Acoustulux damping material must be added internally (cabinet fabric inside). Comprehensive computer simulation software can be used to address issues at an early stage of the product development, but has not been at the project group's disposal or knowledge of how to use it.

All internally loudspeaker components and assembly considerations are constructed without physically working at DALI's headquarter. From the beginning of the project, it was planned to work and be a part of the team in the development department to gain valuable insight in loudspeaker construction by mechanical and acoustical engineers. Furthermore, it could have added value to the final project outcome in terms of realism of product implementation with i.e. a deeper level of construction detailing. At this state of the project, the project group is ready to present the construction to DALI's mechanical and acoustic engineers, and discuss potential modifications, and if the project duration was expanded it would be the next step to do.

In the following paragraphs, the developed parts will be discussed with additional economical and Product Family reflection.

Additional bracket

The placement of portable devices can vary highly, and because the loudspeaker is available for on-wall mounting, it is necessary to take this aspect into consideration in the final product proposal.

The developed additional bracket is a slim, bending bracket which is in contrast to the very solid elliptic shape of the loudspeaker. It is very cheap to produce, and can be powder coated in another colour like illustrated in the "Product Family" chapter. The bracket has a problematical consideration, which briefly will be discussed in here. If a user has a very unique and expensive smart phone or etc. a portable music player, it may be perceived as being risky to place it on the very slim bracket. It may drop or slip even though the bracket is coated with TPE for minimizing exactly that issue. In contrary, a delicate strap (etc. leather) could fixate the device. A dedicated pocket integrated into the bracket could also fixate the device.

Consequently, the additional bracket needs be redesigned in perception, feeling and being physically stiffer so users are comfortable placing their devices on the bracket. This hypothesis could be tested by involving the users like in Phase 1 & 2, but due to limited time it is not an option in the project period. Another area of focus is when children are playing, or adults by mistake hit the bracket. It must resist a certain amount of loading, and fixate the portable devices when unexpected scenarios occur.

On-wall bracket

The on-wall bracket is an outcome of the in-build functions of rotating 45° from its centre line, and the opportunity of easy mounting and removal.

It is designed being produced by injection moulding in SAN, which is chosen due to FEA calculations and a systematic material selection method. The stress level is with point of departure in worst case scenario, and a dead weight of 3 kg. derived from the original Lektor 1's weight of 3.1 kg. The bracket was naturally selected as a component to do FEA analysis and systematic material selection because of its crucial main function of fixating and restraining constant loading. In addition, the on-wall bracket must not fail, which can result in the loudspeaker being dropped to the ground.

Another solution to the on-wall's in-build function of rotating could be a ball-joint where the loudspeaker could turn in multiple directions for final adjustment. Consequently this option would result in the loudspeaker being able to be angled in- or outwards in relation to the wall. It is not acceptable because either the volume or source wheel would physically hit the wall due to the loudspeaker's elliptical shape. If the user wants to place the loudspeaker at other heights, it can be wall-mounted horizontally or on the stand.

The bracket needs to be tested with use of a 1:1 prototype in the selected plastic material. The tests can resolve issues concerning the mounting and removal, but also if the on-wall bracket needs locking pins in-between the bracket and loudspeaker back body ensuring that the loudspeaker is totally fixed. The bracket is designed being automatically fixed when mounted in a horizontal position, but it is very difficult to verify the construction without a final prototype or functional prototype.

Stand

In the "Concept Presentation" chapter, which is a result of the presentation material made for the status seminar, a stand is presented to illustrate that the loudspeaker can be placed elsewhere than on a wall for greater flexibility. This scenario is seen plausible in some households of use, or even preferred instead of on-wall placement.

The shape of the stand has been redesigned towards being very minimalistic and anonymous in its expression making the loudspeaker the dominant part when standing on a floor or shelf. The stand is being detailed due to its potential influence on the loudspeaker and its idiom. The on-wall bracket is reused because of its in-build functions and in securing that the same fixation is achieved when placed on the stand.

The loudspeaker's opportunity of being horizontally mounted on a wall is evaluated less important due to the stand and its flexibility of placement. Even though, the loudspeaker's horizontal placement opportunity is maintained, and can with use of focus groups be verified if the stand is undertaking the purpose of being horizontally placed.

Body parts

The overall dimensions and shape of the loudspeaker have not been modified since the "Concept Development" Phase hence the attention to the dimensions of the inner components before entering that phase of the project. It is mainly a consequence of carefully seeking information about the amplifier size, demand to internal volume, and experience in product design from previous projects.

One crucial aesthetic issue is the assembly of the front and body parts. The parting line is placed in the centre of the loudspeaker as a result of focusing on optimizing the parts for injection moulding. It is very difficult to hide this parting line, whose visibility must be tested through prototyping due to the loudspeaker body parts are coloured black (may not become an issue due to black-in-black colouring). Furthermore, the parting line will be visible because of production issues like dimensional diversity when moulding i plastic, form stability, creeping, or/and tolerances of the parts. The parting line has a R0.2 fillet to make the transitions from each part more smoothly.

Another option is to make fake lines or grooves as a supplement to the real parting line. It can revitalise the shape, and this phenomenon is also seen in DALI's existing Motif loudspeaker, and used in many other product series from DALI.

Volume and source wheels

Both wheels are developed with point of departure in the overall outer dimensions of the potentiometer and the loudspeaker, and are used in constructing the wheels, which further on has influence on the internally dimensions of the body parts.

The power button of the volume wheel was the greatest challenge due to the central placement of the button with a rotating wheel on the outside. Its mechanical mechanism is evaluated likely being operational, but the main issue is concerning its smoothness and mechanical action sound when pushed. The mechanical action sound is when the button is being "clicked". and it has great influence on the perceived quality of the product by users *(Lyon, 2000)*.

