_butterfly house berggarten

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_introduction

Nowadays with advancing fabrication methods and the help of digital technologies, new physical construction processes are possible. These can lead to a more resource-efficient production and material-specific design. This way it is not only possible to just produce one building component in mass, but also to slightly variate in every piece, as long as it is possible within the chosen fabrication method.

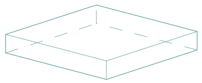
Can you build an entire building out of one variable component?

_index

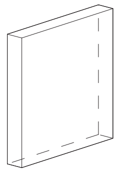
// exterior view //

_design process

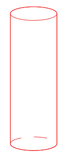
By first trying to create a prototype for the building, the setting of rules is crucial to the design. In order for the building to be made of one component, it must be self-supporting.



ceiling



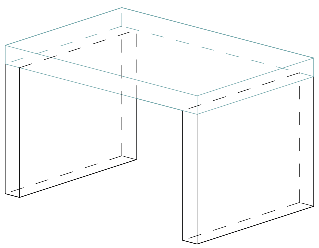
wall



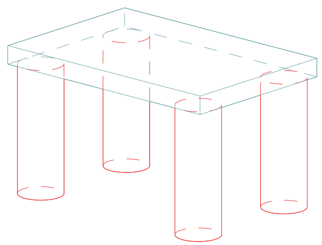
column

// support members //

Consideration: In order to build the structure from only one component, the use of a single support member is advantageous. The question is how to combine multiple structural components into one to get the benefits of both.



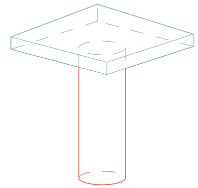
wall+ceiling



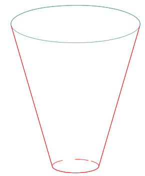
column+ceiling

// combinations //

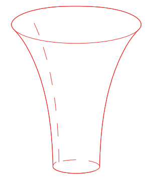
Combination of different types of support members, such as walls, columns and ceilings to create a construction.



single column+ceiling



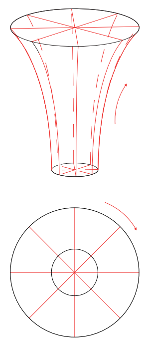
radiale structure



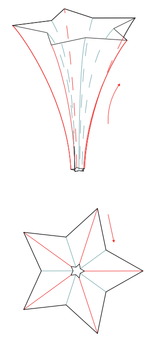
adapation

// support element //

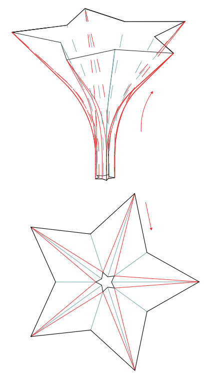
A column offers a great flexibility by its punctual distribution in the room. The idea is to create a single support element, which fulfills the function of a column as well as of a ceiling. The radial structure here serves to distribute the weight to the base of the column. To gain space the coloumn becomes exponentially slimmer downwards.



double curved surfaces



single curved surfaces

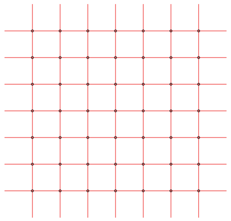


variation

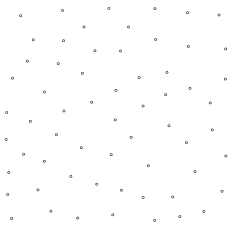
// decomposition into sub-elements //

Instead of subdividing the silhouette into double curved surfaces, which are difficult to fabricate, it is folded inwards at regular intervals to obtain single curved surfaces.

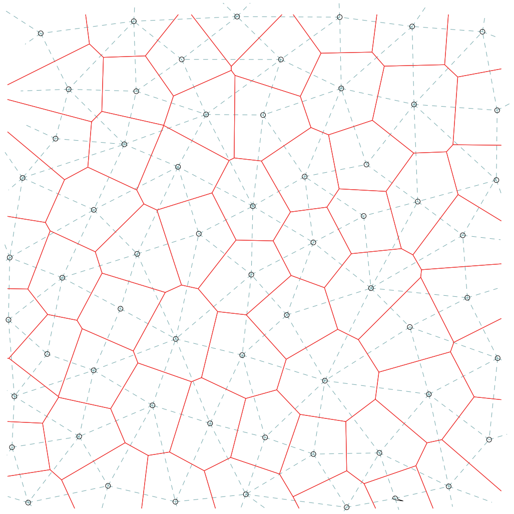
The variation kinks here at other intervals.



grid



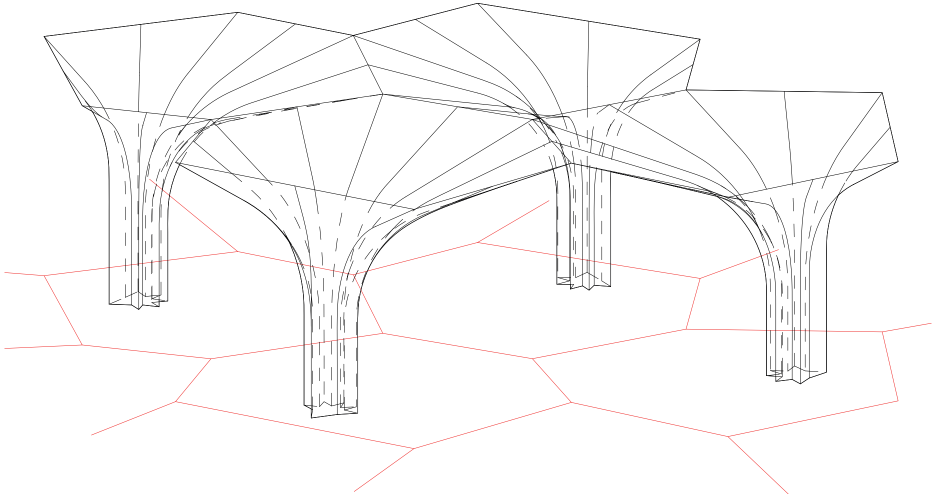
free distribution

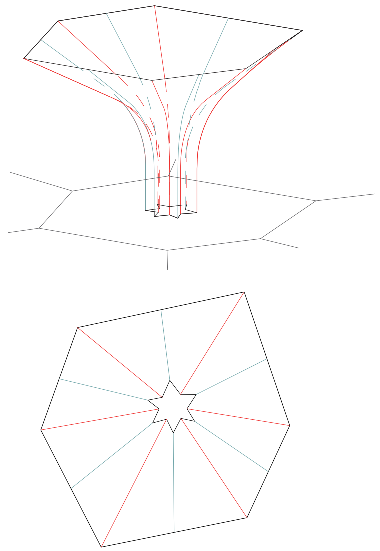


voronoi diagram

// distribution in space //

There are two alternatives here. Either you stick to a certain grid or you distribute the supports freely in the room. The points form the center of a region and encompasses all points of the space that are closer to the center of the region in relation to the Euclidean metric than at any other center. From all points that have more than one nearest center and thus form the boundaries of the regions, the Voronoi diagram is created. The advantage of the second variant is that you remain more flexible in the further design process.

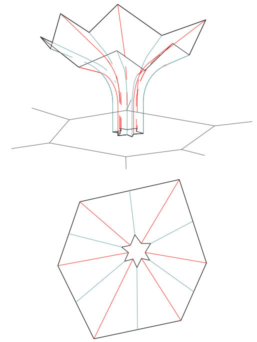




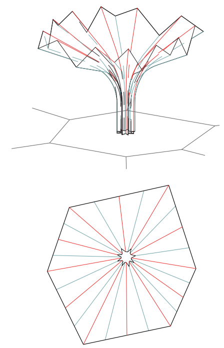
adapation voronoi cell

// adaptation voronoi structure //

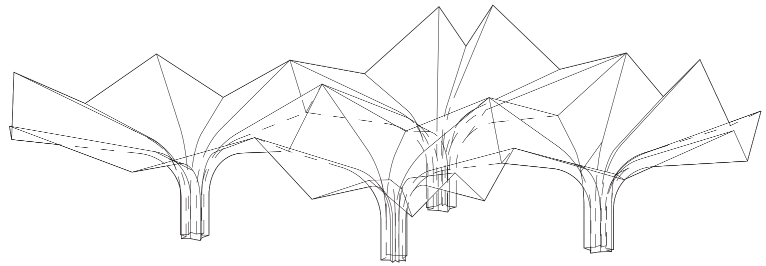
The column is now adapted to the superordinate structure so that it fits into the respective Voronoi cell.



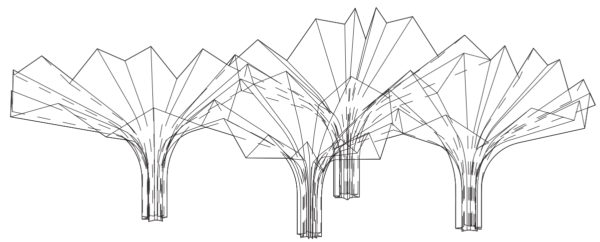
variation I



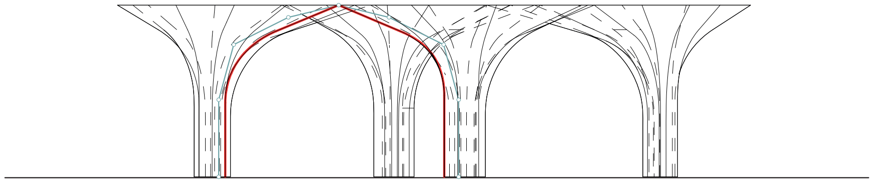
variation II



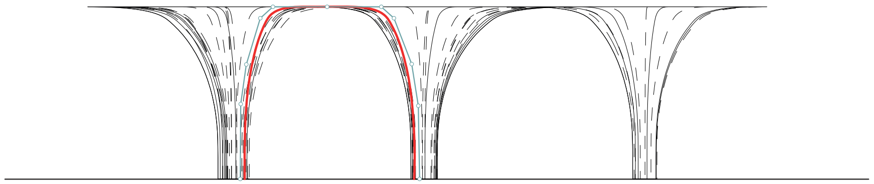
adaption voronoi structure
variation I



adaption voronoi structure
variation II



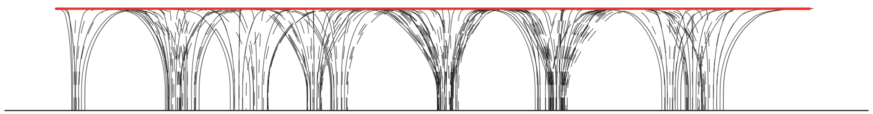
overlapping forces



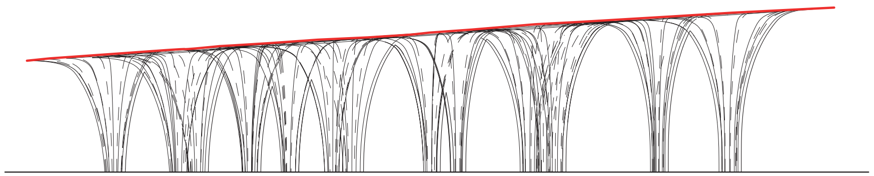
colliding forces

// horizontal connection //

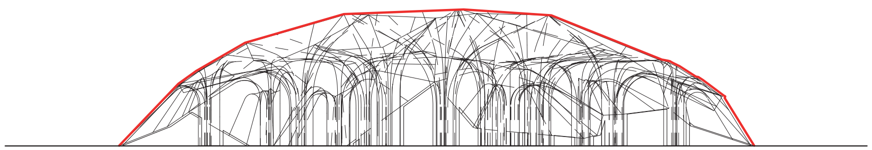
It is important how the columns meet horizontally. At the points where they touch, the forces must collide rather than overlap.



