The Papason Project

Edwin Modin & Sebastian Wicksell
The initial objective with our project was to develop a product that would evoke the feeling of fulfillment by having created something yourself. Our project resulted in a customizable speaker kit that the user assembles with simple tools which leads to a speaker that is portable and wireless, with a price tag of around 4000 SEK. The result evolved through various sound and material tests. Due to the shape, sound quality and manufacturing capacity, the best option was to cast the prototype in a composite of polymer resin and filler material. The prototype was casted in molds created by manual and CNC machining. The Papason speaker is a product that, when assembled, is comparable to the high end brands on the market today, regarding design and quality. Furthermore, the user will experience a closer relationship to the product due to the invested time and personification.
# Table of Contents

## INTRODUCTION
- Background 8
- Motivation 10
- Brief 12
- Papason Experience 14
- Choice of product 16

## PROCESS
### Research
- History 20
- Trend 22
- Existing market 24
- Build kit 28
- Survey 30
- Final brief 32
- Scenario 34
- Complexity 36
- Function analysis 38
- Our product 40

### Exploration
- Types of speakers 44
- Components 46
- Electronics 48
- Material 54
- Test boxes 56

### Discovery
- Moodboard 74
- Form exploration 76
- Detail design 86
- One button solution 92

## RESULT
### Final design
- Prototype build 98
- Manufacturing 108

### Final prototype
- Dimensions 130
- Customize, Assemble, Enjoy 142

### Discussion
- 152

### References
- 154
Before the official start we knew that working together would be both beneficial for the project and for our personal development. We have been working together before and therefore know each other’s strengths and weaknesses. We also had similar goals and ambitions for the Bachelor’s project, for instance we wanted to do something that would end up with a product that could be manufactured in small scale by ourselves and with low effort scale up the production. We did simply not want to do something conceptual, but rather a product where manufacturing methods, materials and details are closely considered. We both have an interest in technology and machines so we wanted a project where we could use our knowledge and interest as a statement for what kind of designers we want to be.
Motivation

We are currently living in a society that encourages the citizens to consume and to have an unhealthy habit of throwaway thinking. Instead of having a deeper relationship to products like we used to, we buy, wear and throw products in a shorter lifespan than necessary, thus creating a wasteful cycle of consumerism. In our project we wanted to change this behavior and at the same time encourage people to get knowledge of hands-on experience and being able to restore something instead of throwing it away.
How can we evoke the feeling of creating something yourself, yet using the simple and enjoyable process of a high end product?
What is the Papason experience?

The main mission with the project was to work with the fantastic feeling of having completed a creation. Not only the result but the whole process of creating and the knowledge you can gain on the way. Our goal was then to find a way to design a product in such way that this feeling would be evoked. The name Papason comes from a misunderstanding in our communication during the project, but the name Papason stuck. The word comes from father and son (pappa & son) and we where talking about the Father and son experience and the bond they can share. This is of course not limited to the relationship between father and son but can also include mother and son and the opposite. The experience and bond could still be the same and equally strong. The idea with our product is that anybody should be able to experience this feeling, either as an activity with someone or alone.
With the goal of creating a product that the user would assemble oneself we analyzed a broad spectrum of potential products that would be suitable for this project. We felt that home electronics is an area of products that are greatly affected by the negative sides of consumerism. With the tradition of releasing new products as soon as new technology is discovered, consumers tend to buy similar products before the old ones lifespan is depleted. We felt that in order to reach a large target group we had to choose a product with the appropriate size so it could easily be transported and assembled in one’s home. It would also give us an opportunity for us to work extensively and detailed with the form development. Furthermore, it should be something that most people can relate to and are used to interact with.

