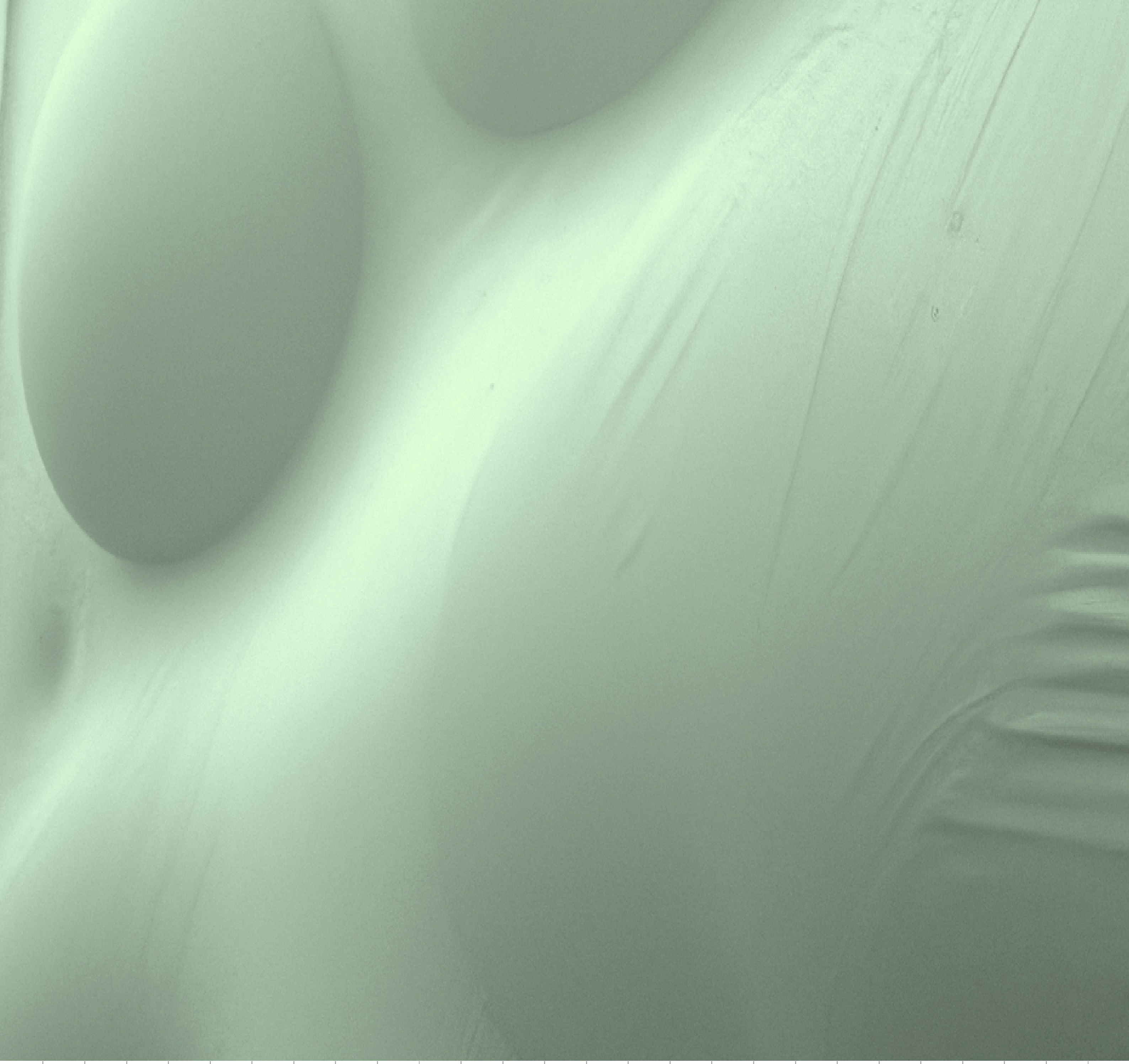


FELIX MALLINDER

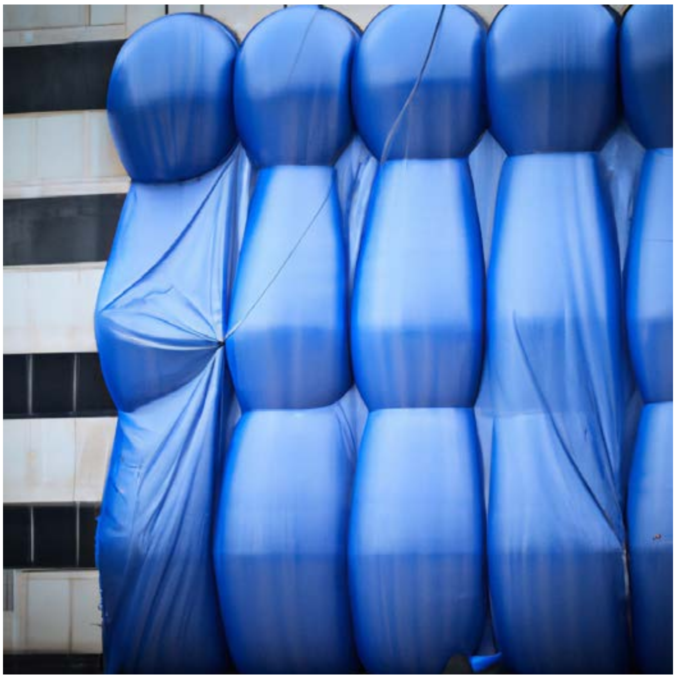
COMPUTATIONAL ARCHITECTURE

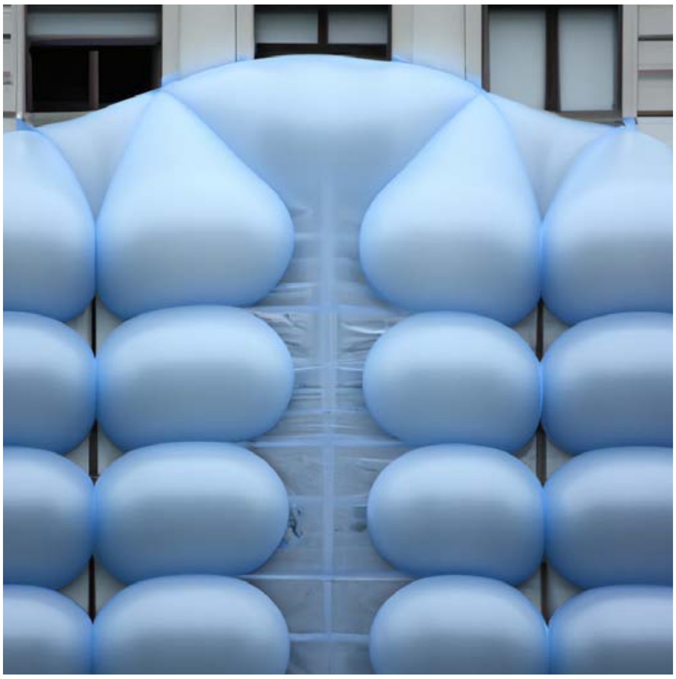
DESIGN RESEARCH 2023

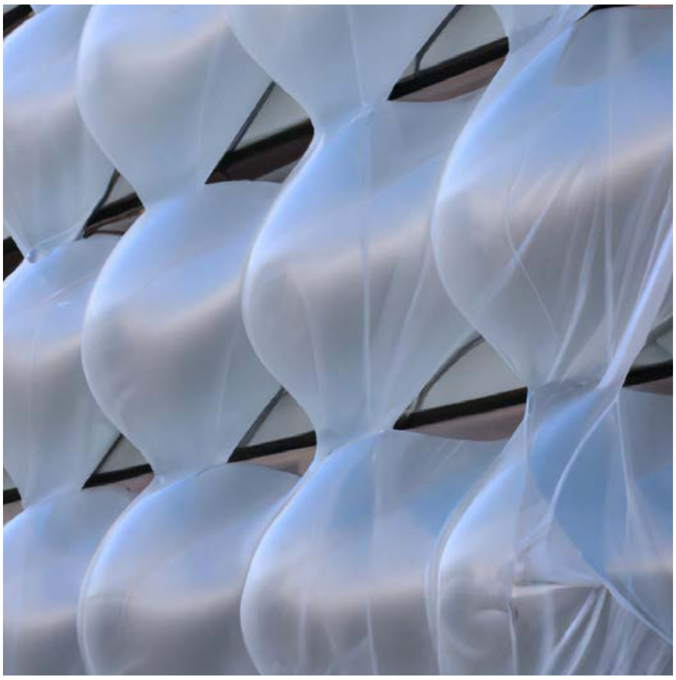
How can pattern logic influence volume variations in pneumatic façade systems ?

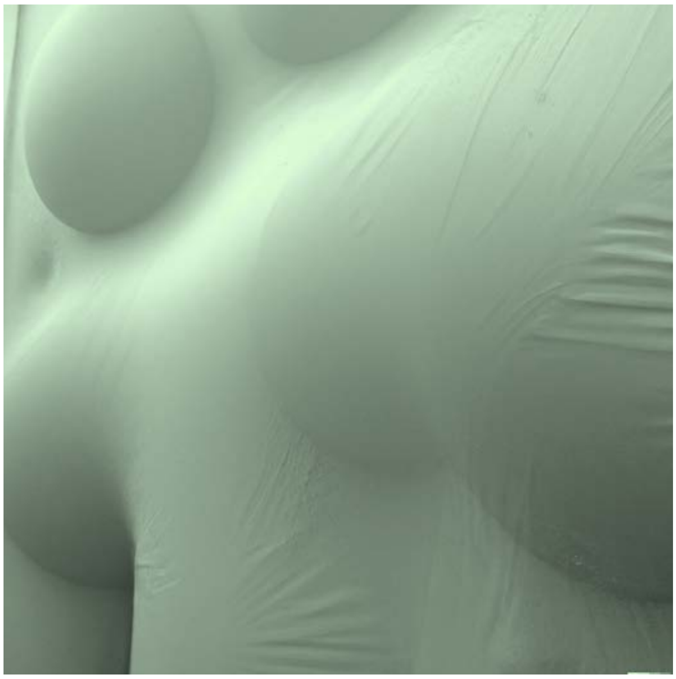
Felix Mallinder

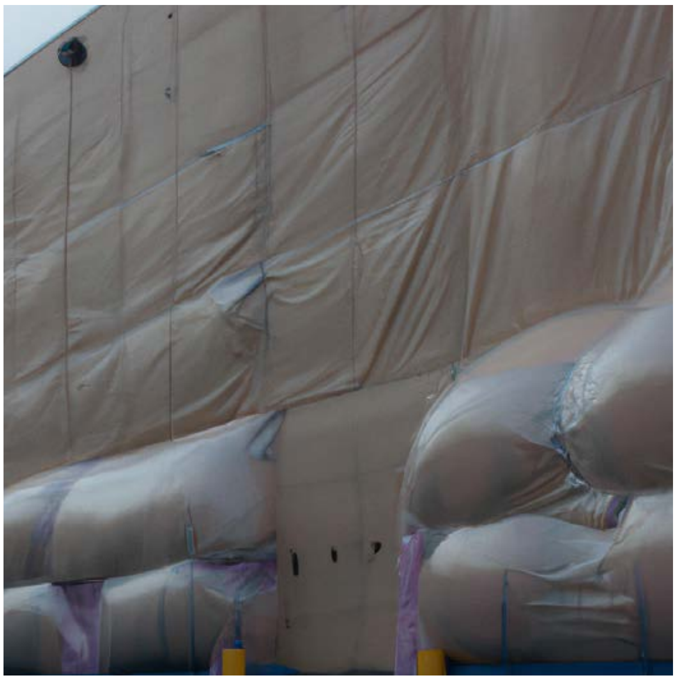
Contents











A1. Enviromental Context

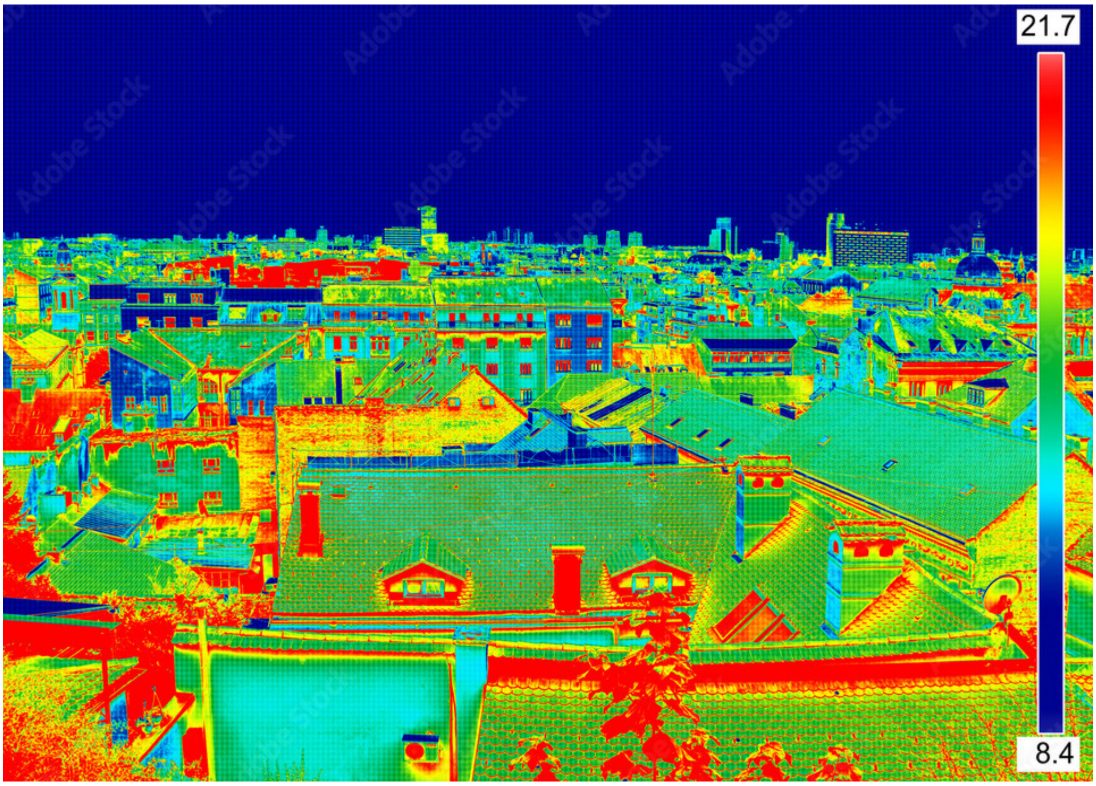
In the current era of ‘Great’ Britain, we are facing unaffordable energy bills, extreme levels of fuel poverty and thousands of people dying every year due to the cold in their own homes (Wakefield, 2021; ONS, 2022). This is made no easier by our impossible-to-heat buildings, of which 38% were built during or pre the 2nd world War, thus resulting in the ‘leakiest homes’ across Europe (Nicol et al., 2016). On average properties are losing over 3 degrees of heat every 5 hours (Atkins, 2022), way beyond the European average of 1.6%.

The bleak statistics on the current heat poverty of the UK lead to the intuitive and obvious solution, insulation. It is clear the whole country needs wrapped in a fiberglass blanket, to retain this unattainable heat loss.

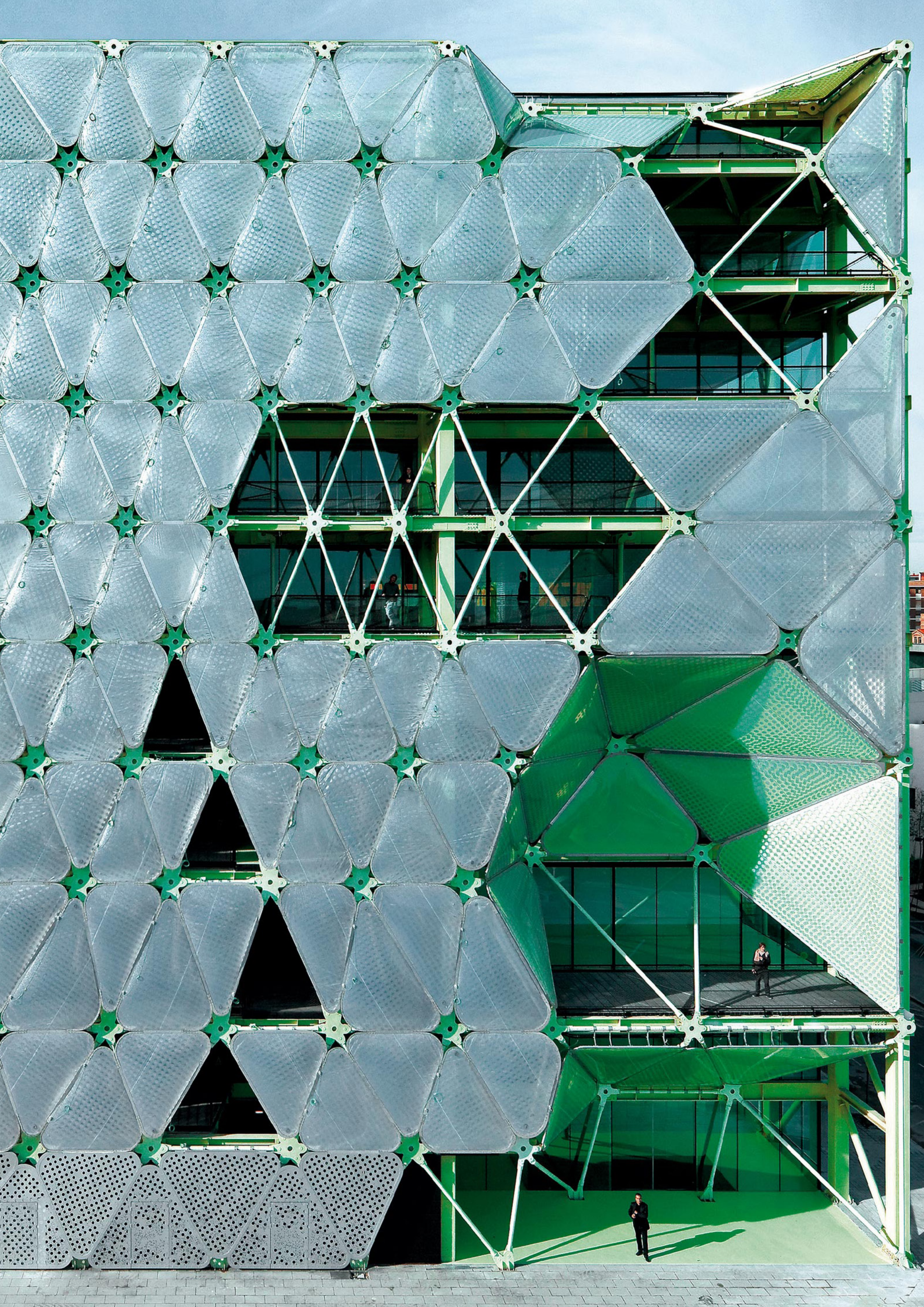
Sadly, there is a second challenge that prevents an easy application of this solution, Climate change.

Climate change has and will continue to cause harsher winters but equally cause hotter summers, and everything in-between. As a result, temperature fluctuation is occurring faster and more frequently than ever before (US EPA, 2016) – meaning our architecture is struggling to keep up with the increased heat as much as the harsher colds. This means that purely increasing the volume of insulation will have an adverse effect on the built environment’s adaption to temperature.

Heat changes from season to season but also from night now generate a diverse climate, of which tonnes of energy must be consumed to keep these buildings habitable. Something which itself, is unsustainable.



[1] Thermal Image Panorama, photograph by Smuki - Adobe Shutter Stock



A2. Inflation

The problem we look to solve now requires a dynamic solution. Insulation usually occurs in the form of fibreglass pillows packed in our walls, something which has very little dynamism.

Although similar thermal insulative properties can be achieved through air pockets, this is because air has a high specific heat capacity as well as a low thermal conductivity. Air pockets can be created from the not-so-novel method of inflation, the pneumatic principle can provide a dynamic and deployable application of insulation.

The development of a pneumatic façade system, controlled by a central air system would allow for a multi-state system, where the level and volume of insulation can be adapted to current climates and heat loadings. Providing a solution to the need for insulation whilst allowing cooling in hotter periods. This sort of dynamic solution will not only tackle the current challenges but better set us up for the inevitably worsening climate to come.

[2] Media TIC, Barcelona, photographed by Iwan Baan - arquitecturaviva

A3. Case Study

The best example of a successful implementation of a pneumatic system like the proposed solution, and perhaps the greatest inspiration of this project, is the Media TIC in Barcelona, by Enric Ruiz Geli.

This building effectively achieves a low operational energy demand due to the implementation of a pneumatic façade. Situated in Barcelona the primary function is to shield the building from extensive solar heat and light. It uses inflated ETFE panels in a pneumatic façade system to dynamically adapt to environmental conditions.

The system is built from a series of air pockets, multi-layered in ETFE sheeting, using an array of solar and thermal sensors the façade inflates, uniformly, about the environmental conditions. Although the primary gain of this system is for solar shading by implementing the discussed techniques of pneumatic inflation, it does achieve a vastly improved insulative performance from this low-energy approach (IAAC Blog, 2020). The resultant environmental impact is a 95% reduced Co2 footprint in operational efficiency (World Architects, 2017) – proving implementation of such a system can achieve effective results with a significantly reduced environmental impact.

This report proposes an abstraction of this logic for a retrofitted solution, instead of packing our old building with new insulation. The workflow will show how we can apply a dynamic, pneumatic system to existing areas of heat loss – providing that protective layering between a building and its environment.

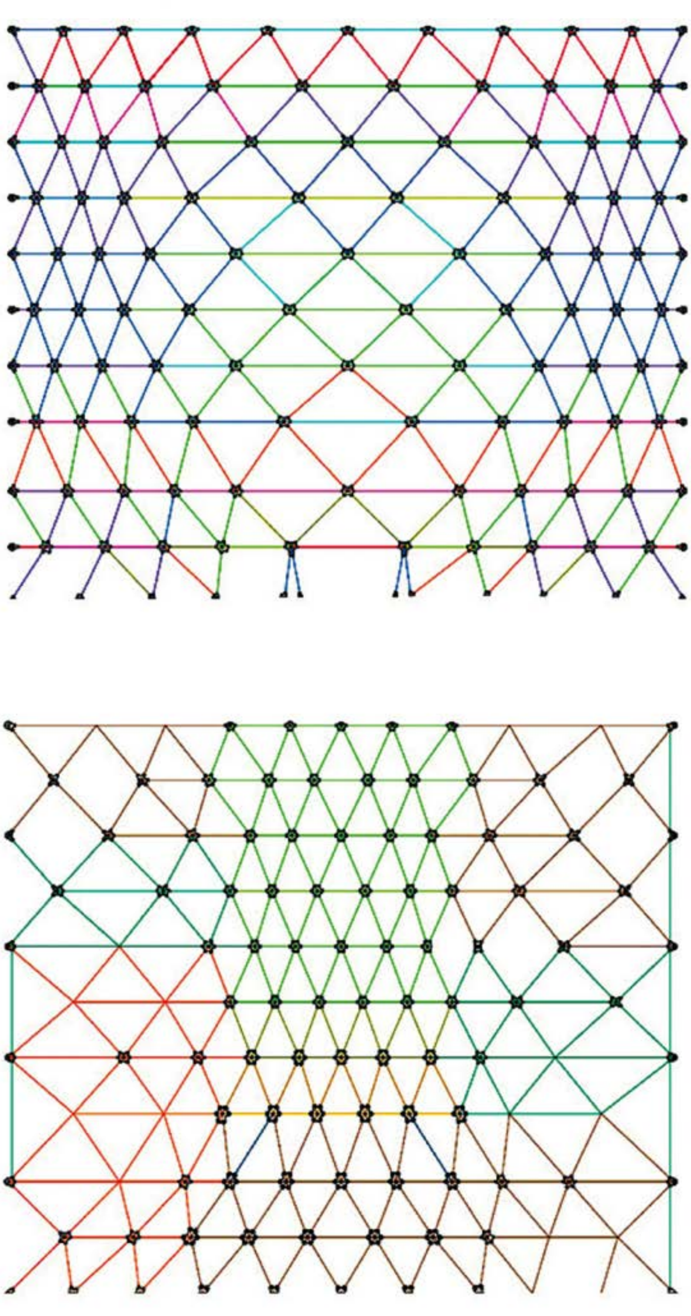
[3] Media TIC, Barcelona, photographed by Iwan Baan - arquitecturaviva

A4. Patterns

Built-in 2009, the building won 'World Building of the Year' in 2011 and was dubbed the 'Technological La Pedredra' - and it's not difficult to see the comparison of the system façade to works of Gaudi's iconic and intricate architecture through Barcelona.

Although the patterns of this steel façade system are what dictate the form of the façade 'cushions'. The unique challenge of creating a structure of this size with no internal columns was solved by this uniquely patterned structural system.

This project begs the question of how the pattern influences the performance of the pneumatic façade system, given a circumstance where the structural element is no longer an influence how could expression and exploration of the patterns improve or adjust the efficiencies of the systems?



[4] Structural Configuration of Media TIC Facades, Cloud 9

1. To develop a series of parametric scripts, which provide unique and exploratory pattern generations

2. To develeop and example a computational workflow which identifies and models the relationship between façade pattern and volume of inflation.

3. Test and optimise itterations of pattern design in context, in line with quantitative volume and spread calculations.

B1. Aims & Objectives

This exploration is a consideration of the logic, symbolism, and method of pattern forms in an abstract sense. As well as being a consideration for generative design application, the movement of results in context and how the harmonious adoption would allow for design improvements further from the standardised design.

The expectation of this research is not for a complete ad functioning configuration that is quantitatively greater than that of the Media TIC but instead produces an argument and workflow for the adoption of generative design and parametric exploration in design.

This is greatly important and valuable in the case of high tech & environmental performance architecture, as maximising the results and capacity of the building systems can only greater the goal and achievements of the architecture.

B2. Patterning

To achieve objective 1c - The focus is on robust parametric systems which allow large permutations of results, the greatest way to achieve this is starting simple. To do so I have abstracted simple systems in-volving a minimal input variable for large variation of results. Identifying the logic at the most organic level, how do we generate a line and how does the repetition generate a pattern? And what does the effects of this pattern present?

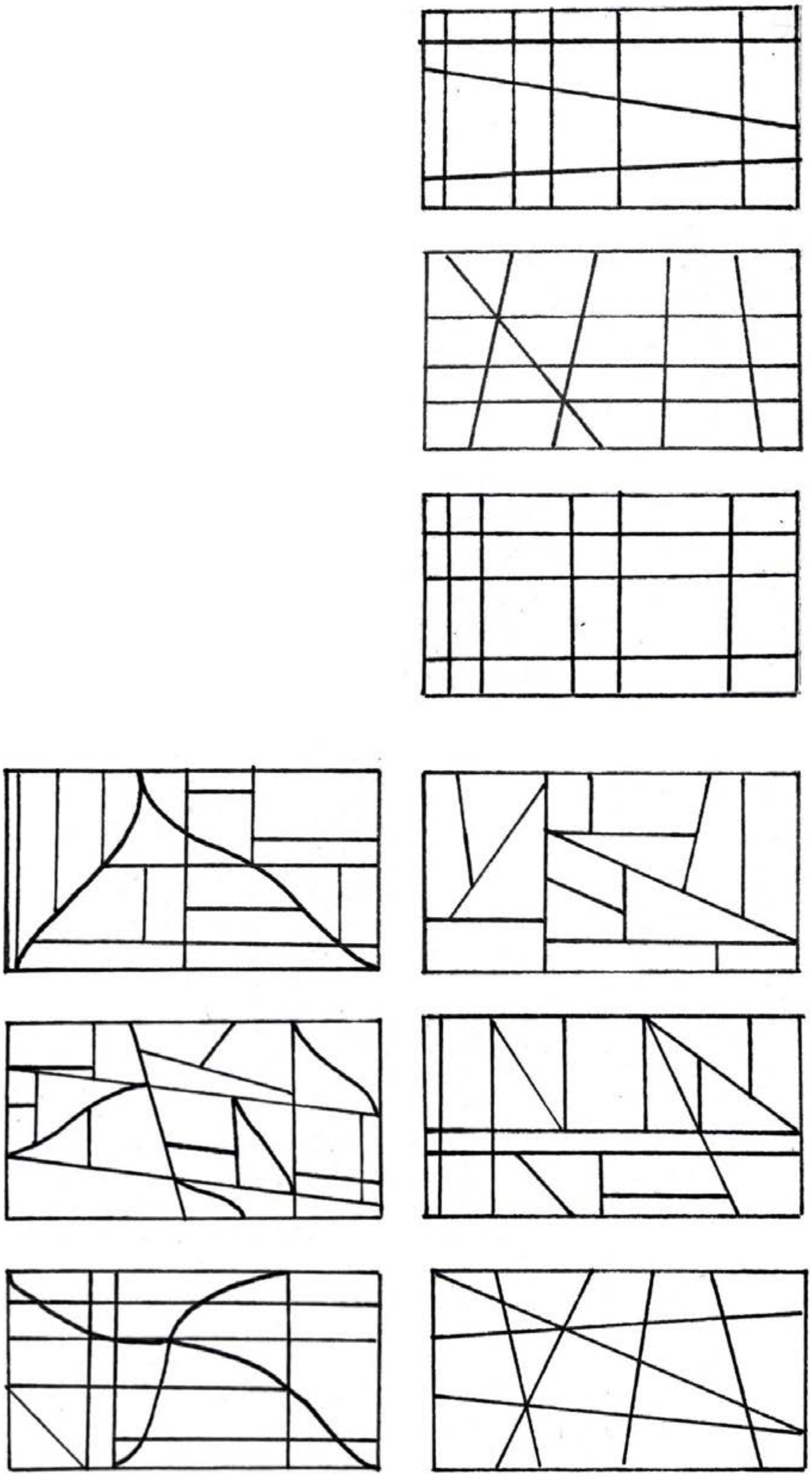
These systems come under 3 categories, which in turn are ideologies for understanding pattern logic and movement. Details of these categories, Lines, Points & Panels, and the permutations that exist within will follow but the logic is as such:

Lines are generated as the framework for patterns, in these cases we are studying straight and bisecting lines, controlling start and end points within a system to generate a lattice effect. The methods involved in the line orientated patterns are the most simplistic but hold the po-tential for robust generations.

Points give the inverse of the lines, instead of looking at the logic of the frame, what is the log-ic and relationship of the negative space between the lines, controlling these as points can open a purpose of movement and, importantly to this project opens a new avenue of permuta-tion and exploration.

The ideology of panels embodies the repetitiveness and sequencing of lines and points but in a new extra dimension, it allows the investigation to reach an exploration of less standardised geometry, it also opens a conversation about individual shape which encourages the logic of corners and angles, curves and dimensions, from a simplistic scale to be replicated in global geometric relationships.

The panelling investigations are a development born from the previous iterations & experi-ments, but informed by outside influences, from mathematical and cultural pattern influences. Combining this tried and tested logics for a new depth of complexity and then mixing this with the parametric work flows again accelerates the objective discovering new permutation and possibilities.

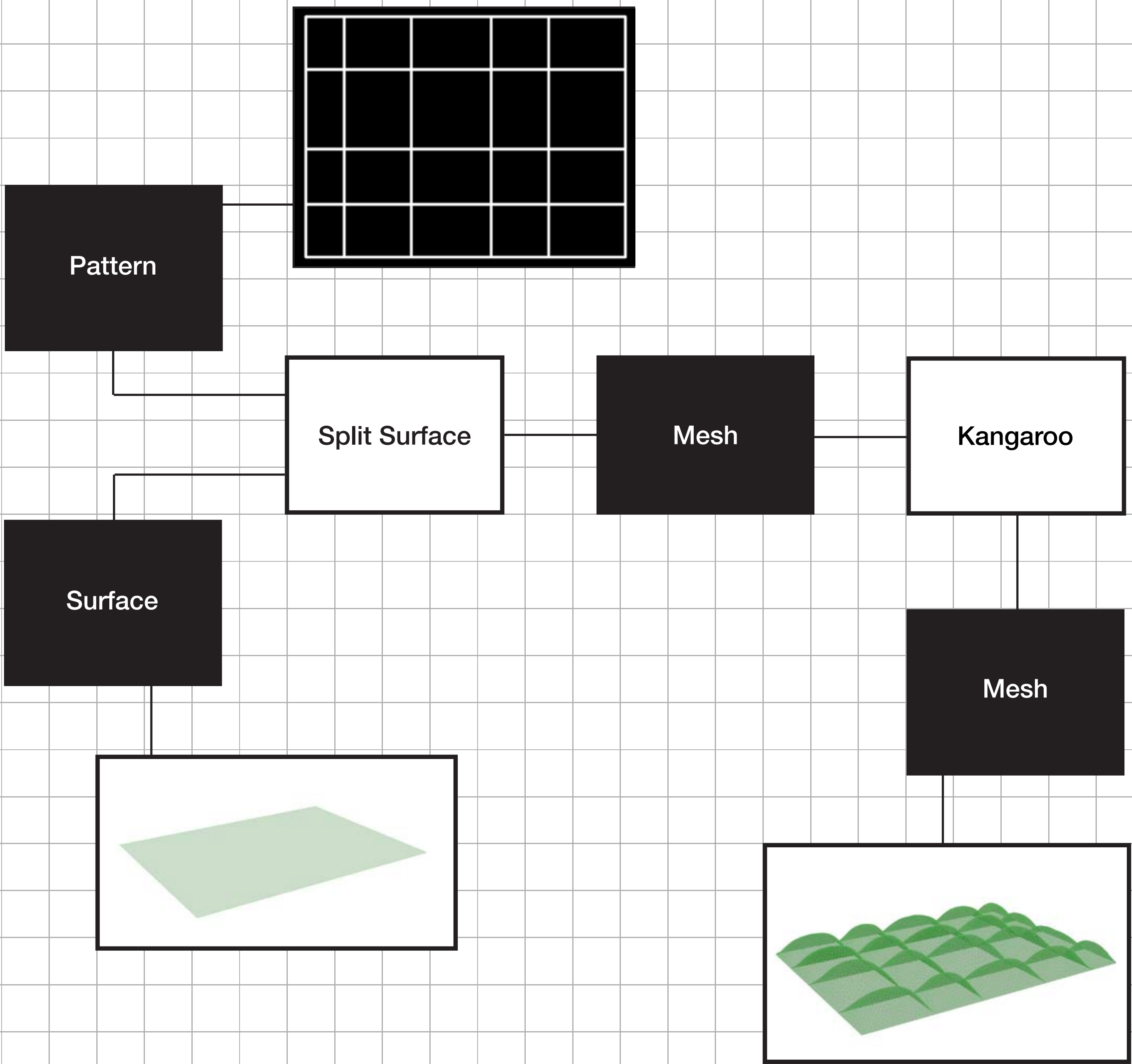


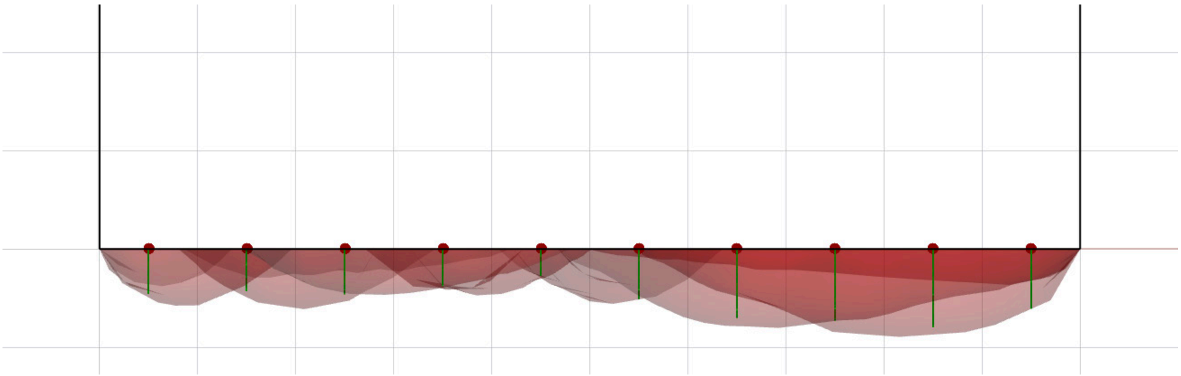
[5] Concept Sketches of patterned facade

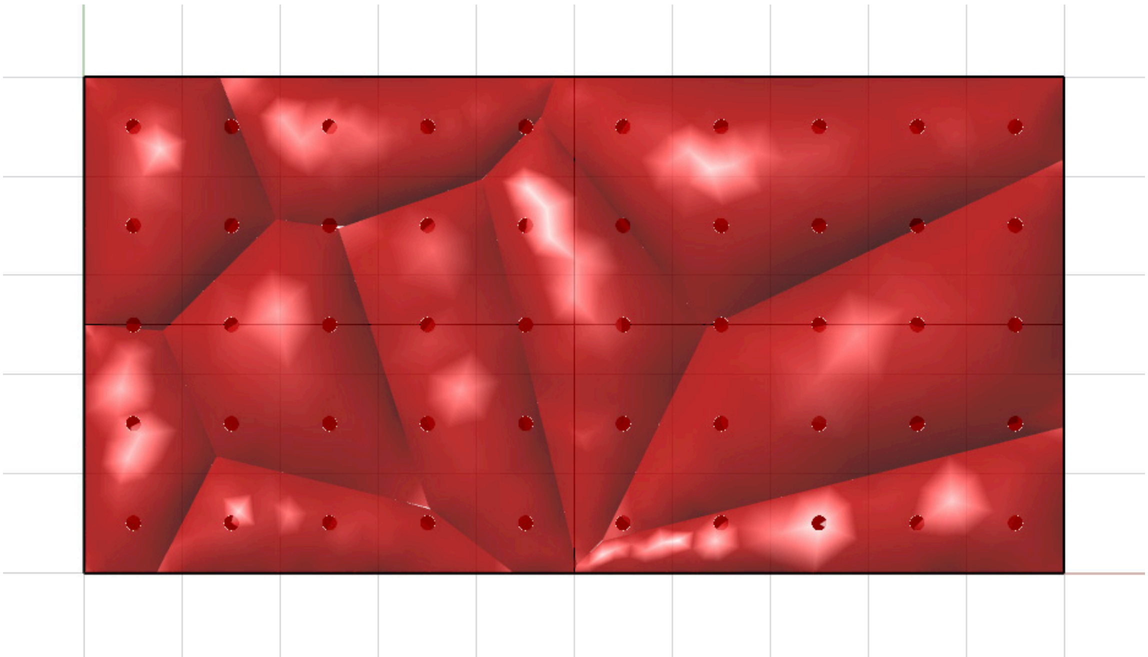
B3. Inflating

To achieve objective 2 - An effective workflow for presenting the relationship of pattern can be achieved computationally, being the focus of this project's iterative design testing and exploration it makes sense to continue the fabricated elements to be shown and founded computationally.

