

Re-design for Sustainability: USB Speaker

- TUTOR:
- DAVID MORRISON-LOVE
- 2345063M
- 2463524H
- 2387527G
- 2509621O

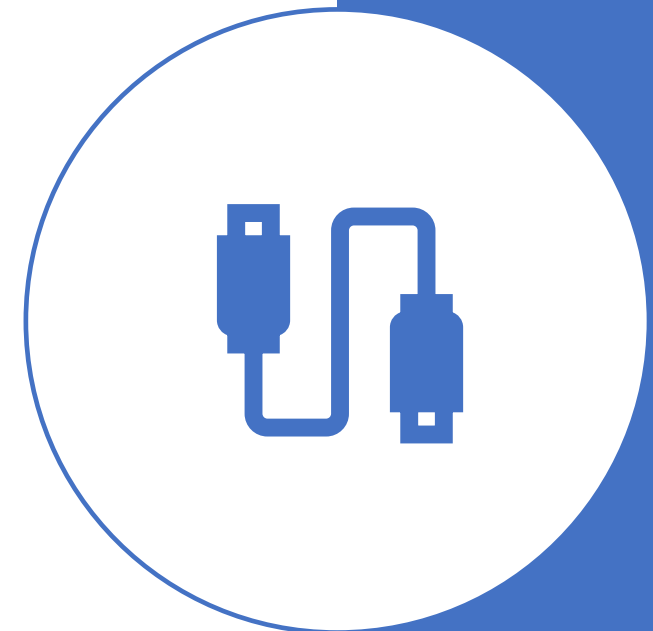


Table of Contents

- Page 3: Project Schedule.
- Page 4: Design Specification/ SWOT Analysis.
- Page 5: Design Evaluation.
- Page 6: Identifying Customer Needs.
- Page 7-8: Idea Development (Idea Generation).
- Page 9: Idea Development (SCAMPER).
- Page 10: Material and Form Product Psychology Research.
- Page 11: User Trial
- Page 12: Material Document.
- Page 13: Engineering Bill of Materials.
- Page 14: Product Pricing.
- Page 15: Electro Technical Document.
- Page 16: Design Justification.
- Page 17: Technical CAD Drawings.
- Page 18: Final Marker Pen render.
- Page 19: Bibliography

PHASE 2: DEVELOPMENT AND MANUFACTURE.

PROJECT SCHEDULE MATRIX.

Analysis of final concept designs. SWOT analysis Weighted objectives matrix and radar chart.	Prototype 1: Block/Scale Models: Minimalistic Prototype.	17 March: Iterative Development Cycle 2 - Start.	Evaluation: questionnaires, focus groups, user trials, test rigs. (User research cycle) Prototype 2.	3 April: Start Finalisation.
Establishment of the final design idea.	User Research: Identifying Customer Needs.		Material EBOM.	
Refined Design spec and vision statement.	Prototype 2: Concept 3D CAD model with hanger.			Technical Orthographic CAD drawing + Exploded Views, partial enlargements, sectional views.
SCAMPER – Concept Development.	Form and shape user trials.	Prototype 3: Concept 3D CAD model with stand.	Product Pricing.	Final 3D Textured Render. Bonus: Working animation.
1. February: Iterative Development Cycle 1 - Start.	Material Research.	Evaluation: questionnaires, focus groups, user trials, test rigs. (User research cycle) Prototype 1.	3D Inner Rig of final prototype.	Final Marker Pen Render on Paper.

Design Specification

Vision Statement

Our vision is to design a desktop speaker which will improve aspects of product quality and user experience whilst, using principles and approaches of sustainable product development.

Design Specification

Target User:

- 1.1 Frequent users.
- 1.2 Infrequent users.
- 1.3 Optimized for home and office users.

Function:

- 2.1 Speaker must maintain at least the same quality audio output as the Hama speakers.
- 2.2 Must be a freestanding USB/desktop speaker.

Aesthetics:

- 3.1 Contemporary/fashionable appearance that appeals to target user.
- 3.2 Must have less than 4 different colors.
- 3.3 Minimalistic – Nice to look at appearance.
- 3.4 The design should have a unique appearance and stand out in the market.

Ergonomics:

- 4.1 Must be able to fit on an ordinary office table without taking up more than 15 - 20% of the space.
- 4.2 Maximum 5 buttons for easy usability.

Environmental Considerations:

- 5.1 Sustainable in design.
- 5.2 Increased product lifecycle.
- 5.3 Majority of components must have upcycling features.

Materials/Manufacturing:

- 6.1 Must show durability improvements.
- 6.2 Sustainable materials with the aim of 0-10% waste.
- 6.3 Easy for assembly and disassembly (Bosses and screws etc).

Cost:

- 7.1 The design, material and production cost should not outweigh the total resale profit.
- 7.2 The cost should allow for a profit margin of at least 20%.

Safety:

- 8.1 Product should have no sharp edges.
- 8.2 Electronics should be contained within casing.

SWOT Analysis

SWOT analysis is a useful strategy for identifying strengths, weaknesses, opportunities, and threats when creating a new product. As a group, we evaluated each other's speakers to further understand which speaker we will be taking forward.

Design 2345063M

Strengths

- Compact design style will utilise desk space
- Controls are assessable and easy to use for the user.
- Angled body with environmentally friendly materials.
- Variety of possibilities of usage i.e., speaker, decorative feature.

Weaknesses

- Sound quality.
- Size and shape of the design may be hard to re-assemble and disassemble.
- Cork material on the body of the speaker may not be suitable.

Opportunities

- Scope for development in terms of design features placement of the dial and accessibility of the internal parts.
- Additional features/ secondary functions.
- Exploration on the other environmental materials.
- Manufacturing methods most suitable.

Threats

- Cork may cause issues with the quality of sound and weight.
- Material may be hard to source and assemble.

Design 2509612O

Strengths

- Beneficial environmental sustainability features of materials proposed.

Weaknesses

- High quality materials will result in increasing the retail price which could demotivate general home/office users from buying.

Opportunities

- Could open new market niches such as office users which need speakers in a professional audio office.

Threats

- Size reaches the limit of the brief which could cause potential threat when users have smaller tables to work with at home or in the office.

Design 2387527G

Strengths

- Sophisticated appearance allows it to fit into most living rooms.
- Saves shelf or desk space if hanging under shelf.
- Secondary function provides unique selling point.
- Rounded shape with little dust traps will be easy to clean.

Weaknesses

- Curved wooden shape could be expensive to manufacture.
- Some users may find the design old fashioned.
- Wires might cause issues if the speaker is hanging from shelf.

Opportunities

- Different colour scheme and materials could be used to make the speaker more modern.
- In depth analysis of sound created could lead to better sound quality
- Clamping system to shelf could be simplified or alternative attaching method found.

Threats

- Retro styled products could go out of fashion.
- Users may find secondary function unneeded or complicated.

Design 2463524H

Strengths

- Sleek and modern design.
- Original Design.
- Eye-catching colour scheme.

Weaknesses

- Quality of sound.
- Not multifunctional.

Opportunities

- Enter a niche the niche market of office speakers.

Threats

- No demand for such a speaker.
- Struggle to make it to universal standards.

Design Evaluations

Weighted Objective Table

A Weighted Objective Table is used to compare and rank several different aspects of a design. We first had to weight each aspect based on the importance based on how-well it fulfils the design brief. When weighting the objectives we decided as a group to give environmental sustainability and maintenance the highest value, we decided this as we wanted the design we took forward to be ecological just as the brief desired.