We chose to work further with the concept of creating something new on the cluttered market of speakers. A speaker is a product that most people can relate to and is widely available in electronic stores. People are moved by music and that gave us an opportunity to work deeper with the experience and interaction with music. We also saw that it was a great product but not the only one to test our new concept of consuming products on. Lastly, it is a product that with the right ambition could provide a decent challenge and opportunity for us to test our technical and design skills.
Research
When we started to listen to recorded music there was just one mono unit that filled the room with sound. As technology advanced the music format became digital and sound systems grew larger and larger and took a bigger part of people’s homes. The trend today is that we have gone back to the smaller single units, the modern gramophone. With the technology we have today most people connect wirelessly with their smartphone/tablet or PC and stream their music directly to the speaker. Some people still have big high-end stereo sound systems, although the majority of people have one wireless unit that works in every room. We want to focus on the segment of the market and therefore we decided to make a single unit speaker.
Our market research was conducted with field trips to electronic stores and a survey asking how people interact with music helped us in identifying two different types of speakers that we saw people buying.
The first speaker type is a smaller portable unit, this is the one you would bring to the beach and later use in the kitchen while cooking. It is small and portable but therefore also lacking in sound quality and sound pressure. Usually people complement this speaker with a bigger sound system in one’s home.
The second type is speaker is still somewhat portable but bigger and therefore potentially much better in sound quality and sound pressure, which should be able to fill a big living room with music. This is the type of speaker that you would have standing stationary in your living room but also be able to bring outside on the terrace for a BBQ. Since we wanted to make a high quality product that is enjoyable to have in a home, this is the type of speaker we chose to create.
The majority of the existing speaker building kits looks similar to what you see on the picture to the right. They are difficult to assemble and sometimes requires precision tools, in most cases the result is not a professional look. We analyzed what steps of the assembly process we could simplify in order to achieve a higher quality end product.
We conducted a survey of how people interact with music in their homes. This was helpful for us in order to identify what type of speaker people are using today and what types of functions they would appreciate in a new model. It also made us realize that the customization aspect was important in order for people to specify a look that would either blend in with their environment or pop out.
Design and create a speaker build kit that lets the user personalize and assemble without a compromise in quality and appearance.
The intended user scenario is an almost endless cyclic process. The idea is that any consumer that wants to buy a new speaker can visit an intuitive website, where one would be presented with either the option to choose from a number of preset designs or use the presets as a base for customizing and choosing between materials and colors of different parts on the speaker. Later on the speaker will be delivered home in a smart package and with the help of simple tools that most people have (or a toolkit ordered with the speaker) the speaker can be assembled either as an opportunity of learning or simply as an practice in a hands-on experience. When the speaker is assembled one can enjoy it as any other high end speaker on the market but with a unique and personal touch. When new technology becomes available or a part breaks, the user can go to the website again in order to buy new components and, when delivered, return the old ones for recycling. The user will hopefully have learned enough from the building process to identify broken parts, or else go to the website and easily get help with troubleshooting.
One of the essential tasks in our project was to determine at what level of complexity the assembly process of the speaker would be. We had to find a balance where the user would still feel that they have created something themselves and not only assembled the speaker. If the process would have been too simple, the feeling of creating would have diminished and instead become a demanding and unnecessary task for the user in order to obtain a functioning product. Instead we wanted it to be fairly simple for anyone with interest to assemble and not get scared of the process. With additional complexity the learning curve would have been too steep for our target group. It would also require special tools that most people are not willing to spend money on, nor time learning to use. Therefore we chose to put the complexity level where it would be an advantage for someone with some technical skills but a fully possible learning process for someone with less knowledge.
Function Analysis

Main function  MF
Need  N
Desirable D
Unnecessary U

Function

- Produce sound  MF
- Feel creative  N
- Allow portability  N
- Offer wireless connectivity  D
- Be modular  N
- Be stable  N
- Intuitive usage  N
- Blend in home environment  D
- Offer charging  D

Usage

- Easy connection  N
- Offer On/off control  N
- Battery indicator  D
- Offer volume control  U
- Offer motion controls  U
- Offer touch controls  U
- Offer physical controls  N
- Play/pause controls  U
- Offer On/off indicator  N
- Handle for carrying  D
- Occupy small surface area  D

Form

- Express quality  N
- Express durability  N
- Express simplicity  D
- Emphasize details  D
- Express professionalism  D
- Express mobility  D
Based on the background and our concept combined with our research, we decided on the following demarcations that would shape the creation of our speaker.

