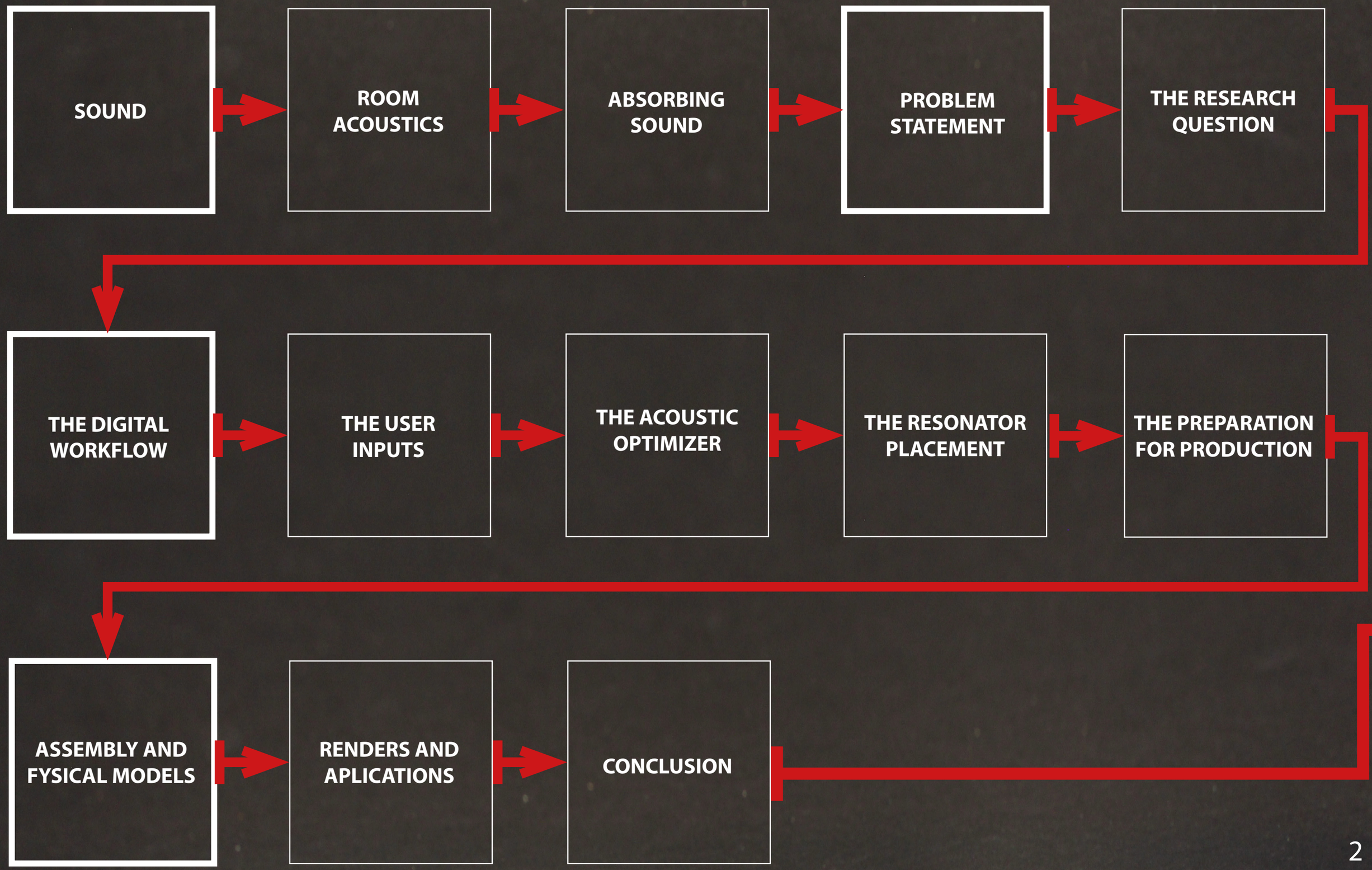
Designing a resonant panel based on Helmholtz resonators with reduced geometrical complexity

Master thesis by Jordy van Eijk

TU Delft

TABLE OF CONTENTS



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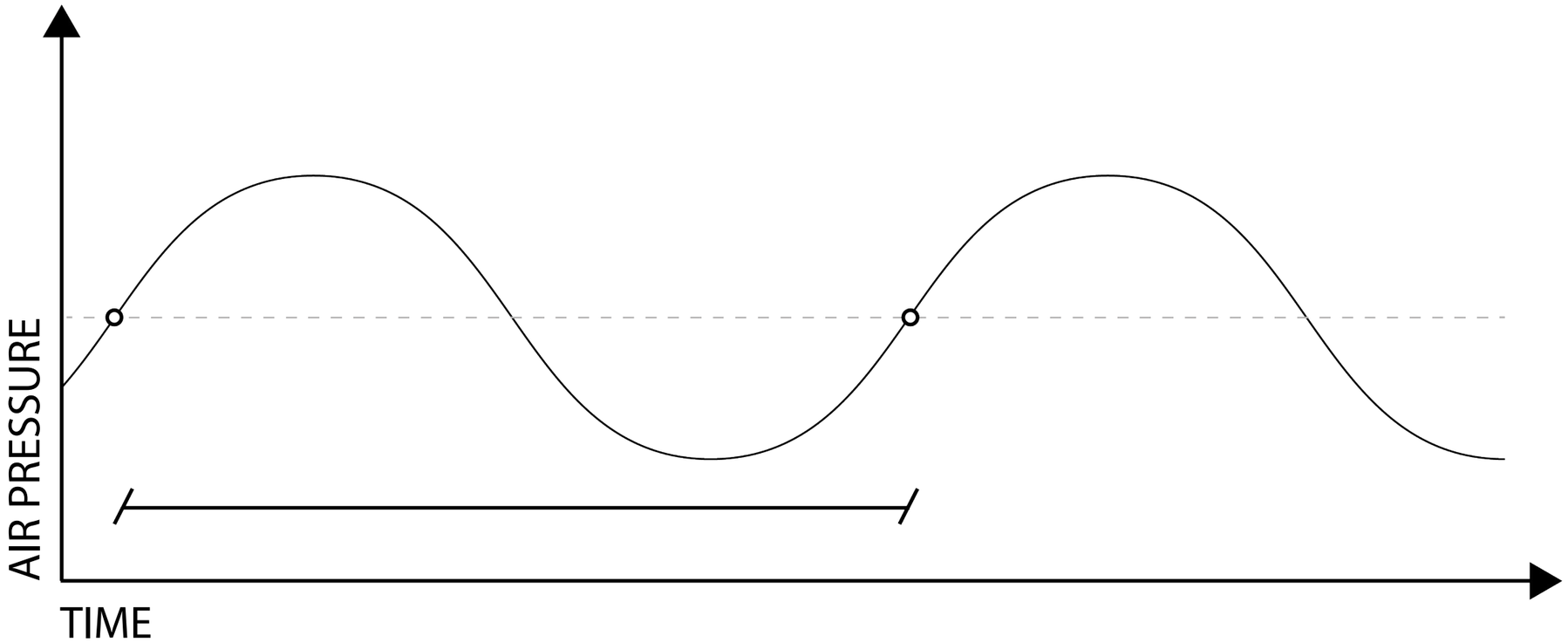

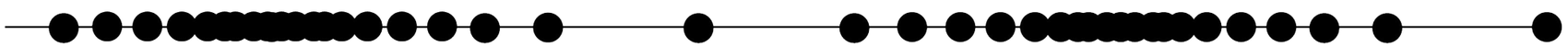

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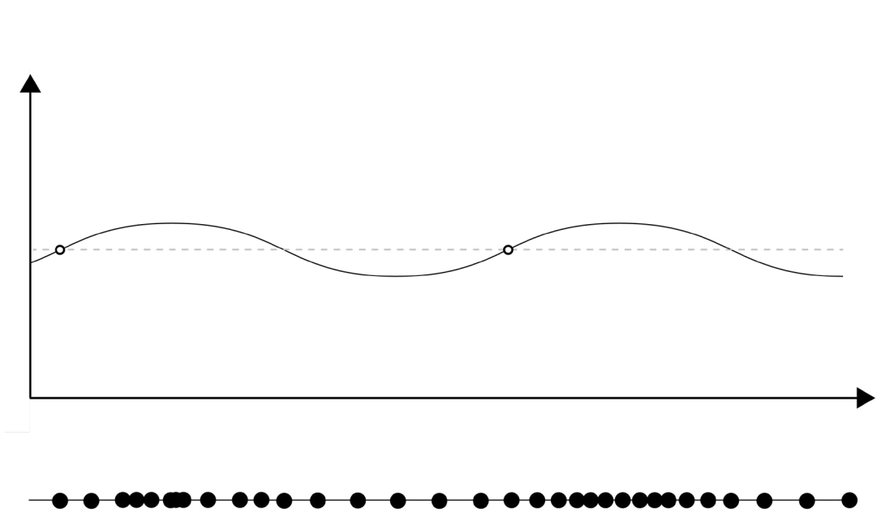
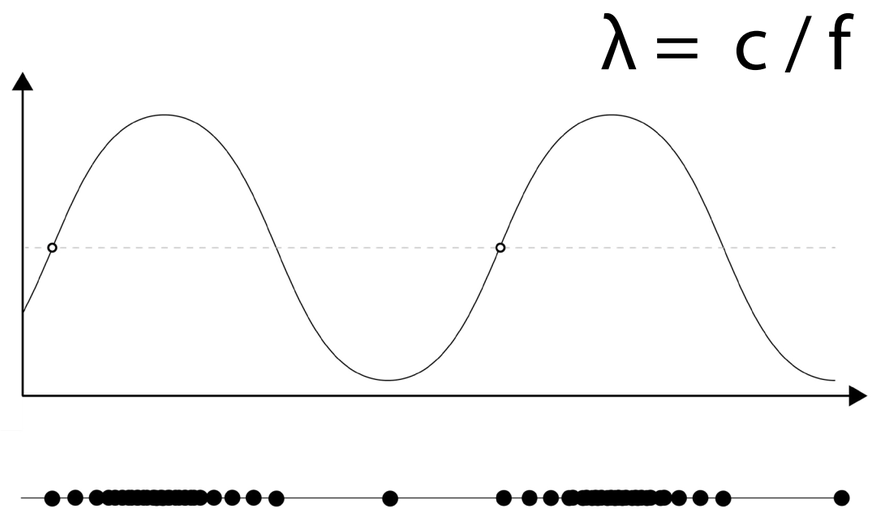
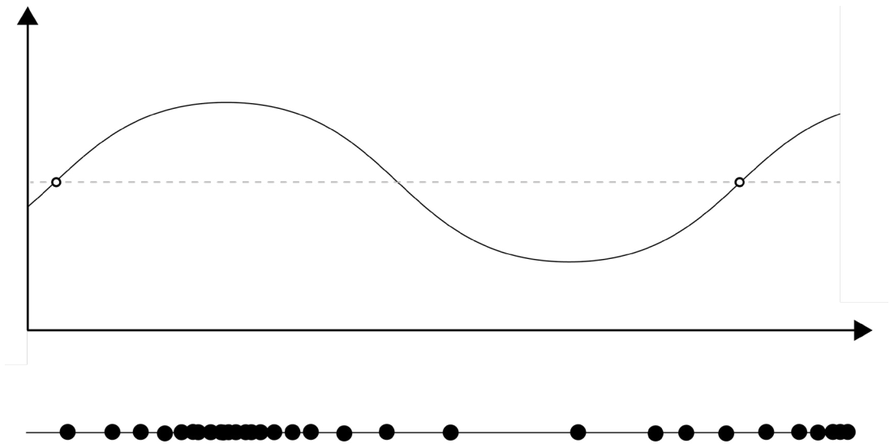
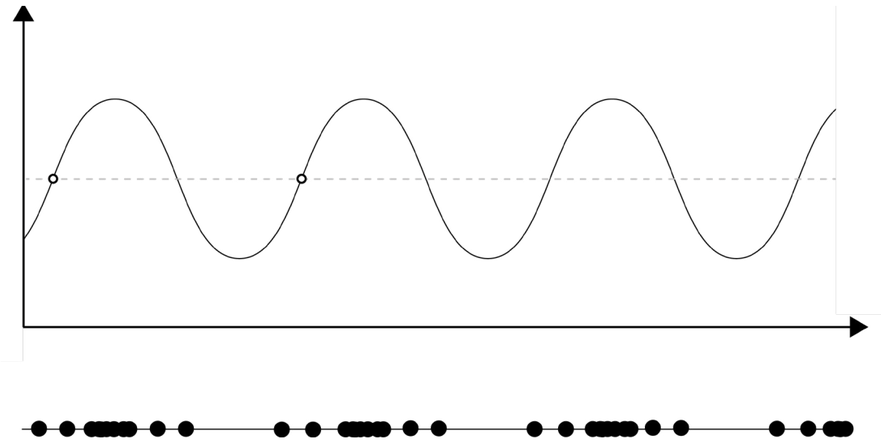
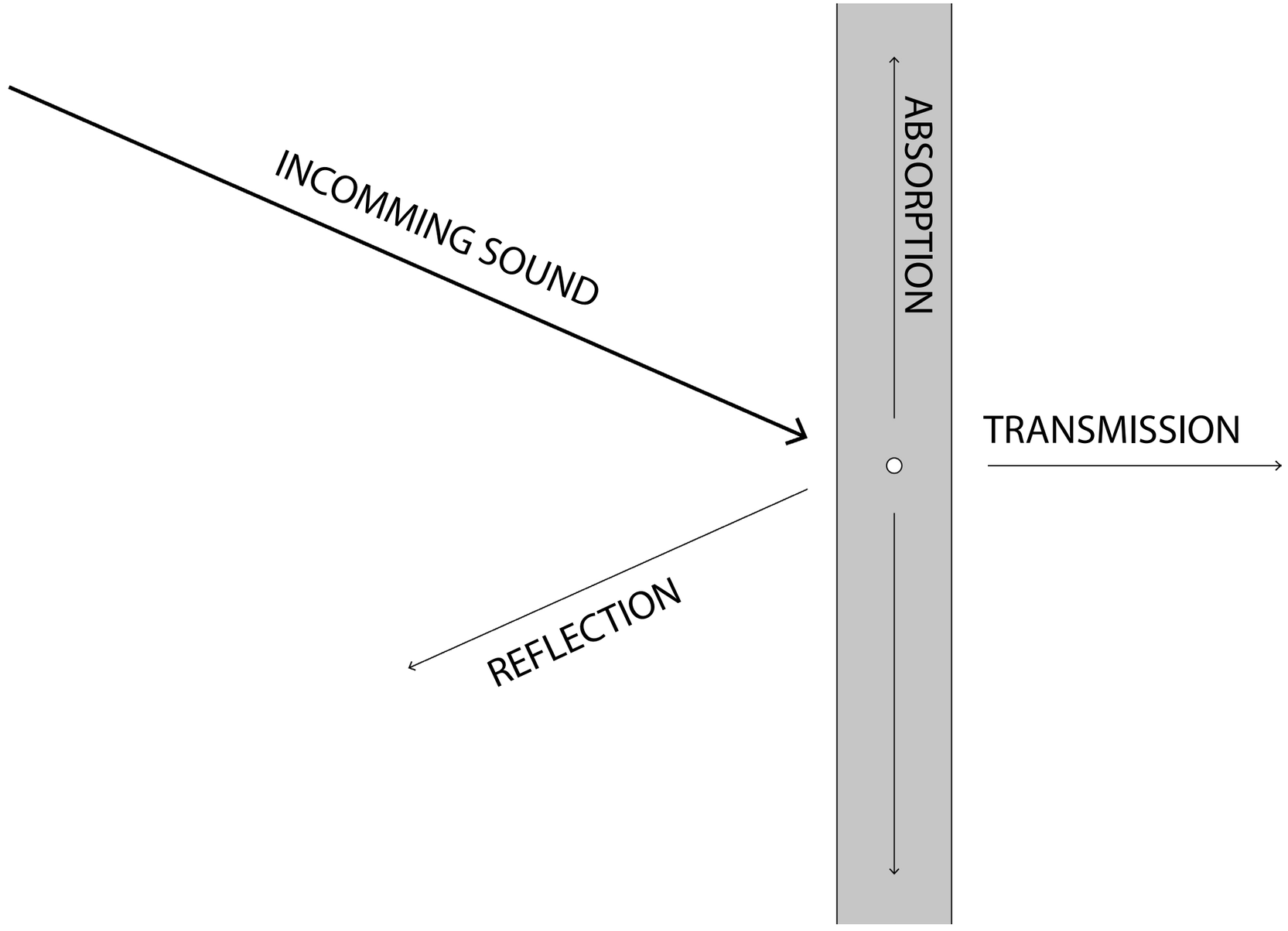