The micro switch is generating the sound, but the internal construction of the body parts and power button have major influence on the mechanical action sound of the micro

switch and hereby its transmission path *(Lyon, 2000)*. It cannot be tested before a final prototype is manufactured. The smoothness of the volume and source wheels can be justified by integration of a ball bearing. Initially, ball bearings are found as a relatively cost expensive addition to the target cost price, and therefore not included.

Another important constructional aspect is the space between the power button and volume wheel. At the moment, the space is minimum, and it is seen likely to be expanded ensuring that the volume wheel and power buttons are not interfering with each other when users are interacting with the parts.

Economy and production

The economy and production spreads are made with basis in the project group's own experience and production examples in literature. It has provided valuable insight in which components which have major influence in the overall cost price. In here, the amplifier, and other electronics (etc. wi-fi module) are all guesstimates, and can with the help of a dedicated purchase manager, find suitable prices and components resulting in a lower cost price.

It is not seen plausible to use other processes than injection moulding to cast the front and back body, which both are the essence of the loudspeaker construction. The only alternative is die casting in aluminium, but is delimited with consultancy by Mads Møller because of its potential higher cost price.

The on-wall bracket covers are also manufactured by injection moulding, and are seen more feasible to use TPE stickers as an alternative instead of the introduction of dedicated tool. Also, the introduction of die casting tools for the stand's back and foot are adding costs to the project economy, and can instead with limited start-up costs be manufactured by CNC drilling. The individual cost price of the parts will increase, but the economical risk is in contrary limited.

Product family

The illustrated USB-dongle, remote control and subwoofer are part of the Product family, and are all designed in order to elaborate potential products related to the loudspeaker. Other DALI loudspeakers are also part of a product series, which is common when developing loudspeakers. It is not that often that a loudspeaker is being introduced without supporting products due to many scenarios of use.

Remote control

The volume control is easy to manufacture due to the reuse of components from the top part of the loudspeaker. Ideally, it would be possible to change source directly on the remote, but not an option at the moment because of the source selection is carried out mechanically. It can only be integrated if the source control is digitally controlled in the loudspeaker. The source wheel should still be a mechanical turnable selection but processed digitally inside due to the interaction with wheels, only, on the loudspeaker.

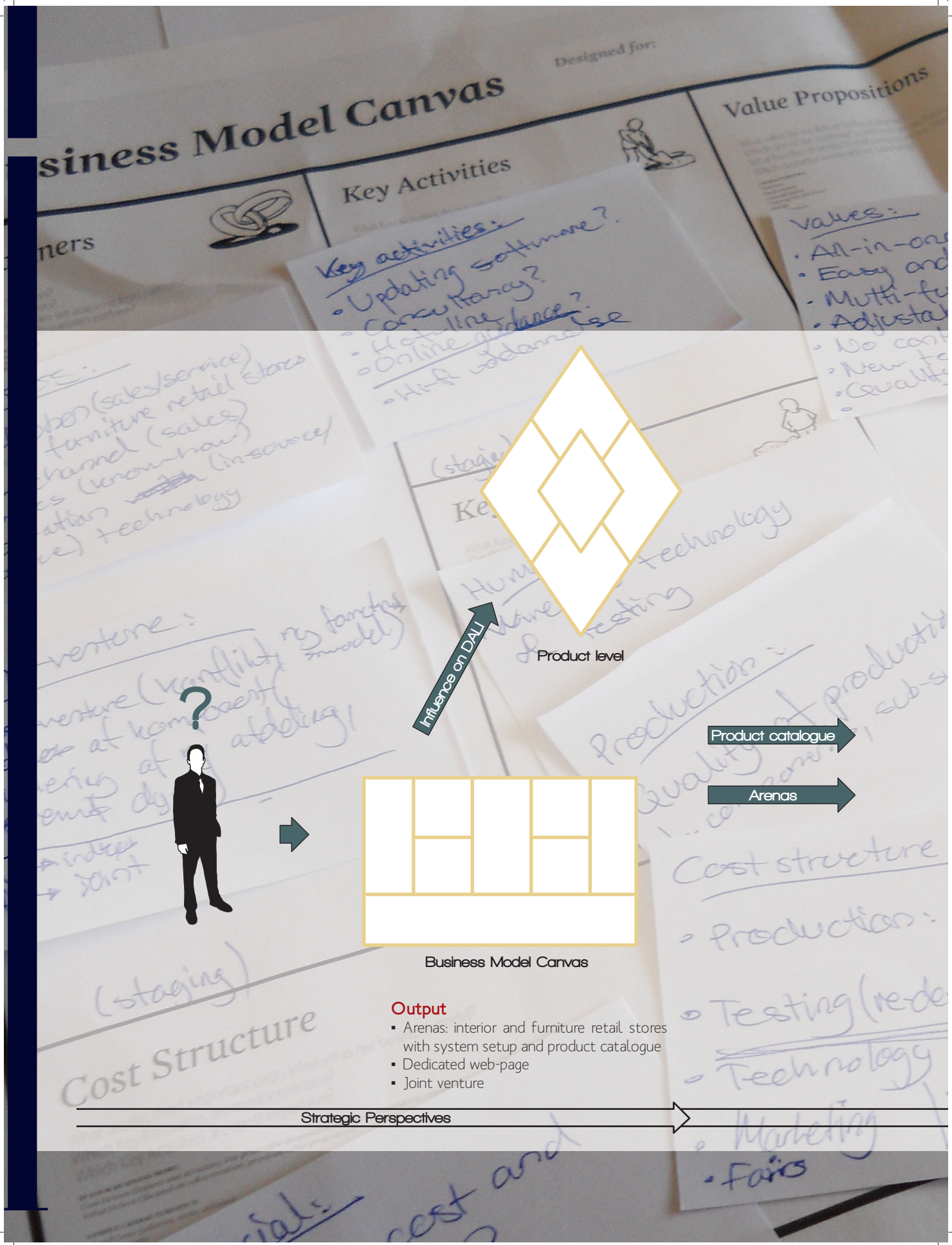
It will demand a greater need of electronic engineering, and a mechanical redesign of the source wheel. This can add value to the use of both the volume control and system setup if the source automatically changes on every loudspeaker connected to the same wireless channel/or selected room.

