URBAN PATCH

TECHNISCHE UNIVERSITAT WIEN
Vienna University of technology

MASTER-/DIPLOMARBEIT

URBAN PATCH
activating the city of Lodz

ausgeführt zum Zwecke der Erlangung des akademischen Grades
eines Diplom-Ingenieurs / Diplom-Ingenieurin
unter der Leitung

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E253

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eingereicht an der Technischen Universität Wien
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Abstract:

[DE]

Die Masterarbeit, '*Urban Patch - Aktivierung der Stadt Lodz*' vollzogen an der TU Wien unter Leitung von Prof. M. Berthold mit Beratung in Bereich der pneumatischen Strukturen und Statik von Prof. J. Hennicke, ist ein konzeptioneller Entwurf eines temporären, flexiblen, beweglichen, und öffentlichen Pavillon, der eine Stadterneuerung in die post-industrielle Stadt Lodz bringen soll. Nach einer kurzen Beschreibung des historisches Hintergrunds von Lodz und Diskussion der aktuellen Strategien, einen Architekturvorschlag gemacht wurde, der den öffentlichen Raum versucht zu verbessern und Einwohner im Zwecke des Aufbaus der bessere Zukunft zu engagieren. Das Projekt nutzt moderne Bautechnik - Luft aufgeblasen Schläuche die, aufgrund ihrer einzigartigen Eigenschaften erwartet werden, um flexible, variable, bewegliche, Räume zu erstellen. Simulation des Verhaltens von Luft-schläuche mit der Umsetzung der Kangooro-Live- Physik-Engine, in Rhino Grasshopper Programm getan wurde.

[EN}

The master thesis: '*Urban patch - activating the city of Lodz*' done at the Vienna Technical University under supervision of Prof. M. Berthold with advisory in field of pneumatic structures and static from Prof. J. Hennicke, is a conceptual project of a temporary, flexible, movable, public pavilion, that is aimed at bringing urban regeneration to post-industrial city Lodz. This master thesis, after shortly describing the historical background of Lodz and commenting on the actual strategies, makes an architectural proposal that aims at enhancing the public space and activating the inhabitants in purpose of building better future. The project uses a modern construction technology - air-inflated pipes which, due to their unique characteristics, are expected to create a flexible, variable, movable building. The simulation of the behaviour of air-inflated pipes was done with implementation of Kangooro - live physics engine, running in Rhino Grasshopper programme.

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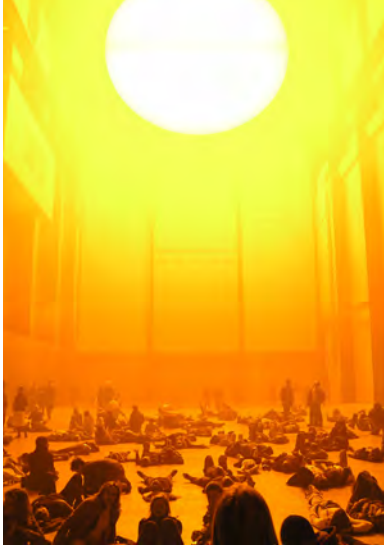

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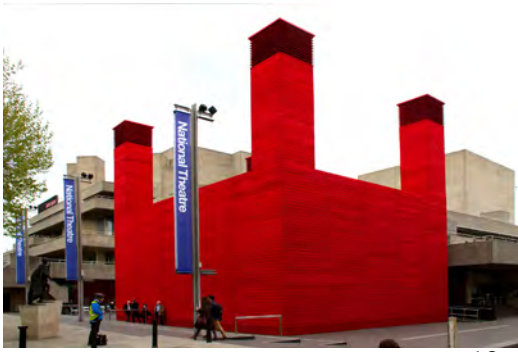

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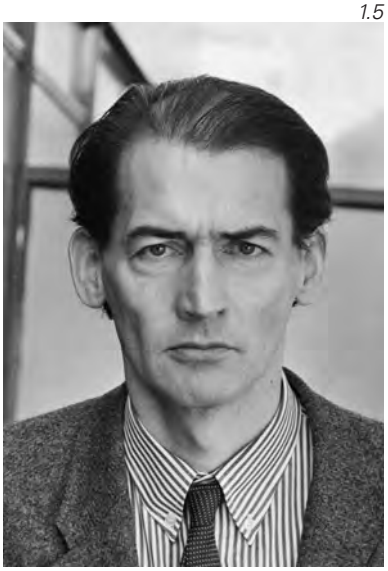

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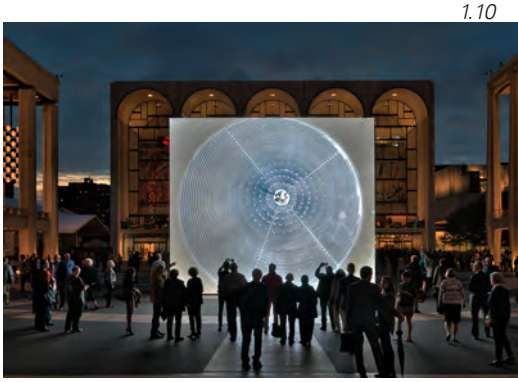

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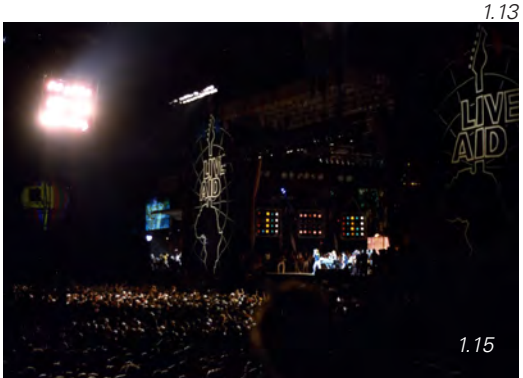

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1. INTRODUCTION

Working on each master thesis in architecture consists of two stages: the first one is defining a challenging problem and the second is finding a valuable solution.
When I started working on this project back in April 2014 nothing was predefined - I was given total freedom. Inventing an architecturally demanding topic that would summarize my studies, was itself a challenge. Just like in every architectural work the choices and ideas were evolving throughout time. In this paper I summarize and present the output of this fascinating process. The presentation is organized in accordance to scale - from a wide urban perspective, where brief and aims of design are formulated to detail solutions of particular elements. Furthermore this scale-based explanation follows relatively well the chronological order of my work - looking at the progress of the project from time perspective I conclude with confidence that I worked much from big urban to small detail scale.

In the Introduction, I would discuss the two very first decisions: to create an architecture that matches the atmosphere of our times (chapter 1.1) and to build in my home town (chapter 1.2), with the purpose of revitalizing (chapters 1.3,1.4).
In the main part succinctly defined topic would with each section get more and more substantial. Firstly the typology is defined (chapters 2.1,2.2.2), next the building technology chosen (chapter 2.2.3), and finally the geometry (chapter 2.2.5), system elements (chapter 2.2.6), and applied methods (chapter 2.2.8) are presented. The project summary (chapter 3) is followed by drawings, renderings and model photos (chapter 4).

1.1 The City - urban shift

The cities are places for activities, for art, for communities and for culture. They are like stages creating background for the people to work, to play, to build, to know, to change. This need - of gathering to create or admire - defines contemporary cities.

Number of occurrences like pop-up events, performances, festivals, open-air concerts - all taking part in public space - are blooming in the best developed metropoles. In my opinion the new centre of gravity for future cities are those cultural cores, where people meet to share ideas, experiences and opinions.

I believe that in spontaneous acts of inhabitants within the urban fabric lie a great potential. It could be interesting to treat this topic of urban creativity as an architectural challenge and try with building solution enhance this ‘culture’. I believe that egalitarian nature of our times, where freedom is taken for granted, could not earn better mirror.

1.2 The site

The idea of designing something for my hometown came from my advisor: prof. Berthold. After two years of my not being in Poland I knew that I could make profit of my objective and distant view. The possibility of using the potentials of Vienna University of Technology to make a design in Lodz, that would match the standards of XXIst century sounded promising.

1.2.1 Lodz

Lodz with around 700 000 inhabitants is the third biggest city in Poland. It lies in the heart of the country about 135 km west from the capital - Warsaw.

Lodz got the city rights in 1423, however till 1810 it remained a small village with less then 200 inhabitants (state 1796). It was in 1820, when, with the decision of governmental authorities, Lodz was converted into an industrial city. The village of Lodz was chosen due to geographical reasons. The area was rich in small rivers and forests, it lied on the newly built road Leczyca-Piotrkow, and belonged entirely to the state, which enabled the parcellation of land.

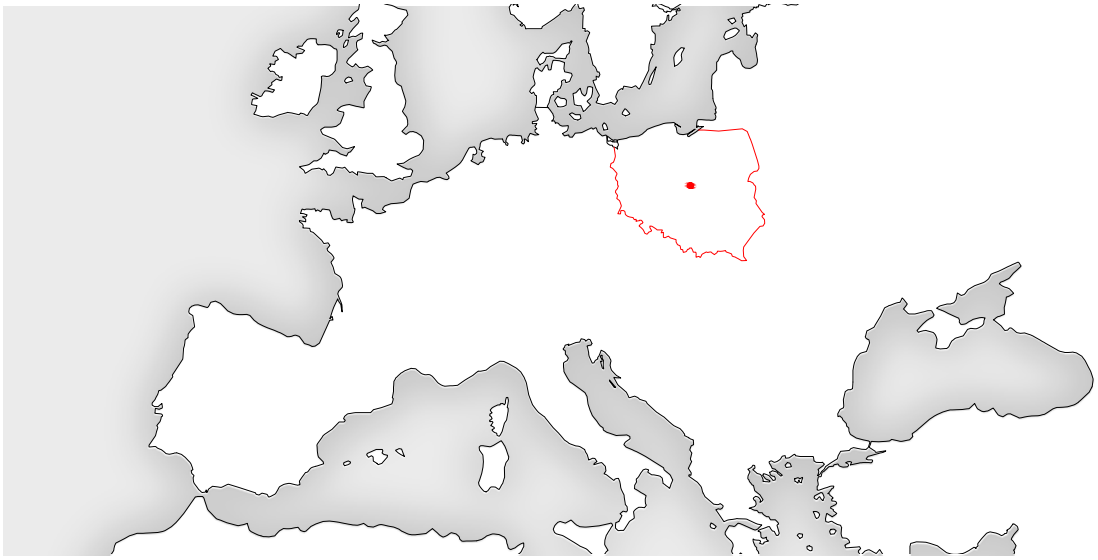
Lodz was meant to be a textile city. To encourage investors profitable tax allowances were offered. A new period of rapid, uncontrolled development of the city began. The population exploded. It doubled every ten years in period from 1823 till 1873. From 4 343 inhabitants in 1830 to 600 000 in 1915 - in merely 85 years the city merged from a village into world recognised metropolis.

In the interwar period the population growth slowed down. The city still remained a textile capital, but simultaneously significant public investments were made. In this period the fundaments for universities in Lodz were laid. There was an attempt to consequently refill urban fabric within the boundaries of railway belt surrounding the city and avoiding territorial expansion.

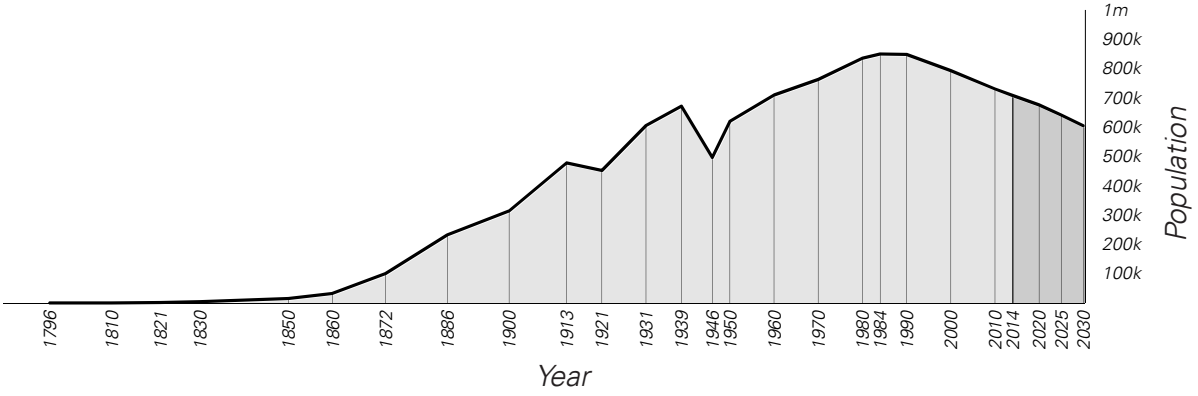
From ‘45 till ‘89 (Poland as a state of Soviet Union) Lodz strengthened its position as a leading textile manufacturer. Unfortunately good economics and high production rate did not reflect in spatial development. One of the most poisonous decisions was the construction of settlements of prefabricated panel buildings outside the centre. People willingly exchanged old tenements for flats in apartment blocks in favour of modern infrastructure.

This tendency of city spreading outside the centre has not been stopped. Nowadays people dream of a private house with garden. Consequently the amount of inhabitants of inner city decreases. The situation of Lodz could be compared to other European post-industrial cities like Manchester or Lion. The difference is that this process, took place there several decades ago. The collapse of Lodz started only 25 years ago, with the fall of Soviet Union, when most of the eastern markets were closed.

Nowadays my home town is suffering an outflow of inhabitants - just contrary to this exciting time, when the city was born - Lodz loses each year about 10 000 inhabitants, mostly young, talented people. The demographic prognosis for the city is unpromising.



1.17 Location of Lodz in Europe



1.18 Population development of Lodz, with prognosis till 2030; based on selected data from Polish main statistical office

1.19 Growth and change of urban fabric in Lodz during it's most rapid development period; based on 'The Atlas of Lodz city' chapter 5 by prof. J. Wesolowski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1.2.2 Lodz development - current situation:

There are few important motors triggering the city centre to change in a worse or better direction. The first arena I would like to comment on, is Piotrkowska street (no. 1/ fig. 1.20 /opposite page) - the most important dominative element of Lodz urban structure - originally the axis along which the textile city was developed. In the 90'ties Piotrkowska was one of the best shopping streets in Poland. This splendour is lost due to construction of two huge shopping malls - Galeria Lodzka (no. 4/ fig. 1.20) near Pilsudzkiego street and Manufaktura (hosted in revitalised fabric of Poznanski; no. 5/ fig. 1.20) near Ogrodowa street. Nowadays Piotrkowska carries functions of gastronomy, pubs, cafes and music clubs being a main venue of Lodz nightlife. Some offices, public institutions, and shops are located there as well. Main part of the street is traffic-free. Rich architectural detail of XIXth century facades neighbouring the street contributes to the quality of this space. The challenge for Piotrkowska is to win back the biggest possible revenue source - bring prestigious shops once again to the street.

Second area of enhanced development in Lodz is the rearrangement of west-east Pilsudzkiego (no. 3/ fig. 1.20), which aims at minimizing the car traffic with a double level solution - underground transit for cars is being built. The street above is meant to be refilled with hi-rise buildings. This axis of the city should possess a 'modern, dynamic' image and be a counterpoint for historical Piotrkowska.

The third and most important urban development is Lodz New City Centre (NCL). The decision was made already in 2007 that there would be an attempt to fix 'no-transit' situation of Lodz railway connections. In this purpose the railway station of Lodz Fabryczna is being built underground to be later extended with a tunnel and to go through the city. This would enable the Warsaw - Berlin trains to stop in Lodz. Although the station is under construction and should be finished within the following few months there is no plan or guarantee for the tunnel. Apart from the railway station also cultural institutions are being built as a seed of NCL. An old historic heat-station is transformed into museum of technic and supplemented with some additional cultural buildings (opening planned till end of 2014). During the development of NCL many conceptual projects were made: conference centre by Frank Ghery, the gate, office building by Daniel Libeskind, as well as huge tube like art museum. Due to different reasons those initiatives did not succeed.

1.3 Lodz urban strategy:

In 2012, the: 'Integrated development strategy for Lodz 2020+' was successfully passed. This document tries to define Lodz policy of further development. The defined key objectives are: *'improvement of the quality of life (...); reversal of adverse demographic trends; creation of a sustainable transport network (...); strengthening of social bonds, fostering of citizens' participation and building of self-government community; efficient management of the city regeneration of urban space'*[1].
All those aims are to be realized within three development categories - pillars: economy and infrastructure, society and

[1] *Resolution no. XIIII/824/12 of the city council in Lodz of 25 June 2012 on adoption of the "Integrated Development Strategy for Lodz 2020+".*

opposite: 1.20 figure floor plan of Lodz centre in scale 1:50k, including significant development zones

culture, space and environment. Those pillars are based on a foundation of '*efficient and friendly Lodz'*. In following chapters each pillar is provided with some details and in the final part the potentials of the city and implementation methods are mentioned. In my opinion this short document sets a correct standard for the development of Lodz. Freely and lapidary formulated aims and methods outline the proper way to fight the rapidly growing problems. However, the publication of the strategy was already 2 years ago - how does it correlates to current situation?

Surprisingly, some of the points defined are being consequently realized. For instance; projects run by the city are being consulted with the public; the 6th August street has become traffic-free to create attractive urban zone (civic budget initiative); or the transportation system and infrastructure are being upgraded - a new airport was opened and the renovation of railway station Lodz Fabryczna is under construction.

1.4 Criticism:

Although the strategy and passed resolutions are promising, there are some risks. Firstly, these documents poses no executive power. They set some standards, but do not create law-guaranteed regulations for which, one must wait till 2016, when a new local land management plan would be passed. According to this plan (for highly urbanised areas in 1:1000 scale) the building permits are released. How much would the plan correspond to what is written in the strategy - only the time will tell.
Another point of criticism relates to the scale of the investments especially NCL. The city wants to arrange a land of 100ha, creating hi-intensity district. Although nobility of this intensions is clear and I do not want to be sceptic, a sober look at this plan, referring to Lodz investment abilities, is needed. Nowadays, the inner city of Lodz possesses many weakly used or empty spaces. Through the last decades it was very difficult to find investors willing to build within the centre. Would the attitude of investors change towards this newly developed quarter? This project could only succeed when build fabric would engulf the bigger part of the plot. Otherwise it would remain just like all the rest of Lodz - not fully build, low intense and inefficient. Apart from that, the masterplan itself is in my opinion troublesome - it brings no variety into the urban fabric. The proposed spaces are similar to historical Lodz (scale of buildings and urban interiors). How much quality would this project earn when in the middle a public park would be located and the intensity criterion would be fulfilled with hi-rise?

To sum up, my critic mainly concerns ambitious plan of NCL. This investment - already being realised - triggers a lot of risk relating to its scale. In the following years the city would strongly support this development steering most of the public funds in its direction. This equals the outflow of money from the rest of the city centre, which paradoxically looks more feasible than NCL. I would suggest that a better solution for Lodz would be to systematically renovate one city block per year. After 25 years of freedom, we would have now 25 renovated city blocks; which would mean a large, modern attractive, revitalised urban zone. It seems that risky utopian visions are more appealing.

In my master thesis I would like to create an alternative for those huge plans and enhance the social aspect of the city. Maybe Lodz should try to increase the involvement of the citizens making a gesture towards them, showing to whom the city really belongs.

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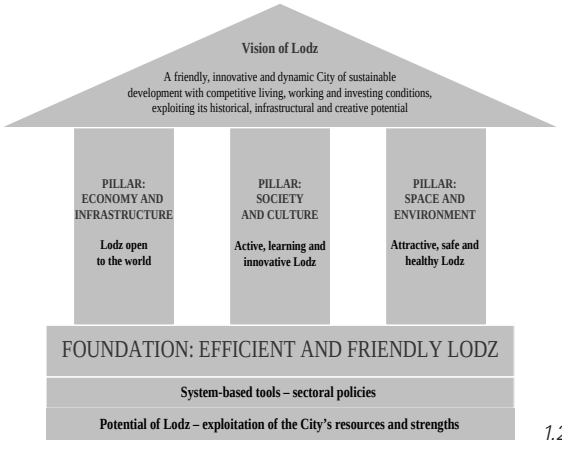

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1.21 and 1.22 6th August Street transformation - (left: after; right: before), done this year (summer 2014) as a civic budget initiative

1.23 area of Lodz New City centre - on the left renovated heat plant hosting museum of science, behind additional cultural buildings; on the left: construction of underground railway station: Lodz Fabryczna

1.24 proposed and passed in Lodz City Council resolution masterplan for future Lodz New City - enormous project in context of city's investment capabilities

1.25 "Integrated Development Strategy for Lodz 2020+" - the new standard for city development properly defining key fields, however in conflict with what is acutely being build - enormous new investments absorbing most of the fonds and leaving the historic center under-financed


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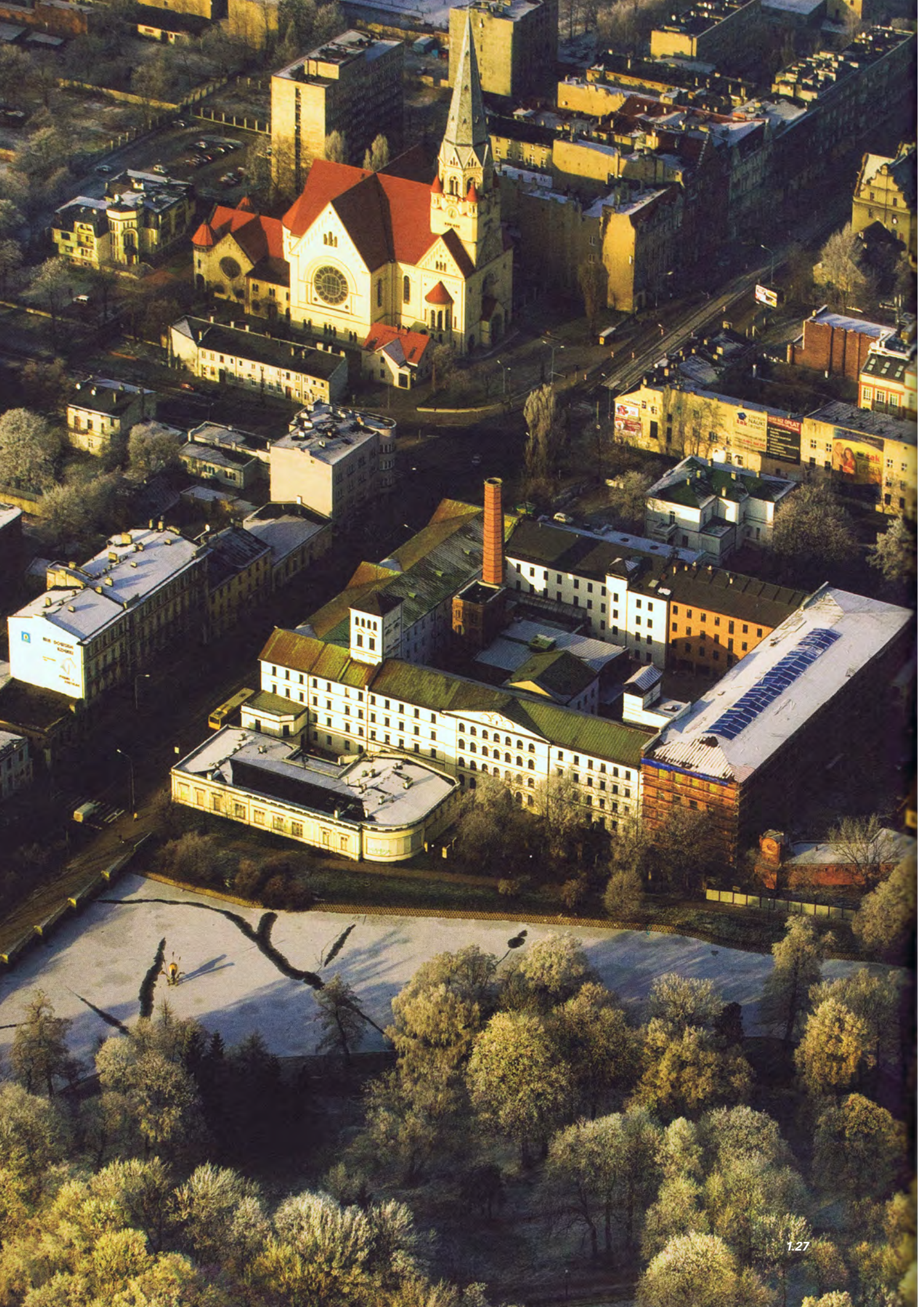

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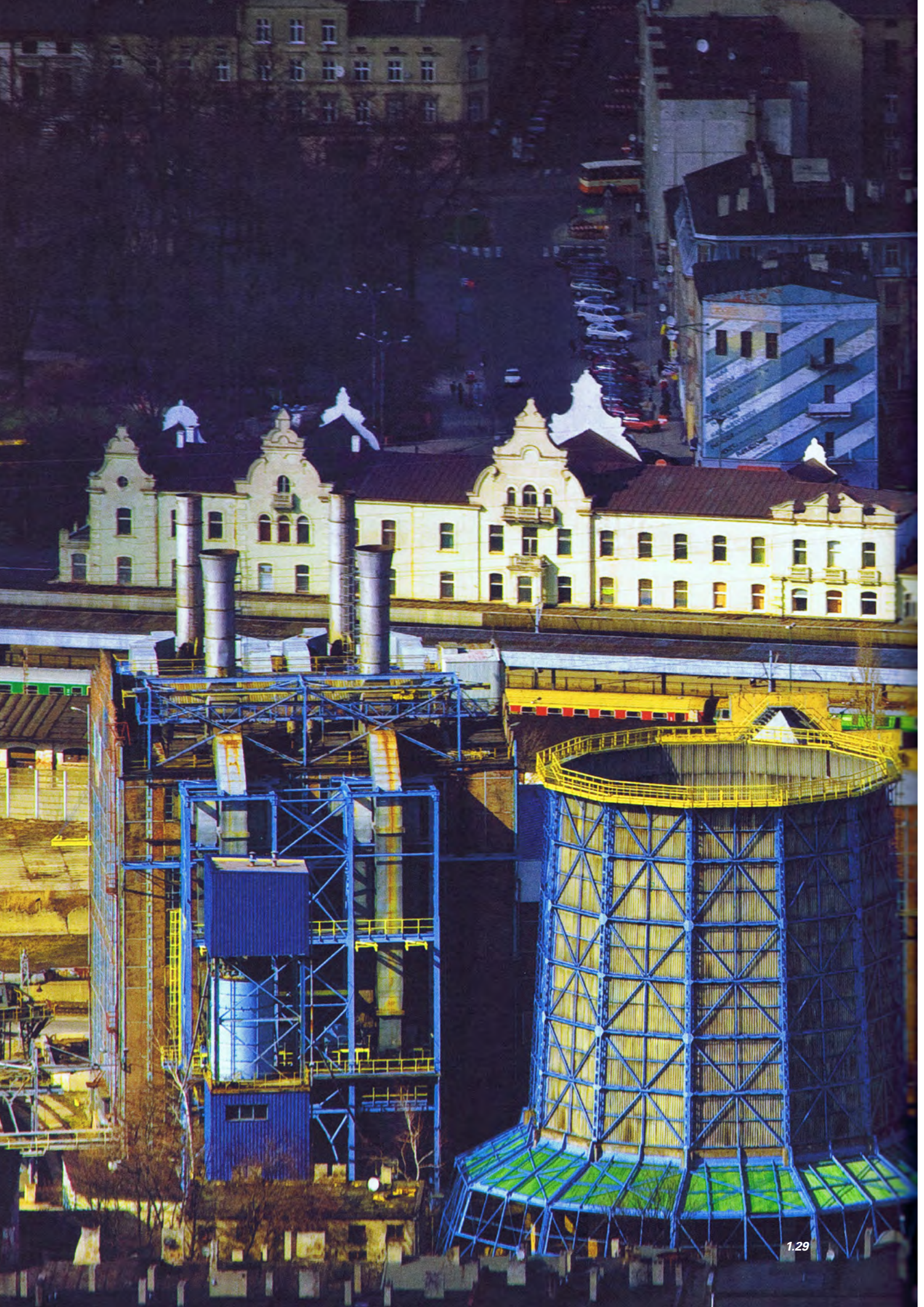

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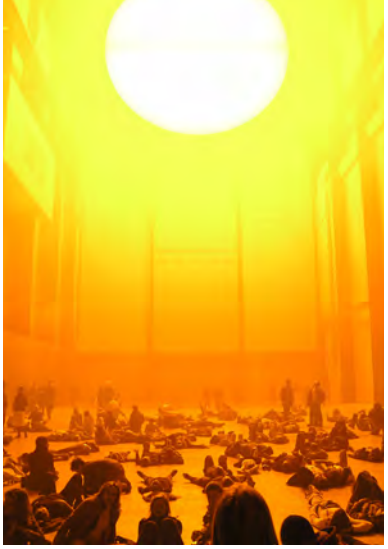

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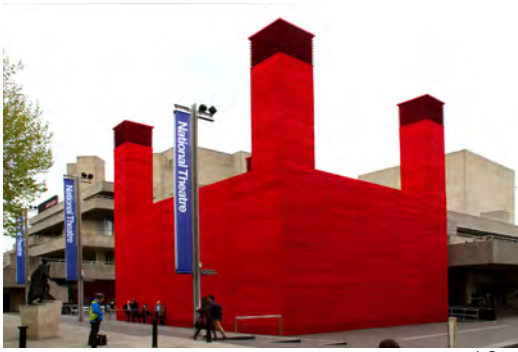

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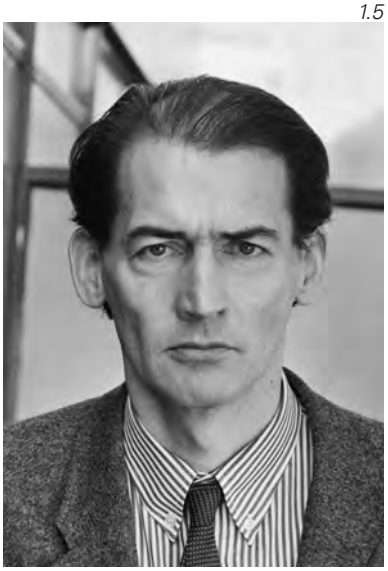

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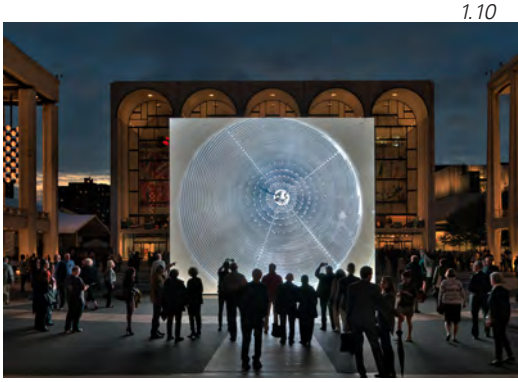

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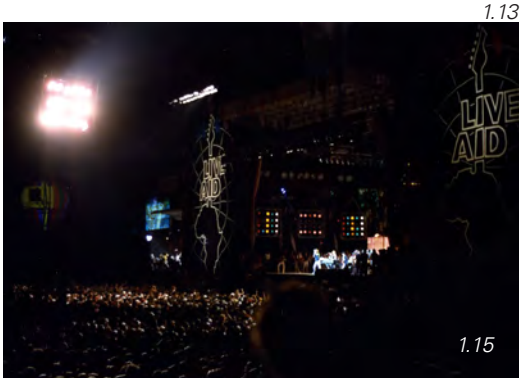

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2.1 Main Part I Strategy

2.1.1 City of participation

The problem is defined as a post-industrial, semi-sized city in the heart of Poland - Lodz tries to change the tracks of its development by stopping further urban degradation.