parallel to ground



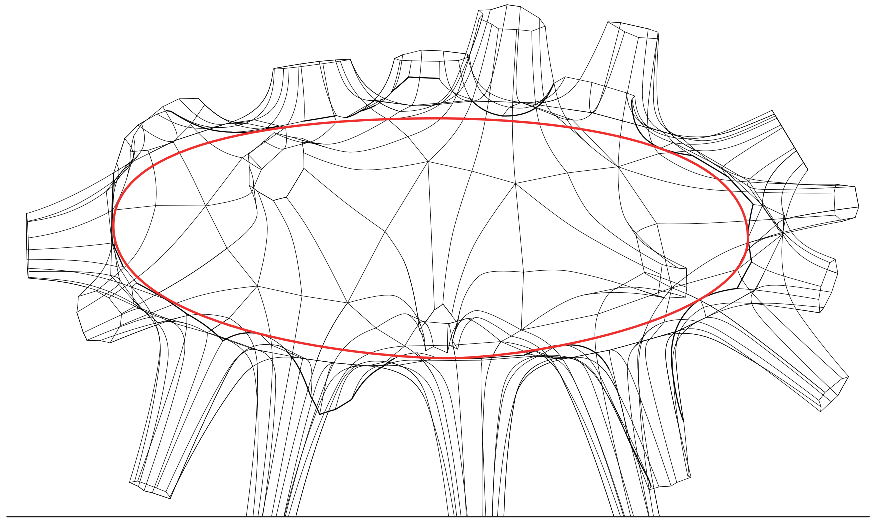
rise



dome

// edges //

The system can now be freely distributed in space. However, the question is how it closes towards outside. If possible, by avoiding a new element such as a glass wall on the outer edges.

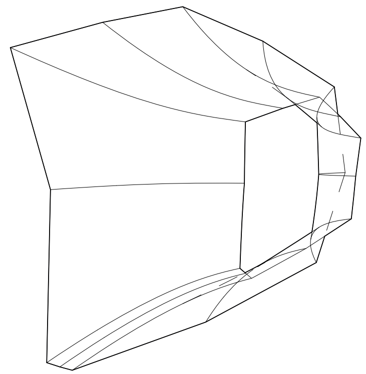


sphere

// resolution of the edge //

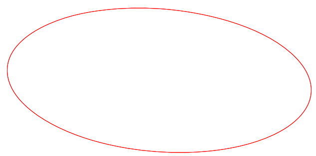
One possibility would be the dissolution of the outer edges, this could be achieved by forming a sphere.

Now, however, the individual components no longer only fulfil the function of a support. It remains to investigate which function these can take over with regard to the design of a butterfly house.



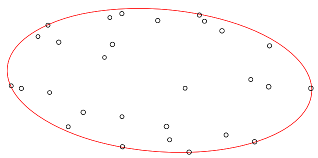
_parametric design

Starting with a sphere the form-finding process will be optimized by certain design goals, which will lead to a final form.



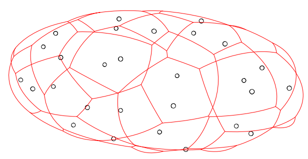
// sphere //

Create a sphere according to needed dimensions.



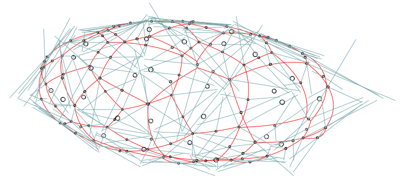
// populate points //

Populate points on sphere.
n=28



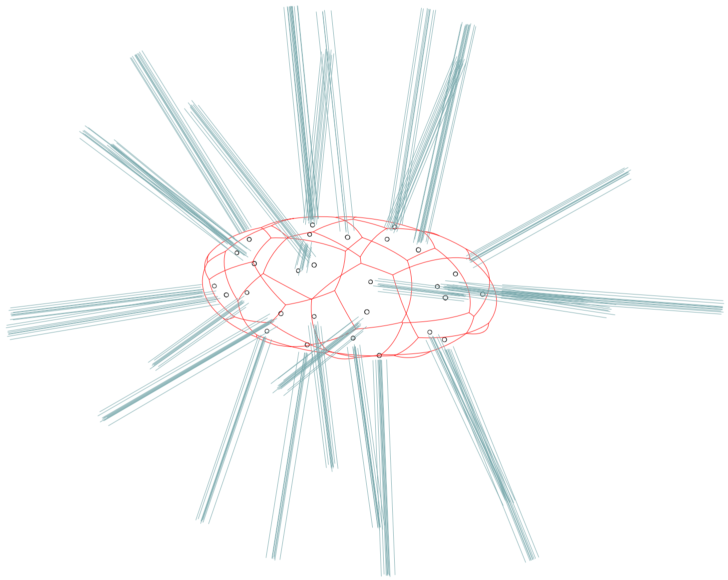
// voronoi diagram //

Overlay voronoi diagram over the sphere. The populated points represent the centre points of the voronoi cells.



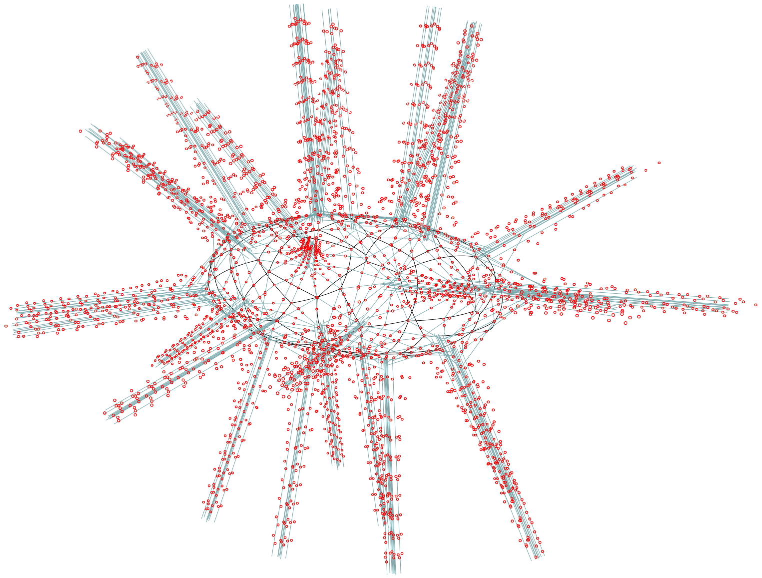
// tangent //

The tangent to the sphere gets determined by connecting the voronoi cell centre points with the corner points of the according cell.



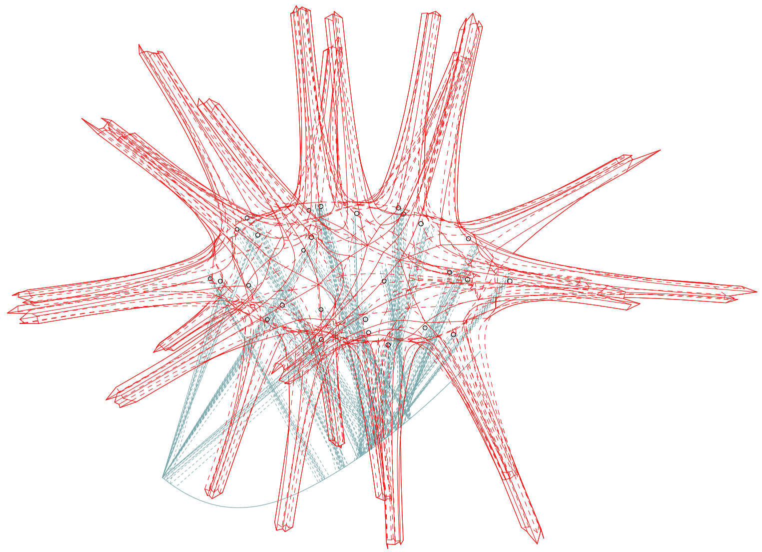
// perpendicular //

Normal vector line of the voronoi cell centre point.



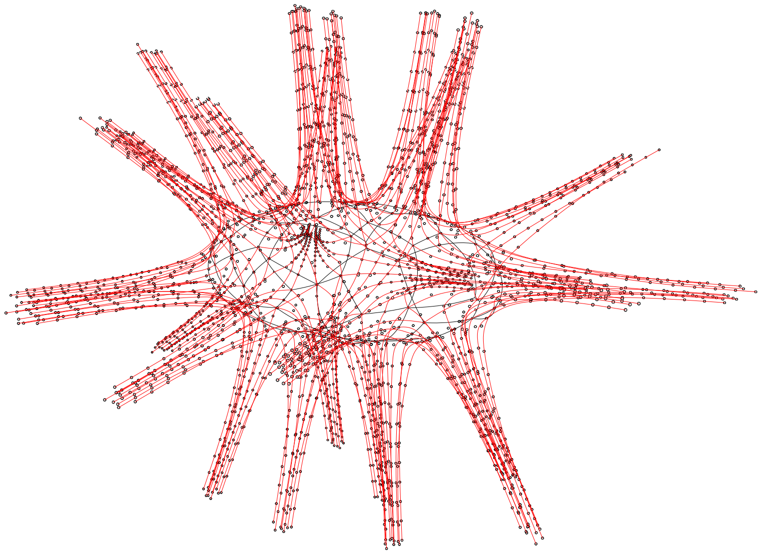
// control points //

The tangent and the perpendicular set up planes in order to position the control points which will later be used to create the shape of the shells.