- Price range 2-4000 SEK
- Enough volume and quality to fill a living room (<30 m²)
- Visually customizable for the user to blend in or pop out in one’s home
- Allow for easy upgrades in the electronics
- Portable and wireless
- Enjoyable and easy assembly
- Express a high quality end finish for longer lifespan
Exploration
On the right you can find the most commonly used types of speaker enclosures. An enclosure for the speaker drivers are necessary in order to get the required output level. The horn enclosures are usually used in bigger sound systems to yield a higher SPL (Sound Pressure Level), due to the size this type of enclosure was not suitable for our speaker. The most commonly used type for our size and application is a box with a passive radiator, in our case that would require a special made passive radiator and since we could not make or buy this for our prototype we excluded this option. Then we have the sealed and vented enclosure left to choose from and since a vented enclosure outputs a higher SPL with the same input, but requires a slightly larger enclosure we saw it as the best option and an acceptable compromise in size.

**Sealed**
- Pros: Small volume, easy to make
- Cons: Low output

**Vented**
- Pros: High output
- Cons: Larger volume

**Horn**
- Pros: Highest output
- Cons: Largest volume

**Passive radiator**
- Pros: Same output as vented but less volume
- Cons: Complex, custom components
To be able to fully understand how we would design and create our speaker, we needed knowledge about the required components. Since we wanted to make a portable wireless speaker, these are the needed parts.
To be able to transfer the signals from the playback device to the DSP and amplifier we need either a wired or wireless solution. We chose Bluetooth in the end.

Connection

The playback device is where you store/stream and playback your music from. This can either be a smartphone/tablet or a PC.

DSP

The Digital signal processing unit converts and alters the signal between the playback device and the amplifier. The DSP lets you filter the signal so the correct driver outputs the right frequencies.

Amplifier

An analog signal is sent from the DSP to the amplifier. The amplifier amplifies the analog signal to the drivers. We chose to use a class-D amplifier since this is the most energy effective class on the market.

Drivers

A speaker driver is an individual transducer that converts electrical energy to sound waves. Since we wanted to make a working product we had to limit us in what’s available on the DIY market.

Power source

To deliver power to the speakers we have two options: either battery or power converter. With the power converter we simply need to convert mains voltage to the specific voltage of the system. For battery there are a few options to choose between. But we chose to use 18650 cells, this has the highest density energy/weight, and Tesla cars use the same type of cells.
### Bluetooth

Bluetooth is the most common way to connect to wireless speakers, mainly because its compatible with most devices. The connection sequence is very simple and the bluetooth module is the most energy efficient of the wireless ones. Bluetooth has a shorter range than WiFi but is still able to reach up to 25 meters.

- Works with any bluetooth compatible device
- Simple connection script
- Energy efficient
- Shorter range than WiFi
- Plays all system sounds

### WiFi

WiFi has the highest connection speed and delivers the best quality sound, it is a great solution if you have a home network and many speakers to connect. The setup process can be complex, especially if you have different units that should be connected. There are yet no solutions for both Android and iPhone available.

- Long range
- Network connection
- High audio quality
- Complex setup process
- No universal solution for every WiFi device

### Auxiliary (AUX)

AUX inputs have been the market standard for over 40 years and are still available in products. You simply connect a cord that transfers the analog signal and delivers high quality sound and is a foolproof connection.