The current strategy of the city bases on the idea of 'building new' - the majority of public funds in Lodz is being invested to create brand new urban zones or upgrade the existing infrastructure. I do not neglect the need of those steps. Of course, technical infrastructure is of extreme impotence for every city. What I would put into question is how much this strategy corresponds to the atmosphere of our times? Would the city, that the authorities of Lodz are trying to construct, be a decent response to the needs of future generations in the 21st century?

In my opinion, the contemporary city is not about the fabric, the roads or buildings; it is much more about the people and their activities. For me a city is like a jungle of possibilities. Museums, bars, cafes, cinemas, theatres, parks, sport facilities, universities, libraries, shops - they are all part of this jungle. Using them means being there, but at the same time participating in them. This attendance, this activity, it is important, because it boosts up both: the social capability of the city and economics of the region. It is much easier to meet a future wife on the market than on a deserted parking lot; and it is probably easier to run a shop near crowded street than on the outskirts.

Good cities possess a quality of delivering many opportunities of participating - there is a wide, varied offer, of activities, which are easily accessible. I would risk hypothesis that such an offer might drive the social capabilities of the city to the next level - the feeling of being part of a bigger society is build.

Taking this point into consideration, but looking from a different perspective. Hundred years ago the only possibility for people living in the city was to go out of theirs flat. There was simply nothing else to do - no television, no radio, no computers or internet. Public space was the only choice and self-evidently it was full of people taking advantage of it. The contact with the others was inevitable - the possibilities of building relationships or societies were for the asking. Nowadays there is a strong competition between different instances wanting to catch our attention or time - unfortunately most of those are far away from authentic.

I feel that in modern city it is important to attract people to use public space in purpose of building societies. The core of a healthy, sustainable, modern city lies in its inhabitants. They are offered places but in return their attention and participation is awaited. What they experience could inspire or influence their creativity. In my opinion, this is the essence of contemporary cities.

2.1.2 Strategy - Brief

Considering all the above mentioned - apart from new infrastructure Lodz perhaps needs an incentive, that would invite the people to participate in a city. An attractor that gathers the attention of inhabitants; a place where lots of people meet to build worthy bounds between each other. When the attention is won, a second step starts: discussion and progress. Would this method of releasing the energy of the citizens be a proper alternative to pre-programmed strategy and philosophy: 'build new' of current authorities in Lodz? Indeed, I think that this strategy could be worth devoting a master thesis. Two questions remain unanswered: how and where to attract.

I decided that the best way to attract citizens to the city would be with cultural function. All in all, one of the factors stimulating the cities to grow is culture. Places like stadiums, museums, concert halls very often seem to produce a certain positive aura. Maybe this occurrence could be explained by their importance impact - on a map of each city a place with 'moma' label immediately wins an image of significant and 'cool' spot. It quickly dominates a certain area and often becomes a landmark or symbol. Those buildings are like cathedrals of our times. Examples are plentiful: Centre Pompidou in Paris; Gugenheim Museum in Bilbao, National Library in Copenhagen, or National Stadium in Warsaw.
Why not use this interesting quality of cultural spaces to bring the attention of citizens right there where it is really needed. The mixture of cultural usages, in a package that invites the public to use it and to participate could generate a desired positive spirit.

The second question to be addressed: where should the project be located?
Obviously, for such cultural function we need a rather big open space to capacitate hundreds of people. Characteristic of Lodz is its relatively dense, yet not intense city fabric. It is dense in the sense of materiality: the spaces are small and narrow - the streets, that are dominating the landscape, are only 14 to 18 m wide. On the other hand, this urban pattern is inefficient: very little functions - usable spaces are there - the intensity is missing.
Nevertheless there are few spots in Lodz that from different reasons remained unbuilt. Which one of them should we choose as the target for our intervention? The truth is that all of them are dramatically wishing a shift - in no way the quality of them matches demands of contemporary cities. Taking this fact into account, the choice is to create a temporary - easily movable structure. In this way the location of this attractor could be periodically changed - it would be like a weapon in the hands of citizens to drive the urban qualities of selected zones/areas to the next level.

Finally the brief for this master project could be formulated:
with a temporary, movable building, carrying cultural functions ; an urban renewal in Lodz, based on participation of the inhabitants, should start.
The following pages show the pictogram with short explanation expressing the desired effect. The pictographs were drawn with consideration of particular chosen site, the description of the chosen site follows in the next paragraph.

opposite: 2.1 figure floor plan of Lodz centre in scale 1:50k, including possible target of the intervention

ARCHITECTURAL JAM / SLEEPING URBAN STRUCTURE

Asphalt Domination

2.2 Pictograph/Axonometry: Stage 1 Architectural jam/sleeping urban structure

SETTLEMENT...

Urban Experiment...

2.3 Pictograph/Axonometry: Stage 2 Settlement...

INVASION !!!

New Perspective - Landmark instead of parking lot!

2.4 Pictograph/Axonometry: Stage 3 Invasion!!!

ENERGY EXPLODING...

New Perspective - Exploration

2.5 Pictograph/Axonometry: Stage 4 Energy Exploding...

DEVELOPMENT

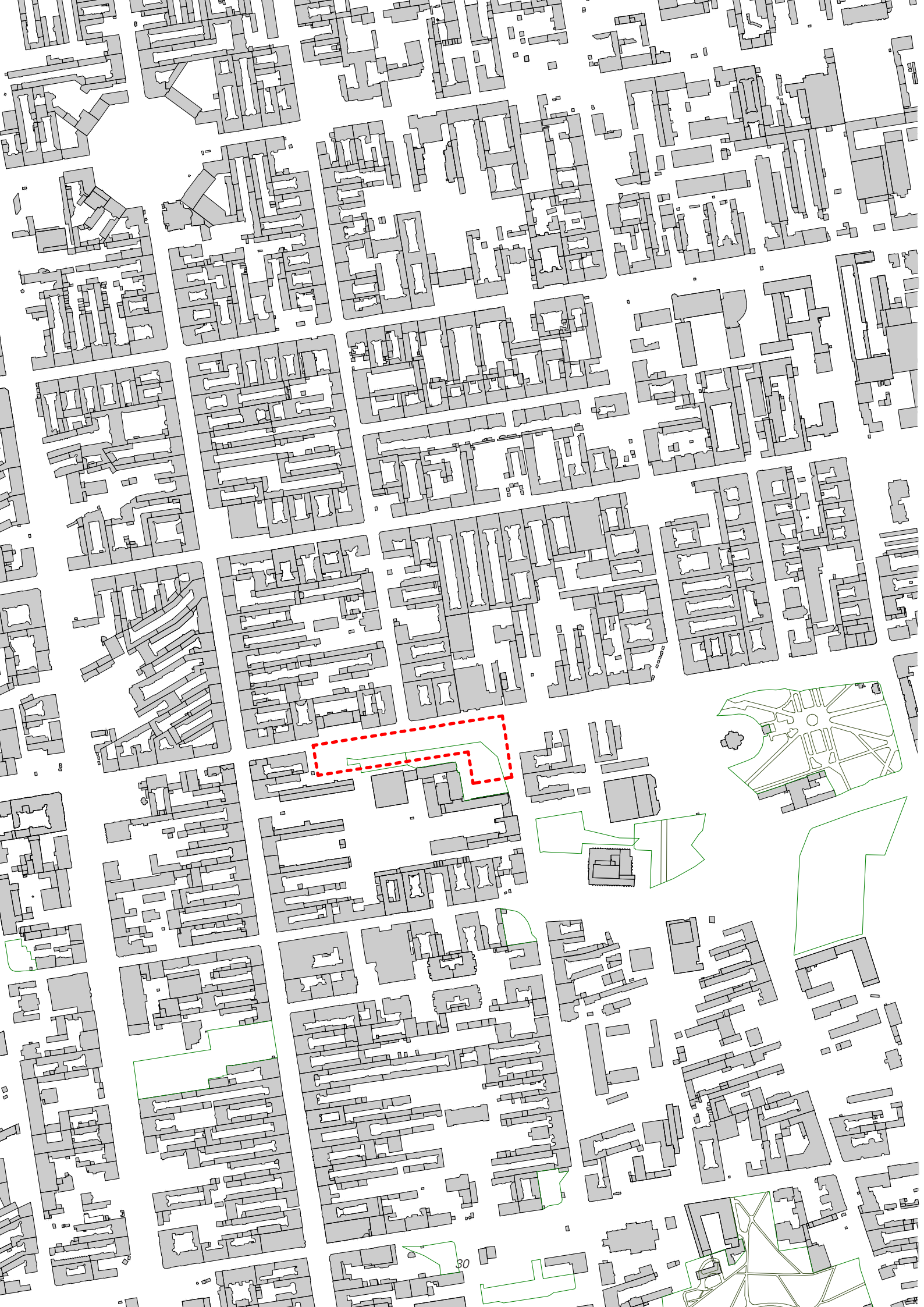
Sustainable City - city of participation

2.6 Pictograph/Axonometry: Stage 5 Development

UP LEAVES TO ANOTHER LOCATION...

Bond: Citizen - Town

2.7 Pictograph/Axonometry: Stage 6 Urban Patch leaves to different location in the city...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2.2 Main Part | The Project

2.2.1 Chosen Site

Proper presentation of an architectural project should always refer to a particular context. For this reason I have chosen a site in Lodz: *4th July Square*. It is located on the crossing of *Narutowicza* and *Sienkiewicza* Streets - just in the middle between *Lodz New City Centre (NCL)* and *Piotrokowska Street*. Initially *Narutowicza* was meant to connect the main, north-south-oriented *Piotrkowska* with the railway station *'Lodz Fabryczna'* by simultaneously creating perpendicular west-east counterpoint to an axially developed city.

Due to policy of widening the streets in 60's and 70's - almost all of the south frontage of *Narutowicza* was demolished. Fortunately, because of monument protection, the buildings at the crossing with *Piotrkowska* remained preserved.

Many cultural or public institutions are neighbouring (within 300m) the square: *Regional Television Headquaters; Lodz Governor's office; Lodz Philharmony Hall; Jaracza Theater; or the Grand Theater.* The square nowadays functions as a parking lot. It was named: *4th July 1989 Square* (the date of the legendary election ending the communist era in Poland) in 2010. Earlier the place was known as a 'parking lot in front of the television building'. Apart from changing the name nothing was changed here for decades.

There are few reasons why I have chosen this site. Firstly I consider the location between Lodz New City Centre (NCL) and historic core - Piotrkowska Street very important. This place could connect and integrate the old urban fabric with a newly planned district.

Secondly, the site does not correspond to modern architectural standards - the land is inefficiently used and it lacks quality. There is a dramatic need of changing this place. The importance of this location should be reflected with the attractiveness of this space. This square should represent the ambitions of Lodz to be modern, friendly, sustainable, and attractive.

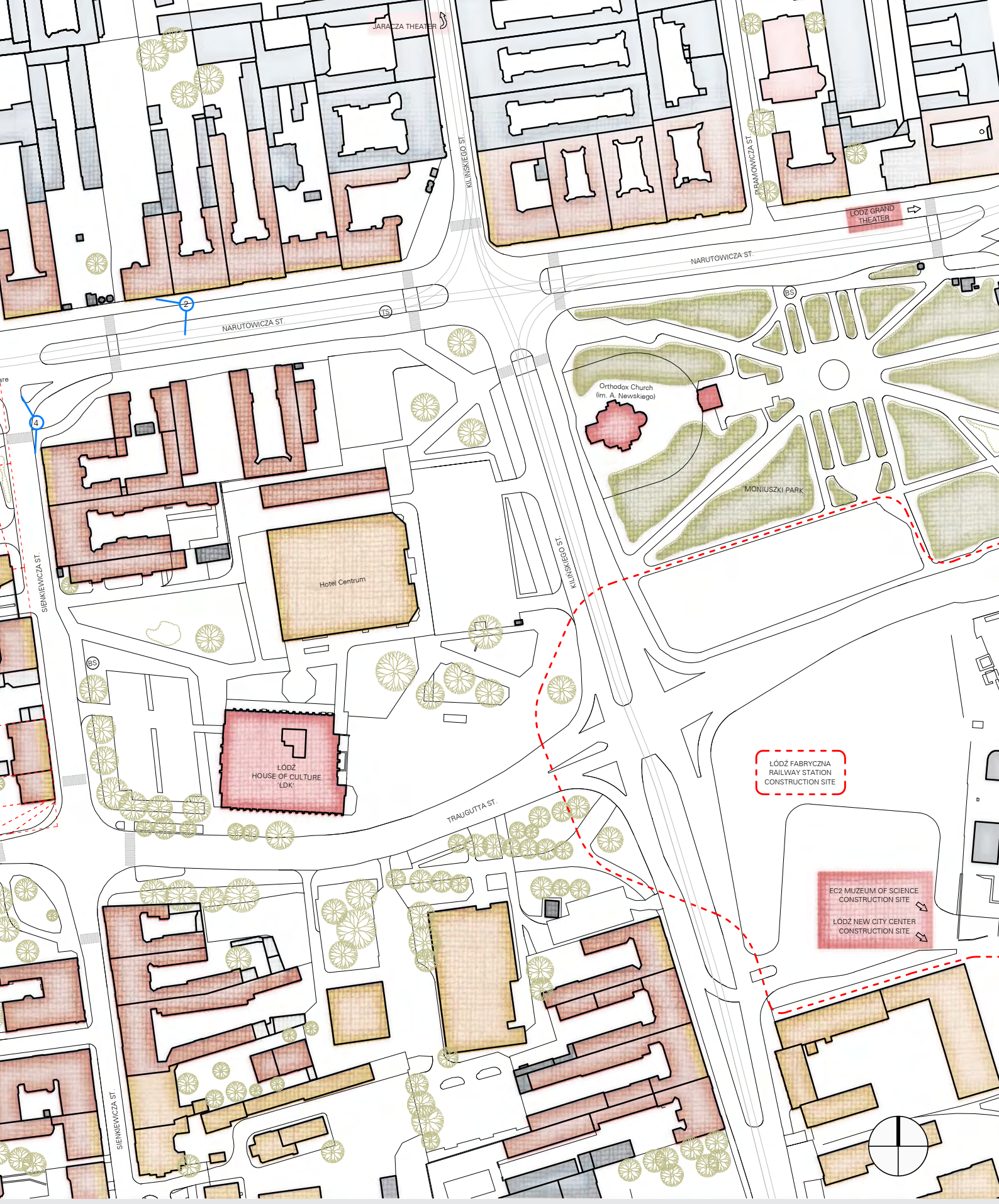
The potential of this site is presence of numerous public institutions in the neighbourhood, which contain very pleasant and desired functions. Maybe only a slight signal is needed to release those into the public space. This possibility of using neighbouring institutions as actors - possible hosts - was one of the earliest ideas.

On the following pages photos and plans for this site are attached.

opposite: 2.8 figure floor plan of Lodz centre in scale 1:25k, including chosen location

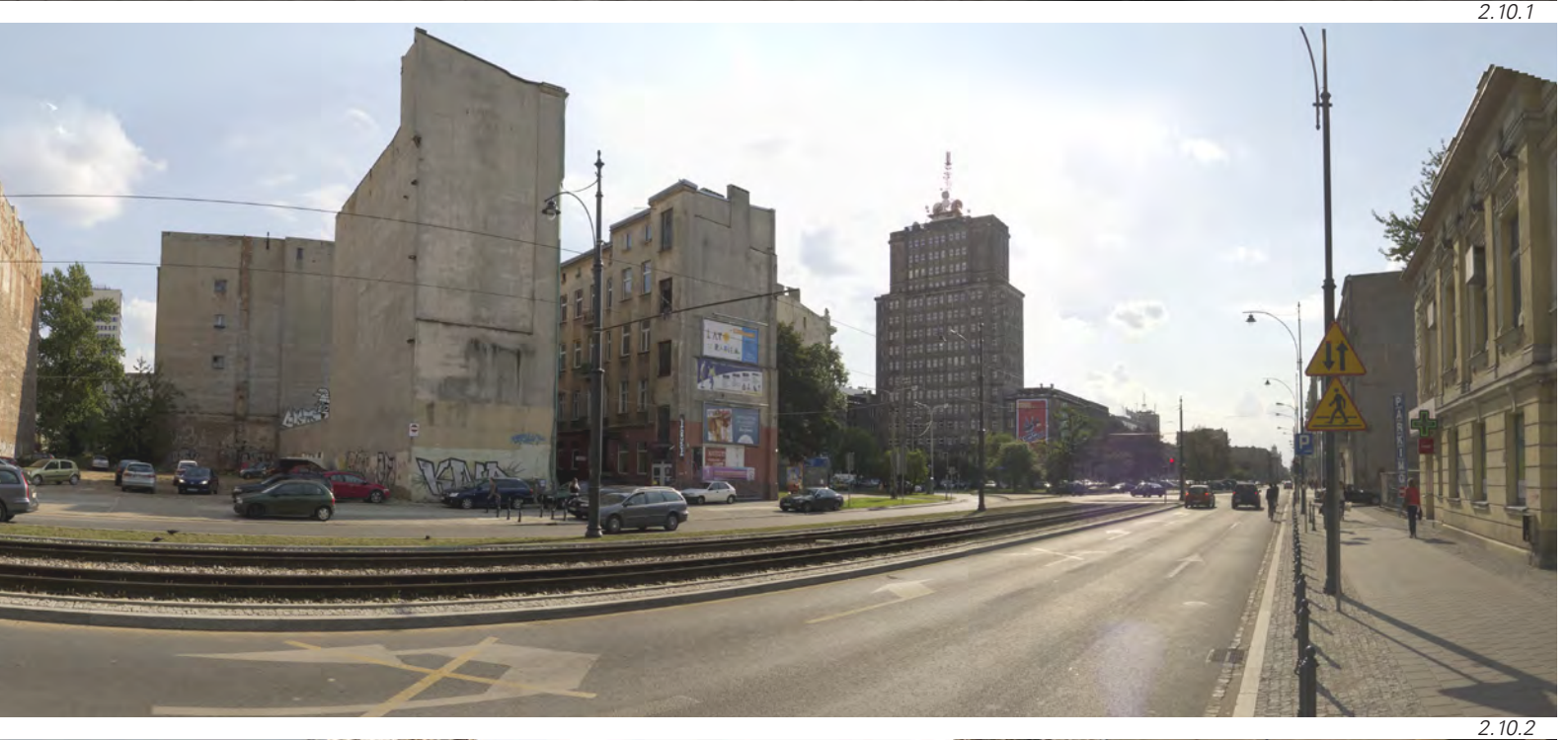
2.9 Air-photo in scale 1:2000 of chosen location

- green zones with potential
- public buildings, cultural function
- privte buildings, services: office, hotel, shop, restaurant, etc.
- tenements (dwellings)
- deserted building
- garages or depots
- build fabric - not analized functionally
- Parcelation - parcel boarders (partially marked)
- Tram Stop
- Bus Stop
- Traffic-free
- Reduced traffic
- Photo (attached on the following page)



2.10 Function analysis on figure floor plan in scale 1:2000

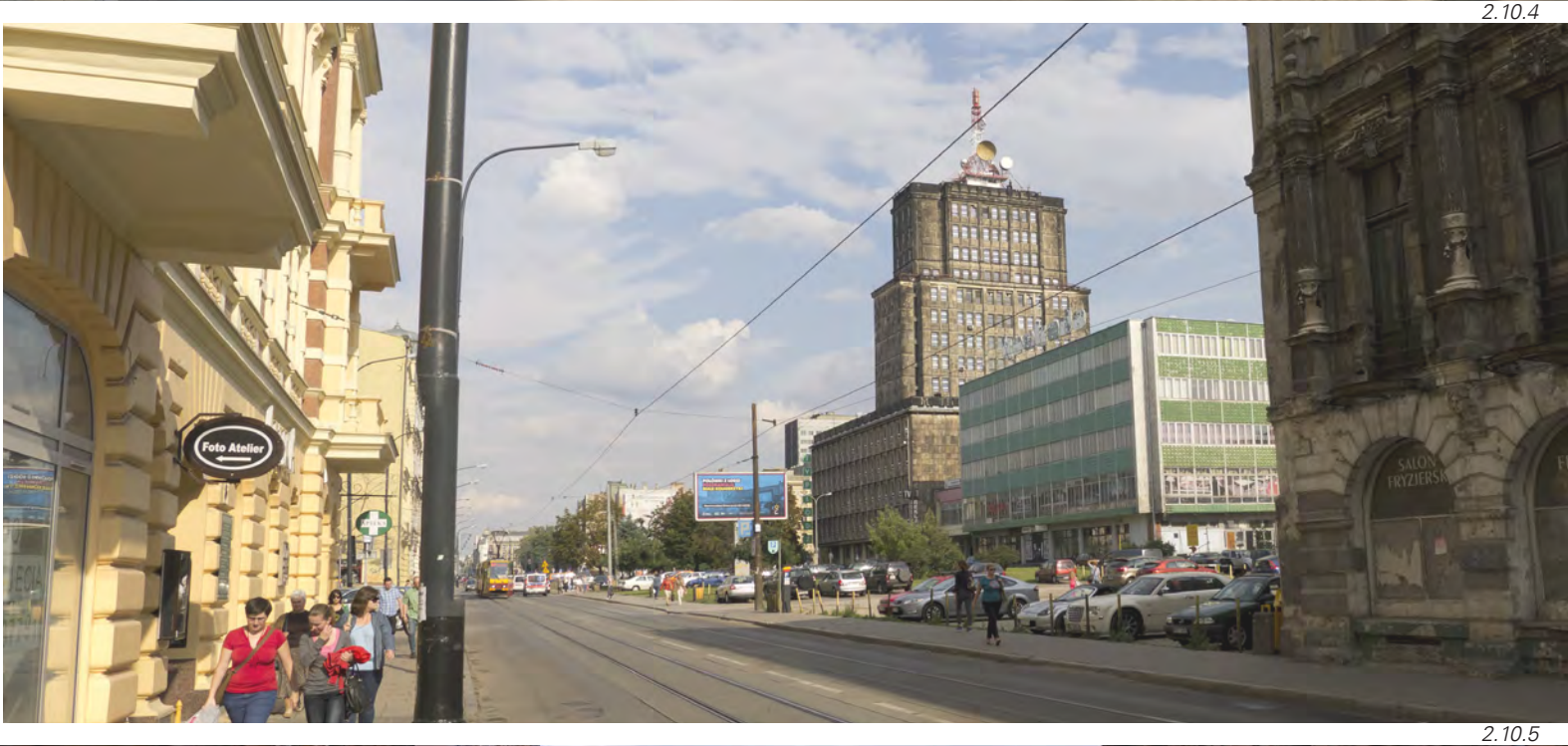
2.10.1



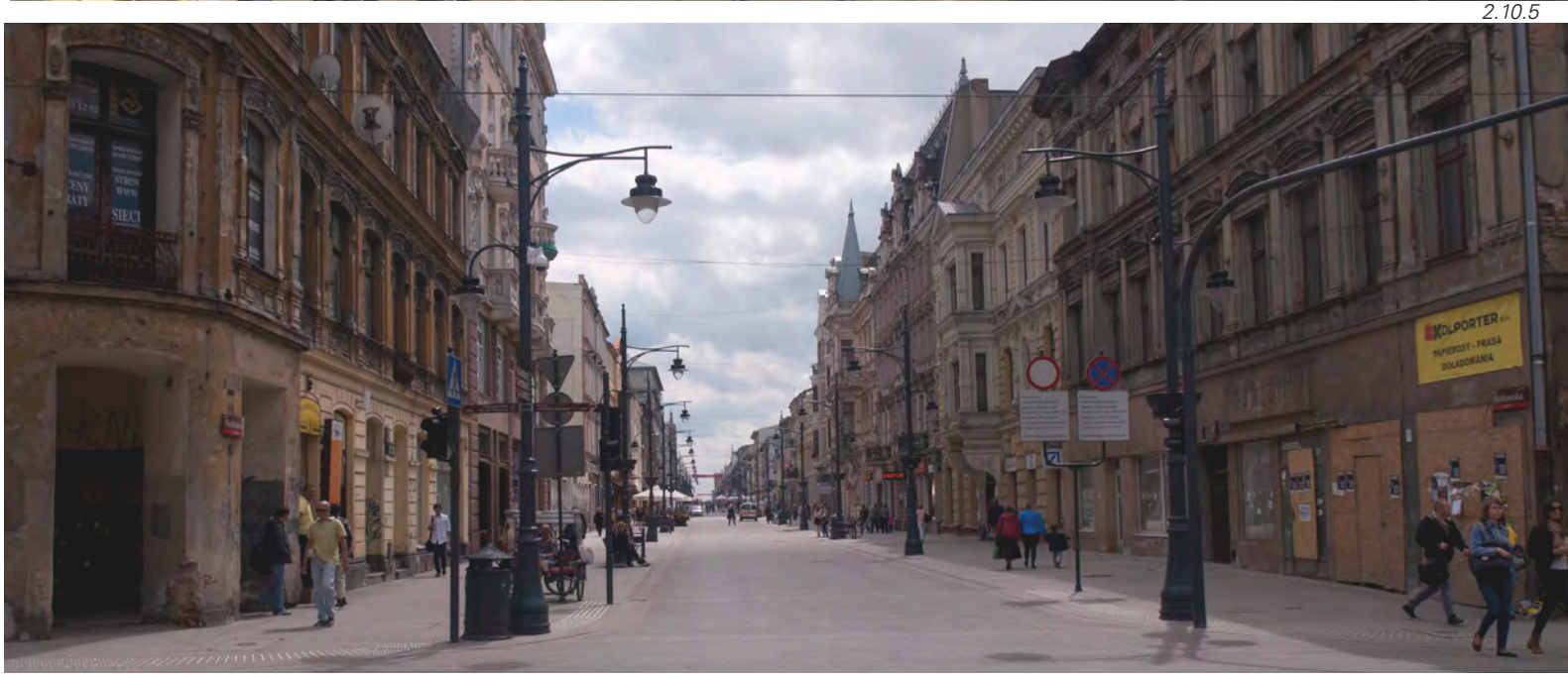
2.10.2

2.10.3

2.10.4



2.10.5



2.10.6

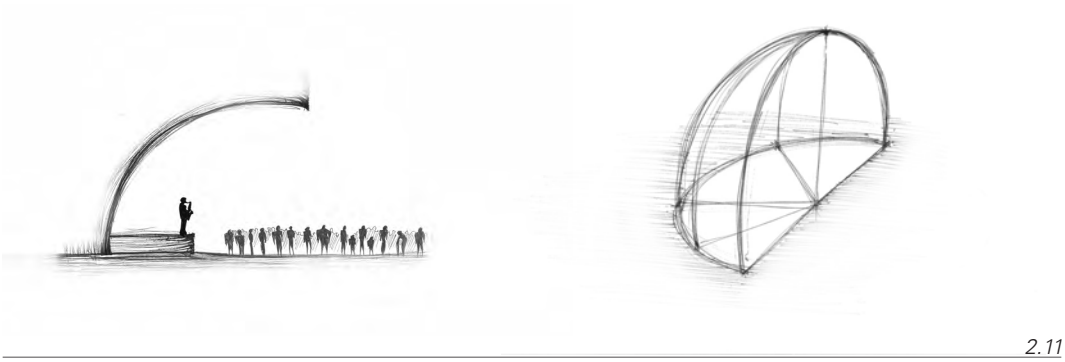
2.2.2 The dream: flexible space

The starting point for the design was asking the questions: what will be happening there? how should the place function?
I wanted to achieve the atmosphere of gathering - like coming to a circus or a theatre, where many people meet. I imagined a place with a spirit of happiness that could be experienced at a festival or at a flea market on a sunny day.

The idea was to create a spot - of a positive/active and interesting/ unexpected image - where people go to discover something new, have fun, and enjoy the time. A number of different cultural functions like exhibitions, concerts, shows, discussions were to take place there. What kind of space could be suitable for this mixture? Of course, in every situation the demands are different. For a concert we need a scene; for an exhibition a set of connected rooms; for a theatre an isolated generous hall. I thought that this could be an interesting challenge - to create an answer for all this different usages with one structure - one system. This building due to its flexibility, could change in time, and behave like a living organism.

On the other hand, this gradient of spaces - small rooms, huge halls or courts - could be an accurate metaphor of a city itself. The city, in its complexity, could be understood as a mixture of different places, that serve diverse functions and are aimed at various groups or users. When we take the city and analyse the existing fabric accordingly, we would notice that private buildings - like houses, offices, shops are well developed - consist of fairly complicated gradient of different rooms. In comparison, public space is simple. Regardless to this simplicity in healthy cities it plays multitude of different roles. Simple stairs somewhere in the public, theoretically just a path to reach a next level, could supply sitting possibilities for a group of tired tourists, create a stage for a performing artist or be a fun-park for a skateboarder. The possibilities are endless. Imagination should be the only limit. Modern public space should take advantage of creative, positive, egalitarian spirit of our times.

Why not create a structure that makes public space more useful - more adaptable; that makes the division between built and open delicate and light? The structure that, due to gradient of spaces, is a building, but at the same time represents total openness and symbolises our creative era.