Subwoofer support

The subwoofer is dimensioned with basis in the existing Lektor 1 subwoofer, and is mainly redesigned in terms of the integration of a wireless module and its visual appearance. Another option is to cable connect the subwoofer directly to the loudspeaker, and hereby the possibility of using an existing subwoofer from DALI's product catalogue. Subwoofers are often hidden as much as possible due to its big size, and minor effect on the sound quality because of transmission of low frequencies sound waves (reflected on walls/ceilings/floors and bounced around the room). In contrary, the newly designed subwoofer is seen plausible being visual in the household because of its shape and idiom.

Colouring

The loudspeaker is chosen being coloured in DALI's standard black colour, RAL 9005, and hereby not offering the loudspeaker in white. In the Strategy Canvas defined in Phase 1, it is defined that the personalization parameter is kept at a minimum in keeping the production costs as low as possible. Consequently, a white version would result in the body parts being injection moulded with a white master batch affecting the logo, on-wall bracket, and on-wall bracket covers. On the contrary, the additional bracket can easily be powder coated in white, which is not in conflict with the visual appearance of the loudspeaker.



Output

- Arenas: interior and furniture retail stores with system setup and product catalogue
- Dedicated web-page
- Joint venture

Strategic Perspectives

Phase 4: Marketing & Implementation

Product name

Structure

Context pictures

Renderings

System description

Logo

Output

- Product name: Ellipse
- Delicate, visual product catalogue available in new arenas (interior and furniture stores)

Product Report / product catalogue

Figure 87: Phase 4 overview.

Strategic Perspectives

With use of a Business Model Canvas, strategic perspectives are discussed with point of departure in the strategy diamond from the Design Brief. The strategy diamond is used on a product level emphasizing evaluated differences, which needs to be made in order to introduce the new product to the Danish market.

With market introduction of the new loudspeaker, several strategically aspects are influenced and furthermore in conflict with DALI's present strategy. To illustrate and discuss these matters, a Business Model Canvas *(business-modelgeneration.com, 2011)* is used in which the main points can be seen in the strategy diamond to the right.

The business model including post-its can be seen in Appendix on the attached DVD *(see Appendix 16: Business Model, DVD)*.

Product features and differentiation

DALI's product series has not changed from the early beginning in relation to the intention of use. Their products are mainly made for active listening setups where correct stereo perspective is achieved. Active listening is when users sit in a correct position and actively listen to music. Passive listening can instead be defined as background music or/and where users are not in the centre of the stereo perspective (own definitions).

This issue of passive listening is in conflict with DALI's product series, and the product's existence is highly dependent on DALI's intention of moving towards this rising market. In the "Problem Analysis" chapter in Phase 1, several new products in Hi-fi Klubben's product catalogue are multi-room solutions, and hereby passive listening system setups illustrating a new market tendency. Furthermore, the conducted user research is a result of users preferring other parameters than one of DALI's main values; performance.

Consequently, the new product differentiates itself on several parameters of great importance in relation to existing DALI products, but also within Hi-fi Klubbens range of products. The differences are as follows; simple, intuitive, all-in-one multi-room system solution, which is produced with respect to DALI's manufacturing standards in quality materials and drivers.

Live demonstrations in contexts of use

Due to the diversity of the loudspeaker in functionality and idiom, other arenas can be used in promoting and branding the product. It is seen beneficial to setup the loudspeakers in a system solution in interior and furniture retail stores showing its full system potential. In addition, retail stores have context setups of living rooms, kitchens, bedroom, and other rooms found in users' household at which the loudspeaker is targeted at.

Several systems can be placed throughout the retail stores illustrating that the loudspeaker is a system with many loudspeaker connected to the same source by wireless streaming and transmission. In supporting the product, a catalogue can freely be taken from the store for users to take home, and discuss the product with relatives. In the product catalogue, information and several context pictures are found about product features, the Product Family, and where to seek for more information. The content of the product catalogue is elaborated in the chapter "Marketing Material" in the next spread to come.

It is a far more aggressive marketing of the product than DALI is practising at the moment (and yet more expensive due to maintenance of setup, contract with retail stores, etc.). Products are normally introduced in Hi-fi Klubben followed by an intense product description in Hi-fi Klubben's yearly product catalogue distributed freely in the store or send by mail. Additionally online magazines and tests are conducted, and articles written in specialist journals, which readership is diverse and not hitting a mass market.

In addition, a dedicated web-site can support the marketing of the product, which is a relatively cheap one-time investment with minor maintenance costs. It can elaborate the product features in an illustrative way, and show context pictures for inspiration (like the aim of the Product Report). Furthermore, it is possible to advertise through medias and magazines creating an awareness of the product's existence.

Revenue streams

The market price is maintained at DKK 3,000.-, each, even though it is seen difficult to hit the estimated target cost price without exceeding production costs. The target cost price is a guesstimate, and must be further detailed before a market price increment may become relevant.