ROOM ACOUSTICS



ROOM ACOUSTICS

REVERBERATION TIME

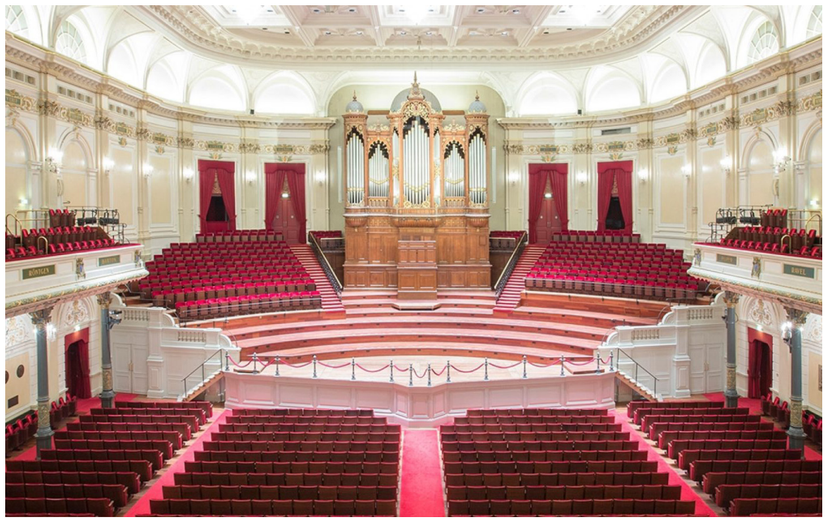
TIME FOR -60 DB

FREQUENCY DEPENDENT

FREQUNCY BANDS

63 - 125 - 250 - 500 - 1000 - 2000 - 4000 - 8000

AVERAGE ABSORPTION



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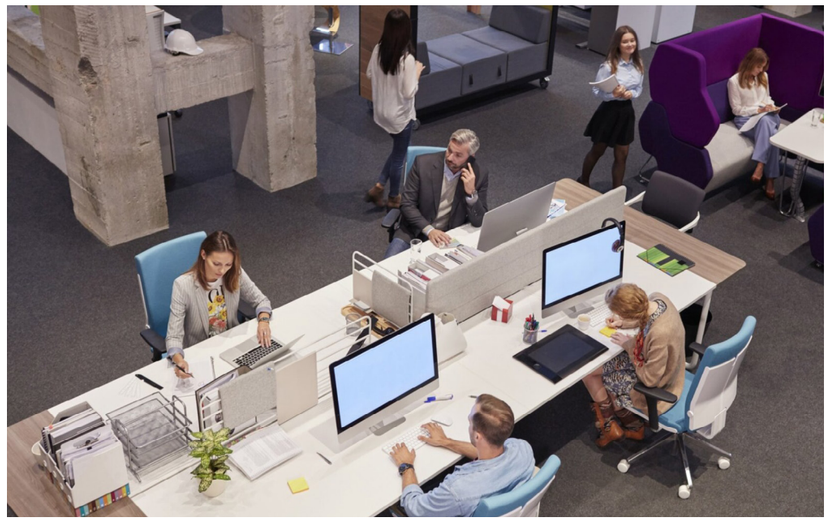


ABSORBING SOUND

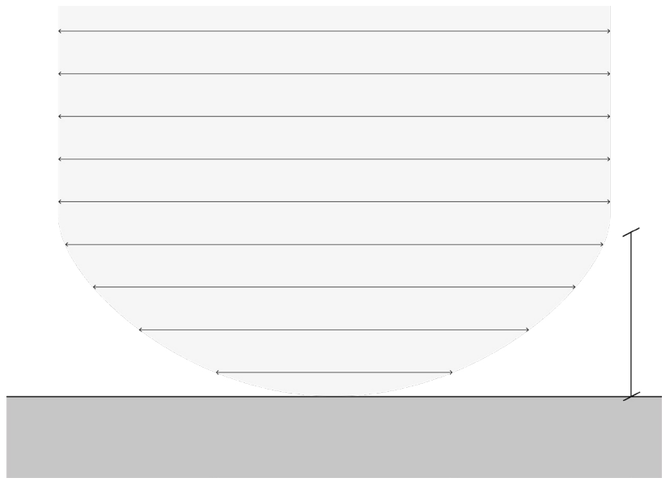
POROUS ABSORBERS

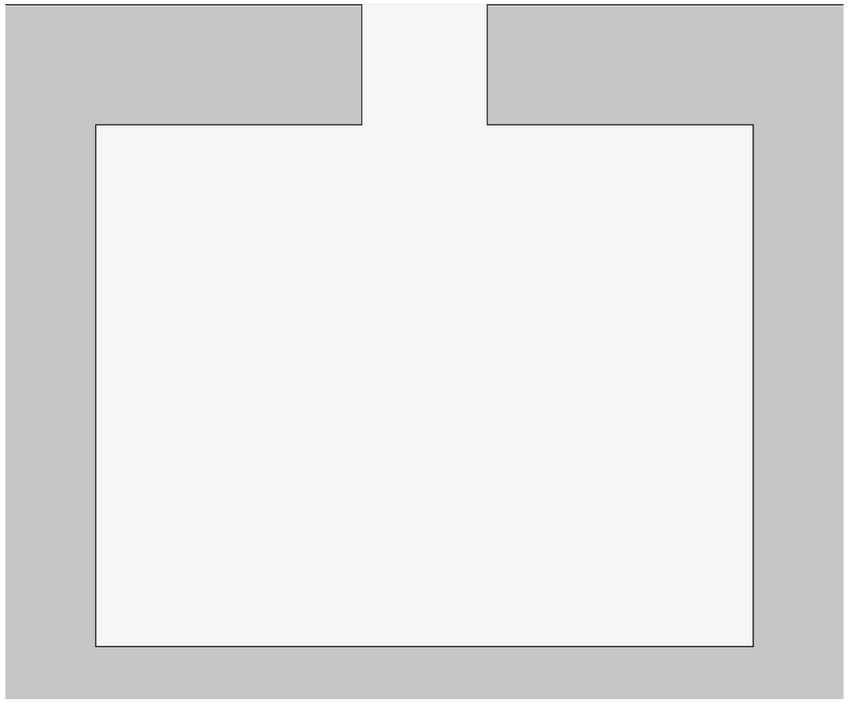
- VERY SUITABLE FOR HIGH FREQUENCYS
- BROADBAND ABSORPTION
-ABSORBSION BASED ON MATERIAL PROPERTIES

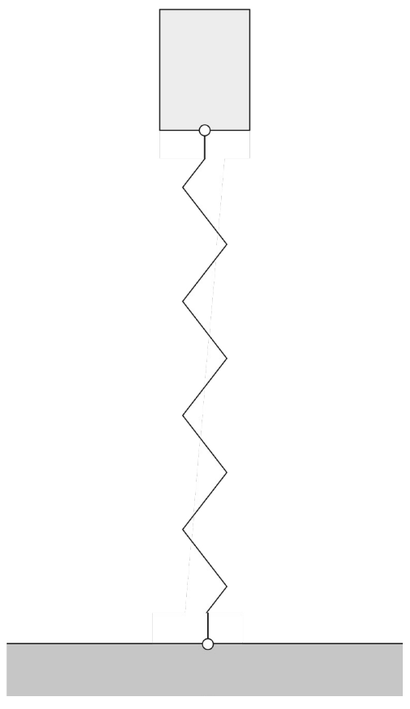
RESONANT ABSORBERS

- VERY SUITABLE FOR LOW FREQUENCYS
- TARGETS ONE FREQUENCY
- ABSORBESION BASED ON GEOMETRY

THE HELMOLTZ RESONATOR







PROBLEM STATEMENT

WE SPEND MOST OF OUR TIME INSIDE SURROUNDED BY SOUND

SOUND ABSORPTION FOR HIGH FREQUENCYS LIKE SPEACH CAN BE DONE QUITE EASILLY WITH THE USE OF POROUS MATERIALS

SOUND ABSORPION FOR LOW FREQUENCYS LIKE INSTALATION SOUNDS IS HARDER TO DO

PREVIOUS RESEARCH SHOWS THE POSSIBILTIES OF RESONANT ABSROBERS AS A OPTION FOR LOW FREQUENCIES BUT USES COMPLEX GEOMETIES TO ACHIEVE THIS

RESEARCH QUESTION

CAN A PANEL BASED ON HELMHOLTZ RESONATORS BE DESIGNED WITH REDUCED GEOMETRICAL COMPLEXITY WHILE RETAINING A BROADBAND HIGH ABSORPTION COEFFIENT FOR LOW FREQUENIES?