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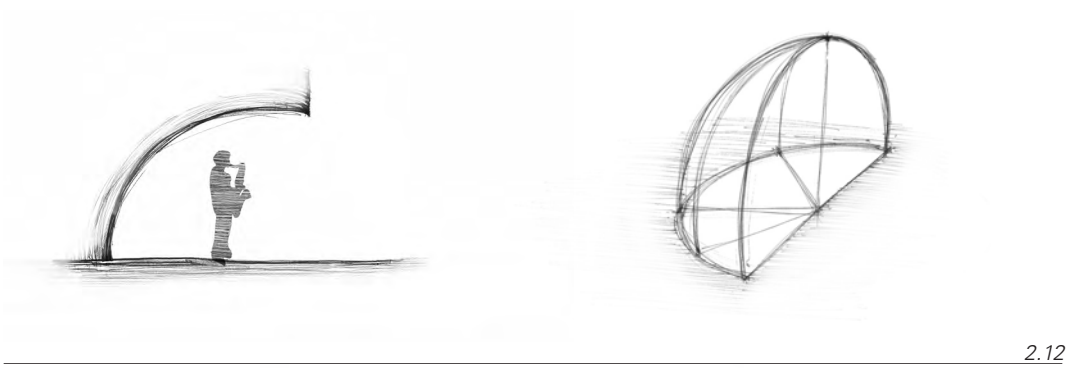

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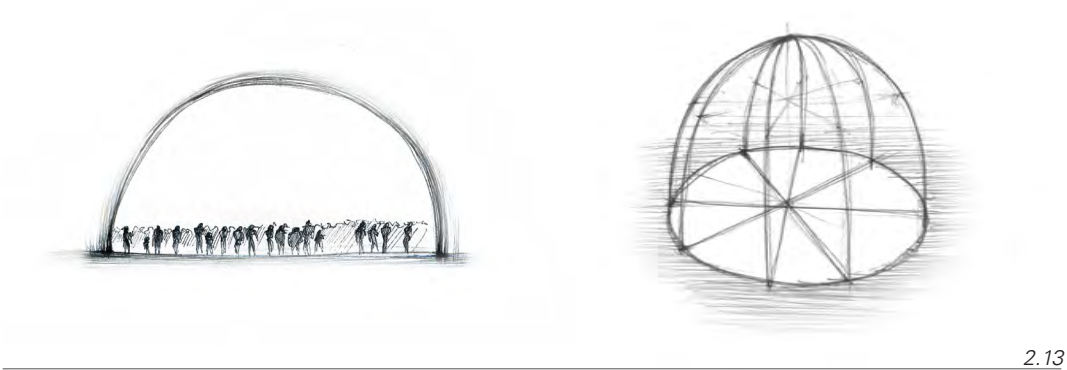

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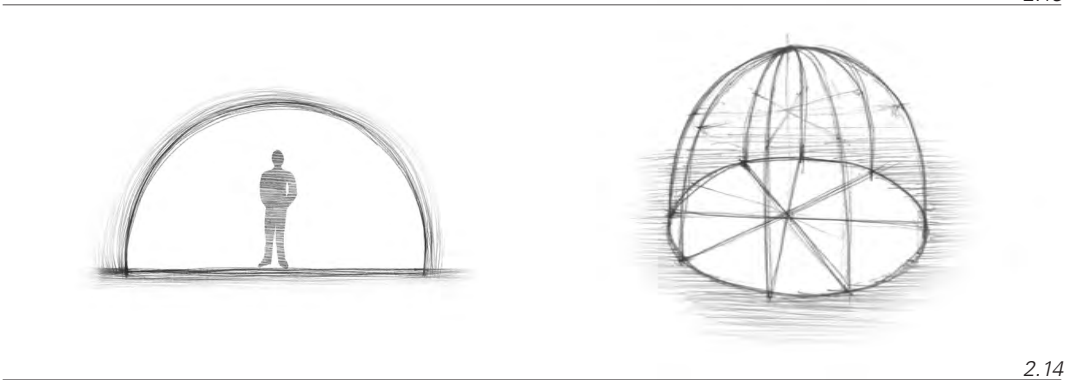

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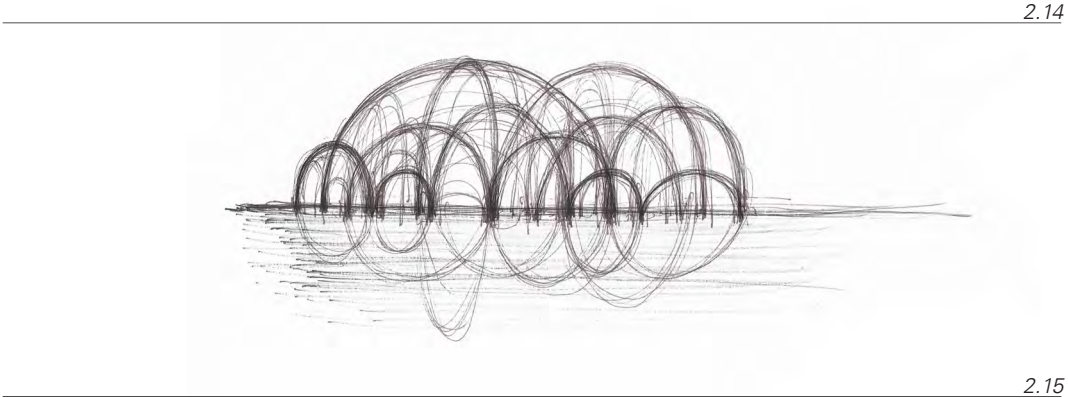


2.15

Conceptual early sketches:
2.11 -2.14 variation of size and openness of forms
2.15 gradient of different spaces - notion of urbanity

2.2.3 Construction system - inflatable

The realization of this dream - flexible dynamically changeable space for different cultural usages could only be addressed with a revolutionary and modern technological solution. I decided to try constructing this temporary building out of air-inflated tensioned beams. Air-inflated objects poses a quality of lightness - their mass is unproportionally small in comparison to the sizes they reach. This paradox makes them playful - children want to play with a balloon or with an air-inflated toy. Why not use this characteristic, make the object - building: light, movable and playful. Those qualities fit into my concept.

The construction method influenced the form. Air inflated objects are mostly driven by the shape of the fabric and pressure inside - it is hard to obtain perpendicularity in those circumstances. This characteristic in my case works as an advantage - the project earns its interesting organic form, being driven by forces controlling the air pipe configuration.

2.2.3.1- Inflatable architecture

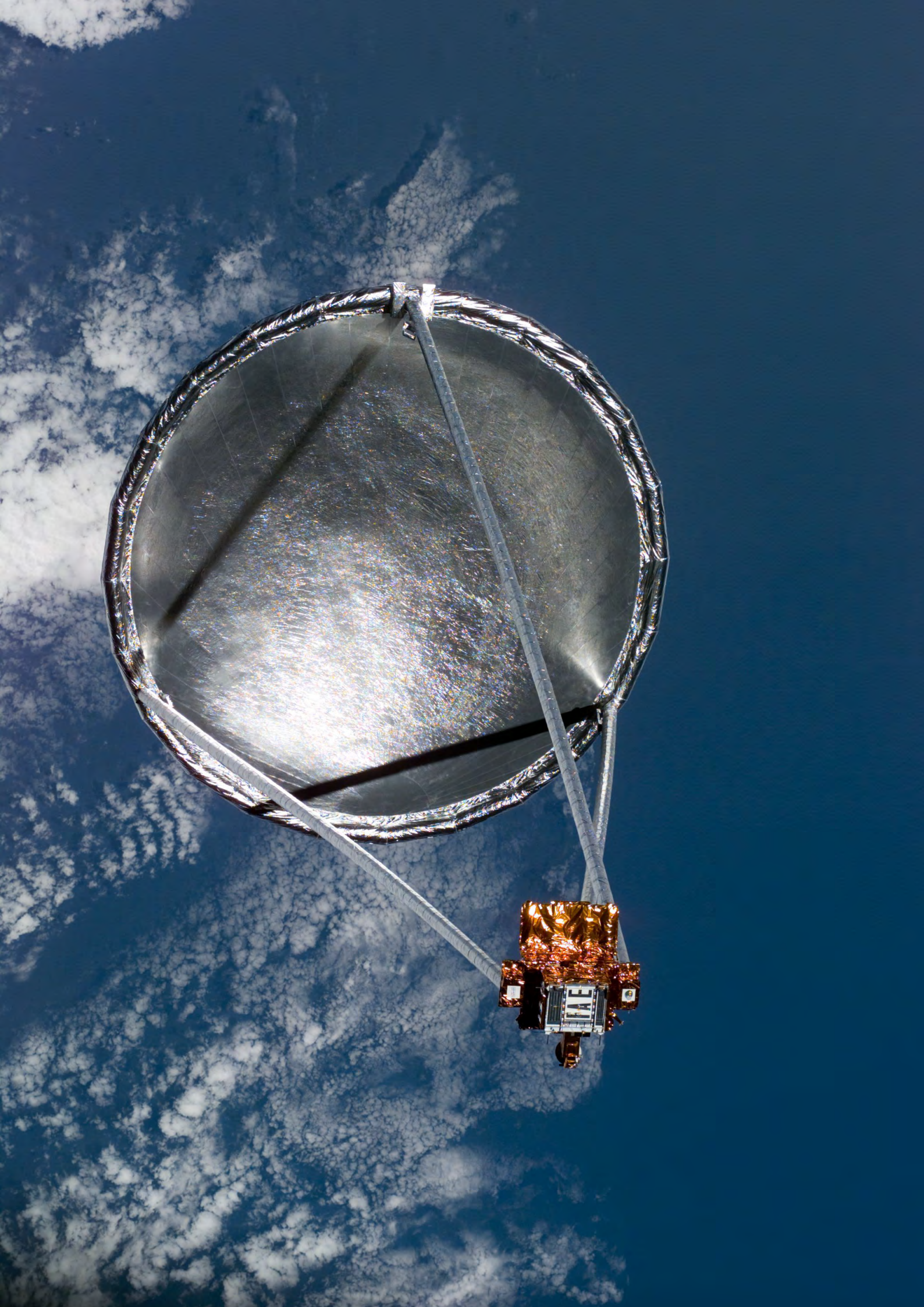
Air inflated objects belong to the tensile structure category. They possess bearing capabilities and stiffness due to the tension of the fabric, that is caused by a pressure differential over their skin. The skin is made out of membrane and the choice of material is wide: from thin plastic films (PC,PPS, PEI, PE) to advanced architecture textiles (many layers of different materials). The technology advances in textile and their manufacturing methods are consequently making every time more projects feasible.

Air inflated objects possess plentiful, unique advantages being characteristic only for this type of structures. Those are: small weight to attainable volume ratio; fast deployment with limited need of additional equipment or staff; small package volume and fail-safe collapse. Latter unique features of air-inflated objects influence the spectrum of usages - they are used in numerous different fields including: architecture (temporary shelters), civil engineering (construction methods, bridging), space (energy absorbers or space capsules), auto industry (air bags), mechanics (pneumatic muscles), aviation (inflatable wing).

2.2.4- Architecture - references

The decisions about material (air inflated pipes - textile) and function (temporary culture) have been made. Before defining the form let us take a look at the examples of similar already realized projects.

opposite: 2.16 Inflatable Antenna Experiment released from shuttle Endeavoour during STS-77 mission in 1996 - the power of inflatable construction technology


KAE

Spacebustler; location: New York, US; year: 2008/2011; architect: Raumlaborberlin (fig 2.17,2.18/opposite)

This fascinating project, done by a young collective of architects from Berlin is hardly a building. It is a remake of a truck, that carries a huge, air-inflatable balloon. The balloon functions as a venue for events, trying to activate places and people. When inflated this plastic bubble sticks out of the track's back - to enter it we have to use passenger's door and go through entire length of the van.

Tubaloon, location: Kongsberg, Norway year: 2006, architect: Snohetta (fig 2.19,2.20/opposite)

The Oslo based architectural office Snohetta designed this pavilion for a prestigious jazz festival in Kongsbergn, Norway. Annually, this structure is assembled to function as a stage and background of cultural events. After three week it is dissembled to be stored in container till next year. It is made out of PVC architectural tensioned fabric and the bearing system is partially supported by air- pressurised tubes. This pavilion is characterised by organic forms, that could be understood as a reference to jazz instruments (saxophone,thrum), or to the shape of the ear.

Prada Transformers; location: Seoul, South Korea; year: 2009; architect: OMA (fig 2.21,2.22/opposite)

The fashion house Prada has been cooperating with Office for Metropolitan Architecture, lead by star architect - Rem Koolhas, since 1999. One of the fruits of this profitable arrangement is Prada Transformers Pavilion in Seoul, completed in 2009. The building is a steel framed structure with a spanned membrane across it. It neighbours the 16th Century Kyeonghee Palace and functions as a modern counterpoint to this historical site. The structure is formed as a Tetrahedron with each side of a different shape to provide different functions. The rectangular base is for cinema and projection, round for fashion shows, hexagonal for commerce, and cross for exhibitions. The whole structure is rotated with shafts to accommodate particular event - the project is innovative due to this capability to morph. An oversight is a construction system - with a steel frame the building earns weight. The process of transformation means involving three shafts and is both time and labour consuming - almost as demanding as initial construction.

2.17

2.18

2.19

2.20

2.21

2.22

Teehause; location: Frankfut am Main, Germany; year: 2006; architect: Kengo Kuma (fig 2.23/opposite)

This small (20 m2) pavilion was developed for the Museum of Applied Arts in Frankfurt by the world-recognised Japanese architect Kengo Kuma. A two-layered, pneumatic structure made out of durable, semi-translucent, hi-tech, PTFE material encloses nine places for the ritual of tee-drinking. It is possible to divide the inside-space by a fold-up wall. From the outside the building appears like two connected spheres. Additionally, functionality is boosted by a coal oven hidden in the floor (to warm the water) as well as lightening led system which is mounted in the interval between two tensile skins.

Cedric Price and his conceptual work

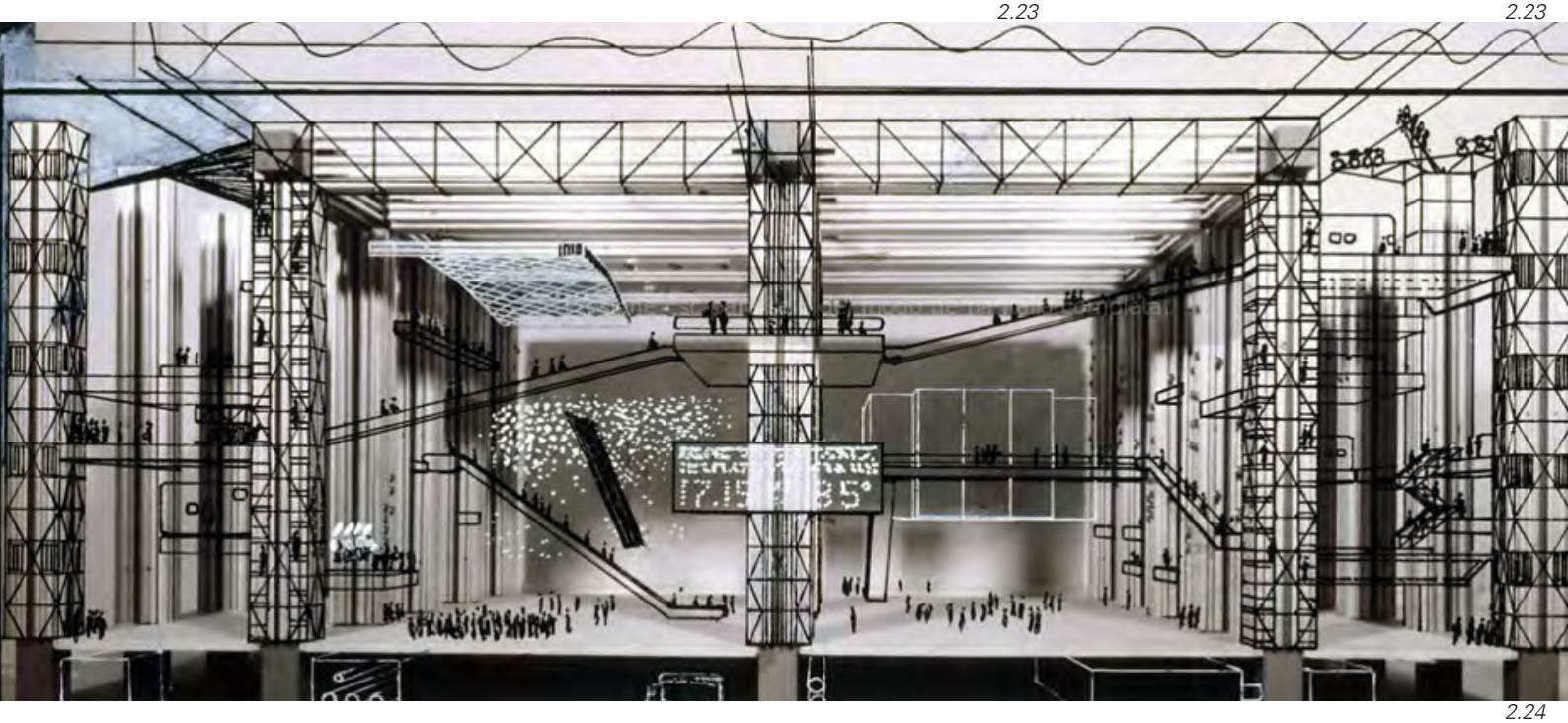
One of the most interesting and inspiring XXth century architects was Cedric Price. He is known mainly for his conceptual work - only a handful of his project was realized. The most recognised, never built, project of his is Fun Palace (1961-1965; fig. 2.23,2.24/ opposite), which is assumed to be an inspiration for Centrum Georges Pompidou competition entry, done by the duet of Rogers and Piano (1969). The former building after its completion in 1972 became an icon of contemporary architecture, and lied the foundation for both architects to start their up-till-now world-renewed practices.

Characteristic for Price is his attempt to exceed the limits by making the built fabric changeable. Architecture was to be influenced by the user - morph accordingly to the needs. This unique feature was promoted by Price, due to his believe that through the means of architecture economic and educational qualities could be brought into society. His designs are emphasising the public domain - trying to enrich public space, which importance during the period of his most prolific years('60 and '70) was just being raised. Although Price left very little argumentation on his work, it responded to particular needs of England at this time. The industry collapse deepening the unemployment, or decreased working and increased leisure time were the background for his considerations of alternative occupation for the people. He wanted to activate the people by enriching public space with architectural solutions.

What is more, Cedric Price was investigating air-inflated objects. Some of the projects utilising this construction technique are: Surface Oil Containment (1967); a roof over the pedestrian shopping area of High Street in Southend-on-Sea England (1972); Waterwall, a floating breakwater in Abu Dhabi (1973). Although none of this fascinating works have been realized; Price remains among the precursors in ambitious topics of temporary, movable, public architecture.

2.23

2.23



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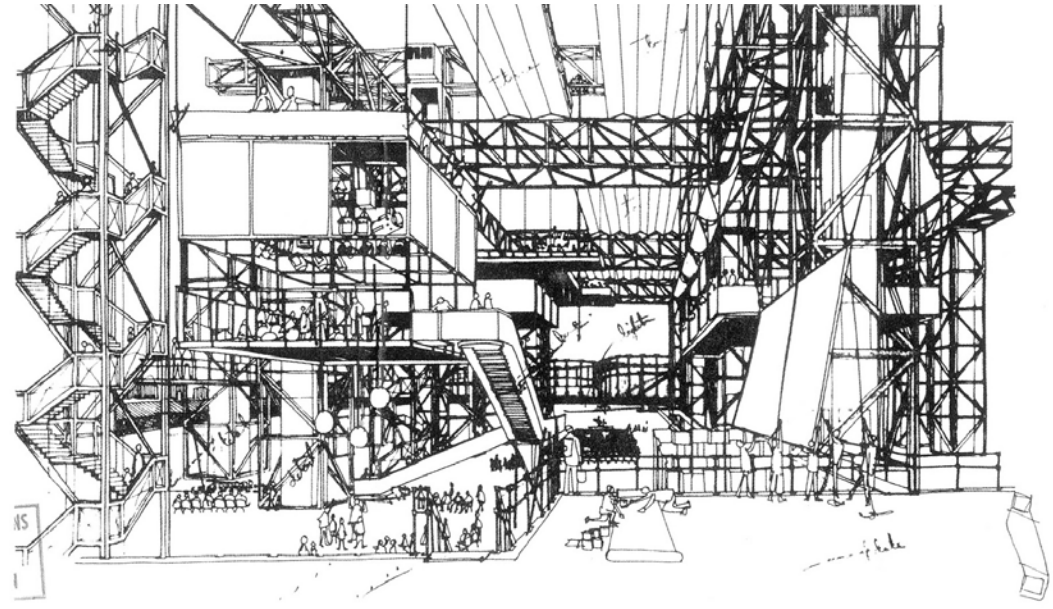


2.25

2.2.5.1 Form - The Sphere

The form firstly appeared on paper with sketches by drawing spherical spaces. Sphere is the most efficient geometrical form. All the points across its skin lie in same distance from the centre, making the ratio of volume to surface optimal. No other form with such little outlay could supply that much volume.

Referring back to the sketch of different, desired configurations (fig.2.11-2.19 / p.39)- generous space was to offer an atmosphere of gathering, while a small room just at the opposite - was to create intimacy. I thought that those deliberate emotions would have the strongest effect in spherical space, which apart from volume viability is easily readable - the user has eye contact with the whole room after his entry.

Another point in favour of the sphere was that, although geometrically perfect, it is rarely build. The landscape to be created with such forms monetarily wins the interests of people - it is new and exciting. Filled with an extraordinary function this place could get an image of an important, cool spot and become a symbol in the eyes of users.

The most challenging topic is still waiting for an answer - how to construct a spherical space, which could enable control over its size and openness.

2.2.5.2 Form - finding

At this point of my work, there was a blurry vision of the object that I wanted to achieve. I imagined the atmosphere and shapes that the building should have, but the construction system, details, and overall way how the building would work or look were unclear.

The effect - particular geometry and consecutive system, that I am about to present, follow the experimental way of finding a form. After mastering a tool for live physic simulation on the computer (explained in chapter 2.2.9.1) I was testing different possible configurations of air pipes by applying forces to 3D simplified geometry (chapter 2.2.9.2) and observing the results. The final geometry, that I have chosen is the most successful that I have found. It possesses beautiful, geometrical, repetitive patterns.

2.2.5.3 Kinetic Geometry

The geometry bases on a regular, triangular mesh (fig. 2.23 / p.48). Each two triangles are paired and joined to create a rhombus. Each rhombus in the plan means a saddle shaped, minimal surface, in reality (fig. 2.24,2.25 / p. 48).

It was assumed that the membrane is made out of an elastic material (for example hypalon). It stretches in order to reach the shape dictated by the boundary edges. Boundary edges of the saddle-shaped membrane (rhombus in plan) are air-inflated pipes. Those pipes, due to air pressure tensioning the material, from which they are build - try to straighten themselves. They are willing to form a line by simultaneously producing the force(fig 2.26-2.28/ p.49).

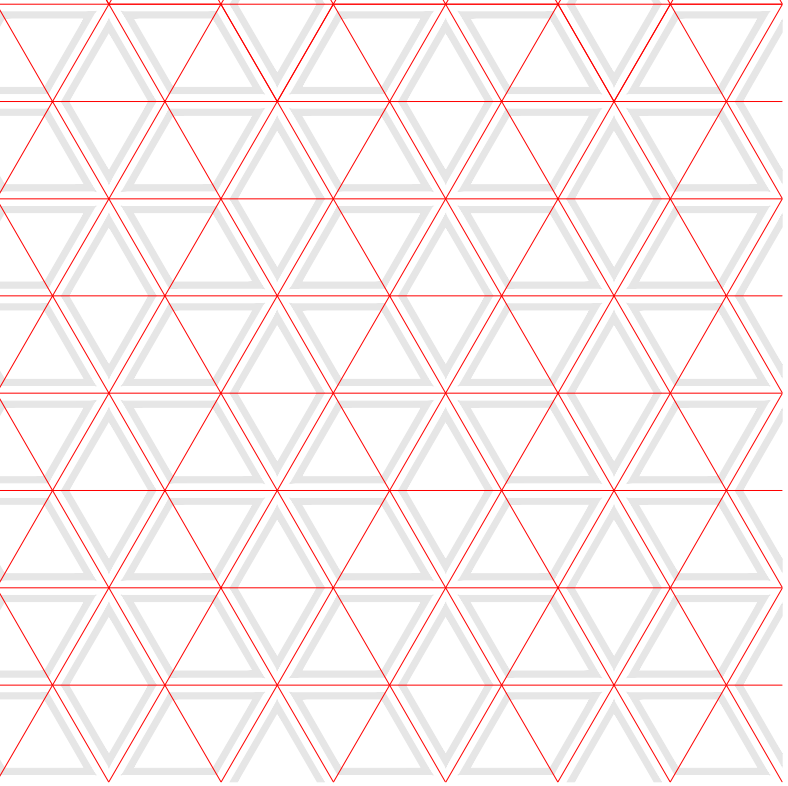
Rhomboidal shape of the beam configuration makes control and change of the angles and forms possible. The kinetic choice rhombus instead of a triangle (the former is statically determinate) means that the structure is susceptible to deformations. For example, when strong wind enters and the straightening-out force of an air tensioned beam would not withstand the air resistance, the structure would deform. However, air tensioned objects in contrast to other building techniques, are likely to recover its original form when the load is removed. The problem of the structure deforming due to wind loads is solved by not solving it at all - the deformations are allowed.

Another problem is the rain fall, which is solved via the organic shape of the structure. There are no flat surfaces. The saddle shape of the membrane guarantees that water flows always towards the direction of one of the knots. Hopefully, the tension of the elastic membrane is great enough to withstand the water fall in time and the occurrence of water-bags, hence, is avoided.

2.2.5.4 Configurations

The project was aimed at delivering unique and distinct shapes instead of regular, monotonous forms. This diversity was achieved by combining numerous modules to build differently sized, varied spaces.

Additional flexibility is gained due to the mounting of the wall / roof textile elements. It is possible to leave the fields without membrane. In this way the structure achieves also functional advantages - it can be used in winter (no snow loads) or summer (good ventilation) as a three dimensional grid enriching the space. The following pages (fig. 2.28-2.35/p.50-51) present pictographs of a different space configuration of this geometry.



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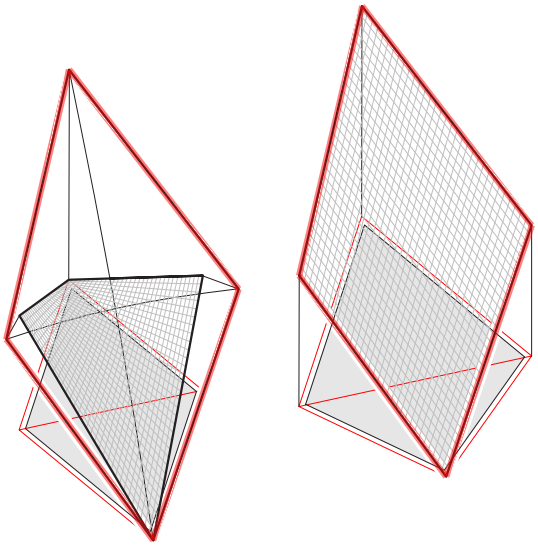

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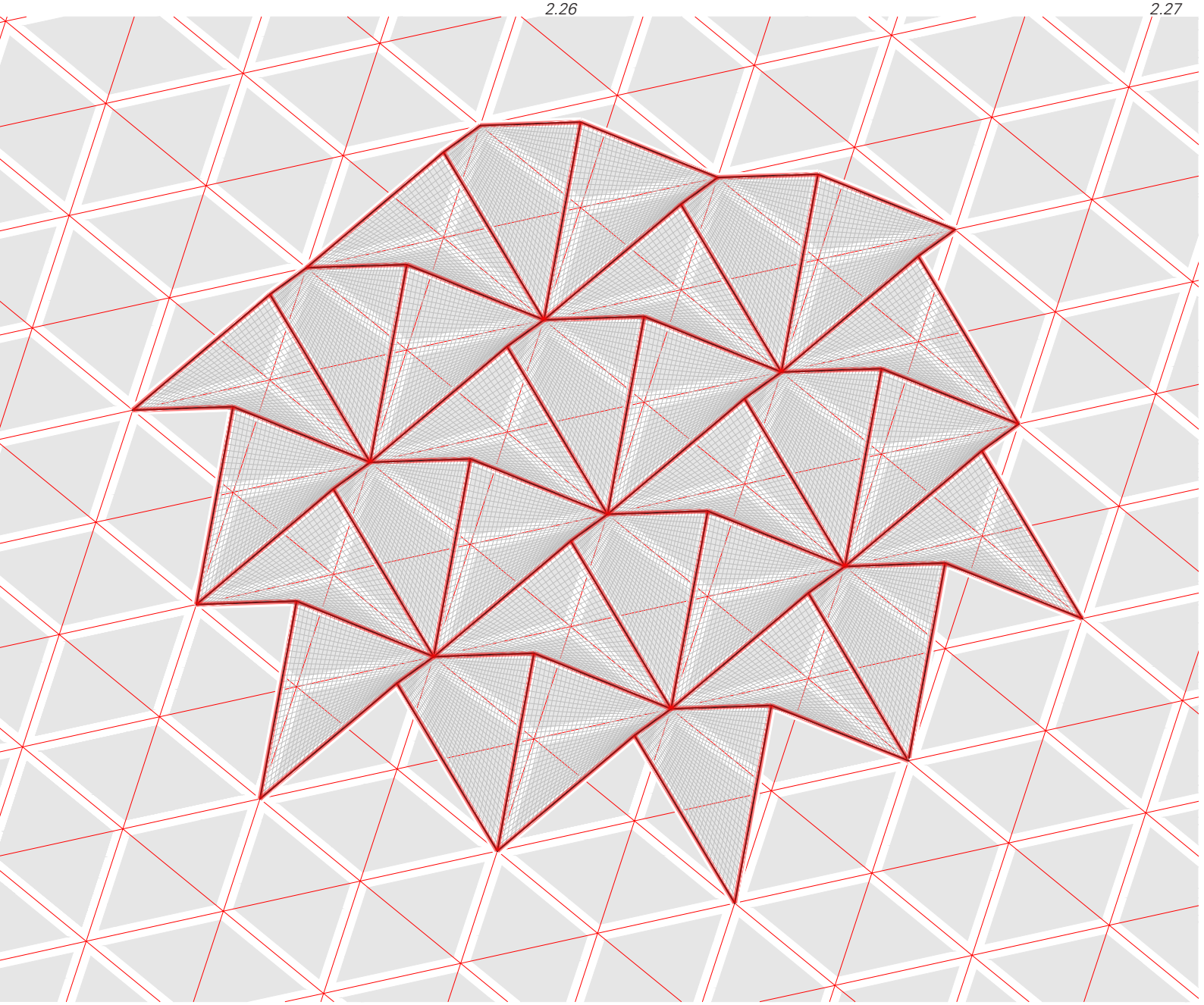

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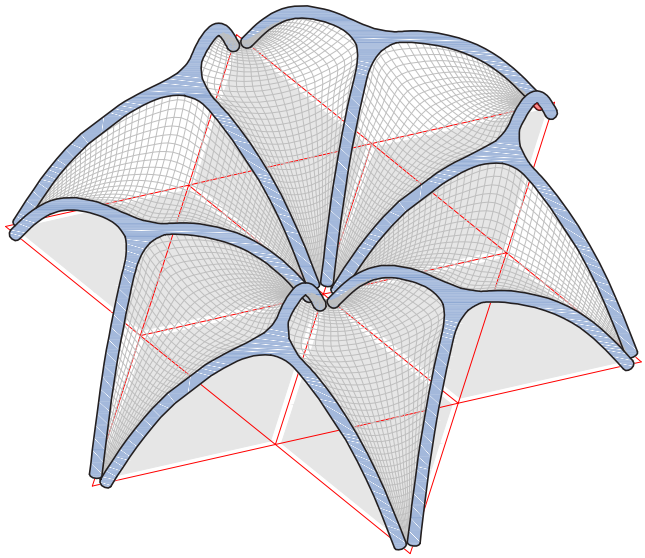

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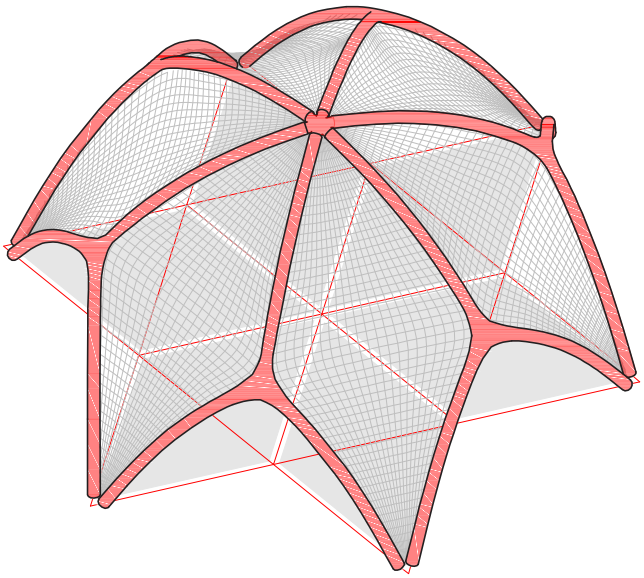