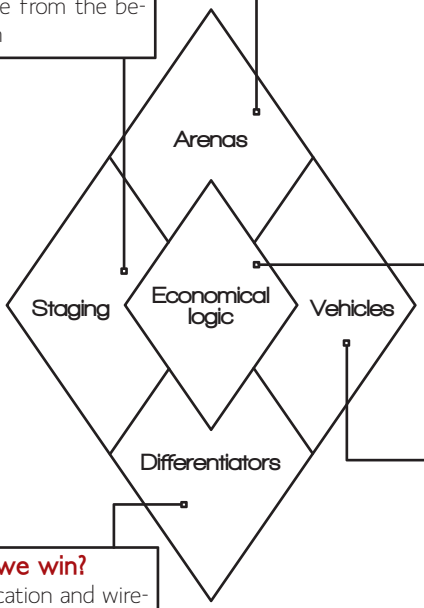
The potential of the loudspeaker is only fully explored when purchasing more than one system. Therefore, it is seen likely that a discount can be introduced in supporting the purchasing of more than one set at the time. Additionally sets can be bought after initially purchase. Furthermore, products from the Product Family can support revenue streams by a higher profit margin in each product.

Staging: What will be our speed and sequence of moves?

- Using the DALI brand value of quality material and performance in support the loudspeaker being introduced to the market (just like B&W and the introduction of Zeppelin)
- Firstly introduced to the Danish market with opportunity of expanding to other stores in Scandinavia.
- DALI has high quality standards, and does not launch a product before comprehensive testing (quality assurance beneficial for users)
- Wireless technology must be tested including updating and maintenance of technology
- The Product Family is available from the beginning of market introduction

Arenas: Where will we be active?

- Hi-fi Klubben in Denmark
- Hi-fi tests in magazines, online reviews, demo setups, fairs, press
- Dedicated web-page with elaborating concept description, pictures, and illustrations
- Setting up demonstration systems in interior and furniture retail stores hitting a potential mass market. The setup is a system solution playing background music showing its system potential. Furthermore, the design and appearance is suitable for showrooms
- A product catalogue is available for further information about the product (free to take)
- The targeted audience is "value identity" and "value for money", or a merging of these groups



Economical logic: How will we obtain our returns?

- Fewer revenues in the beginning of market introduction creating product and brand awareness about DALI in other arenas
- Difficult to match product in terms of price contra quality
- The product has higher costs in start-up production, manufacturing, marketing, maintenance, and is therefore an investment for DALI with certain risks

How will we get there?

- Make a cooperation agreement with selected interior furniture retail stores
- Joint venture concerning wireless technology and system setup programming
- In-sourcing of amplifier setup, modification and final implementation into the product

Differentiators: How will we win?

- The loudspeaker has amplification and wireless technology integrated minimizing the overall music equipment of the household
- It can play music in multiple rooms at the same time
- Small, elegant shape which suits many Danish contexts of use
- Integrated, new interaction with focus on users behavioural usage of the product
- Professional educated service personal at every Hi-fi Klubben retail store

Figure 88: The diamond is summarizing the material conducted in the Business Model Canvas with focus on the product and how it differs from the originally strategy diamond made in the Design Brief.

Marketing Material

The Product Report is an outcome of the conducted material from the strategy diamond and Business Canvas.

The Product Report is composed as a product catalogue with the purpose of enlighten and advertise about the new DALI product in new arenas of interior and retail stores on the Danish market (Danish written catalogue). Furthermore, the catalogue is conducted to introduce the concept of the loudspeaker with illustrative renderings and diagrams in different contexts of use to potential new costumers (mass market).

In the illustrations the right, the content of the catalogue is illustrated with explanations about what information is available at each page. All context pictures are from DALI's internally press intranet, which the project group has been allowed access to. On the back page, a URL named "www.dali-ellipse.com" is stated, and it is a webpage not operational at the moment. In relation to the strategy diamond in previous chapter, the loudspeaker has a dedicated web-page with further information about the concept. Throughout the catalogue, the written language is addressing costumer values instead of i.e. loudspeaker specifications. This is done in targeting the catalogue for the defined target groups.

Product name

The name of the loudspeaker is decided being "Ellipse". Ellipse is directly referring to its shape, and can hereby more easily be recognized by costumers compared to DALI's other product series names. In addition, the elliptic name is a symbolism of a unified integrated product where design and technology are merged together. In the following illustrations, several proposals are made whereas the final logo is used throughout the product catalogue.