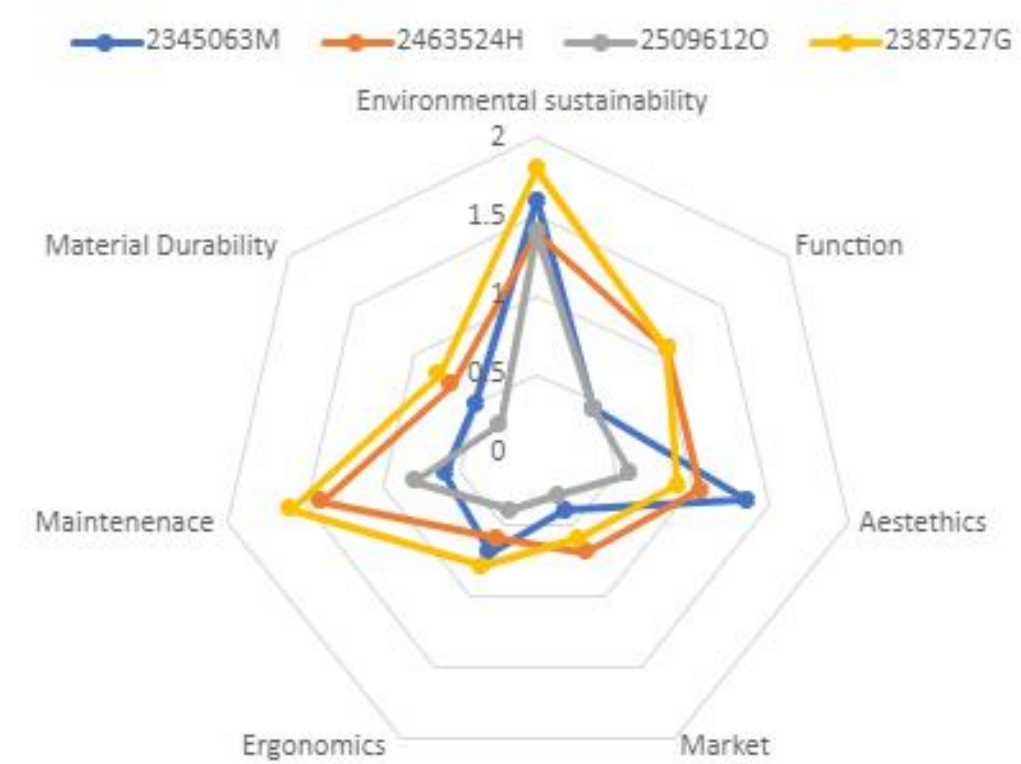
		2345063		2463524		2509612		2387527	
		M		H		O		G	
Relevant design factors identified.	Weight-ing	Score	Utility	Score	Utility	Score	Utility	Score	Utility
Environmental sustainability	0.2	8	1.6	7	1.4	7	1.4	9	1.8
Function	0.15	3	0.45	7	1.05	3	0.45	7	1.05
Aesthetics	0.15	9	1.35	7	1.05	4	0.6	6	0.9
Market	0.1	4	0.4	7	0.7	3	0.3	6	0.6
Ergonomics	0.1	7	0.7	6	0.6	4	0.4	8	0.8
Maintenance	0.2	3	0.6	7	1.4	4	0.8	8	1.6
Material Durability	0.1	5	0.5	7	0.7	3	0.3	8	0.8
Total Utility			5.6		6.9		4.25		7.55

- **Scoring Key:** Very good – 10/9, Good – 8/7, Satisfactory – 6/5, Poor – 4/3, Very Poor – 2/1.
- **Utility** = Weighting x Score.

Results

As shown above, Design 238727G scored the greatest with a score of 7.55. As a group we decided the Weighted Objective Table was conclusive and this design will be taken forward for further development. With our focus now on one design we further examined the table , from the table the design scored lowest on aesthetics and market, so in addition to trying to improve all design factors, an effort will be made to greatly increase these specific scores before the final evaluation to create a well-rounded and dynamic handle.

Radar Chart



The radar chart shown above has been created to help visualise our evaluation of each design instead of in individual areas. This helped reinforce that areas such as market and environmental-sustainability should be prioritised during the development process.

Identifying Customer Needs

Participant Review

Identifying customer needs is an important part of the design process, it can guide our design team on areas within design that need improvement. We asked six potential customers what they thought the most important factors in a speaker are. We asked each participant to indicate on a scale of one to five how important this factor is to them. To achieve accurate answers, we further clarified the scale.

- 1. Factor is undesirable.
- 2. Factor is not important.
- 3. Factor would be nice to have.
- 4. Factor is highly desirable.
- 5. Factor is critical.

Factors	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Average score
Sustainability	4	4	5	4	4	4	4.2
Function	5	4	5	5	4	4	4.5
Aesthetics	4	3	4	4	3	2	3.3
Ergonomics	3	3	3	2	4	3	3
Maintenance	3	2	3	2	3	3	2.7
Materials	4	3	2	3	4	4	3.3

From the table, the results show that the participants believed that function and sustainability are the two factors they would most want to see in a design of a speaker. Maintenance and ergonomics scored lowest suggesting they are not as sought after as the other factors.

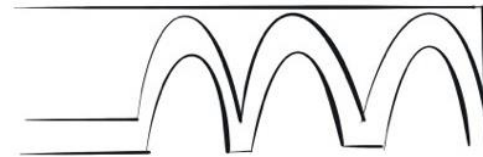
The radar chart shows the comparison between the results of potential customers and the results we gathered as a team. The consensus from this chart is that the two teams have very similar thoughts on the importance of factors in a speaker. However, there is a towering difference of opinion between the groups on function. This aspect may have been overlooked by our group and will require a more extensive investigation. This concludes that the sound quality of speakers are more important than what we as a design group believed to be the case.

Comparison Chart

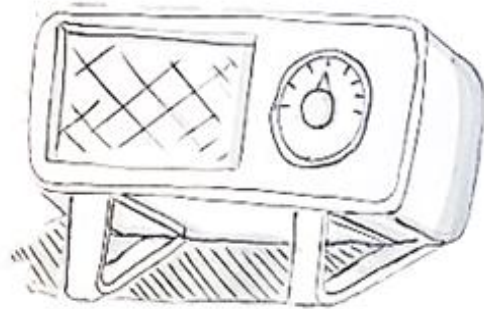
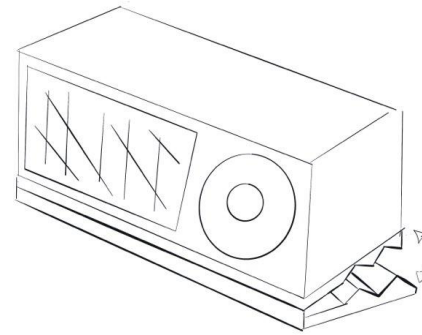


Idea Development- Idea Generation

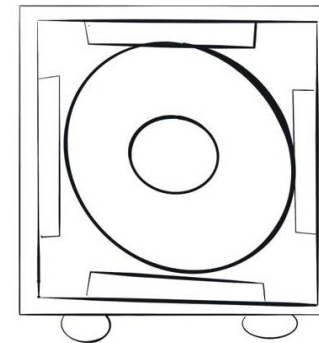
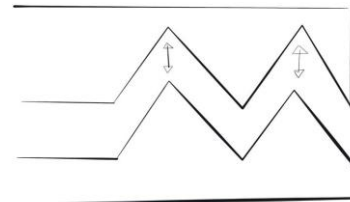
Wider cabinet with taper edge back.



Claw grips to attach to shelves. Can possible be expandable to different width.

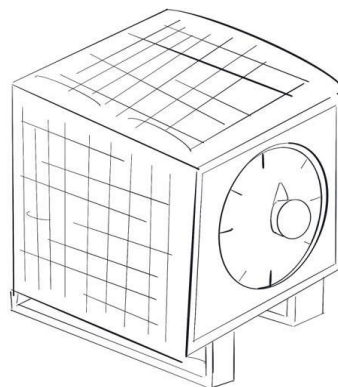
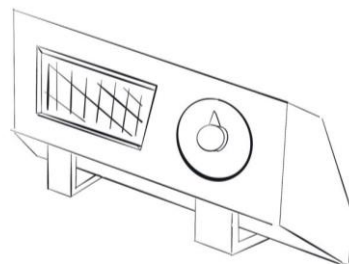


Removing the legs, abandoning secondary function?