- Easy connection
- Foolproof
- Cord (not wireless)
Our test setup includes a MiniDSP and two D-class amplifiers. These products are available on the market and were a good fit during our tests. However, in our end product, we are unable to use this setup due to price (1400 Kr) and size. We therefore decided to develop a custom solution that would allow us to reduce the price and size but also to create a modular system that lets the user assemble and upgrade the electronics. This custom solution needed to contain a Bluetooth module, a DSP, and an amplifier.
The most suitable material for a speaker is somewhat subjective since it determines what characteristics the sound gets. But preferably it is a material that is sonically “dead” meaning that the enclosure is not attributing to any resonances. We had to find a material that would both fit the specifications regarding acoustics, manufacturing and aesthetics. The optimal material we found was acrylic composite. It is a recyclable material that is great for acoustics, available in either machinable sheets or as a casting process and available in many different surface finishes and colors. It is mostly used in counter tops and bathtubs.
Since the sound quality and characteristics of a speaker is not only subjective but also measurable, we decided to use an acoustically sealed measurement chamber at LTH. Here we brought the different test boxes, electronics and drivers to back up our preliminary decisions regarding internal volume, driver size and quantity.
• 2 Dayton ND91 Full range drivers
• Vented - Pipe
• 6 liter internal volume
• 180x250x150 mm
• 4 Dayton ND91 Full range drivers
• 2 Dayton ND16 Dome Tweeter
• Vented - Pipe
• 8 liter internal volume
• 350x350x160 mm
- 4 Dayton ND91 Full range drivers
- 2 Dayton ND16 Dome Tweeter
- Vented - Pipe
- 8 liter internal volume
- 350x350x160 mm
- Facing drivers
• 2 Dayton ND105 Full range drivers
• 2 FaitalPRO 3FE22 Full range drivers
• Vented - Pipe
• 10 liter internal volume
• 350x350x160 mm
• Facing drivers
• 2 Dayton ND105 Full range drivers
• 2 FaitalPRO 3FE22 Full range drivers
• Vented - Slot port
• 10 liter internal volume
• 350x350x160 mm
• Facing drivers
- 2 Dayton ND105 Full range drivers
- 2 FaitalPRO 3FE22 Full range drivers
- Vented - Holes
- 12 liter internal volume
- 350x350x160 mm
- Facing drivers
With the professional sound measurements of different enclosures and volumes, combined with listening to the test boxes in different sized environments, we were able to decide the size of the speaker needed to achieve the required SPL and sound quality. This also helped us in selecting the right drivers and appropriate electronics.

Internal volume: 12 liter
Drivers: 2 bass/low midrange 4 in drivers, 2 treble/midrange 3.5 in drivers
Discovery
We established a mood board of the form we wanted to create combined with describing words. This was a tool to inspire and to get the feel of what we wanted to create. We wanted to create a minimalistic and timeless form that could fit in most home environments and be customizable.
Limitations
- 10 liter internal volume
- Production
- Easy to open

Considerations
- On/off button
- Charging port
- Carrying feature
- Feet
Rather than continuing sketching different forms, we decided to make foam variations to determine the right shape of the design. This also allowed us to get more constructive feedback when consulting with colleagues.

Ultimately we decided on a flat standing tapered cylindrical shape. This was a decision based on the requirements we had from previous research like internal volume and driver placement. Further on the shape expresses a simple but yet an interesting form language that had the opportunity to be tweaked and refined. We saw that a speaker with this shape would be unique in its appearance compared to traditional and existing speakers on the market. Although the volume is quite large, the shape with the right treatments allows for a light and clean look that can blend in with the environment.
Wierd flat surface

Sharp edge

Bowl like

To big chamfer

Good size chamfer
Final shape to refine

Curved back

Flat front to mount drivers

Tapered for slimmer look
User Customization
Natural look

Small contact point

Floating

Unstable look

Too thin, finger like

Unstable

Bulky
Handle

7kg weight test

Balanced

Stable

Unstable
In the beginning we tried out different designs where we had power and volume buttons. We saw directly that the option for us was to place the buttons on top of the speaker since we didn’t wanted to disturb the front neither making it inconvenient to reach. Although this concept changed due to our one button solution.
In order to make the interaction experience effortless and simple, we decided to remove all clutter, and introduce a **one button solution**. Since both playback and volume control are always present in your playback device, we decided to exclude this in a physical form. For the user to be able to move around freely in the room, yet still have full control over the speaker’s functions, we again concluded that the physical buttons were not needed. The Bluetooth technology makes it possible for your playback device to pair with the speaker instantly after power on, and use the built-in controls that are needed for the best user experience.
After deciding to go for a one button solution the placement of the button was tested on the full scale mock-up. After placing the handle more in the center of gravity to make it more convenient to carry we made four different placement options. As a result of discussing with colleagues we decided upon a placement that felt natural to reach. It was connected to the handle but not disturbing when carrying.
Since we wanted all interaction with the speaker to be an intuitive and simple process we wanted to make the charging action to be just that. To do that we established a mood-board that made us aware of what was on the market and what could be done.
Final Design
USER CUSTOMIZABLE