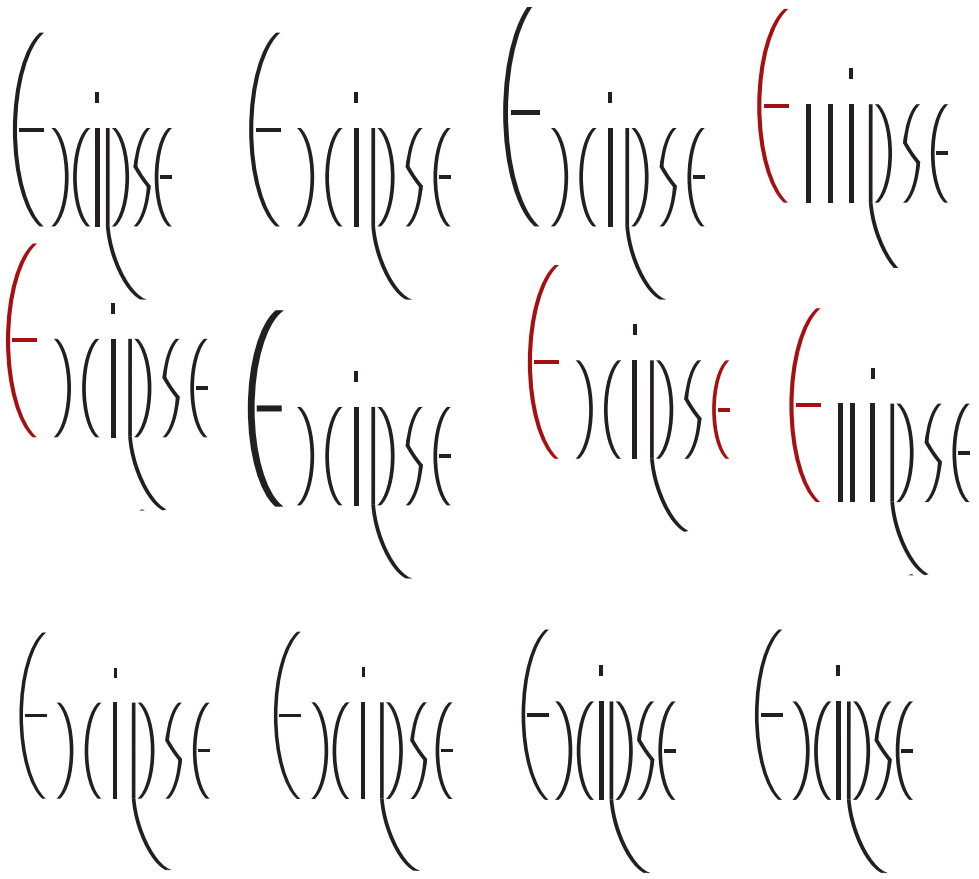


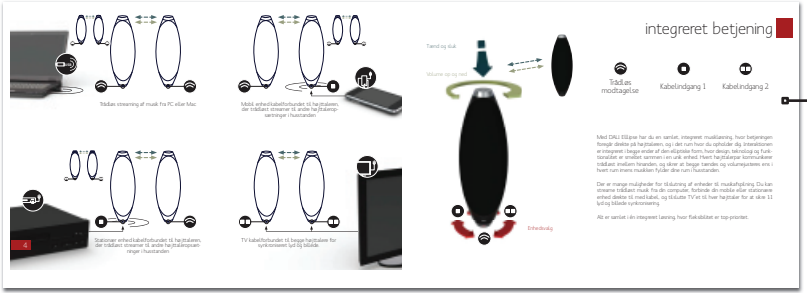
Figure 89: Different types of logo proposals.

Front page

- Product name "Ellipse" and DALI logo
- On-wall illustration of loudspeaker which is wireless connected to a laptop

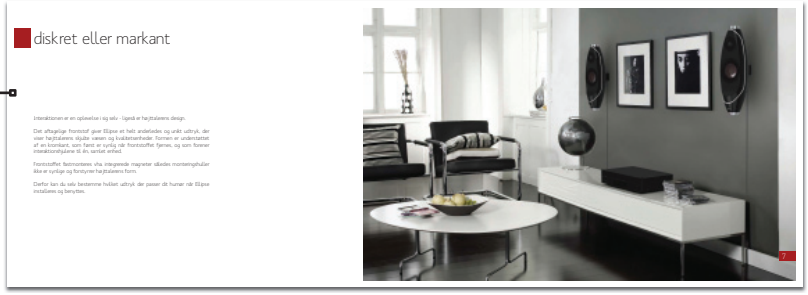
Spread 1 (lyd i alle rum)

- Multi-room product with introduction of colours symbolizing channel selection and source icons



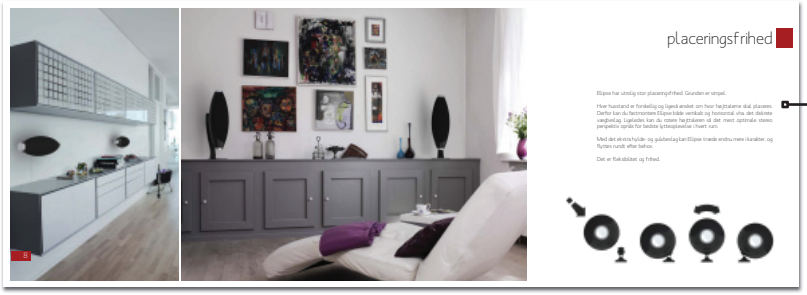
Spread 2 (integreret betjening)

- Illustrating interaction wheels and how they internally are connected
- Showing connection of sources



Spread 3 (diskret eller markant)

- The loudspeaker's design illustrated without front cloth

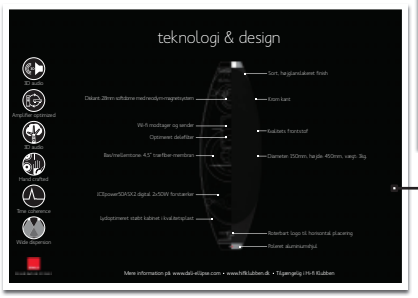


Spread 3 (placeringsfrihed)

- The flexibility in placement of the loudspeaker
- Rotation of loudspeaker on-wall

Spread 4 (produktprogram)

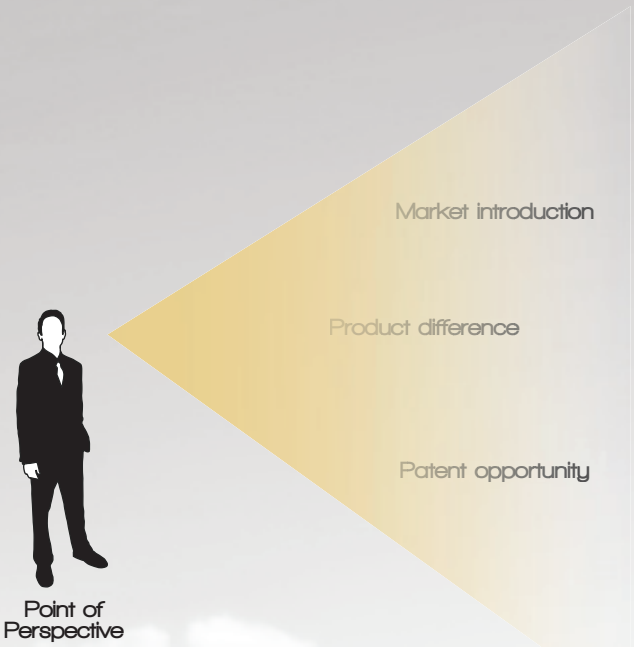
- All accessories available when purchasing the Ellipse loudspeaker



Back page (teknologi & design)

- Integrated product (teknology and design merged into a loudspeaker)
- Specification and further information

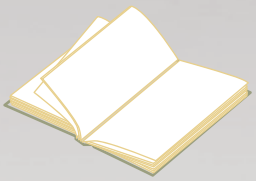
Figure 90: Product Report walk-through.