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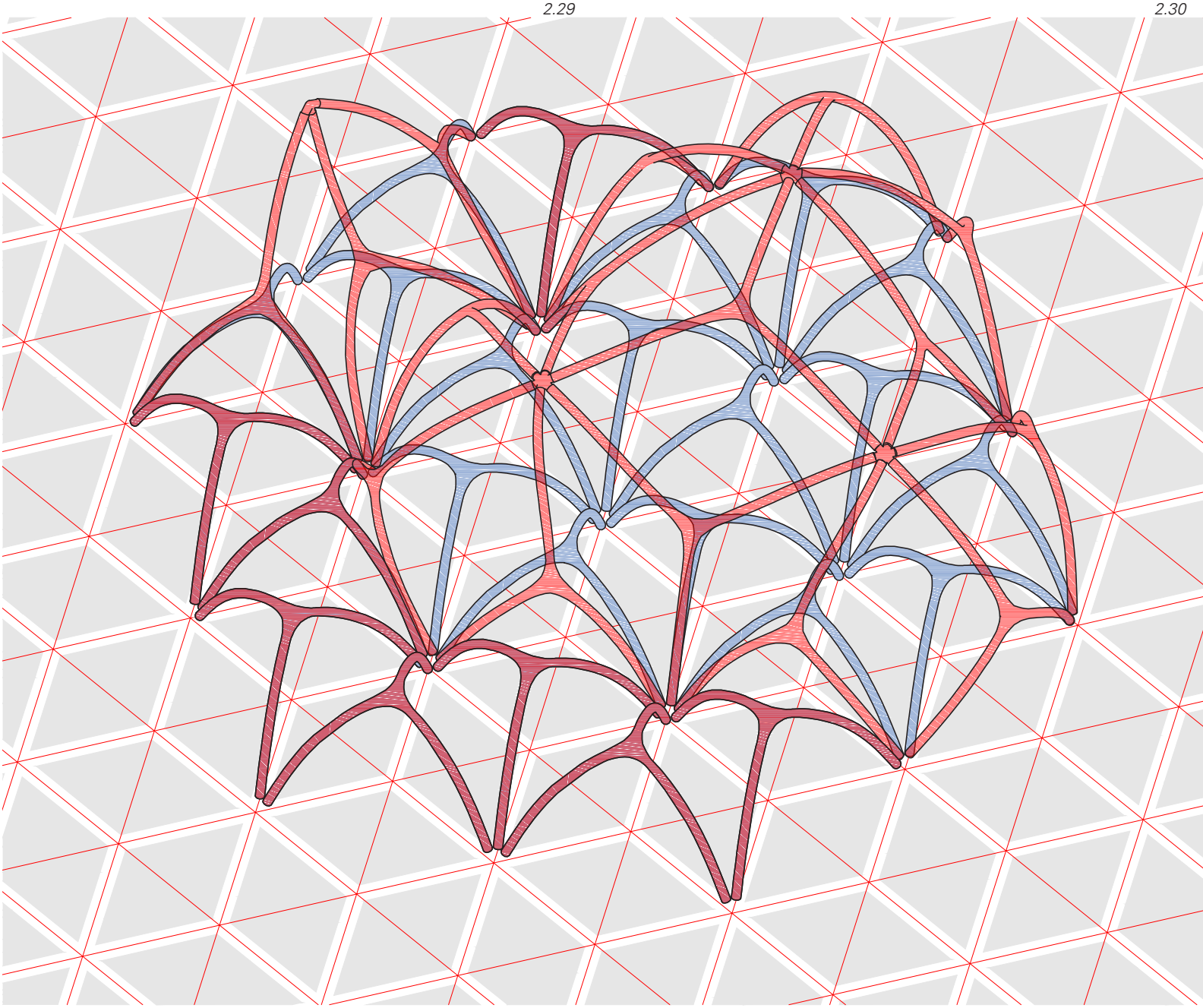

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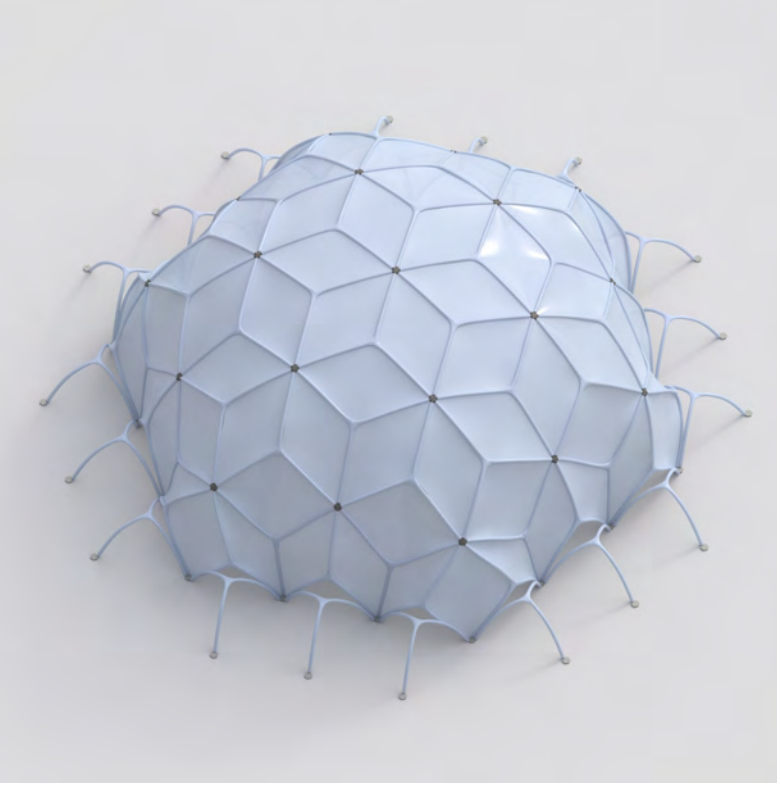

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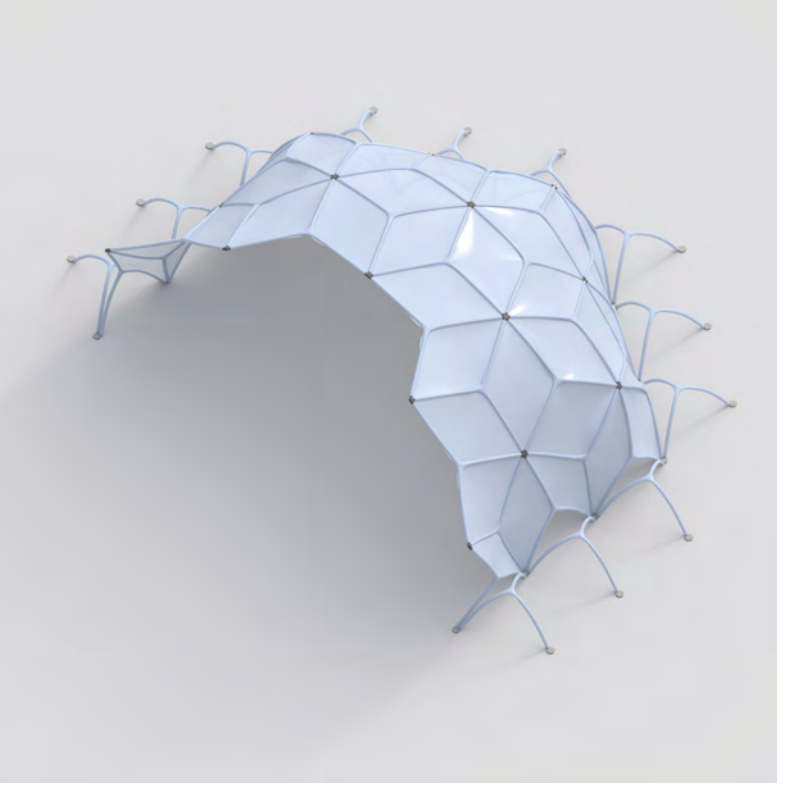

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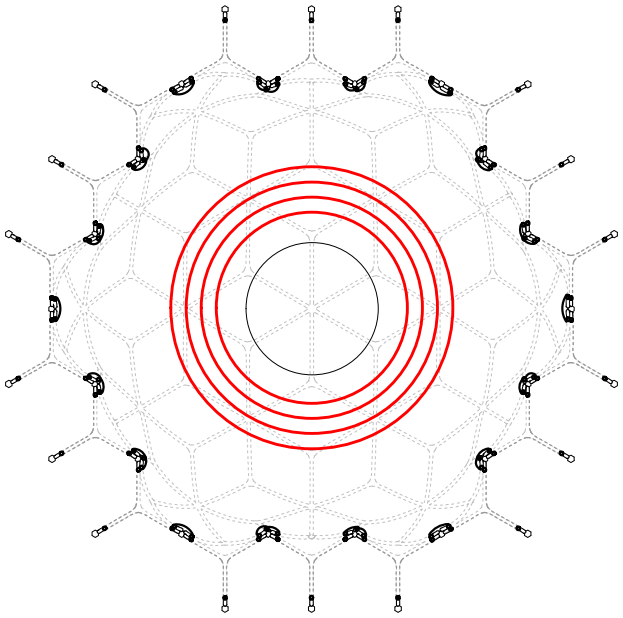

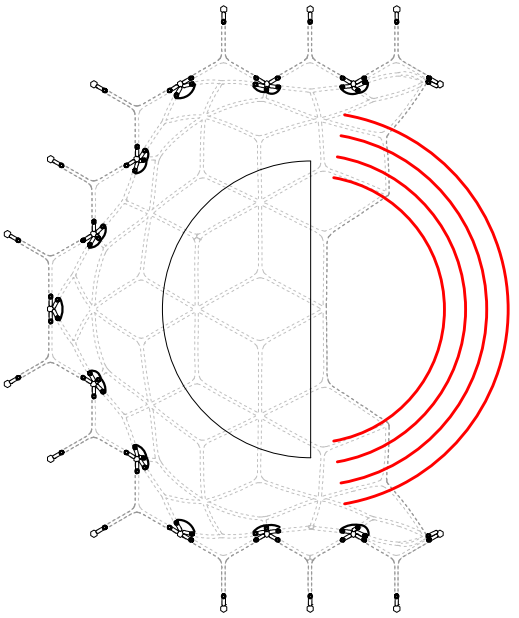

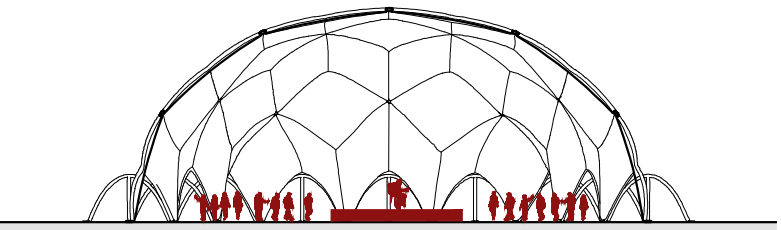

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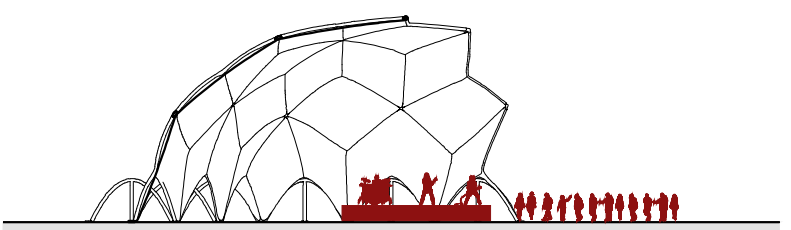
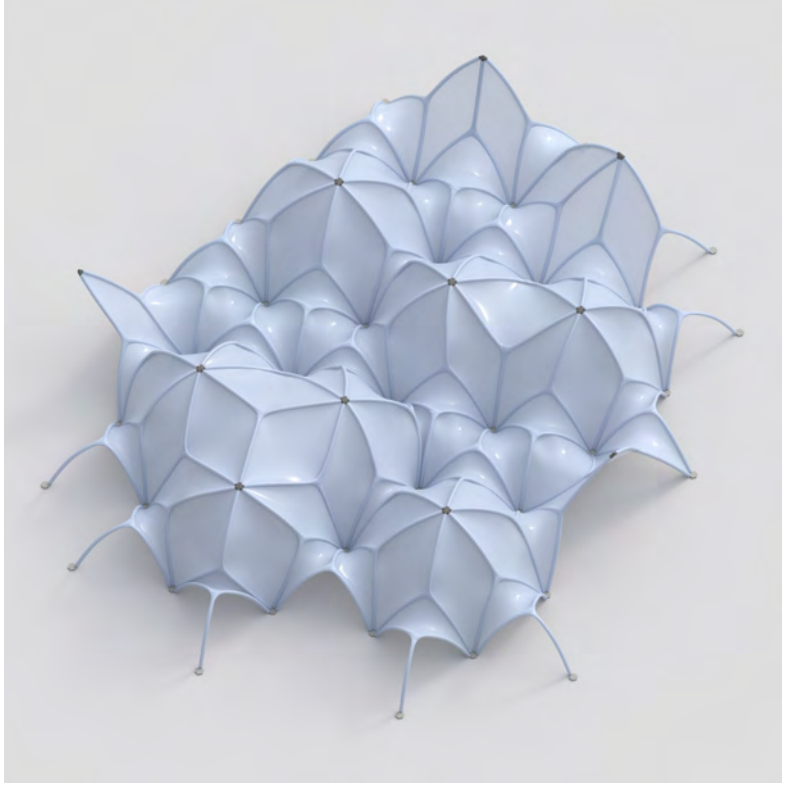


2.35

2.28- 2.29 Space/Form: generous, closed

2.30- 2.31 Space/Form: generous, open



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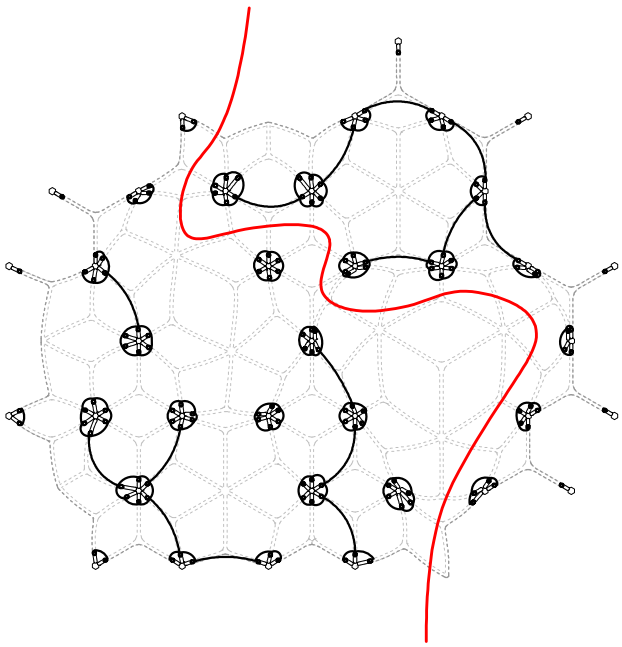

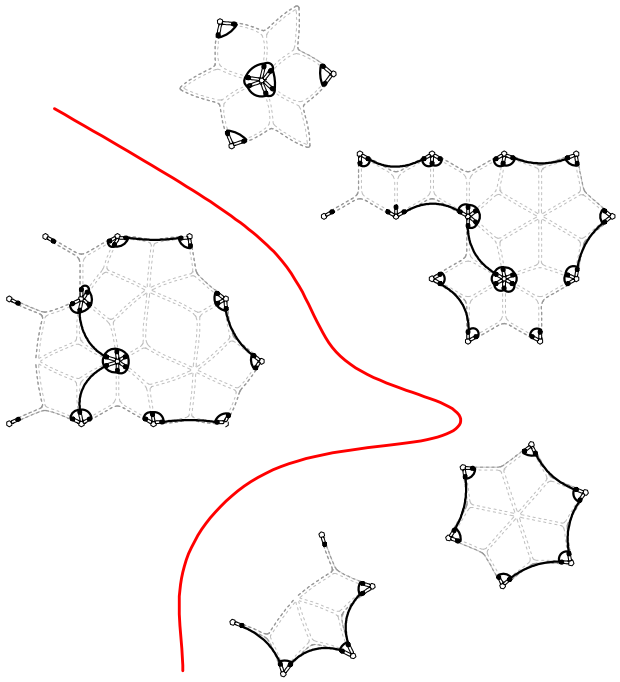

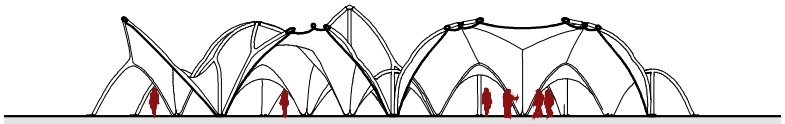

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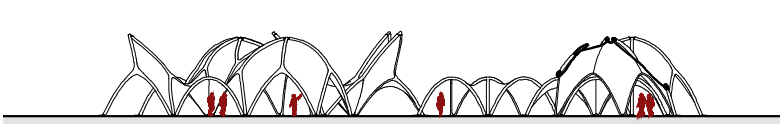


2.38

2.32- 2.33 Space/Form: modest, closed; united

2.34- 2.35 Space/Form: modest, open; dispersed

2.2.6 The system

Regular raster gives the system it's modularity.
The repetitive elements are as follows:

Air-pipes:
- y- shaped, prefabricated, air-inflated, structural elements;
- a metal part in the end of each pipe;
- at each end an additional screw connection out of hi-quality plastic (frp);

Knots type A - anchor points:
- bending-free connection (ball joint) between air-pipes and the ground
- an air-pipe fitted into a knot by a screw
- the knots type A are connected with each other by strings, being additionally connected to ground with a ballast from steel
- made out of steel and hi-quality plastic (frp)

Knots type B - air connection:
- a fix connection between y-shaped pipes;
- made out of carbon fibre and hi-quality plastic (frp)

Membrane:
- elastic material for roof and walls
- connects with air-pipes with a zip, that goes around the fabrics' border
- made out of semi-translucent white Hypalon

Additional elements:

This pavilion-system must be supplied with additional elements to provide different functions. The content of this thesis is a conceptual project and considering the complexity of the air-inflated, temporary, flexible roofing itself, it was assumed that elements like lightening or furniture can be chosen from those available on the market. Taking into consideration the presented build examples those accompanying solutions/elements could be treated as being possible to solve or build.

2.2.7 Scale: urban vs design

The project challenges the urban problem - the regeneration of particular site, by simultaneously attempting to introduce new functionality by means of architectural pattern of flexible spaces. There is a certain mismatch between those two scales - the first one refers to a big almost city-like scope, while the former lies on the border between architecture and industrial design.

The raster and shape of the geometry just like its kinetic mechanism were invented - the form, material, and function were found. However, this system still did not got its final dimensions - it was possible to scale it in each direction with the same ratio,

retaining its shape. I decided to work with a fairly large raster - the main mesh is built out of equilateral triangles with a 3.3m side length. The smallest possible distance between a pair of columns (air-pipes) equals twice the height of this triangle, in my case 5,71m. In terms of private build substance, this span would be already a meaningful number. However in terms of public, urban fabric it remains tiny. I suppose that the mismatch of scales described at the beginning of the paragraph, can be solved by choosing a fairly big architectural module, that in the reality of the city is like a handful of dust.

2.2.8 Scale vs static: forces/materials

The main building element - y-shaped air-pipe is to be spanned on a floor plan of an equilateral triangle with 5,71m side.
Each cylindrical part of the y-shaped air-pipe is 4.5m long, counting from the end of the pipe to the centre of the element. After the inflation of this cushion with the three ends anchored to the ground the highest point is reached at 3.1m.

Connecting those pipes into different configurations enables the construction of spherical spaces up to aprox. 17m in radius. The bigger the room obtained, the more numerous columns are - in case of the biggest dome (mentioned 17m radius) the loads are distributed across 18 columns. Although this relationship is beneficial, the structure statically is the least favourable with the biggest size of the dome. The radius of the pipe and the air pressure are to be calculated for this case - all the elements used to construct smaller forms are over-calculated.

The construction technique out of air-inflated pipes brings a lot of freedom into dimensioning - the tension of the outer skin, building up the stiffness of the element, is linearly dependent from the radius and the pressure (stress: longitudinal = p*r/2, radial = p*r). A manipulation of those variables enables control over size, aesthetics, costs or technical advancement of the investment.

In my case the radius of the pipe (10cm deflated/ 11cm inflated) was chosen as small as possible in favour of limiting material consumption. The stiffness is ensured by very high working pressure (1 bar). The pipe is made out of architectural woven reinforced fabric for instance SEFAR® TENARA® Fabric 4T40HF; while the elastic membrane used as a roofing is from DuPont Hypalon 20 elastomer.

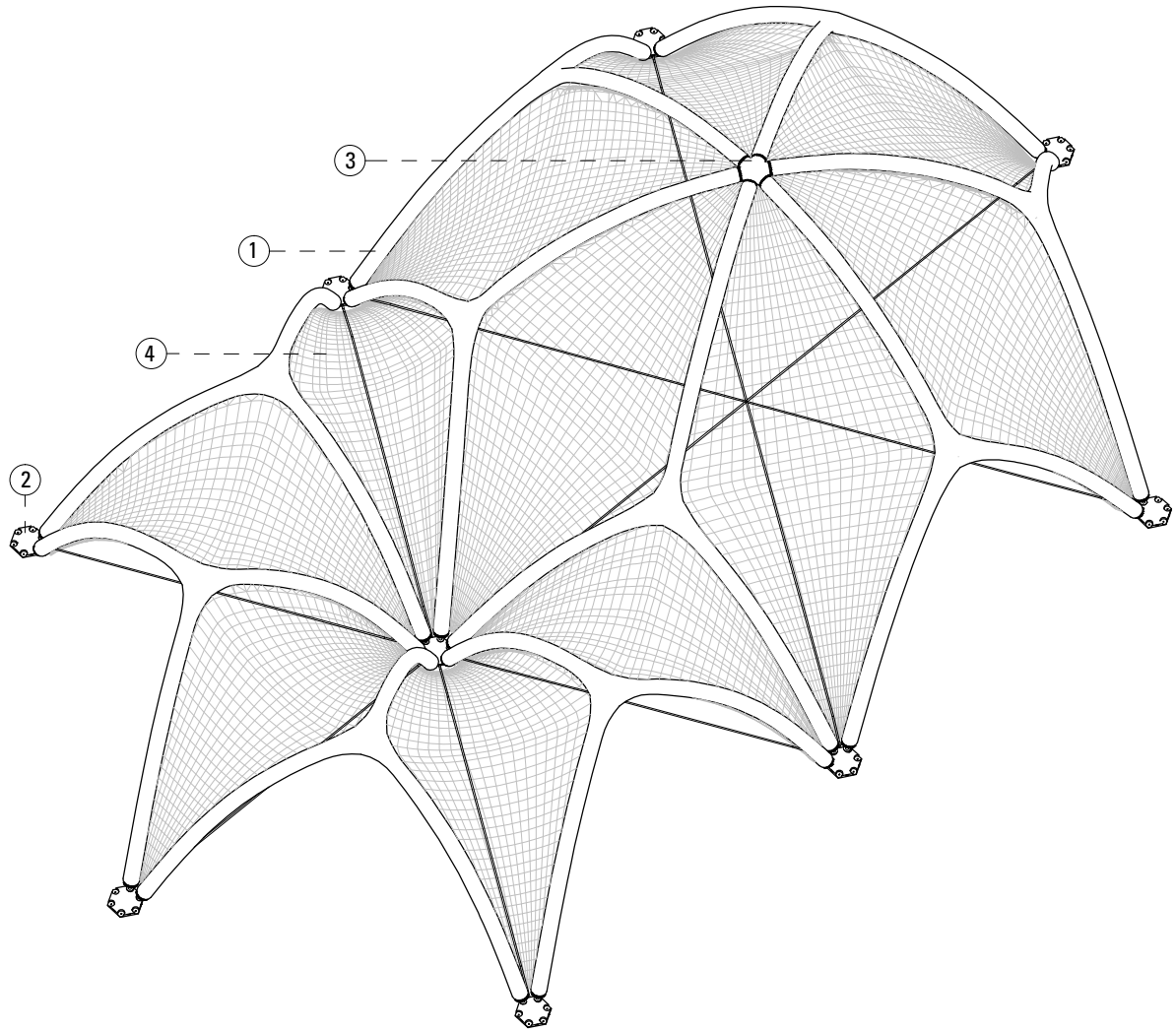
Although the method used for the simulation of the structure (chapter 2.2.9) uses standard international units and there is a strong coherence between this method and reality, I was however not able to assess the working behaviour of air-inflated beam and to supply for the simulation real-live values of the straightening-out forces. Furthermore, the optimization of this project, especially in correspondence to its behaviour under wind loads is open to further research.

Drawing of system elements,
in normal and exploded views,
including connection methods:

1 - Air-pipe
2 - Knot type A - anchor
3 - Knot type B - pipes connection (carbon-fibre)
4 - Membrane Roof
5 - Membrane Wall

Detailed Drawings:

6 - Line connecting knots with each other
7 -Steel plate as a foundation
8 - Steel, bend -free ball-joints
9 - Screw connection between air-pipe and Knot
10 - Cord for air supply
11 - Zip connection of membrane - as a tube



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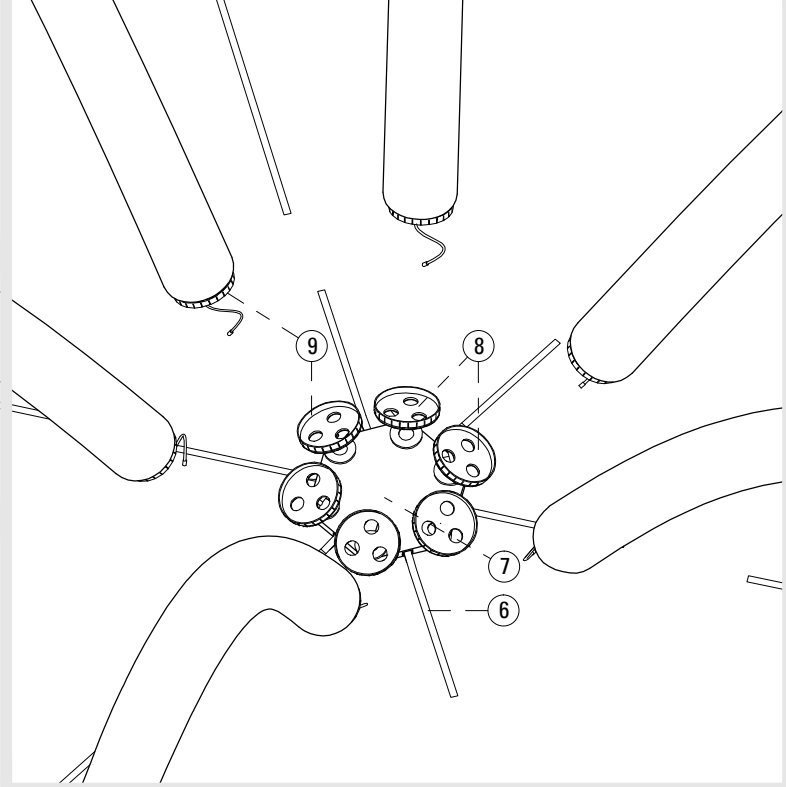

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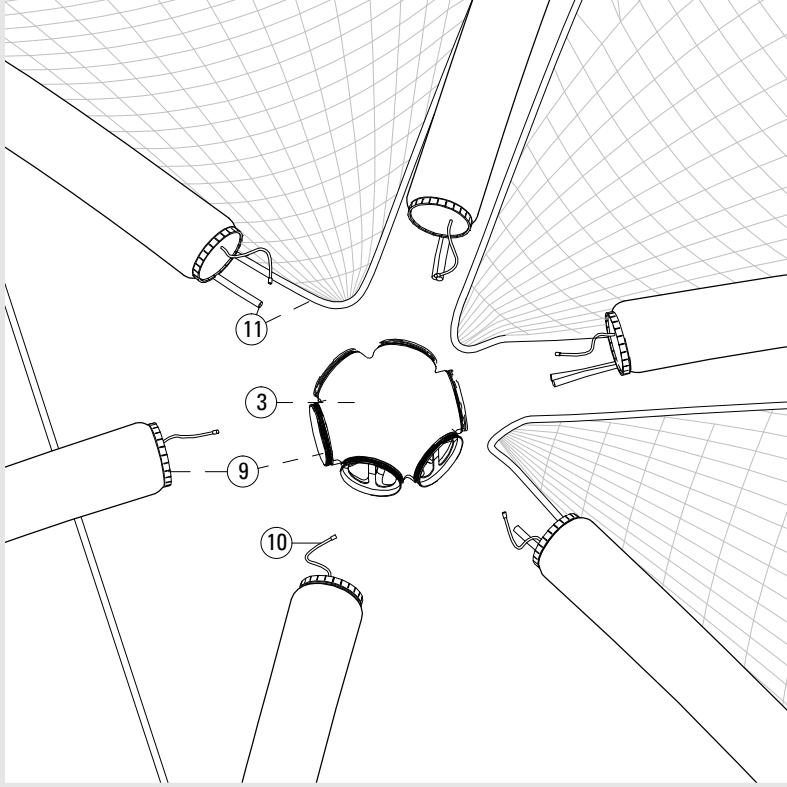

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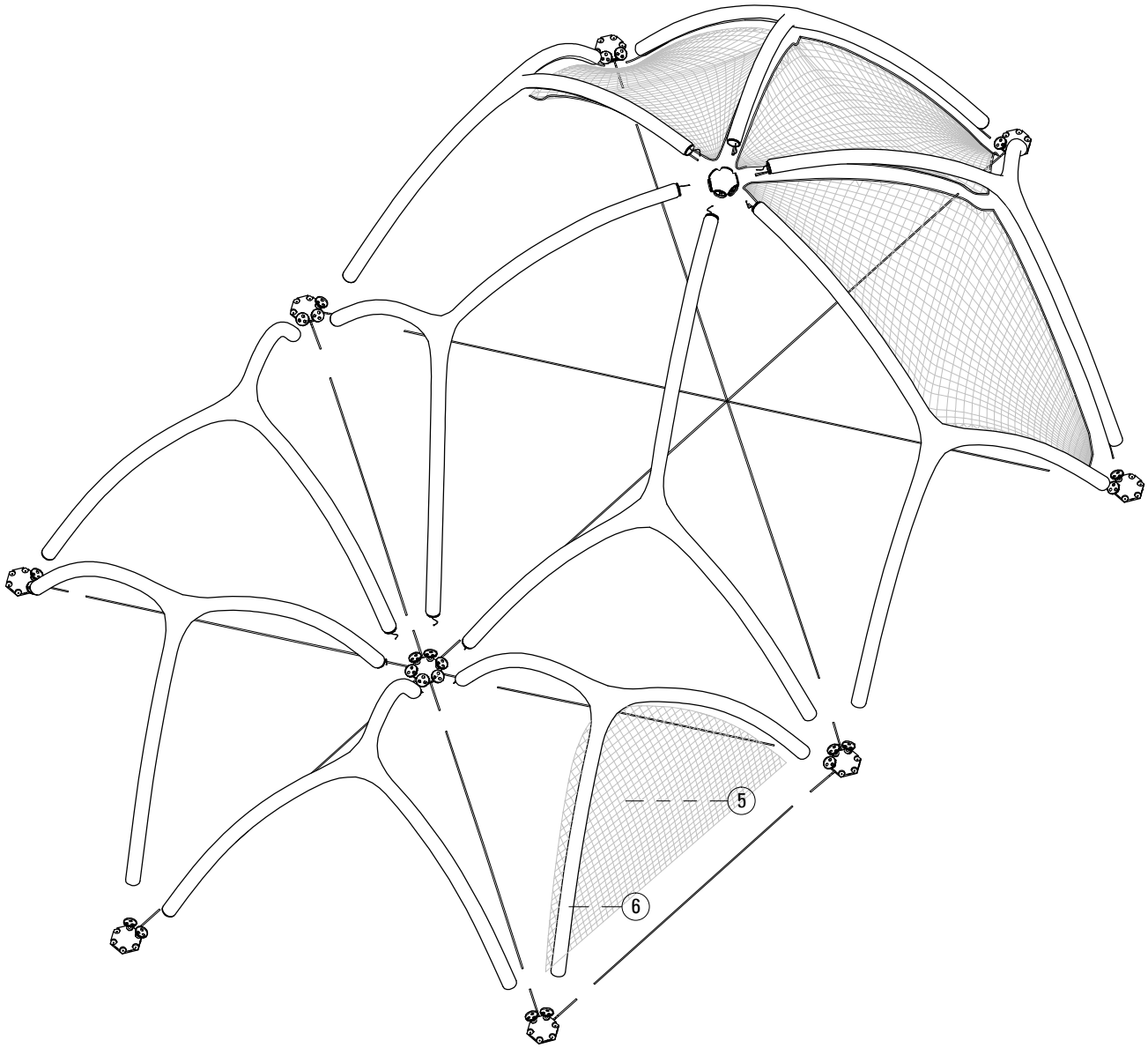


2.42

2.2.9 Methods - simplifying and animating

The difficulty, for me as an architecture student, was how to bring this idea of air-inflated building onto paper? After a short time of research, I discovered that there is a plug-in for Grasshopper Rhino, which implements a physics simulation engine into architectural/design environment. I decided to master this tool. This took some time - approximately 3 mouths of attempts - the information available in the internet is limited and without earlier education in mechanical/statical calculations, and experience with programming methods it is not so easy to understand how the system works. On the other hand, using this tool opens to architects number of interesting perspectives concerning form finding methods like: hanging models, origami shape analysis, panelling tools for meshes etc.