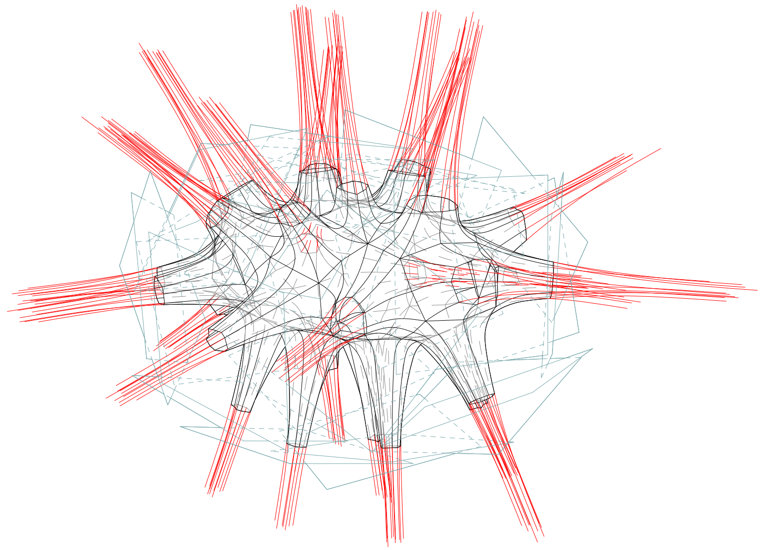
// evaluate //

Evaluating the model with certain criteria, in order to give the shells their specific length. In this case the shells get evaluated by their closest point to a curve.



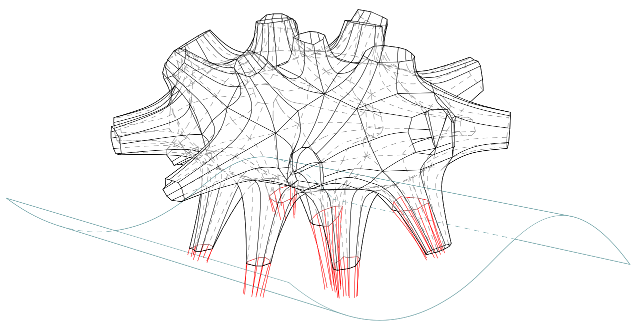
// curves //

Framework of the individual shells.

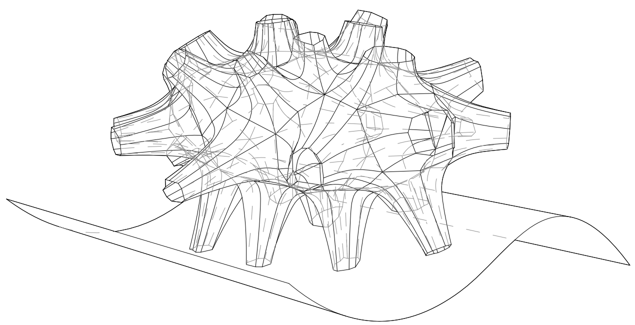


// trim //

The shells get trimmed according to the before evaluated criteria.



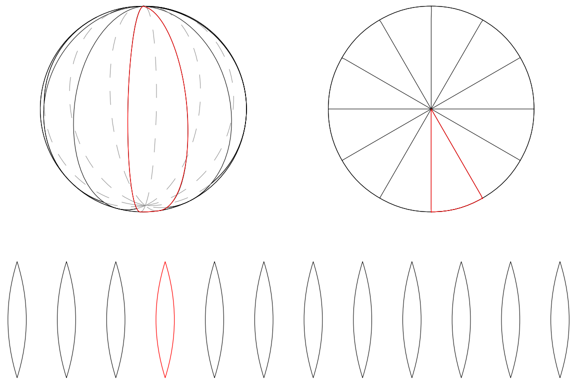
// terrain //
At last the model gets adjusted to fit into the scene.



// data model //
The data model is updated according to the design history, so that the operations can be accessed at any time.

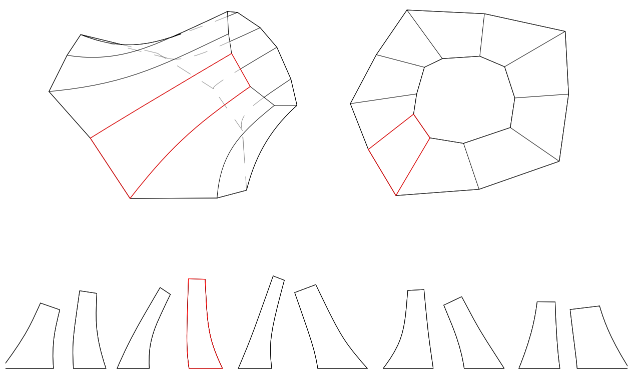
_connection types

By producing a paper model, it gets clear that one of the key factors in order to maximize fitting accuracy is the type of connection between the individual parts. Small scale connection types would be gluing, stitching or to use rivets. All of these are to some extend scalable and need to be adjusted accordingly.



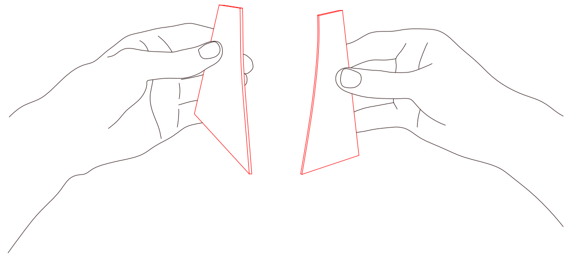
// surface development sphere //

The properties of a sphere make it very difficult to bring it on a flat piece of sheet. One way to unroll the sphere would be to slice it.
The other way around: If you bend all the individual parts of the sphere together, you will end up back with the sphere, since they are form giving.



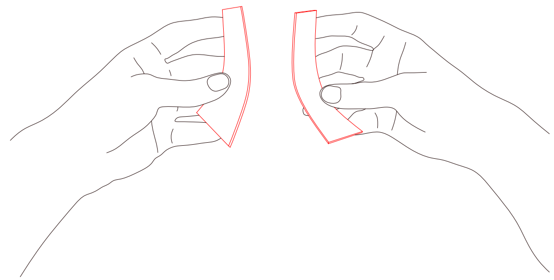
// surface development shell //

The same way goes for the shell. If you bring the edges of the according parts together, the amount of curvature on the surfaces adjust itself. This means that once all parts of the shell are together, they determine the form.



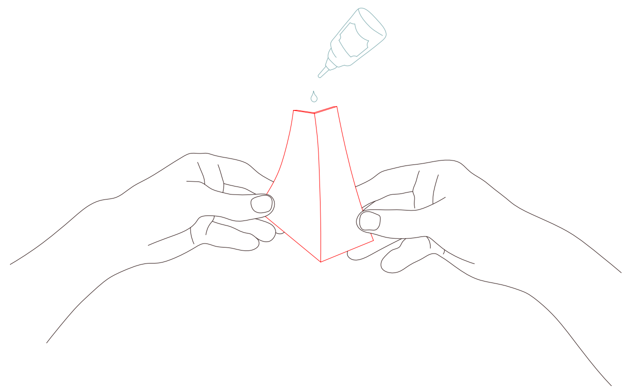
// paper model //

For this paper model gluing was chosen as the connection type. The first step would be to sort all parts and to then bring the according parts together.



// bending //

By over-bending the paper sheets to some extend it makes it easier to bring the parts together.

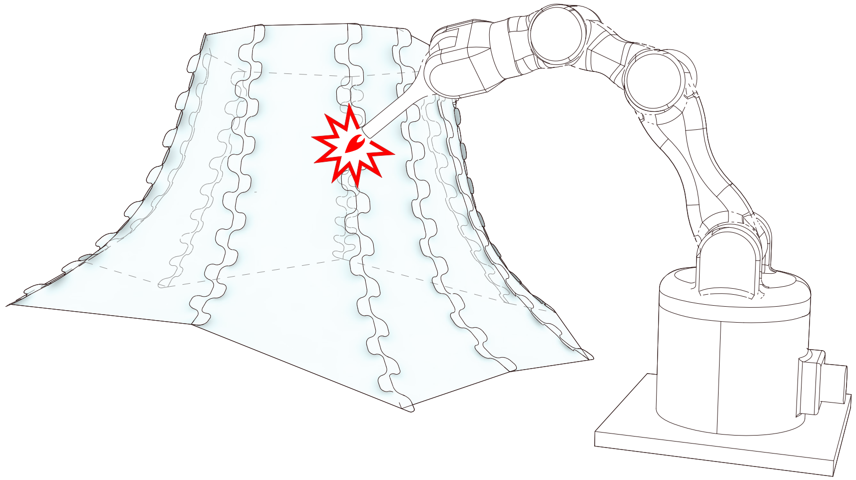


// gluing //

When not using an instant glue, all the parts need to get fixated with crepe tape in order to stay in the correct position while drying.

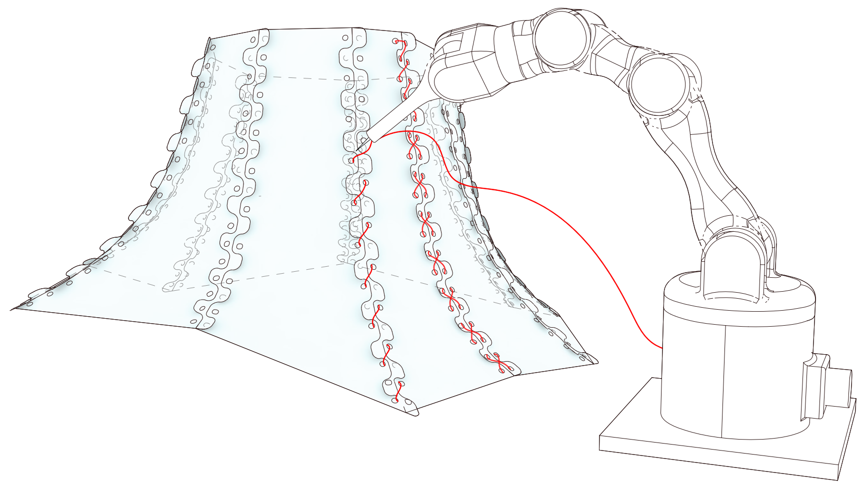
_large-scale model

Below are three variations on how a possible connection of the parts in a large-scale model could look like.



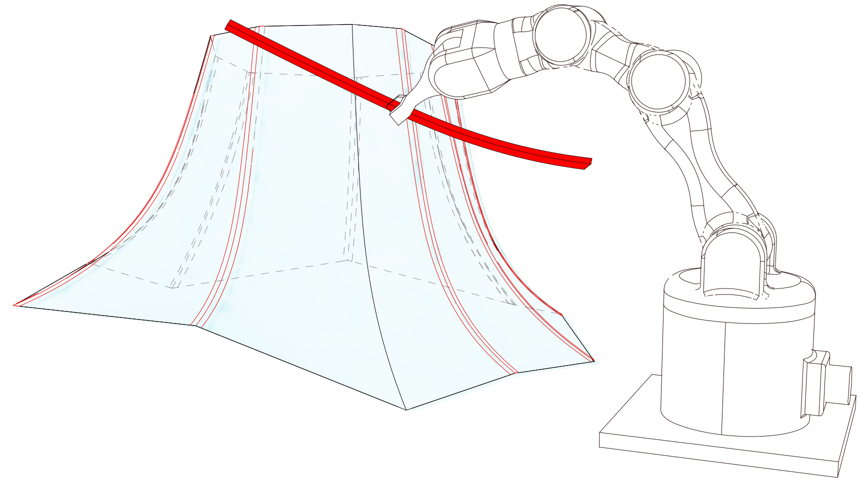
// welding //

The idea here is to forgo on a new material. Instead the panels, which could be made out of polycarbonate, are going to get welded together. The panels will get mill out with gear teeth on the sides, which are firstly there to bring the form in shape and on the other hand serve as material for the welding.