To do so Kangaroo physics simulator for grasshoppers is used as the major tool in this research. This allows a simulation of inflation, as shown in the adjacent flow diagram. The input system will be brought directly from pattern generation and applied to a standardised surface (1400 x 1100), which is our control variable. Subdividing the surface into smaller surfaces within the bounds of the patterns allows inflating each surface individually to create a tessellation of 'air cushions'.


Pattern
Split Surface
Mesh
Kangaroo
Surface
Mesh





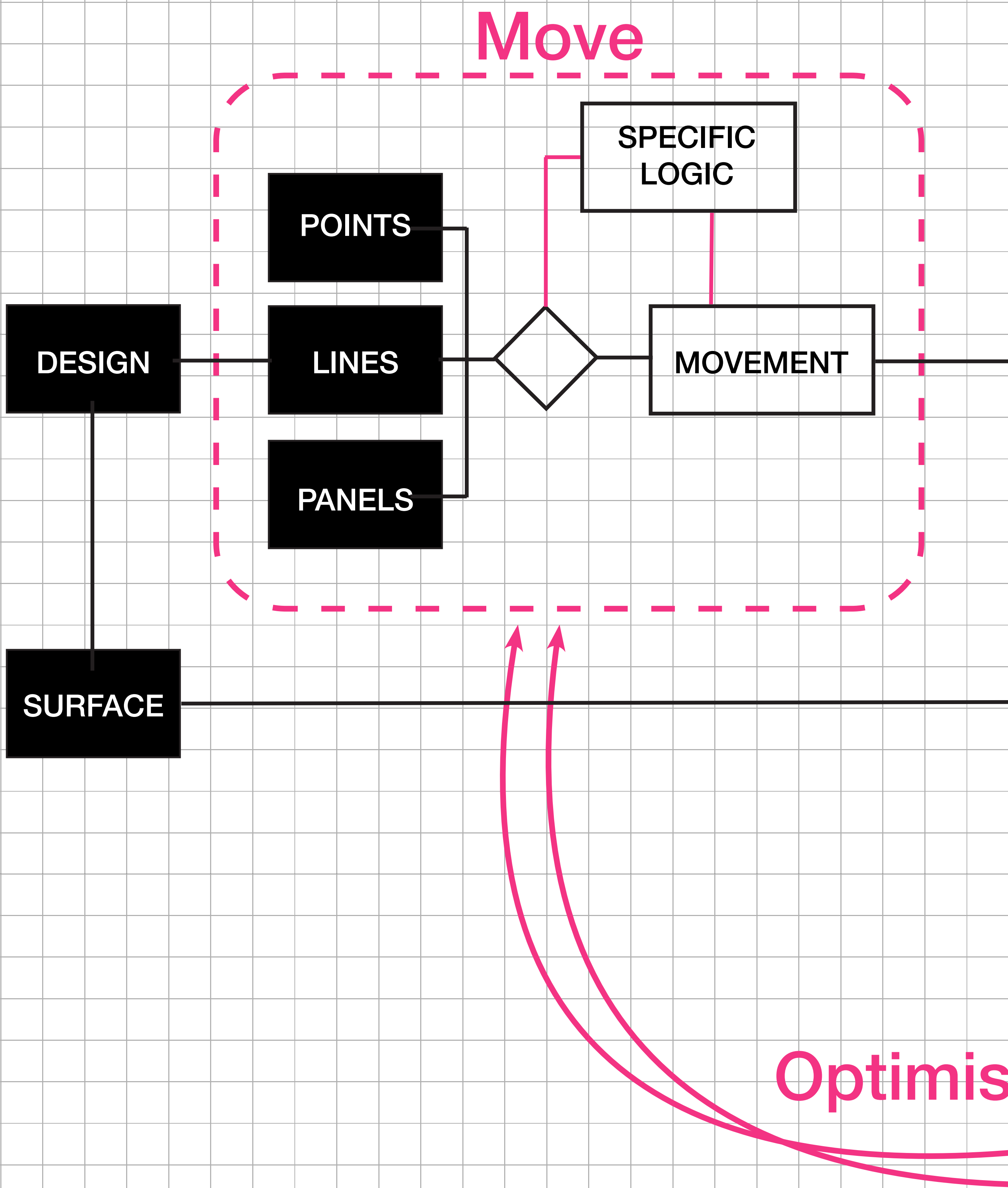
B3. Testing

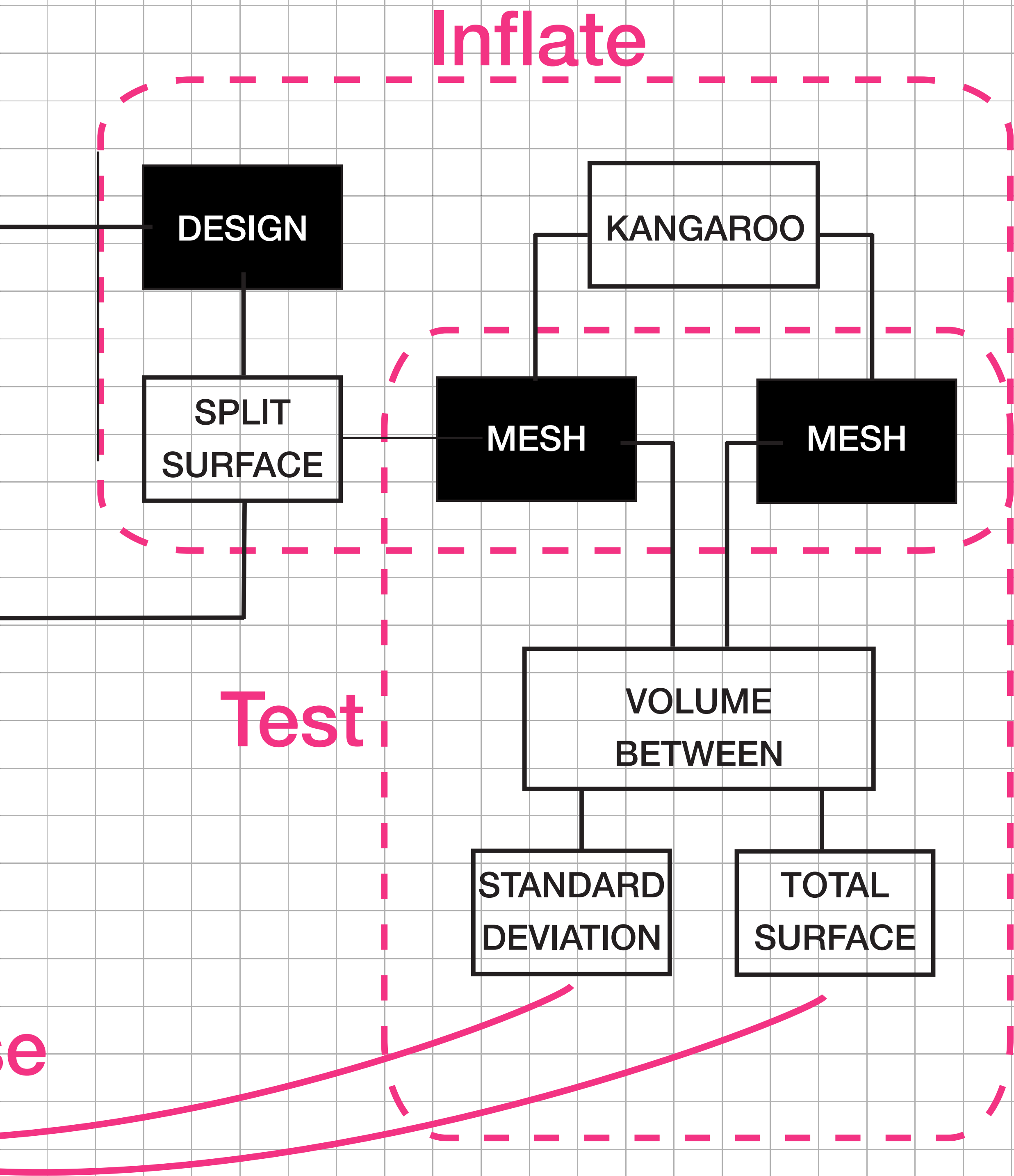
To achieve objective 3- From the results of inflation modelling, it is possible to quantitatively assess the performance of the design iterations. As heat transfer is inversely proportional to the depth of air (CLEAR, n.d.) we can assume we can see an improvement in performance through the maximum volume of inflation as well as the spread of volume across the façade, i.e. standard deviation. It is understood that insulative and thermal performance have a range of variable qualities and for effective implementation, more criteria must be considered, but for the scope and focus of this research, we seek only this relationship between the pattern and volume differentials.

We can test volume two ways computationally, by the volume of space in between the inflated mesh and the original. But also can test specific depth through the volume at specific points, as shown in the images. Thus, allowing texting with additional data, in the context testing of this project these depths are paired with a heat loss data matrix on the same surface, allowing a direct calculation of heat transfer through various thicknesses of air cushions. In the context of the experimentations, volume is scored as a ratio to the surface area, thus allowing effective testing between design models.

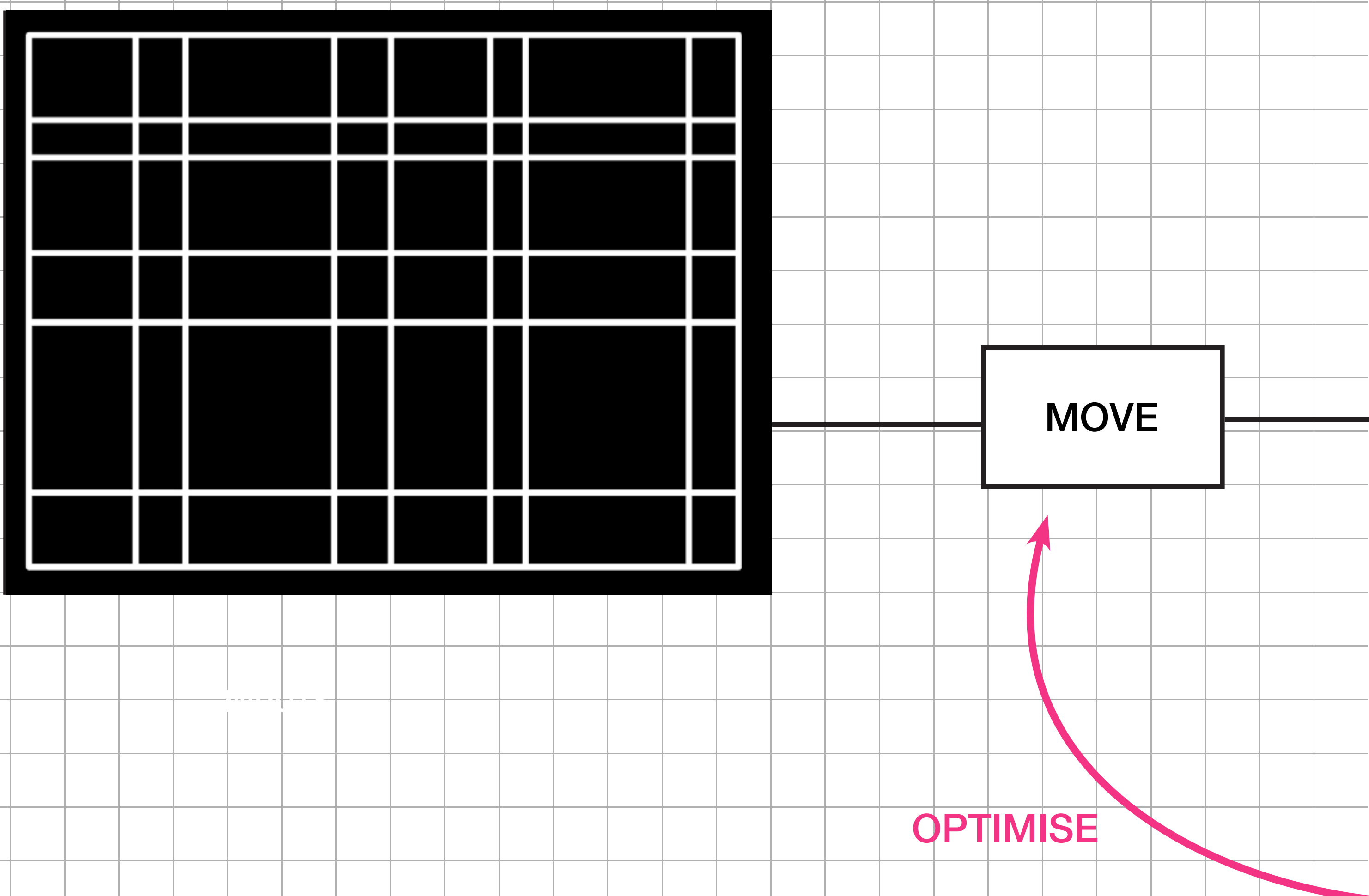
The standard deviation of the results is considered in the initial experimentation testing, this is due to a design constraint when testing out of context. Optimising for volume alone will not provide an effective system but potentially concentrate volume in one area, this can be seen in the early experimentation, and hence adding standard deviation scoring allows for the effects of volumetric insulation to be seen across the façade system.

For the most part, all experiments are considered on a grid of 1400 x 1100, thus allowing a standard set of results comparable across all design instances and iterations.


Move
SPECIFIC LOGIC
POINTS
DESIGN
LINES
MOVEMENT
PANELS
SURFACE
Optimis


Inflate
DESIGN
KANGAROO
SPLIT SURFACE
MESH
MESH
Test
VOLUME BETWEEN
STANDARD DEVIATION
TOTAL SURFACE
se

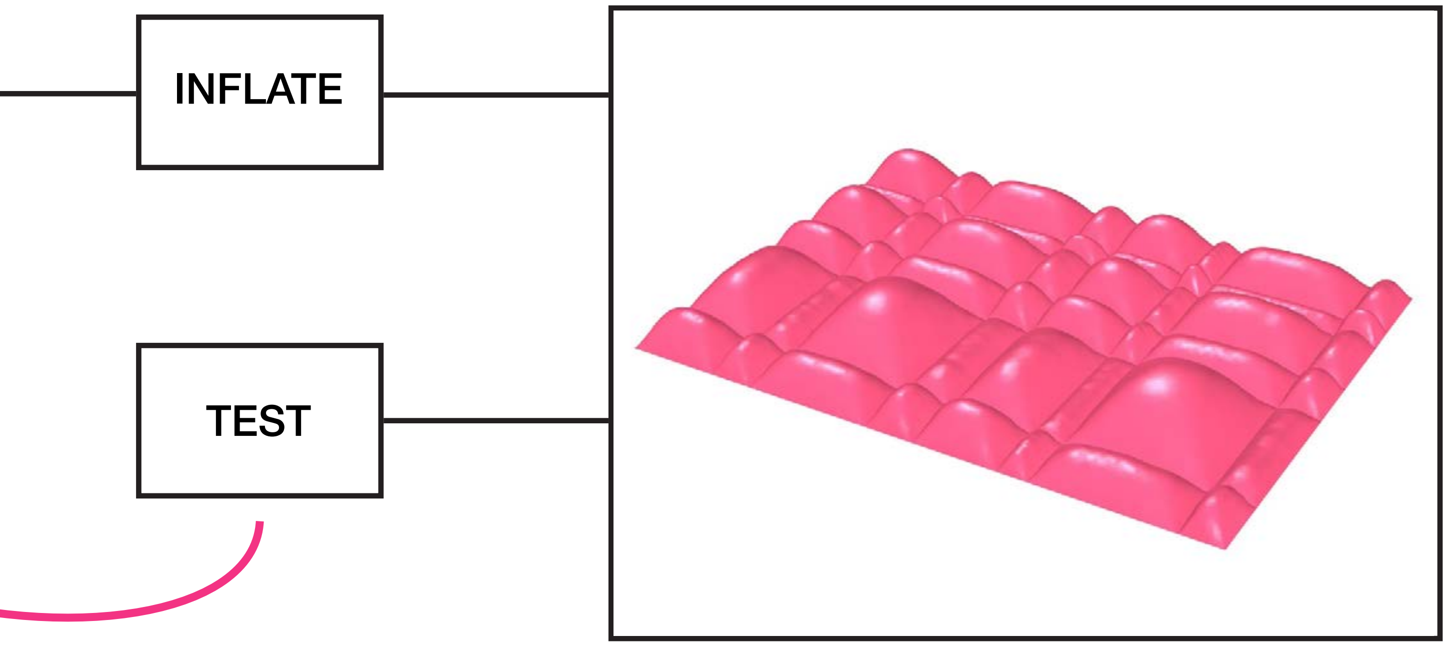
EXPERIMENT 01: LINES, STRAIGHT

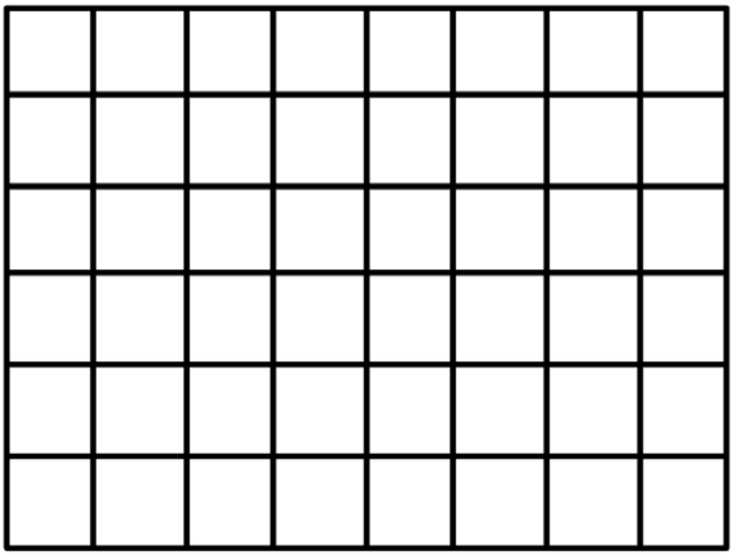


The first experiment starts with the most simplistic process, identifying the smallest change from the starting grid. To do so we identify the bisecting lines of the grid and the location of endpoints, but not as coordinates, as parameter points on the length of the edges. Each line is rigid in direction and extension such that they will always be full length and bound by the edges of the grid.

Providing a bound of movement for the parameter on the x and y-axis of the bounding frame allows for iteration and permutations to be found. In this case, each line was allowed to move freely along the line, resulting in permutations of quad grids.

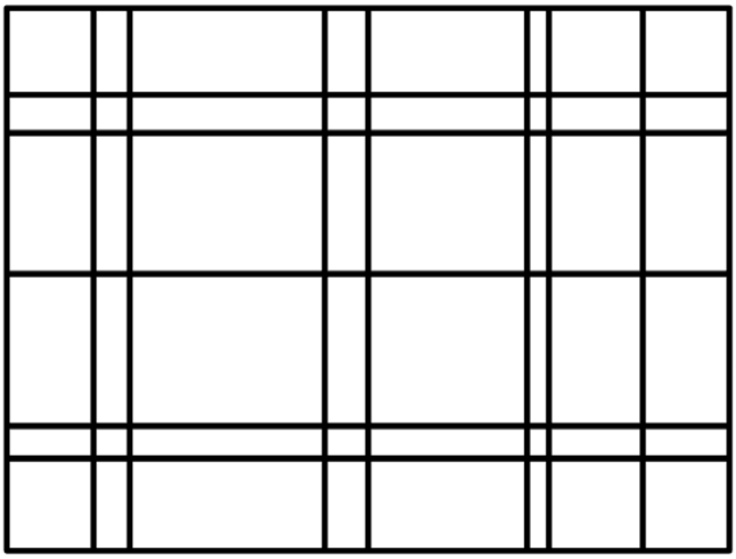
It was found through optimisation of this pattern that the most effective design would be that of a regular grid, hence no increase in performance through pattern design was found for this model.





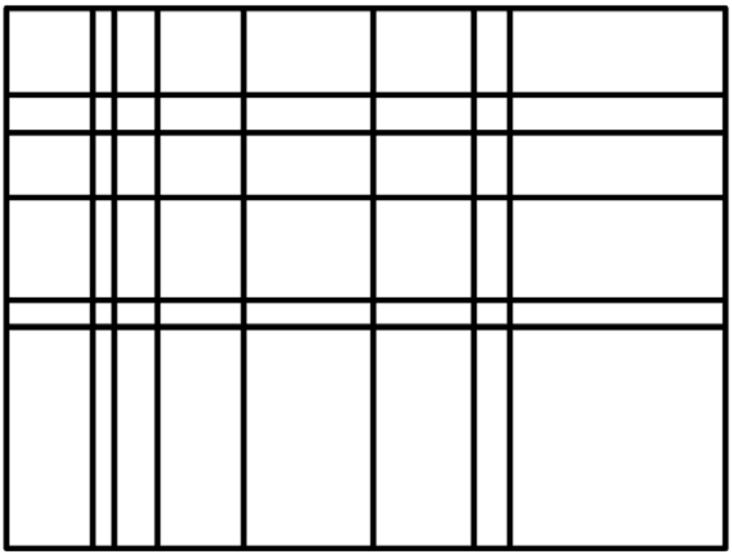
01

Volume 4.802
Deviation 0.092



03

Volume 4.466
Deviation 1.779

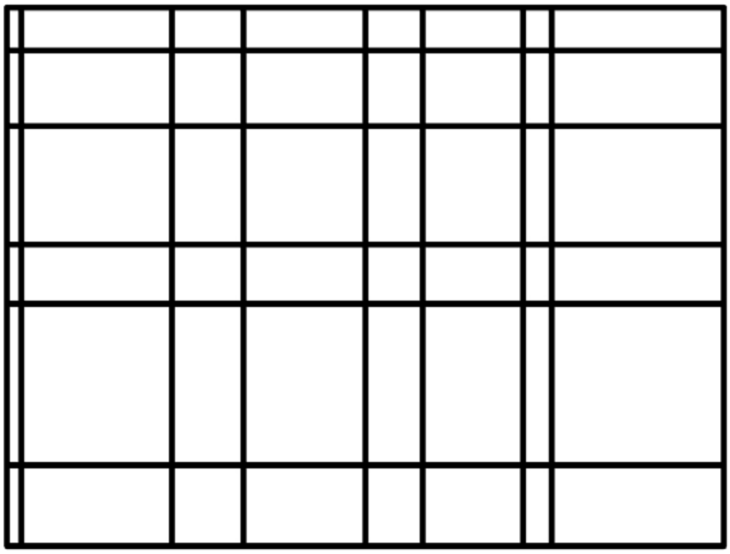


05

Volume 4.331
Deviation 8.231

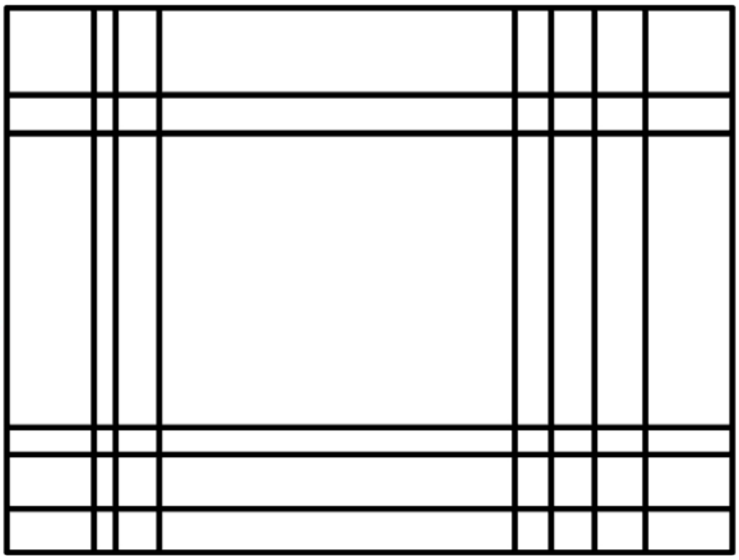
02

Volume 4.452
Deviation 1.583



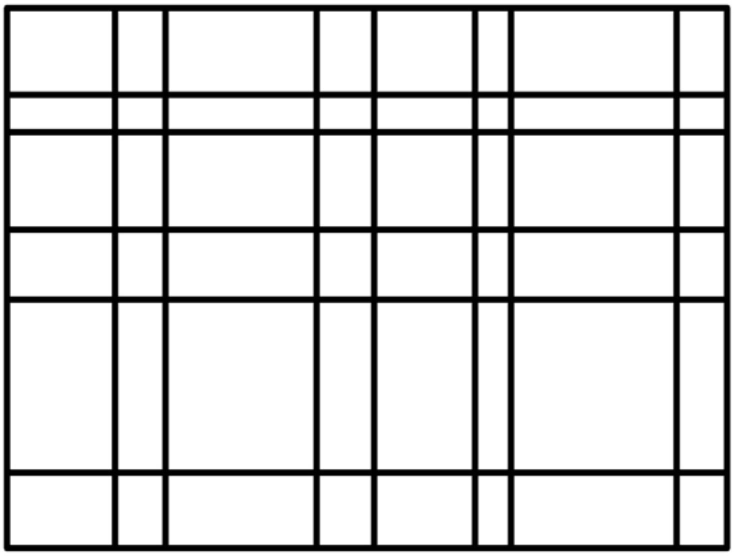
04

Volume 4.560
Deviation 5.751

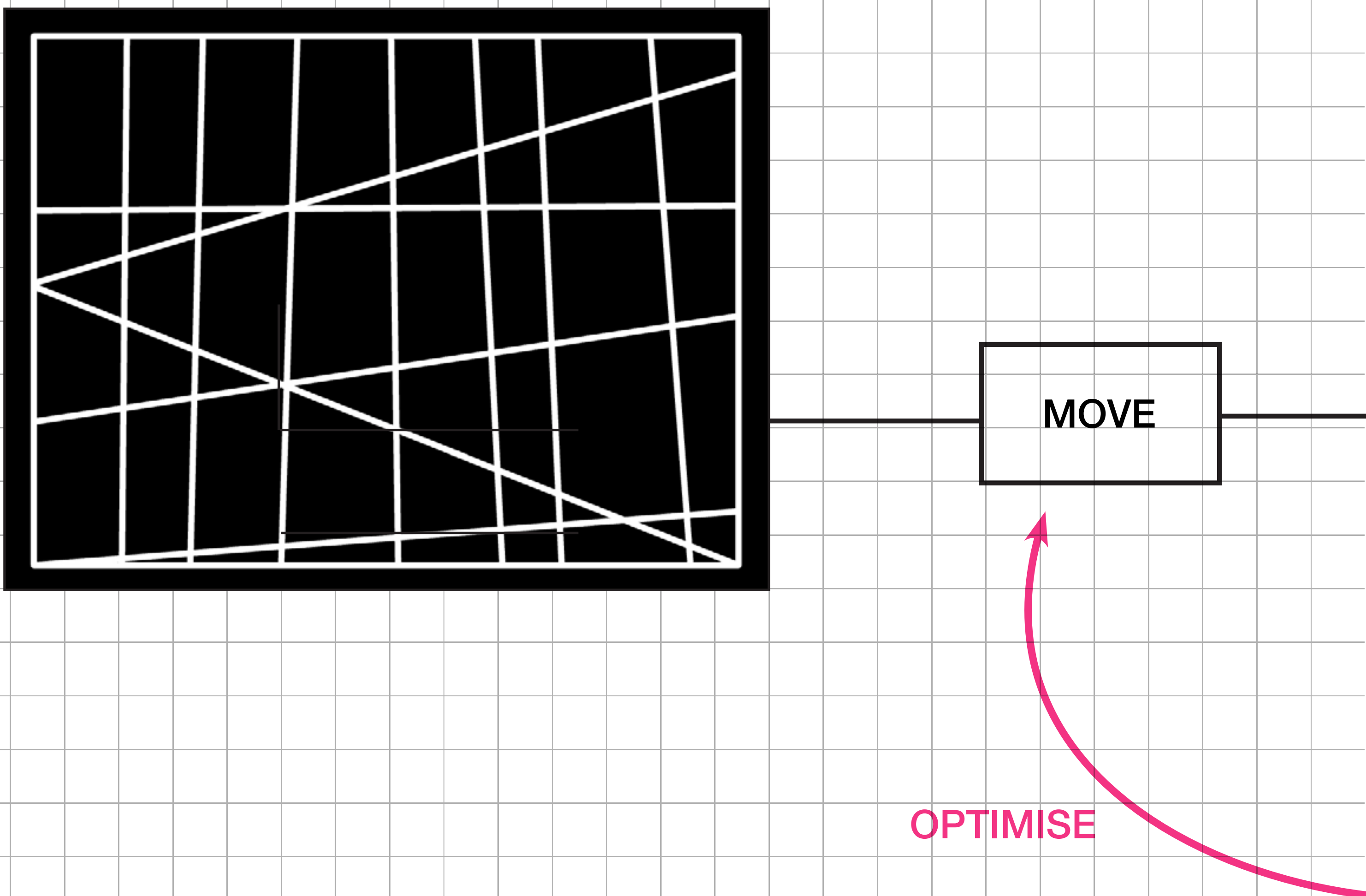


06

Volume 4.346
Deviation 1.498



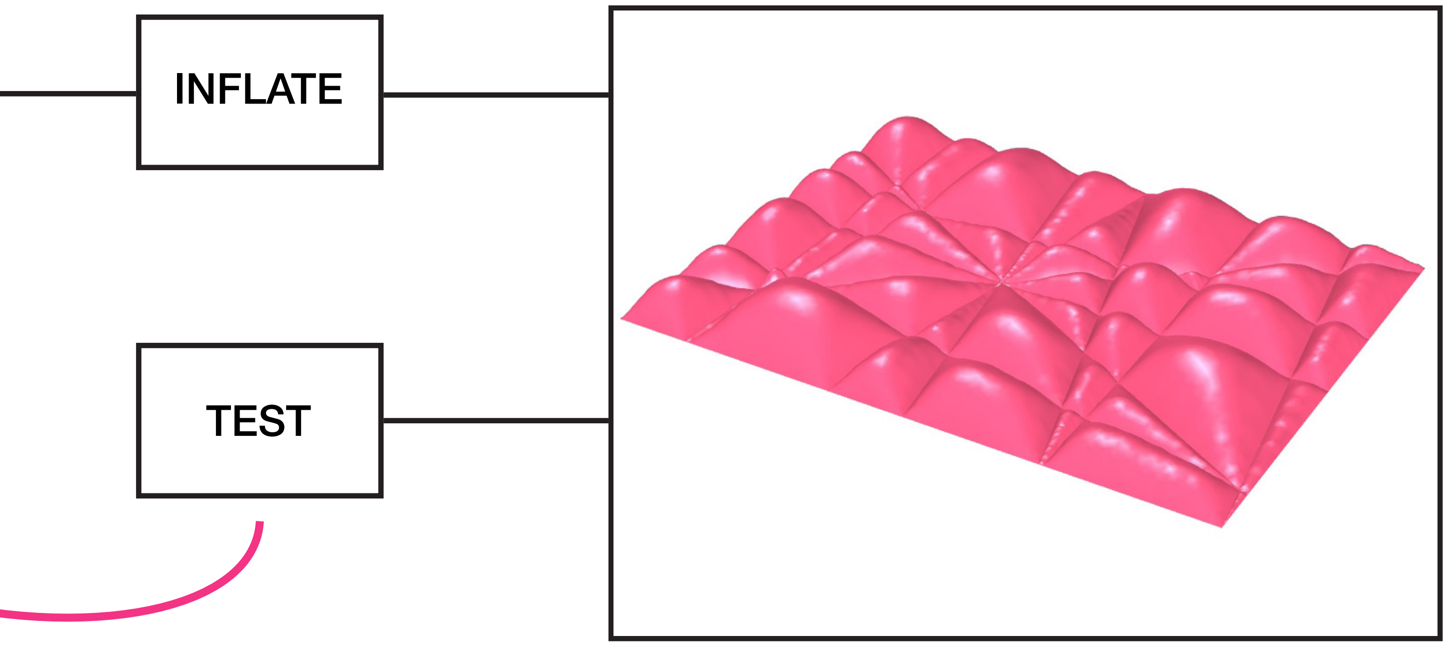
EXPERIMENT 02: LINES, ANGLED

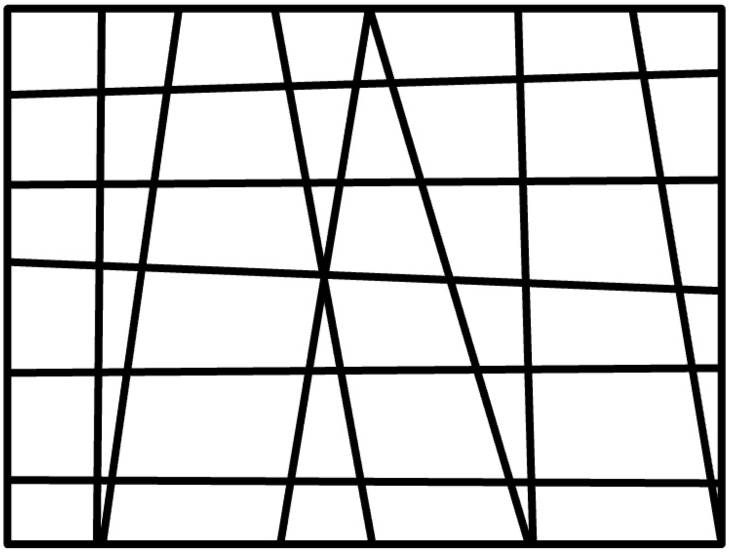


Building on the results of the initial line investigation the extra-dimensional addition is not just one parameter point for each line but two, defining the beginning and end points of each. This means the results as still a panel of quads but this time irregular with lines no longer forced to intersect at right angles, we begin to see a development in how the shape and form effects volume, and not just the area.

The grid only allows triangular 'panels' when two major axes intersect, hence if we control the bounds of each to be the spacing between lines we would get a quad grid and if we allow crossing we get a grid that includes triangles.

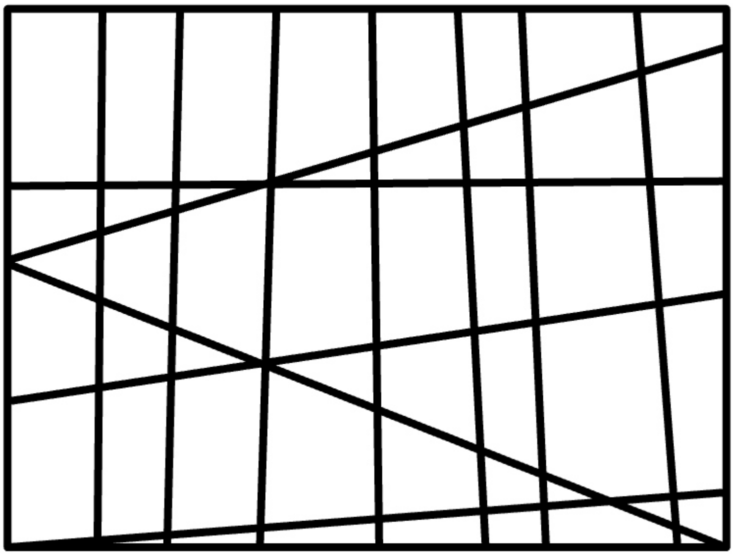
The results of this experiment showed a greater depth in variation and exploration but still didn't surpass the results of the regular grid, proving more complexity would be needed to form a relationship between pattern and increased volume.