2.2.9.1 Live physics engine/ Hook law:

Kangooro Grasshoper bases on the Hook's law, which states that the Force needed to extend or compress a spring by a distance is proportional to that distance, and dependant from a characteristic factor namely the stiffness of the material of the spring. That means: F = kX, where k is the stiffness and X is the extension. In reality Hooke's law is correct only for bodies in elastic state - the force must be smaller than the elastic limit of particular spring. After reaching this limit, the body deforms and reaches its plasticity state.

Nevertheless, Hook's law is a foundation for many branches of science and engineering - it is a commonly used way of calculation. Kangaroo takes advantage of this law. The program reads defined particles, springs and forces to calculate and simulate the behaviour of those in time. Some modification of programmed variables is possible 'live' - when the simulation already runs.

2.2.8.2 Simplifications made:

Kangaroo is distributed as an open-source software and it was developed by Daniel Pixer. The computer calculates each second enormous amounts of data to make the simulation work. Rhino and Grasshopper are single core applications, and therefore, the simulation is possible only on rather simplified models. To simulate the inflation and erection of my modular structure a number of simplifications were made.

The 3D simplified model (fig 2.40/p. 58) consist of the following elements:

- y -shaped pipes: Each pipe is represented by set of polylines. To simulate the inflation, a small bending momentum is applied to each set of neighbouring springs; momentum working in middle point - where three pipes meet together - is half of that working normally

- joints A - anchor points: in simulation this is a set of six points; each of which is fixed - no matter what force is applied, the points can not move

- joints B - air connection: Represented by a hexagonal set of very stiff strings; the angle between pipes meeting in this joint is set to 60 degrees

- membrane an elastic membrane in final calculation was omitted; it was assumed that the tensioning forces of elastic membrane are insignificant in comparison to straightening-out force of the air beam

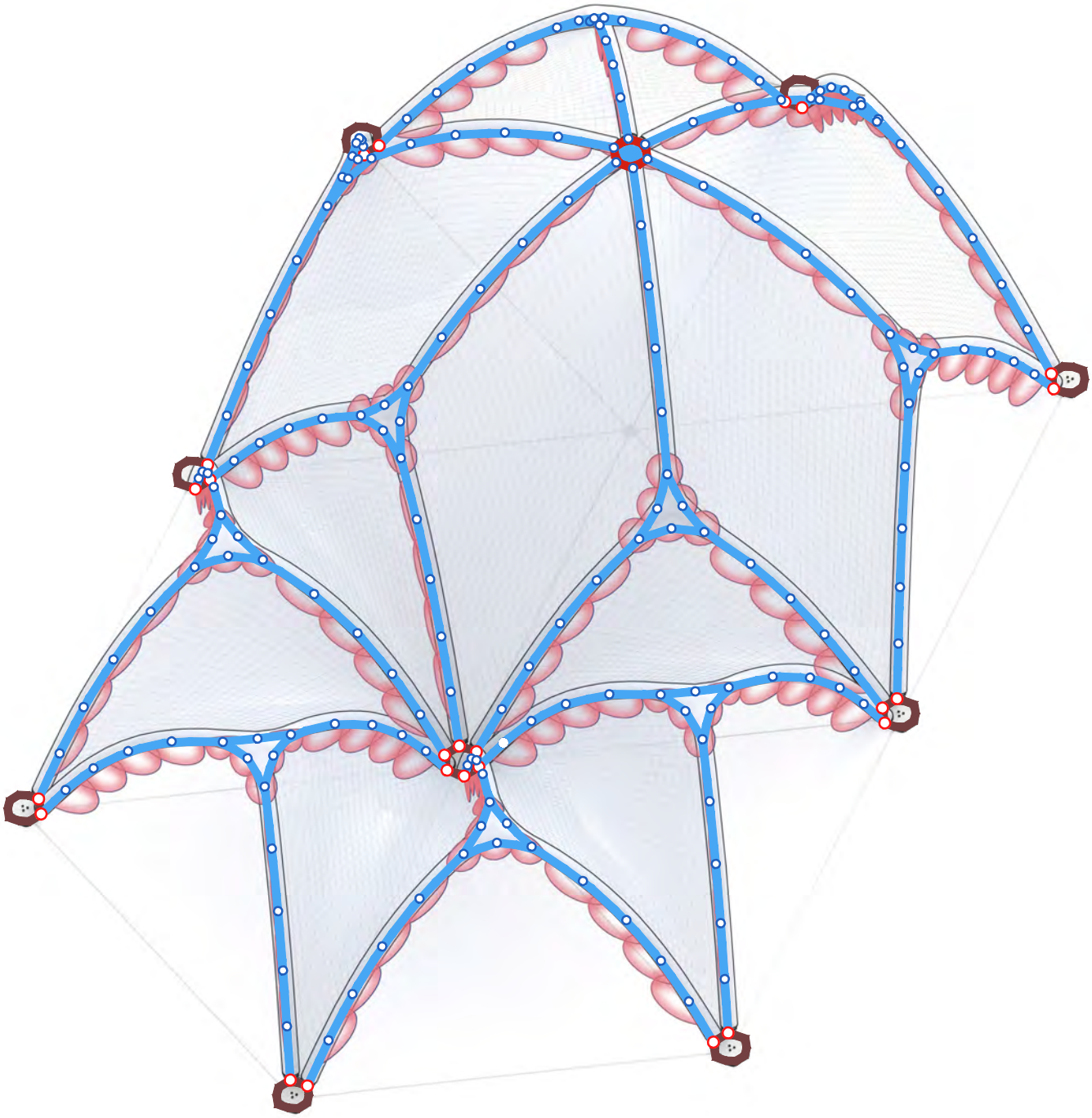
The screenshot of grasshopper solution is presented on the following page.

2.2.8.3 Workflow - outputs/inputs:

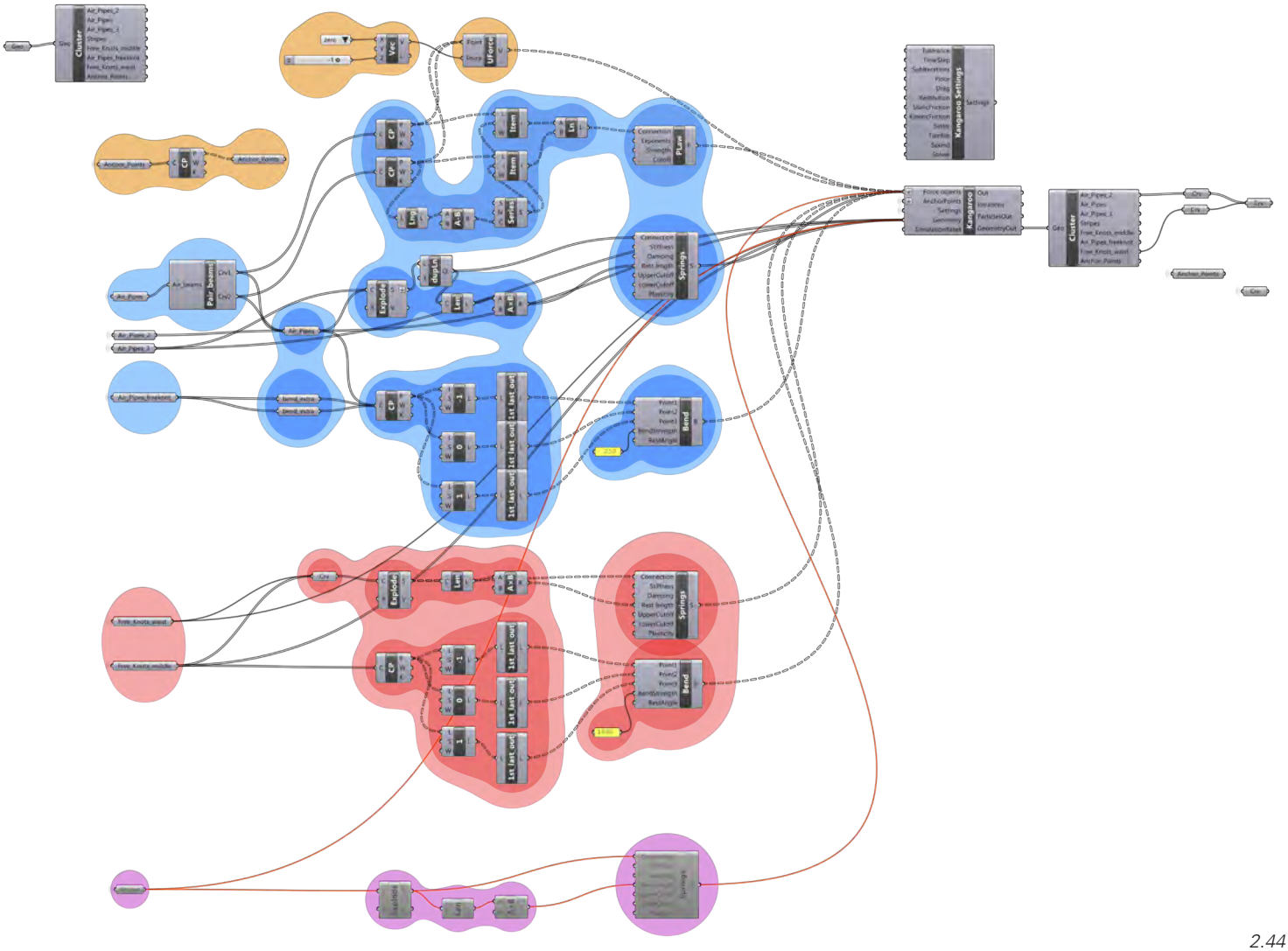
The Grasshopper-Kangaroo script, described above, was just the first programming method used in this project. The script takes as an input set of lines, to modify them according to forces applied and to finally return altered curves. In my workflow, the next step was to turn those into a 3D model from which I could obtain floor plans, sections and perspectives. This second step was also solved via the Grasshopper script.

This workflow of building a project by the means of a script, although being very time consuming at the beginning - with my little knowledge of programming methods I had to invest a lot of time and afford into research and learning - enables the user to very quickly construct whole 3D model. Furthermore, the very fast, almost automatic model construction, enables the data to be easily modified. For example changing the diameter of an air-pipe, in a script-based workflow means defining the radius variable - 'typing new value - 4 mouse clicks', while in the conventional drawing-based environment it would require redrawing every part of the model.

The drawback of this script-based attitude is that each project requires a very individual script and during the evolution of the design it must be updated. It is hard to assess which method is better or more effective; it is evident that the programming methods for architects open up a whole branch of new possibilities - earlier without a computer, some projects (like for example the one presented in this master thesis) could have never been done.



2.43 Simplified simulation model - drawing; symbols:
blue line segments: air-pipes;
pink arches: bending momentum applied to set of neighbouring line segments
dark grey: joint A - anchor point
red: joint B - air connection



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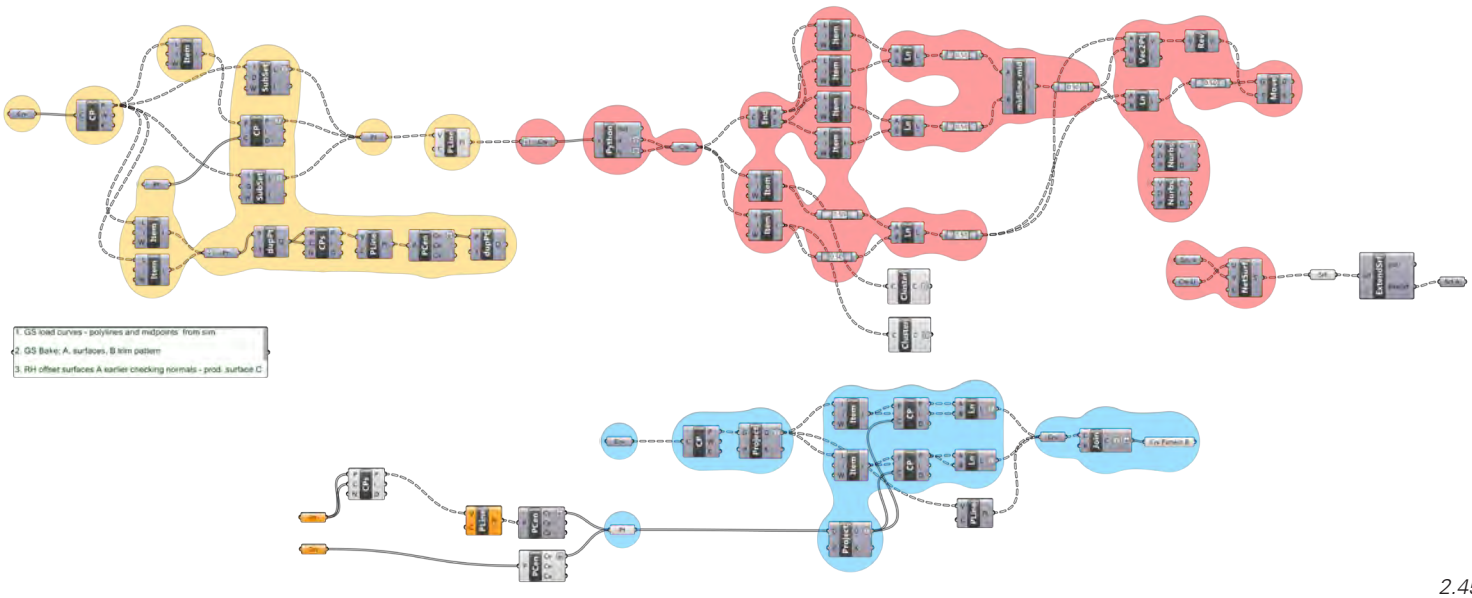

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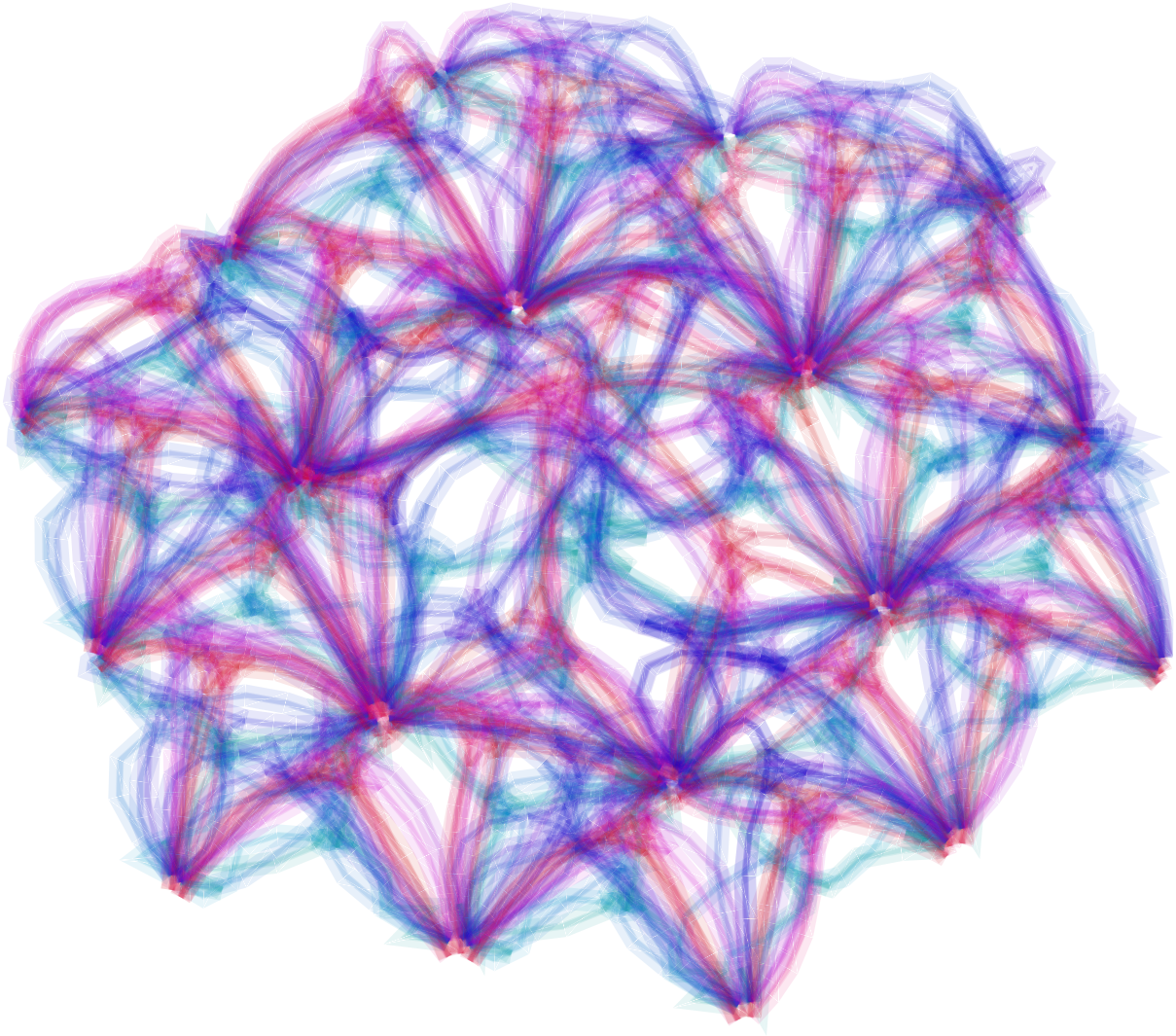
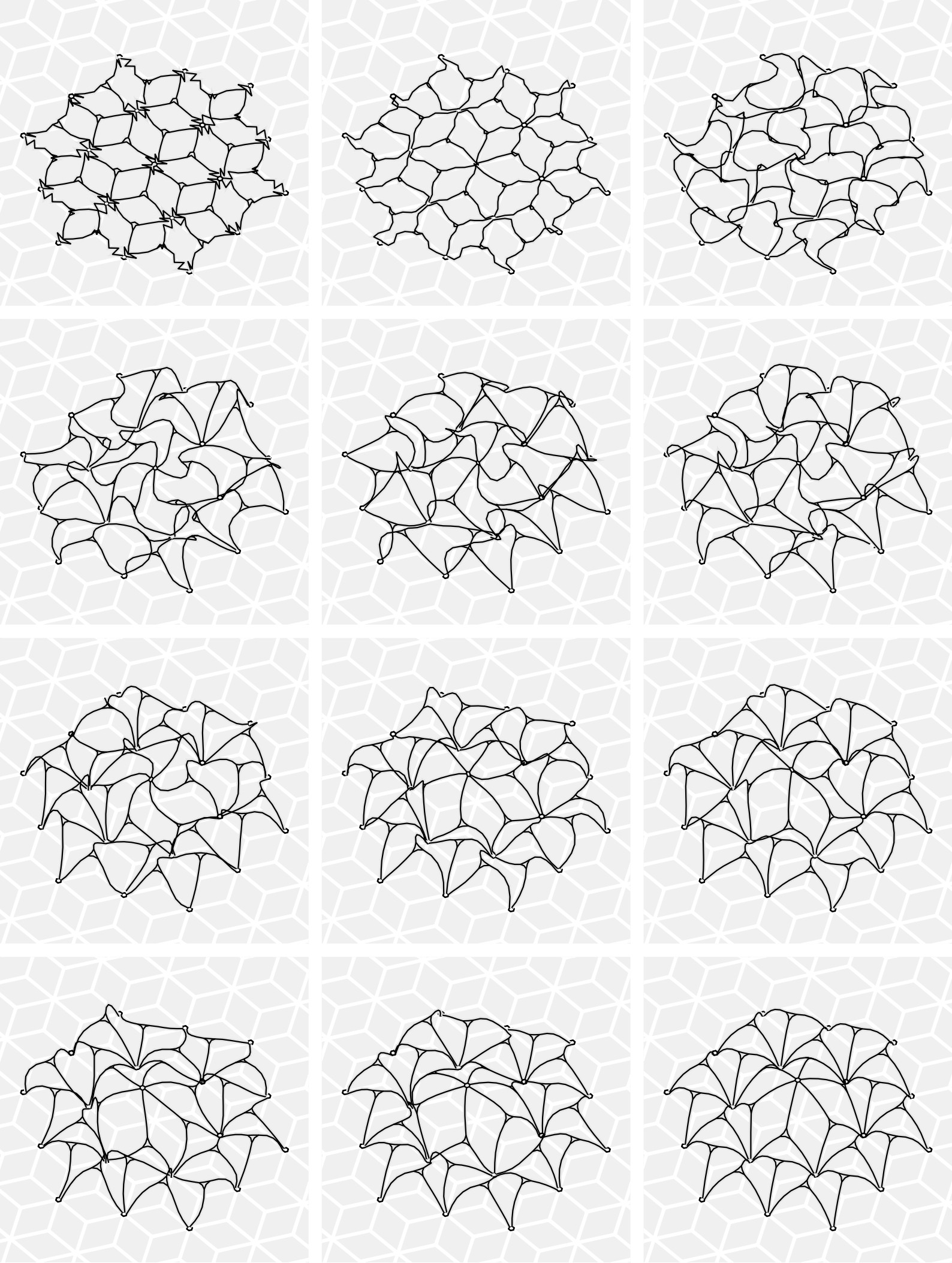
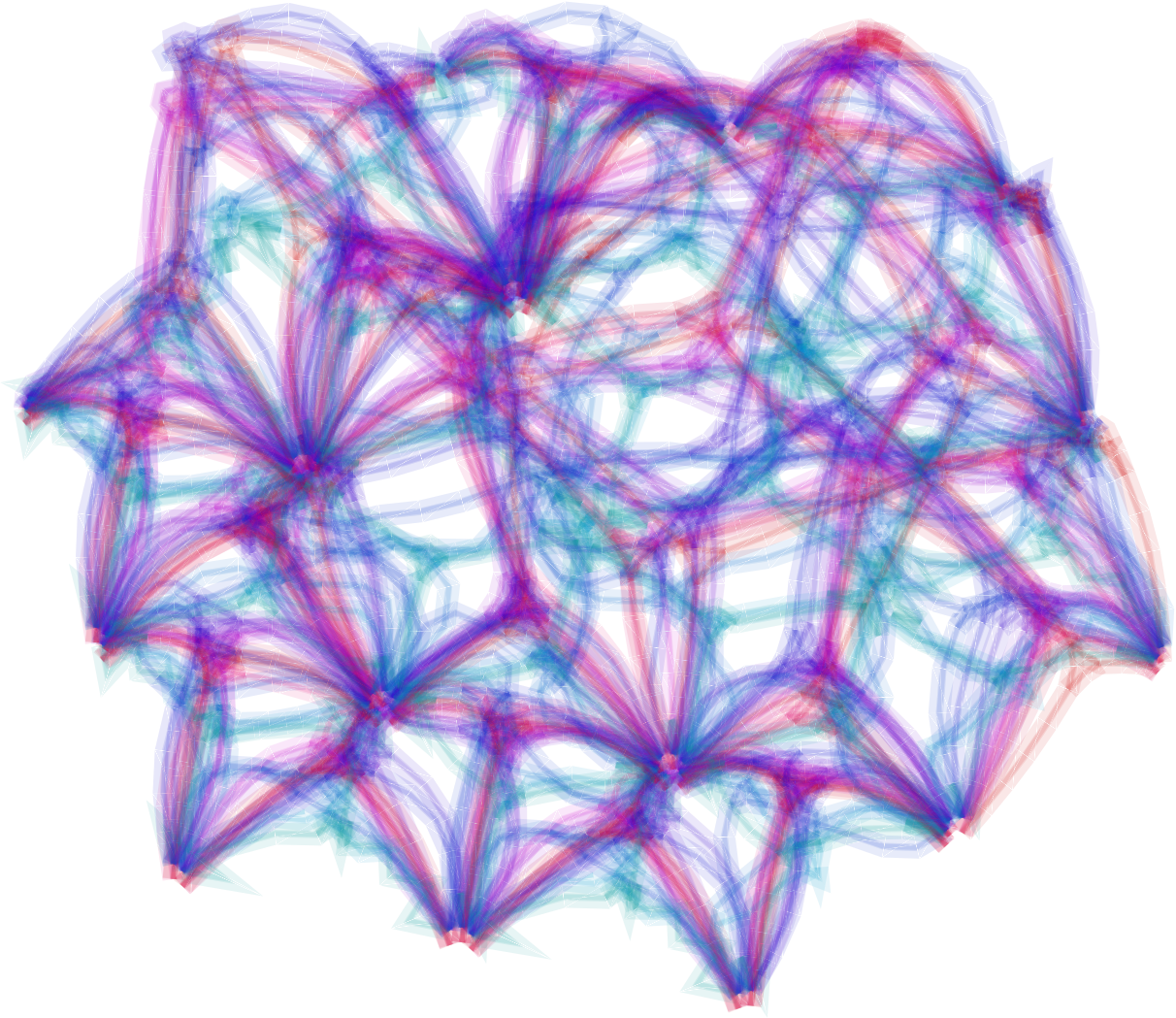
2.44 Grasshopper - Kangaroo script for inflation simulation
2.45 Grasshopper script for generation of tensile elements



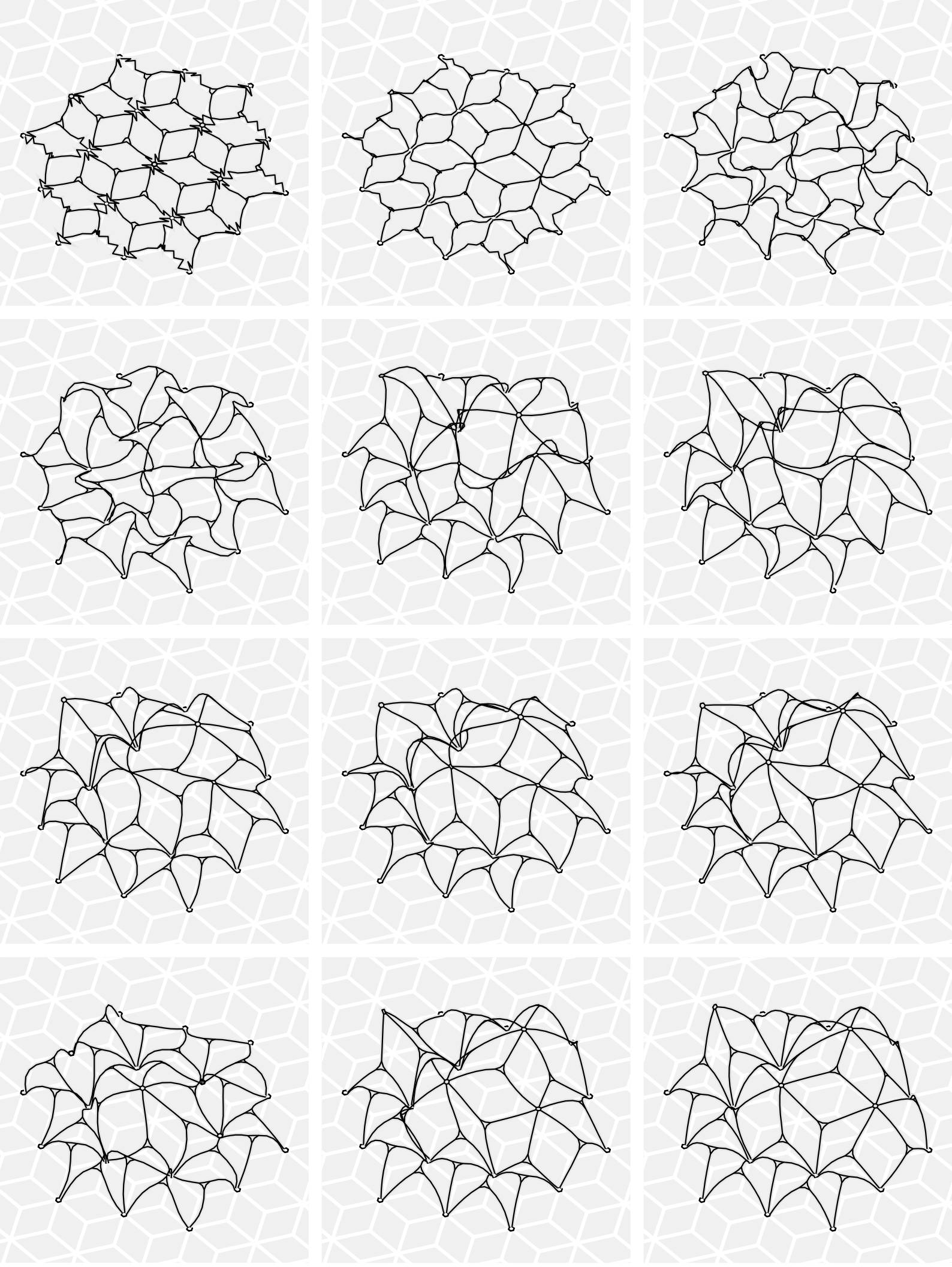
2.40 Abstract representation of inflation process / simulation kinetics / motion as a present element of the design process



2.41 Miniatures of different stage of inflation simulation



2.43 Abstract representation of inflation process / simulation kinetics / motion as a present element of the design process



2.44 Miniatures of different stage of inflation simulation

3 Conclusion

I feel that the project responds to design aims. Challenging criteria formulated during the work are in majority fulfilled by a final proposal. Most of my attention, was drawn by the topics that I found most interesting: kinetic geometry and the possibility of its computer simulation. I think that the solution represents a high architectural standard. It is defined by beautiful geometric shapes - regular, due to a modularity of invented construction system, yet not monotonous or boring - the configuration of curves forming varied, spherical rooms is fascinating.