Output

- Market delay: 1-2 years
- Final prototype testing and calibration
- New market opportunity
- Utility model protection

Formalities



Books

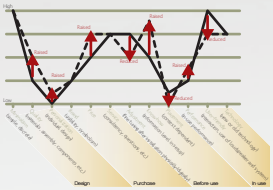
Articles

Learning objectives

Product development process

Collaboration with DALI

Reflection



Figures

DVD content

Output

- New knowledge in user research, loud-speaker construction, and collaboration with company
- Structured time and resource management
- Minimal professional feedback from DALI

http://www...

URL's

Litterature List

Figure 91: Formality chapter overview.

Point of Perspective

The loudspeaker is a system solution that operates in areas which is not within DALI's core competencies in their development department, but is also challenges strategic perspectives in DALI's organization. In this chapter are the market introduction, further development, product differentiation, and patent opportunity elaborated.

Market introduction

The product is not a typically DALI product due to its in-build amplifier, integrated interaction, and of course, wireless streaming of music.

Consequently, all these factors create many new unknown construction and technological challenges which need to be clarified before market introduction. Seen from a strategic perspective, the product is highly different and hereby questioning DALI's strategy. It is far more risky and has greater start-up costs because of the introduction of many new tools (e.g. injection moulding tools) and aggressive advertising. If the product proposal was manufactured using in-house production methods with minor start-up costs, the project had greater chance of faster market introduction.

It is evaluated that DALI is not eager to put this product into production, and it could become more interesting when DALI has greater knowledge about wireless streaming of music and technological issues when developing a complete system solution (DALI is at the moment seeking information in wireless technology). The time horizon described in the Design Brief is therefore expanded from immediately market introduction to 1-2 years. By providing marketing material (Product Report) and physical demonstration of the loudspeakers in furniture shops, the costumer awareness of 50% from the Design Brief is likely to succeed, and will also hit potential new customers. It will strengthen the costumers' awareness about DALI, which is one of the defined business objectives at project beginning.

Further development

The product needs several rounds of prototyping in testing the constructional challenges elaborated in "Phase 3 Reflection". Seen from a more objective perspective, the product needs to be tested in real-life scenarios where the interaction with the loudspeaker can be tested thoroughly.

The interaction is defined due to 2 user interviews, and needs testing where several users are interacting with the loudspeaker in different scenarios. This could be when having a party, listening to music during daily routines, and when the loudspeaker is being installed and moved around.

Another crucial issue is the question about interacting with a music system directly on the loudspeaker itself. It is not seen in many products, which differs this loudspeaker from others in the market. A discussion concerning patent opportunity is included in this chapter.

Before final prototyping and real-life testing, the internal components of the loudspeaker need to be defined with respect to the system setup. The system setup is delimited in the "Concept Detailing" Phase, and is an unknown factor, which can influence the functionality of the multi-room system. The wireless technology is available and functional, and several products (e.g. AudioPro's wireless streaming of music from a USB-dongle) justify the product's existence, but how the presetting electronically is constructed is out of the project group's competencies. This parameter is one of the first issues to address in further product development before finalizing the construction of the loudspeaker.

Product difference

In Phase 1, the scope of the project was defined using theory from Blue Ocean strategy resulting in a Strategy Canvas to summarize how the new product differences itself from other products in the market.

The developed loudspeaker does not revolutionize the loudspeaker industry in Denmark with creation of a clearly defined Blue Ocean. Instead, it defines a new market opportunity which is evaluated highly plausible in succeeding when introduced to the Danish market because of its many product differences. A new Strategy Canvas is made to illustrate the intended curve defined in Phase 1, and the evaluated curve illustrating the outcome of the project. The illustration can be seen to the right where the new product is the dotted line, and the intended Strategy Canvas is in solid black.

Mostly, the two curves do fit, but some criteria are raised or reduced in a negative form. For instance, the price is raised because of its many new in-build components. The loudspeaker could potentially hit a bigger market if the price of loudspeaker is reduced. Furthermore, the loudspeaker cannot digitally be fine tuned, and can only be adjusted physically by rotation. The level of know-how in setup is raised, which also is a negative consequence of the loudspeaker system setup. Ideally, the loudspeaker would automatically detect the system setup minimizing the level of information needed by users. This parameter can be different when final development of the electronics is finished. The level of user-friendliness is reduced be-