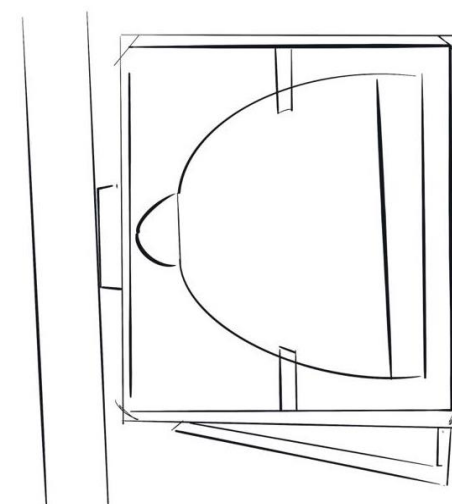


Rubber grips for stability, cross hatching. Textured surface?

Body



Changing cabinet shape to utilise desk/surface area.



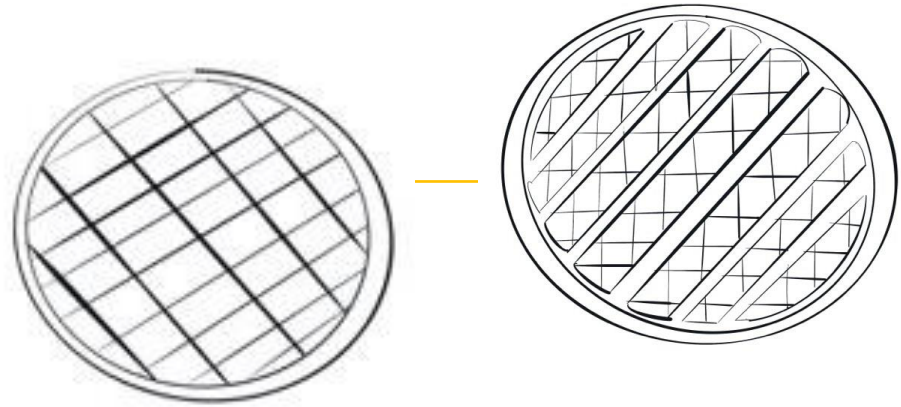
Magnet attachment – internal magnets.

Through Idea generation, we explored many areas of development that we could incorporate or enhance to our final design.

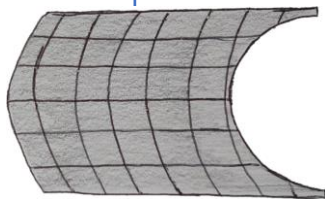
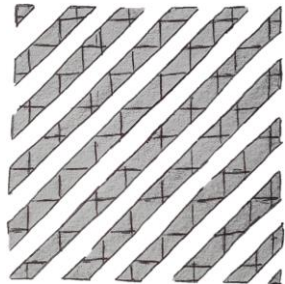
We focused mainly on areas in which would allow the speaker to be utilised more efficiently when within its function, and by adding integrating a secondary function, in which the speaker could hang or attach to a surface, making use of space within the environment.

Development has also been considered with the body, relating back to utilising space as well as the being sustainable within itself. This will allow us to make final decisions that can be taken forward and used within the final render.

Idea Development continued ...

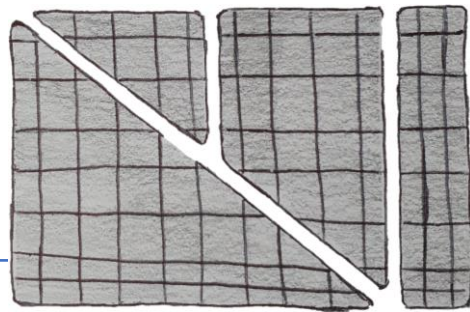
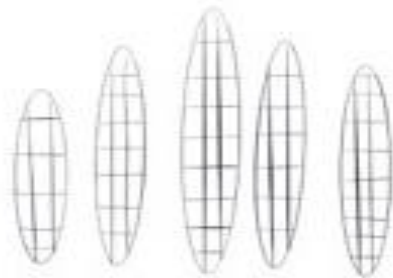
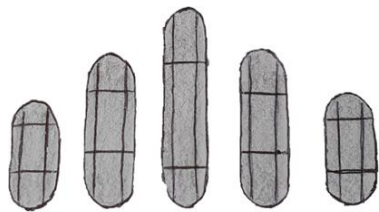


Pattern over speaker

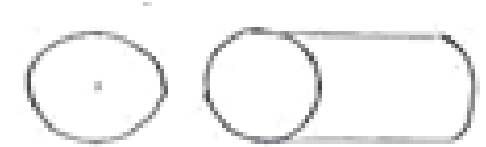
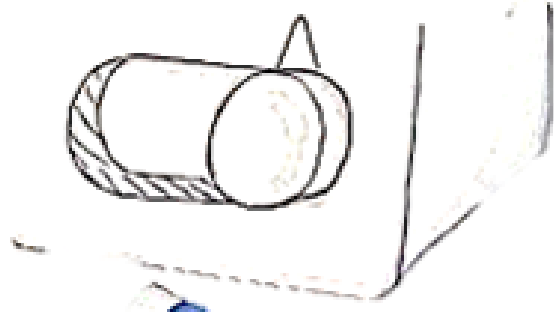