The early considerations about urban context and attempts of its activation by means of temporary, flexible, architectural intervention, reflect the spirit of our times and , perhaps, properly answer current needs.

Presented solution possess a qualities of lightness, temporariness and movability. These advantages open up a varied way of possible usage strategies. It could be an extension for existing public institutions (theatres, cinemas, museums ...), function as an independent institution itself, but as well could be left uncontrolled for the public - everyone would decide for themselves how to use it. Alternatively, some additional methods of management like an internet booking system could be implemented. The way how this object is used could be changed through time. I intentionally leave the definition of usage policy without being answered.

The building is so flexible that change of its substance could appear on daily basis. A structure that is like a living organism - capable to morph, bringing astonishment and surprise -sounds like a revolution. These first imaginations and ideas were like architectural dreams. With this project they are in principal real (fig.2.45-2.60 / p. 66-69).

The difficulty and risk of this challenge were extreme. Furthermore the project remains a conceptual vision. I am aware that some of the proposed solutions are treated lapidary. Nevertheless, the presented stage of the work is a complete concept, making the assessment of its qualities or shortcomings possible, and conceivably opening the gate for further optimization or development.

In the final stage the project was given its title: "urban patch". This name emphasizes the most important intention/aim of mine - integration of the people in favour of jointly building upgraded - better, more compact, and friendly - city of Lodz. The material from which the building is constructed and the second title word 'patch' are secretly referring to genre of Lodz: textiles. I hope that my hometown would find its way in XXIst century - would successfully transform from a post-industrial worker city into a blooming metropolis, full of participating, active, creative inhabitants.

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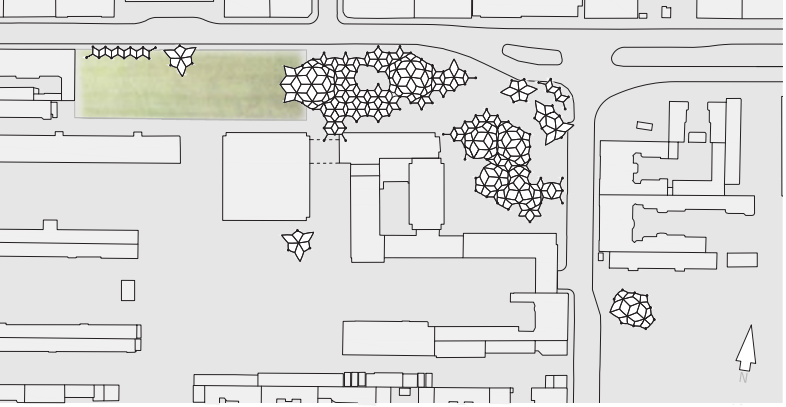

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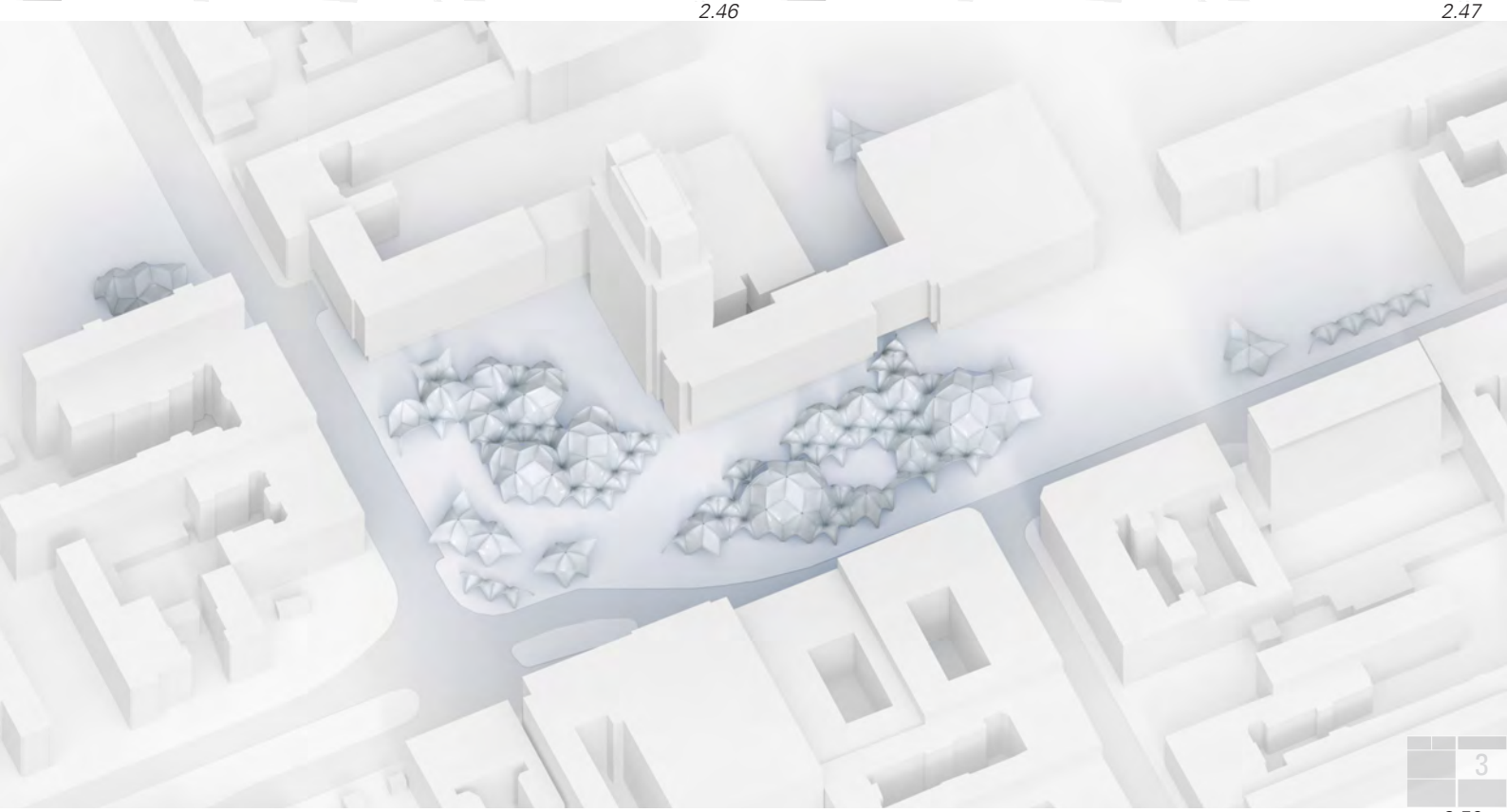

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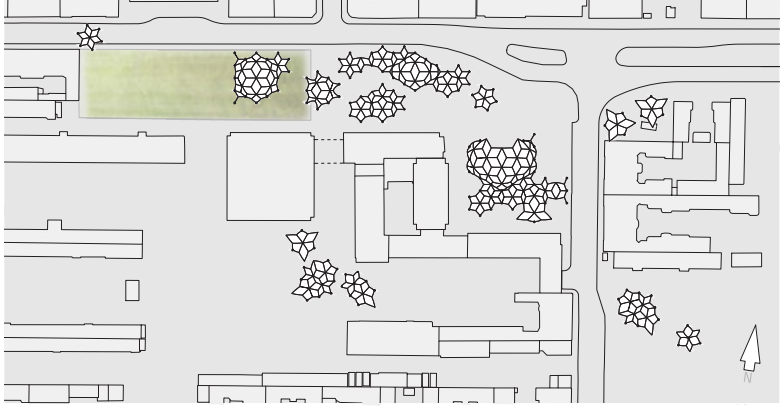

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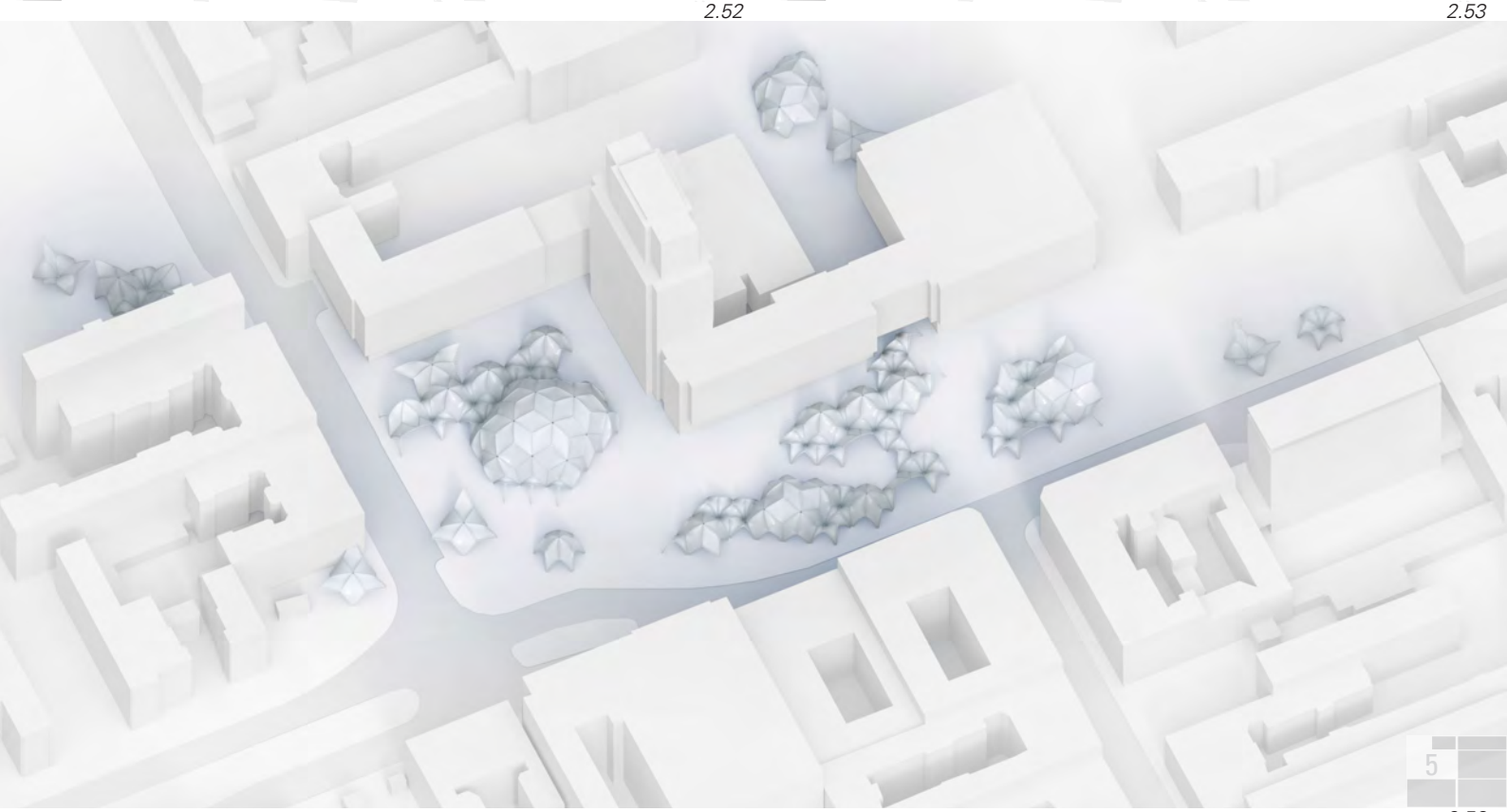

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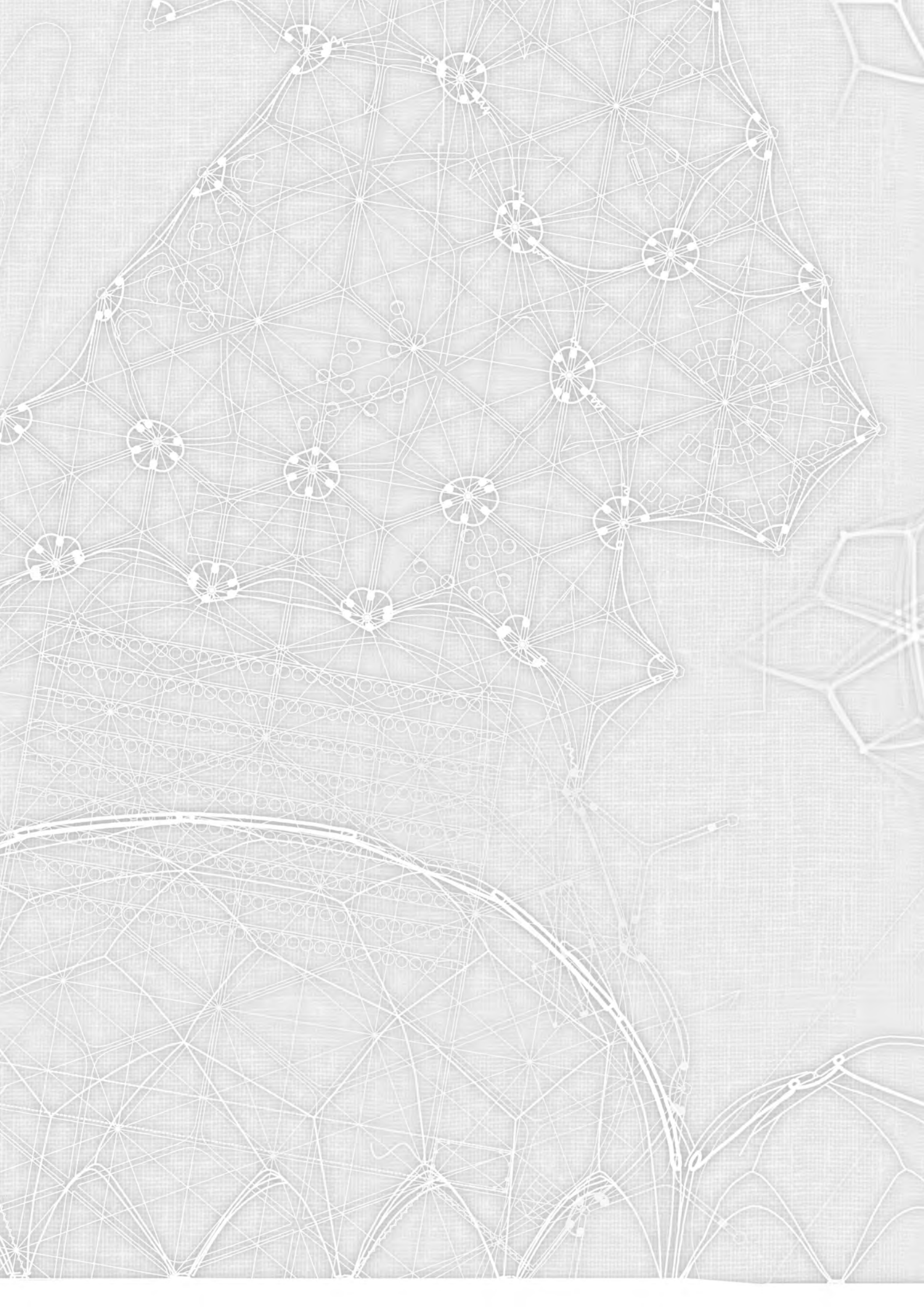
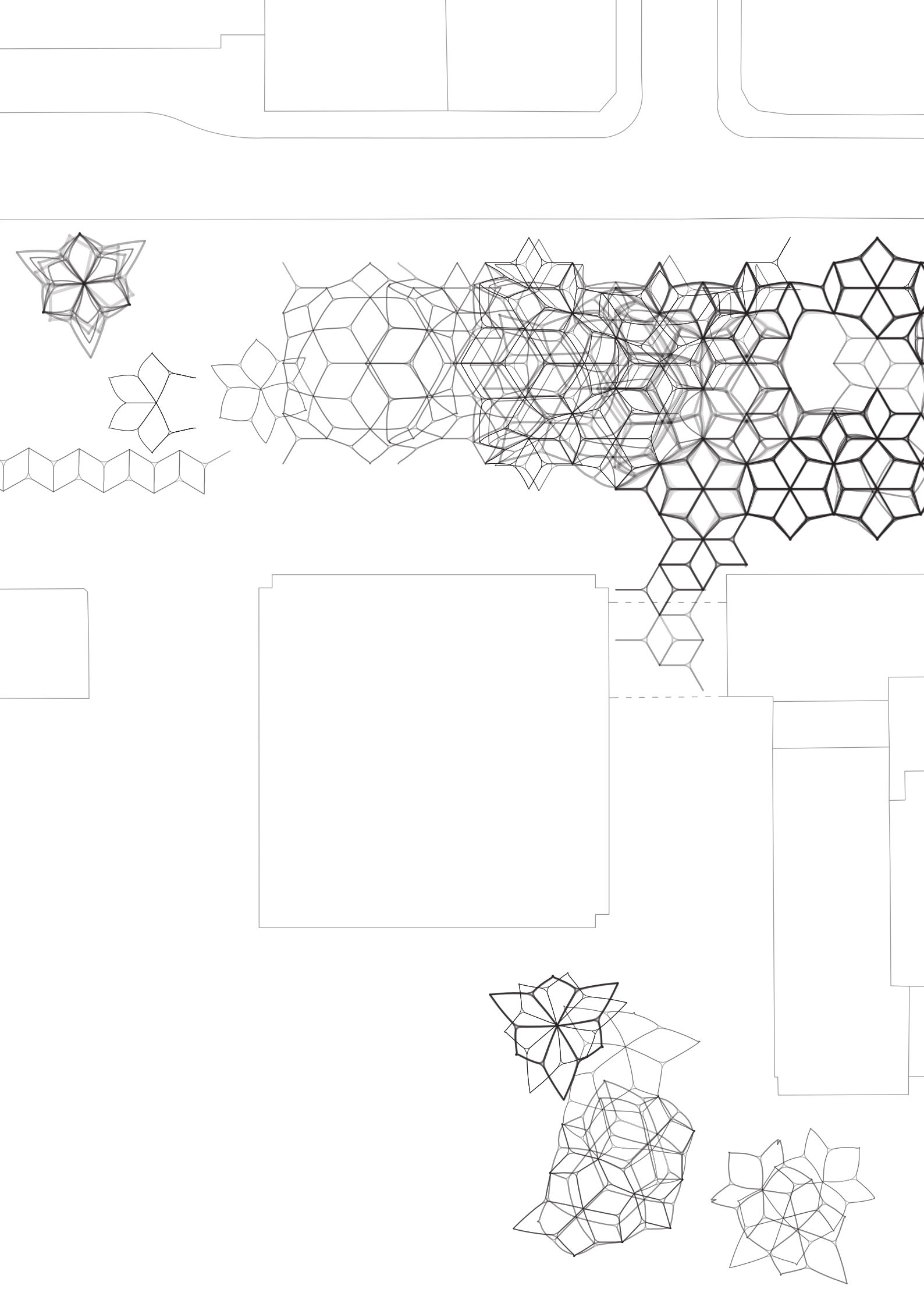
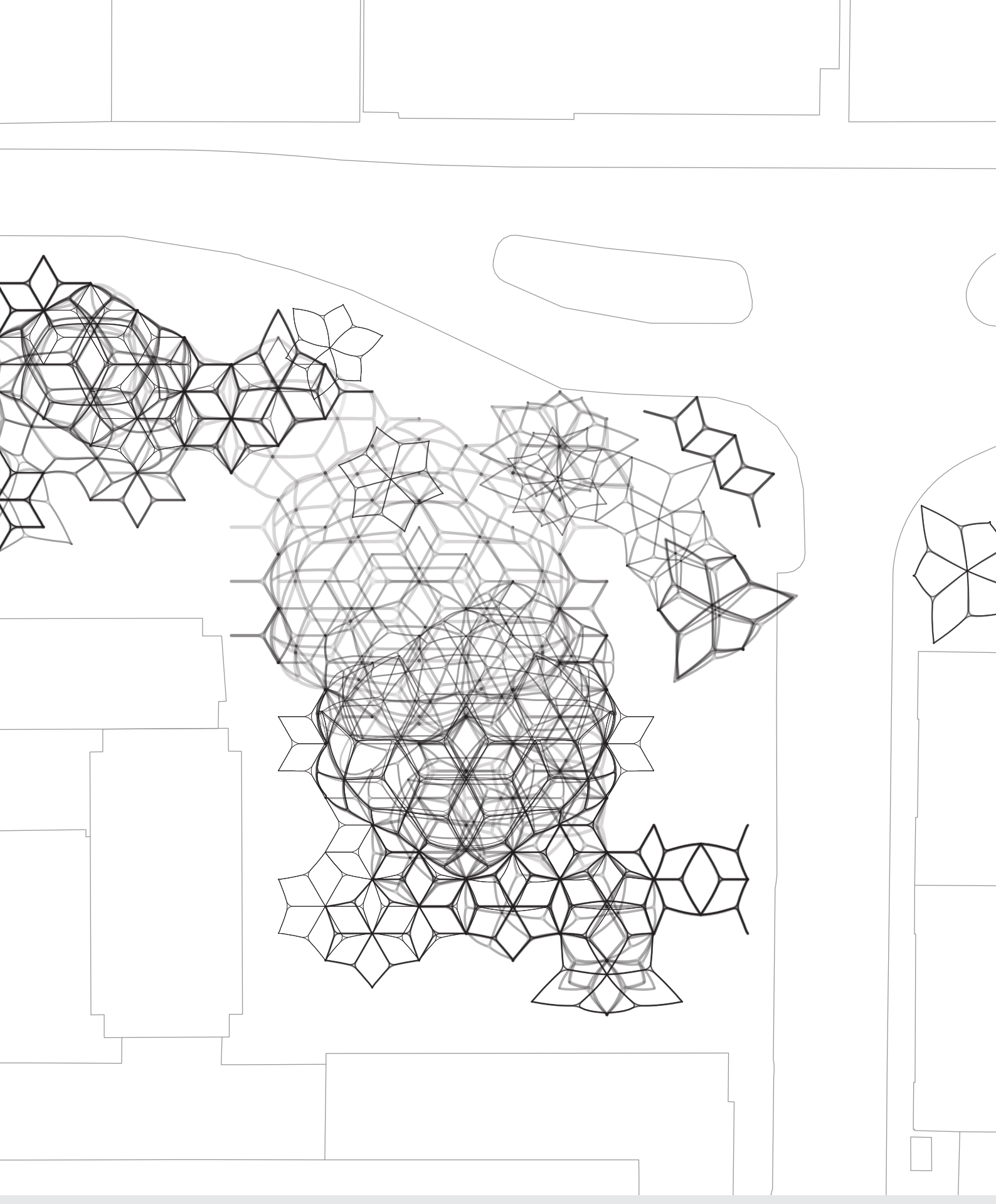


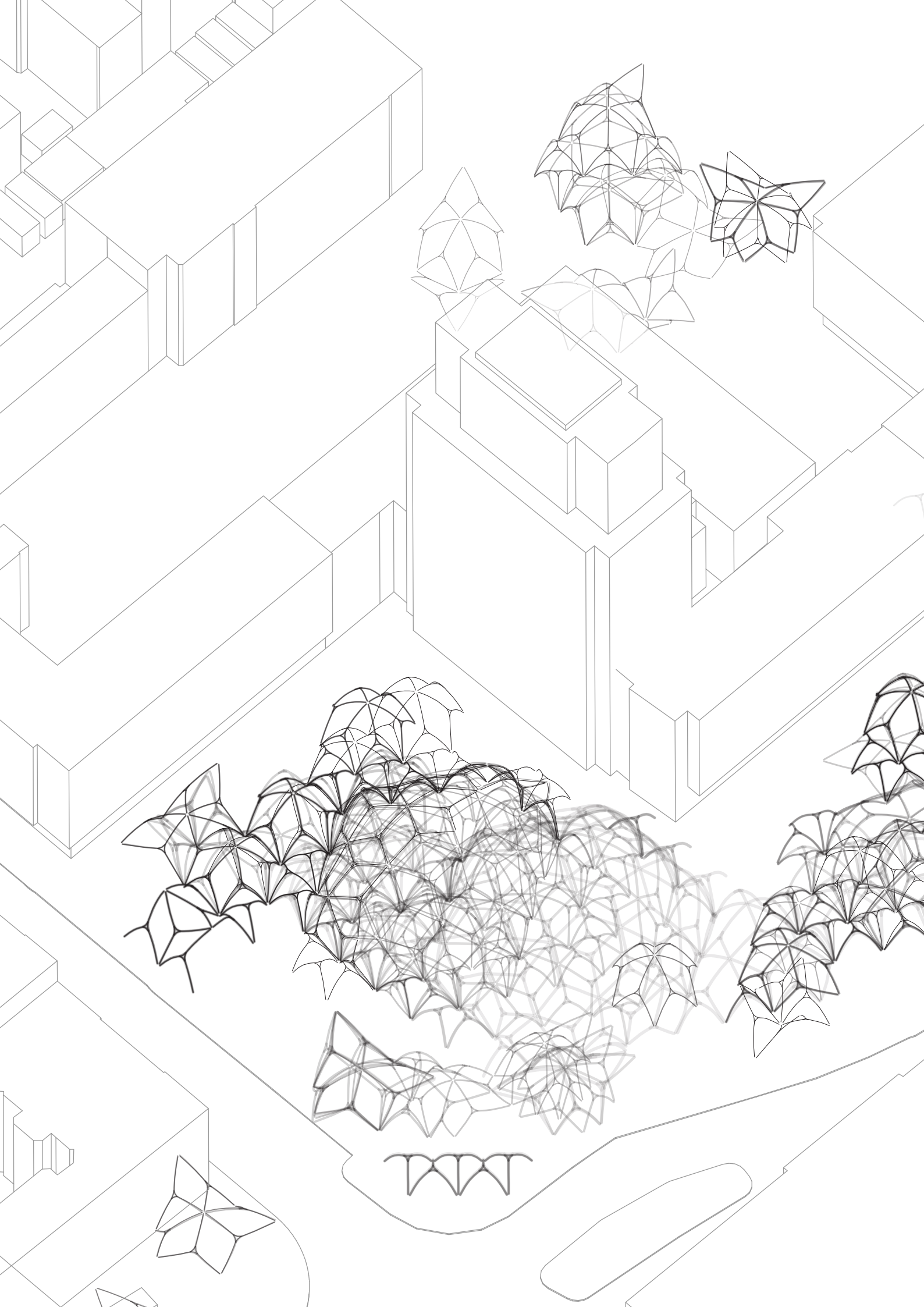
DRAWING PART

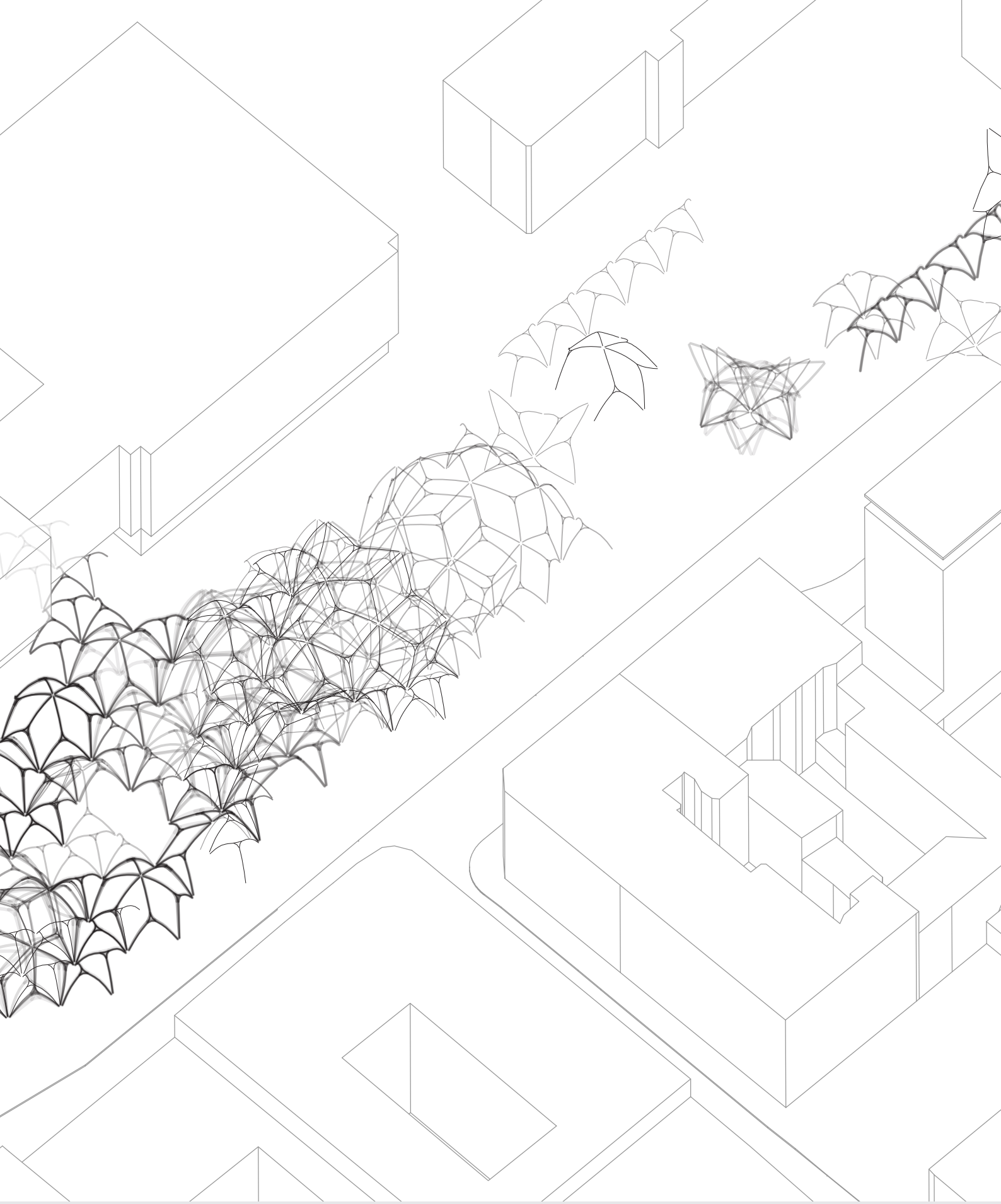




Mutation phase 8 (Scenario B)
Mutation phase 7
Mutation phase 6
Mutation phase 5
Mutation phase 4
Mutation phase 3
Mutation phase 2
Mutation phase 1 (Scenario A)