// stitching //

This time the panels do also have pre-milled holes on the sides in order to stitch the parts together. In order to seal everything rubber tubes could be inserted between the parts while being stitched together.



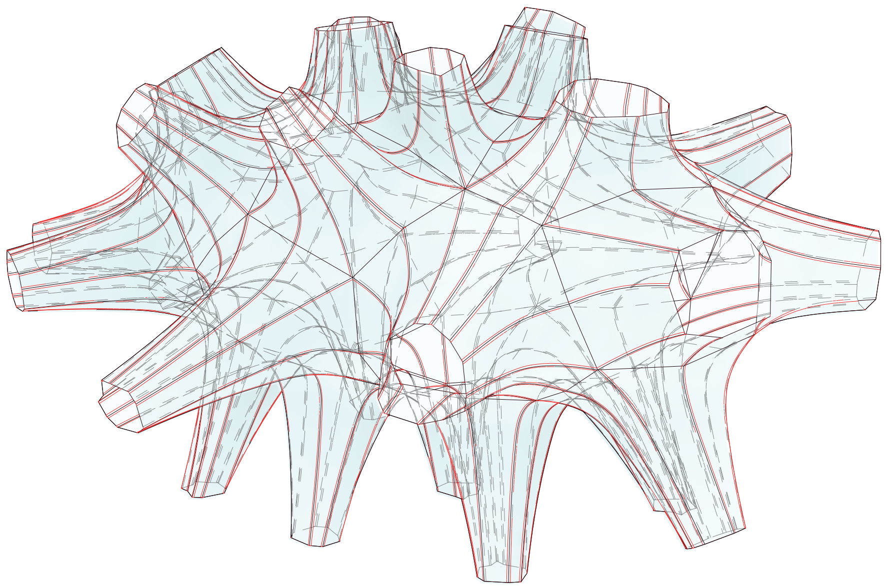
// rails //

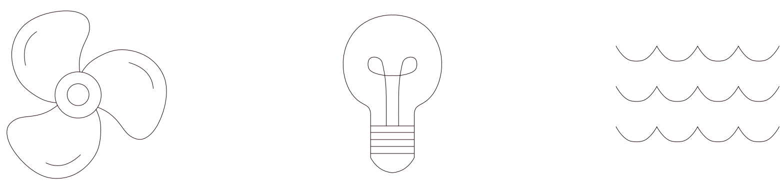
Using rivets, rails would be mount on the edges of the parts. These could either be made out of a rubber, which could be unrolled from a tape or to use pre-bend aluminium rails.

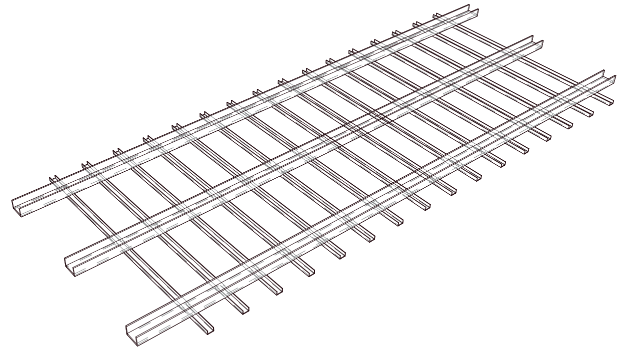
In the following elaboration the connection of aluminium rails was chosen, not because it suits best, but rather to set the focus on the form.

_installation level

Depending upon the technitcal specification of a greenhouse, key factors which may be controlled include temperature, levels of light and shade, irrigation, fertilizer application, and atmospheric humidity. This means that the installation level has a significant impact on the appearance of the greenhouse.

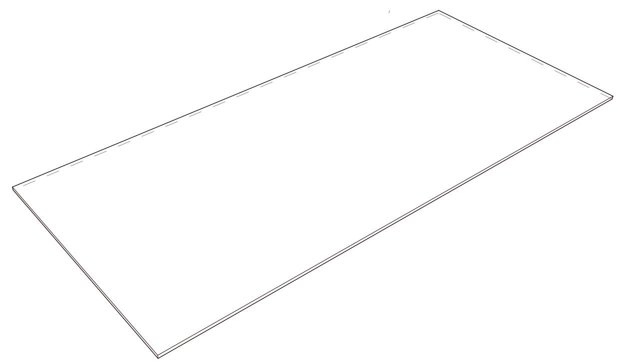






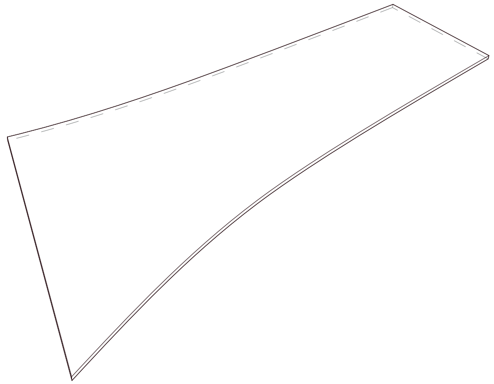
// tracks and carriers //

One of the most common methods for an installation level for greenhouses would be to mount tracks and carriers on the outer layer.



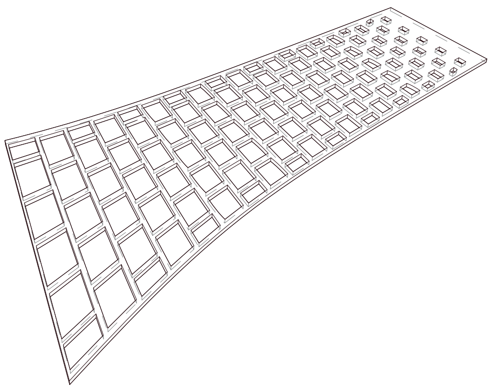
// sheets //

Instead of running tracks and carriers underneath the polycarbona te sheets it would just feel right to have the installation level been made out of surfaces, since the current building is completely made out of surfaces.



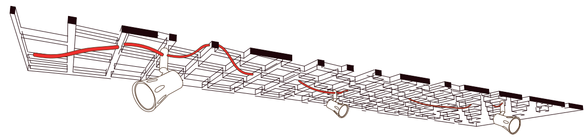
// material //

The surfaces are to be made just as the rails out of aluminium. Thanks to the stability of aluminium the layer can be very thin.



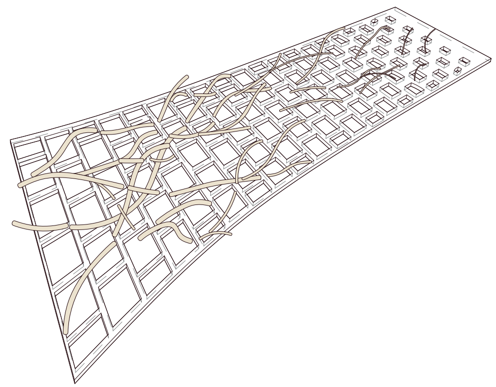
// fabrication //

Just as the polycarbonate sheets the aluminium sheets will get milled, meaning that with the same fabrication method it would be possible to perforate the sheets in order to decrease weight and to let more direct sun light into the building.



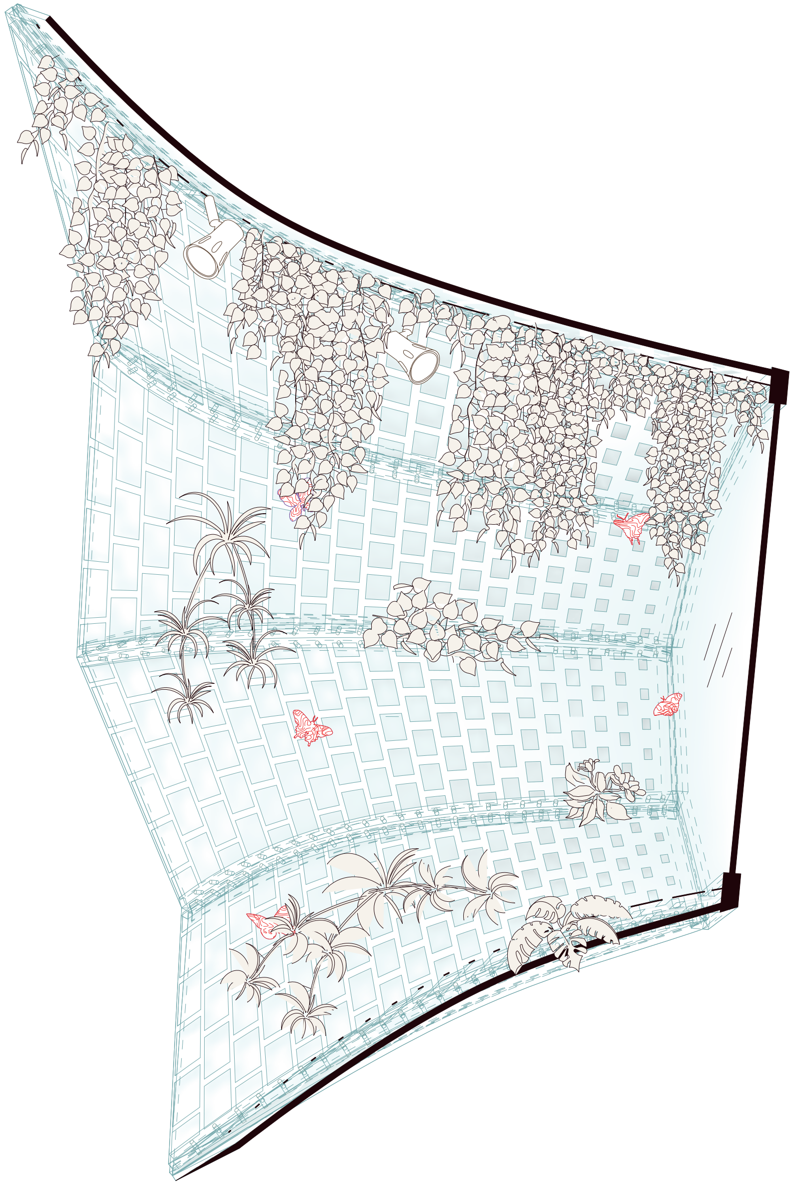
// tubes & wire //

The surfaces are to be made just as the rails out of aluminium. Thanks to the stability of aluminium the layer can be very thin.



// vines //

The surfaces are to be made just as the rails out of aluminium. Thanks to the stability of aluminium the layer can be very thin.