Speaker design with and aesthetic feature

Retro style



Sliding control-retro style

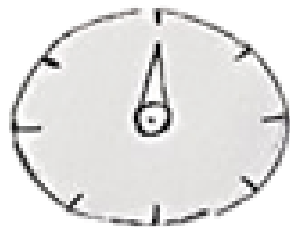


Two controls for volume and power

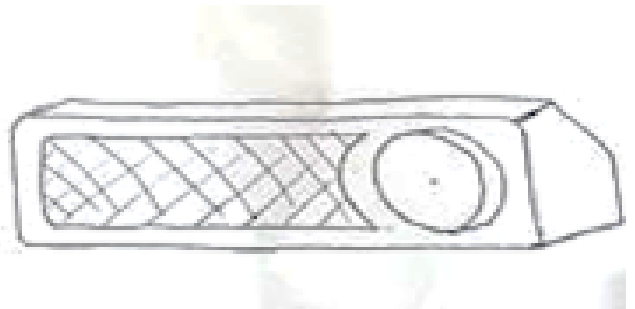


Push on/off dual control

Tuning Style



Controls

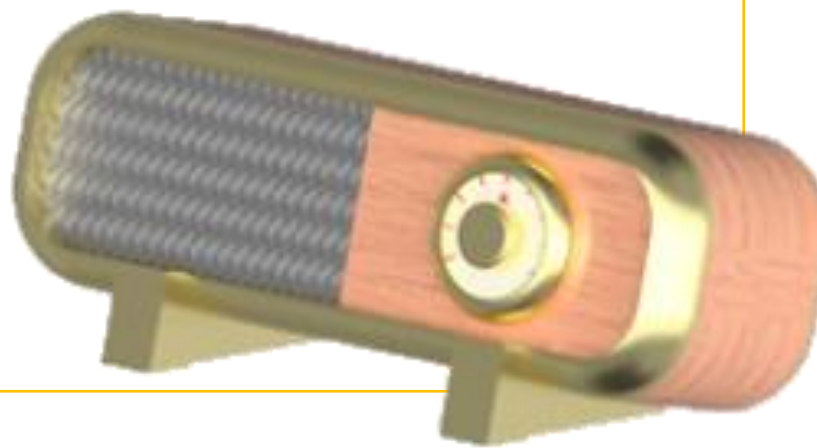
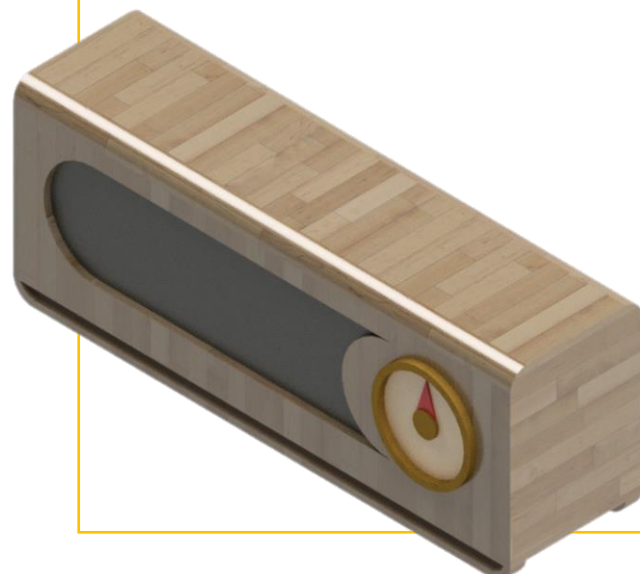
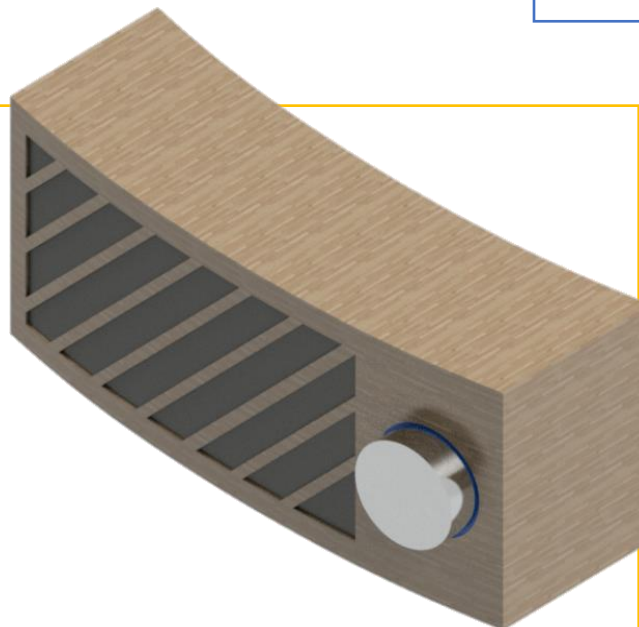
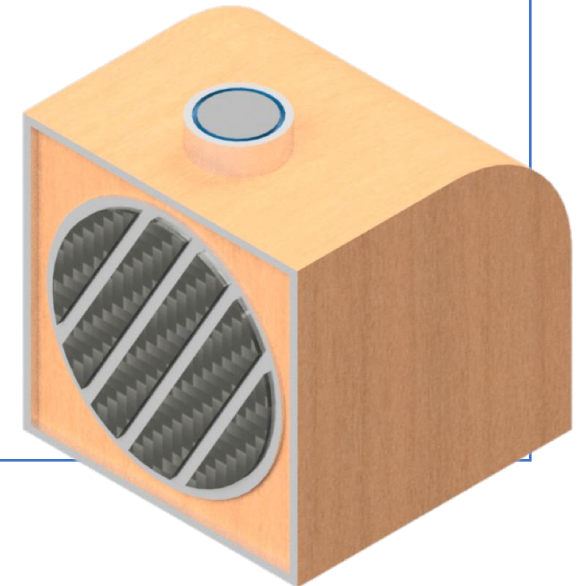


Oval shape- LED modern influence

Further exploration in the detailing of the controls and pattern on the speaker face. The detailing illustrates the modern-retro aesthetic that was in 238727G within the previous research and develops the aesthetic further to fit with the other design points made by the specification and vision statement.

Idea Development (SCAMPER)

- Condensed the size of the speaker to utilise space as well as ensuring that that is sustainable.
- Speaker faces on each side, adding a modern aesthetic.
- Casing is smaller therefore allows for cheaper production cost and manufacturing.
- Exploring materials that will be most sustainable. Considered in further development.
- LED around the dial adding contrast and emphasises the controls.
- Claw grips for the stand. Enables the speaker to attach to surfaces with different thicknesses. (secondary function)



- Explored with different body shapes, again for cheaper production and time.
- Keeping in frequency with the size of the chosen idea ensuring that the speaker is sustainable to the user.
- The body is bent to add to help amplify the sound as well as a design aspect.
- Explored different speaker patterns to tie into the retro style of the original speaker design.
- Further development to be had in materials for final development- ie. Plastic, wood etc.

Materials & Form Product Psychology Research.

Focus Group Observations.

Aim.

Aiming to gain empirical evidence to obtain further insight into viable smart improvements that could enhance user experience.

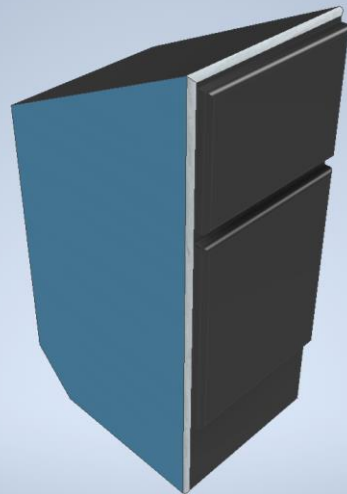
Experiment Description.

This experiment recorded the verbal responses of participants reacting to different prototypes. 2 focus groups of 3 BTech students were presented with 3 different prototypes of 3D CAD speaker models with material textures (Model X, Y, Z). They were asked to speak openly and share details about their initial reaction and comment on specific design factors. Ethical validity: Prior to start focus groups were made aware of the observer/accessor collecting data.

User Questions:

1. What is your first Reaction?
2. What do you feel about the shape/form of the ?
3. What do you feel about the materials?
4. On a scale of 1 – 10 how attracted to the model do you feel?

Model Y.

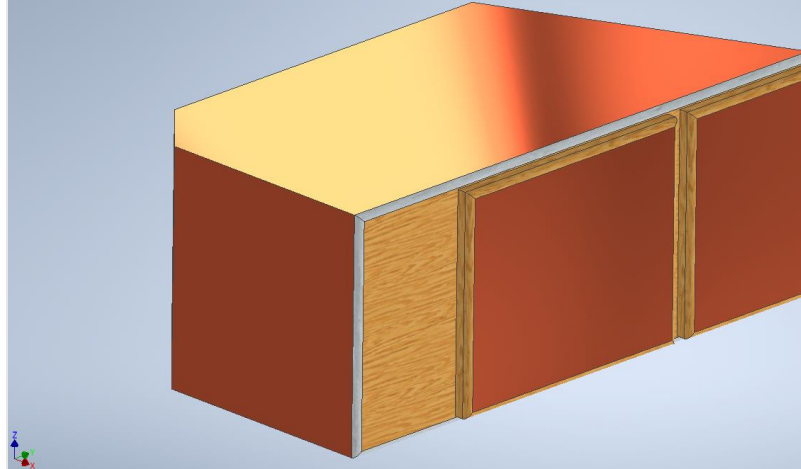


Model Y.

-- User aesthetic observation:
This is too clunky and does not appear stable.

++ The colour combination and metal fillet highlights are appealing and draw users closer.

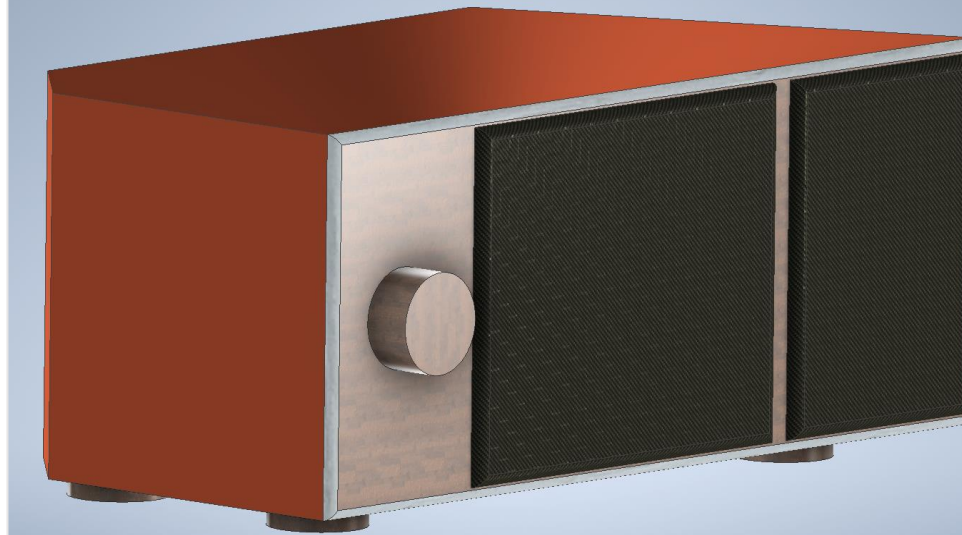
Model X.