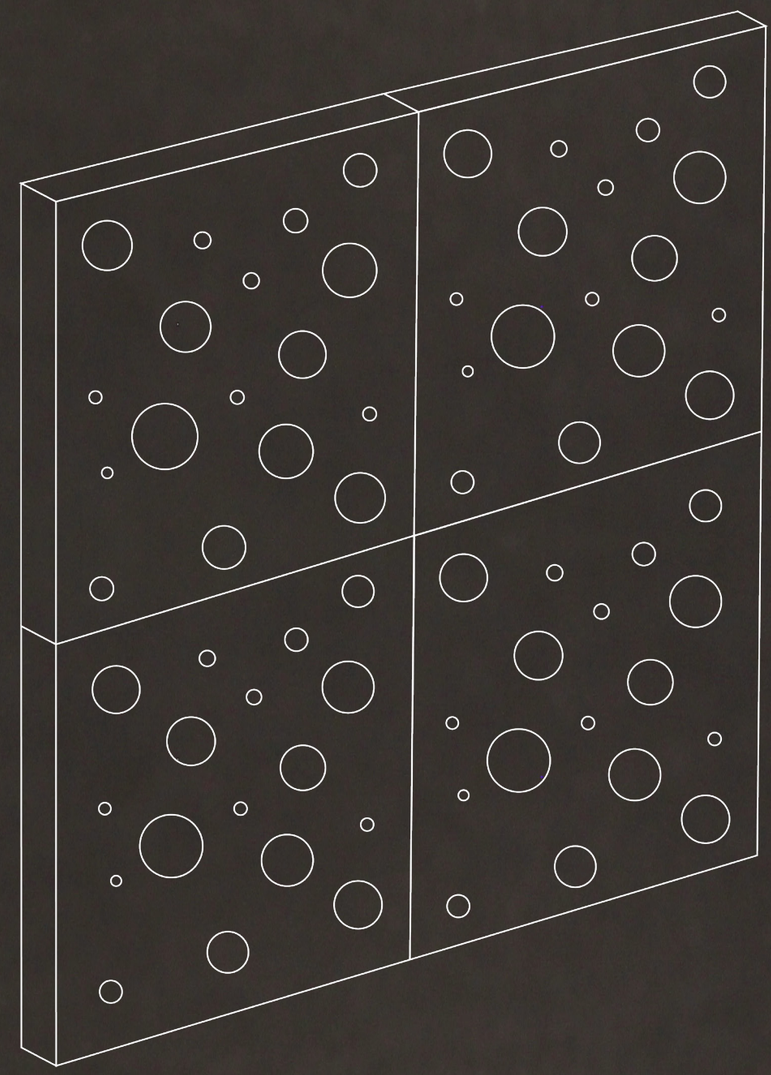
DESIGN GOALS

- PARAMETRIC DIGITAL TOOL

- PANEL BASED ON HELMHOLTZ RESONATORS

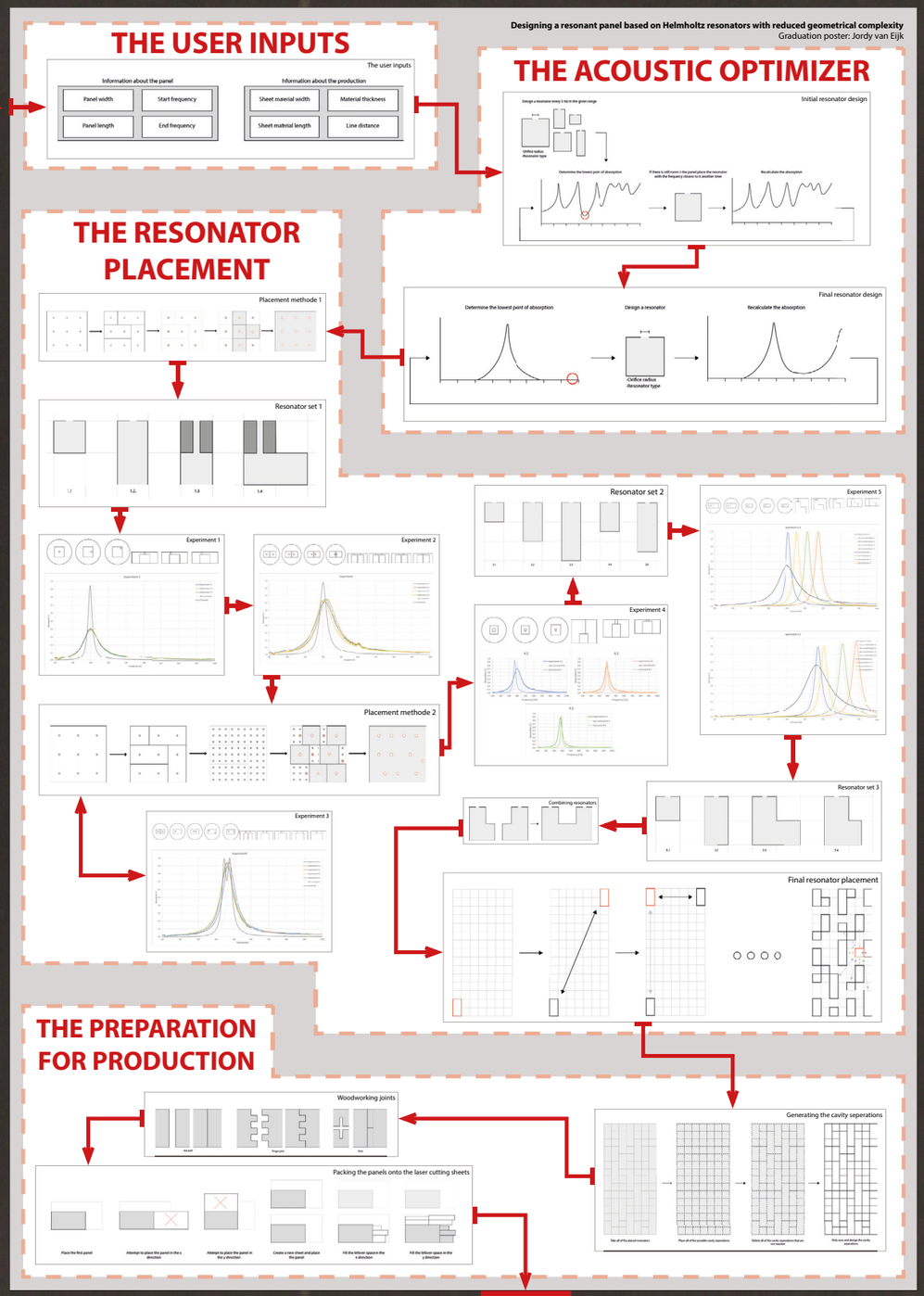
- BROADBAND ABSORPTION

- PRODUCTION THROUGH LASER CUTTING

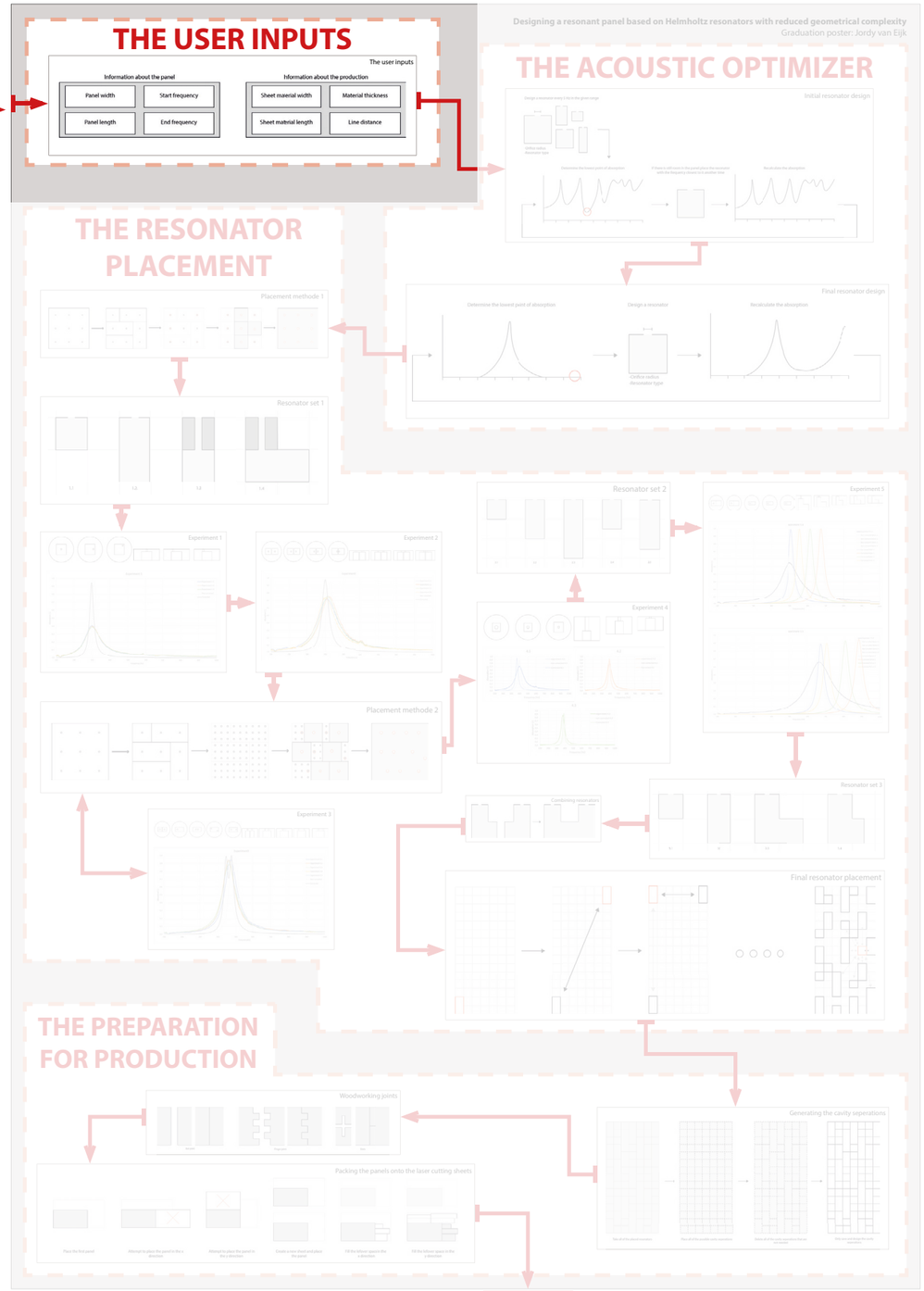


THE DIGITAL WORKFLOW

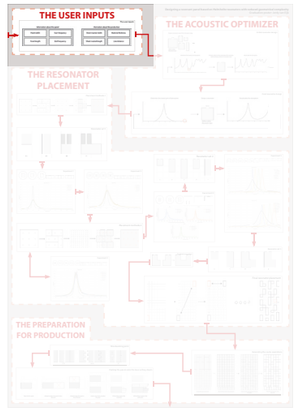
DIGITAL WORKFLOW



THE USER INPUTS



THE USER INPUTS



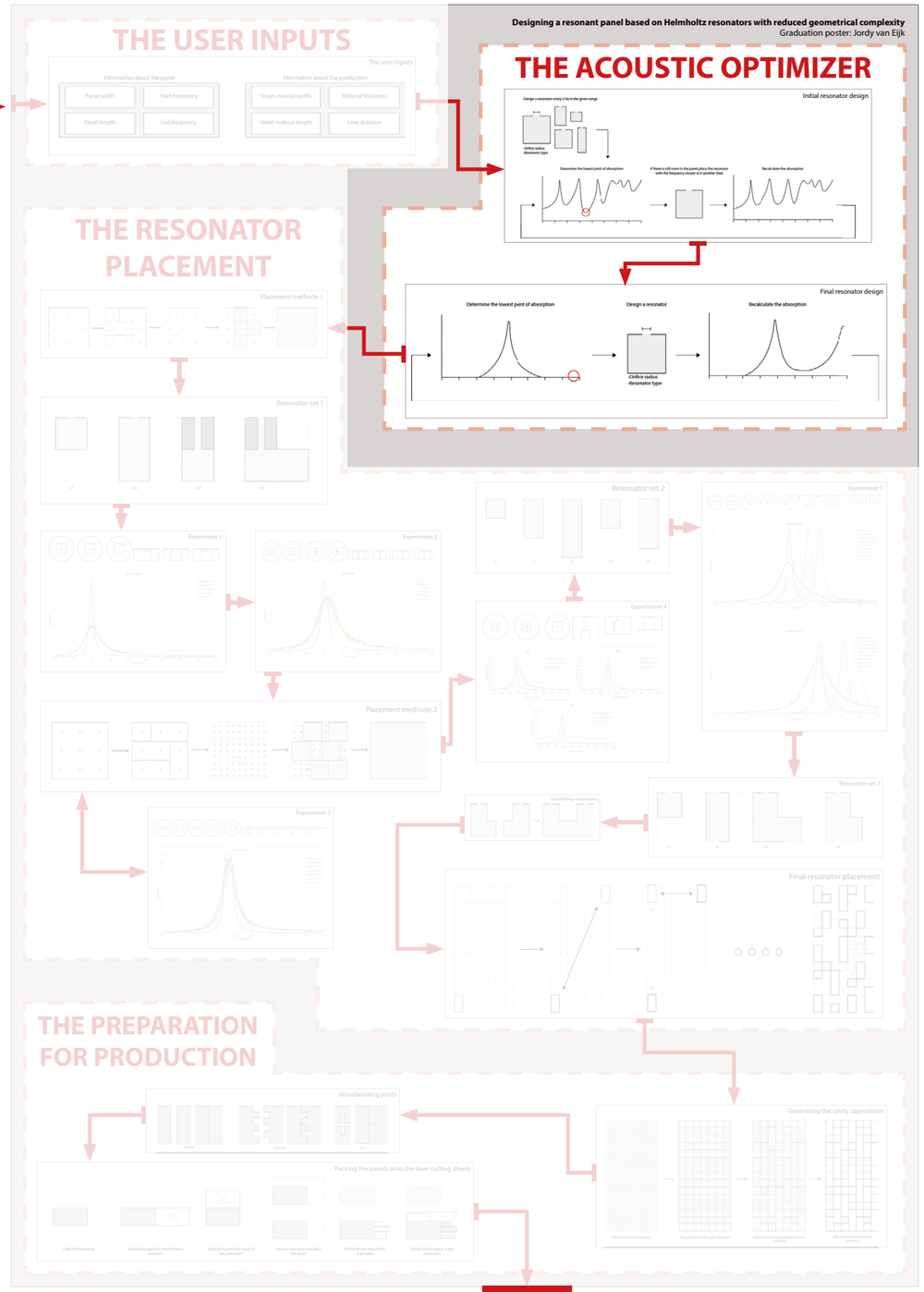
Information about the panel

Panel width	Start frequency
Panel length	End frequency

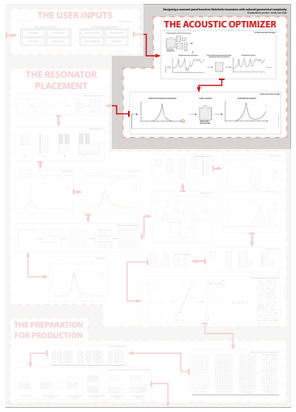
Information about the production

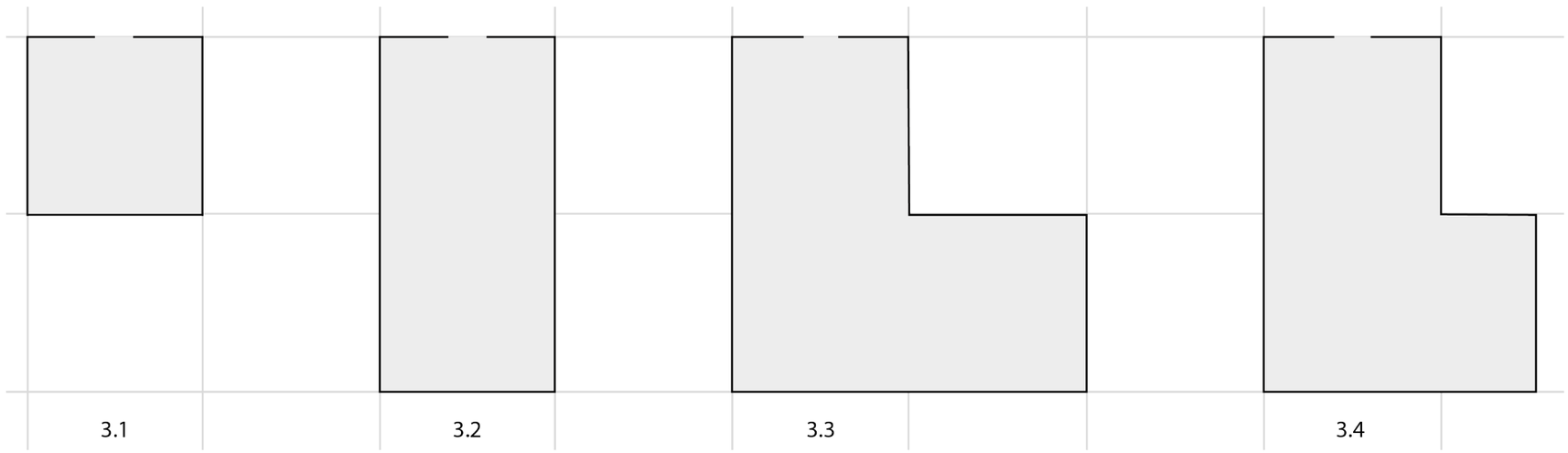
Sheet material width	Material thickness
Sheet material length	Line distance