NON CHANGEABLE COMPONENTS
Customization examples
We started by laminating poplar wood planks to make a bigger block. This was later machined and used to make the shell mold.

In order to use different machines and still keep the piece aligned, we had to create a steel holder that was placed in the rotational center of the wooden piece.
We then had to machine the raw material to the chosen diameter. This was done manually in a lathe.

The next step was to use a CNC mill to make the domed backside. We had to use both manual and CNC machining due to different limitations of the machines. CNC machining would have been preferred through the whole process.

During the machining we also embedded magnets at the position of the legs, handle and power button.
After the first shape we realized that moist resistant MDF was a more suitable material for the plug due to its homogeneous structure. Here again we created a steel holder and used a combination of different machines and strategies to create the advanced shape.
The negative shape from the chamfer was turned from a sheet of MDF glued together with the plug. We also drilled eight holes for the screw inserts that needed to align perfectly with the cutouts which would later form the ribs on the inside of the speaker.

In order to get the finish we wanted on the final model it was very important to get a perfect surface on the plugs, which was done with several layers of spray paint.
We then covered the poplar plug with gel coat and glass fiber to create the shell for the final mold. 24 hours later the shell was cured and could be released from the poplar plug.

A critical task here was also to embed new magnets within the glass fiber that aligned with the ones in the wooden plug.
Both the plug and the shell were first coated with four layers of wax, then one layer of PVA release agent. Both the magnetic inserts and the inserts for the screws were attached and the shell was mounted over the plug.

We used clamps to secure the shell and plug, and then poured the composite resin through the pipe that strategically formed the hole for the charging connector. This resulted in a two part mold with an invisible split line and plugs that released easily during the demould.
Both the magnetic charging connector and the legs were done manually in the lathe. The spacers for the legs were 3D-printed due to limitation of the CNC machines.
The front panel was CNC-milled from a sheet of acrylic composite and the mesh was lasercut out of acrylic and later covered with fabric.

The PCBs were designed by us and later sent to a PCB manufacturer. They were assembled by us and mounted with the rest of the electronics on the front panel.
From the beginning of the project our goal was to create a product as ready for production as possible. By setting such a goal the manufacturing process needed to be considered during the whole process. Form, details and components had to be designed carefully for it to work together. With the chosen shape we saw an opportunity to cast the main body in one piece. This gave us a good surface finish, allowed us to use a wide range of materials and is a good solution when scaling up the production. The smaller parts are rotation symmetrical and can be made easily with a CNC lathe.
Final Prototype

The following pages contains pictures of the fully working prototype.
Customize
Assemble
Enjoy
After customizing online, receiving the parts and assembling, Papason can be enjoyed as any high-end speaker on the market today. With the customization the user is able to create one’s own style to fit their home and personality.
We had a goal from the beginning to develop a working prototype that would be easy to reproduce in small scale and also easy to produce in a bigger scale. We are happy with the outcome of the project and have now a working model. There are a few details that we feel could be developed further, and if we had more time we would have done so. We have all the components but the charging solution needs to be refined and evaluated before going into production. We could also work more with the modular electronics and make a more refined and user friendly solution, what we have now is working but not optimal. In the end we developed a product that in our minds have the perfect balance between the form, design and technology. It was important for us to do a project that would challenge us thru the whole process but at the same time be manageable. We had a schedule from the beginning and divided the work equally. Some parts took longer than expected but since we had planned in extra time all went well. And in the end we are both happy with the knowledge we have gained during this time and our product: The first high end speaker build kit.

Papason.