Model X.

First reactions were mixed, and users did not know what exactly the object was. The shape was described as pointy and edgy. The materials were described as warm and comfortable. None of the users related this model to technology. The mean average of users feeling attracted was 3.8 / 10.

Model Z.



Model Z.

++ The shiny wooden finish with the grain complements the black high quality aramid fiber cones.

++ The leg stumps were noticed by the user and positively attributed to provide higher stability than model Y.

Data Evaluation.

Through evaluation of the data the design team concludes that users are attracted to products that portray stability and higher levels of detailing. Users are often confused by and unwelcome new shapes, especially with pointy edges. Users favour an array mix of different complementing materials included in models Y and Z. This leads the team to start experimenting with different, complementary materials during the next design phase and apply the research findings to further material analysis.

Ecological Validity.

The ecological validity of this experiment was challenged by private situations of participants acting as uncontrolled variables during the questionnaire. This was due to participants participating from their homes instead of being in a controlled laboratory setting: due to COVID-19 restrictions.

User Trial
NGK

Material Document.

Enclosure Material - Weighted Evaluation Matrix.

	Materials.	Polypropylene Plastic.	FSC bamboo or oak.	MDF Wood.	ABS Plastic.	Stainless Steel.	Fiberglass.	Bio Composite Material (Particle Board).
Relevant Human Factors Identified.	Weighting.	Value.	Value.	Value.	Value.	Value	Value.	Value.
Environmental sustainability.	0.25	0.5	1.75	1.5	0.75	2.0	2.0	2.5
*Function (Sound).	0.2	1.2	1.8	1.4	1.2	1.0	1.2	1.4
Aesthetics.	0.1	0.4	0.9	0.6	0.5	0.8	0.9	0.5
Production Cost.	0.075	0.75	0.375	0.525	0.675	0.45	0.3	0.675
Consumer Demand.	0.075	0.3	0.675	0.375	0.375	0.6	0.225	0.6
Material Durability.	0.15	0.6	1.35	1.05	0.75	1.5	0.45	0.6
Material Maintenance Cost.	0.15	1.05	0.9	1.05	1.05	0.9	0.3	1.35
Overall Utility Value.		4.8	7.675	6.5	5.3	7.25	5.375	7.625

- **Scoring Key:** Very good – 10/9, Good – 8/7, Satisfactory – 6/5, Poor – 4/3, Very Poor – 2/1.
 - **Value** = Weighting x Score.

Product Material Composition - Morphological Analyses.

Material Composition A.

Compartment.	Front Housing.	Volume Control.	LED Grille.	Front Panel.	Back Enclosure.
Materials.					
Polypropylene Plastic.					
FSC Bamboo or Oak.	✓			✓	✓
MDF Wood.	✓				
ABS Plastic.					
Stainless Steel.	✓	✓			
Fiberglass.			✓		
Bio Composite Material (Particle Board).					

Material Composition B.

Compartment.	Front Housing.	Volume Control.	LED Grille.	Front Panel.	Back Enclosure.
Materials.					
Polypropylene Plastic.					
FSC Bamboo or Oak.	✓			✓	✓
MDF Wood.					
ABS Plastic.	✓	✓			
Stainless Steel.	✓				
Fiberglass.					
Bio Composite Material (Particle Board).	✓				

Identification of Relevant Material Attributes to Enhance Function.

Denseness: Minimal mechanical pressures and vibrations need to be absorbed as efficiently as possible, so they do not contribute to the sound or cause changes to other frequencies. The denseness of a material is a characteristic.

Rigidness (stiffness): Particularly for bass frequencies this improves the sound quality and less distortion.

Non resonant: Materials that are naturally non resonant are able to provide a more authentic sound true to the recording.

**Function: Efficient amplification with minimal distortion.*

Sub Compartment Material Composition.

The cone, surround, and spider: treated paper coated with an adhesive glue, versus aramid fibre: the pricier alternative.

Speaker: stamped Iron or aluminium.

Permanent magnet: a ceramic ferrite material consisting of iron oxide, strontium, and a ceramic binder.

Stand: silicone rubber, stainless steel or FSC wood? Steel = anti corrosive. Wood has more aesthetic utility. Both are slide resistant viable options that provide high utility in sustainability and durability.

Engineering Bill of Materials (EBOM).

BOM Level	Part Number	Part Name	Material.	Phase.	Description.	Quantity.	Unit of measurement.	*Procurement type.	BOM Notes.
0	00-0001.	Front Housing.	Particle Board.	In Design.	Main Assembly.	1.	mm.	Curstom.	Prototype 3
0	00-0002.	Speaker Front Panel.	FSC certified oak.	In Design.	Main Assembly.	1.	mm.	Curstom.	Prototype 1.
0	00-0003.	Back Enclosure.	FSC certified oak.	In Design.	Main Assembly.	1.	mm.	Curstom.	Prototype 1.
1	00-0001.	Volume Controller.	FSC certified oak, abs plastic, stainless steel.	In Design.	Sub Assembly.	1.	ø.	Curstom.	Prototype 3
1	00-0002.	LED Grille.	ABS plastic.	In Design.	Sub Assembly.	1.	mm.	Curstom.	Prototype 3
1	01-0003.	Stand.	Stainless steel, silicone rubber.	In Design.	Sub Assembly.	1.	mm.	Curstom.	Prototype 2.
2	02-0001.	Speaker.	Stamped iron, silicone rubber.	In Production.	Sub Component.	1.	ø.	Standard.	
2	02-0002.	Cone.	Treated paper with adhesive glue.	In Production.	Sub Component.	1.	ø.	Standard.	
2	02-0003.	Surround.	Treated paper with adhesive glue.	In Production.	Sub Component.	1.	ø.	Standard.	
2	02-0004.	Spider.	Treated paper with adhesive glue.	In Production.	Sub Component.	1.	ø.	Standard.	
2	02-0005.	Magnet	Ferrite material consisting of iron oxide, strontium using ceramic binder.	In Production.	Sub Component.	1.	ø.	Standard.	
3	03-0001.	1 inch Oval Machine Screws – Comination Drive.	Stainless steel.	In Production.	Raw Component.	6.	Inches BSI standard.	Standard.	

*Procurement Type.

Custom: Manufactured according to project specifications.

Standard: Purchased off the shelf.

A Global Manufacturing Economy.

Globalization and social implications in manufacturing are cause to optimize the energy efficiency of the production facility as well as quality control.

Market factors contained in the circular economy connected to the Hama redesign also require manufacturing to minimize byproducts/waste.

The design and manufacturing team pursues a design approach where sustainability plays a key role in the digital transformation of manufacturing.

Product Pricing

End-user customer price



Retailer margin



Distributor margin



Manufacturer margin



Development costs



Cost of manufacture

Price Minus Model

For our preliminary financial planning we used a 'price minus' model. This model works by creating a price for the end-user and then subtracting the retailing and distribution costs, effectively working backwards from a more conventional 'cost plus' model. We didn't use a 'cost plus' model because it is impractical to complete at the product planning stage we are currently at.