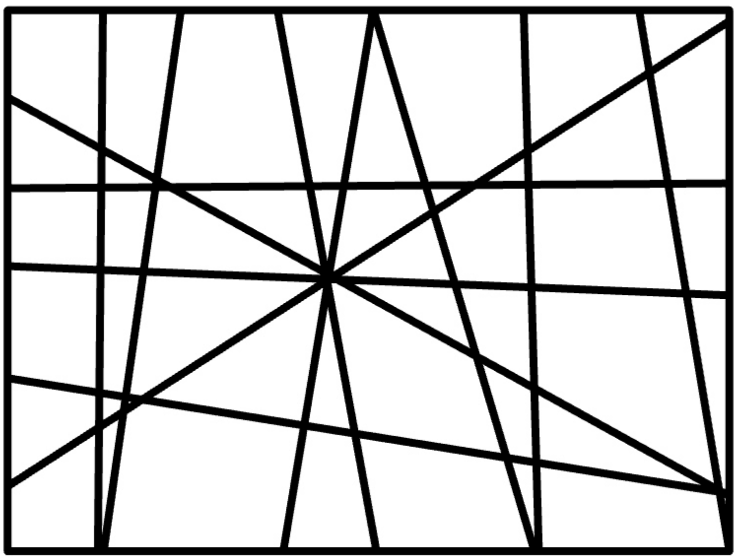
01

Volume	4.181
Deviation	1.044



03

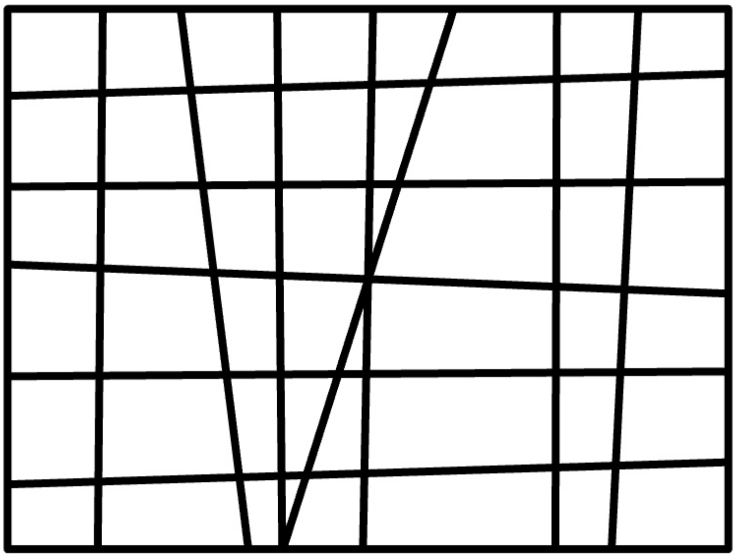
Volume	4.126
Deviation	1.188



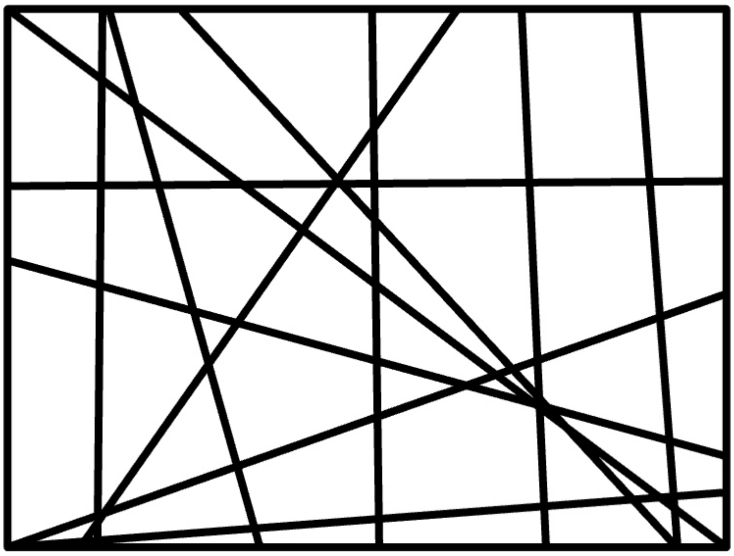
05

Volume	3.877
Deviation	1.322

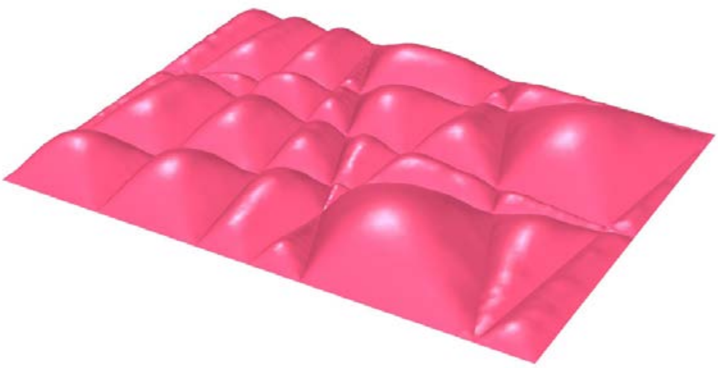
02 Volume 4.373 Deviation 0.798

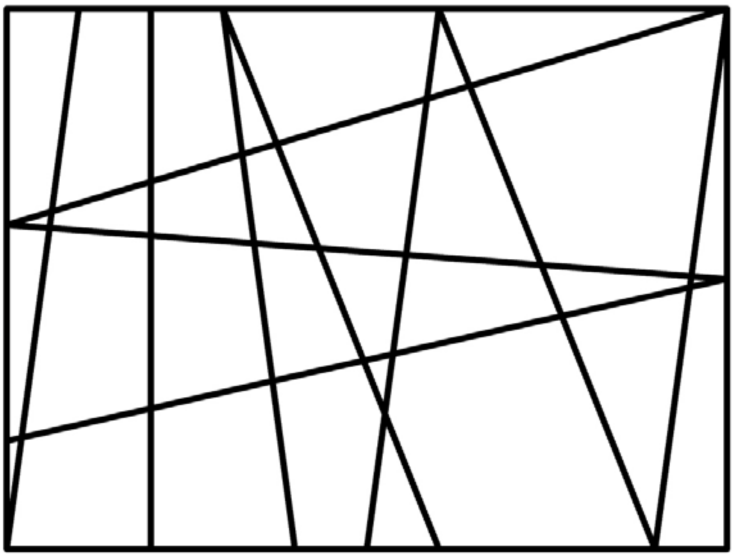


04 Volume 3.763 Deviation 1.259

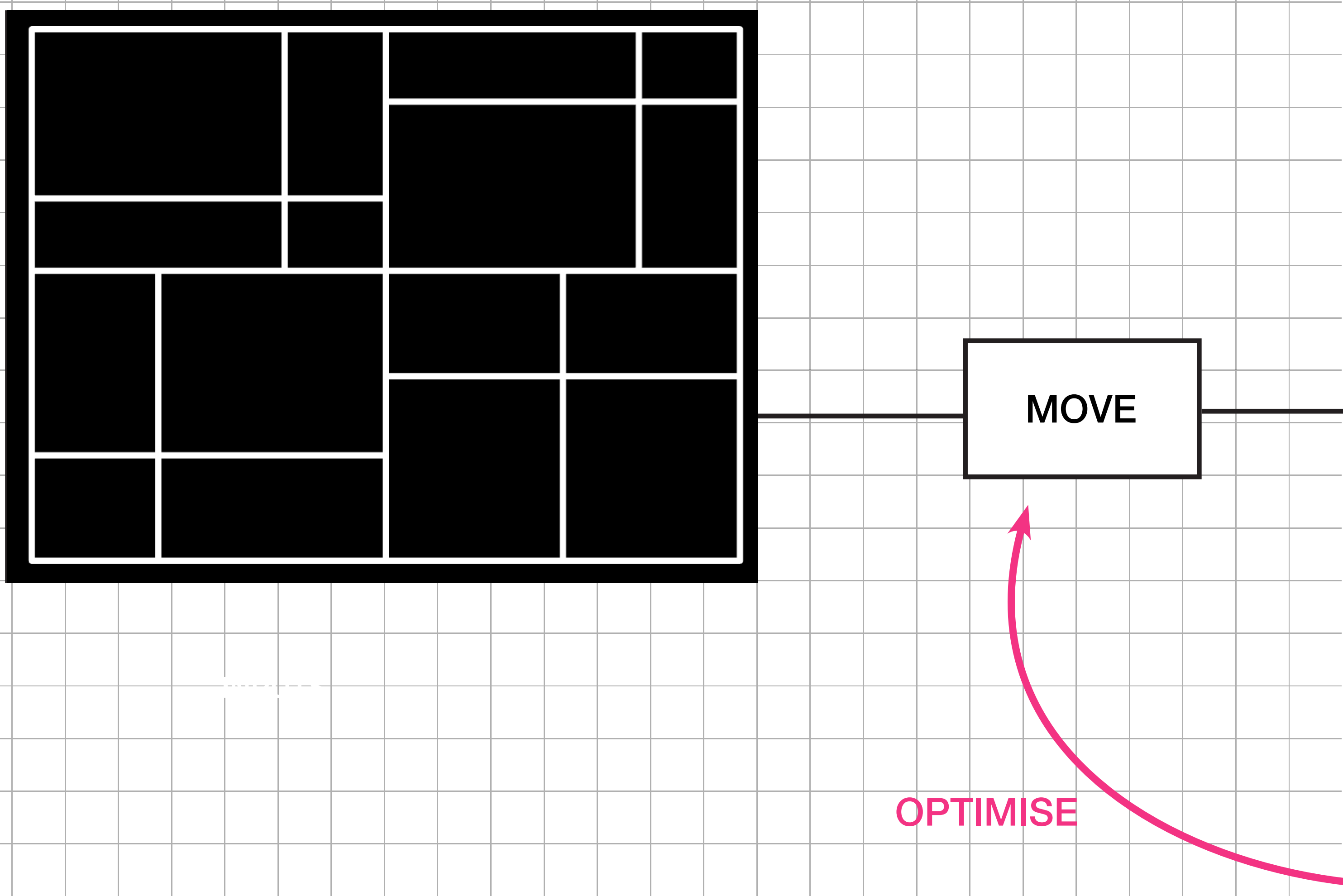


06 Volume 4.496 Deviation 2.851





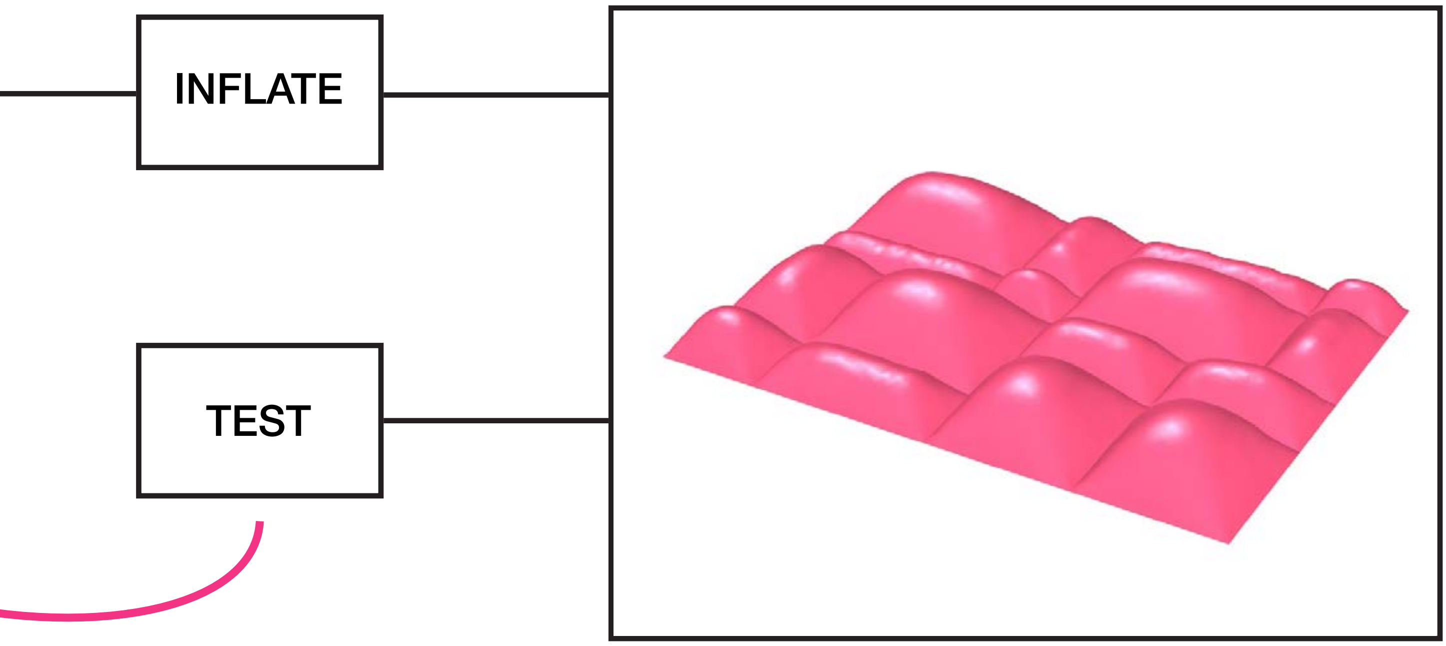
EXPERIMENT 03: LINES, NESTED

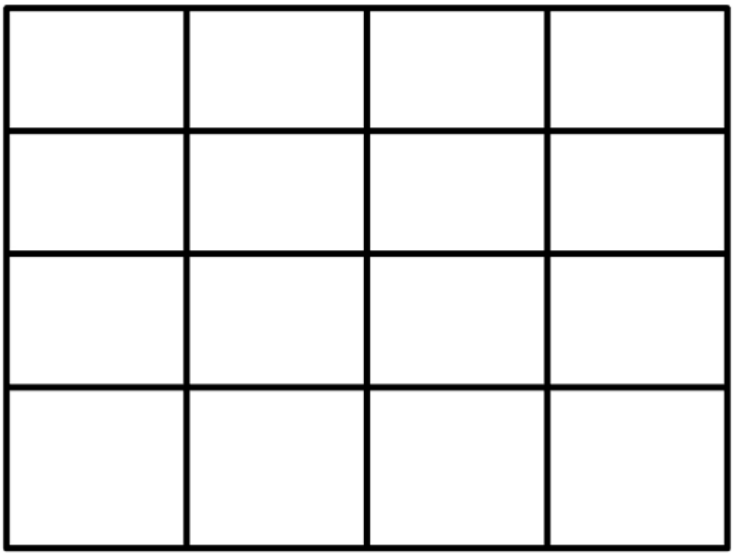


Learning from the previous line investigations, it is clear the angled method produces the greatest results and explorations. It encompasses the first method but also introduces the concept of non-regular quad grids and triangles brought into the quad system.

The next step of development carries the aim of exploring further the non-regular quad system from a different approach, again continuing the sequence of pattern exploration.

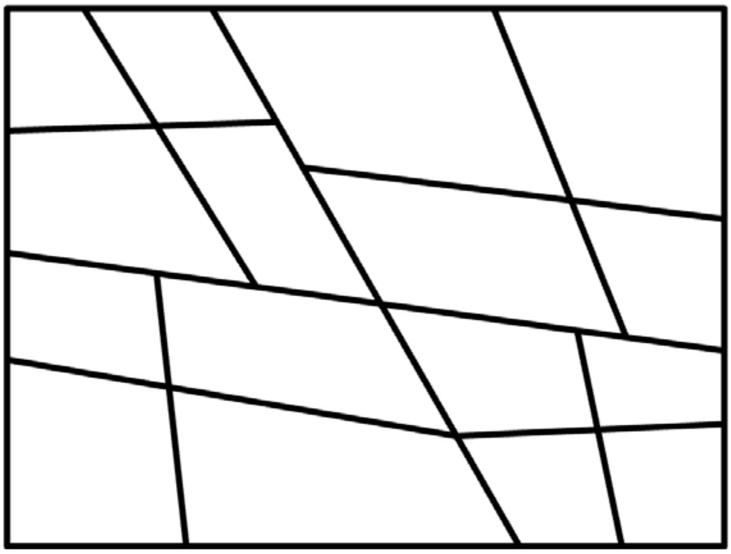
This time we continue cross-section lines bound by parameter lengths, but just using 2. One in an X and one in a Y direction, but nesting and repeating this process. As two lines subdivide they result in a grid of 4 panels, these 4 panels can be fed back into the system to again be redivided into 4 panels.





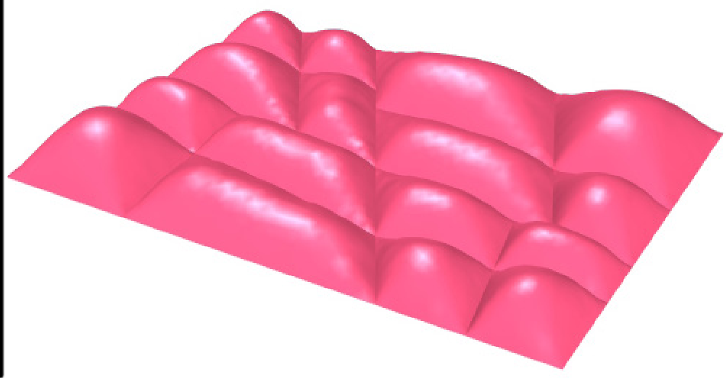
01

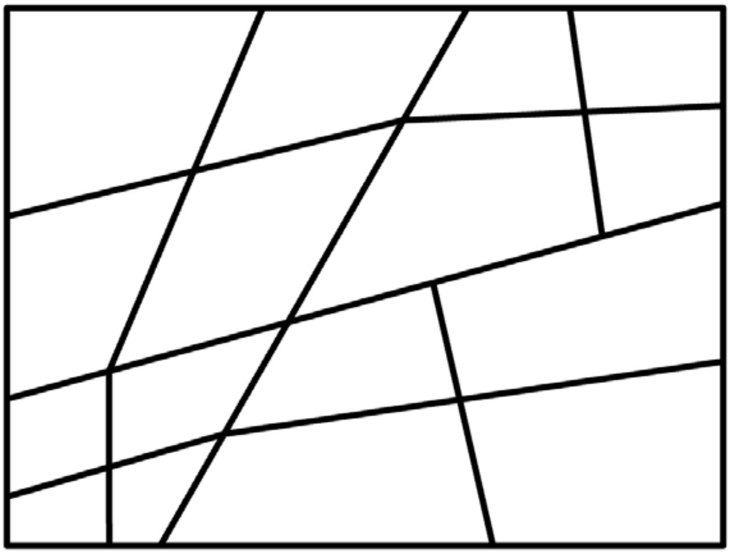
Volume 6.250
Deviation 1.121



03

Volume 5.090
Deviation 2.724



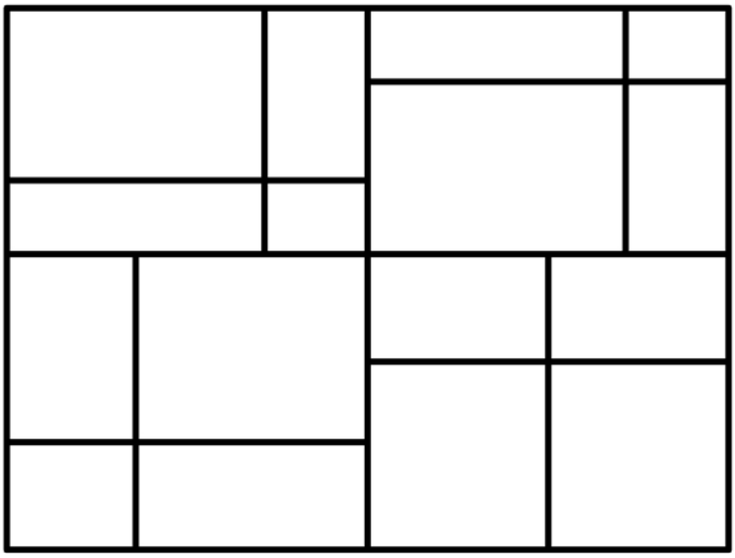


05

Volume 5.108
Deviation 3.116

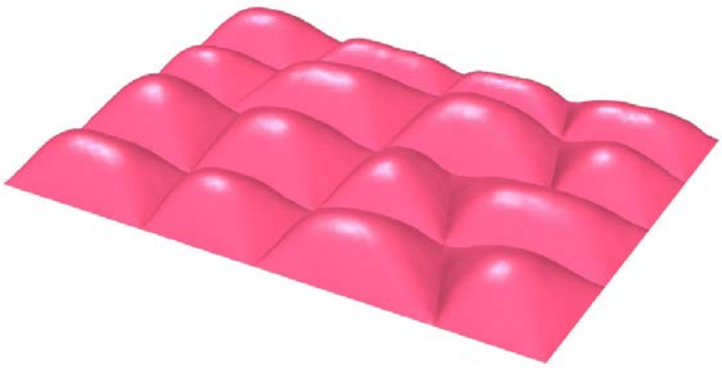
02

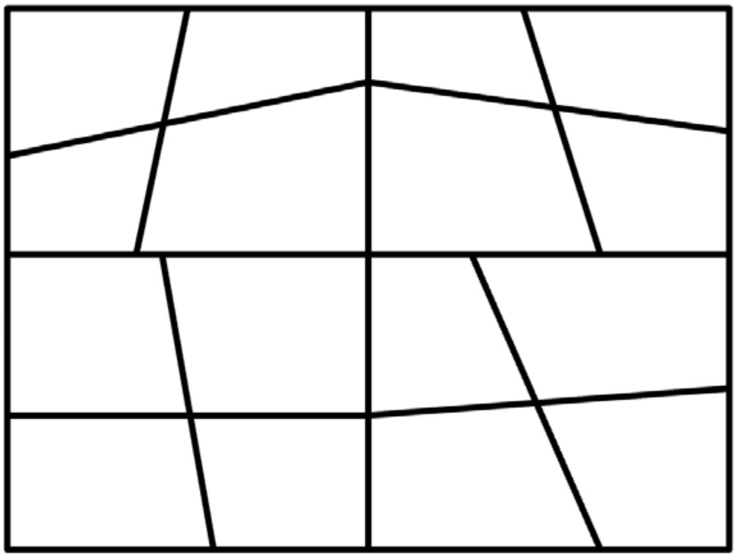
Volume 6.061
Deviation 4.010



04

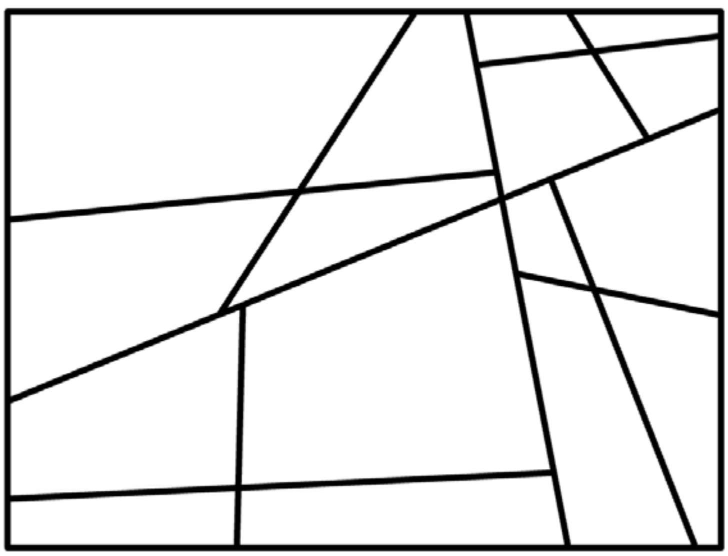
Volume 5.731
Deviation 1.820



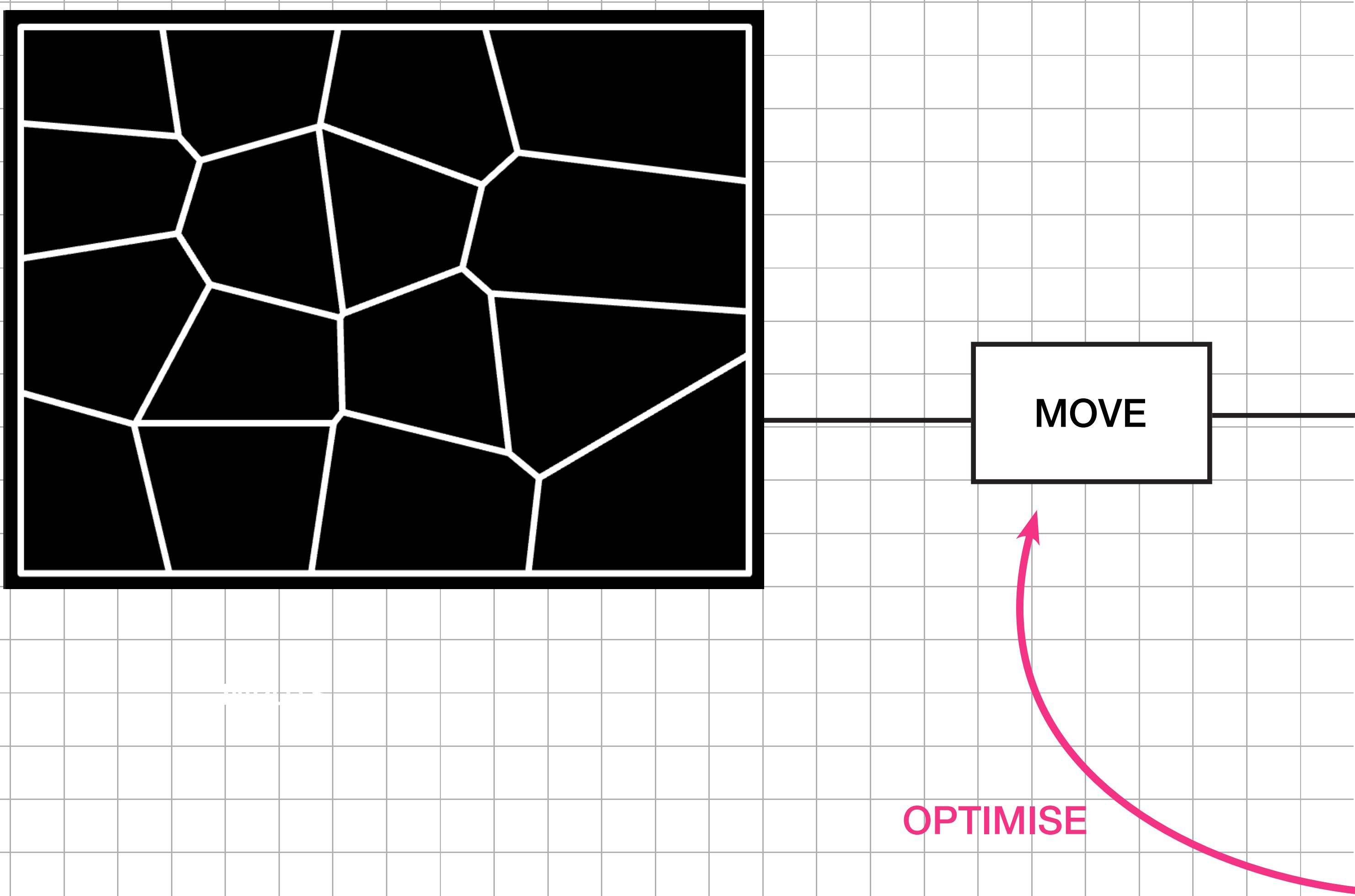


06

Volume 5.137
Deviation 5.855



EXPERIMENT 04: POINTS, VORONOI

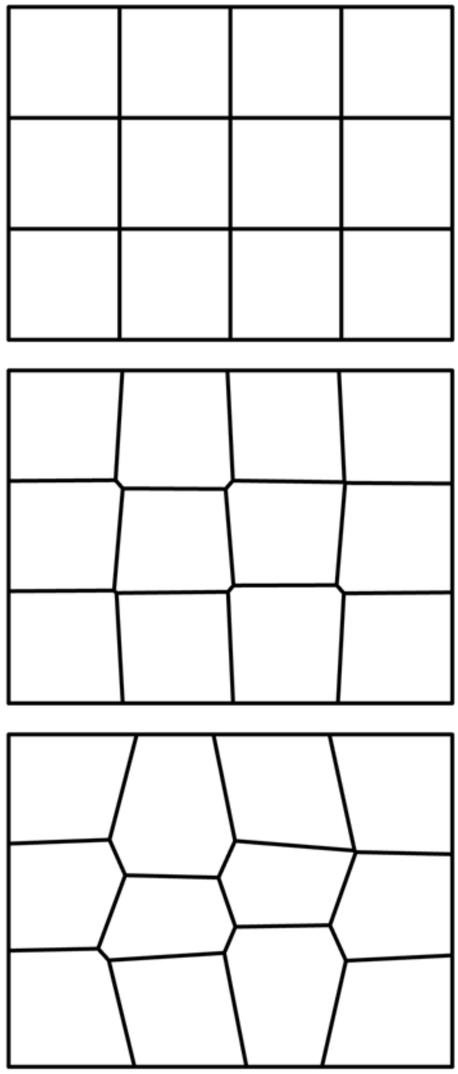


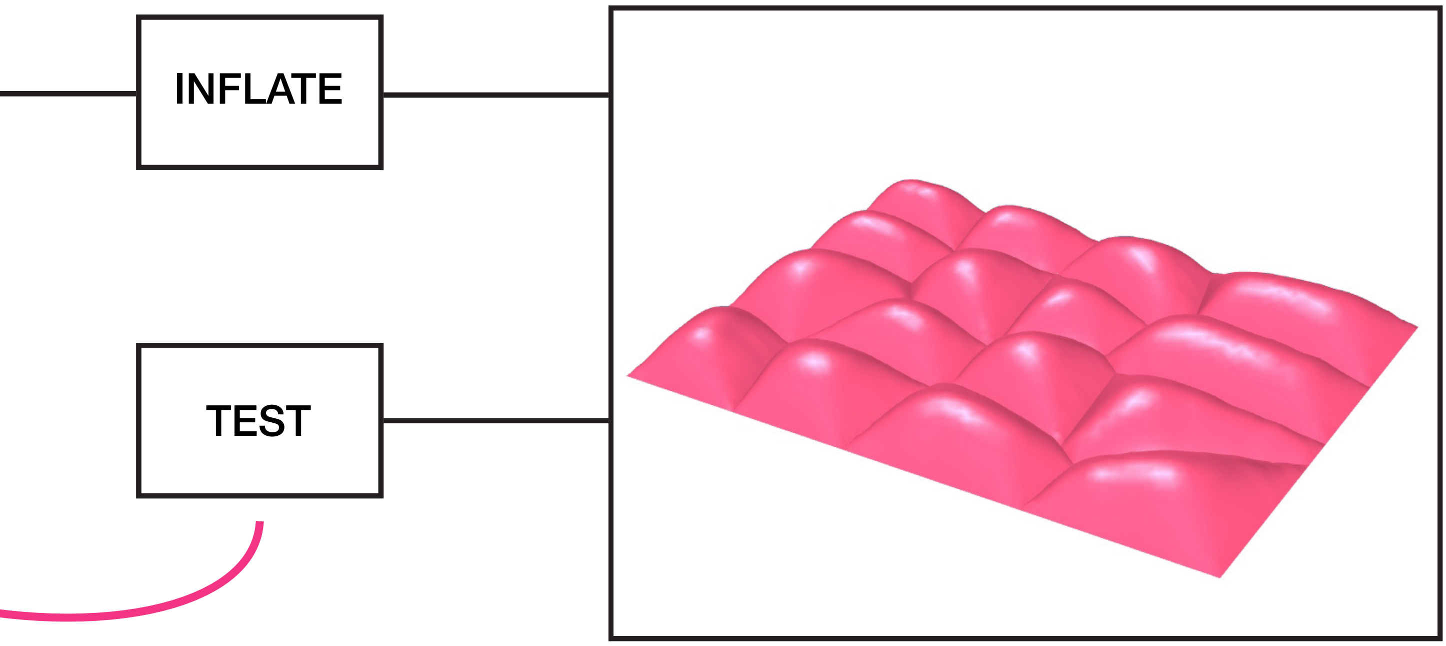
Identifying points as representations of void space in a grid can be achieved through an irregular polygon tessellation method, called Voronoi.

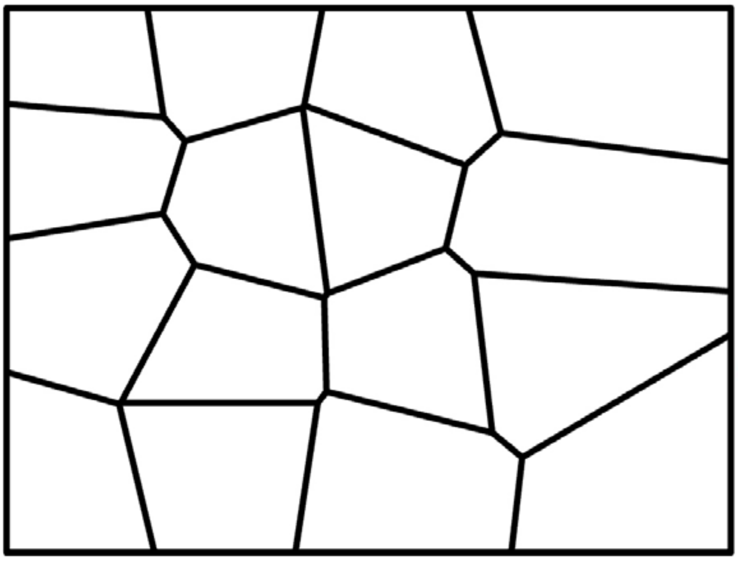
The Voronoi is an interesting pattern methodology due to its apparent visually complex but realistically simple formation, the logic behind the Voronoi is points are placed in a grid space with U and V values, and each point is the centre of a circle with all equal radius (in this case at least) as the circles overlap perpendicular lines can be drawn through the intersection points, the result a tiled irregular polygon effect.

Now the difficulty with Voronoi is as much as it suits the narrative of this research in allowing explorative forms of patterns, the logic between iteration lacks a systemic approach or deterministic results, to generate an appearance of the expected 'natural' or 'organic' forms that Voronoi seeks, an emphasis is put on random generation of points or movement, such that it isn't inherently bound by parameters - which does clash with the narrative of the research.

So, in the interest of this research, the logic of the Voronoi formation was applied systematically. Identifying the existing 4x3 grid system and the points at the centre of it, then applying the Voronoi formation, to the centroids all that happens is the grid stays the same as when 4 circles meet at equally spaced quad of points, the resultant divider meets at right angles and hence squares. When it becomes interesting when we move one of these points, we see the grid is 'shaken' up to a sort where the panels are no longer regular quads but unpredictably irregular polygons. Hence, for this investigation, we give each quad centroid bounds of movement.