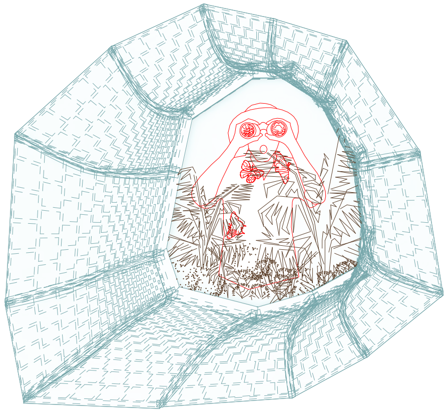


// integration //

By combining the technical needed aspect with the logic of the building the installation layer won't fell as a necessary added layer to the building and instead is homogeneously integrated to give the building a more complete look.

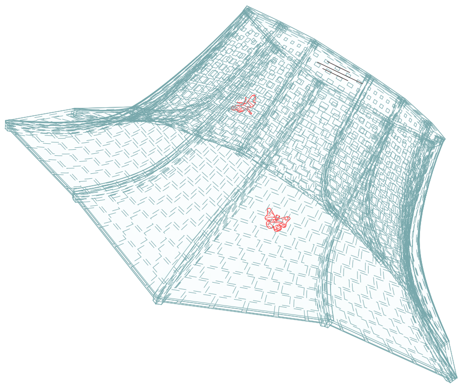
_catalogue

In order to find the final form, it is necessary to think about what purpose each shell can serve. Creating a catalogue of possible utilization can give information on dimension and orientation for the shells. Corresponding to the picked functions out of the catalogue, the structure can then be customised to generate the final form.



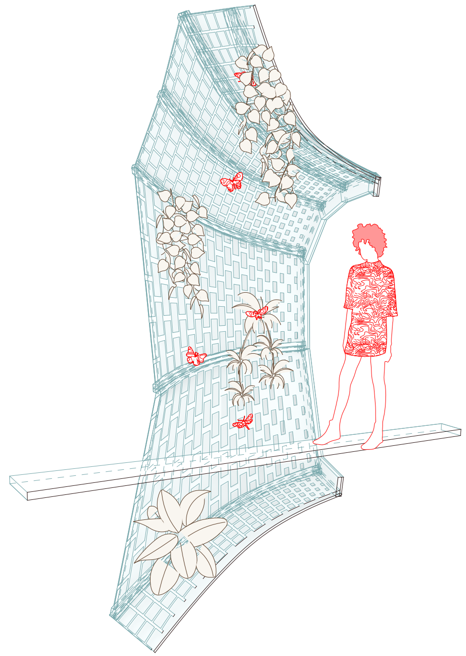
// outlook //

Looking outside the shells almost act like a telescope from the inside. By choosing a specific location and angle on the sphere a specific view into the landscape can get framed.



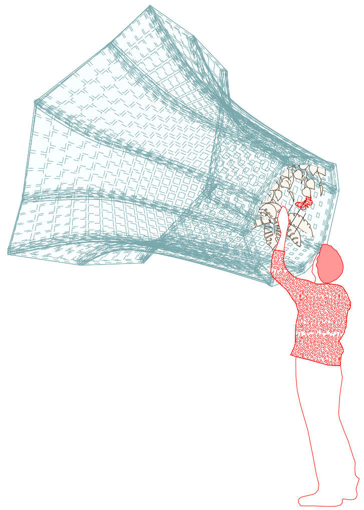
// skylight //

Especially the shells on the top serve well as skylights.



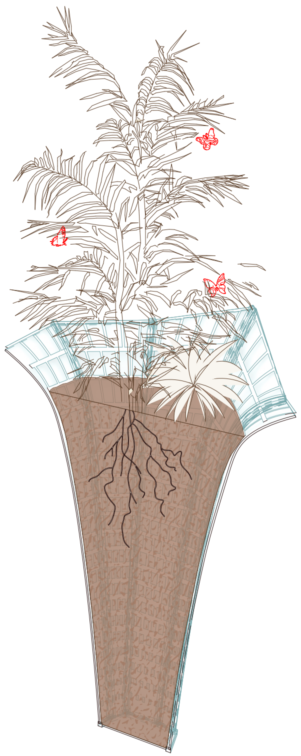
// entrance //

Some way of entering the building.

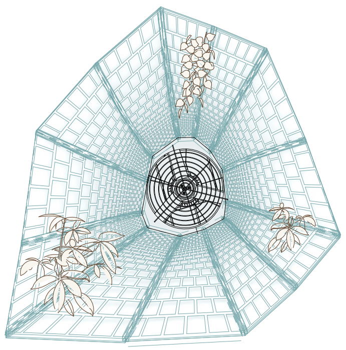


// observation hole //

A way to experience the greenhouse from the outside. Special plants could be planted on the onces which are close to eye-level, acting as a showroom.



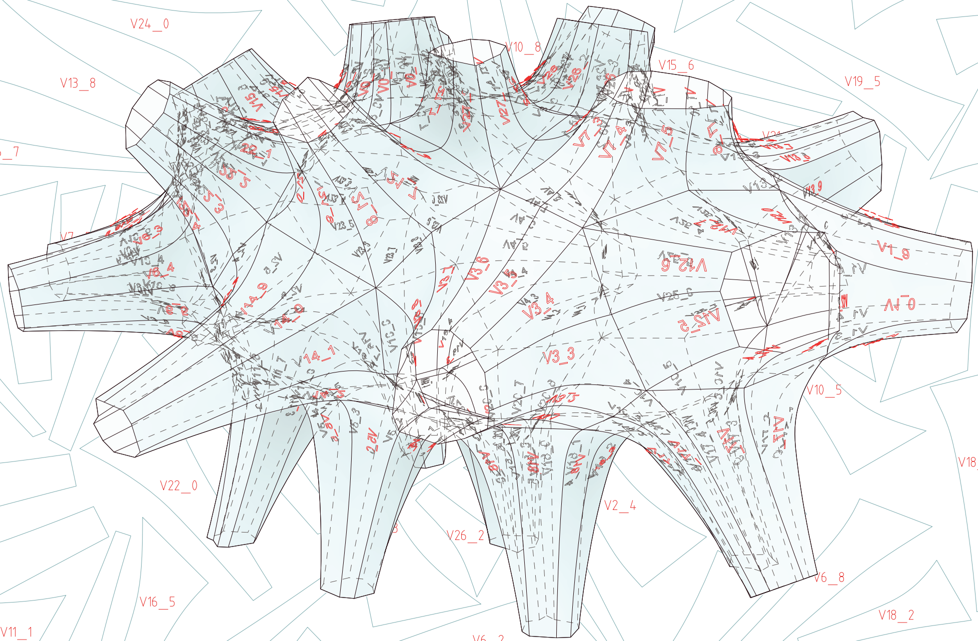
// soil //
Soil could be inserted into the shells which have contact with the ground, in order for bigger plant to grow.



// technics //
Exit for vans or other forms of technology.

_fabrication

Once all outer specifications for the building are set the final model can be generated. In this case 28 shells, each made from eight to fourteen components, make up the building. In order to save the most amount of material in the CNC cut process it is important to place the sheets as optimized as possible. Since all the components look almost identical it is necessary to achieve good structuring and readability.



// cnc_file //
288 components
747m²

{0}
0. V0_0
1. V0_1
2. V0_2
3. V0_3
4. V0_4
5. V0_5
6. V0_6
7. V0_7
8. V0_8
9. V0_9
10. V0_10
11. V0_11
12. V0_12
13. V0_13

{1}
0. V1_0
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2. V1_2
3. V1_3
4. V1_4
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6. V1_6
7. V1_7
8. V1_8
9. V1_9

{2}
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3. V2_3
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6. V2_6
7. V2_7
8. V2_8
9. V2_9

{3}
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8. V3_8
9. V3_9
10. V3_10
11. V3_11

{4}
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6. V4_6
7. V4_7
8. V4_8
9. V4_9
10. V4_10
11. V4_11

{5}
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3. V5_3
4. V5_4
5. V5_5
6. V5_6
7. V5_7

{6}
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4. V6_4
5. V6_5
6. V6_6
7. V6_7
8. V6_8
9. V6_9

{7}
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8. V7_8
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10. V7_10
11. V7_11

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3. V8_3
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7. V8_7
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9. V8_9
10. V8_10
11. V8_11

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3. V9_3
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8. V9_8
9. V9_9
10. V9_10
11. V9_11

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6. V10_6
7. V10_7
8. V10_8
9. V10_9

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8. V11_8
9. V11_9

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7. V12_7

{13}
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7. V13_7
8. V13_8
9. V13_9

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6. V14_6
7. V14_7
8. V14_8
9. V14_9

{15}
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7. V15_7
8. V15_8
9. V15_9
10. V15_10
11. V15_11

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6. V16_6
7. V16_7
8. V16_8
9. V16_9

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6. V17_6
7. V17_7
8. V17_8
9. V17_9

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6. V18_6
7. V18_7
8. V18_8
9. V18_9

{19}
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8. V19_8
9. V19_9

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7. V20_7
8. V20_8
9. V20_9

{21}
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6. V21_6
7. V21_7
8. V21_8
9. V21_9

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4. V22_4
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6. V22_6
7. V22_7
8. V22_8
9. V22_9

{23}
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3. V23_3
4. V23_4
5. V23_5
6. V23_6
7. V23_7
8. V23_8
9. V23_9

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4. V24_4
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6. V24_6
7. V24_7
8. V24_8
9. V24_9

{25}
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5. V25_5
6. V25_6
7. V25_7

{26}
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3. V26_3
4. V26_4
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7. V26_7
8. V26_8
9. V26_9