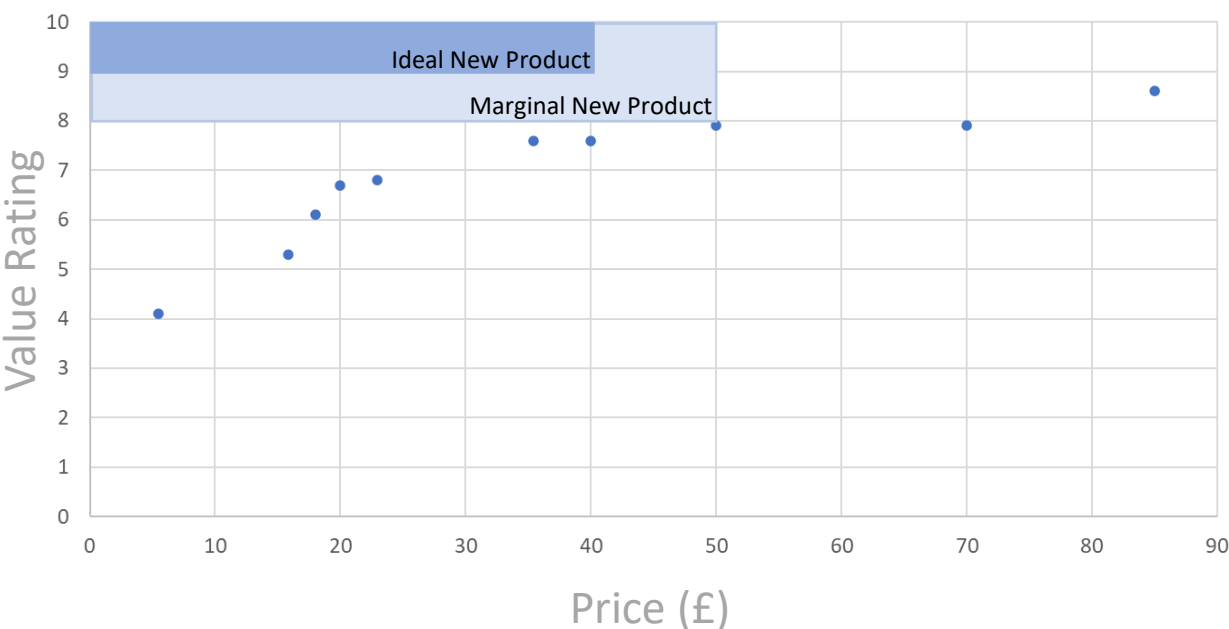
Weighted Objective Table with Competitor Speakers

Each competitive product is rated on a scale of 1-10 with 1 being the worst and 10 being the best score. The total value is calculated as the sum of all the ranks multiplied by their weighting factor.

			Aesthetic	Ease of Use	Maintenance	Environmental sustainability	Function	Total Value (Weighting x Score)
Product	Price	Weighting	0.2	0.3	0.1	0.2	0.3	
Hama Sonice SL-206	£17.99		6	7	3	5	5	6.1
ADVENT ASP20BK20 2.0	£19.99		6	8	3	5	6	6.7
Logitech Z120	£22.96		7	6	6	6	6	6.8
Logitech Z130	£35.39		7	8	8	6	6	7.6
Trust 16697 Mila 2.0	£15.83		4	5	5	5	5	5.3
HY-218 Computer Speakers	£5.49		3	6	2	3	3	4.1
Bose Companion 2 Series III Multimedia Speaker System	£84.97		7	8	7	7	9	8.6
Creative GigaWorks T20 Series II	£69.99		8	6	7	7	8	7.9
Creative Inspire T10	£39.99		9	7	6	5	7	7.6
Trust Gaming GXT Tytan 2.0	£49.99		9	7	7	6	7	7.9

Value Map

This chart arranges competitor speakers to the price they are offered to end-users and their value perceived by customers, these values are seen on the weighted objectives table where we ranked each factor on their importance.



Material Cost

From our research, we determined as a group, that there is a gap in the market for a good quality desktop speaker for £30 retail price. To understand a manufacturing cost we used the equation and made a couple of assumptions about the retailers and manufacturers profit margins.

Target Costing – Sold Through Retailer

Assume an end-user price of £30
Assume a manufacturer's profit margin of 40%
Assume a retailer's profit margin of 45%

$$C = P \prod_{i=1}^n (1 - M_i)$$
$$C = P(1 - M_m)(1 - M_r)$$
$$C = 30(1 - 0.4)(1 - 0.45)$$
$$C = \underline{\underline{£9.90}}$$

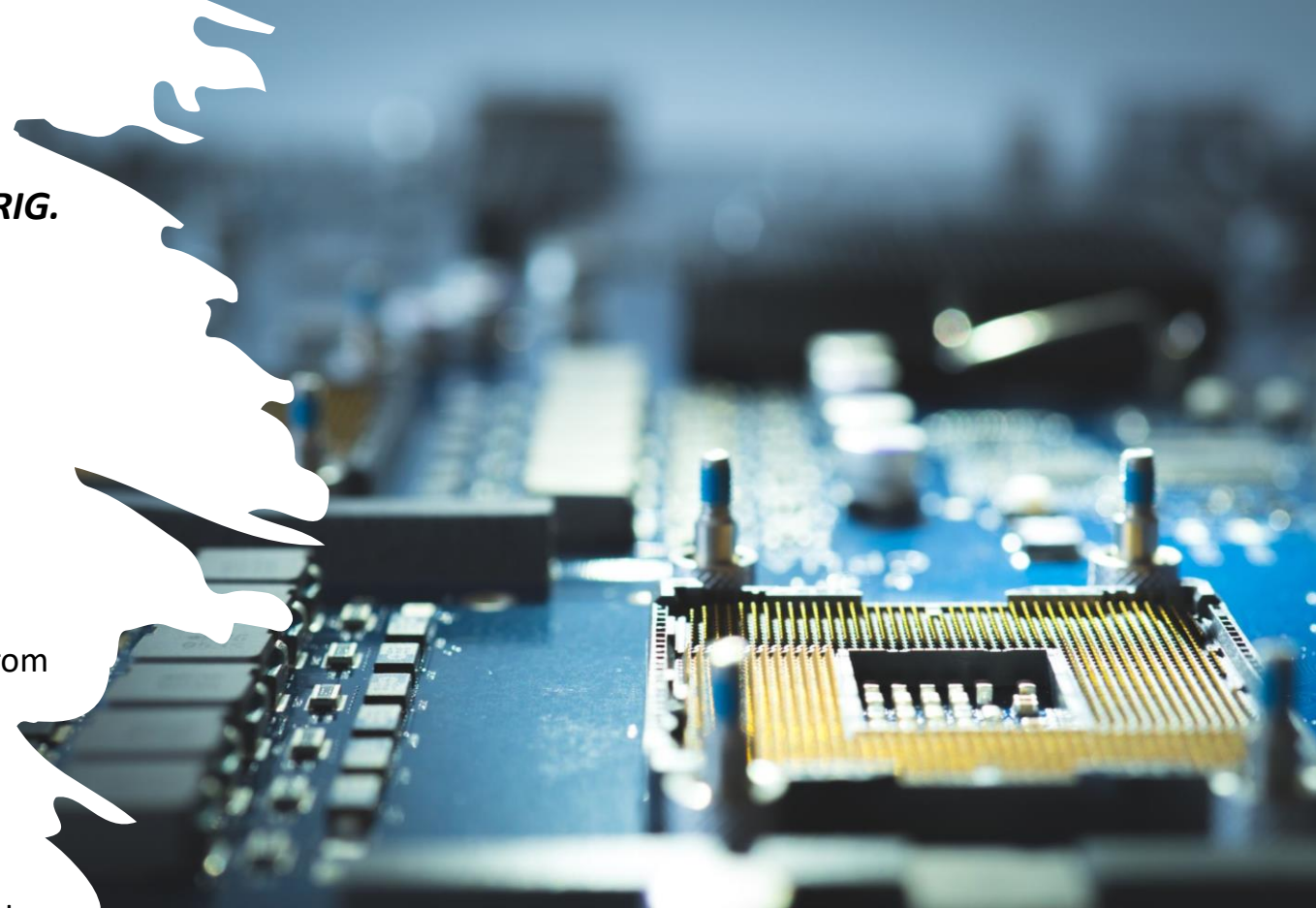
Electro Technical Document.

PCB electronics board for speaker with improvements inside RIG.