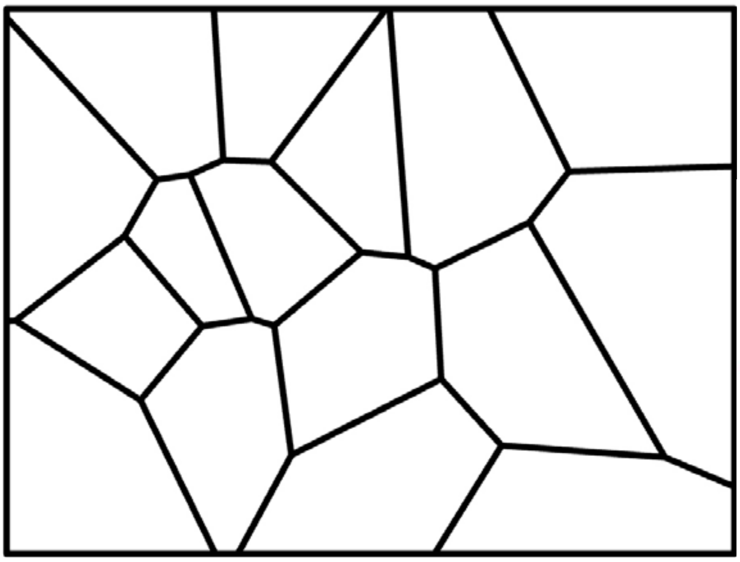






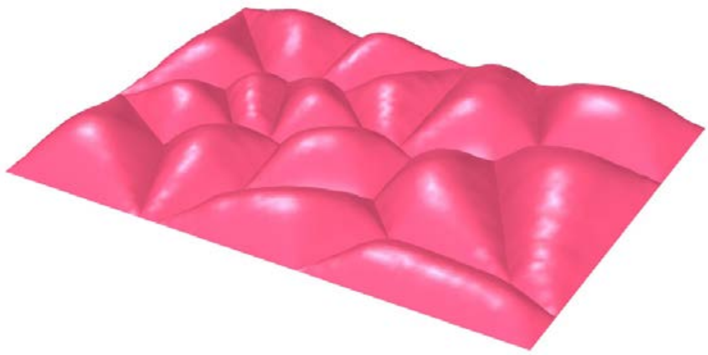
01

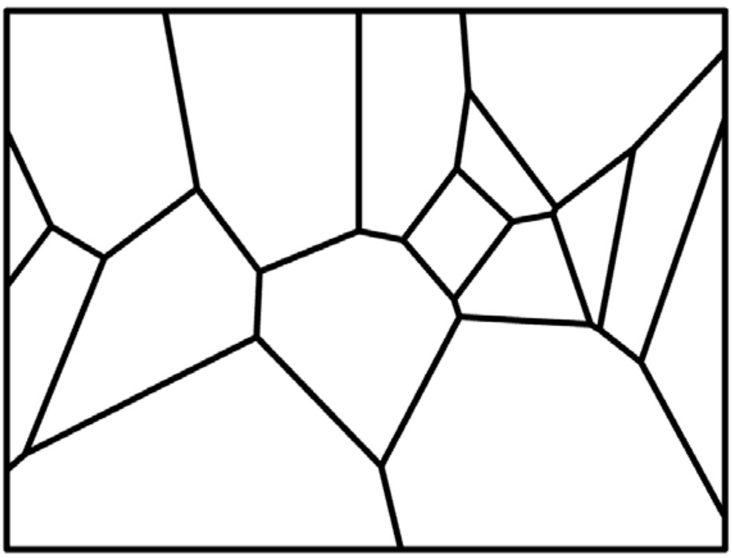
Volume 5.427
Deviation 1.468



03

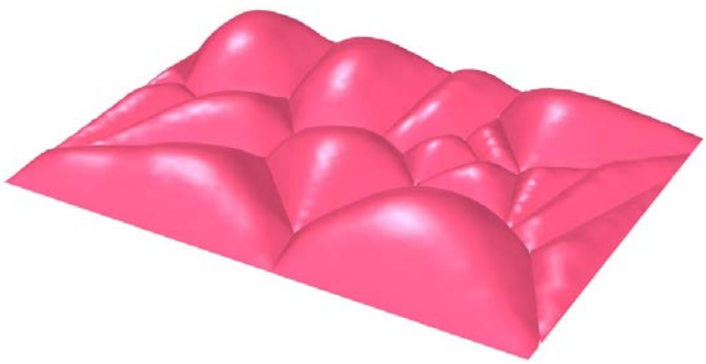
Volume 4.885
Deviation 2.118





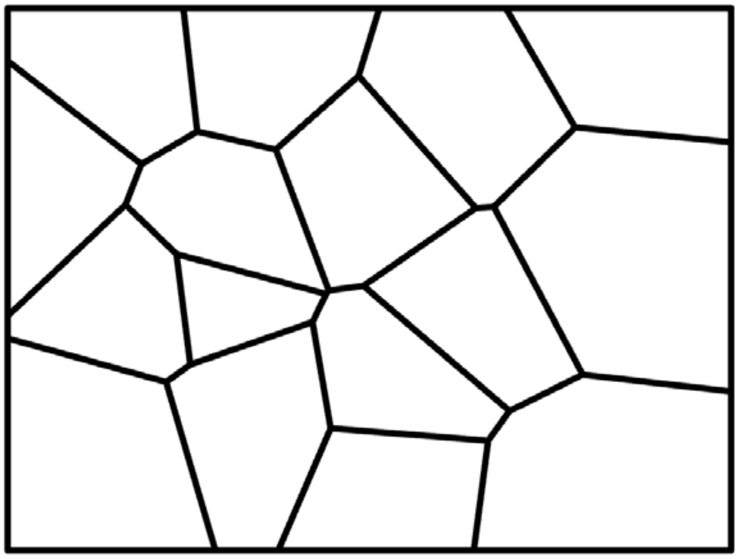
05

Volume 5.390
Deviation 5.211



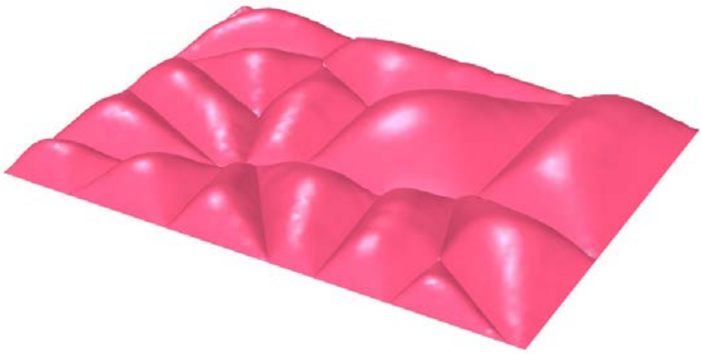
02

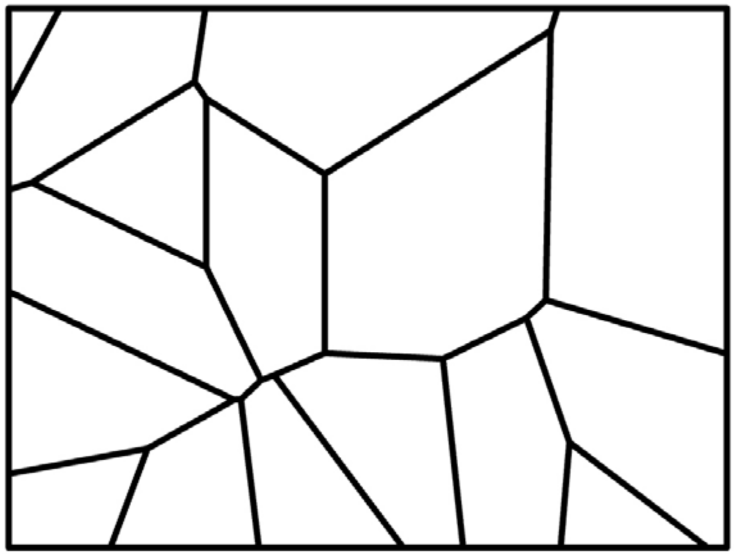
Volume 5.493
Deviation 3.109



04

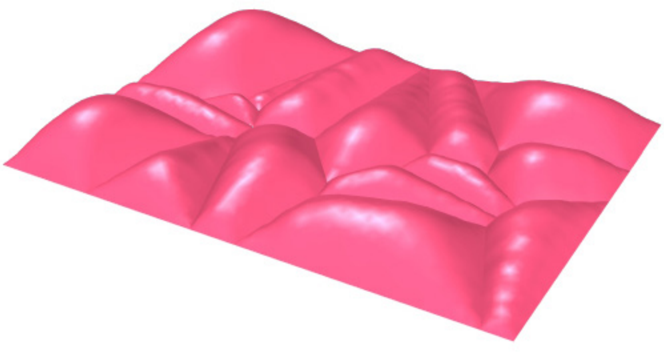
Volume 5.095
Deviation 4.237

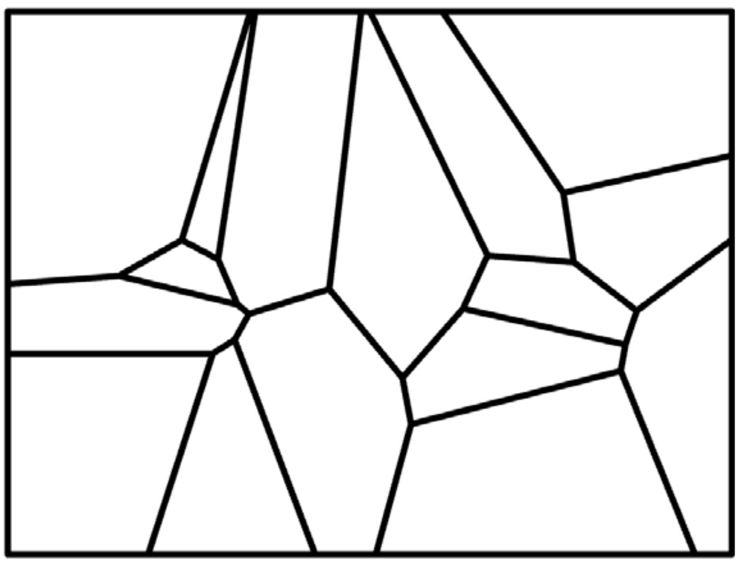




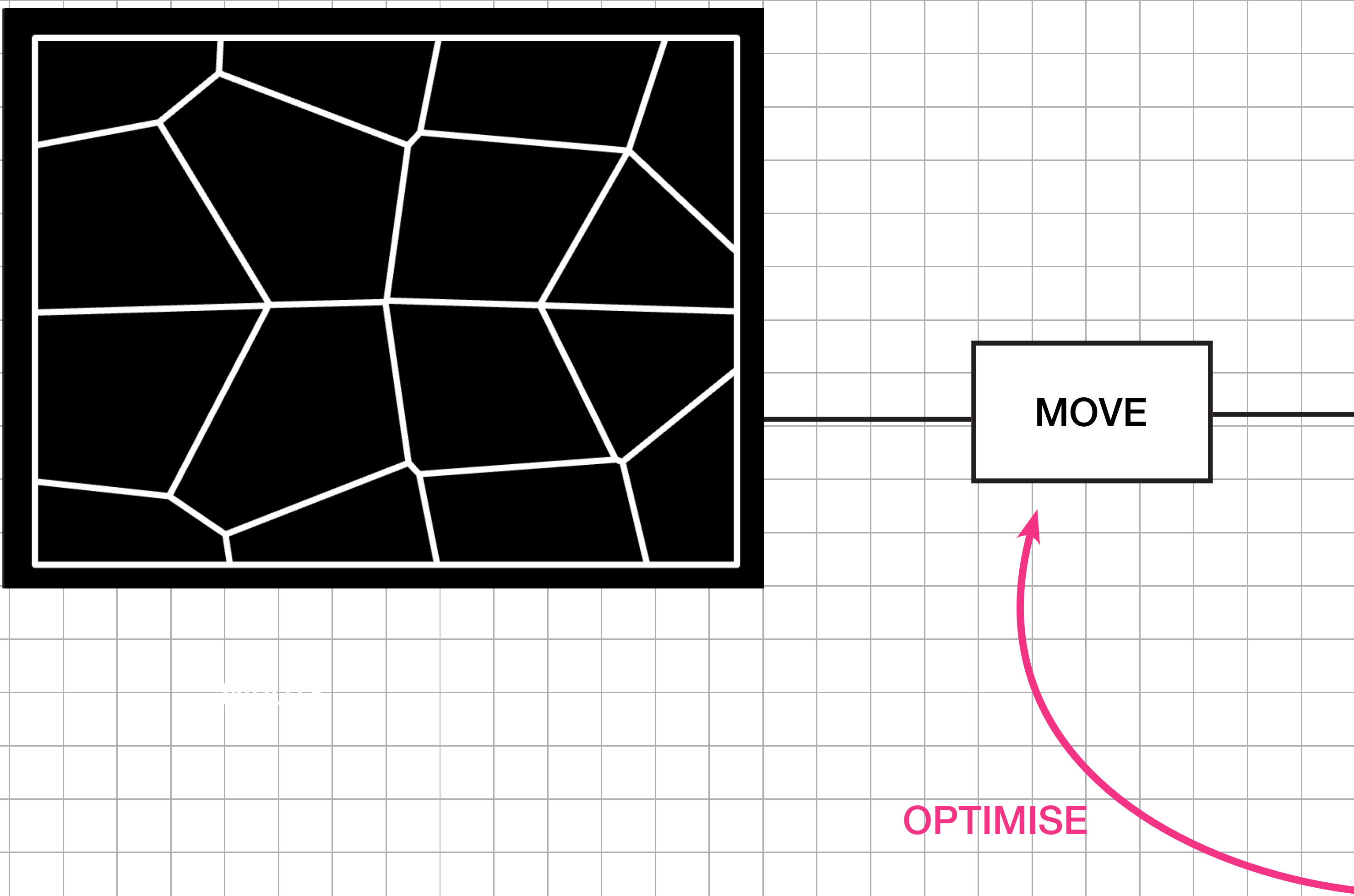
06

Volume 4.970
Deviation 4.013



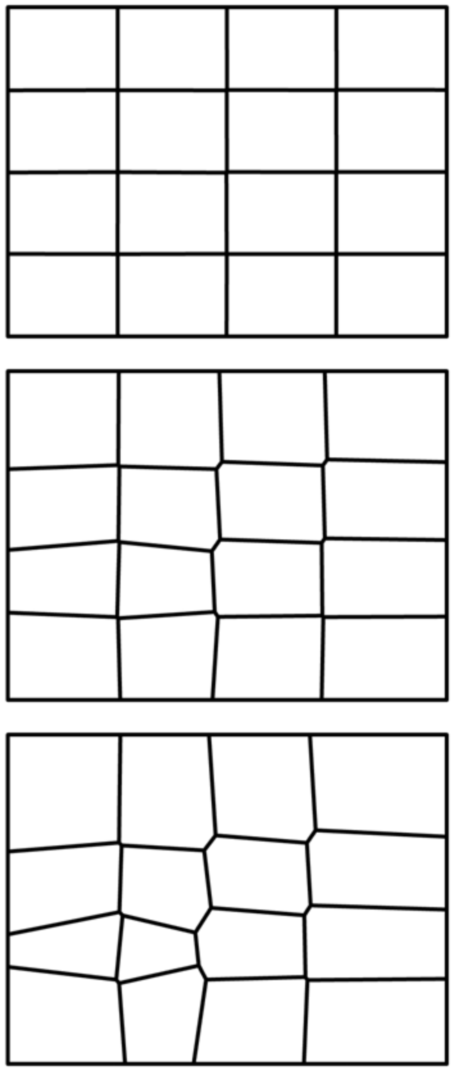


EXPERIMENT 05: POINTS, DISTORTION



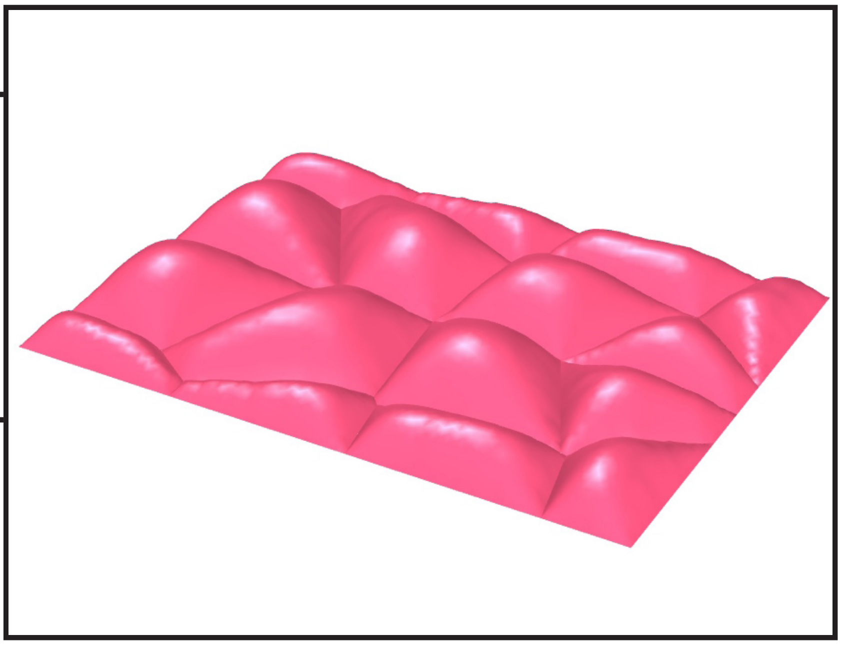
Felix Mallinder
Design Research 2023

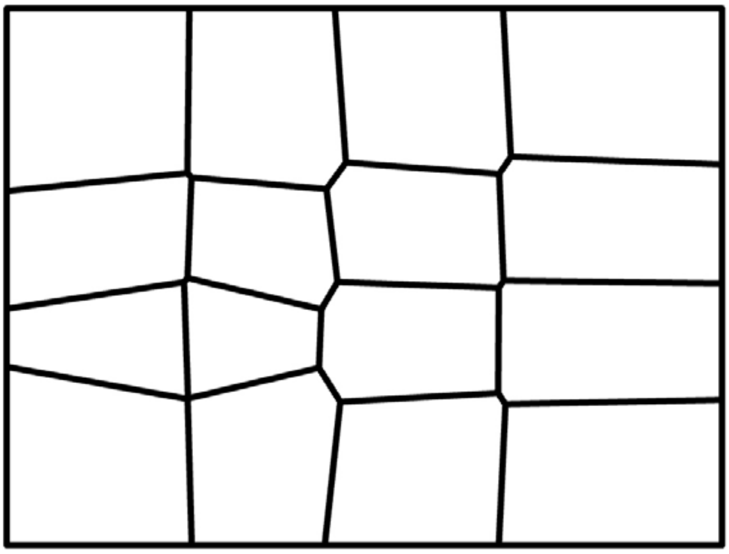
Points allow a representation of space and void in patterns and the previous method has proved this relationship in generative points polygon solution. but a new element which can be tested is the destructive elements of point relationships. Distortion experiments, explore the bounds and connections of points in a pattern-forming approach. Similar to the previous experiments we start with a 4x3 grid formed by a Voronoi, but instead of giving movement to each centroid we use one control point which repulses the centroids, relative to the position and directional relationships. As seen in the image this yields similar morphological results but is found to have a greater expression of exploration.



INFLATE

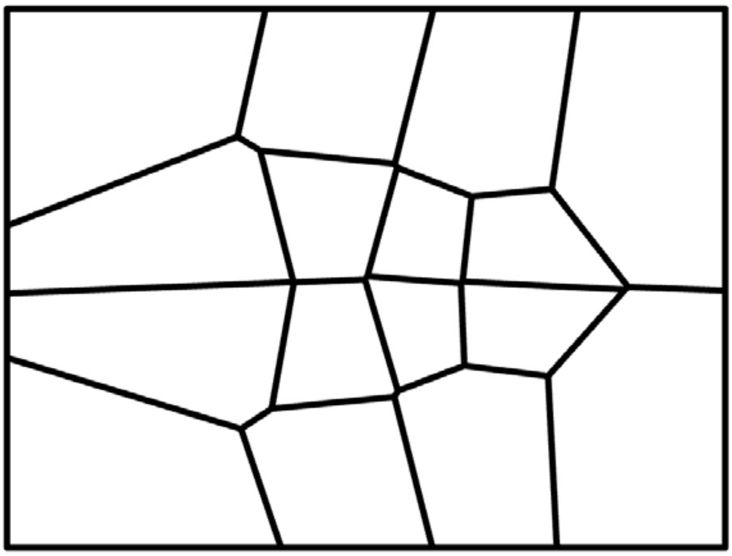
TEST





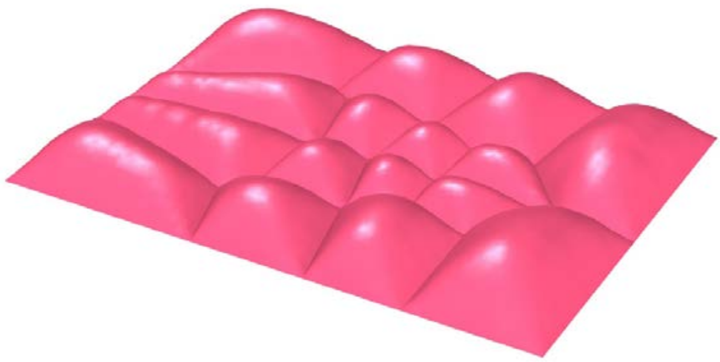
01

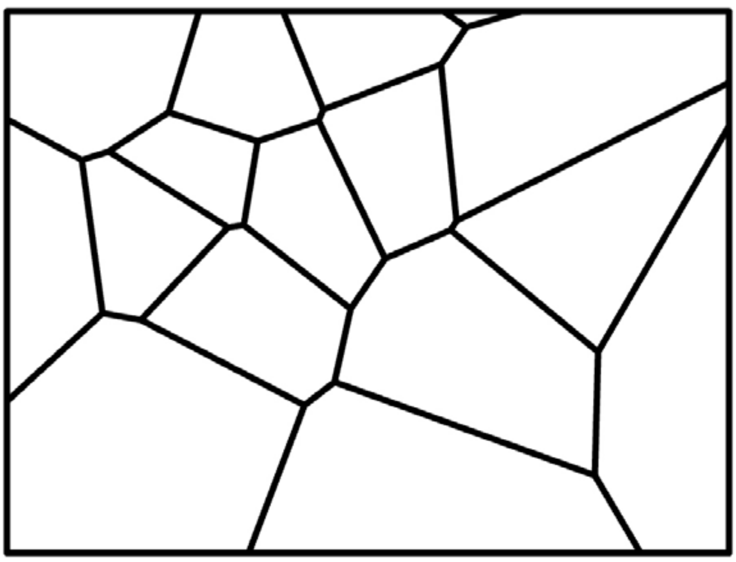
Volume	5.984
Deviation	2.010



03

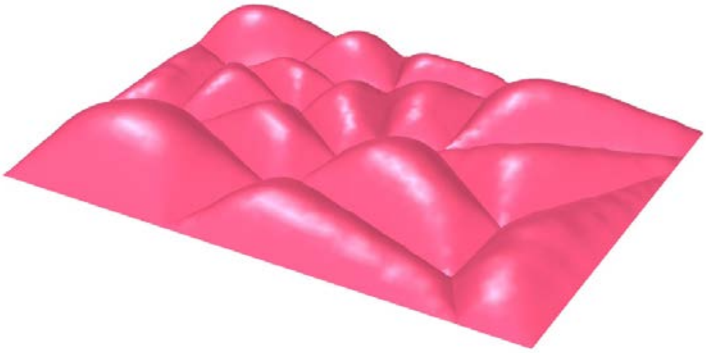
Volume	5.633
Deviation	3.396





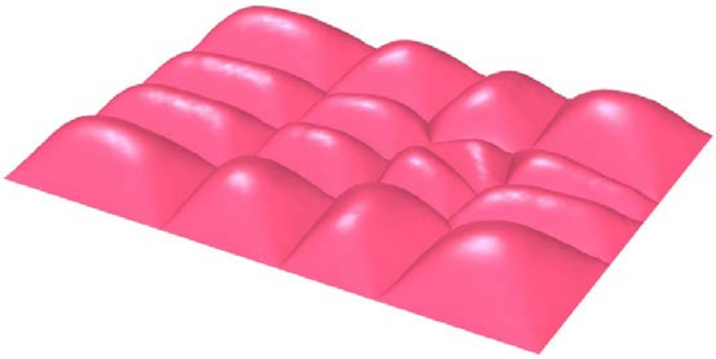
05

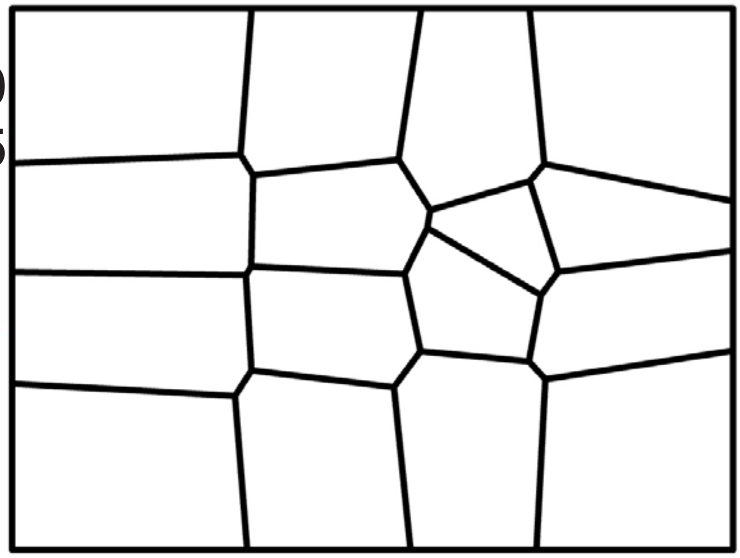
Volume	5.025
Deviation	3.949



02

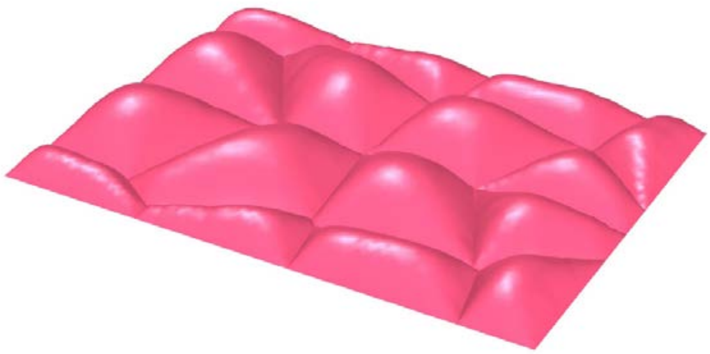
Volume 5.820
Deviation 2.675

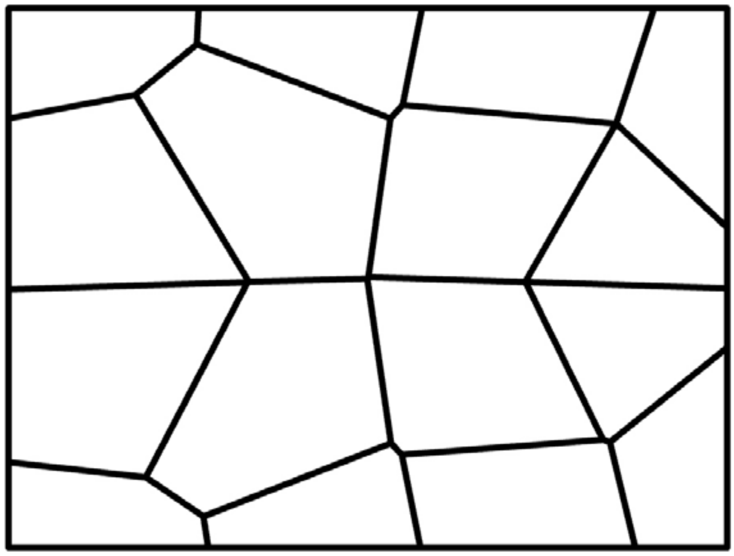




04

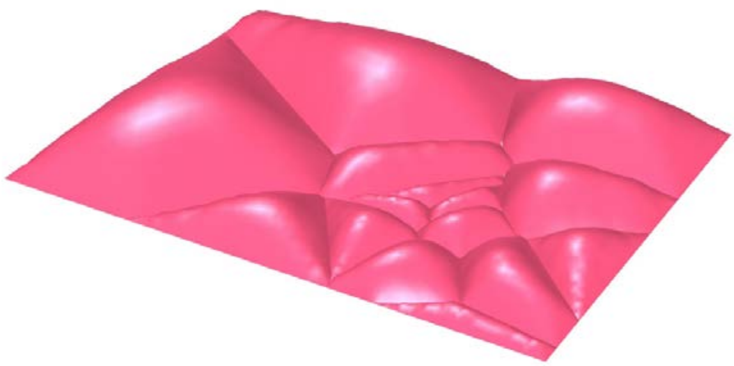
Volume 5.197
Deviation 2.780

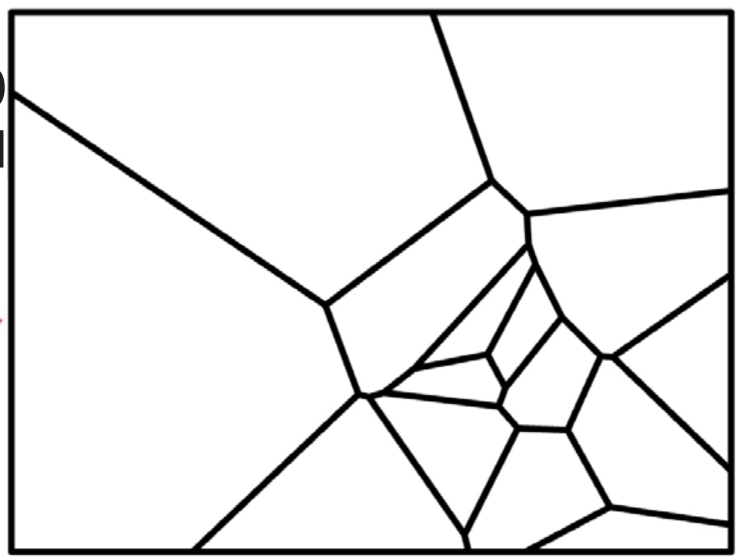




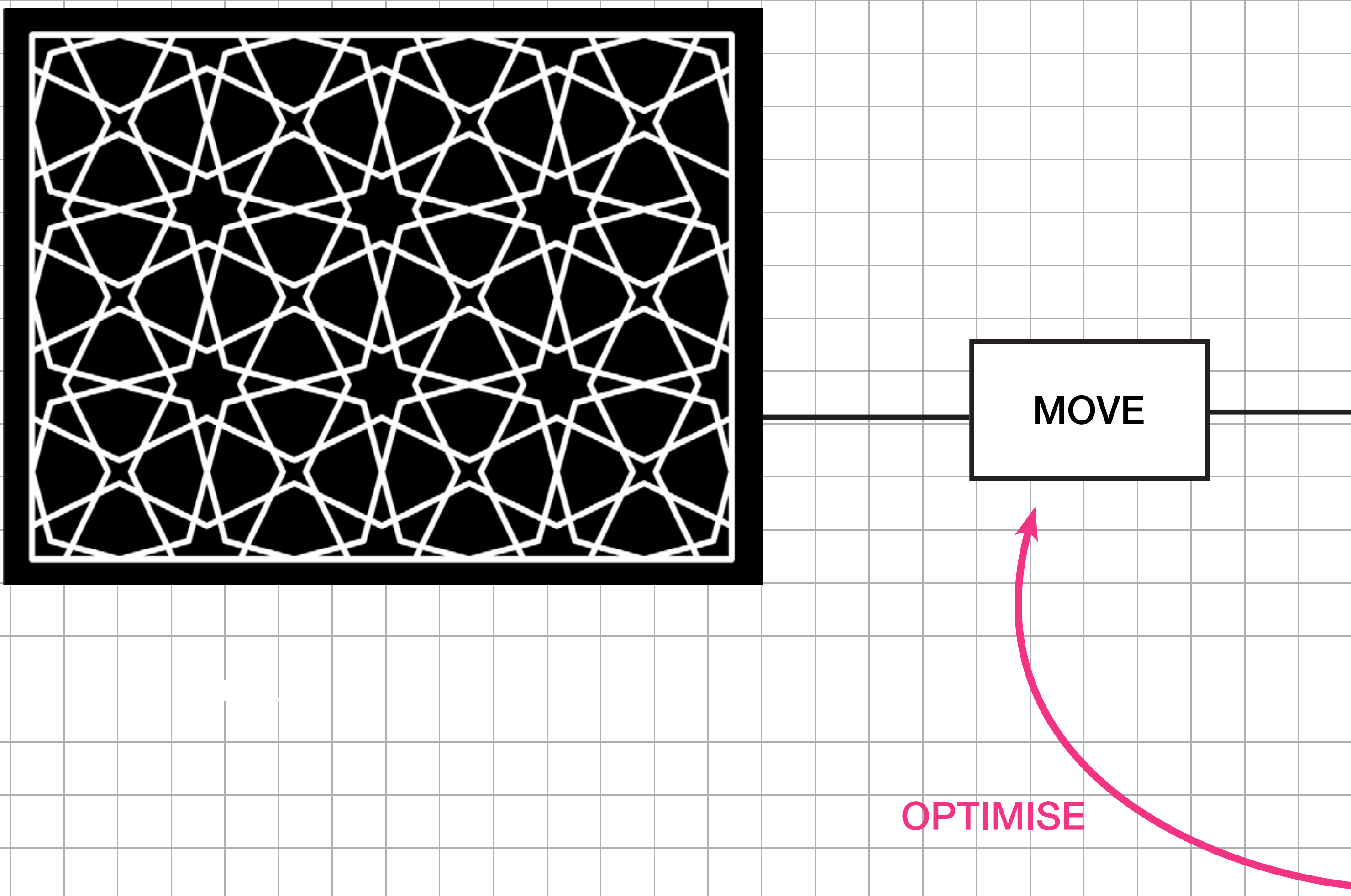
06

Volume 6.450
Deviation 8.231

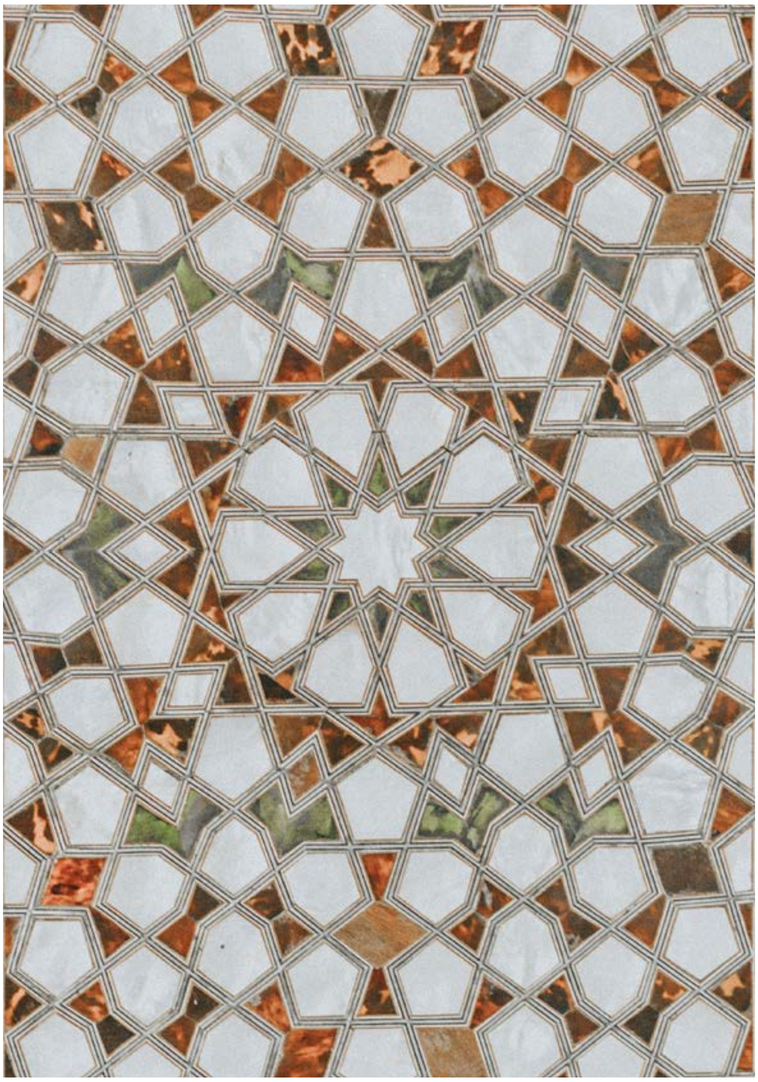




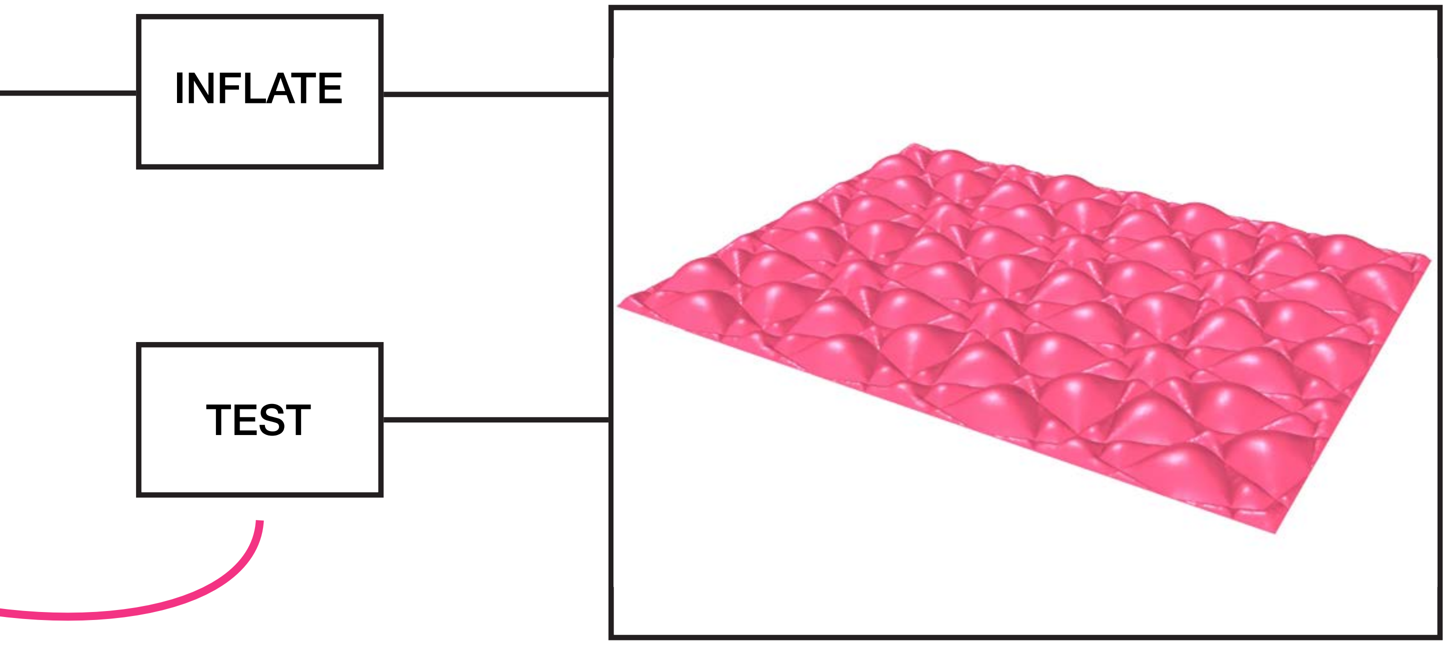
EXPERIMENT 06: PANELS, ISLAMIC PATTERNS

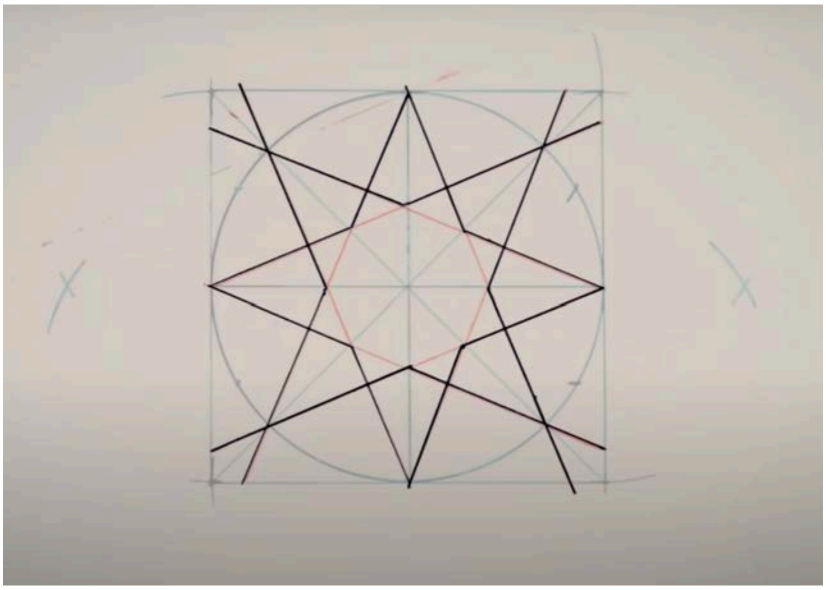


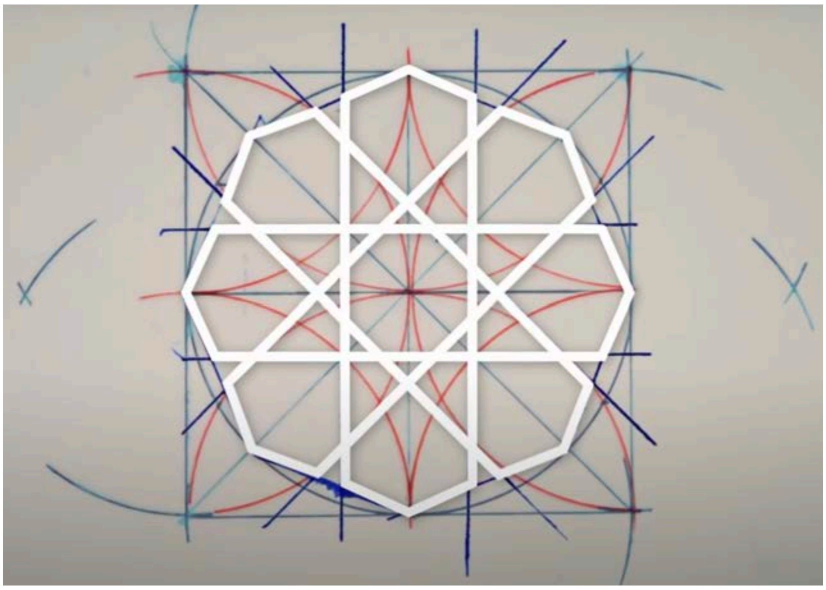
Learning from the previous experiments it is found that points gave us a large 'organic' pool of results that were indeterministic and unintuitive to optimise linearly due to random inputs. Hence the next steps are to create something more rigid in its foundational logic. Here, we look to the intricacies of Islamic pattern design, rich with repetitive shapes and orientated around the logic of intersecting lines, there is an expectancy that this design will provide a deterministic scope of solutions whilst remaining explorative, something imperative to the research.