ROOF PLAN _ SPACE MUTATION _ 1:500



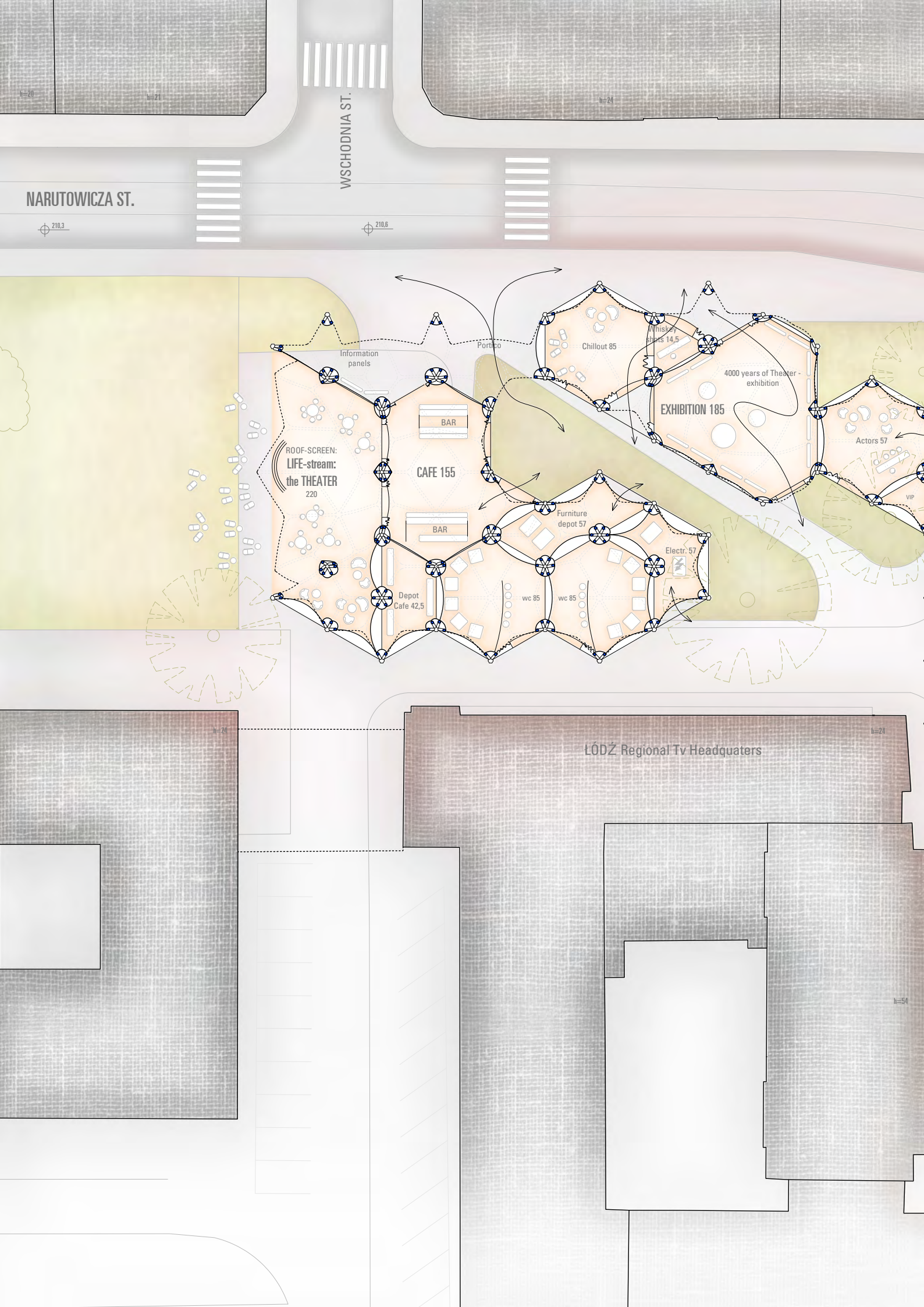


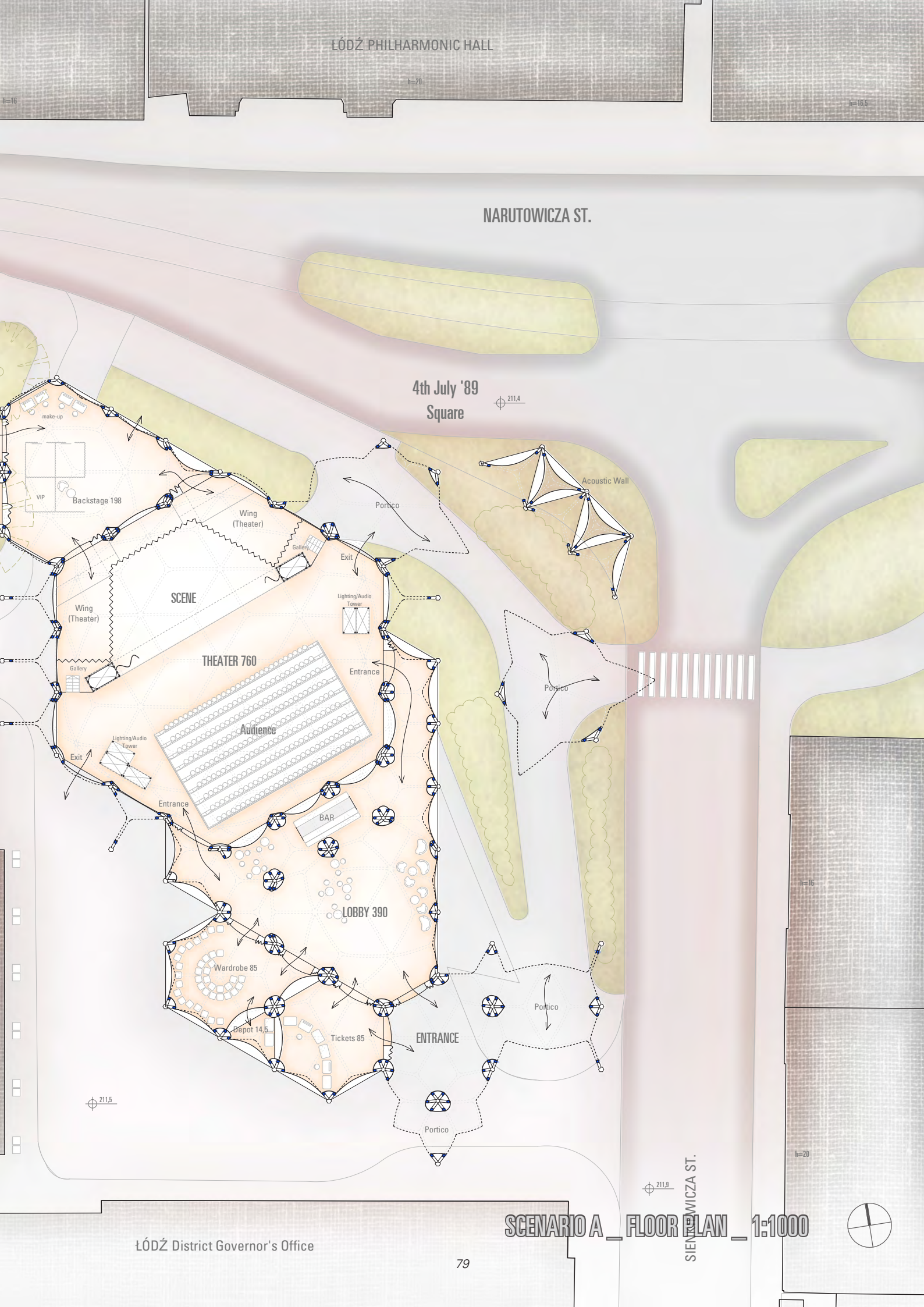
Mutation phase 8 (Scenario B)
Mutation phase 7
Mutation phase 6
Mutation phase 5
Mutation phase 4
Mutation phase 3
Mutation phase 2
Mutation phase 1 (Scenario A)

AXONOMETRY _ SPACE MUTATION

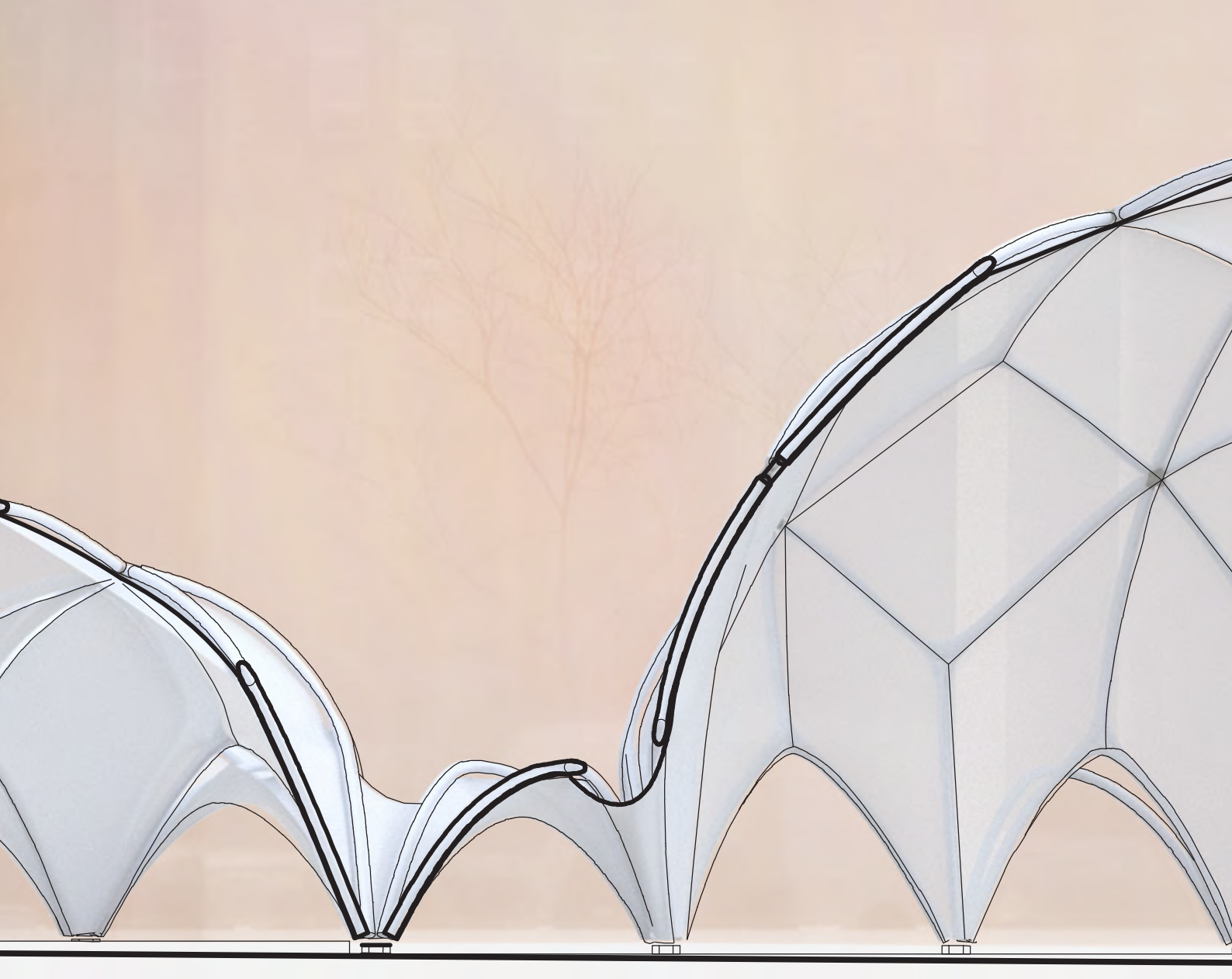

NARUTOWICZA ST.
WSCHODNIA ST.
PIOTRKOWSKA STREET
THE GREAT LAWN
OPEN-AIR CINEMA
210,1
210,3
h=33,5
h=20
h=21
h=18
h=16
h=26
h=24
h=12
h=32

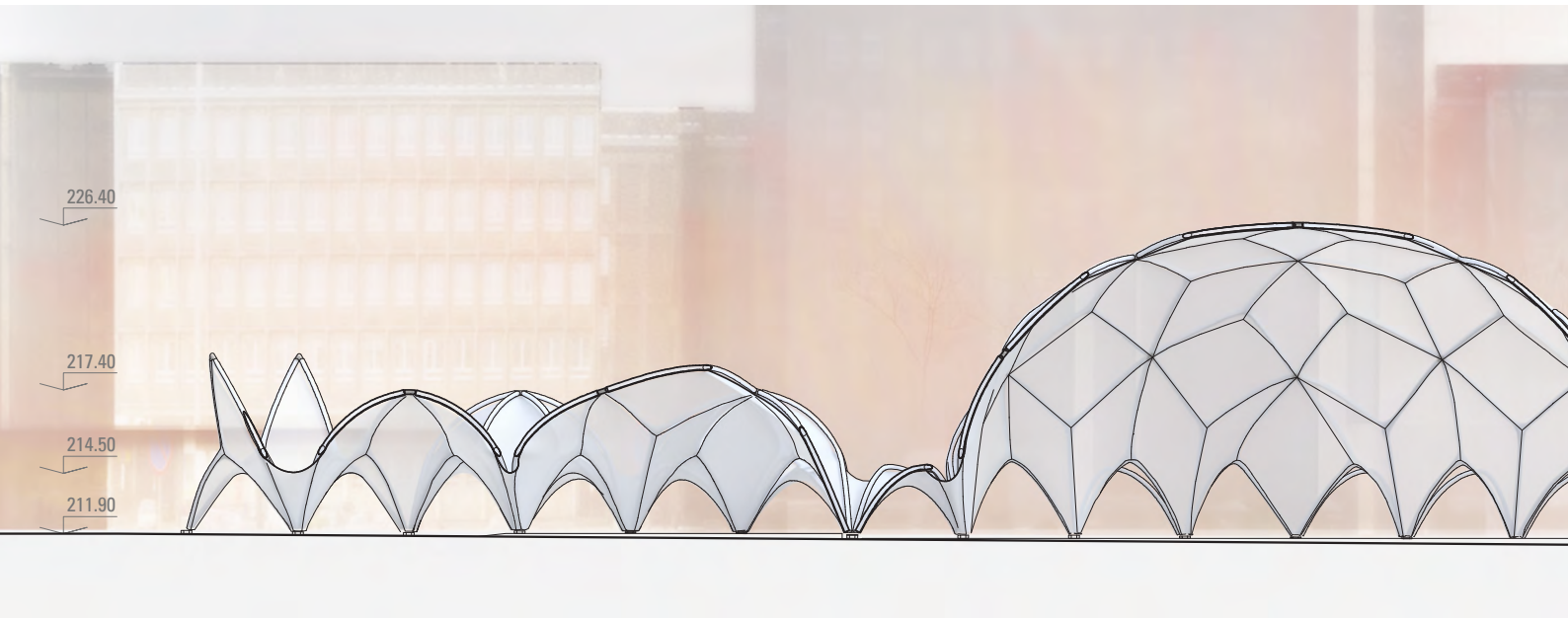

ŁÓDŹ PHILHARMONIC HALL
NARUTOWICZA ST.
4th July '89
Square
EXHIBITION
THEATER
LOBBY
ŁÓDŹ Regional Tv Headquaters
SIENKIEWICZA ST.
ŁÓDŹ District Governor's Office
LODZ NEW CITY CENTRE (NCL)
HOUSE OF CULTURE 'ŁDK'
SCENARIO A _ SITUATION _ 1:1000

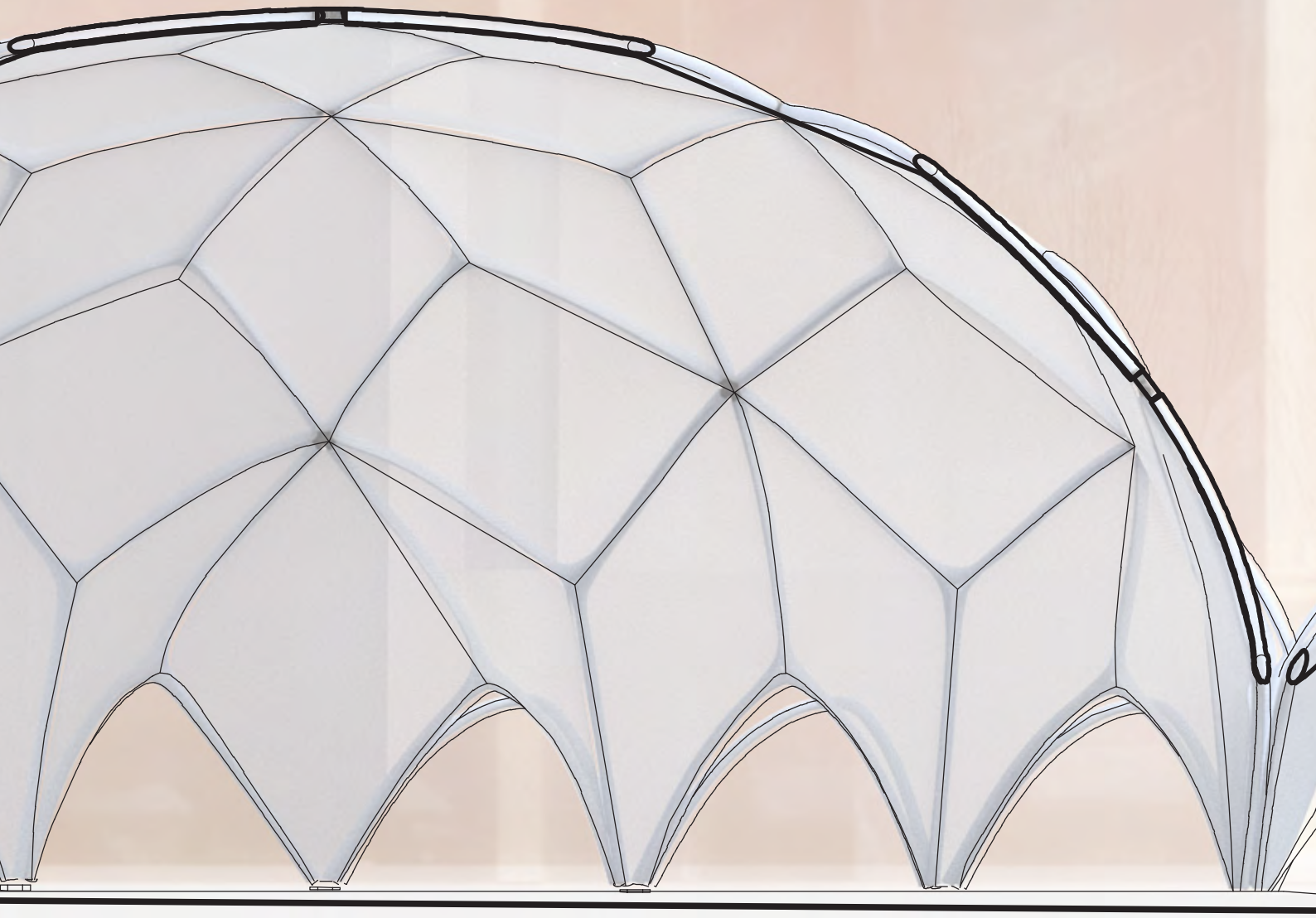

WSCHODNIA ST.
NARUTOWICZA ST.
210,3
210,6
h=20
h=21
h=24
Information panels
Portico
Chillout 85
Whiskey shots 14,5
4000 years of Theater - exhibition
EXHIBITION 185
Actors 57
VIP
BAR
ROOF-SCREEN:
LIFE-stream:
the THEATER
220
CAFE 155
BAR
Furniture depot 57
Electr. 57
Depot Cafe 42,5
wc 85
wc 85
ŁÓDŹ Regional Tv Headquaters
h=54

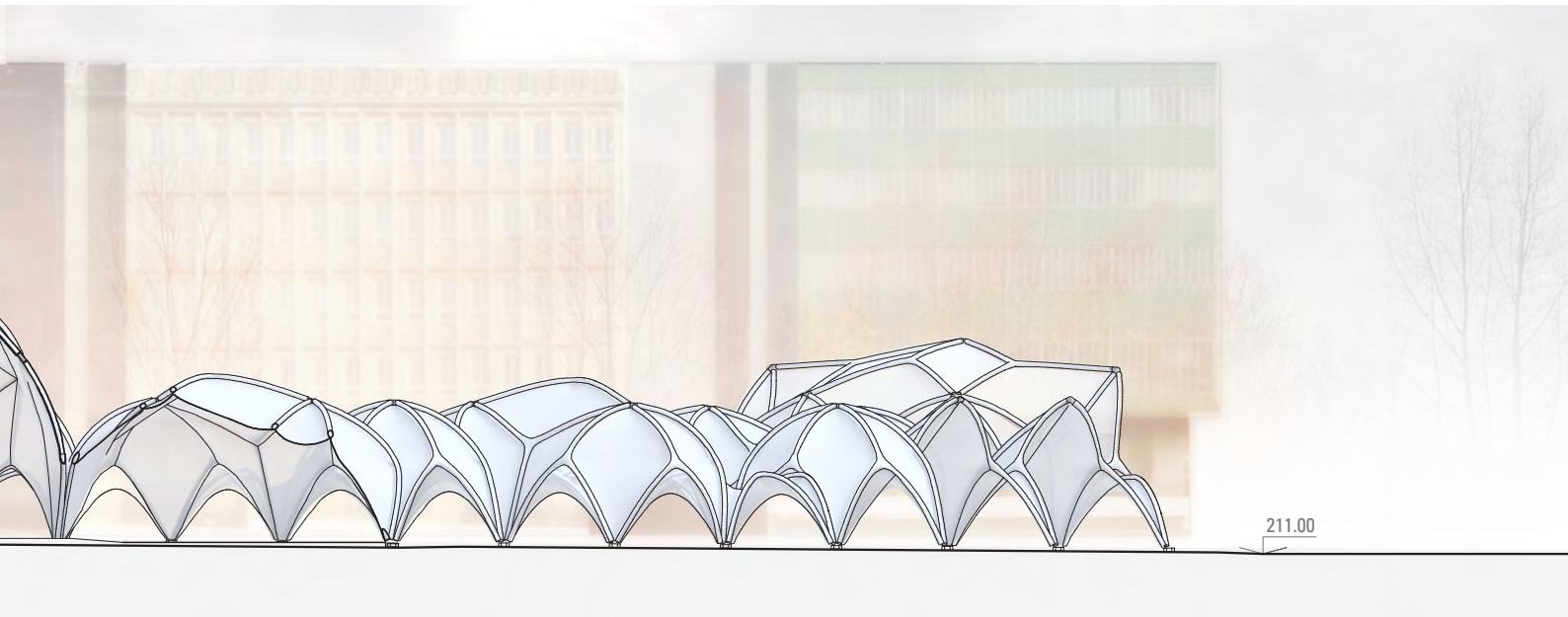


SCENARIO A _ FLOOR PLAN _ 1:1000



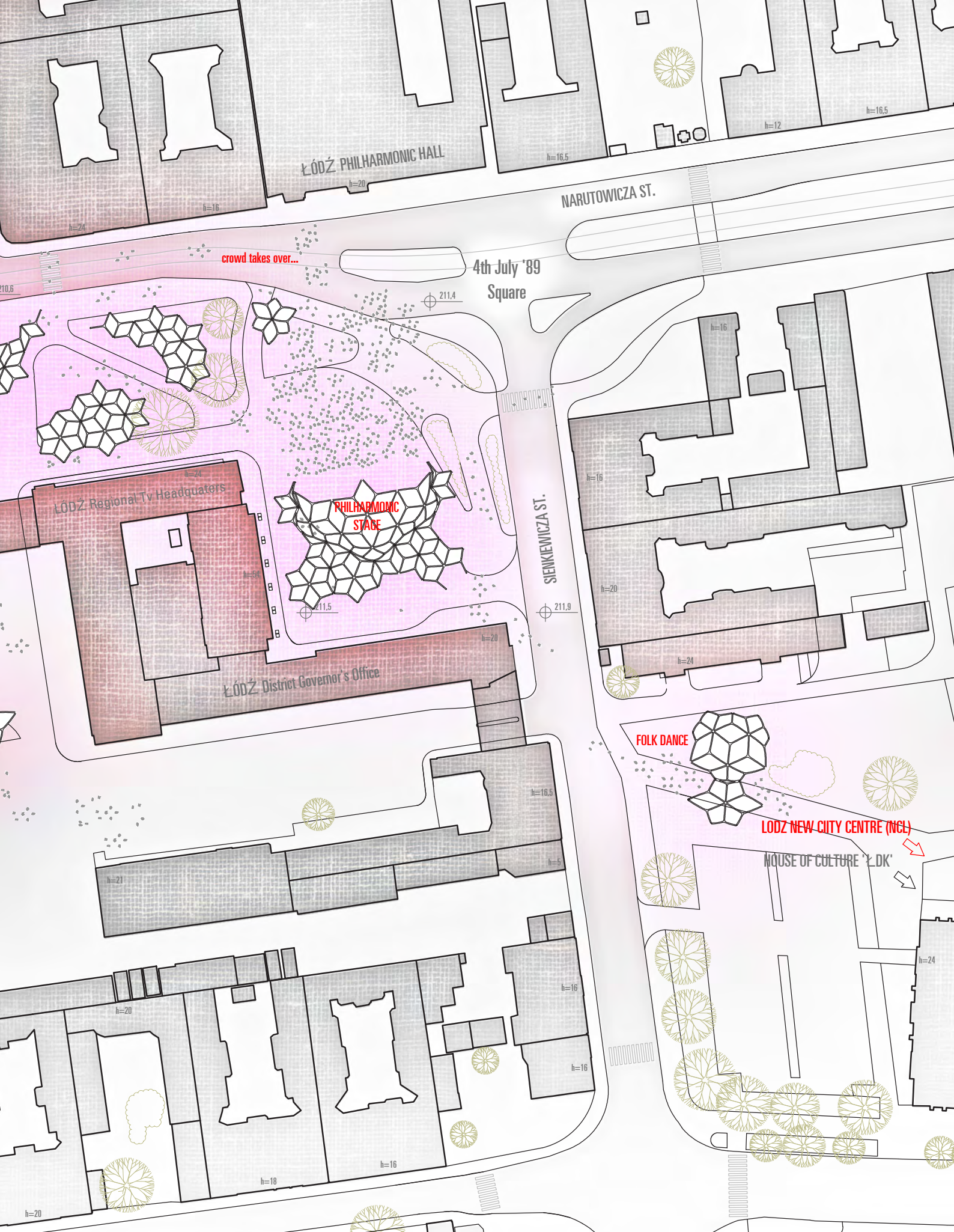

226.40
217.40
214.50
211.90



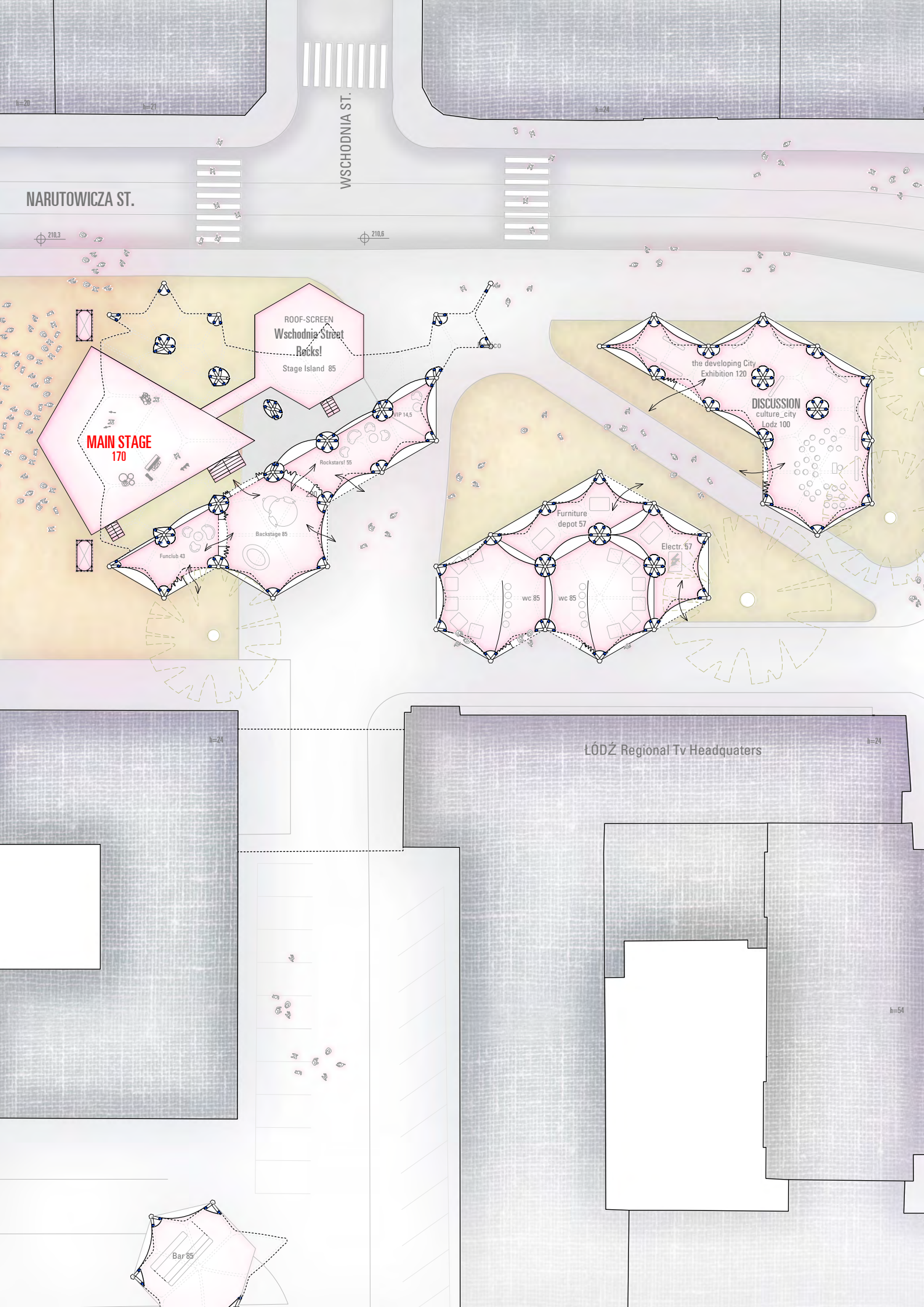


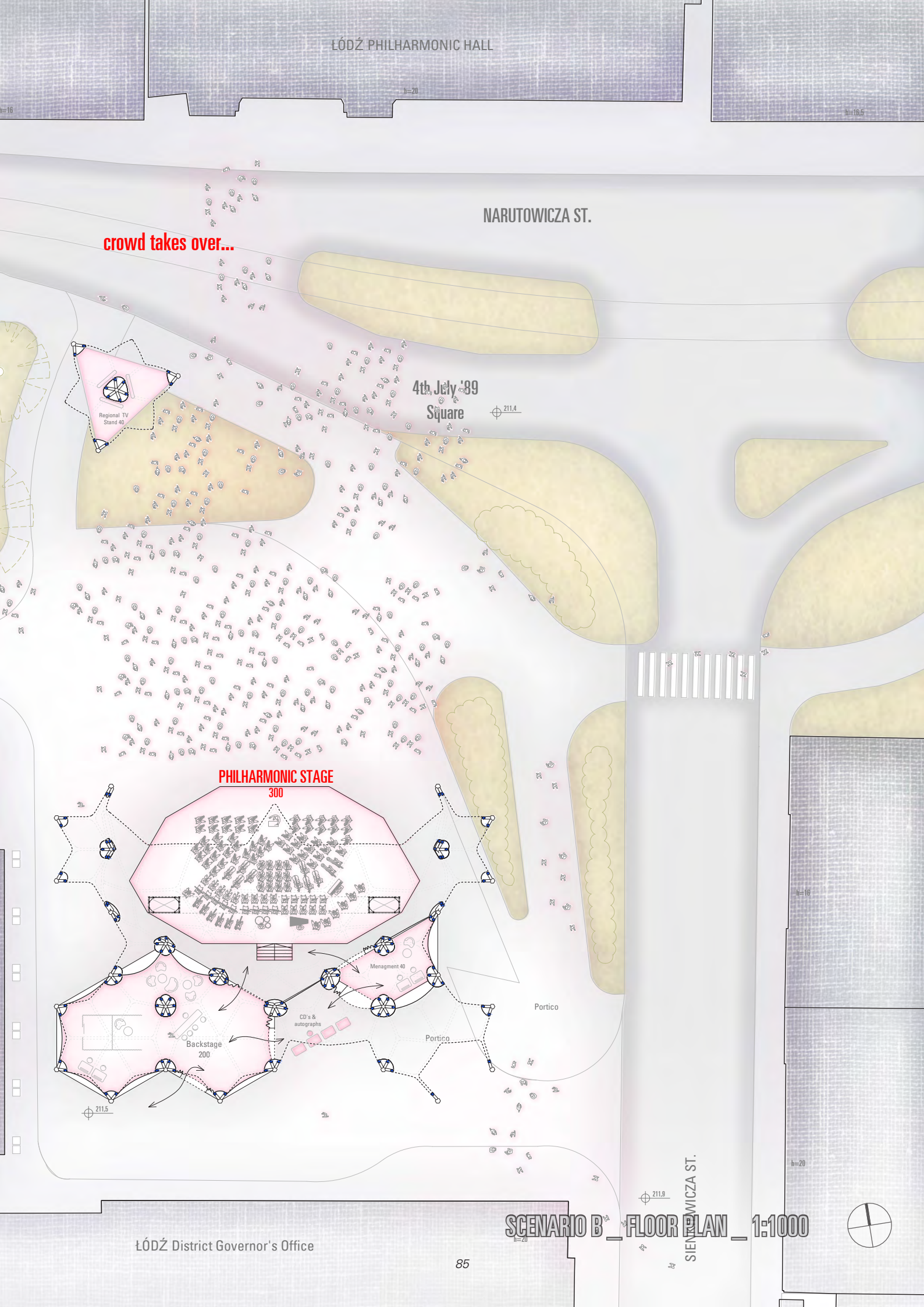
SCENARIO A _ SECTION _ 1:100/1:333


JAZZ STAGE
NARUTOWICZA ST.
WSCHODNIA ST.
INFO
MAIN STAGE
PIOTRKOWSKA STREET
210,3
210,1
h=33,5
h=20
h=21
h=18
h=16
h=26
h=24
h=12
h=32