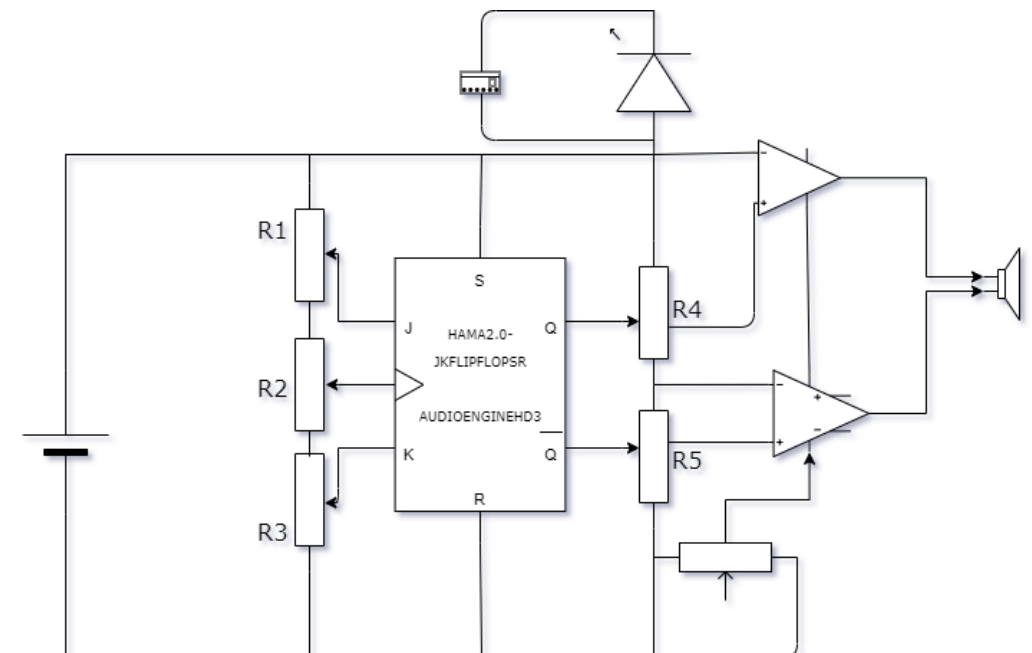
- Improvement of better cable management system.
- What Battery will be used?> Lithium.
- Mid-priced speakers require more power to provide the same volume. Speaker sensitivity is described in terms of the number of decibels (dB) of sound pressure level (SPL) per watt of amplifier power measured at one meter from the speaker. This means manufacturers usually drop the SPL/W/M and just say dB.

Energy Efficiency of the speaker system.

- Nominal power = what a speaker can handle long term without being damaged.
- Peak power = what a speaker can handle in short bursts without being damaged.
- 100db.
- Speaker frequency and volume calculations are required.
- Surround sound – minimal 2.0.
- WILL IT REQUIRE a driver? Microcontroller: USB: Digital.
- USB connection upgrade 2.0 to 5.0.
- Audio Engine HD3.
- High fidelity amplification, no howling.
- Sound propagation distance 150m +/- 10.



Speaker Circuit. Prototype of a Schematic Diagram.