[6] Islamic mosaic, Photographed by Meriç Dağlı - Unsplashed







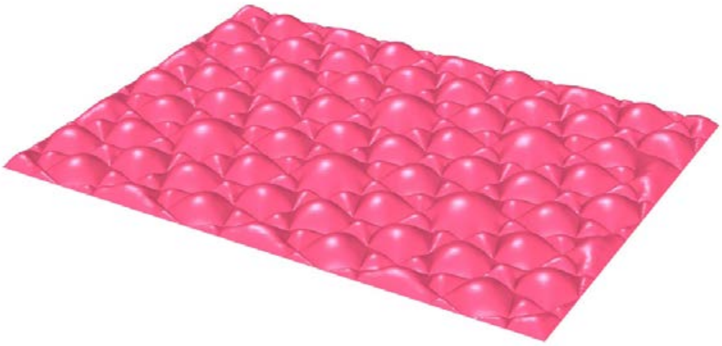
[7] Islamic Pattern formwork, sketches by Eric Broug - Ted Talk

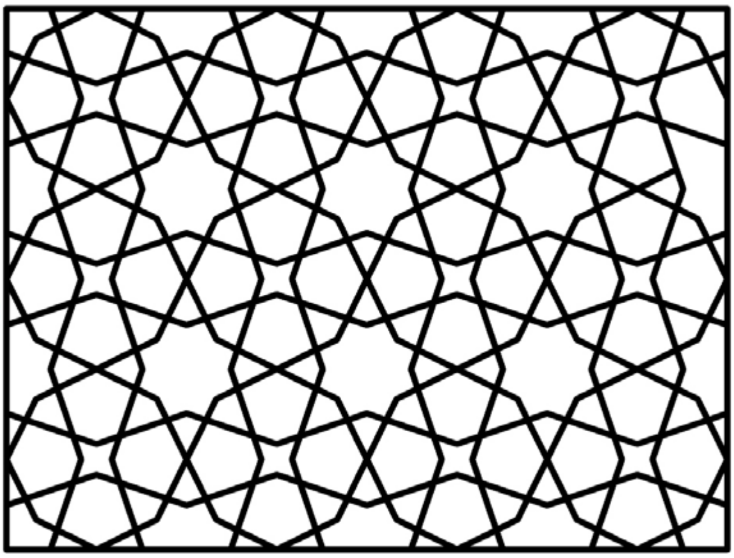
These images are extracts from Eric Broug's Ted Talk, - his book, Islamic Geometries provided the framework for the pattern design in this experiment. His book taught a process of forming these patterns using a grid of intersecting lines originating from a circle, as shown. These grids are then used to draw mirroring and bisecting lines. The parametric design which I generated plays from this foundational logic by generating lines at parameter lengths along the grid systems and mirroring around the circle before replicating as a panel over the surface.

To allow for the repetition the inflation models are 3 times larger, and results are scaled as appropriate.

01

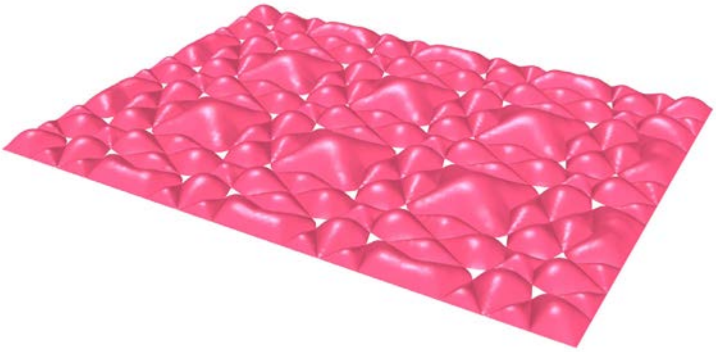
Volume 5.607
Deviation 4.452

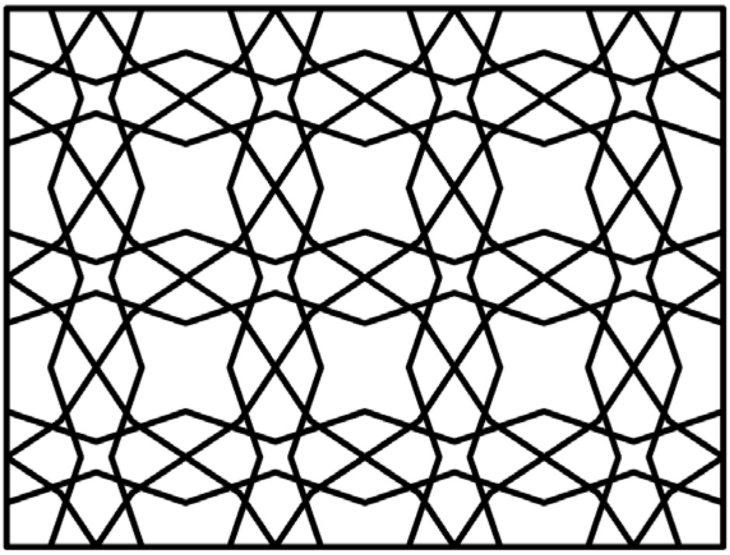




02

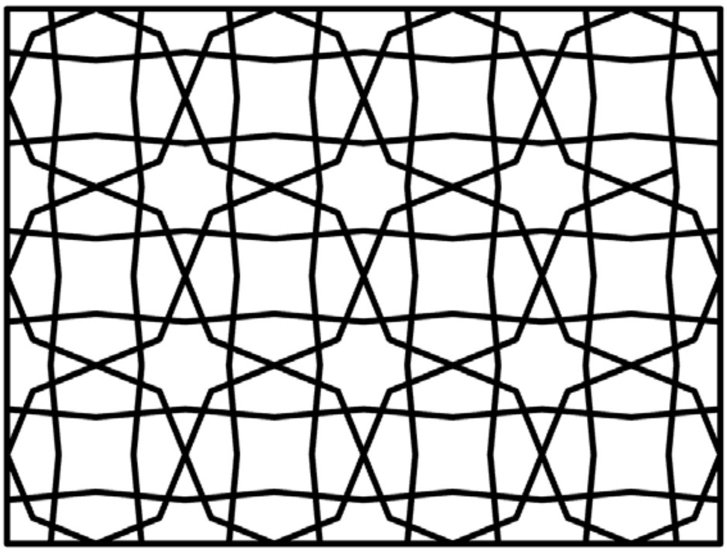
Volume 5.513
Deviation 5.617

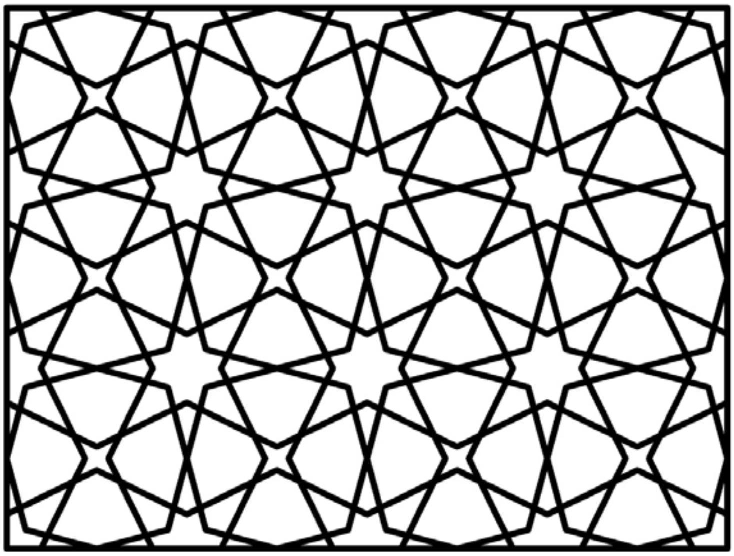




03

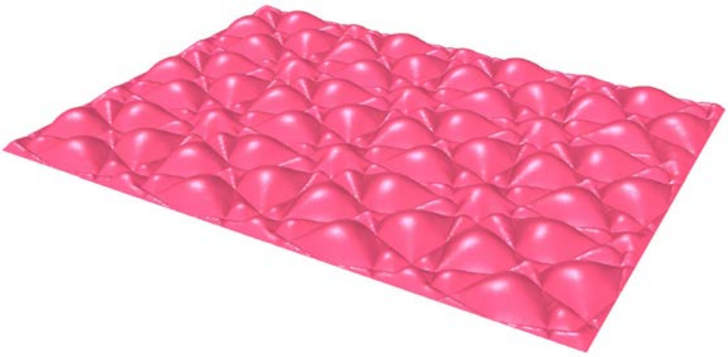
Volume 5.695
Deviation 4.866

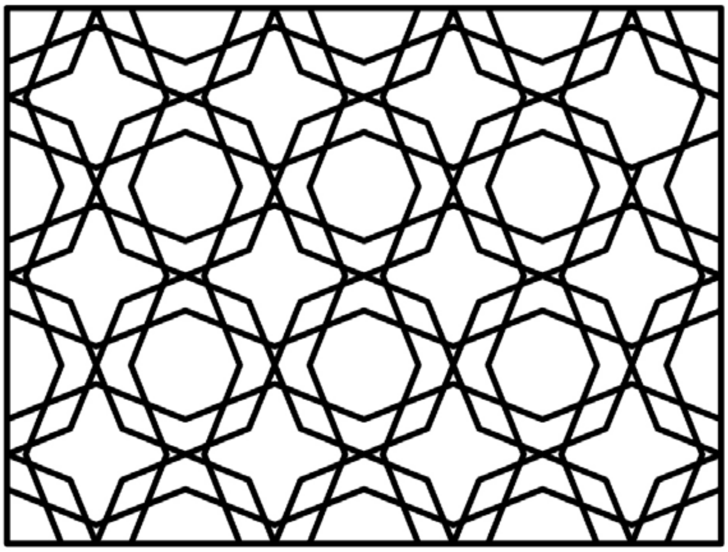




04

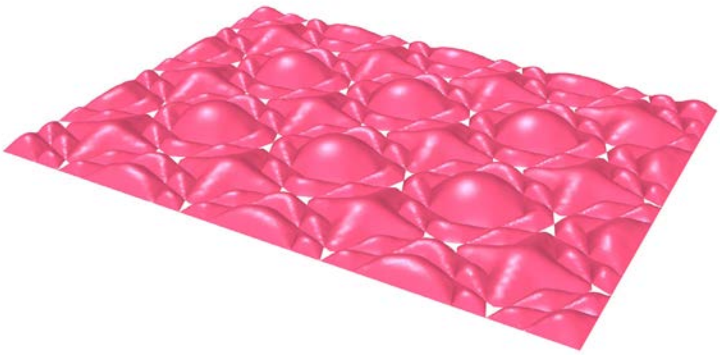
Volume 5.235
Deviation 4.394

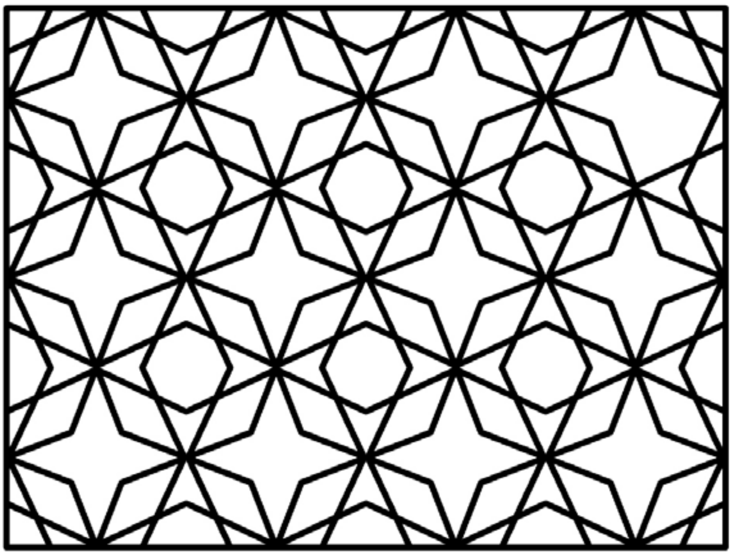




06

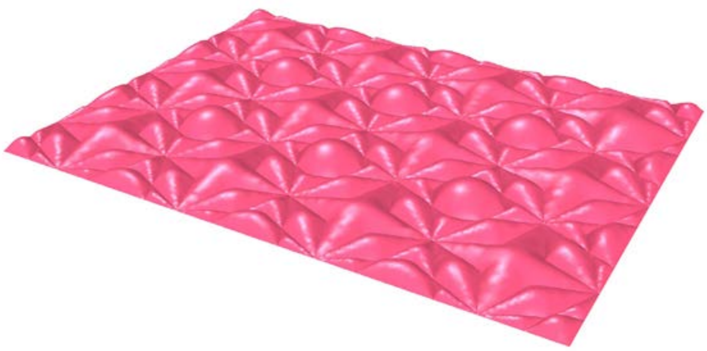
Volume 5.042
Deviation 6.517





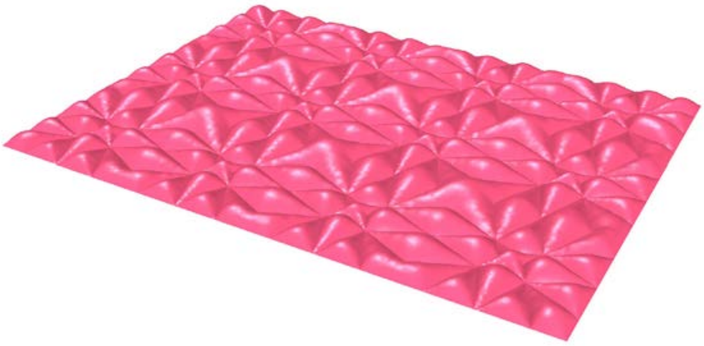
08

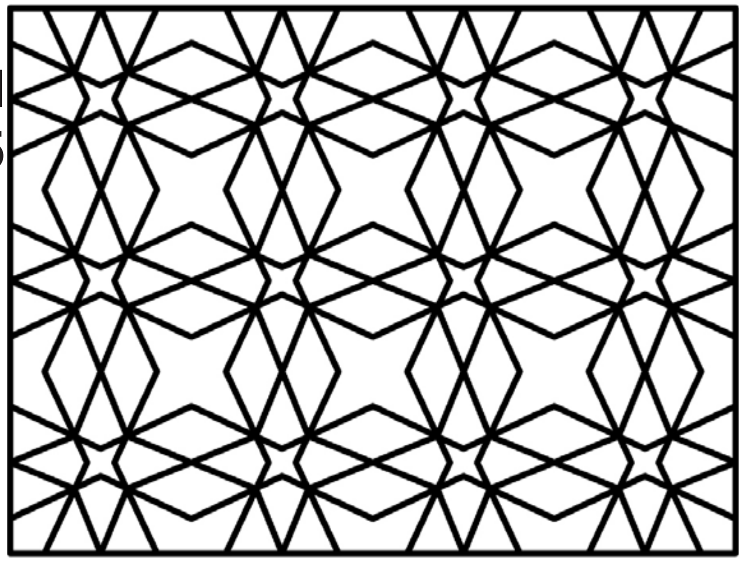
Volume 4.112
Deviation 4.348



05

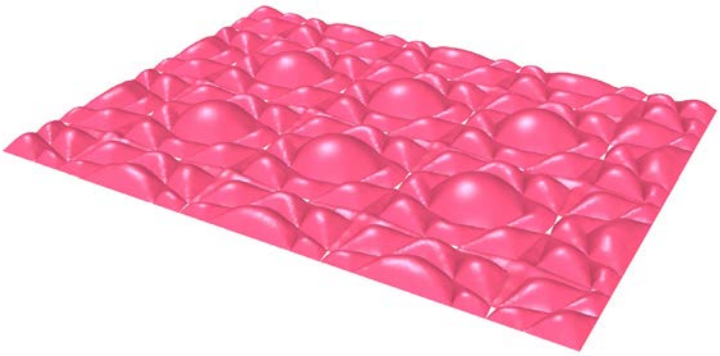
Volume 3.971
Deviation 2.625

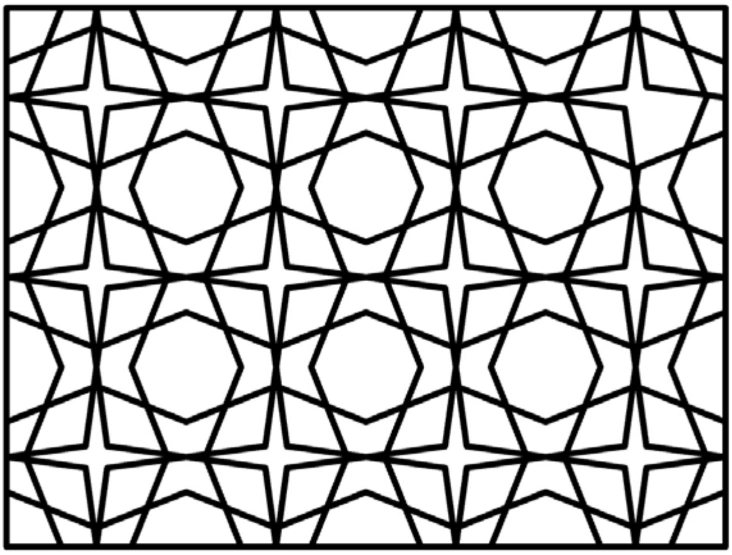




07

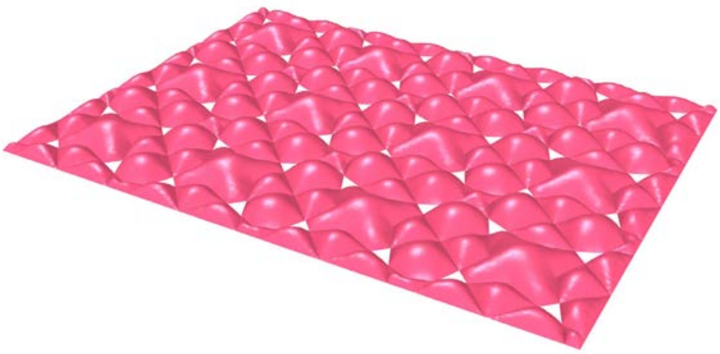
Volume 4.839
Deviation 5.216

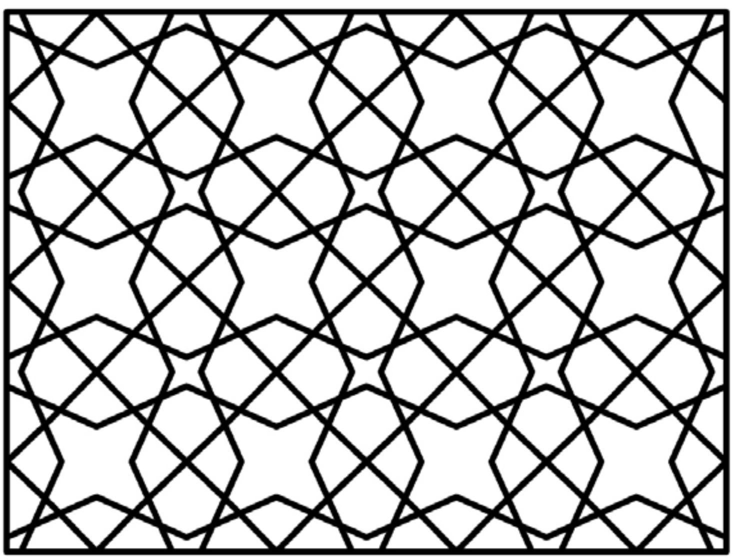




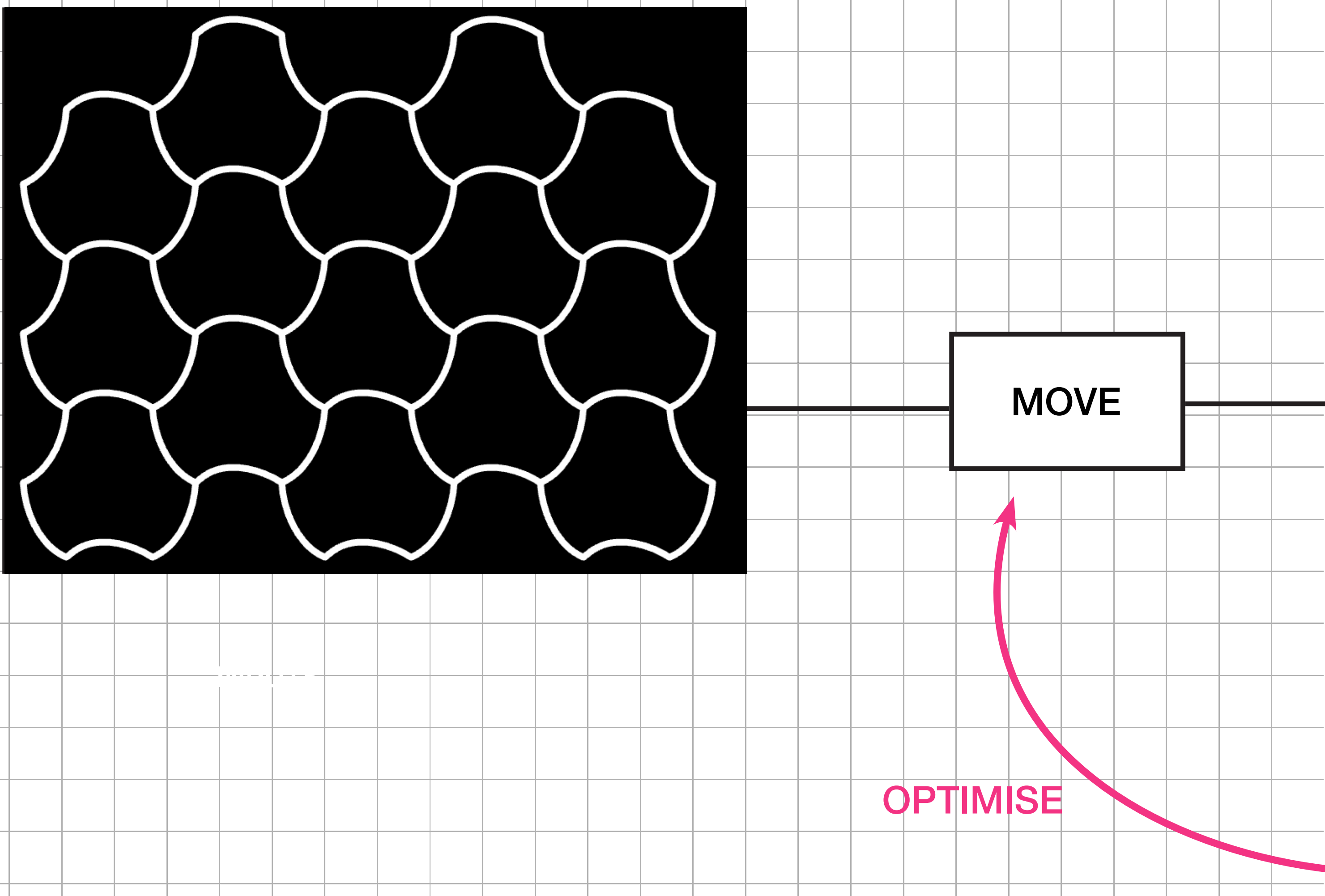
09

Volume 4.900
Deviation 4.254

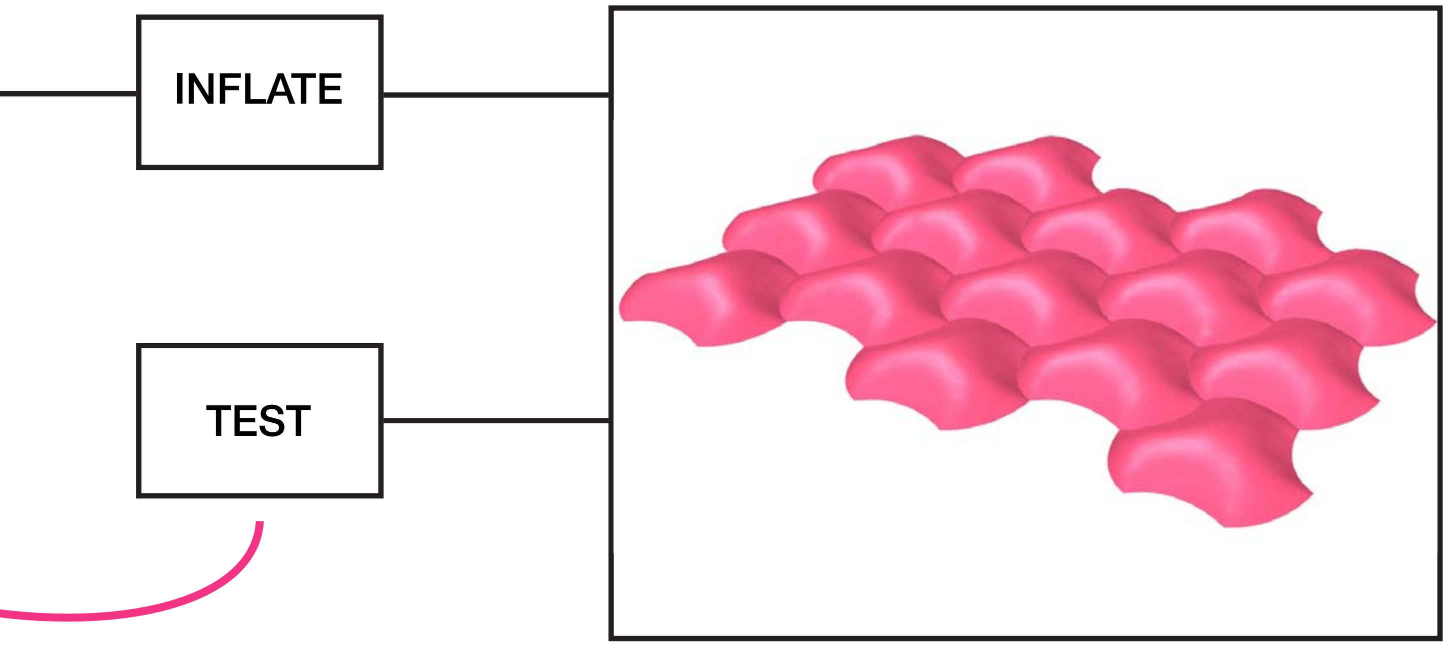




EXPERIMENT 07: PANELS, TESSELLATION

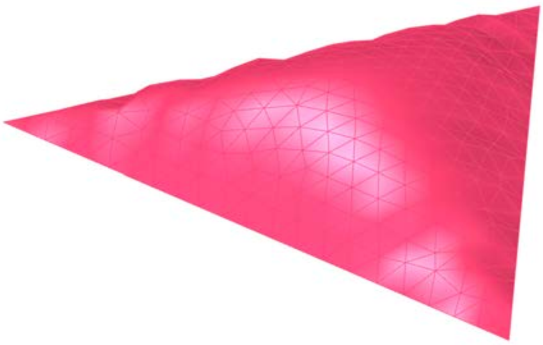


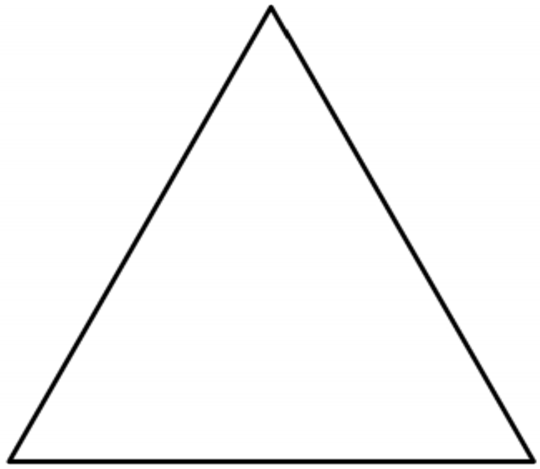
Building upon the results of the Islamic designs as well as pushing the exploration to a new context, this experiment looks to generate repeat shapes that can be tessellated to fill the plane. The focus has shifted from framework patterns to individual shape logic, to identify an optimal surface shape for inflation. The exploration of tessellations came as an answer to the lack of context in the initial designs, when questioning how these forms can be applied as a retrofitted façade there is doubt over the adaptability to non-standardised, flat, large surfaces. This design aims to provide a panel tool which can be applied singularly or as part of a system to build around the existing architecture.



3 Sides

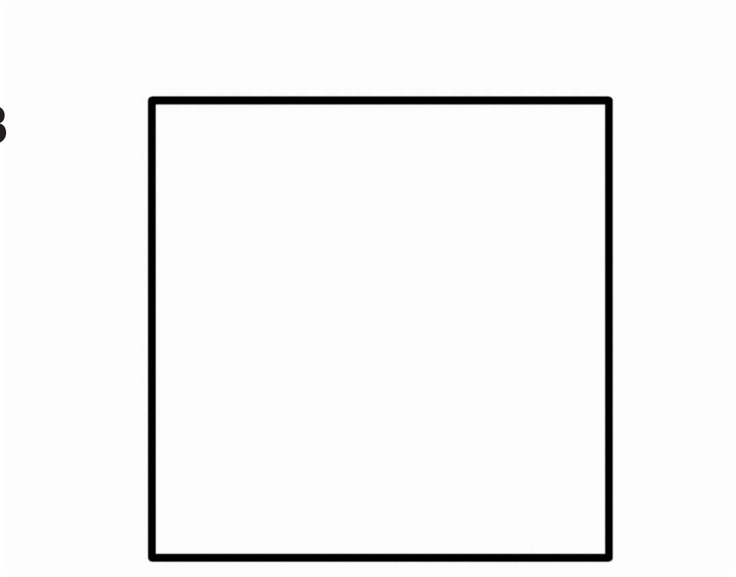
4.603





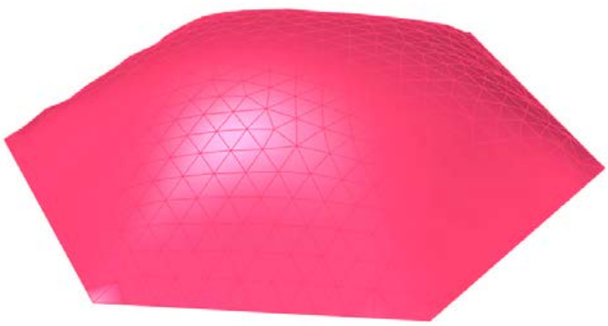
4 Sides

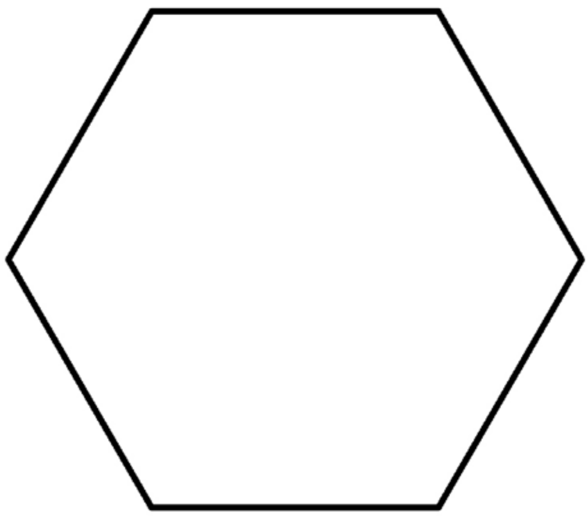
5.543

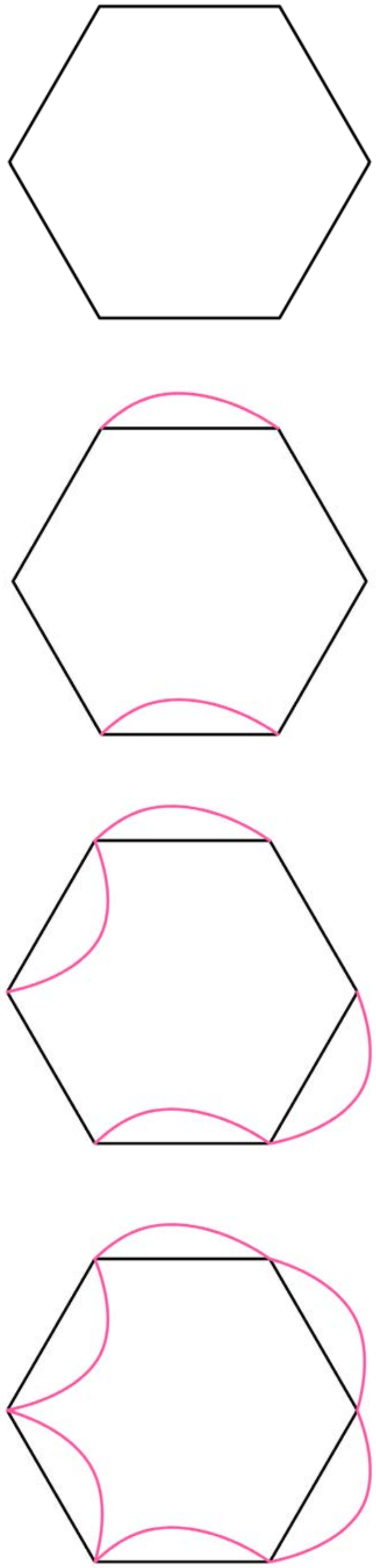


6 Sides

6.778

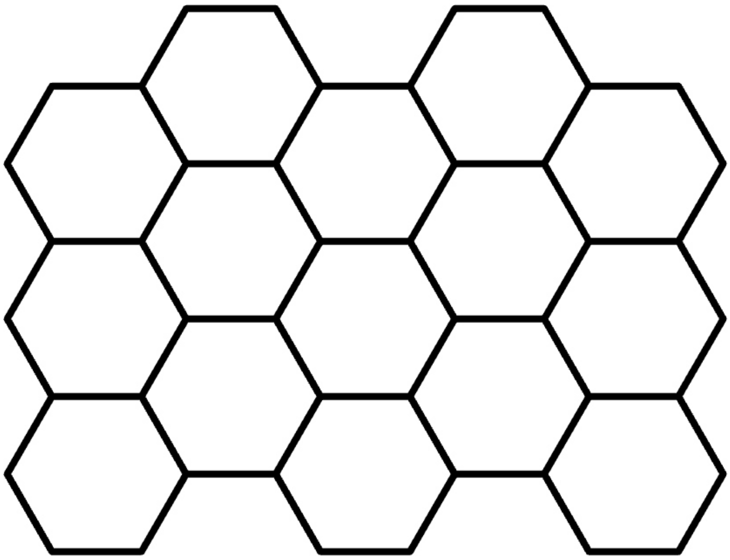






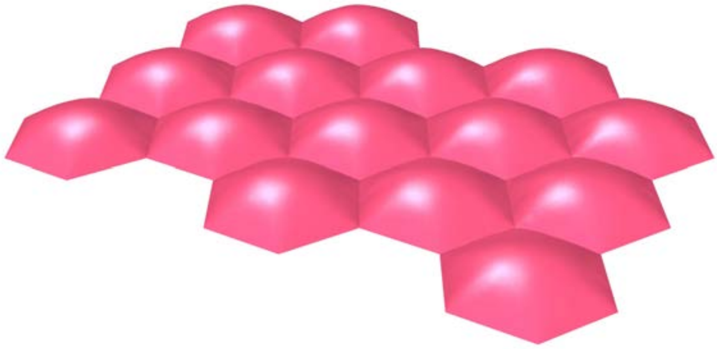
For the scope of this investigation, we start with the optimisation of regular polygons for maximum volume generated to the surface area. There is found to be a continual increase in generated area for an increased side count. Identifying the most easily tessellated of the polygons, triangles, quads and hexagons. From these 3 it is evident that the hexagon will be the most effective for the production of volume. From this the next step is to stretch the breadths of the hexagon by adding curves, which are replicated invertedly on the opposing faces, allowing for tessellated tilling as shown:

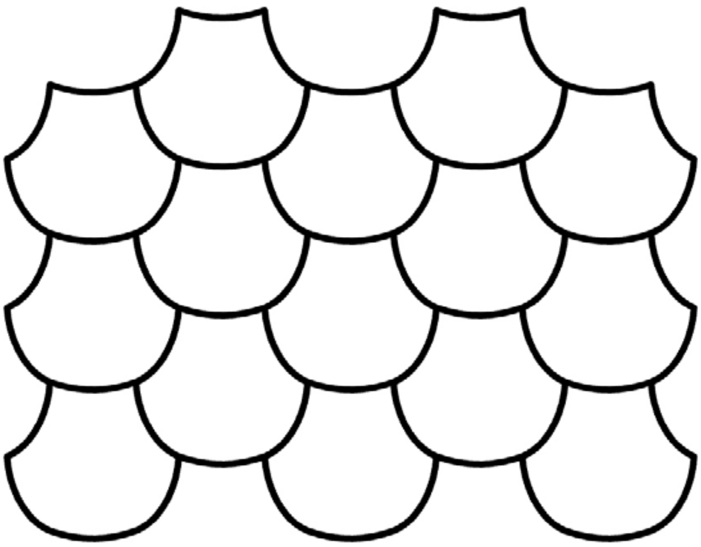
for tessellations there is no standard deviation testing as the expectant volume of each pocket will be equal hence the testing is focused on volumetric calculations alone.