THE ACOUSTIC OPTIMIZER



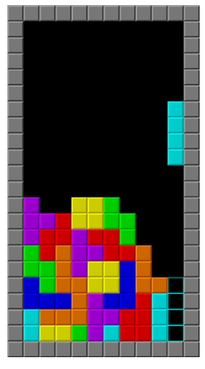
RESONATOR SET



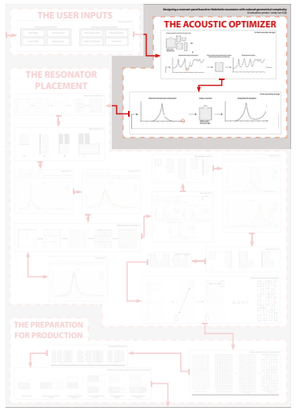


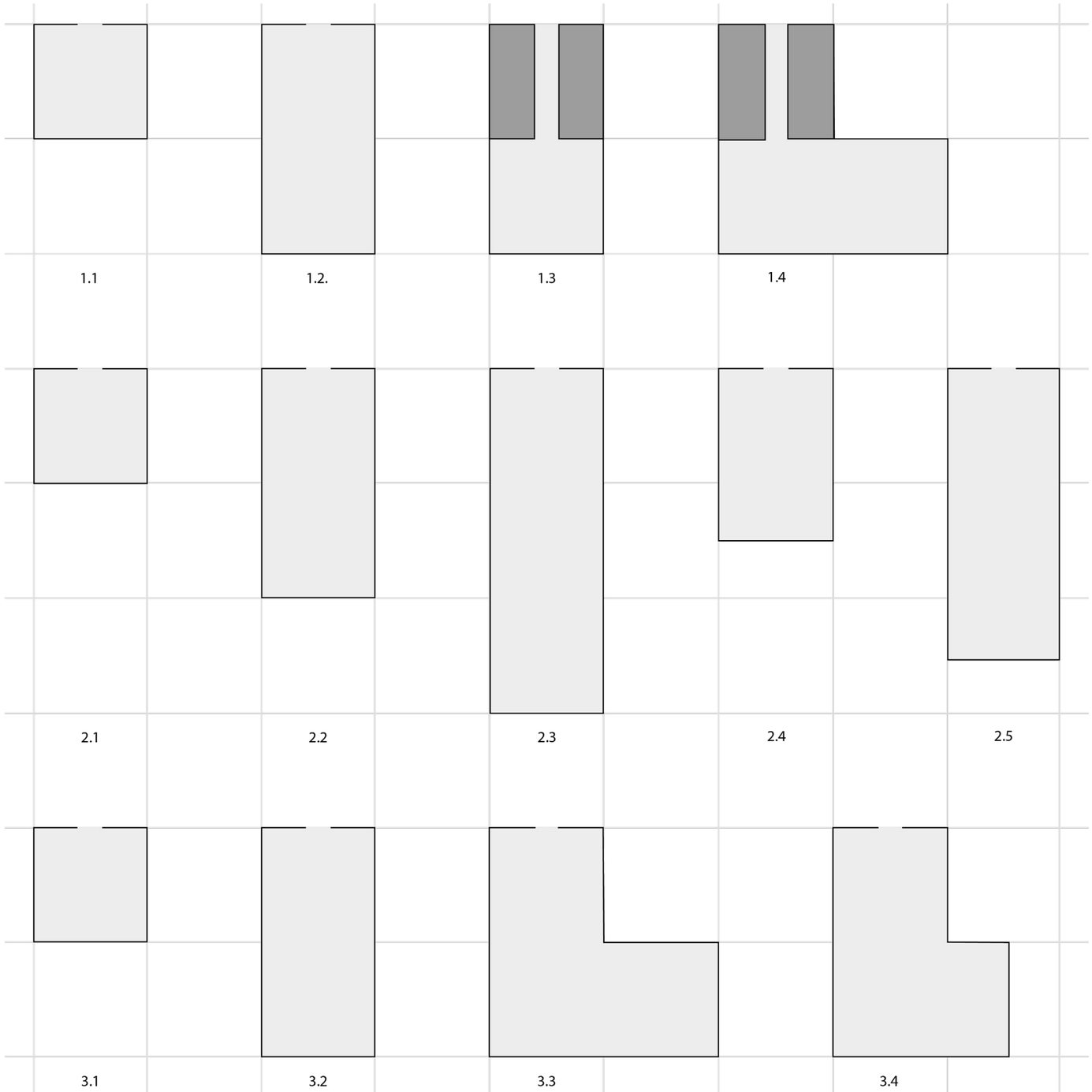
DESIGN GOALS FOR THE RESONATORS:

- PAKCABLE DIMENTIONS
- MINIMAL THICKNESS FOR THE PANEL
- GOOD SPREAD OF CAVITY VOLUMES
- MINIMAL MATERIAL USAGE

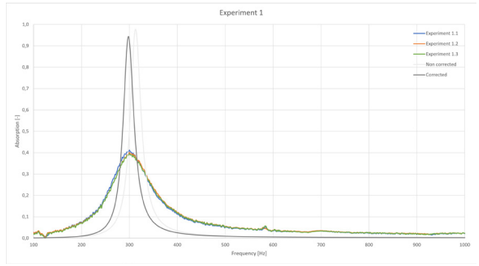


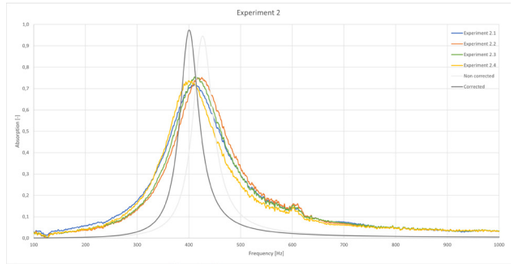
DEVELOPMENT OF THE RESONATOR SET

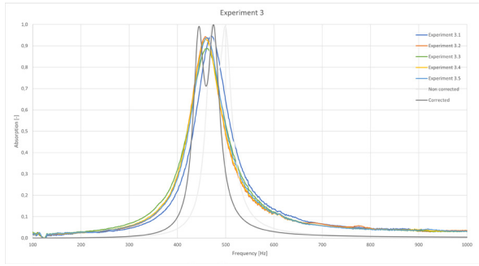


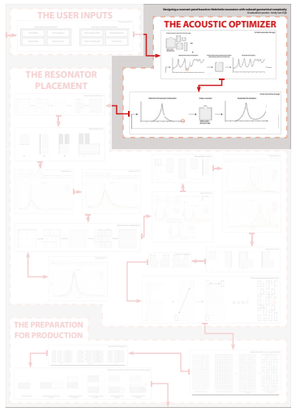


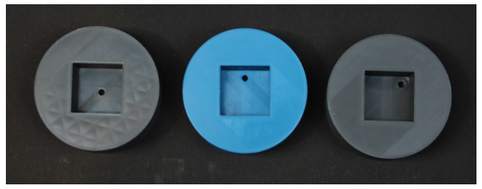
EXPERIMENTS

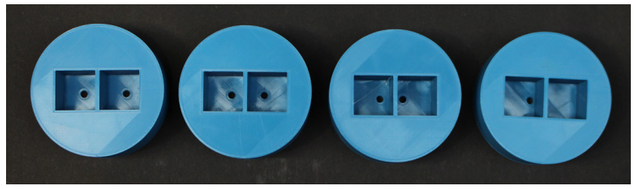


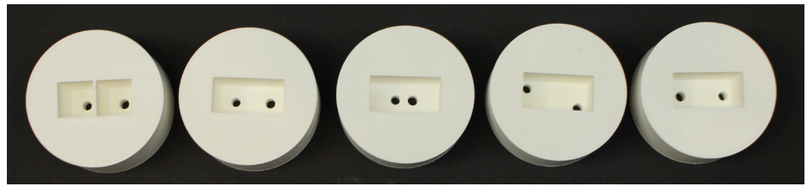


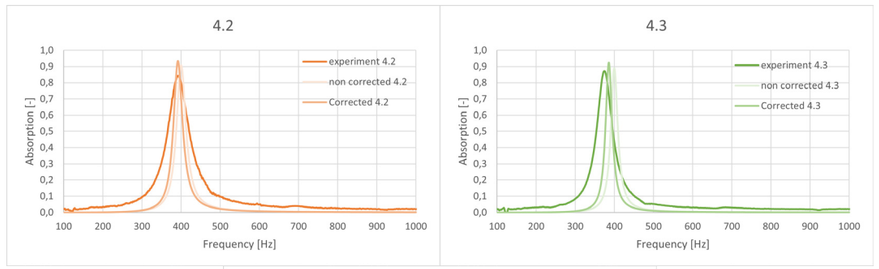


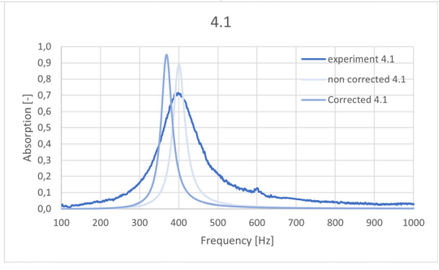


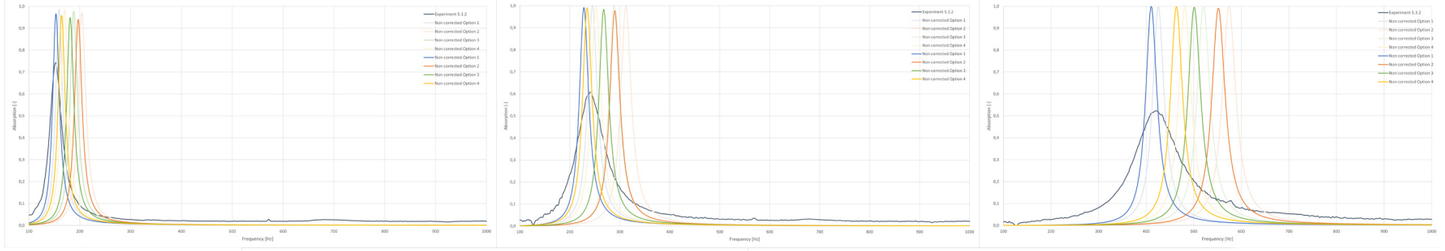


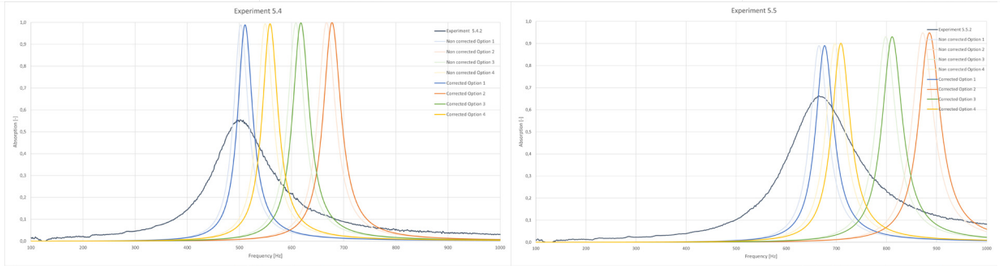


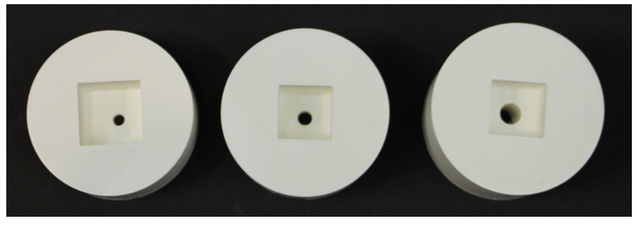


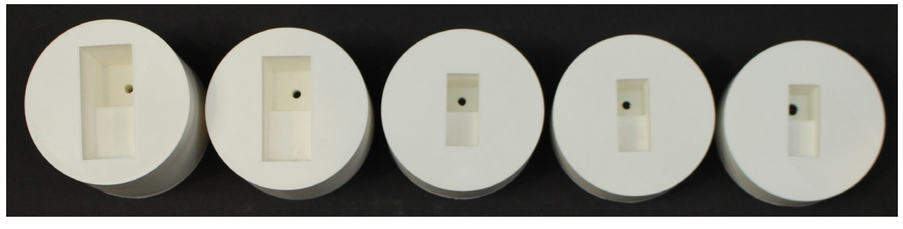




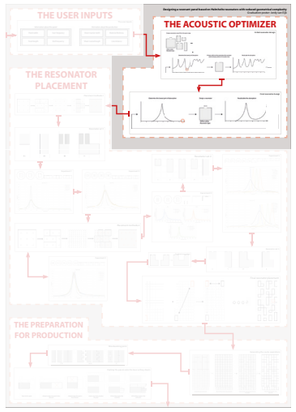






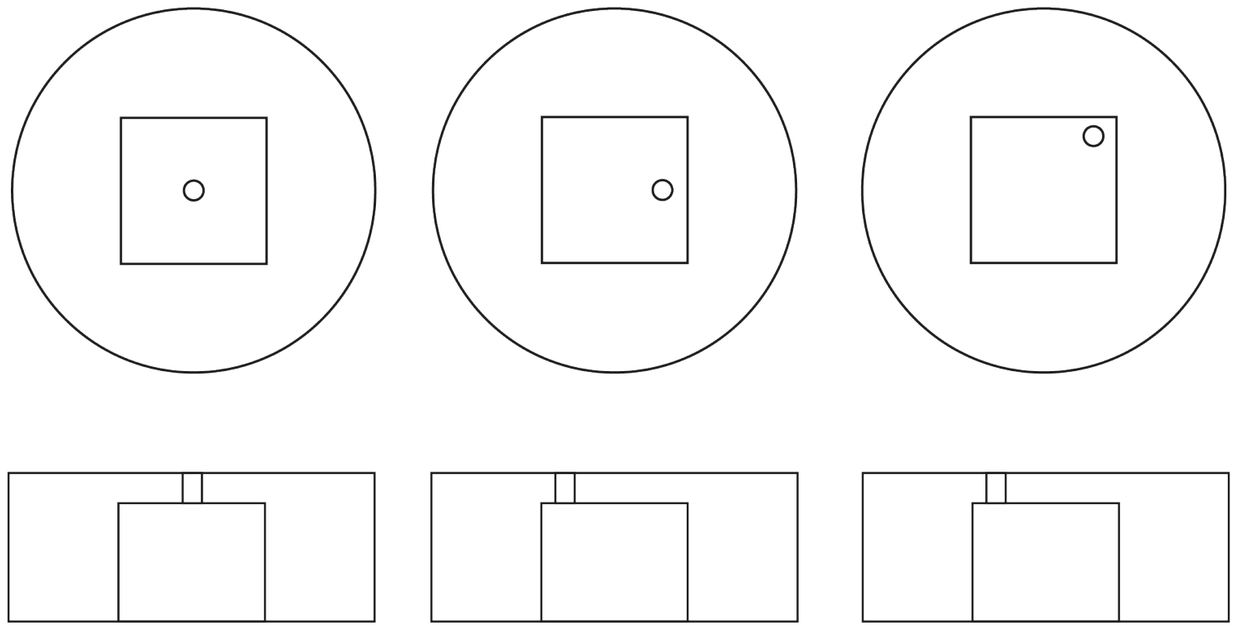


EXPERIMENT 1

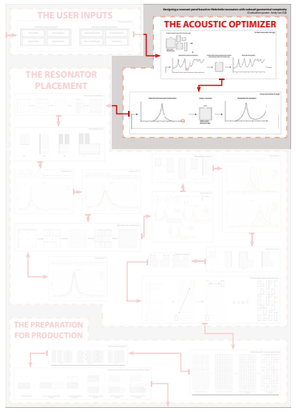


Experiment 1: location of the neck compared to the cavity.