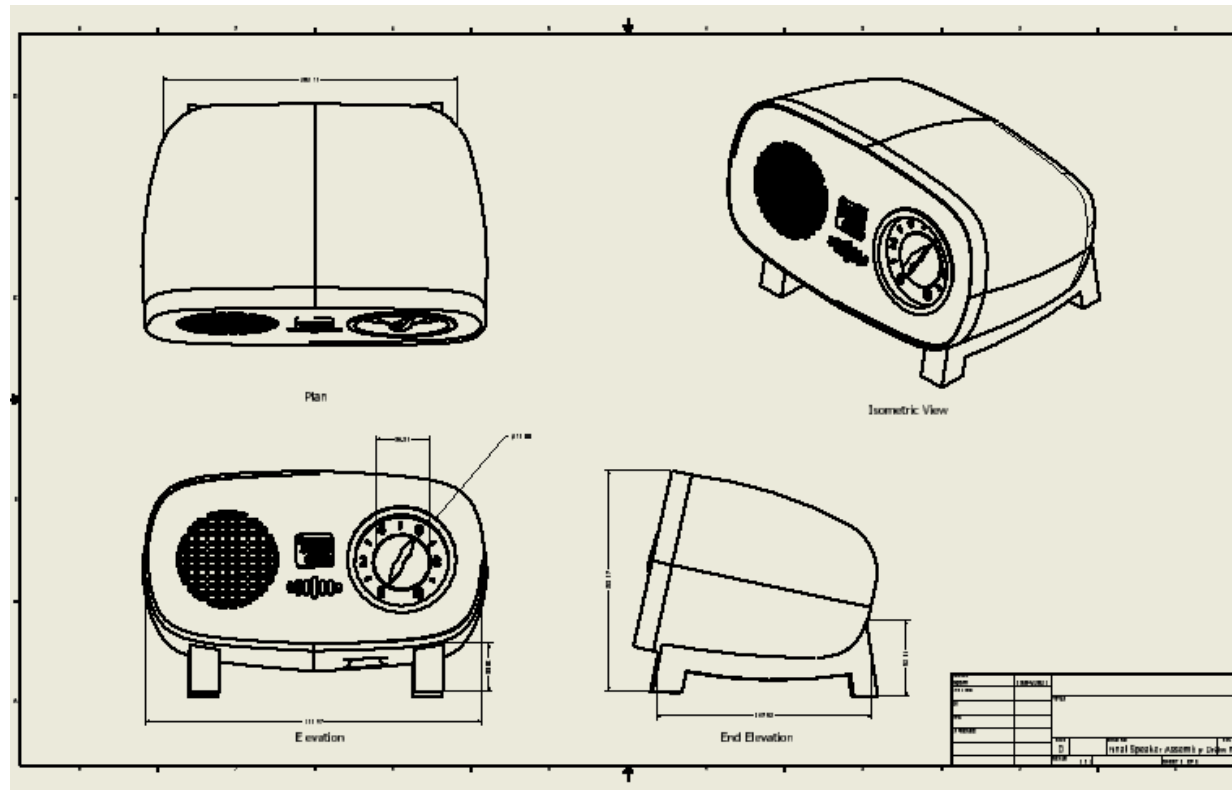


Design Justification

Nathan 3D Design with RIG. + justification



Technical CAD Drawings



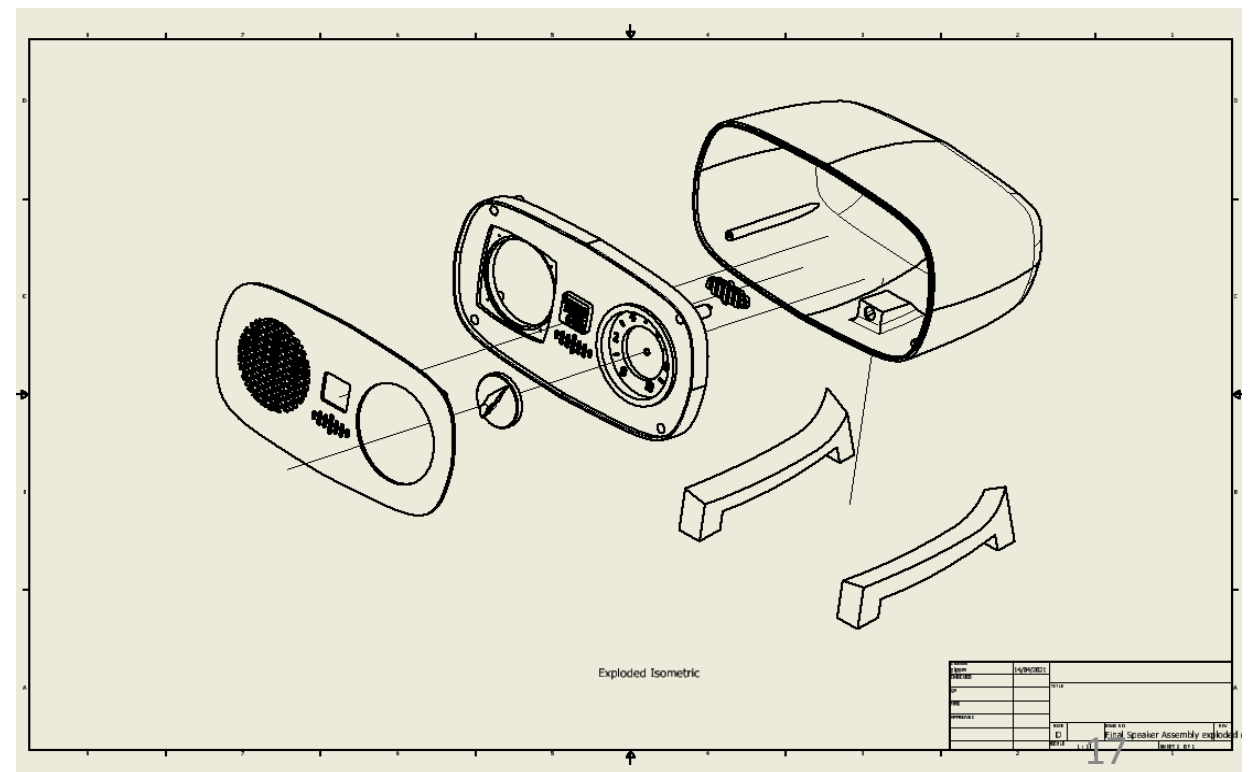
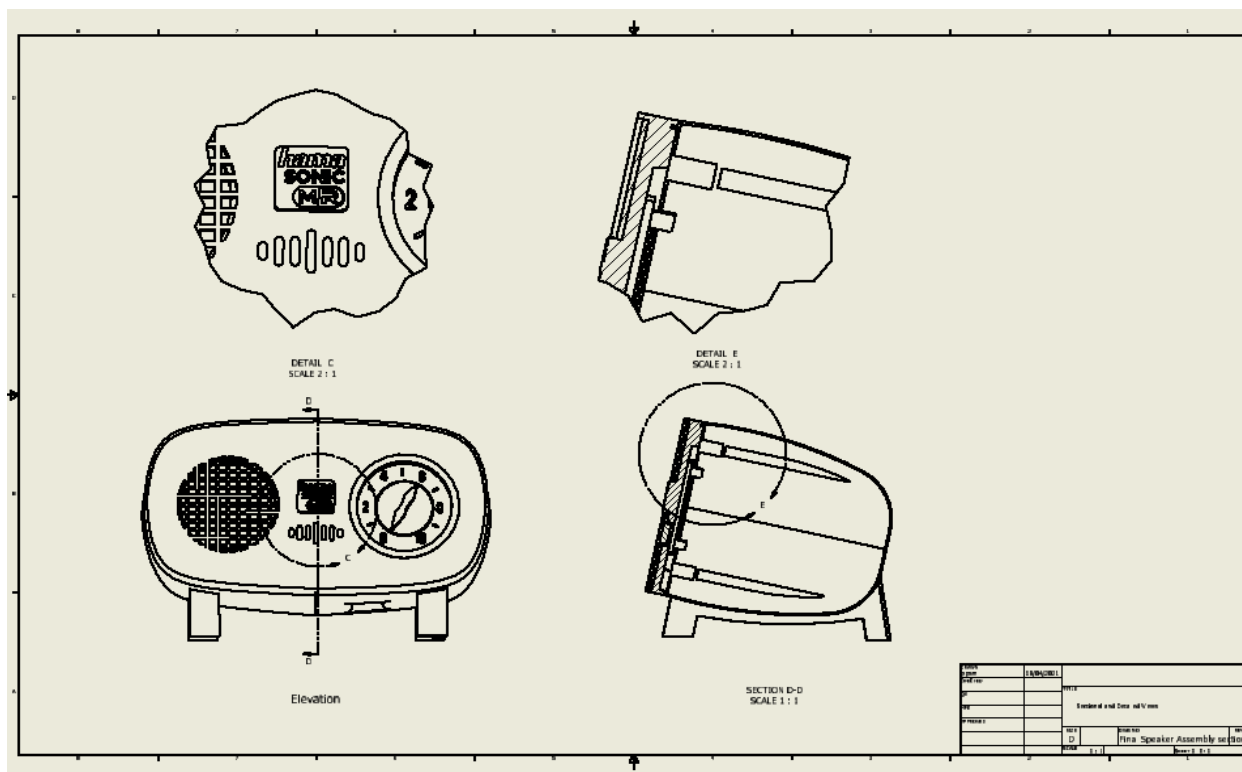
The computer drawing illustrates the exact dimensions of the speaker body as well as the details on the speaker face. Each dimension is true to size and fits with the requirements that is stated within the vision statement.

Within the final model, minor adjustments had to be made dependant on size of the 3D print. The CAD drawings allowed our team to easily adapt our sizes to enable the model to be suitable to be 3D printed.

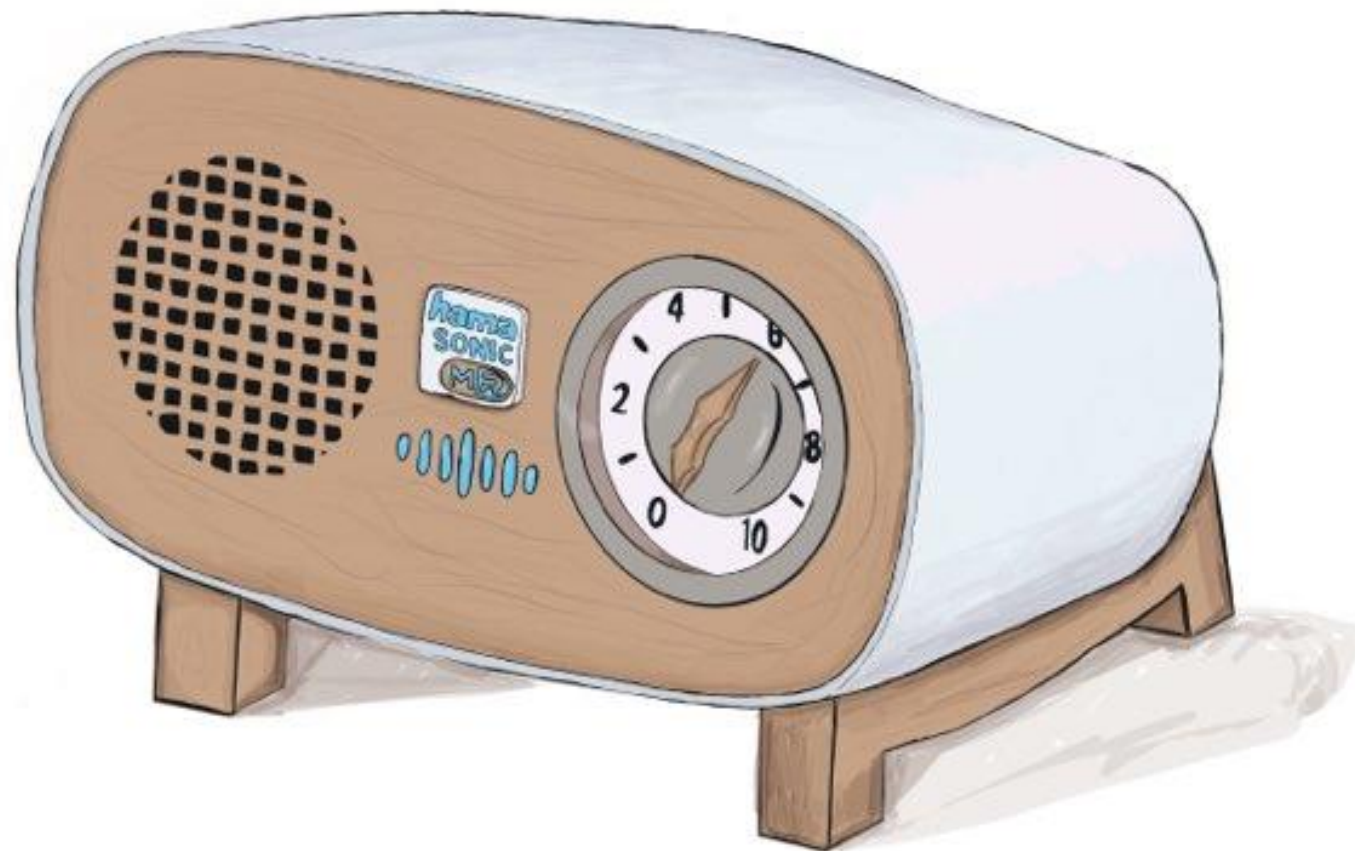
The exploded view displays the inner rig of the model. The main body shows where the internal speaker sits and how the wiring flows through the model.

The speaker sits on top of the wooden stands. The wooden stands have been shaped specifically to the body giving clean modern style to the design.

Each part is attached by screws in which have been taken from the original USB speaker given. The exploded view illustrates where how each part is fixed together.



Final Marker Pen Render



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