{27}
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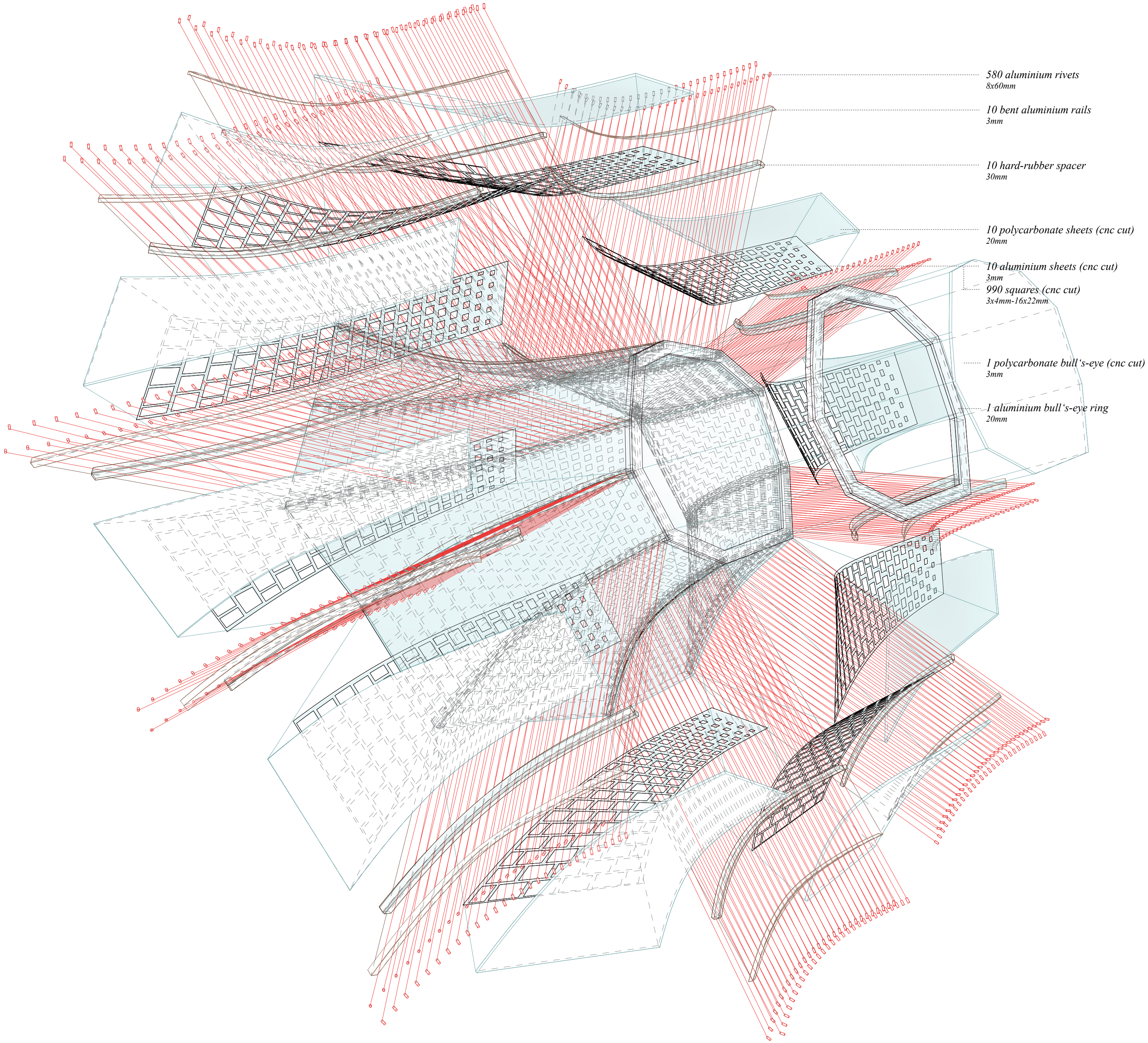
7. V27_7

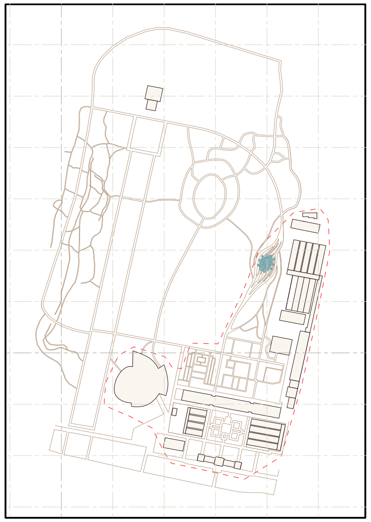


V24_explosion drawing

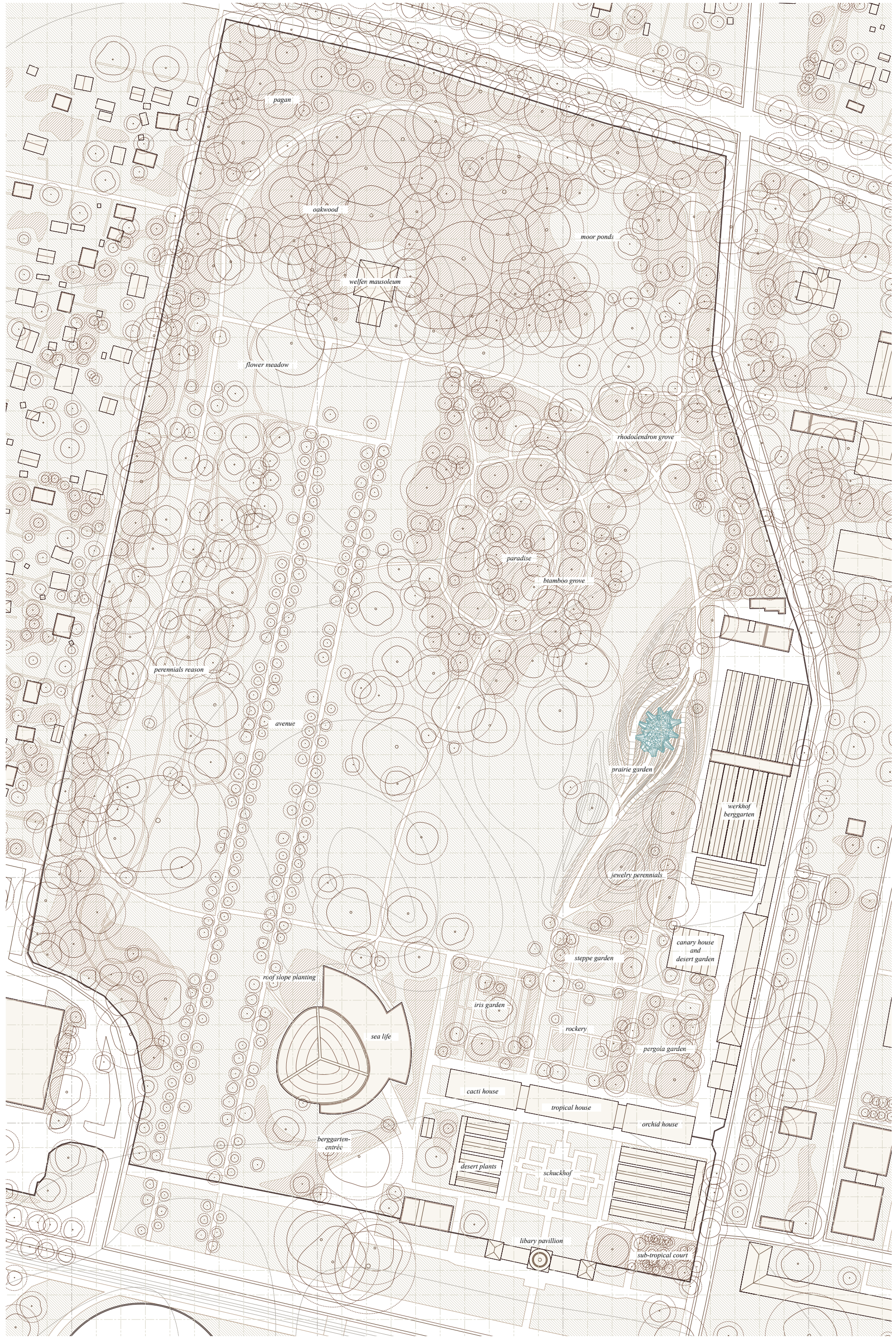
_site plan

The butterfly house is located in the prairie garden, which shows high seasonal dynamics and unusual plant combinations. The vegetation picture is to remind of the North American prairie. While the proportion of grasses there is over 90 percent, the proportion of prairie trees prevails here. They contribute enormously to the show value when they are in full bloom in high and late summer.

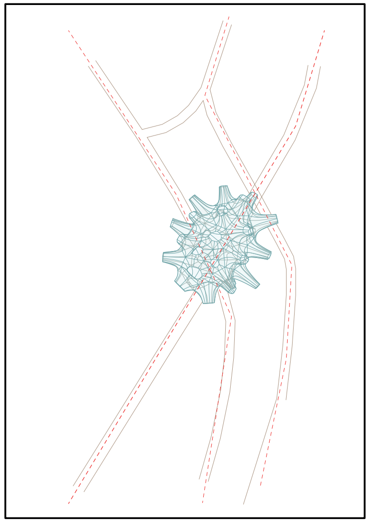
The attraction of the plantation is that it changes a lot during the year and at times looks like a wilderness with vigorous, interwoven plants. In the high and late summer, yellow flowers dominate, including goldenrod (Solidago rugosa, Fireworks') and maiden eye (Coreopsis verticillata), as well as large perennials such as sunflower (Helianthus) and cup plants (Silphium). In autumn Herbstaster (Aster) and Scheinaster (Vernonia) bloom in violet tones. In addition, there are stately grassy branches such as dropweed (Sporobolus), switch-grass (Panicum) and Indian grass (sorghastrum). In winter, not only in snow and hoarfrost, the fruit stands of the numerous daisy family are particularly attractive.



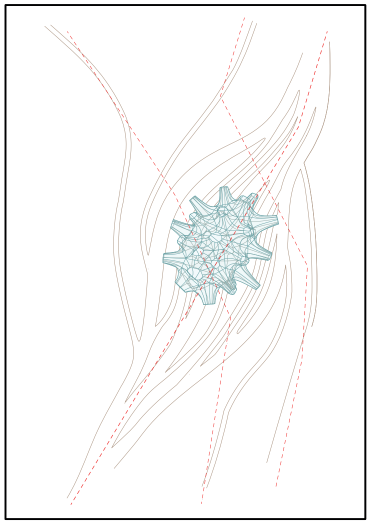
// showhouse area //
Whether showhouses or outdoor areas - the Berggarten offers an impressive plant world.