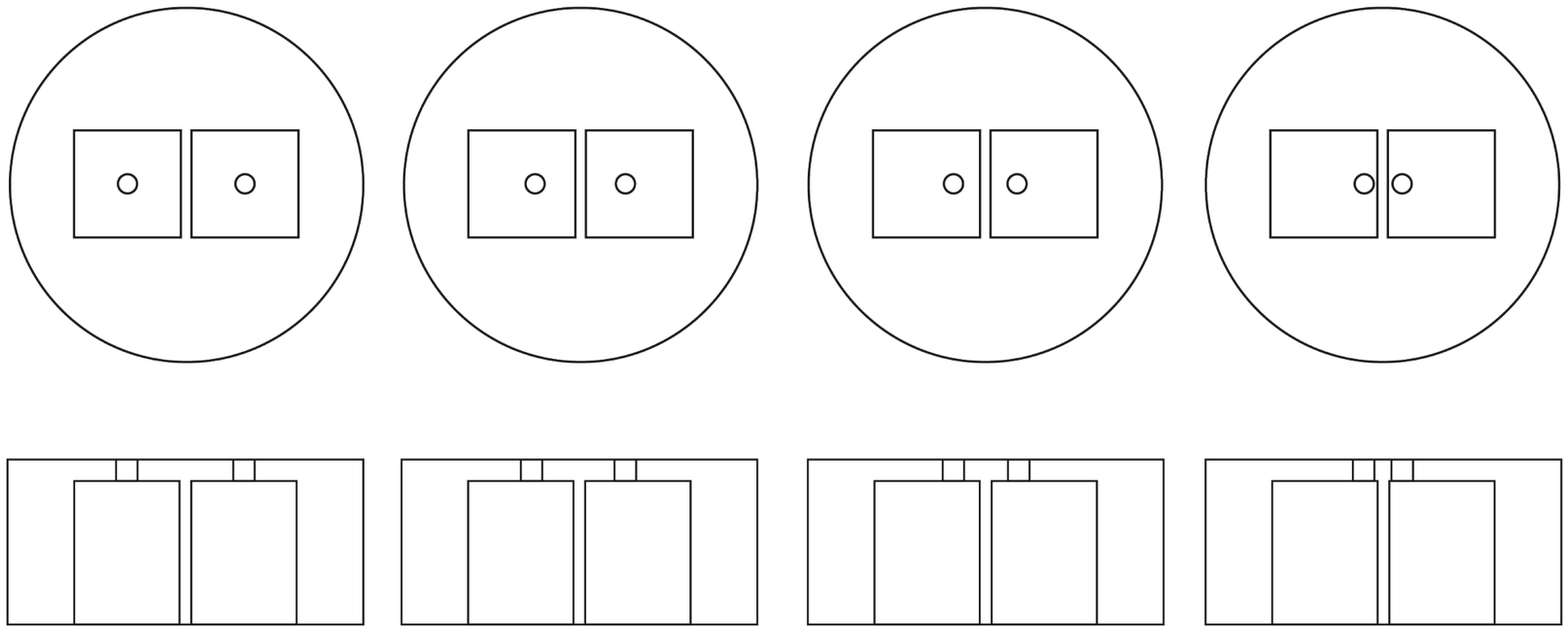
The location of the neck only has a very slight effect on the performance of the resonator.



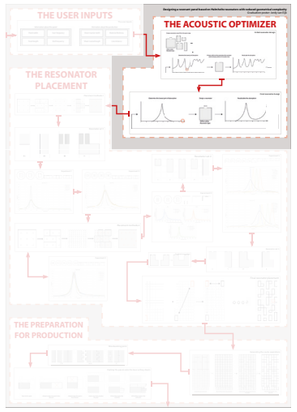
EXPERIMENT 2



Experiment 2: the cross talk effect.
The closer the orifices of two resonators are together the larger the cross talk effect is. However the effect is rather small.

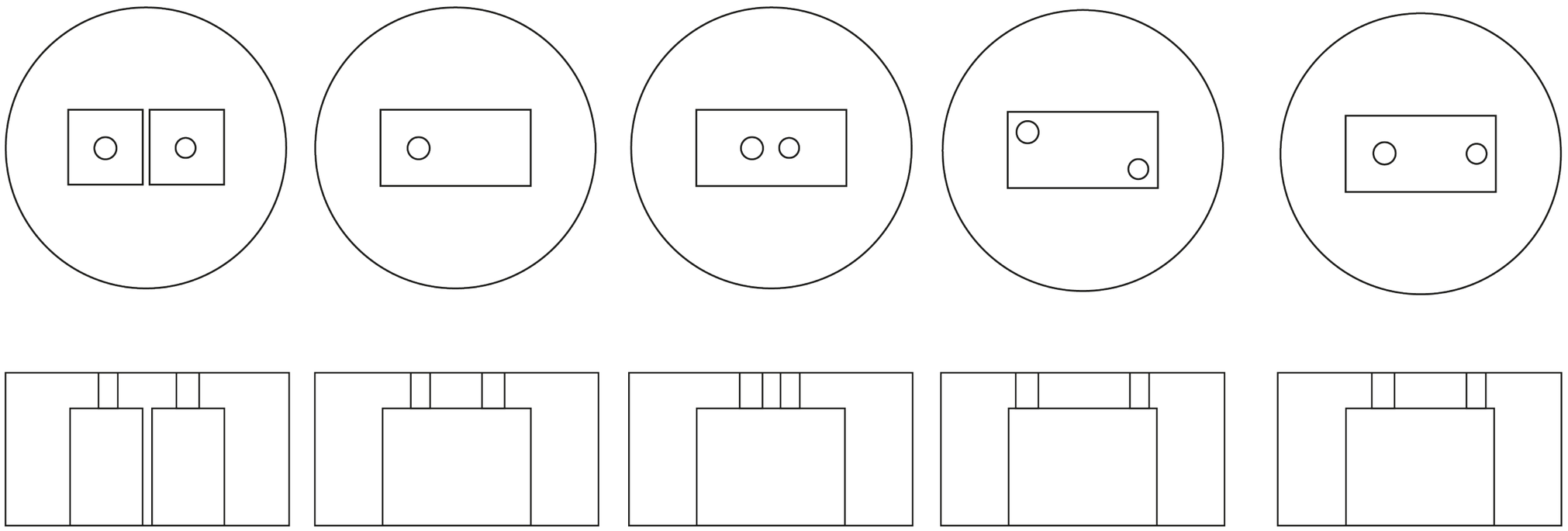


EXPERIMENT 3

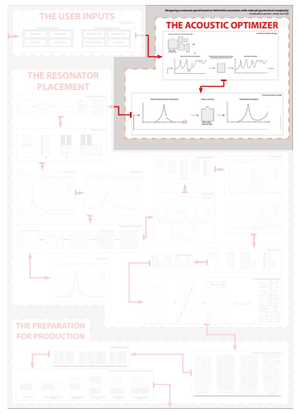


Experiment 3: the effect of the cavity separation between two resonators.

The cavity separation can be removed without a large effect on the absorption of the resonators. The location of the orifices can even be placed non symmetrical in the cavity.

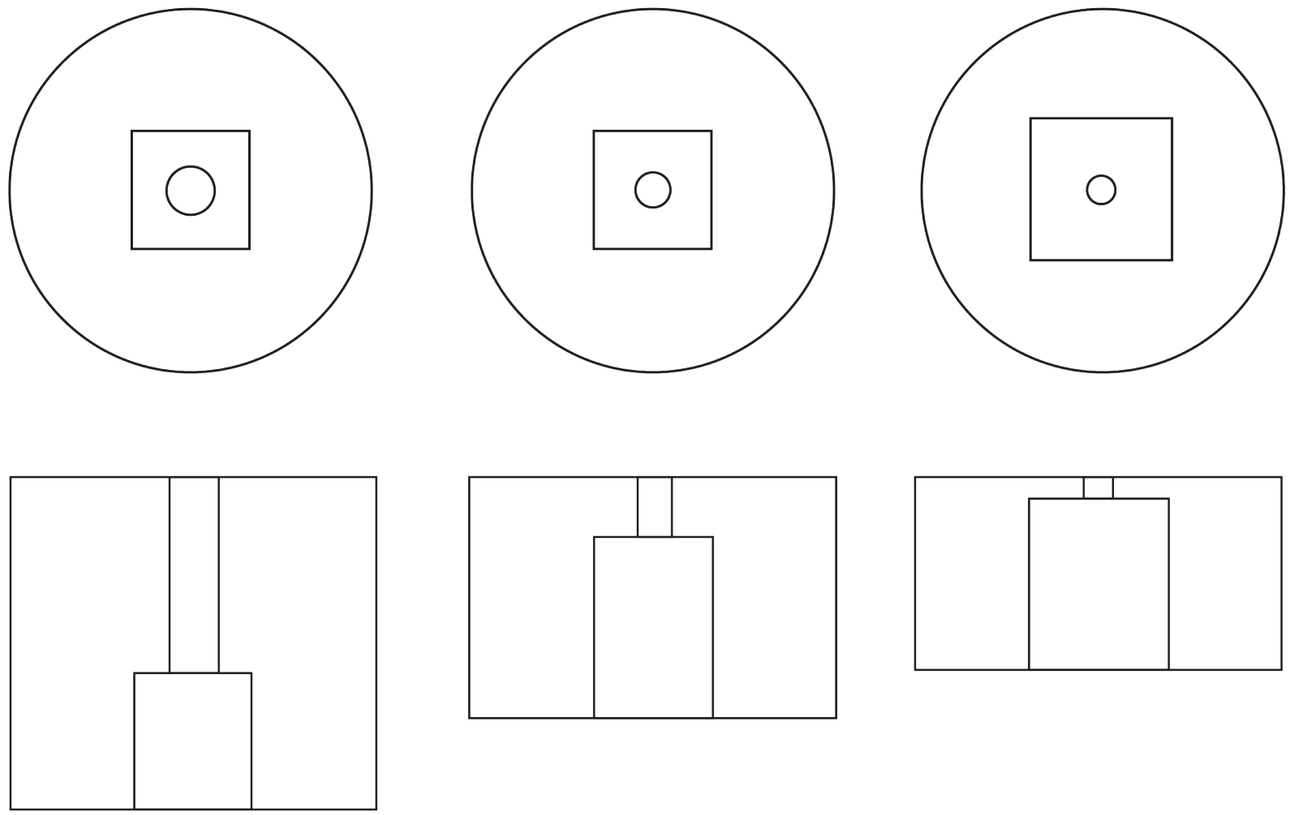


EXPERIMENT 4

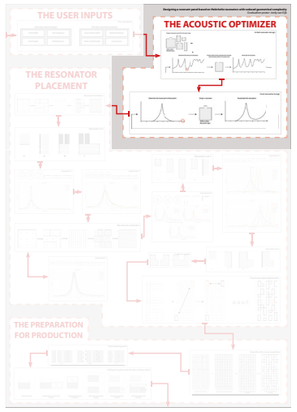


Experiment 4: The effect of the neck length on the width of the absorption curve.

The longer the neck of the resonator is the thinner the absorption curve is.