01

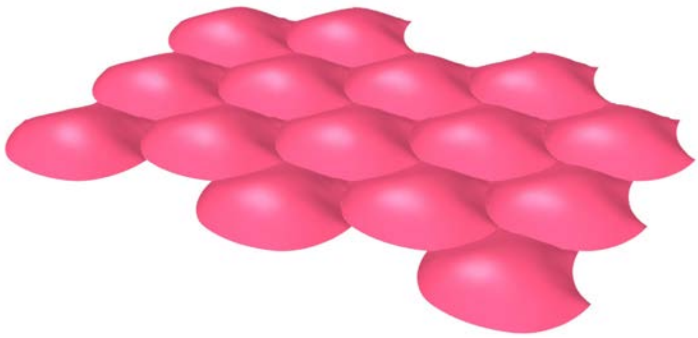
Volume 6.778

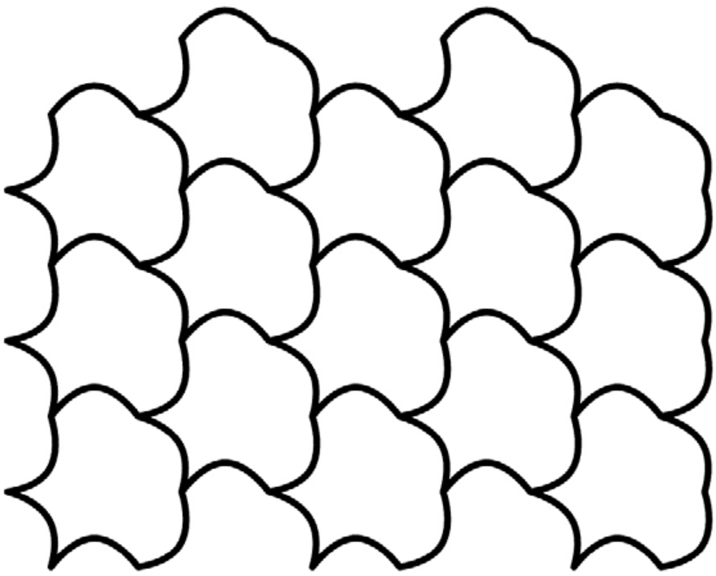




03

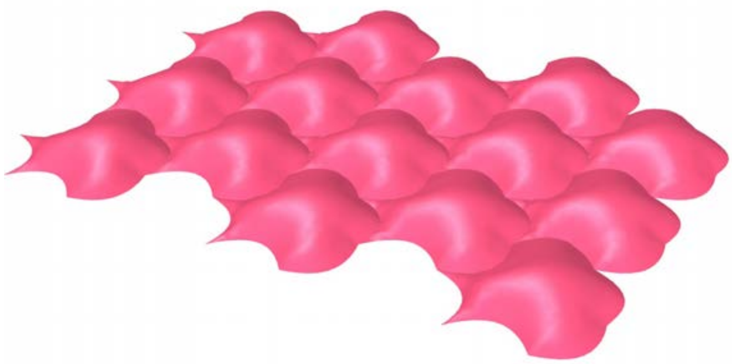
Volume 4.608





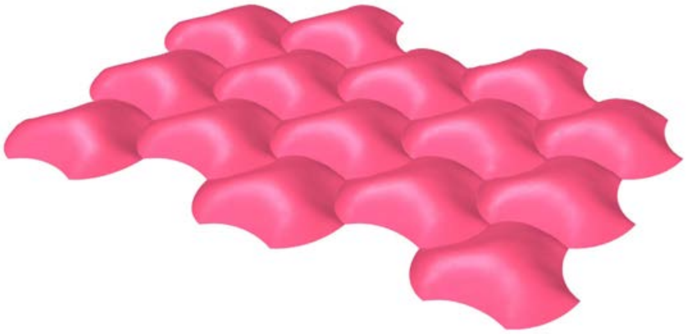
05

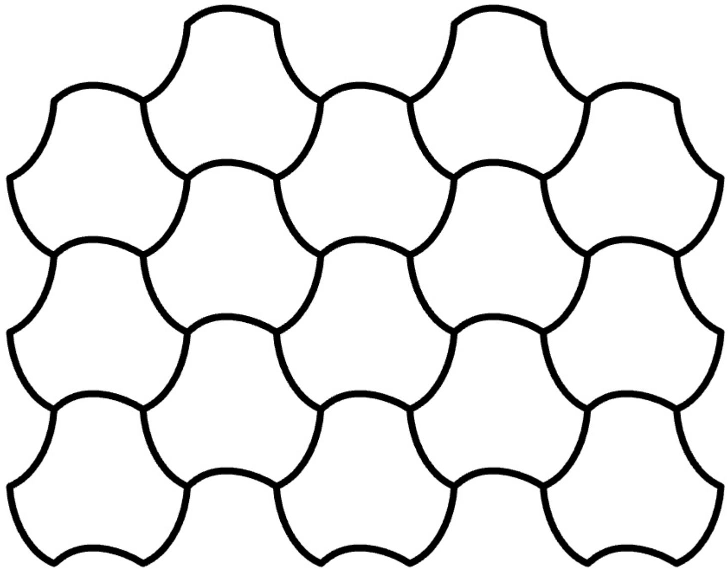
Volume 6.140



02

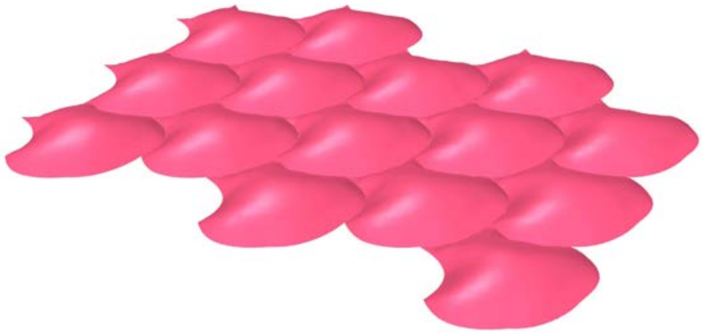
Volume 3.469

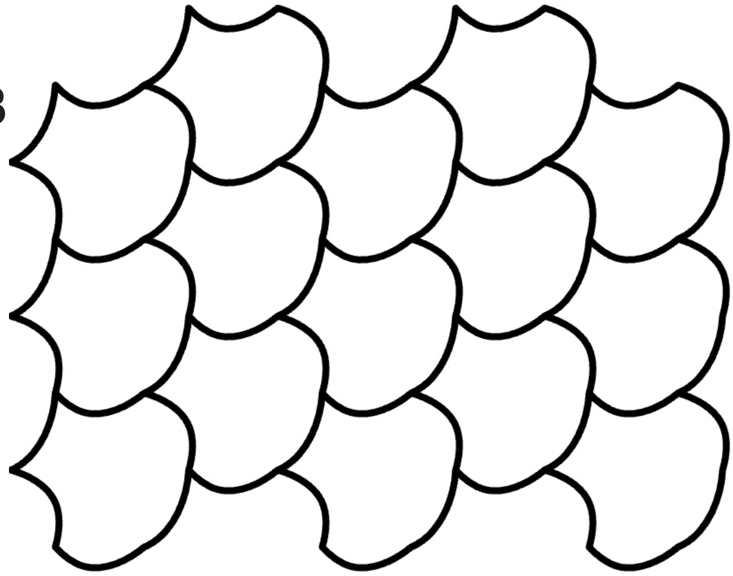




04

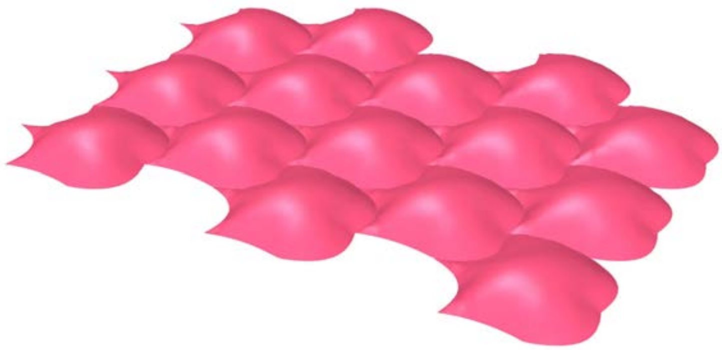
Volume 5.393

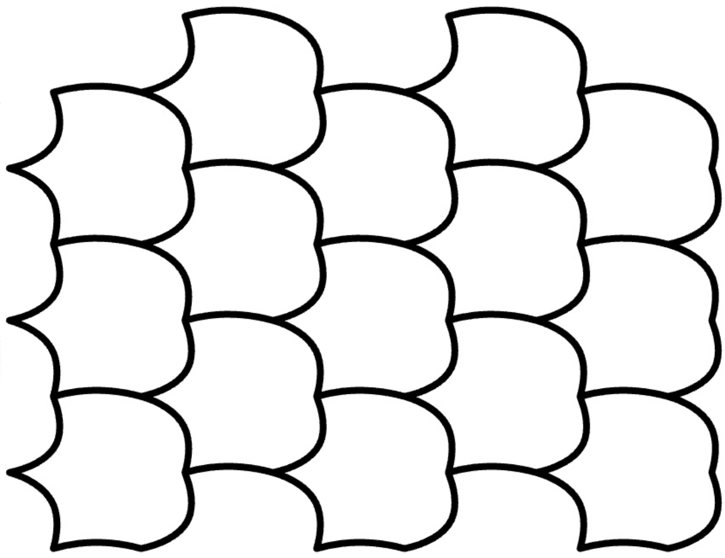




06

Volume 6.938



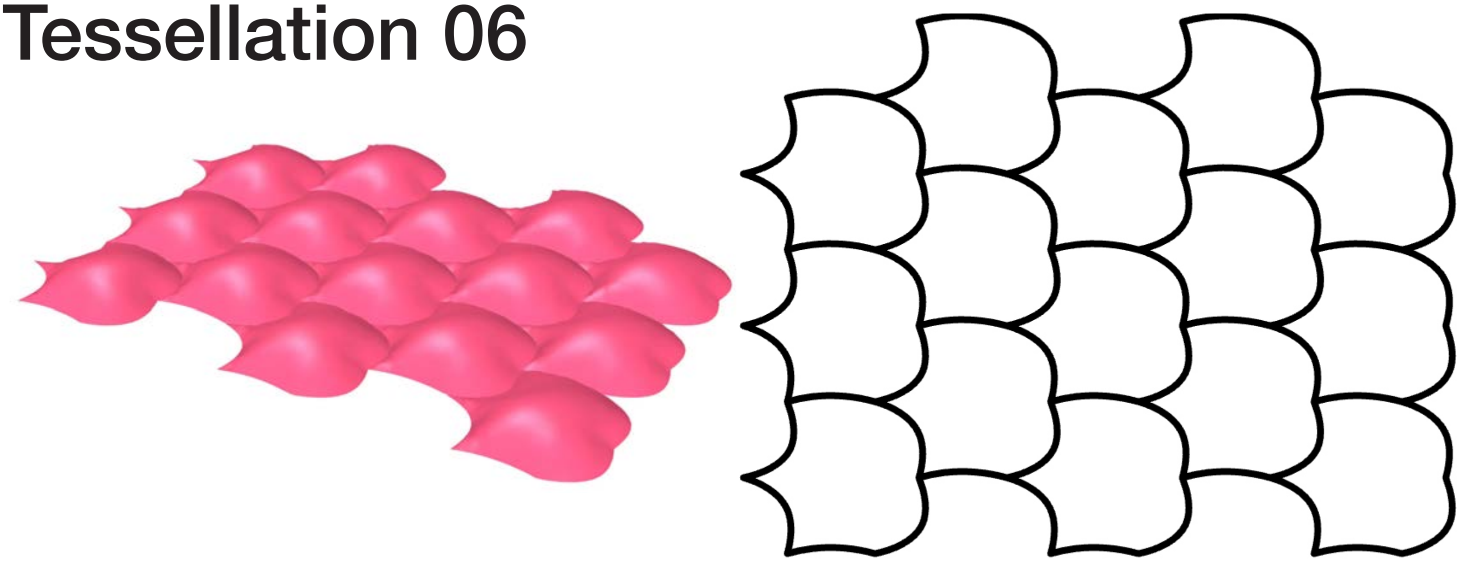


D1. Design Selection

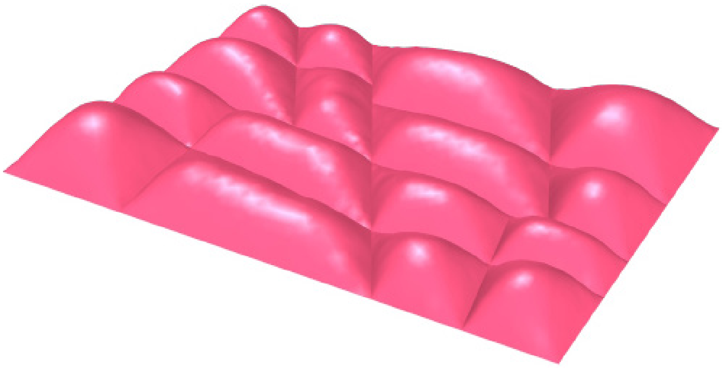
These four designs have been selected for context testing, they've been selected for various reasons and not just the highest scoring, thus allowing continual exploration as well as continuing the objective of an explorative workflow and not an individual result.

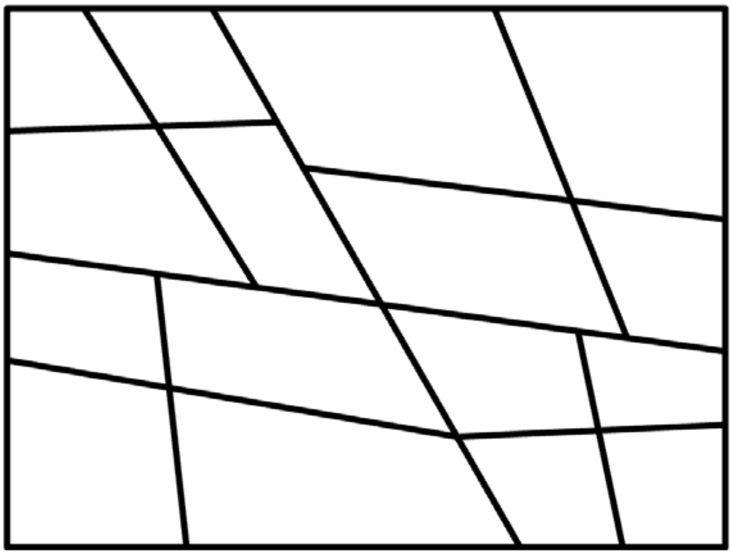
One result has been considered from both lines and points, as they encompass progressions from each experiment. Whereas both tessellations and Islamic patterns are considered forward due to the explorative and interesting contexts provided by both designs.

Tessellation 06

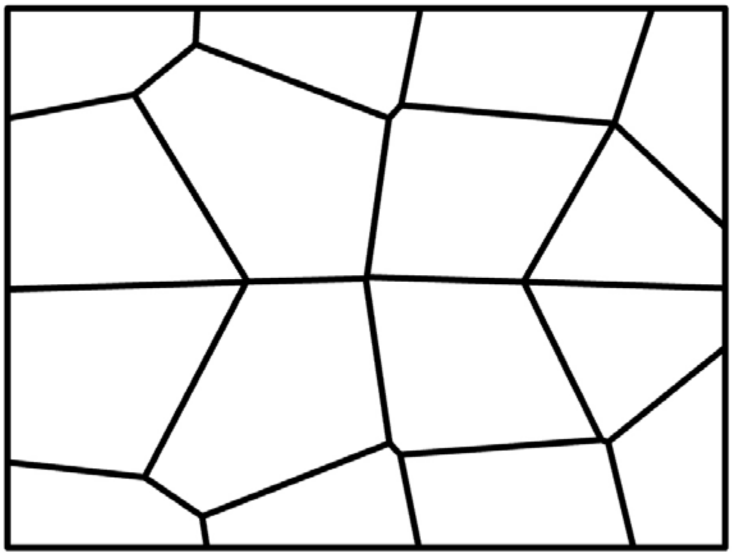


Lines, Nested 03

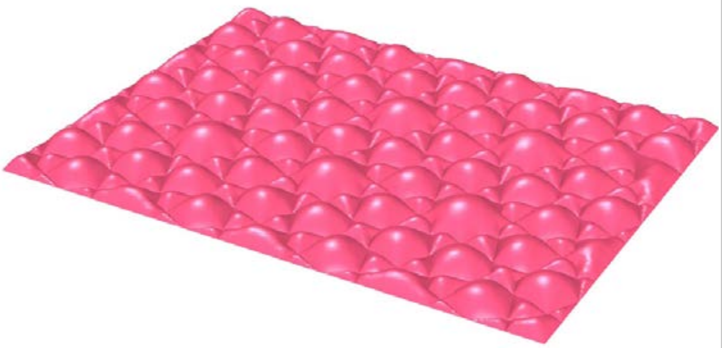


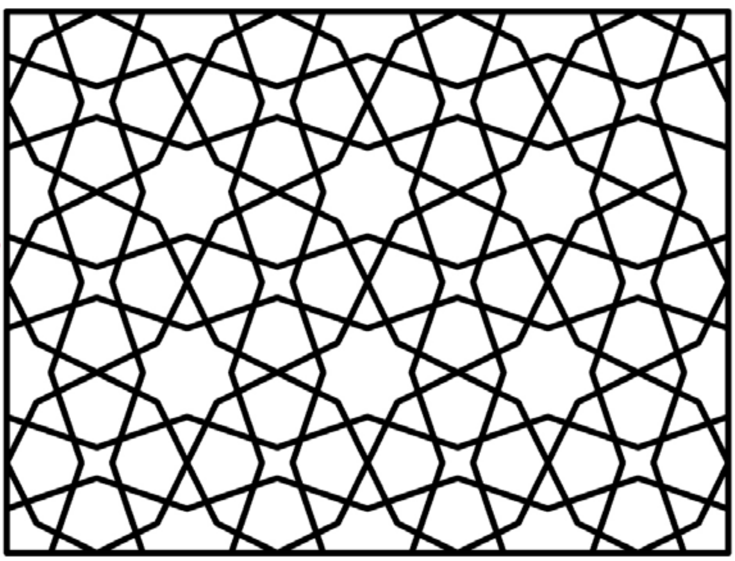


Points, Distortion 01



Islamic Pattern 01



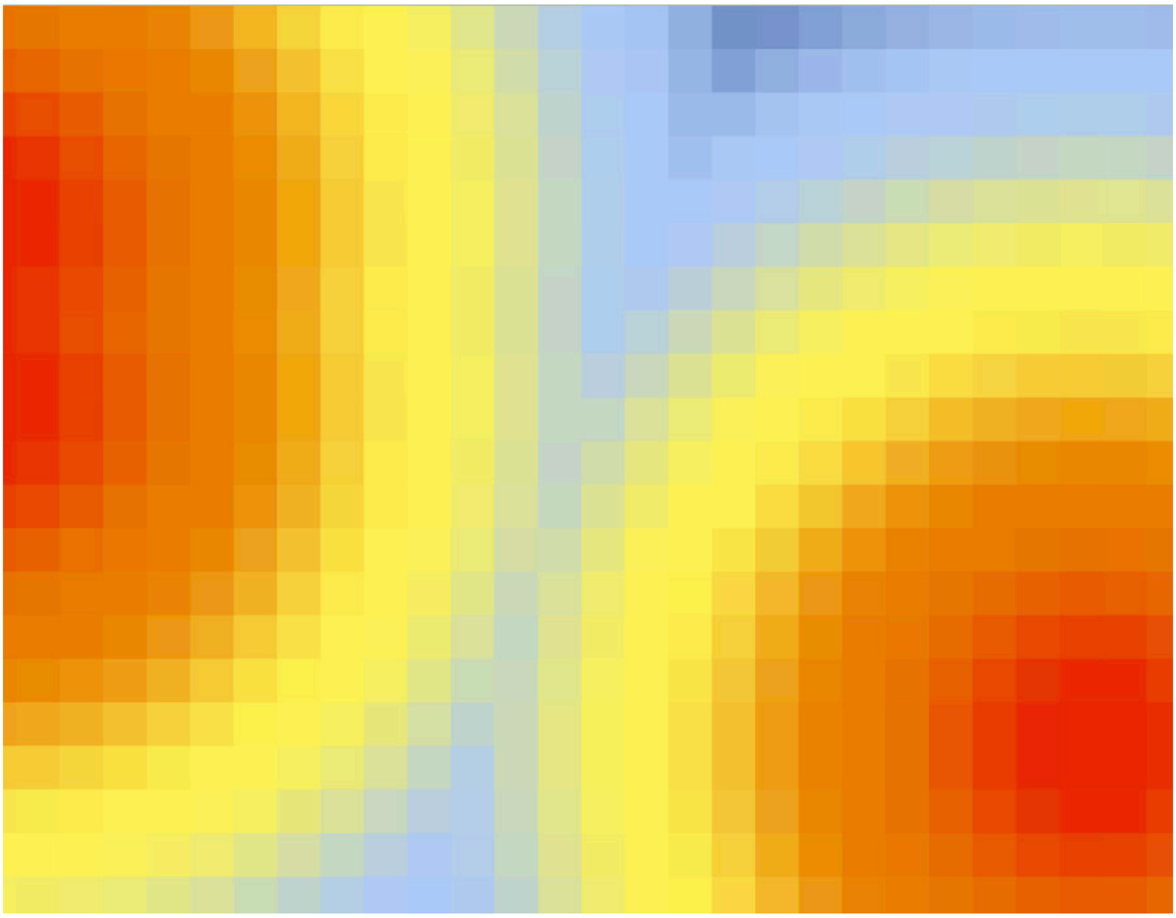


D2. Contextual Results

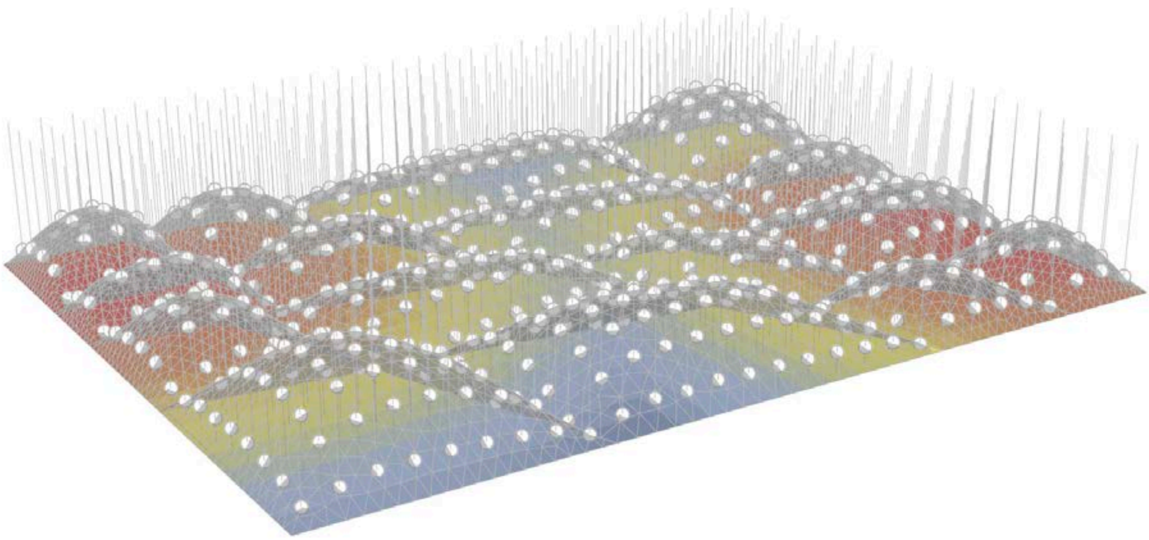
The nature of this research is to identify the relationship between pattern and volume, which has been expressed through testing, but the real application of this study would be provided in the context of the built environment. To achieve evidence of the practical applications a provisional workflow has been created to demonstrate how this method of topology optimisation and volume calculation could result in geo-locationally optimal solutions.

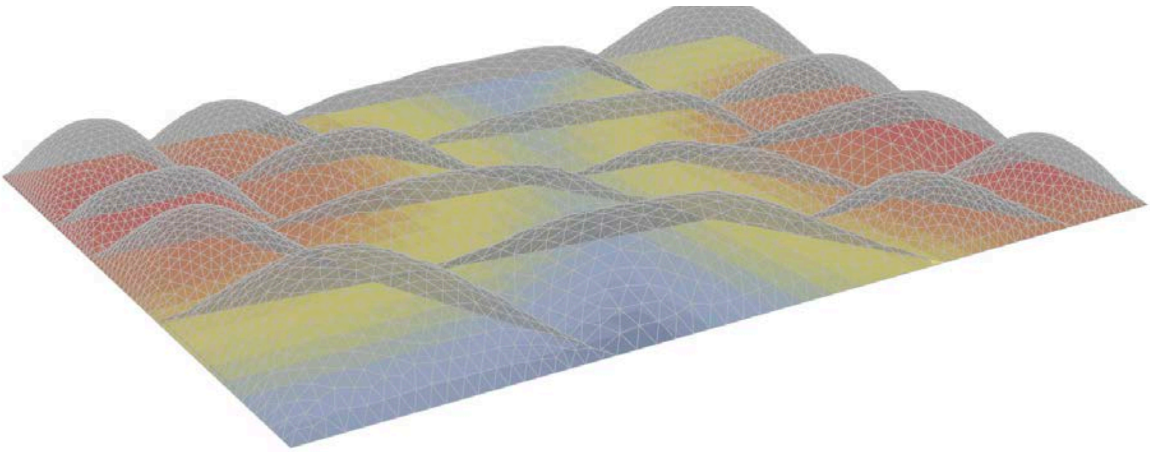
This data is a visual representation of real thermal imaging data, at a low resolution. due to time and processing limitations, accurate site-specific data wasn't used for the presentation of work flow but this example can highlight the adaptability to context data.

The data was built up from digital data sets, imaging, and a grasshopper script to visually and numerically populate a matrix in accordance. This allowed the testing script to calculate a score for insulative energy saved based on escaping heat from the surface at a given point multiplied by the depth of the façade (full inflation) at that same location. Summations of these scores provide a total rating for improved energy capture of each design.

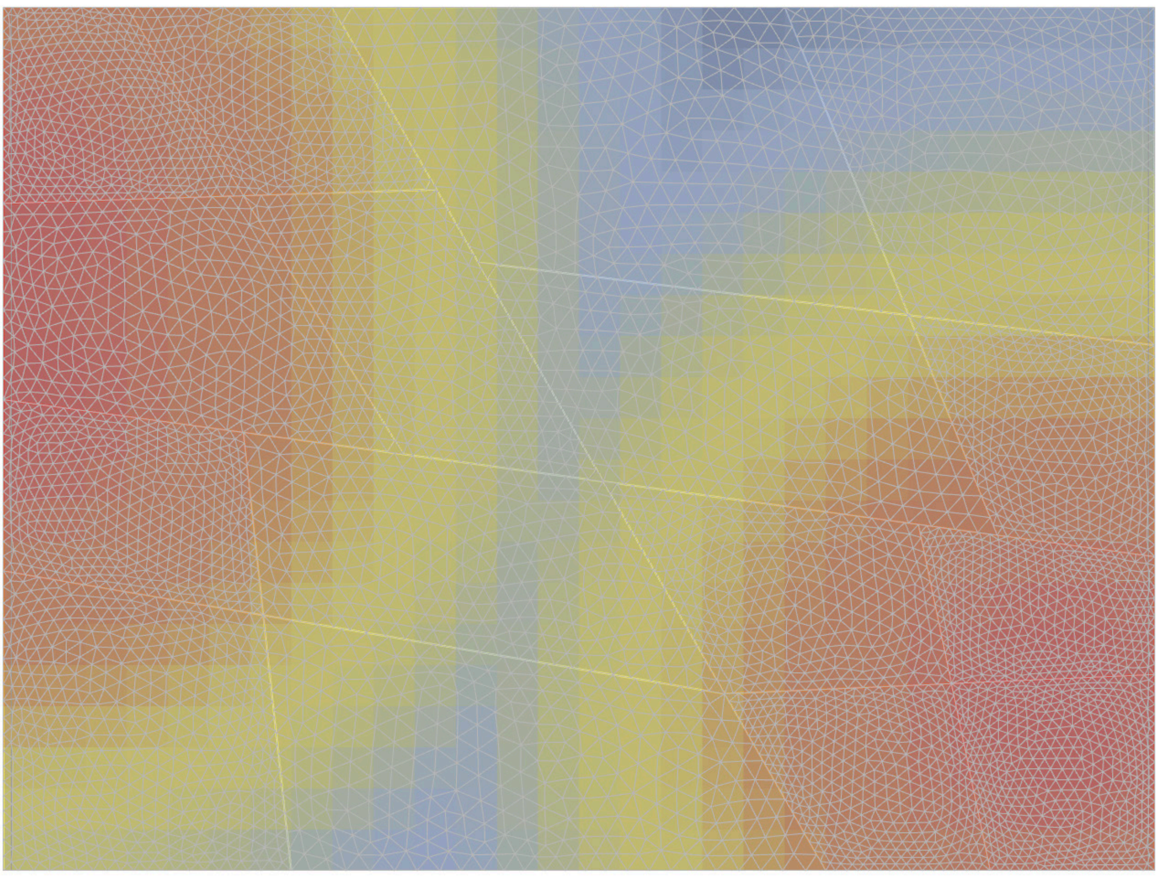


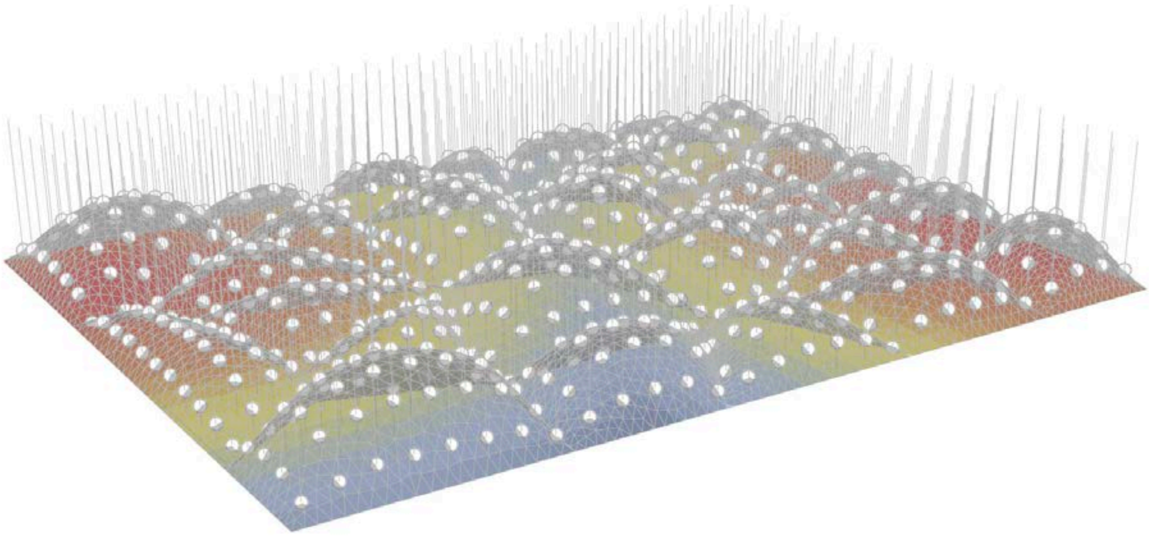
[7] Mock Thermal Analysis matrix, generated through grasshopper + ladybug