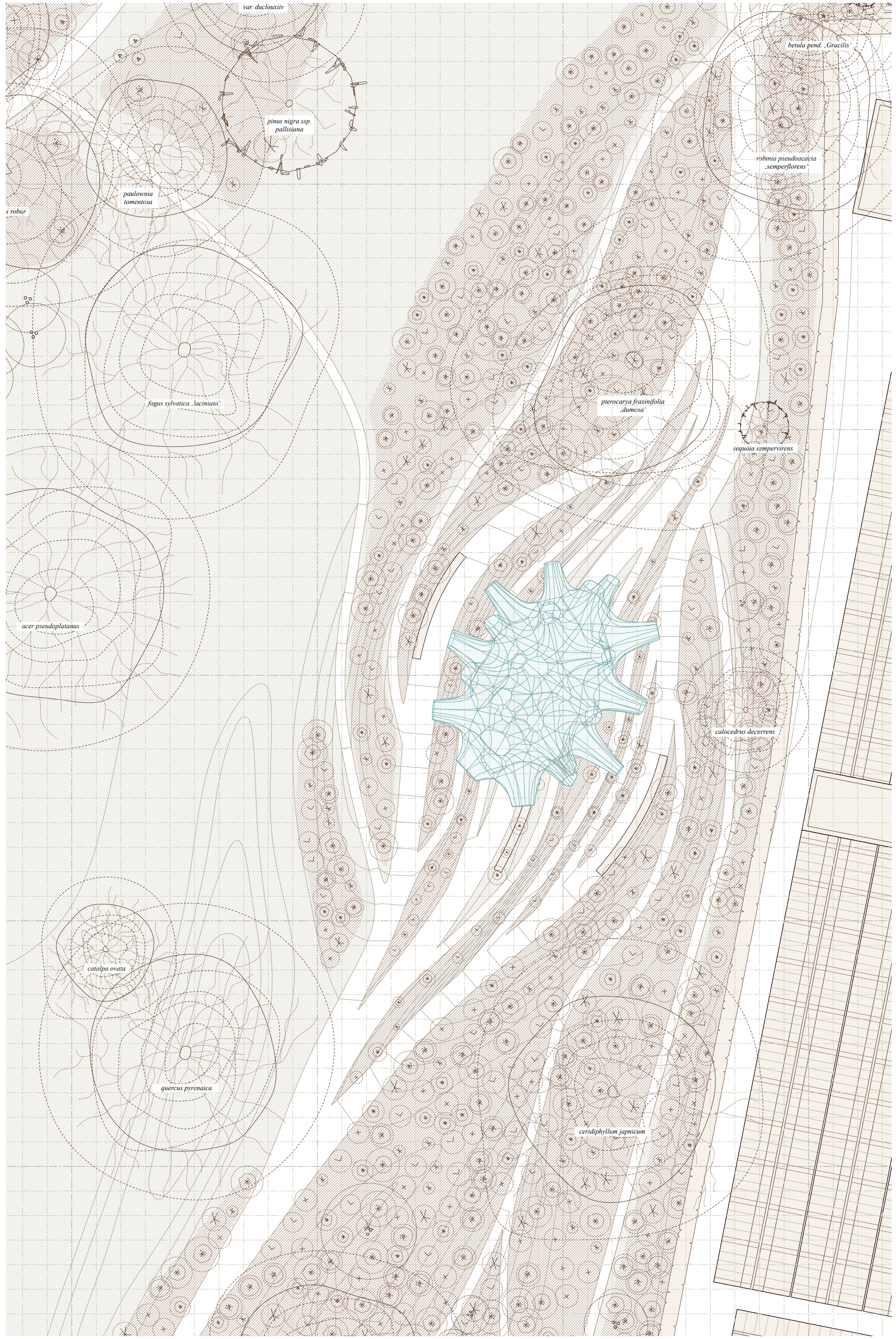
_landscape plan

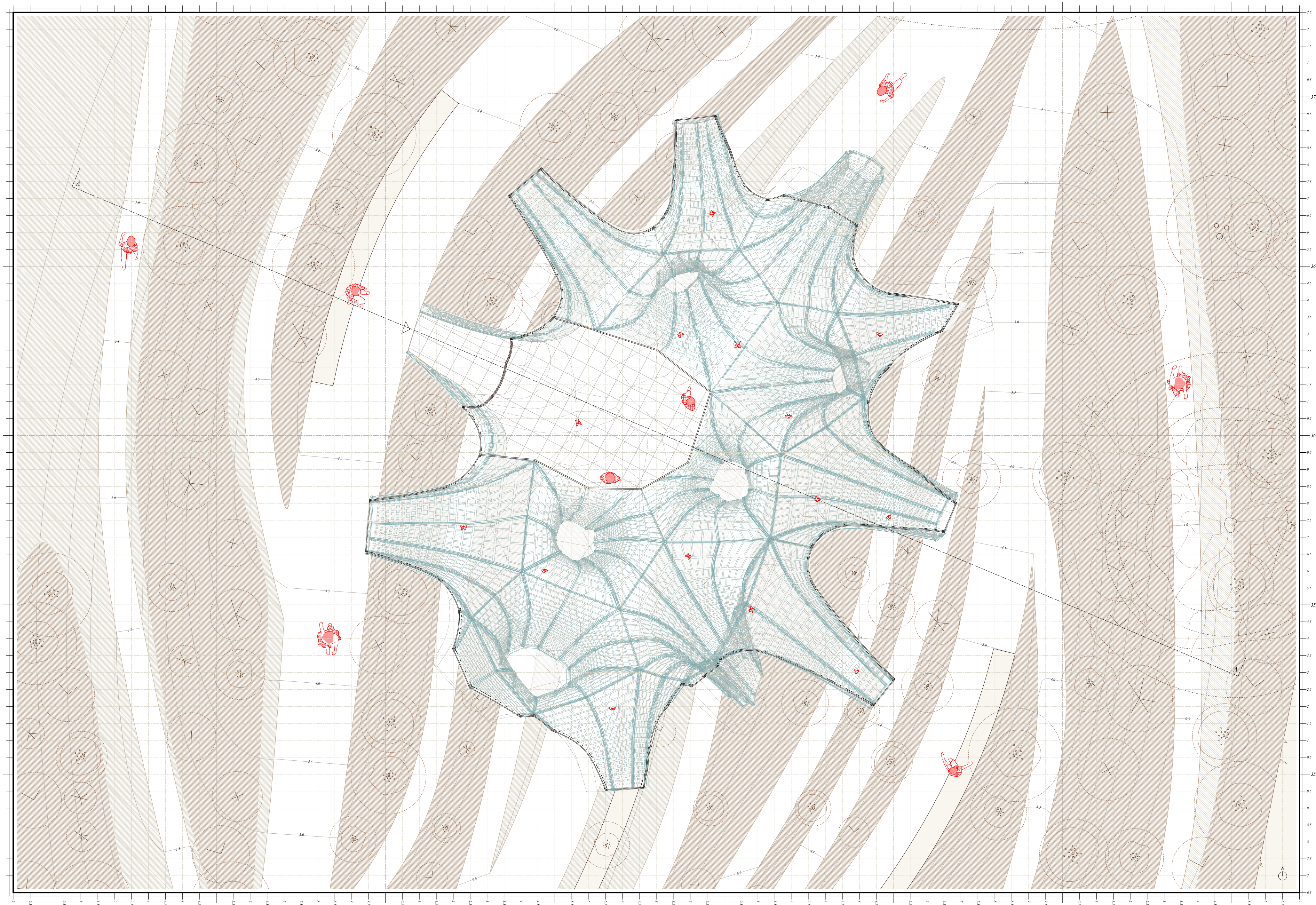


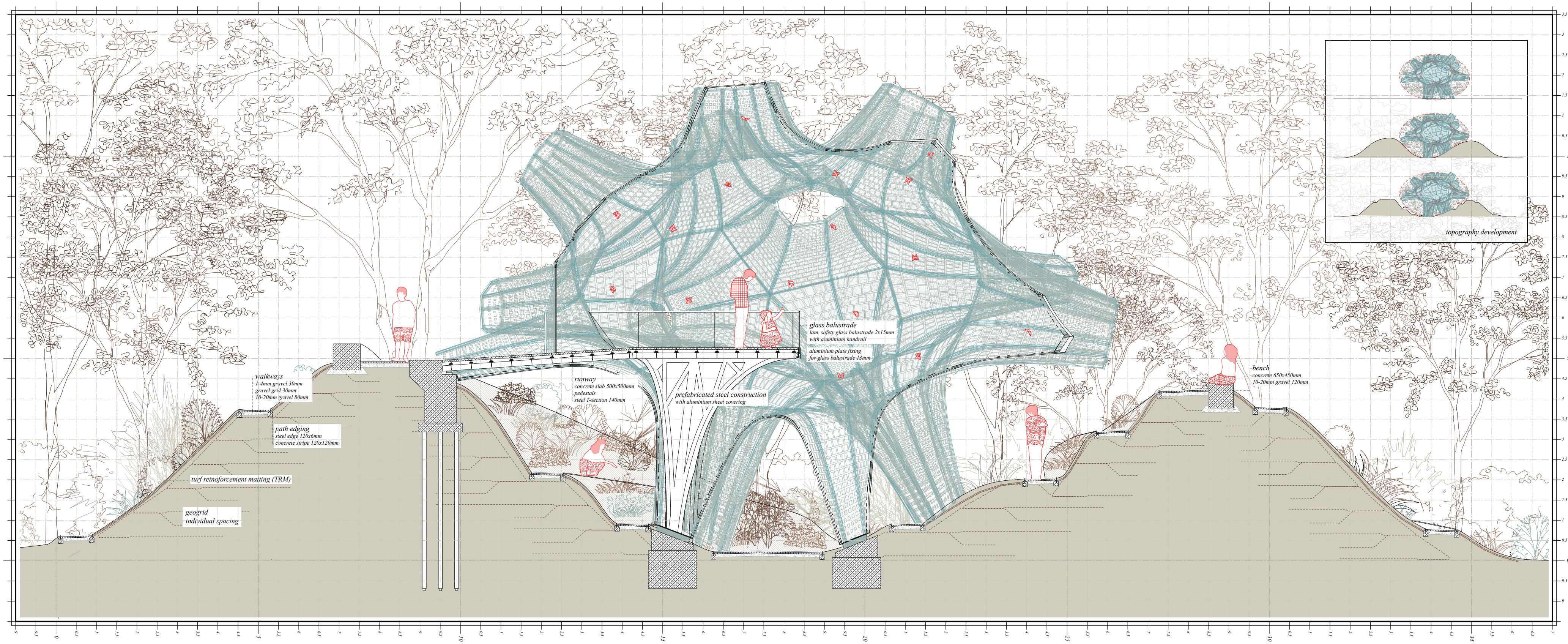
// existing pathes //



// transformation //

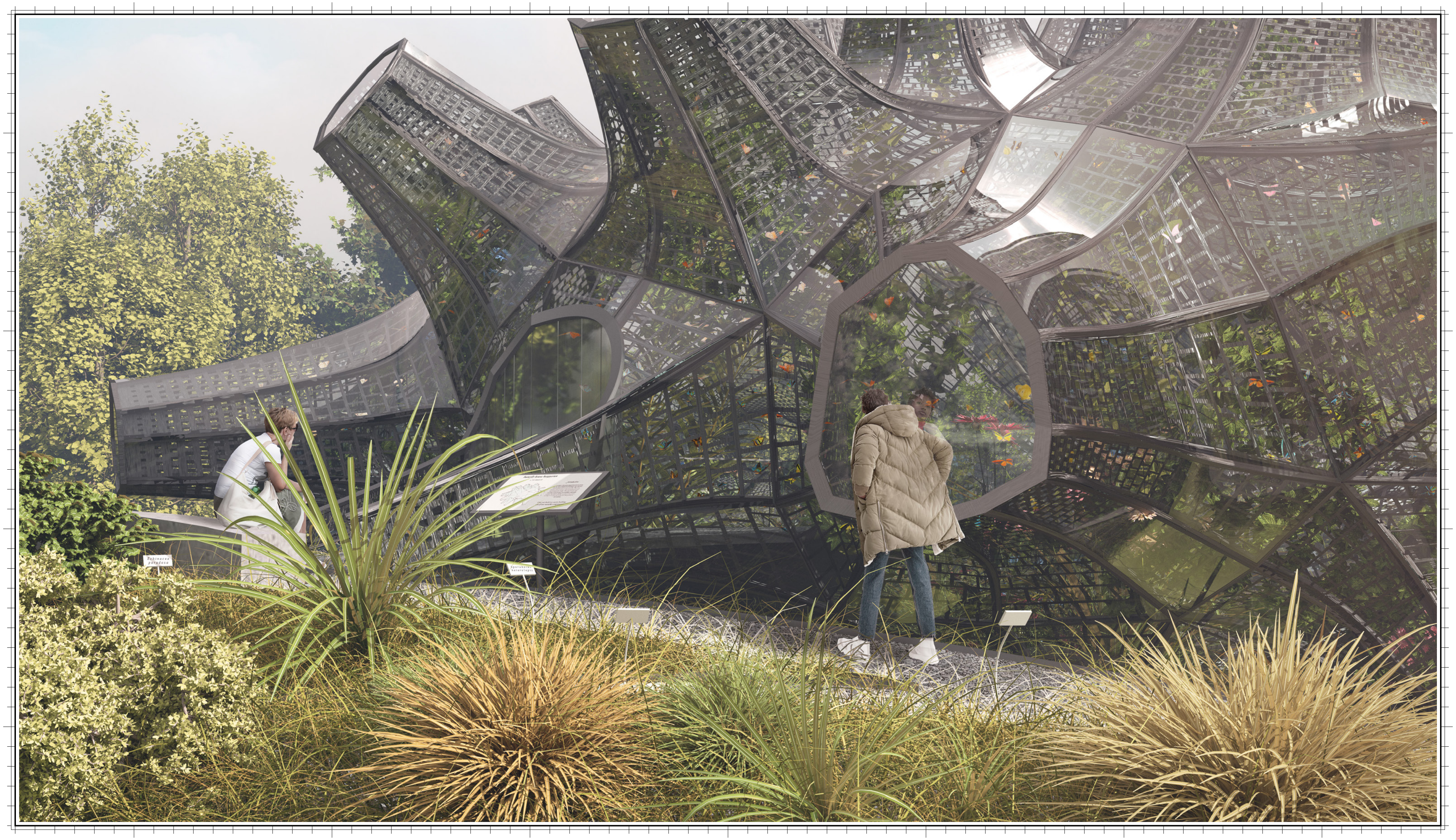



A
370
365
360
355
350
A
N



walkways
1-4mm gravel 30mm
gravel grid 30mm
10-20mm gravel 80mm
path edging
steel edge 120x6mm
concrete stripe 120x120mm
turf reinoforcement matting (TRM)
geogrid
individual spacing
runway
concrete slab 500x500mm
pedestals
steel T-section 140mm
prefabricated steel construction
with aluminium sheet covering
glass balustrade
lam. safety glass balustrade 2x15mm
with aluminium handrail
aluminium plate fixing
for glass balustrade 13mm