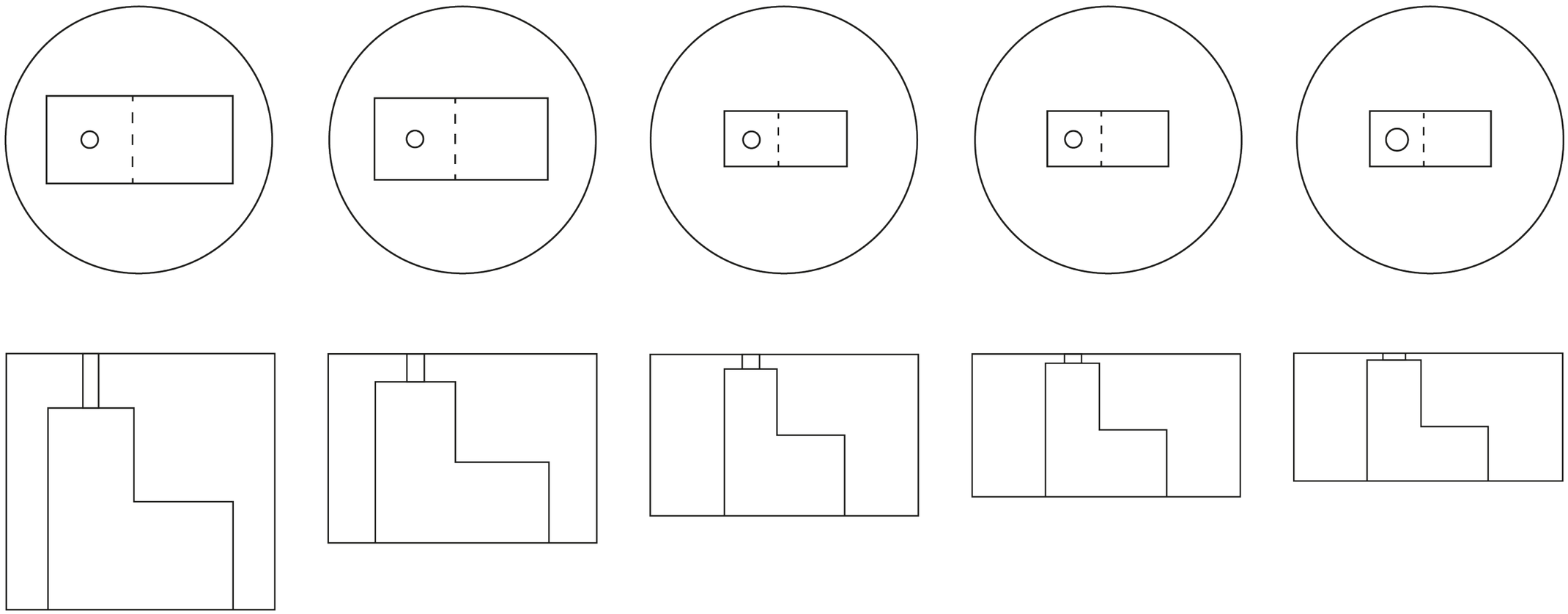


EXPERIMENT 5

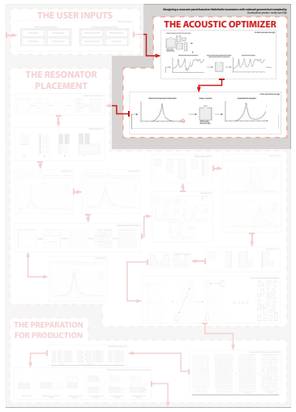


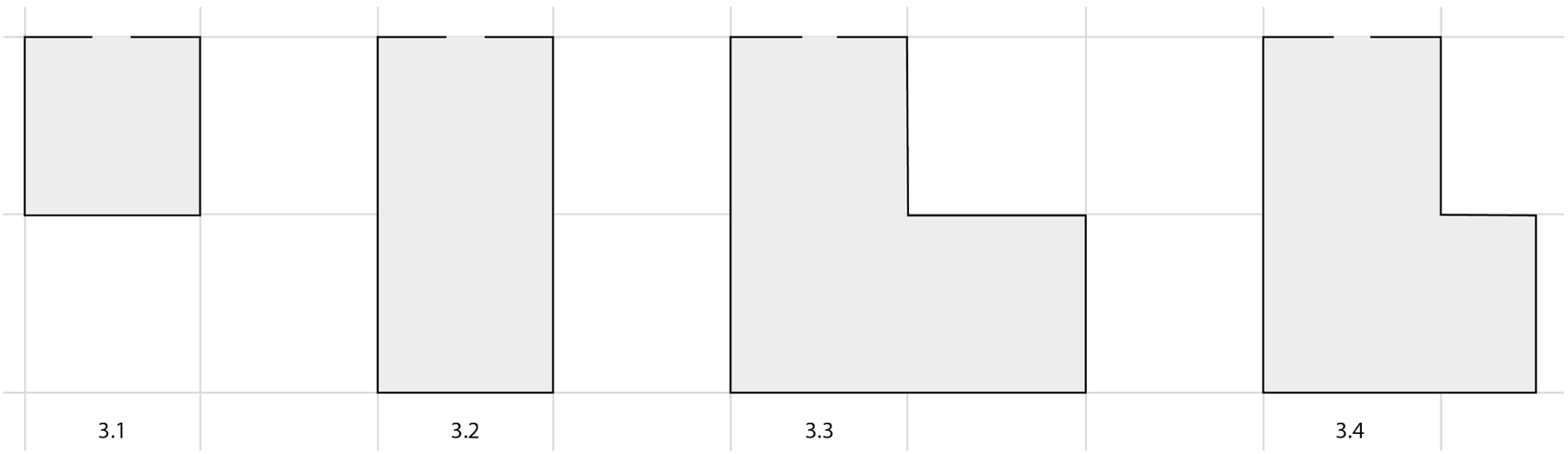
Experiment 5: The theoretical approximation of L shaped cavity's.

The impedance of a L shaped cavity can be approximated by substituting the cavity with a cavity that has the same horizontal section as the original resonator had right below the orifice, but with a greater depth to compensate for the volume of the resonator.



RESONATOR SET

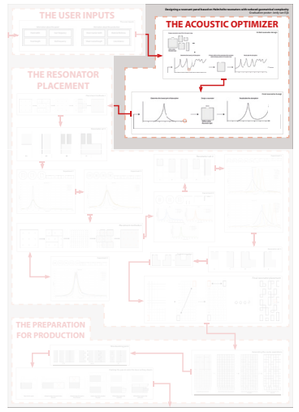


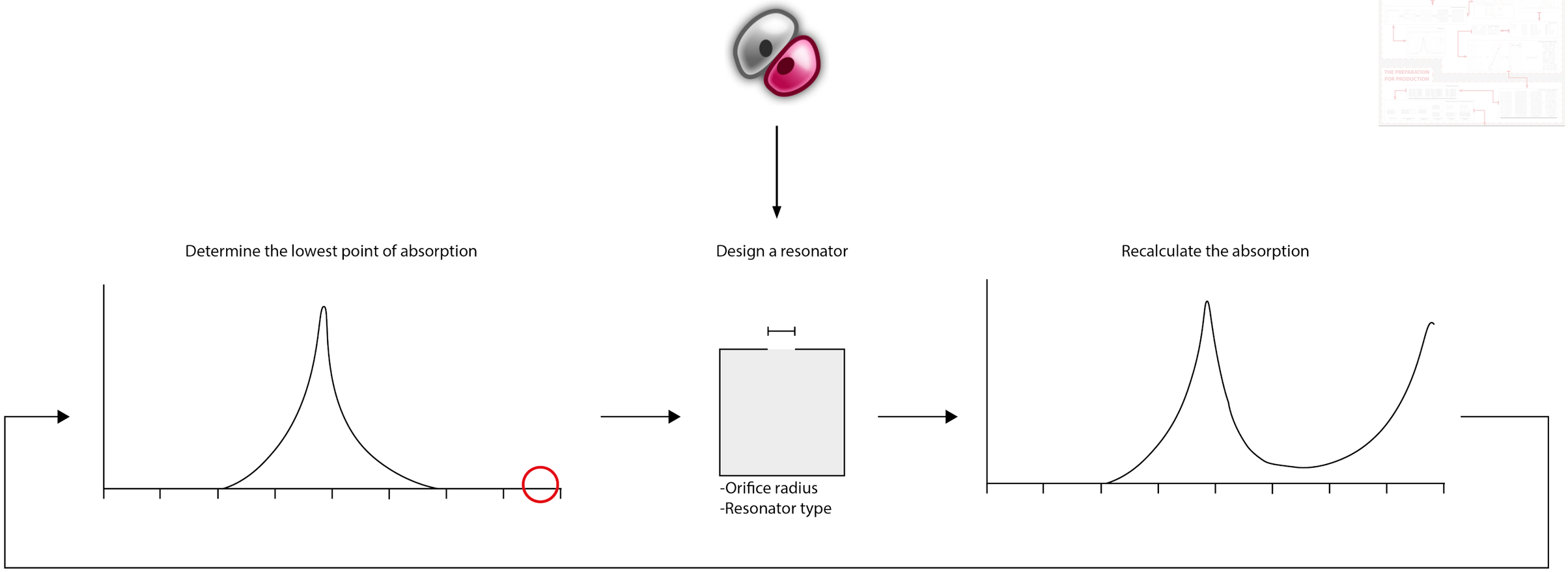


DESIGN GOALS FOR THE RESONATORS:

- PAKCABLE DIMENTIONS
- MINIMAL THICKNESS FOR THE PANEL
- GOOD SPREAD OF CAVITY VOLUMES
- MINIMAL MATERIAL USAGE

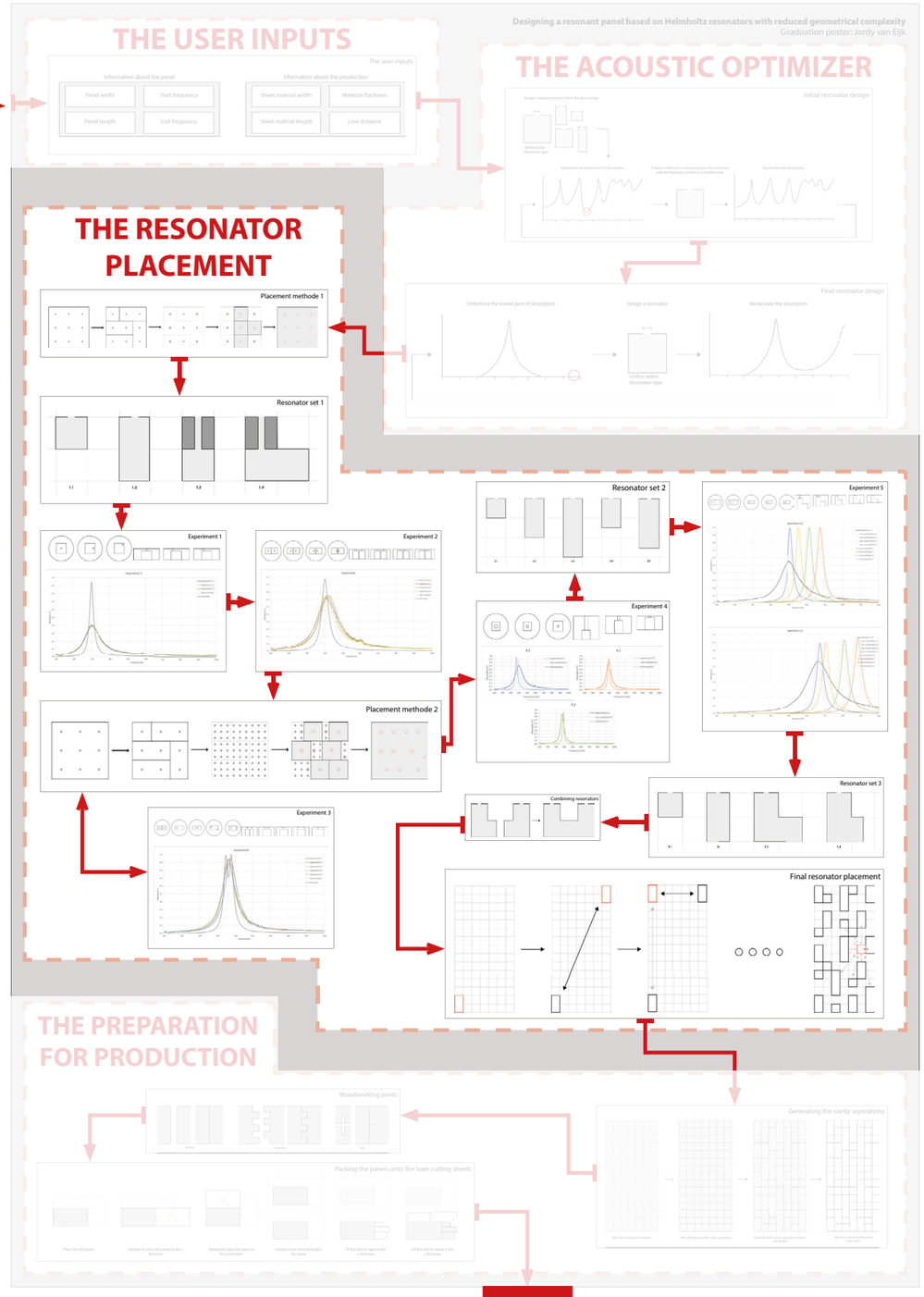
RESONATOR CALCULATION



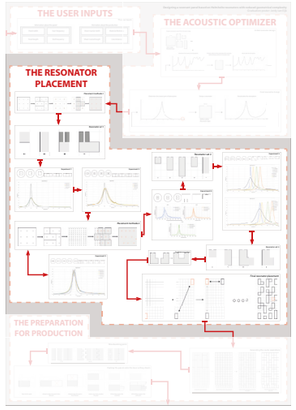


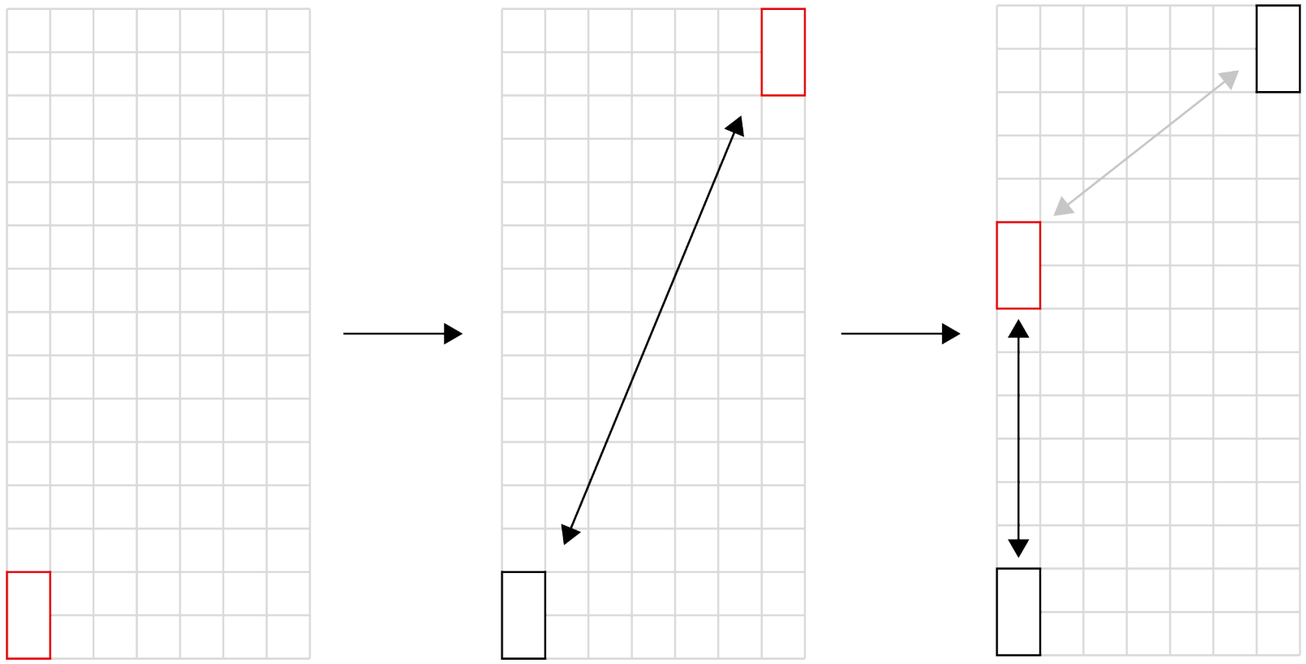
SCORE

THE RESONATOR PLACEMENT

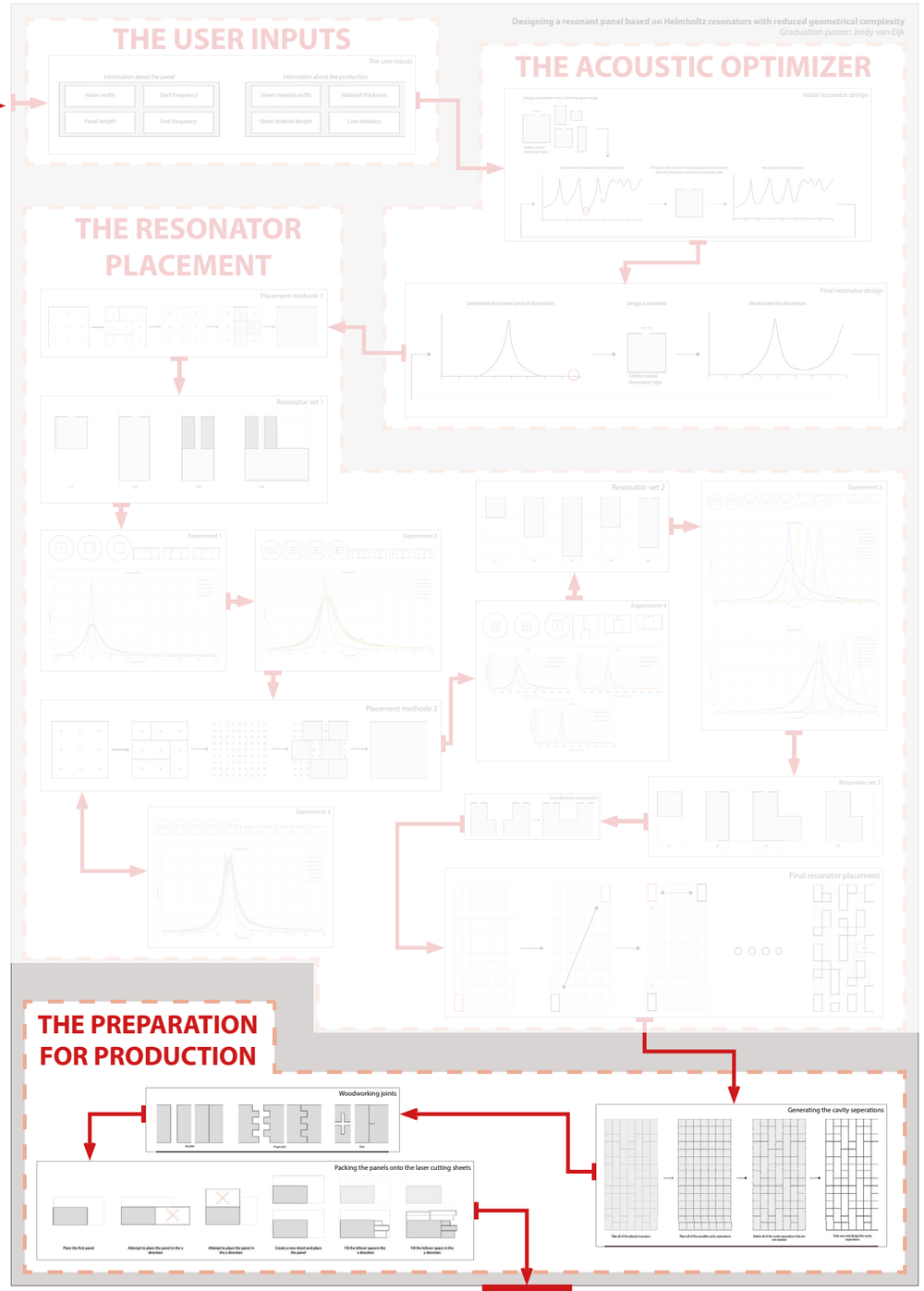


RESONATOR PLACEMENT

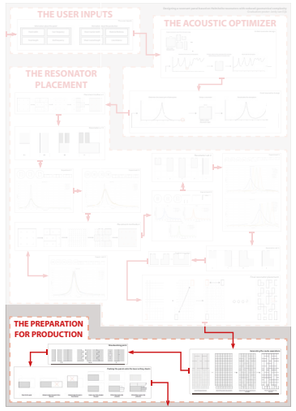


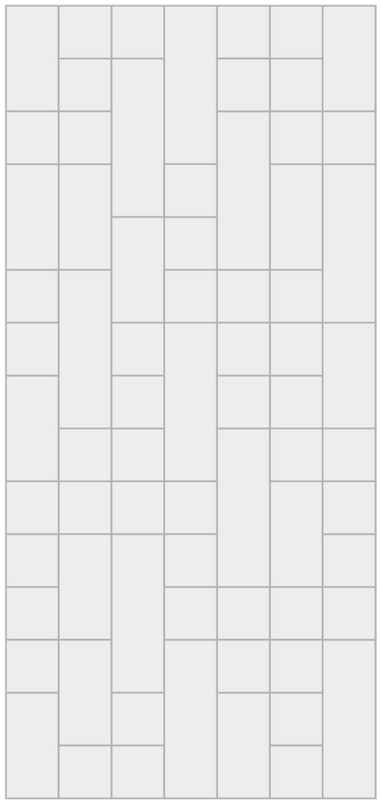


THE PREPARATION FOR PRODUCTION

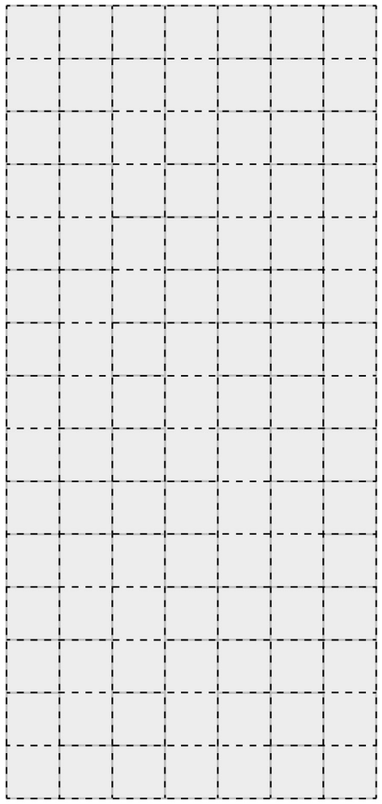


GENERATING CAVITY SEPERATIONS

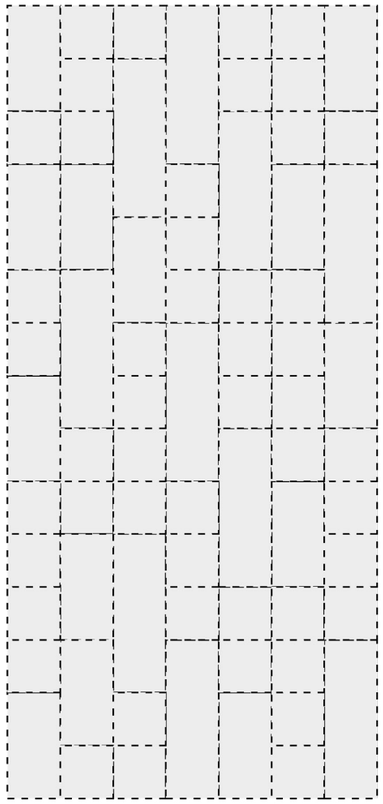




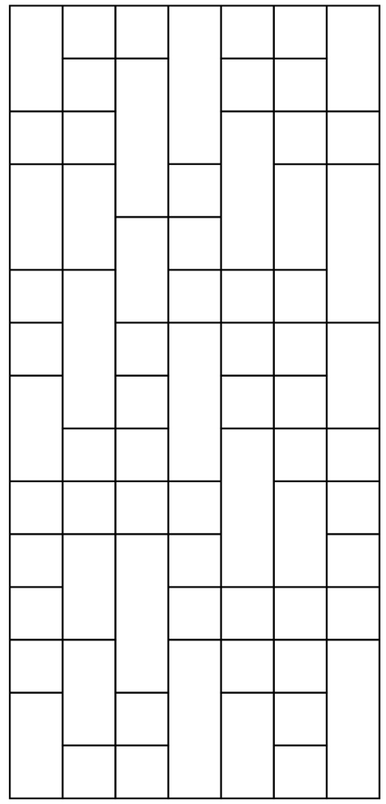
Take all of the placed resonators



Place all of the possible cavity seperations

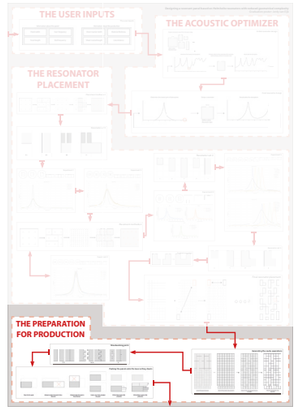


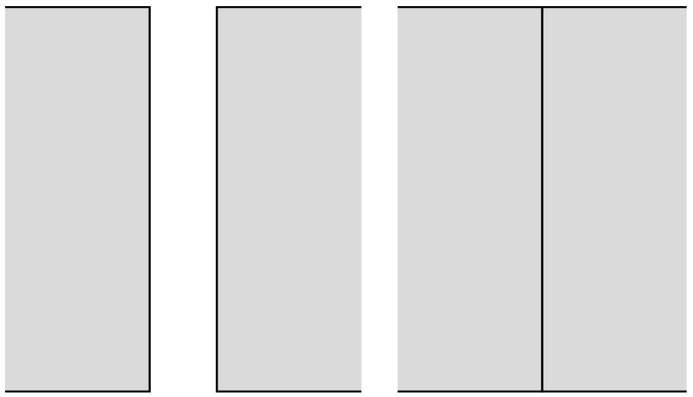
Delete all of the cavity seperations that are not needed



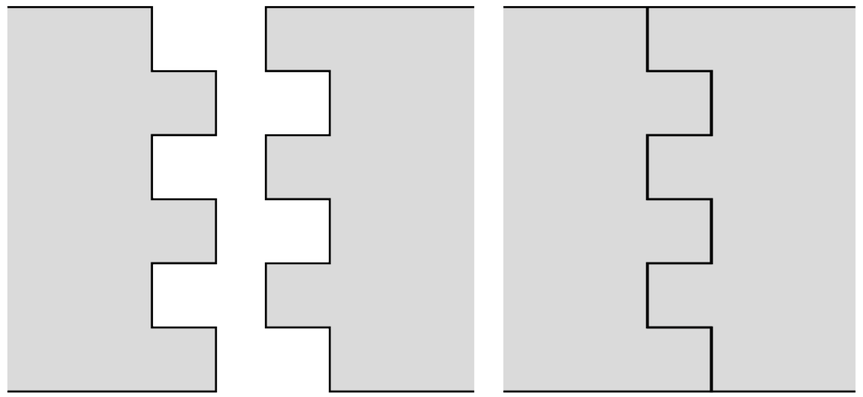
Only save and design the cavity seperations

WOODWORKING JOINTS

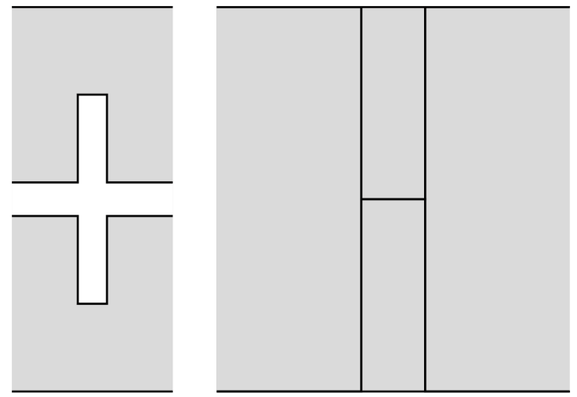




But joint

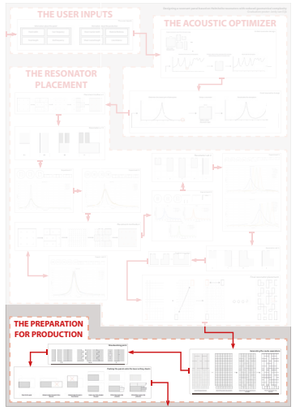


Finger joint



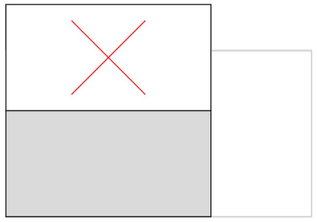
Slots

PACKING THE PANELS

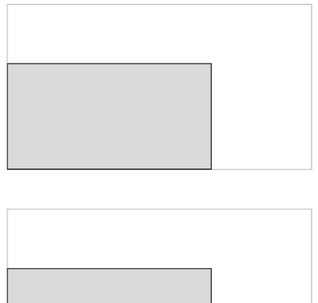


Place the first panel

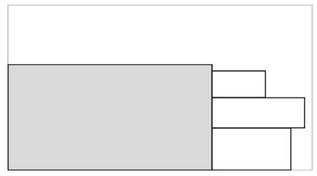
Attempt to place the panel in the x direction



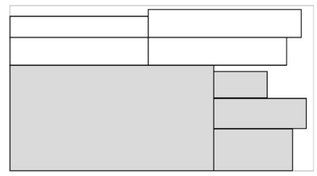
Attempt to place the panel in the y direction



Create a new sheet and place the panel

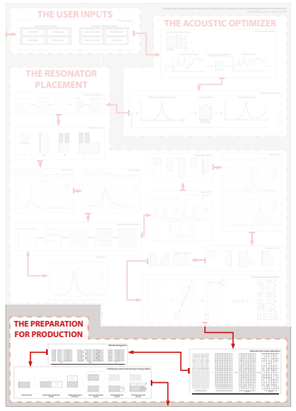


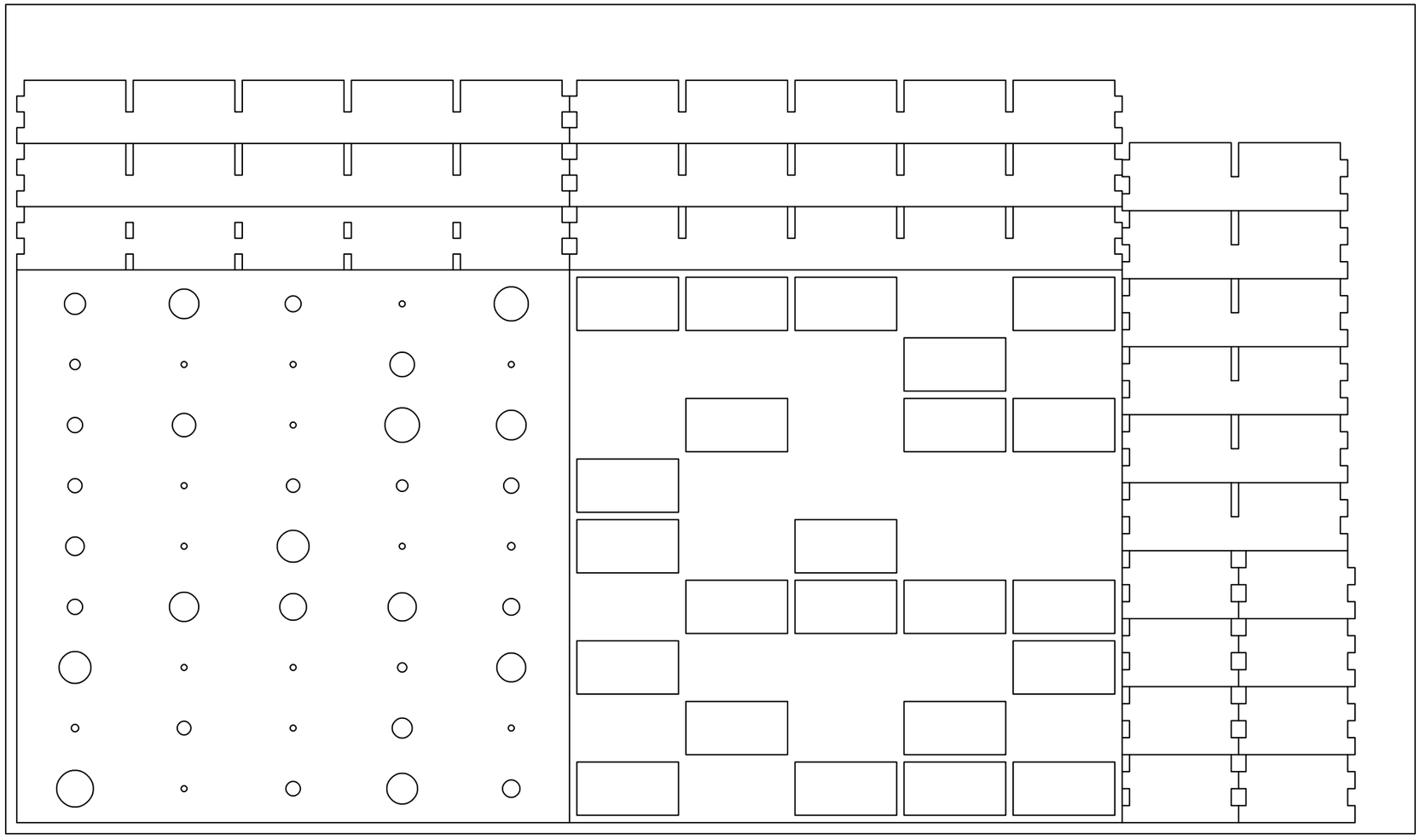
Fill the lefover space in the x direction