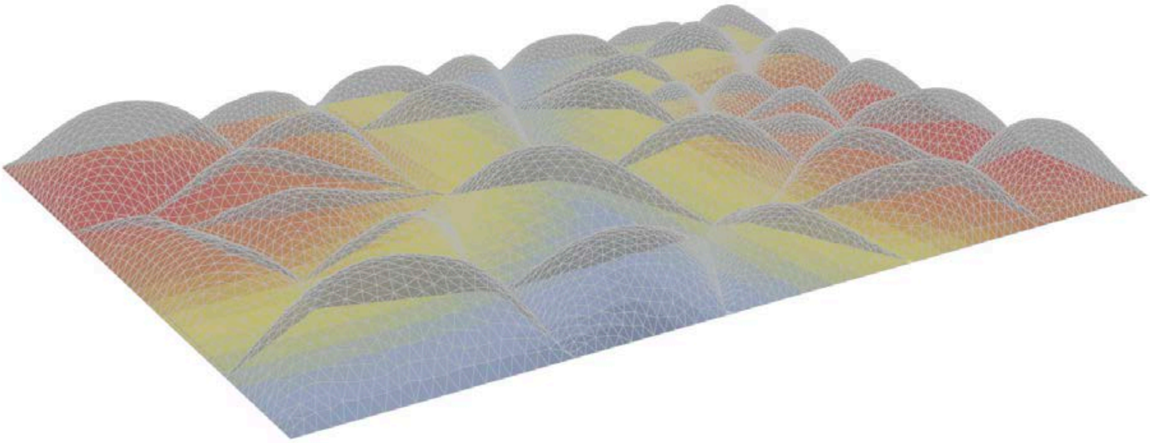




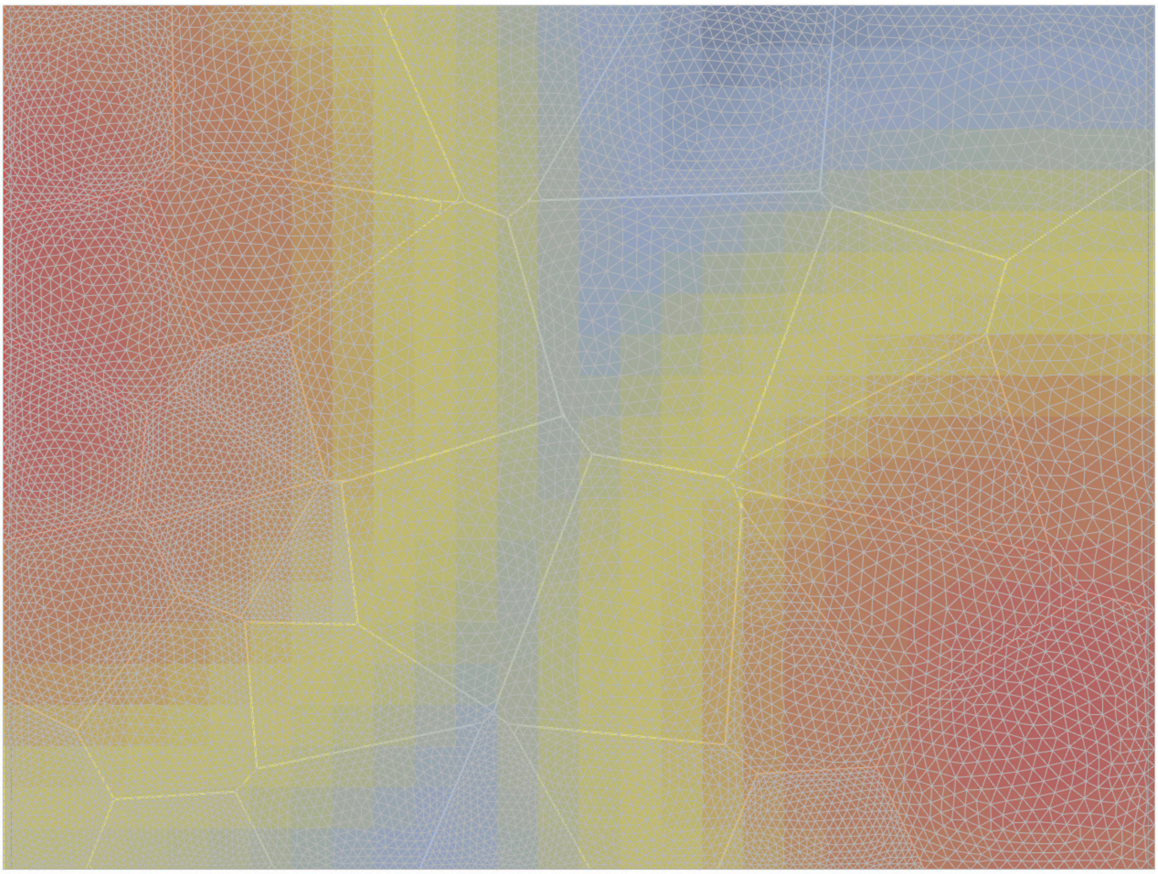
1304

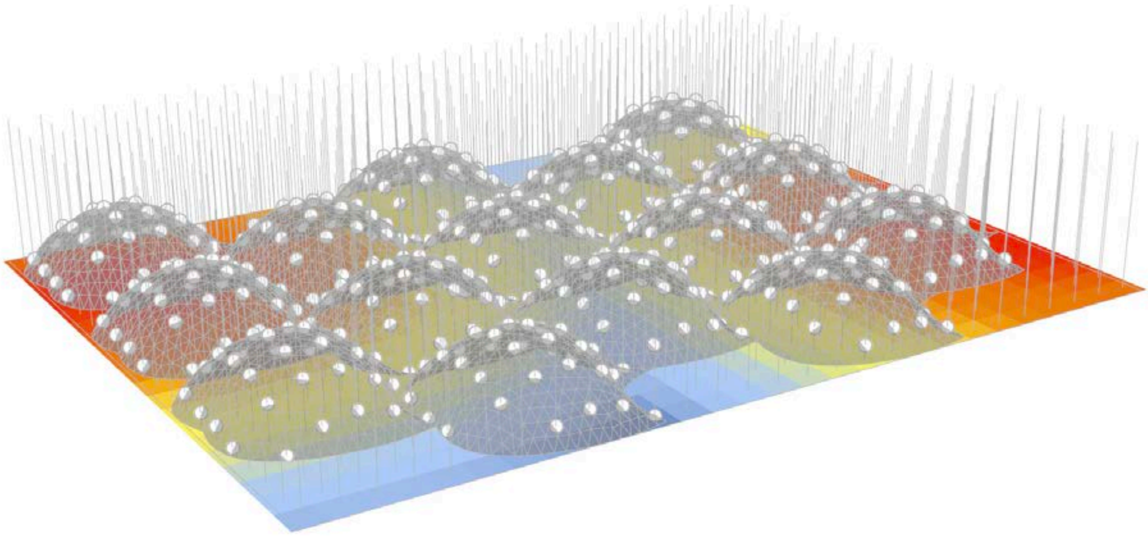


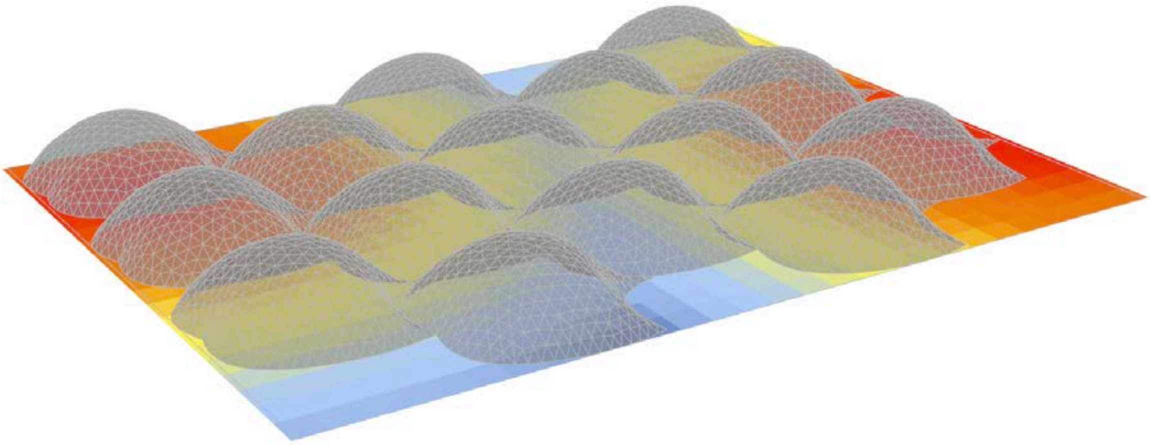




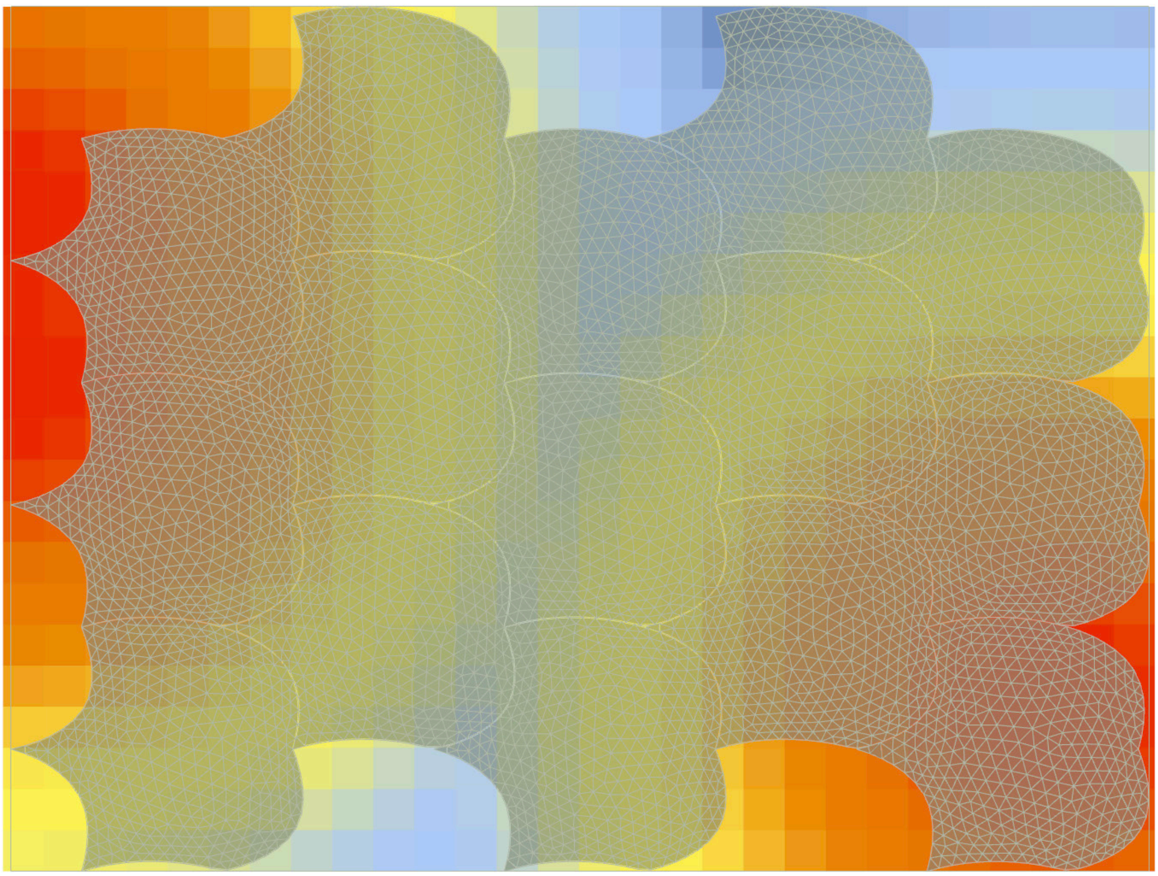
1402

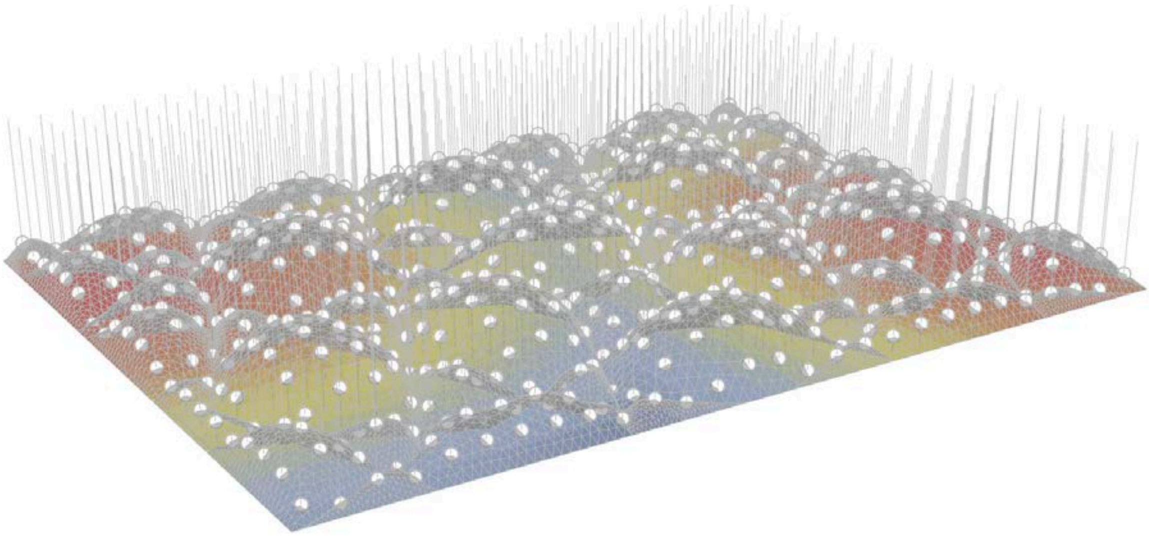


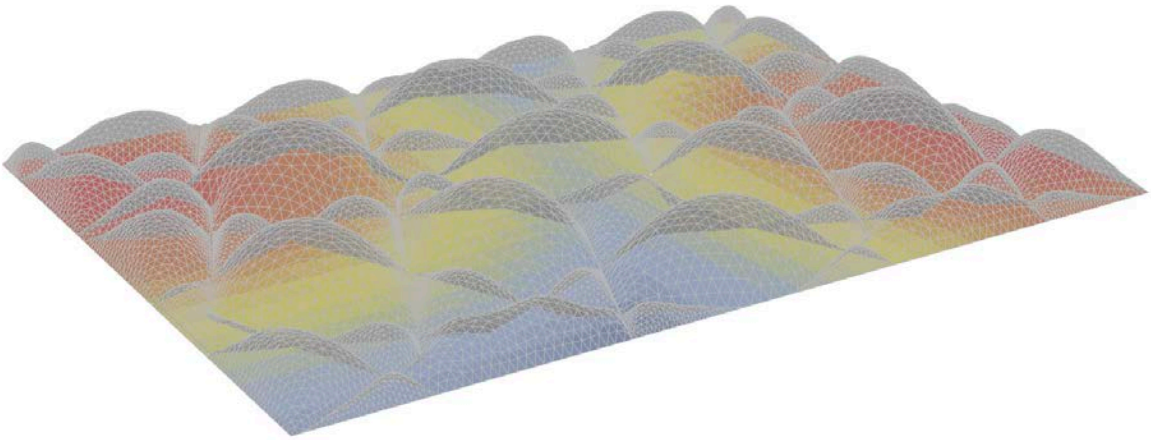




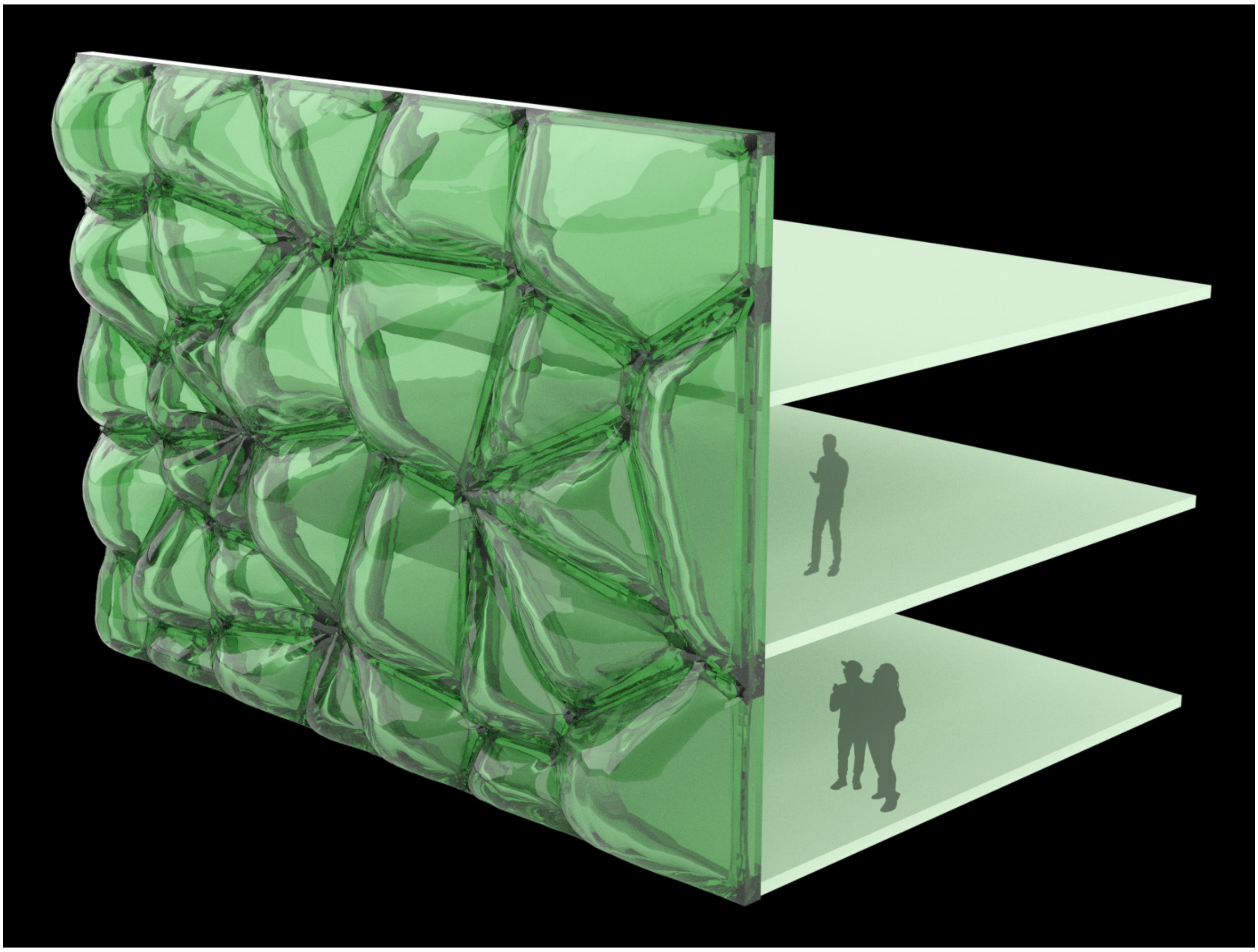
1325

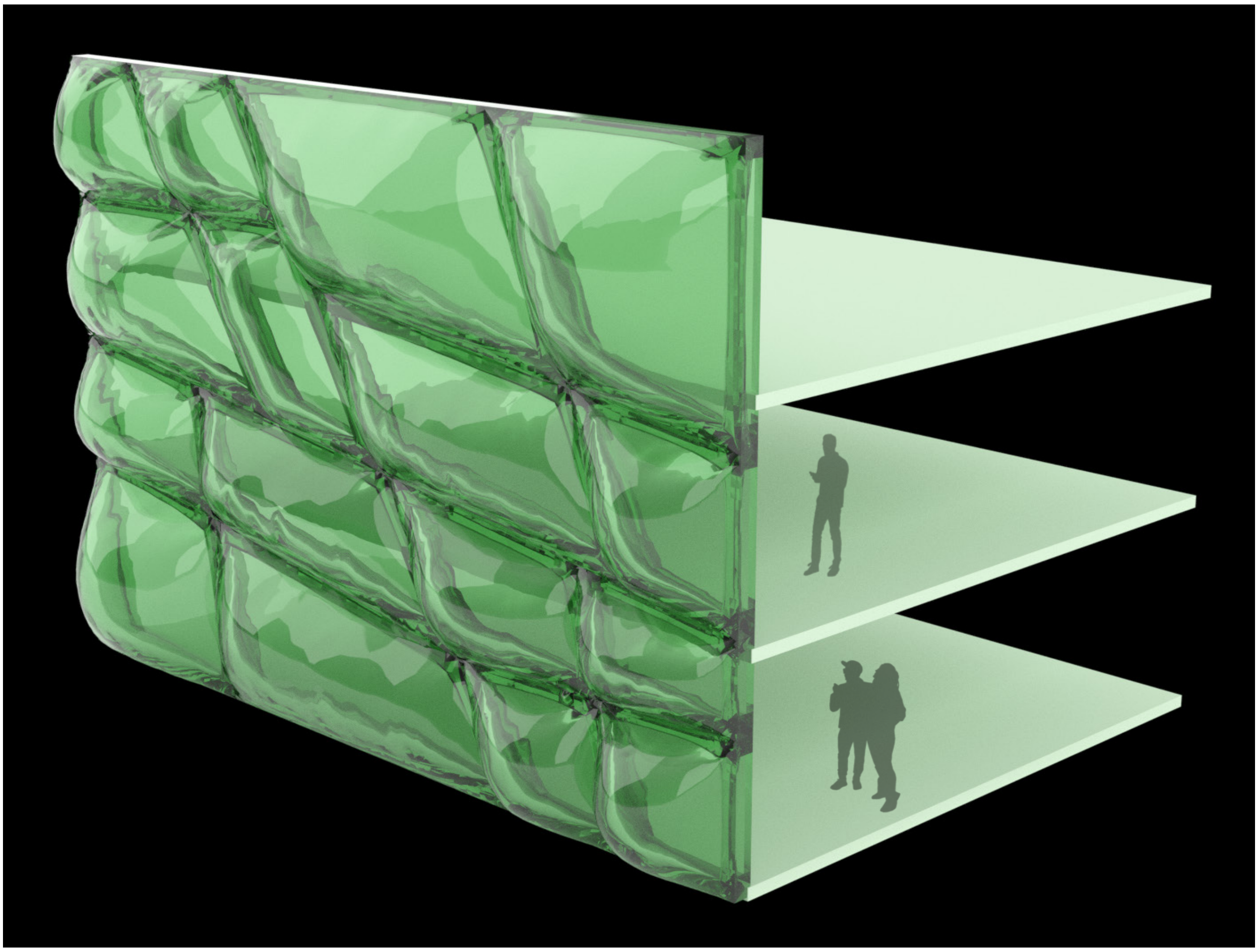


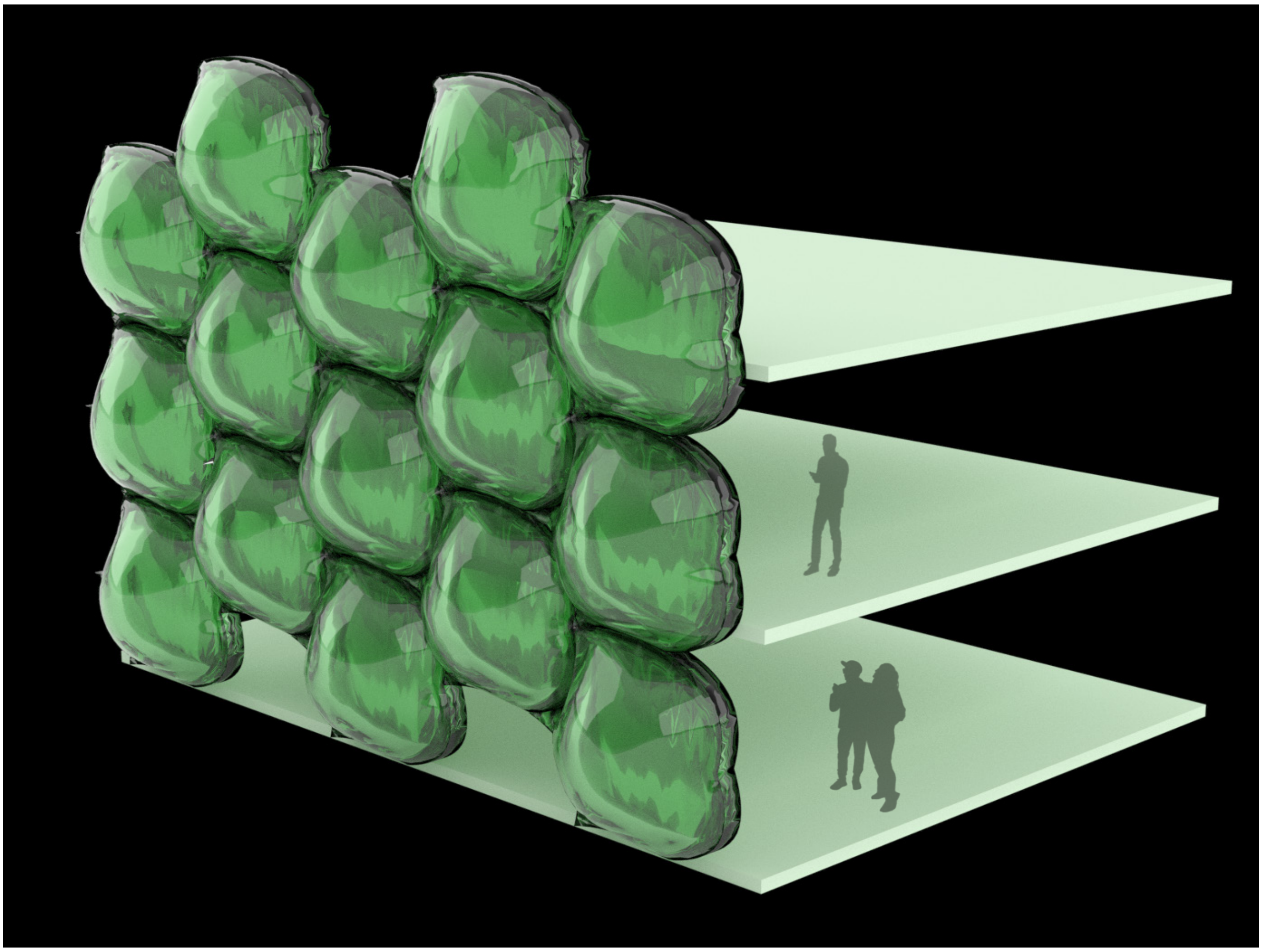


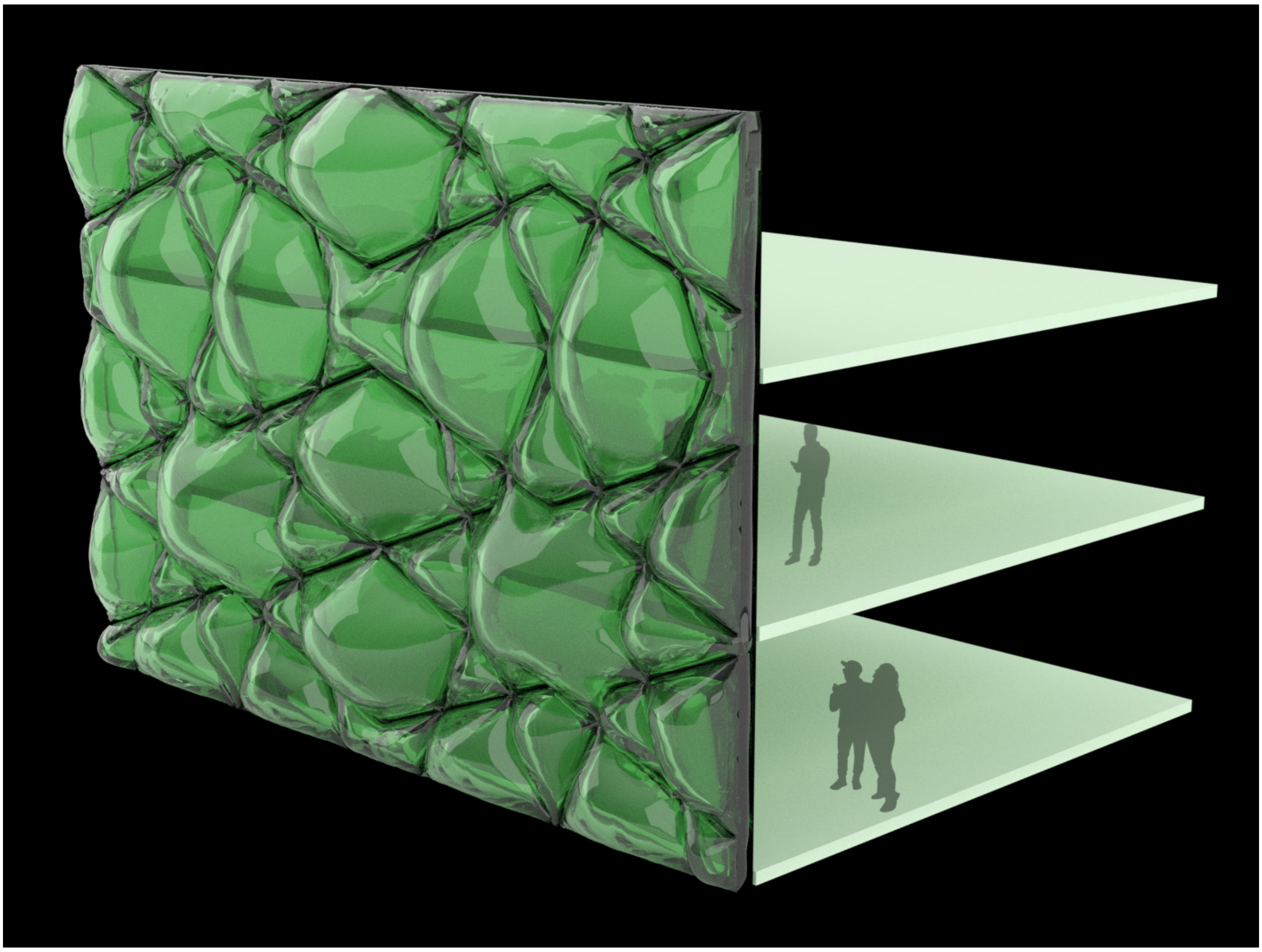


1155









Conclusion

The power of Parametrism in this project is found in the number of results produced from all extremes from just a few design methodologies, with just a few variables. The range of design iterations has allowed explorative findings and proved the relationship between inflation and volume.

The workflow, from design, and parametric to movement and optimisation are all evidence of the role computational practice can have in high tech & environmentally sustainable architecture. In buildings like the case study, Media TIC and contexts such as this report are focussed on efficiency and result-driven performance, something which is proven to be enhanced through the optimisation of the system.

The evidence of localised results and workflow embodies the conclusion of this research, it proves a relationship between pattern and optimal inflated configurations and expresses how the adoption of explorative methods such as parametric design, topology optimisation and generative design can lead to improved system results.

The next stage of this research should focus on exploring interoperability with environmental analysis tools and receiving accurate data for solar thermal and heat loss to test the extremities of the design methodologies in more context. Further exploration of patterns influenced by these results would allow for better results in principle and acting in practice

F1. Mock Exhibition

The mock exhibition set up was produced at a time when tessellation design was the focal point of the study and hence the emphasis on that design only. The focus of that design was to express the adaptability to a variation of buildings, to be retrofitted. To express that through the exhibition presentation panels were generated as 3D models which could be applied, moved, and organised by the user.

The intention being focused on the expression of context and practical implementation there was doubt around the logic of formation, shape & pattern and hence it became a focus for the final exhibition to be centred around the pattern logic and relationship rather than applied practice. This intersection was also present in the formation of the research, which adjusted its focus to the variations of design through parametric exploration.

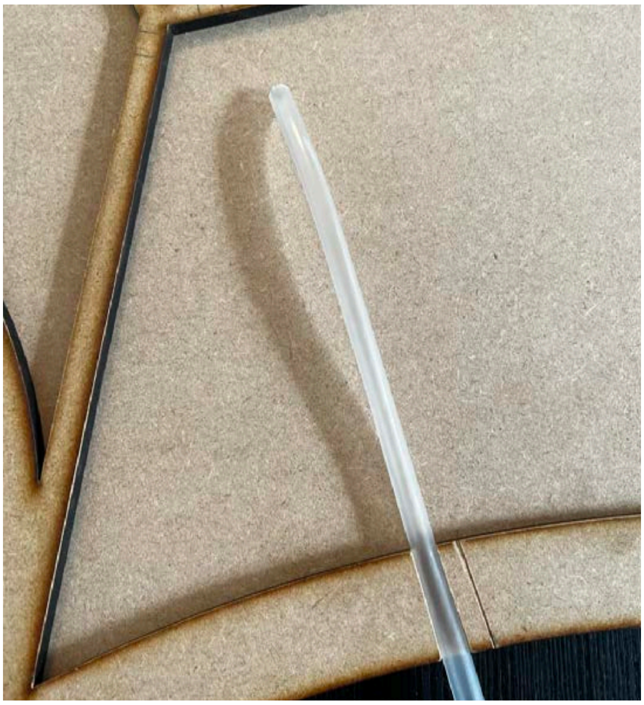
[8] Mock Exhibtion set up, photographed by Felix Mallinder

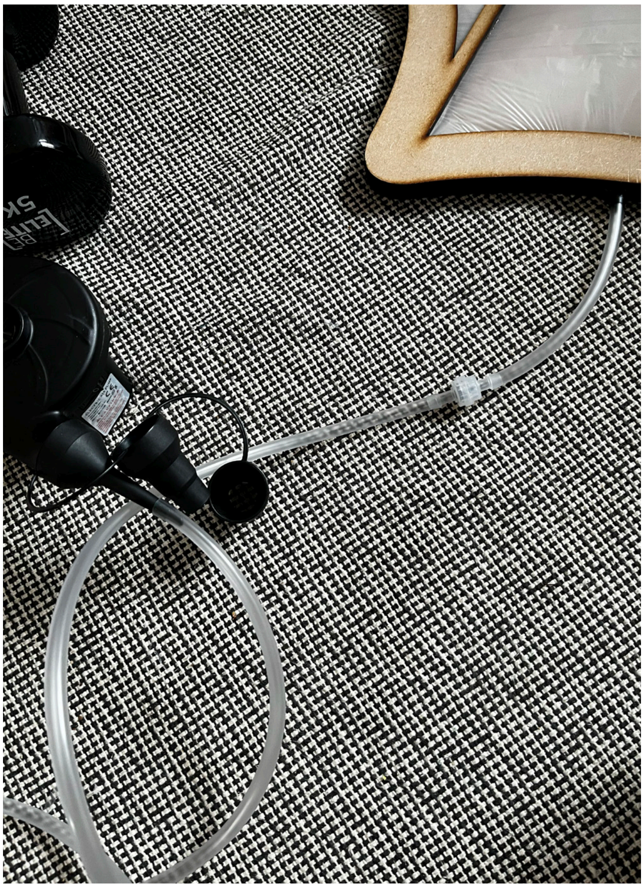
F2. Fabrication

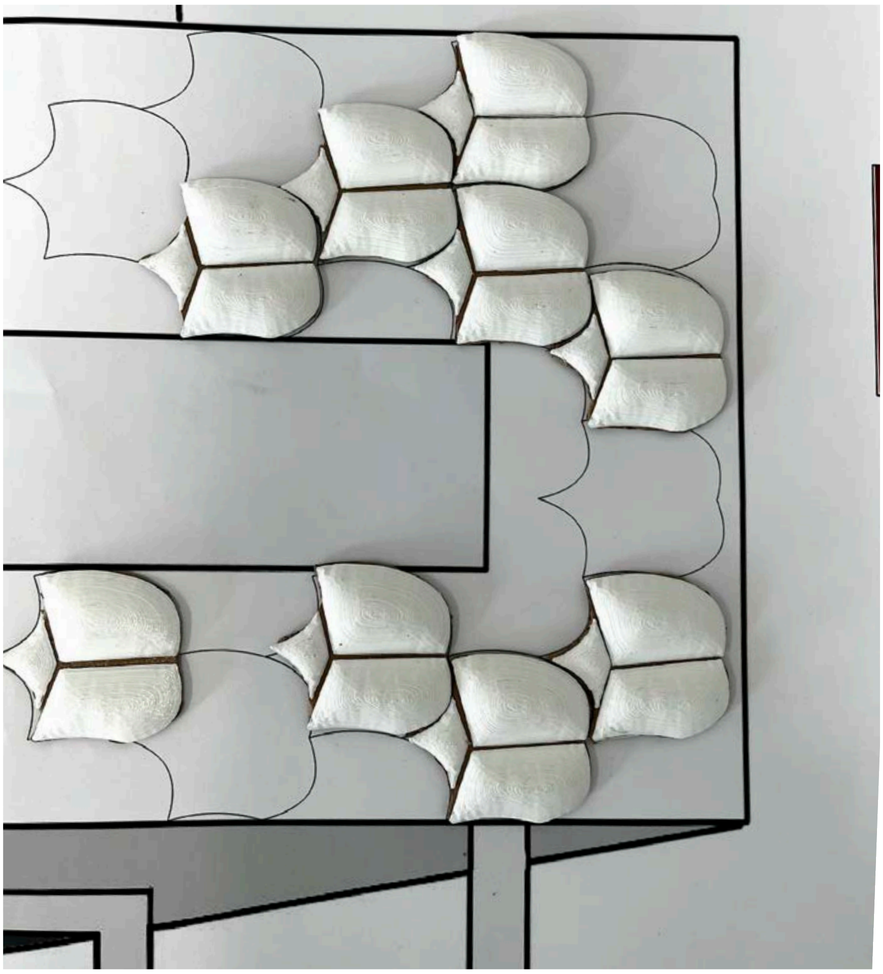
As part of the exhibition, I worked on fabricating one of these panels, exploring the range of materials and methods that could be utilised in its formation. the core of the frame was built from MDF laser cut, although that was a representational material and not the expectancy for application. The inflated cushions were expected to be ETFE panels, like in the case study, and in the case of fabrication, polythene sheets were used instead.