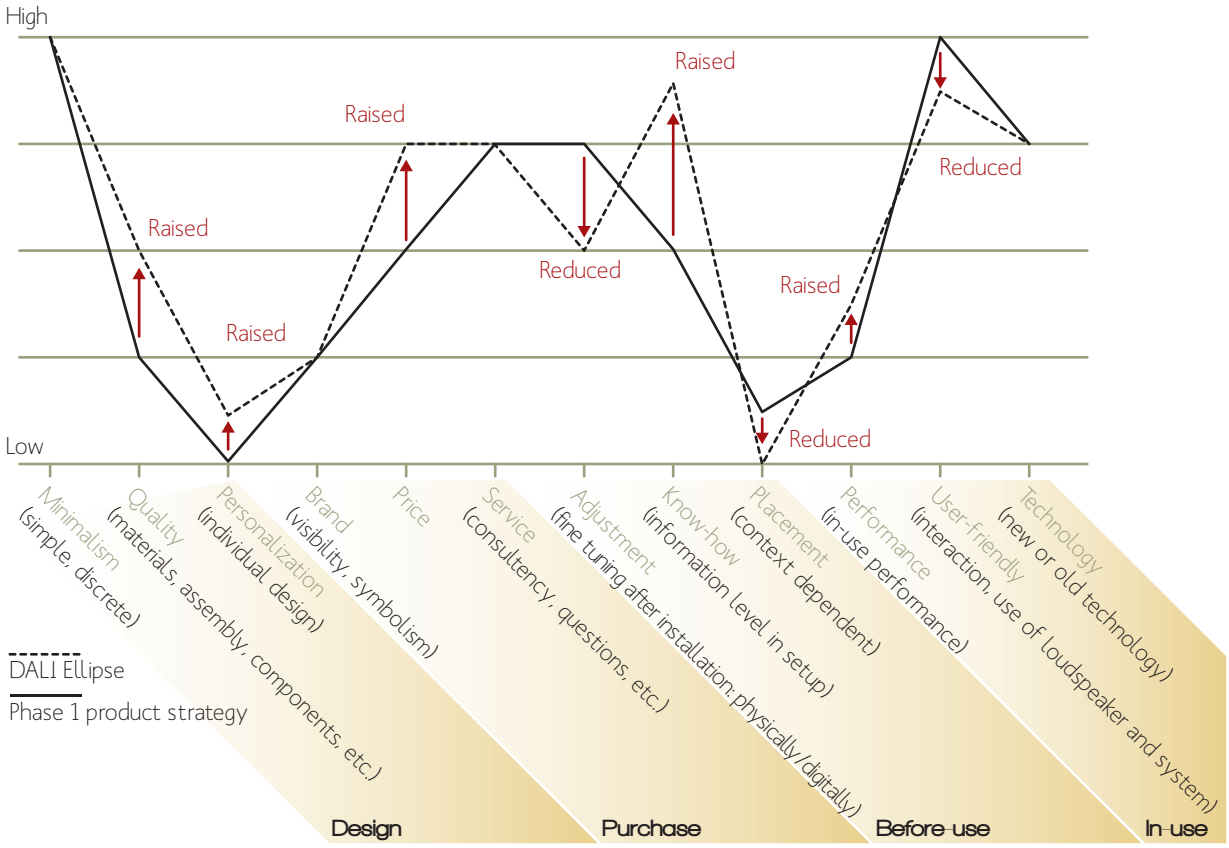


Figure 92: The defined product strategy from Phase 1 and its rating of parameters. The dotted line illustrates what is evaluated as achieved with the introduction of the new loudspeaker.

cause the loudspeaker cannot change a source's track or channel, and it must be done directly at the connected source. In addition, the Apple Airplay wireless module is not integrated, which could raise the level of user-friendliness by wireless streaming of music from Apple products.

Main differentiators

The positive outcome of the loudspeaker is the combination of all these features illustrated in the Strategy Canvas and the weighting of the parameters. Mainly, the product does have 2 features which are unique:

- An easy to use, quality performing multi-room solution with wireless transmitting and receiving of music to the entire household
- All-in-one product which is highly flexible in placement and in use suitable to many rooms in a Danish household

Patent opportunity

The loudspeaker is seen likely to be protected as a utility model instead of patent protected. There are no mechanism designed which is evaluated as a subject for a patent protection.

Instead, the integration of volume and source selection in the loudspeaker's design and idiom is seen as an option to protect by a utility model protection. The utility model has a maximum duration of 10 years, and the application must be registered at the Danish Patent and Trademark Office. It is a less expensive way of protecting the design (compared to patent application) *(dkpto.dk, 2011)*. The product name, Ellipse, can also be trademark registered.

Reflection

In order to sum-up the project, a reflection is made elaborating the learning objectives, collaboration with DALI, and the product development process facilitated in this project.

Learning objectives

The defined Design Brief was used as a platform for communication in-between DALI and the project group. In here, the learning objectives of the project are stated, which is partly about project group management and working as an external design consultancy within the field of designing loudspeakers in collaboration with a loudspeaker manufacture.

Time management and resources

The one-man project group has been a very challenging and exciting process because of demands for disposition of time and resources. As stated throughout the Process Report, main tasks needed being delimited, and are a natural consequence of limited resources. Seen from a personal perspective, it would have been beneficial working in a two-person group so the concept could have been explored more thoroughly. In here, further system setup testing with users would have been beneficial to test resulting in defining a specific system architecture. With that being said, the structuring of time and resources have been optimal with usage of a Gantt-scheme, weekly process update to DALI, discussion with supervisor, and a reflection chapter in the end of every phase.

The overall time management is visualized in the circular diagram below indicating the planned time management (faded), and the actual time management. In here, days are used as indicators, but it does not include used man-hours. In the end of the project period, the man-hours used each day are a lot higher than in the beginning of the project. Even though, the time planned and actual time used are closely related with minor diversity in time spend in the Phase 0 and Phase 4.

User research

A main part of the project was to facilitate user research including data extraction in defining the scope of the problem and focus of project. The reason was simple: the loudspeaker market is a very red ocean with many products with minor diversity in features and appearances. The user research gave valuable inspiration and insight in users' musical behaviour. It directly resulted in the development of an integrated, user-friendly interaction with focus on being very simple in use. The simplicity was without doubt highlighted throughout the interviews, and an important parameter to integrate into the concept.

The initial user research was part one of the user-centred design approach. Furthermore, the users were contacted to discuss the idiom and interaction of the loudspeaker. Unfortunately, only 2 users did participate, and a dedicated focus group could not be facilitated as planned. Instead, situated interviews were used, and gave insights for further concept finalization before entering the "Construction Detailing" Phase. Ideally another round of user-involvement could test the final product proposal and its in-build functions. This is an important issue to explore in further development of the loudspeaker.