bench
concrete 650x450mm
10-20mm gravel 120mm
topography development

section // 1_50

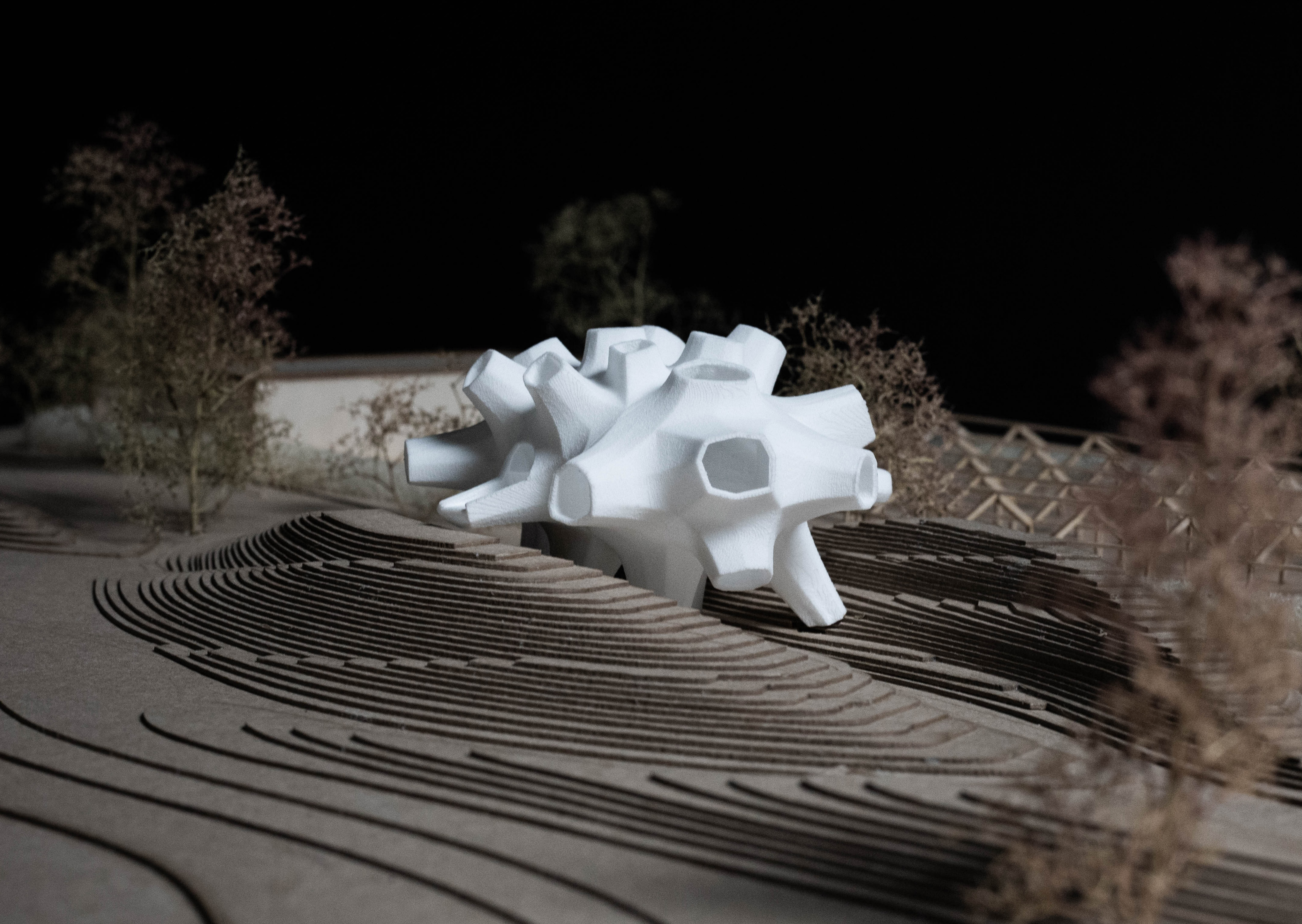


// entrance view //

// interior view //

_model

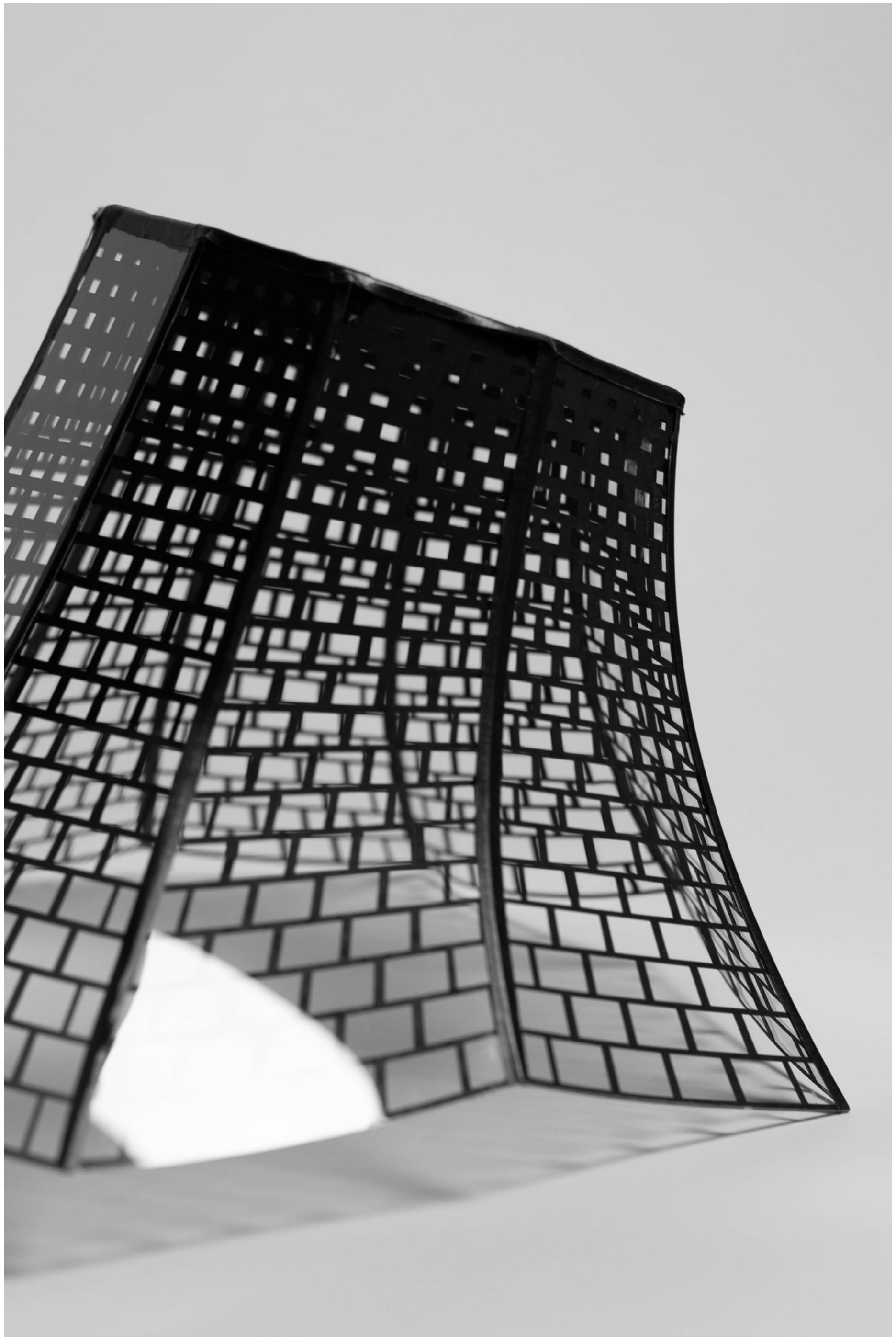
Nils Opgenorth



Nils Opgenorth


V16_0
V24_7
V1_0
V24_0

V11_2
V10_1
V10_2
V10_3
V10_4
V10_5
V3_10
V3_9
V3_8
V3_7
V3_6
V3_5
V2_0
V2_1
V2_2
V2_3
V13_9
V21_2



Nils Opgenorth


V7__10
V17__7
V17__0
V24__2
V5__1
V22__6
V20__5
V6__9
V3__4
V18__7
V17__1
V14__5
V3__9
V1__6
V16__3
V21__0
V20__3
V6__8
V18__4
V4__3
V17__5
V16__6
V26__0
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V27__7
V23__8
V20__9
V25__4
V2__5
V16__9
V26__1
V27__6
V14__4
V3__0
V14__9
V4__1
V15__4