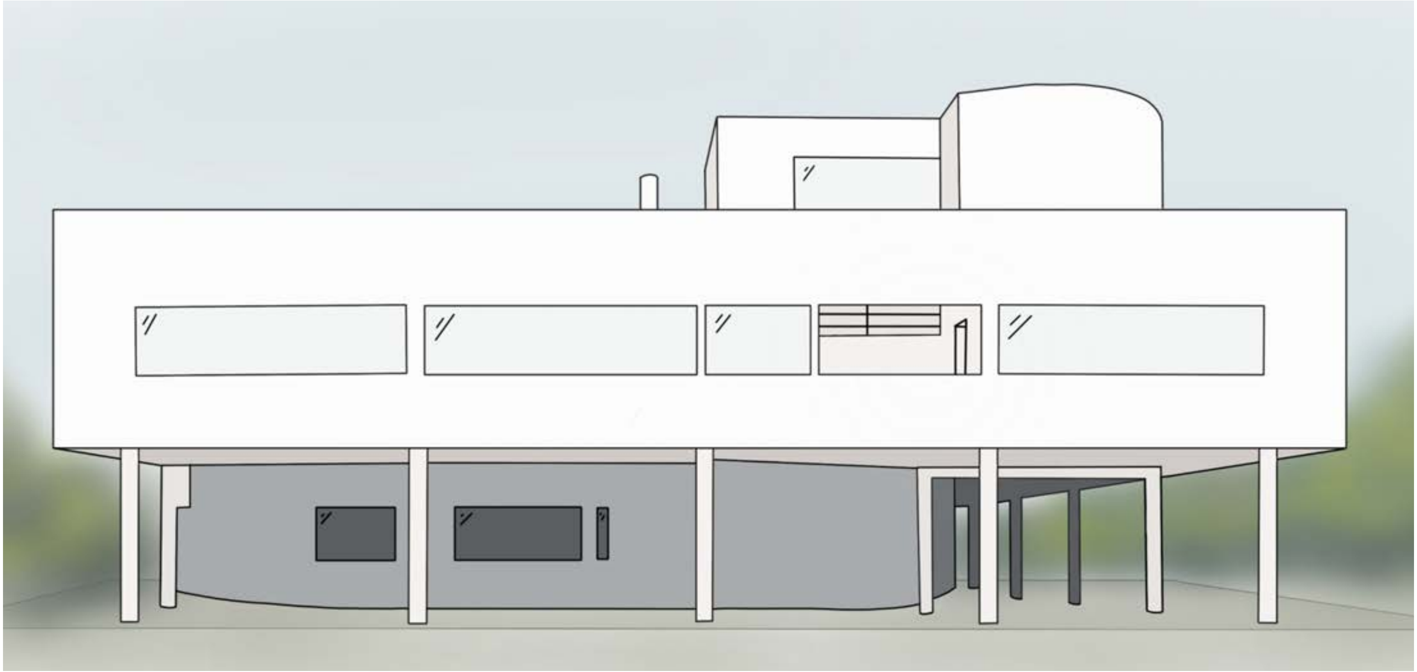
Using an air pump this panel was deployed as if it was part of the whole pneumatic system. Due to material limitations, the inflation was minimal and not as present as seen digitally.

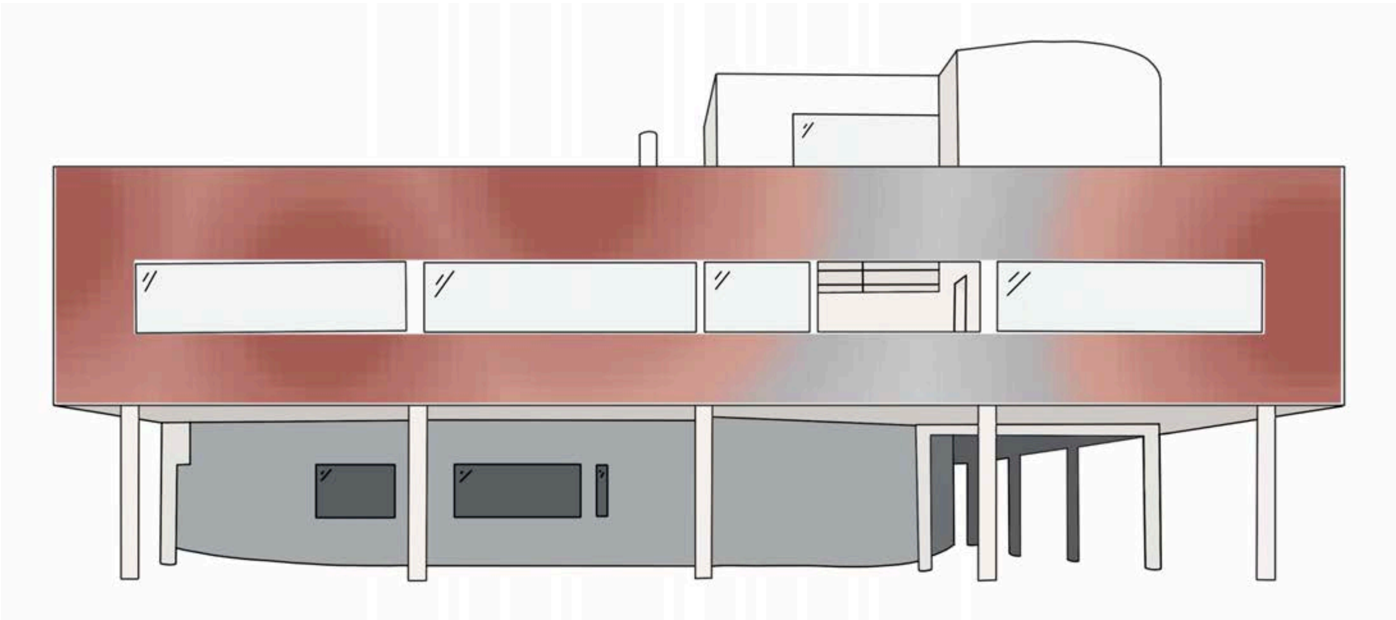
The fabrication process was very informative in the way of exhibition, the expectancy was that a physically inflated model would communicate the objective best but in fact, this model left more to be questioned in the design and for the final exhibition a better method of presentation would have to be found.

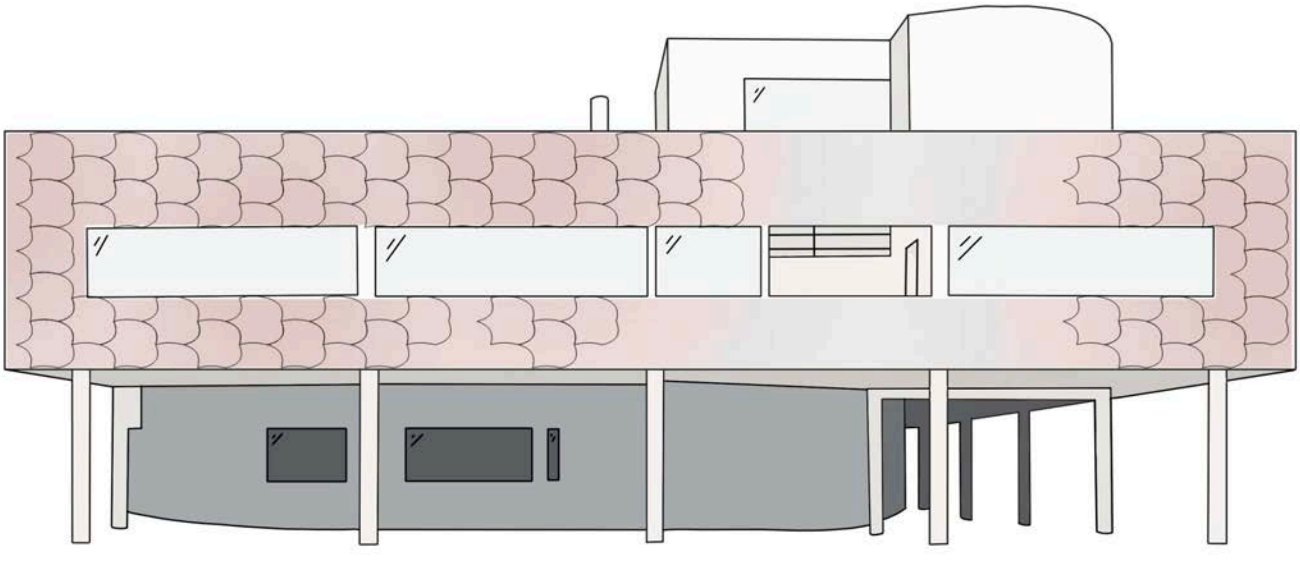












[9] Villa Savoye Skecthes, Panels in Context- Drawn by Felix Mallinder

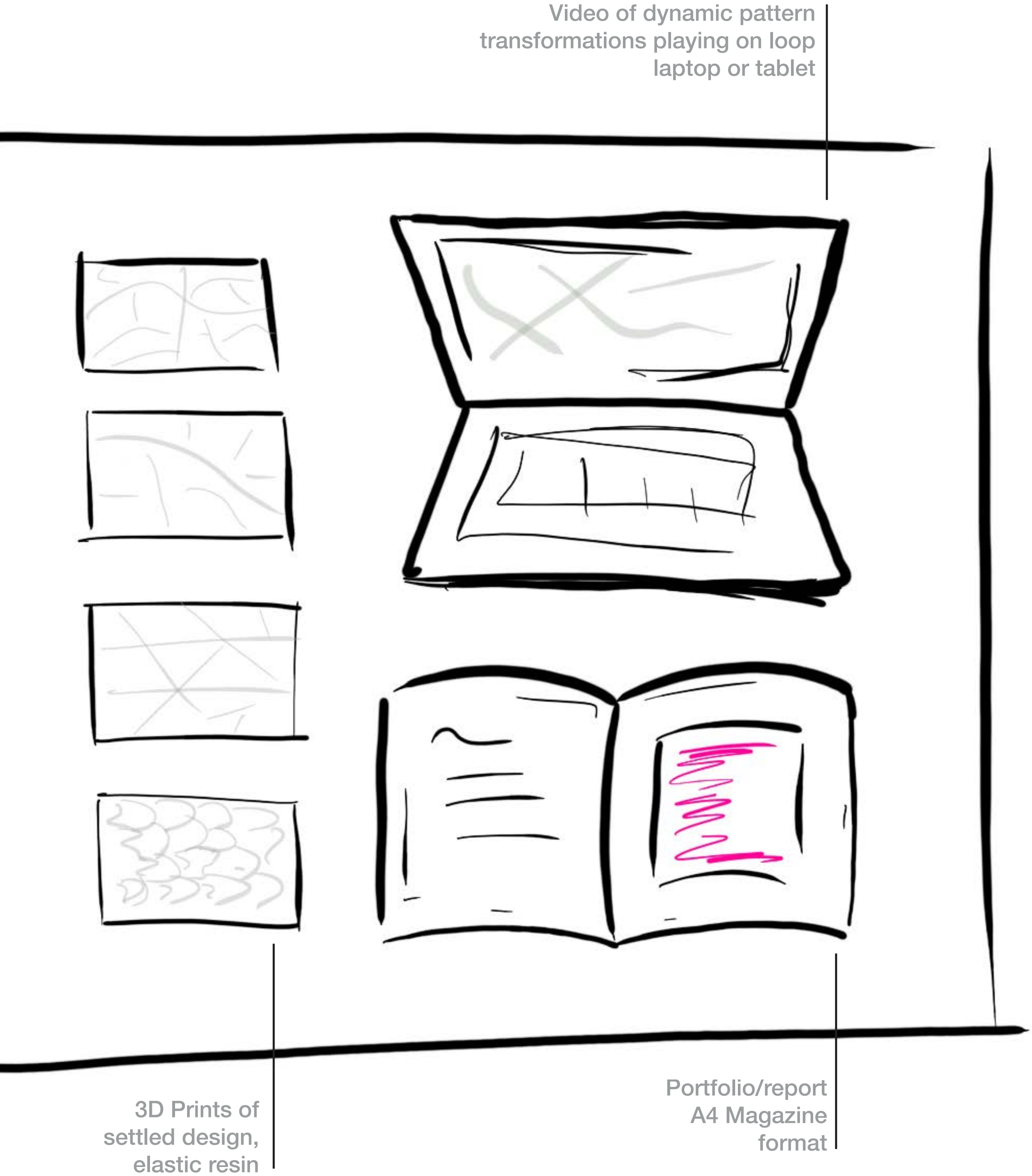
F3. Final Exhibtion

The final exhibition looks to build on the results of the mock exhibition, showcasing multiple expressions of the design process across mediums, as shown in the sketch plan.

The explorative nature of these pattern designs is difficult to display on a 2D, static piece of paper. To understand the full depth of the principle the video must be added to stretch the range of results available. The expectation of this video is not to present results, inputs, or values, as that is the purpose of the report, but to show the wide range of possibilities, the abstract extremes and the unintuitive, convoluted design results.

Only with the video is this extra depth of comprehension provided, to grasp the meaning of the methodology, especially for a viewer not aware of the concepts of parametric design, topology optimisation or generative design.

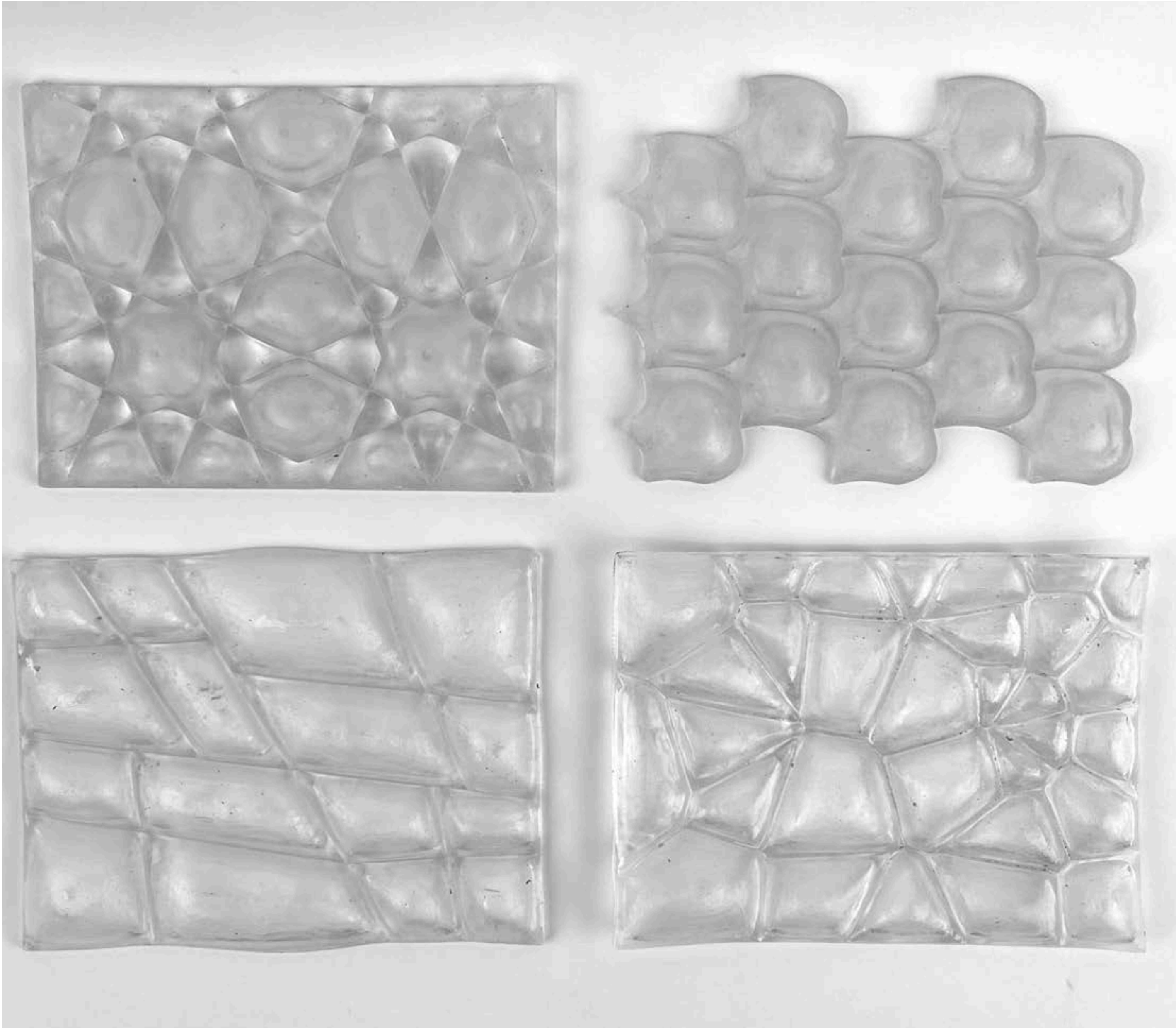
Again, something difficult to show in the visual static medium is how these designs move in a patterned and relational manner, it is easy to believe that this is the sum of parts, especially with systems like the Voronoi but when viewed a sequence of movement the appreciation for design is completely new, I believe this is especially true for designs such as the Islamic and line orientate designs.



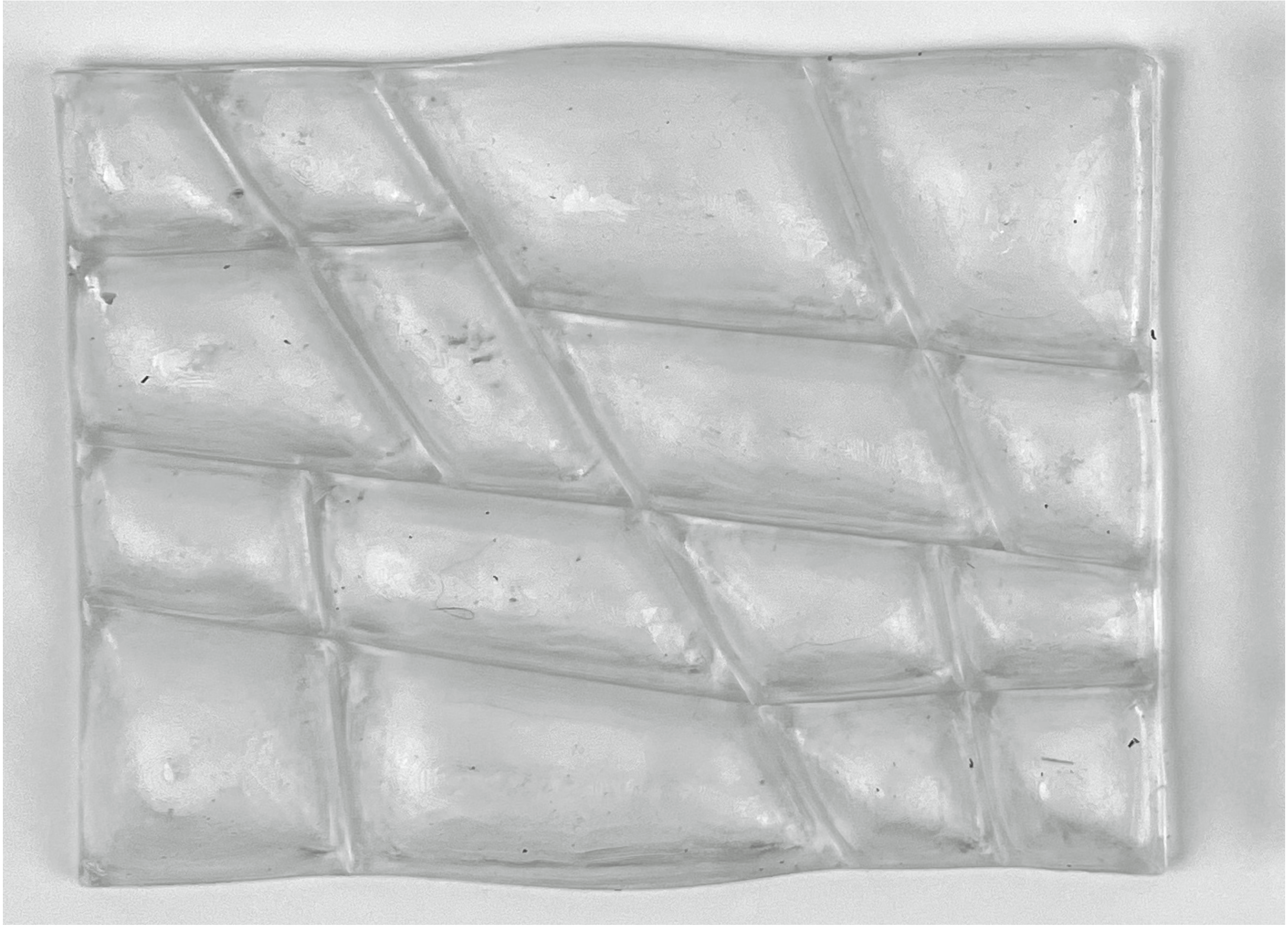
[10] Final Exhibtion Planning, Sketched by Felix Mallinder

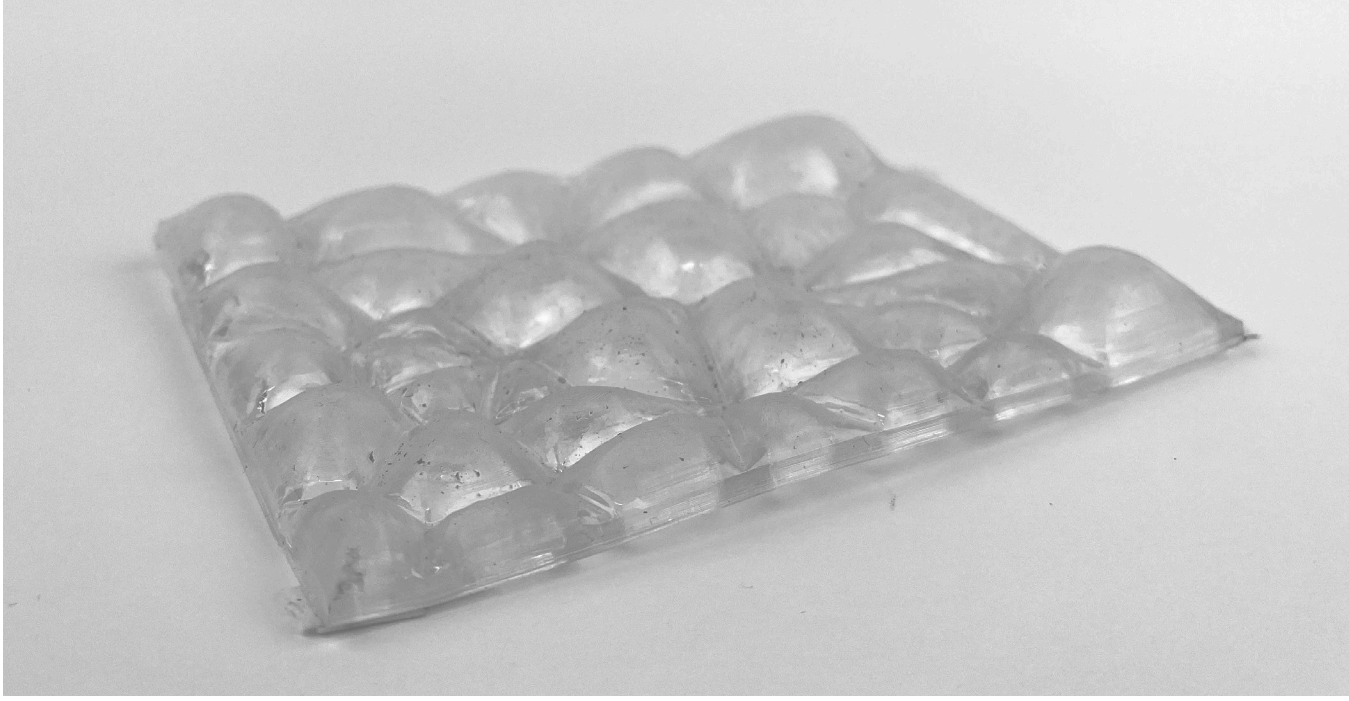
F4. Resin Printing

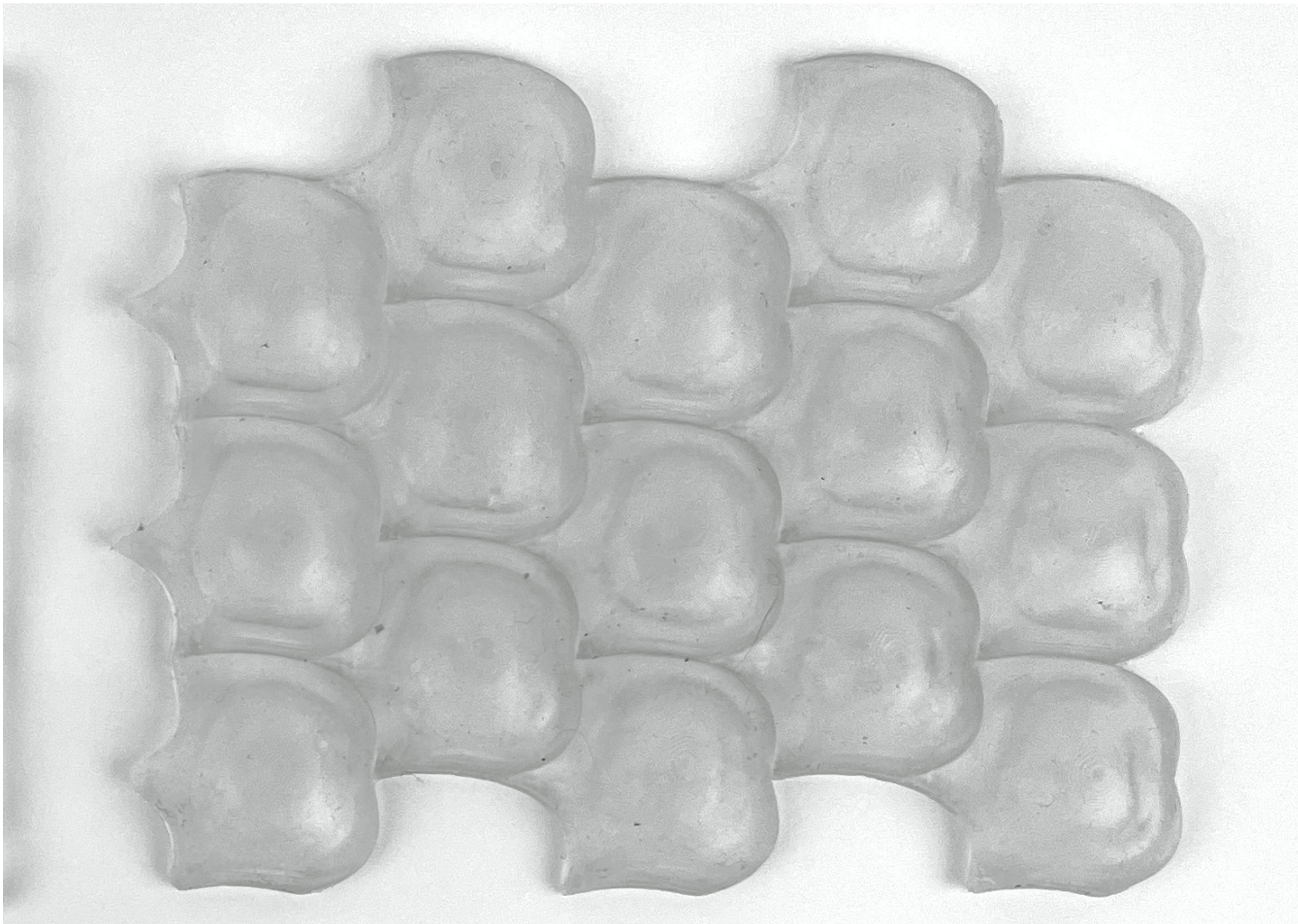
In aid of the exhibition, the presentation of inflation has been developed from a dynamic pneumatic model to a static representation. Utilising the digital fabrication method of elastic resin printing allows for models to be made of the whole façade, which better showcases the inflation as a system. the use of elastic resin means the model still has the visual an physical qualities of an inflated model whilst being able to achieve the extremities of the digital model.

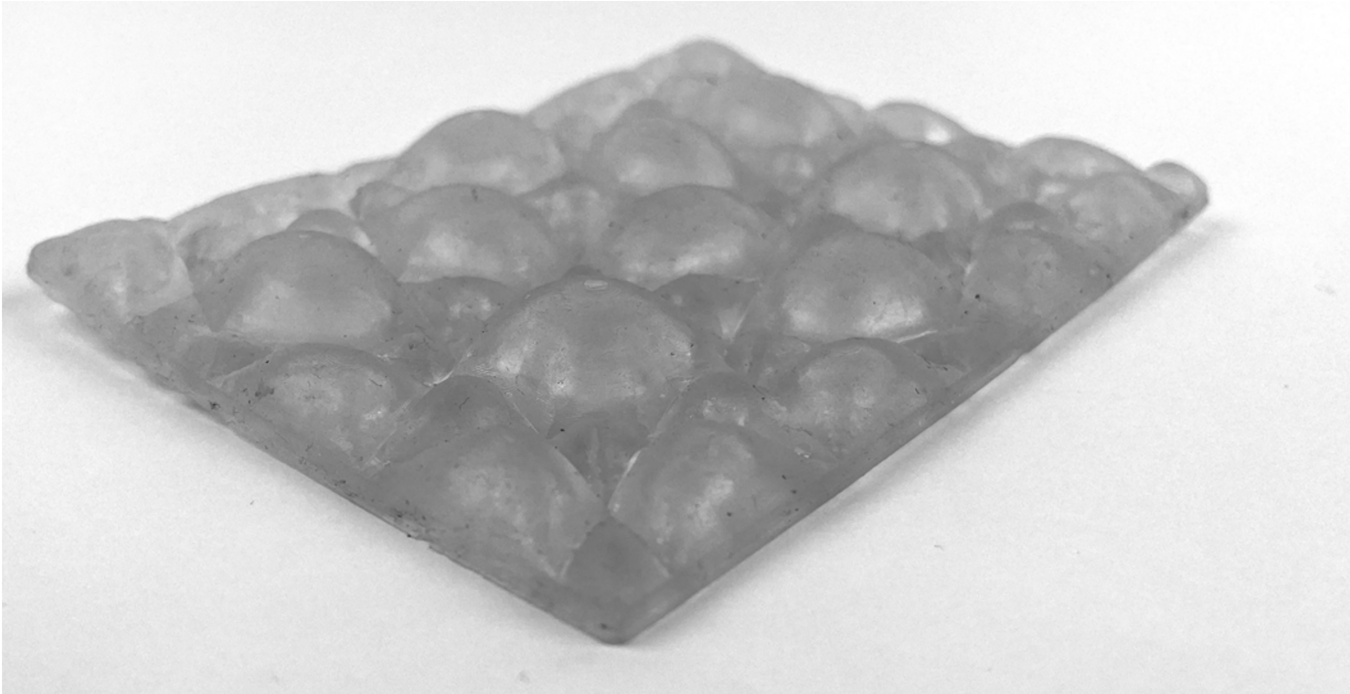


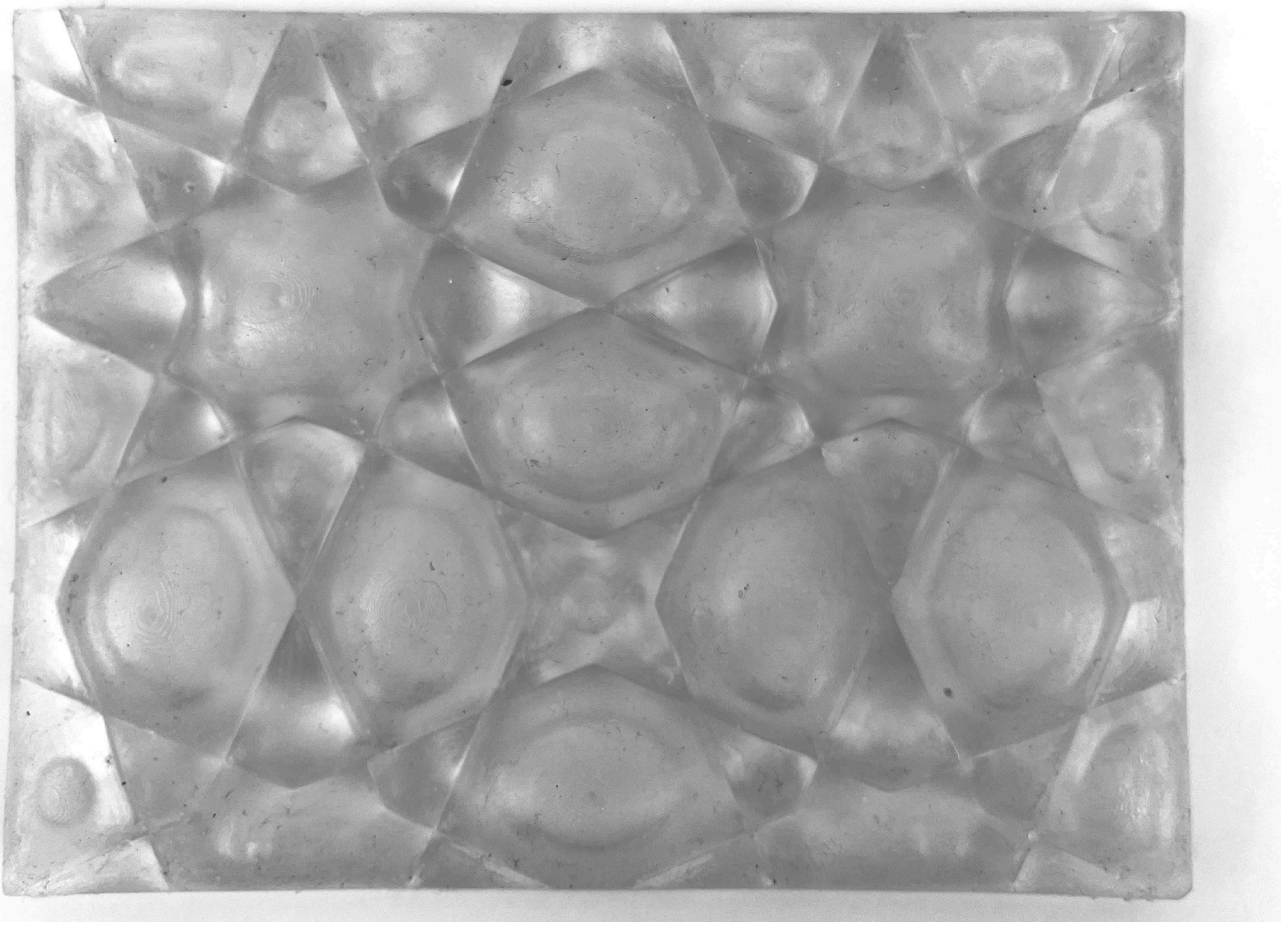
[11] Elastic Resin Prints of Design Itterations - Photographed by Felix Mallinder











References

Atkins, R. (2022), BBC Ross Atkins [Twitter] 1/12, available at:https://twitter.com/BBCRosAtkins/status/1598204115837853696

CLEAR (n.d.). Cavities and Air Spaces. [online] www.new-learn.info. Available at: https://www.new-learn.info/packages/clear/thermal/buildings/building_fabric/elements/cavities_and_air_spaces.html.

IAAC Blog. (2020). Media-Tic: How To Live In Life An Energy-Saving Way. [online] Available at: https://www.iaacblog.com/programs/media-tic/.

Nicol, S., Roys, M., Ormandy, D., Ezratty, V. and Paper, B. (2016). The cost of poor housing in the European Union. [online] Available at: https://www.bre.co.uk/filelibrary/Briefing%20papers/92993_BRE_Poor-Housing_in_-Europe.pdf.

ONS (2022). Winter mortality in England and Wales - Office for National Statistics. [online] www.ons.gov.uk. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/excesswintermortalityinenglandandwales/2021to2022provisionaland2020to2021final.

SuperFOIL. (2023). The UK's Insulation Problem - SuperFOIL Insulation. [online] Available at: https://www.superfoil.co.uk/uk-insulation-problem/#:~:text=Your%20Free%20Guide- [Accessed 28 Apr. 2023].

US EPA, O. (2016). Climate Change Indicators: Weather and Climate. [online] US EPA. Available at: https://www.epa.gov/climate-indicators/weather-climate#:~:text=Scientific%20studies%20indicate%20that%20extreme.

Wakefield, M. (2021). Britain's leaky homes make the energy crisis worse. Why have governments not fixed them? | Max Wakefield. [online] the Guardian. Available at: https://www.theguardian.com/commentisfree/2021/sep/28/britain-homes-energy-crisis-governments-insulation-low-carbon-heating.

World Architects (2017). Media-TIC. [online] Available at: https://www.world-architects.com/en/architecture-news/reviews/media-tic.

[12] Concept Sketch of Islmaic Facade, Drawn by Felix Mallinder

FELIX MALLINDER

COMPUTATIONAL ARCHITECTURE

DESIGN RESEARCH 2023