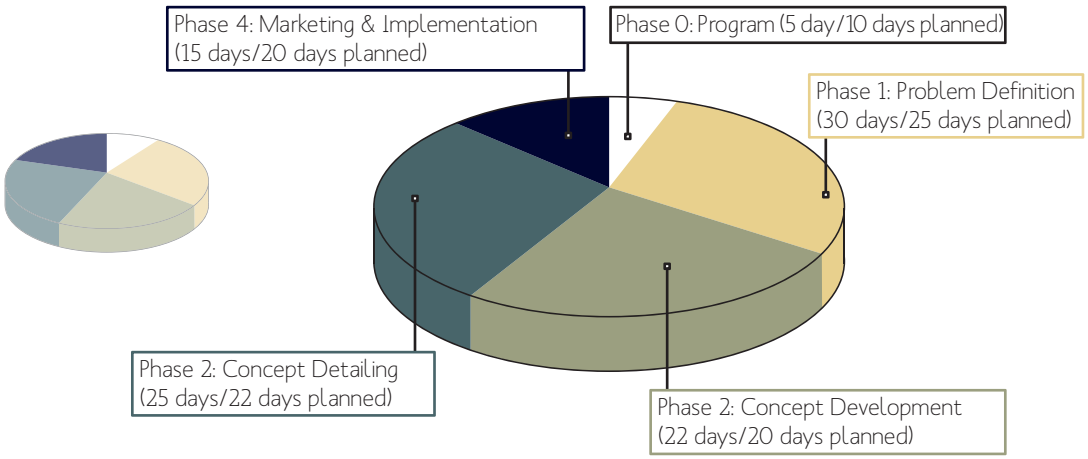


Figure 93: Days used / days planned

Loudspeaker construction

The project group had minor experience in loudspeaker development before project beginning, and wanted to gain experience in how to construct a loudspeaker with respect to its performance. Loudspeaker construction is a very specific area of product design, and is highly influenced by mechanical, electronic, and acoustical engineers working together in a team.

During a three-day period, the project group had the opportunity of working at DALI, and experienced that the shape of the loudspeaker had no directly influence on its performance with reference to the elliptic shape. Acoustical engineers mainly work with calibration software to test and design the crossover. Furthermore, the cabinet's material, volume, and internally damping material have all great influence, which is difficult to simulate using computer software before final prototyping. Therefore, it is a crucial step in designing a loudspeaker to test and calibrate the crossover with the defined cabinet's size and material. In order to gain knowledge in this specific area, the concept of the loudspeaker must be fully defined, and the loudspeaker can from this point of departure be finally calibrated. The wall thickness of the cabinet is normally thick because of DALI is primary using wood cabinets (up to 18mm medium-density fibreboard). In the newly launched loudspeaker series, Motif, the cabinet material is replaced by aluminium, which has a wall thickness of 4mm. It is a relatively thick wall size for aluminium parts, but is determined due to tests, experience, and the demand of a stiff solid cabinet. In addition, the selected wall thickness for the Ellipse loudspeaker of 3mm in plastic must hereby be tested before final implementation.

The distance in-between tweeter dome and bass driver is important, and is maintained from the existing Lektor 1 loudspeaker. It can furthermore be calibrated by an acoustical engineer when redesigning the crossover for the new loudspeaker.

Collaboration with DALI

The professional feedback from DALI has been at minimum level, and may be influenced by the following aspects:

- The project group was mainly working at AAU, and not physically placed at DALI's headquarter in Nørager
- The project group's main contact person at DALI, Mads Møller, has limited resources and time in giving professional feedback about construction of the loudspeaker due to his own agenda
- Strategically and economical aspects cannot be elaborated by DALI due to restrictions and concealment of internal information

Process logbook

A process logbook has been used throughout the project in updating DALI about the progress of the project. It has been beneficial for the project group to reflect upon the process every weekend, and use it as basis in planning the following week to come. DALI has expressed positive thoughts about its easy, communicating form. Ideally, the process logbook could be further developed in being a communication platform in-between the project group and company by providing professional feedback. The logbook has only functioned as a one-way communication, and will in another project be designed differently with the mentioned aspects in mind.

Product development process

The product development process is mainly derived from the process model presented in theory from Ulrich & Eppinger. The model has been used in previous projects, and was modified due to a higher level of user-involvement. Both theory from Chayutsahakij about user-centred design and Blue Ocean Strategy have given the project group new knowledge in how to define and focus a project using different types of tools (etc. Strategy Canvas, and KJ Method for data extraction).

Prior to the project beginning, a project was normally defined from a market perspective by analysing for instance competitors, the market, trends, and technologies using tools like PEST-analysis and Value-chain mapping. This project and its process have provided valuable tools and knowledge about user-centred design and the importance of seeing problems from the user's perspective. Also, interviewing techniques and data extraction method have been used, and can be facilitated in projects to come.

To sum-up the entire process, the project has been interesting, demanding, and most of all, a challenging task of structuring and developing a loudspeaker in a one-man group with limited time and resources available. Even though, the project group is extremely pleased about the final result in terms of the design and functionality of the loudspeaker, but also the process of how the loudspeaker is constructed with user-involvement in seeking a new and different product proposal.

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Figure 26: EBTB - Venus
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Figure 27: SCANDYNA Minipod Mk2
Source: "http://press.scandyna-speakers.com/download/press/minipod/download/mini _ 45 _ blue.zip" - 02.03.2011

Figure 28 to 57
Source: Own illustrations

Figure 58: DALI's Lektor 1 loudspeaker:
Source: "http://www.avreview.co.uk/news/images/Dali _ Lektor _ 1 _ big.jpg" - 05.05.2011

Figure 59
Source Own illustration