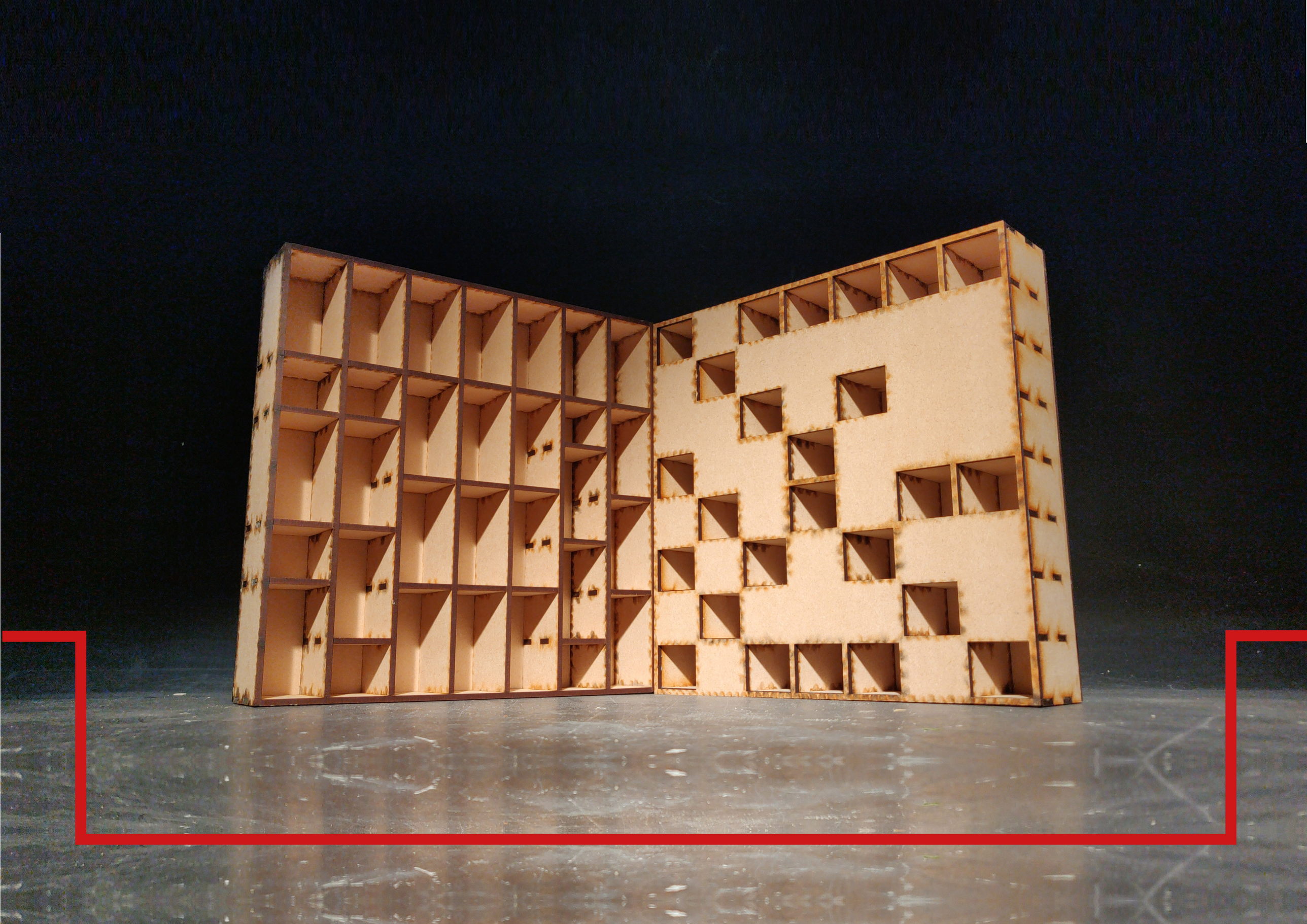
Fill the lefover space in the y direction

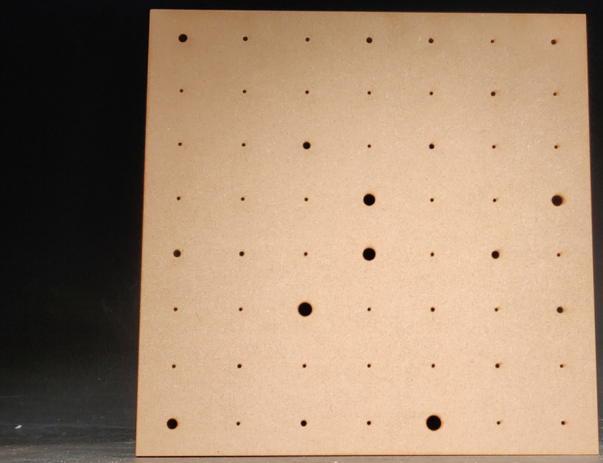
THE OUTPUT

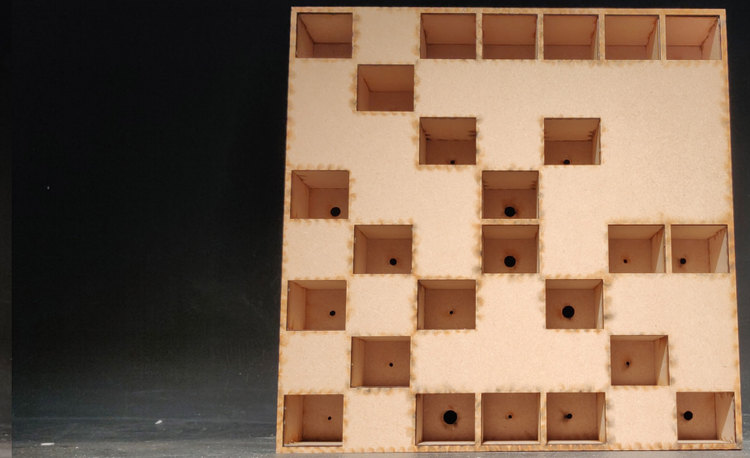

THE USER INPUTS
THE ACOUSTIC OPTIMIZER
THE RESONATOR PLACEMENT
THE PREPARATION FOR PRODUCTION

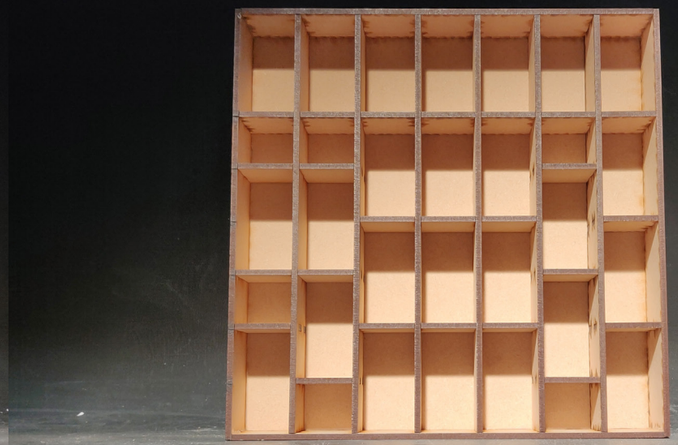


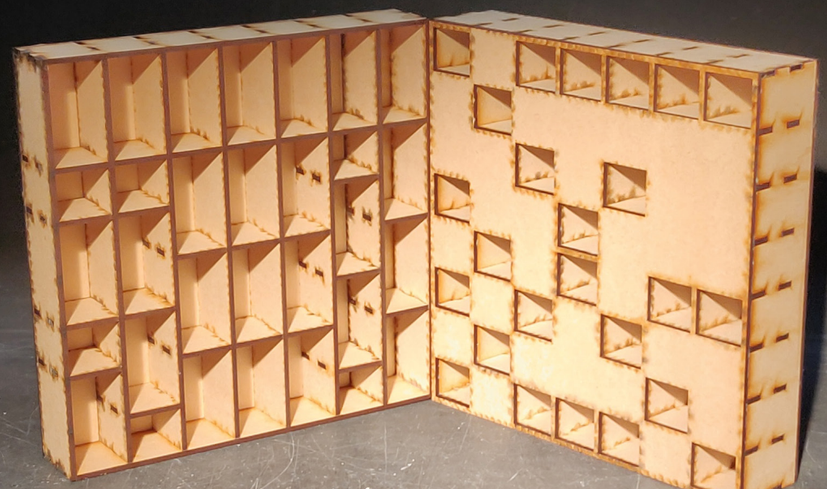
ASSEMBLY AND THE PHYSICAL MODELS

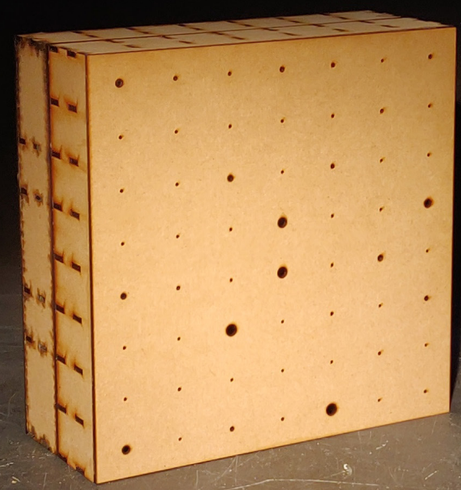




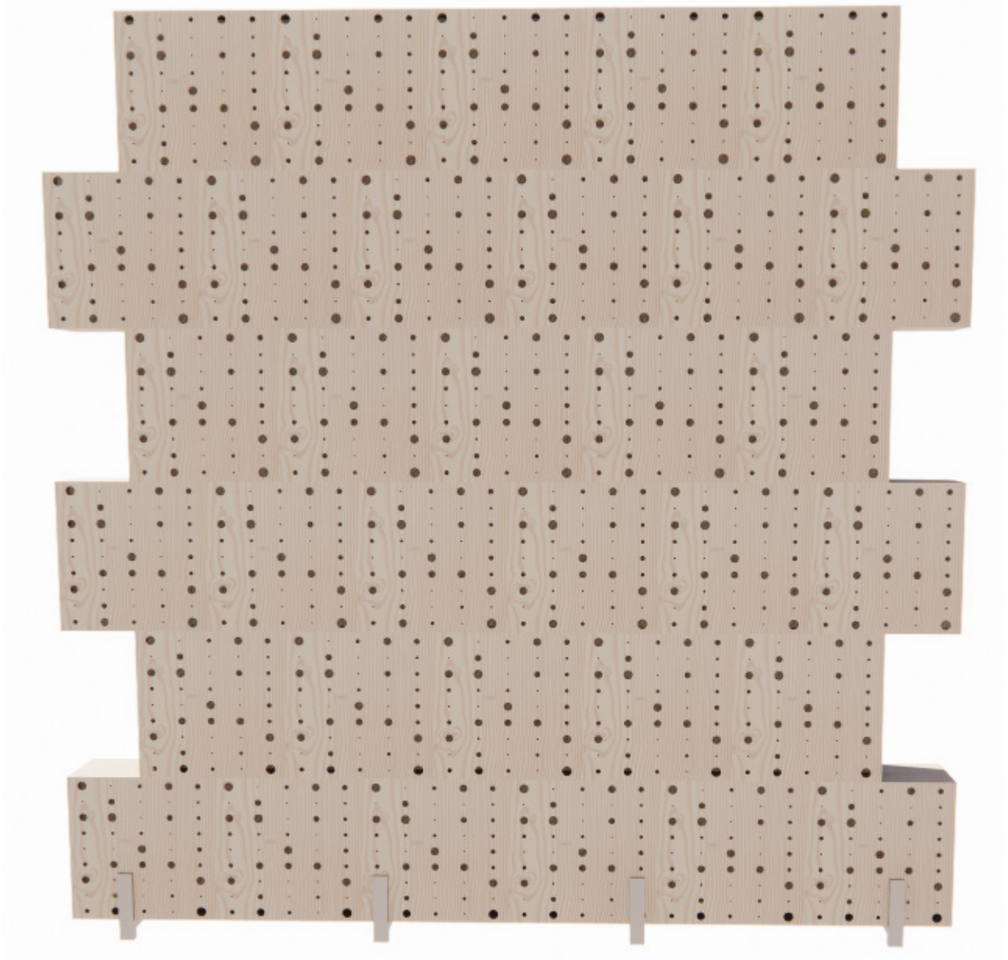








APLICATIONS AND RENDERS



CONCLUSION

CAN A PANEL BASED ON HELMHOLTZ RESONATORS BE DESIGNED WITH REDUCED GEOMETRICAL COMPLEXITY WHILE RETAINING A BROADBAND HIGH ABSORPTION COEFFIENT FOR LOW FREQUENIES?

CONCLUSION

CAN A PANEL BASED ON HELMHOLTZ RESONATORS BE DESIGNED WITH REDUCED GEOMETRICAL COMPLEXITY WHILE RETAINING A BROADBAND HIGH ABSORPTION COEFFIENT FOR LOW FREQUENIES?

YES, BUT.....

THE RESULTS SEEM VERY PROMISING BUT NEED TO BE VERIFIED WITH A PHYSICAL TEST

THANK YOU FOR YOUR ATTENTION