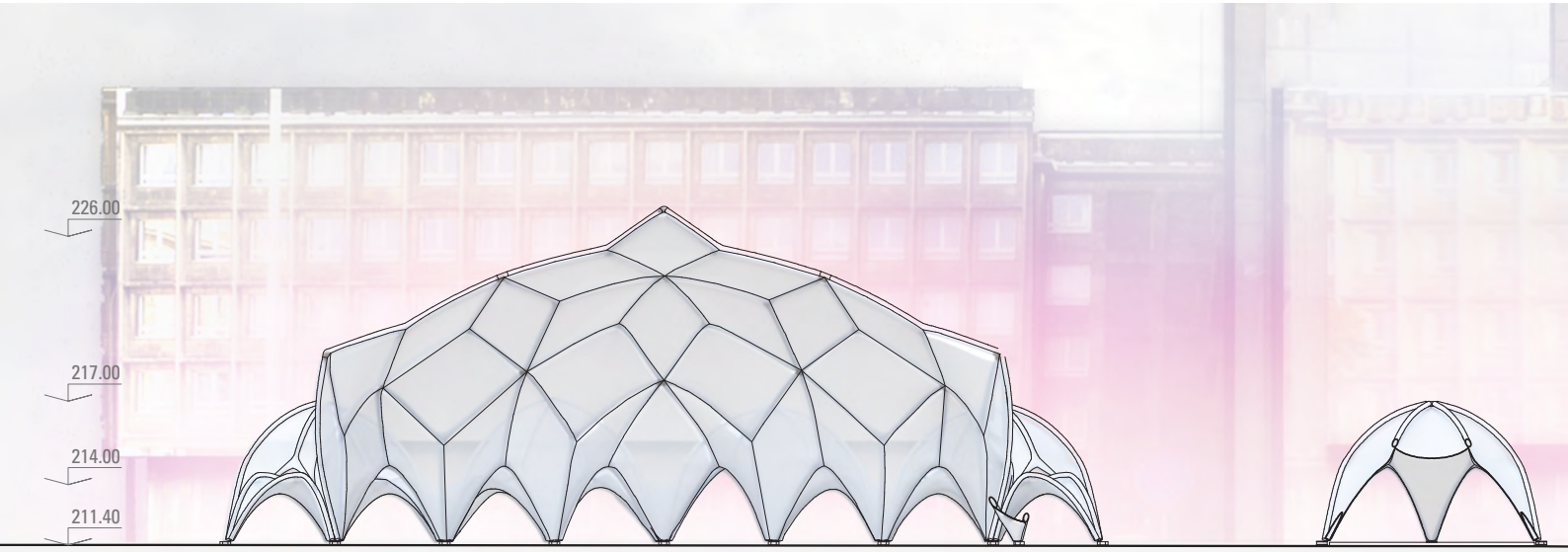


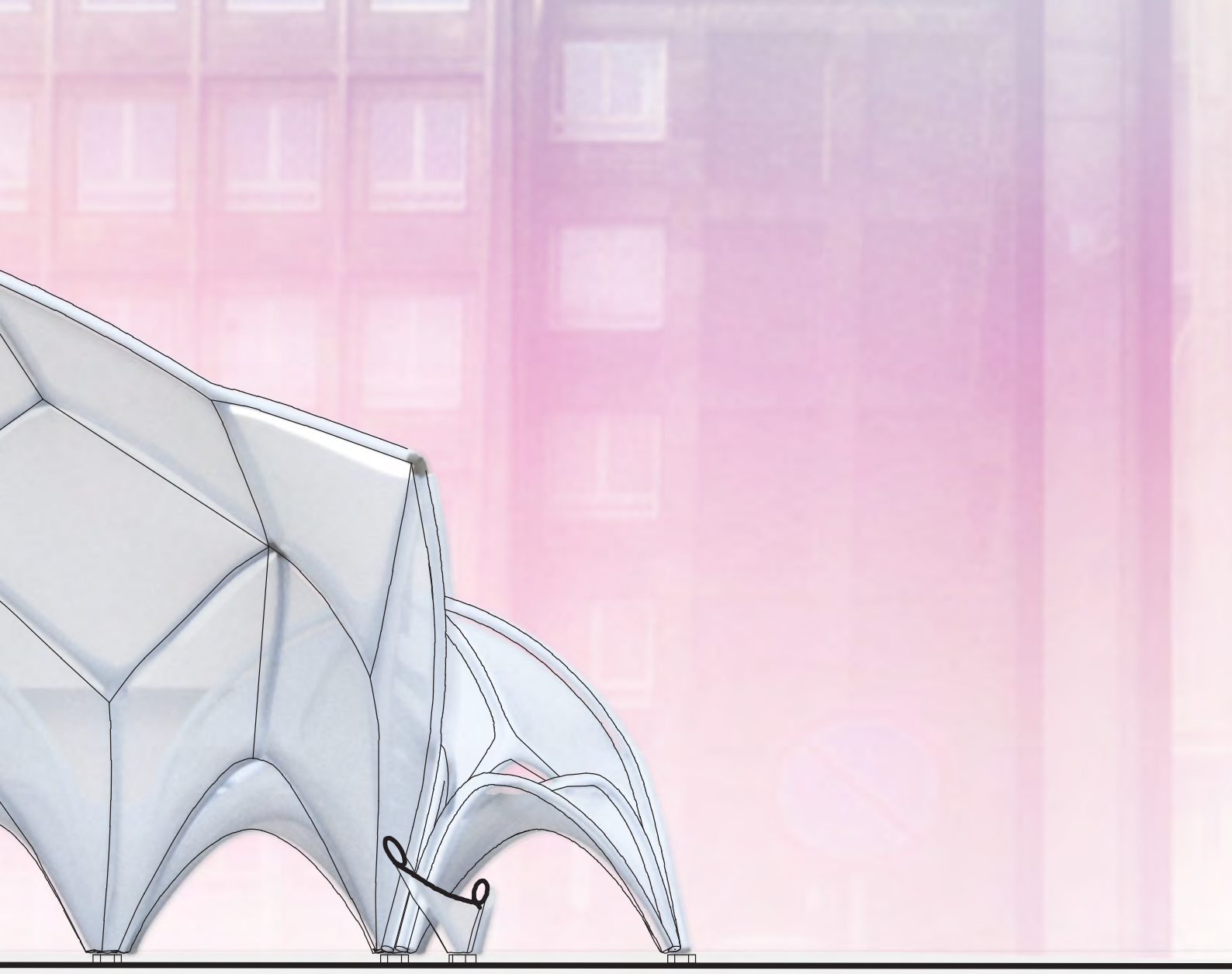
SCENARIO B _ SITUATION _ 1:1000

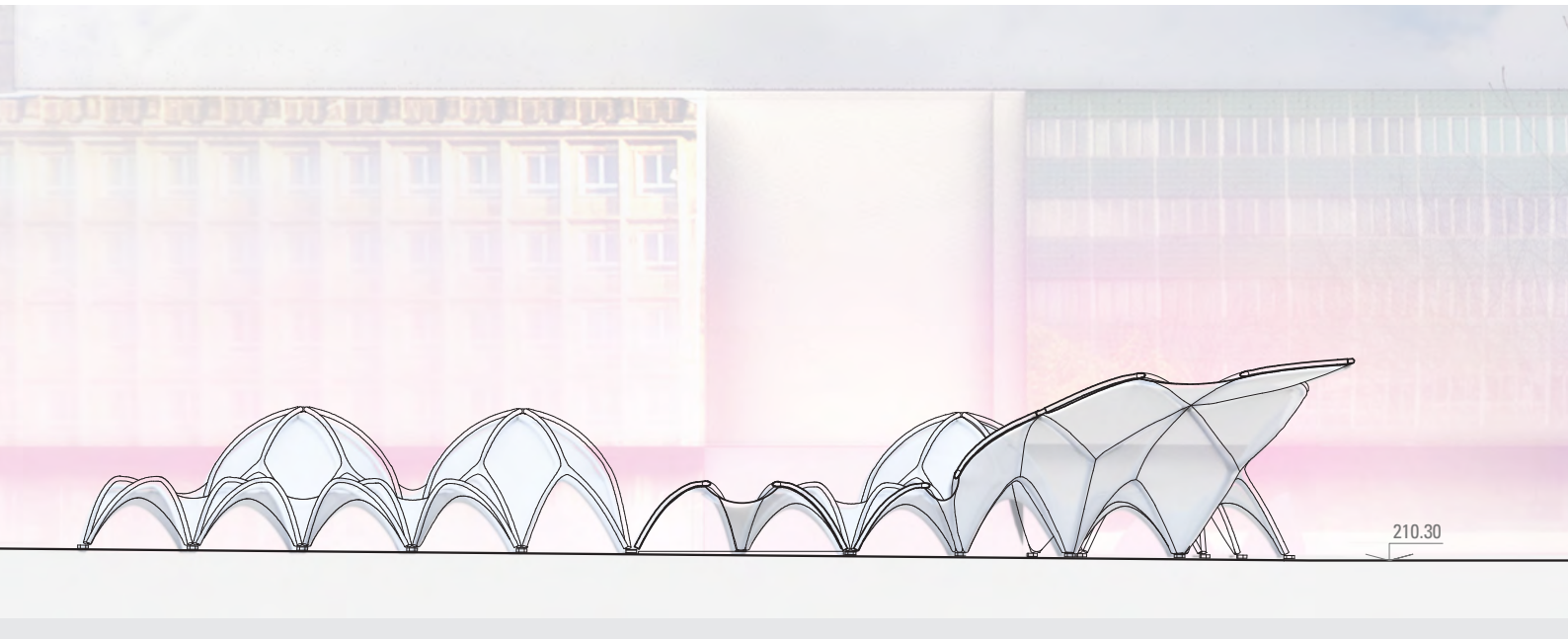

NARUTOWICZA ST.
WSCHODNIA ST.
h=20
h=21
h=24
210,3
210,6
ROOF-SCREEN
Wschodnie Street Rocks!
Stage Island 85
MAIN STAGE
170
VIP 14,5
Rockstars! 55
Backstage 85
Funclub 43
Furniture depot 57
Electr. 57
wc 85
wc 85
the developing City Exhibition 120
DISCUSSION
culture_city
Lodz 100
ŁÓDŹ Regional Tv Headquaters
h=24
h=24
h=54
Bar 85



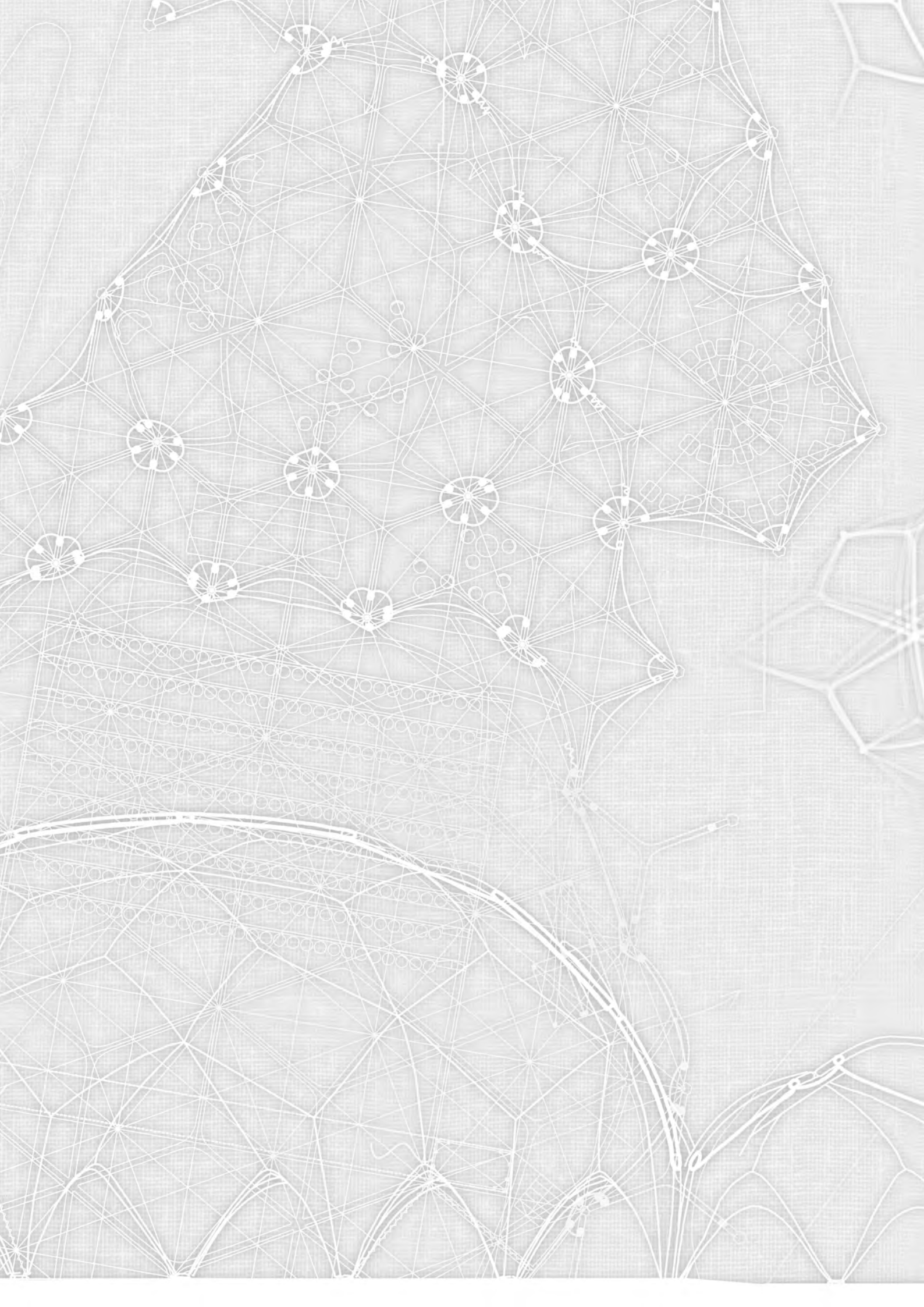
SCENARIO B _ FLOOR PLAN _ 1:1000


226.00
217.00
214.00
211.40

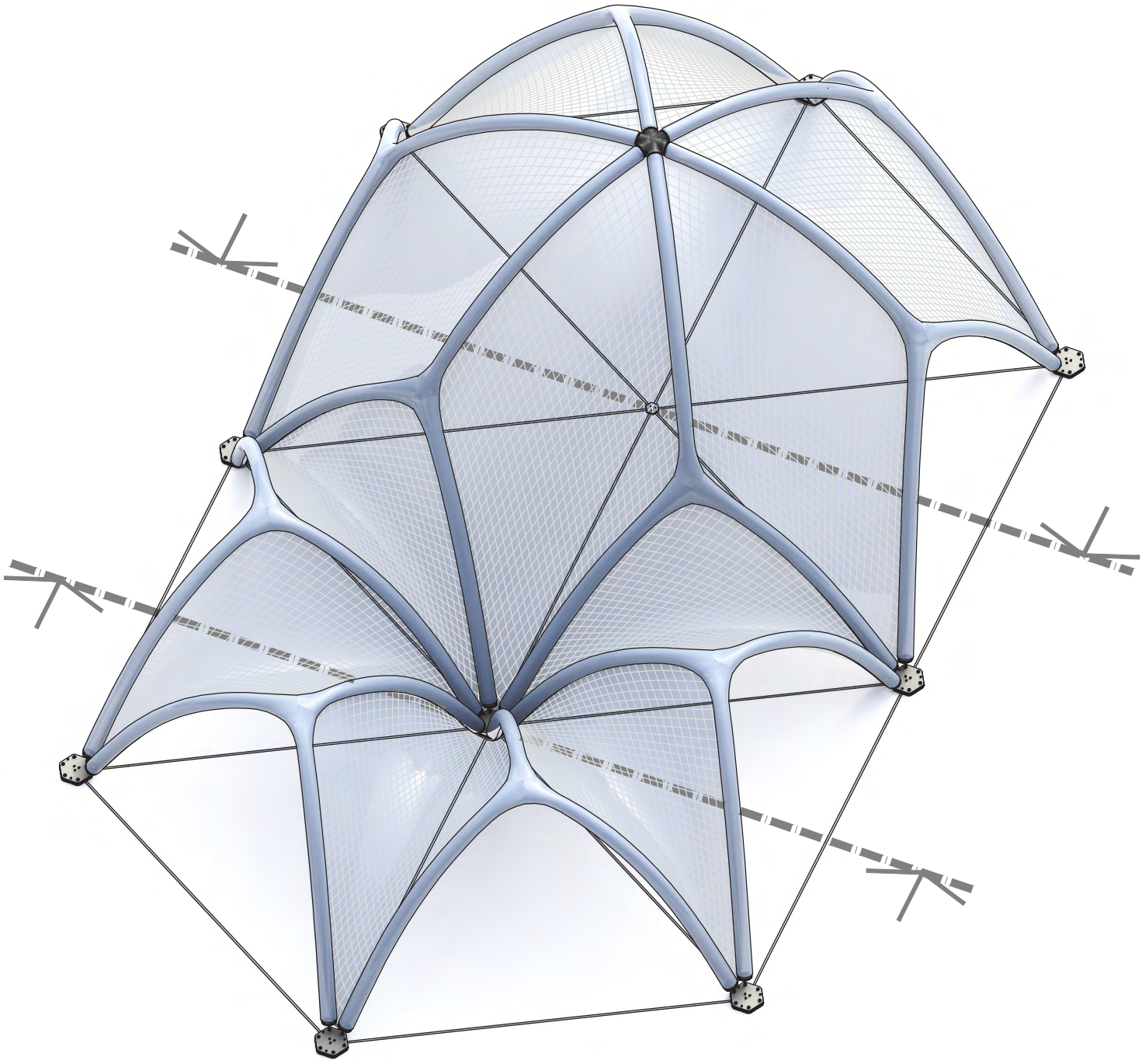


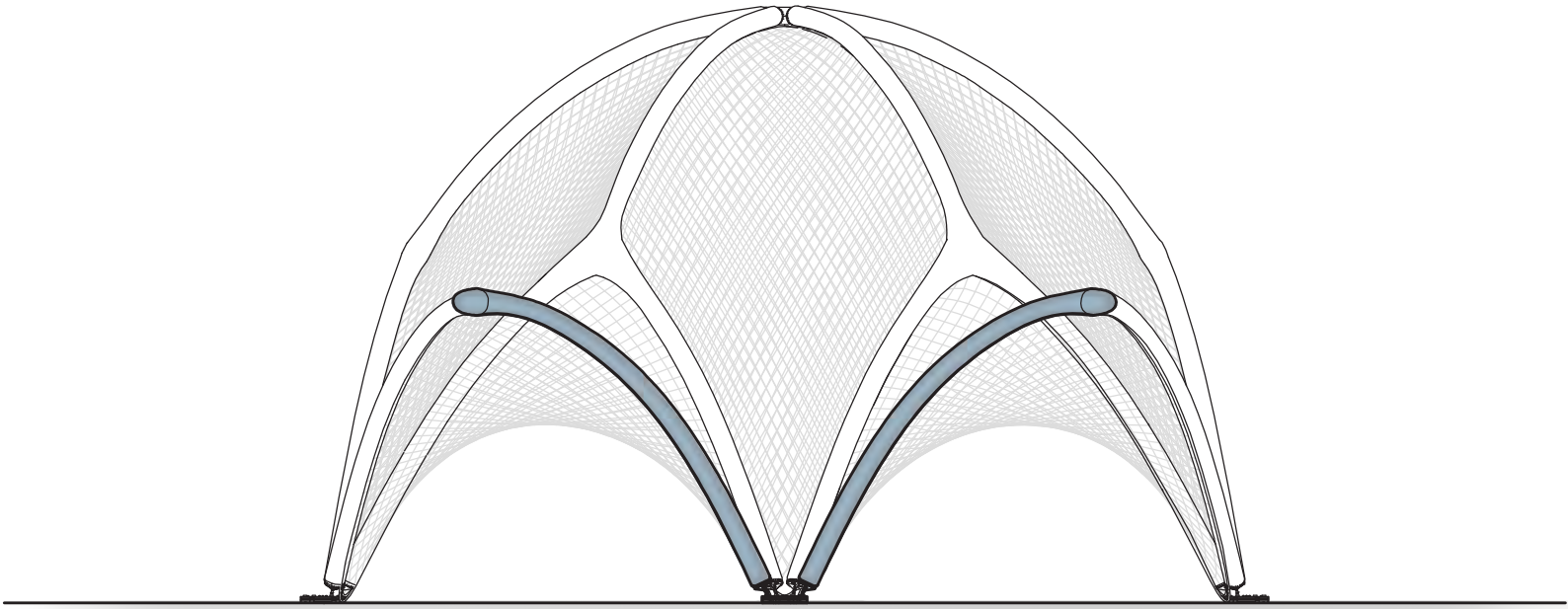


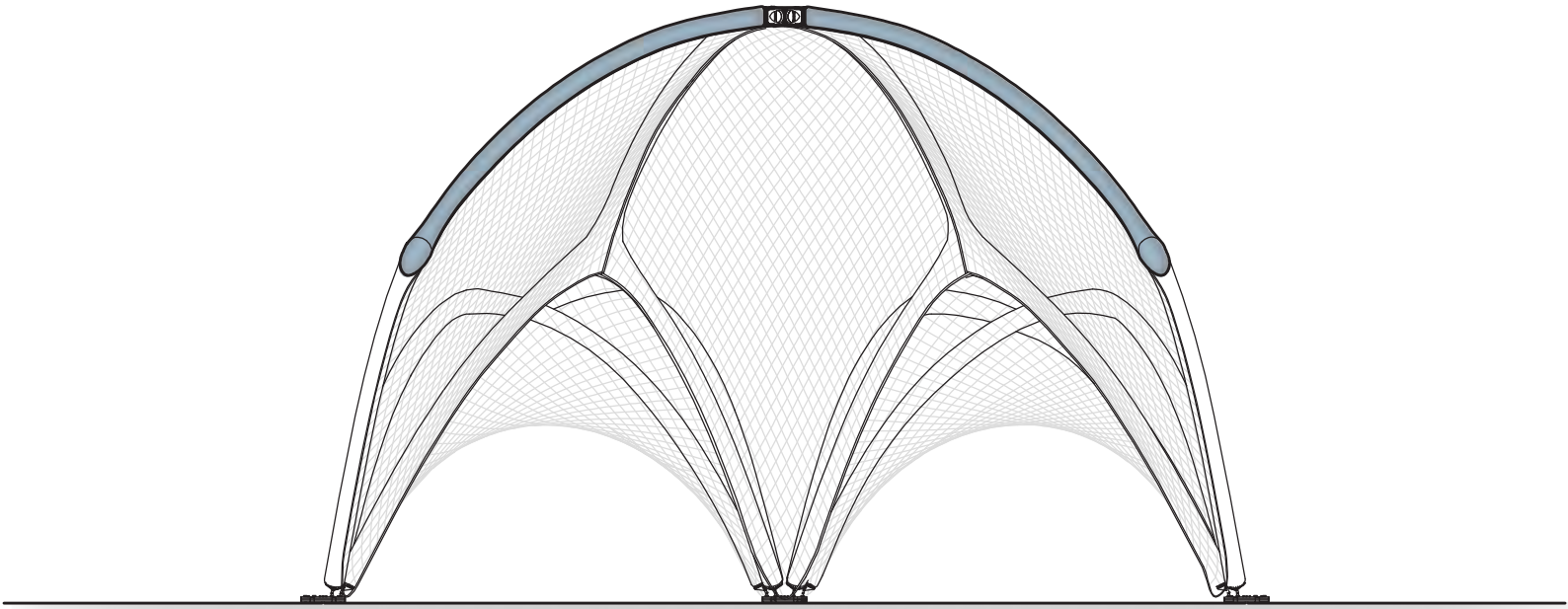
SCENARIO B _ SECTION _ 1:100/1:333

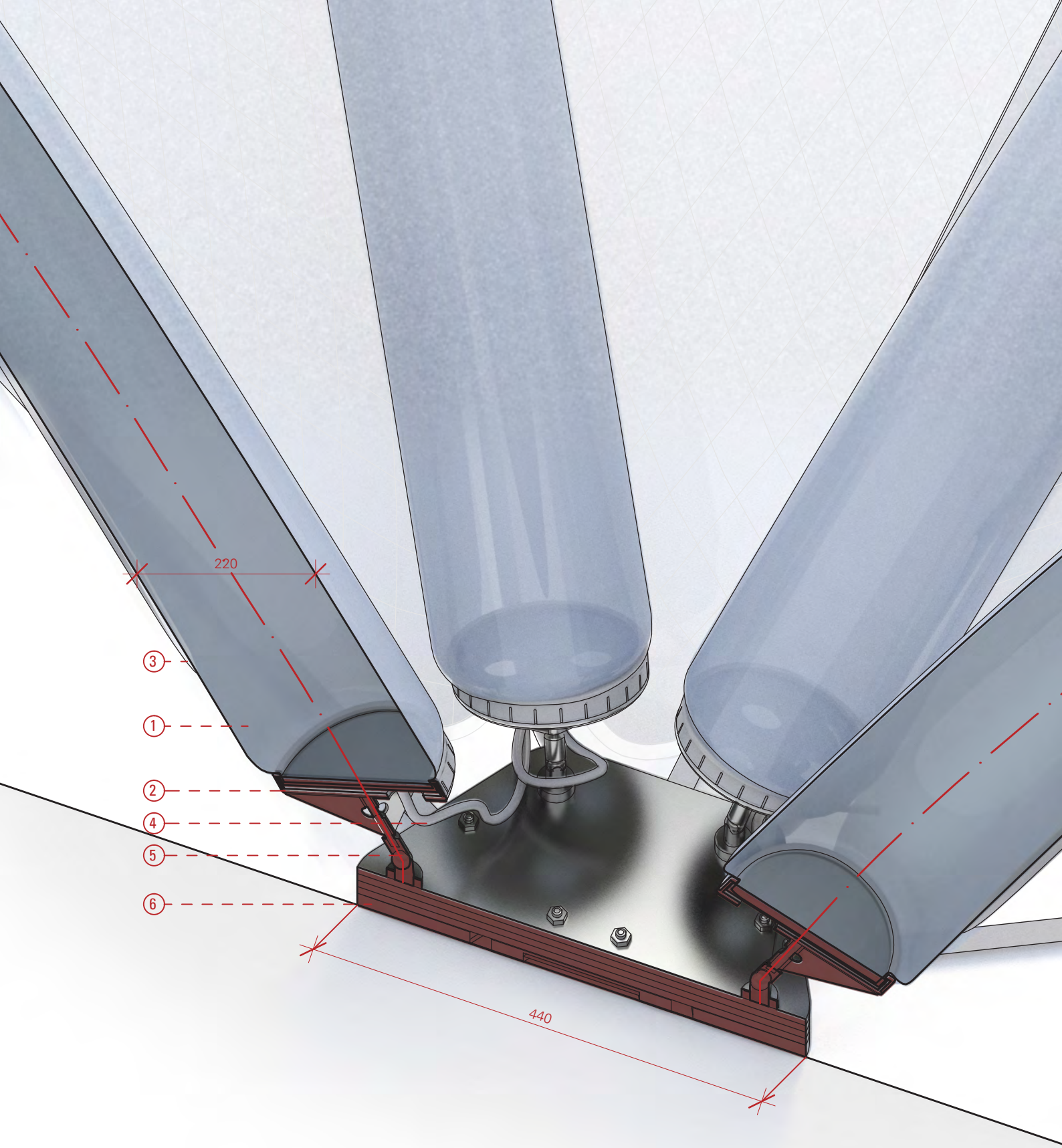



DETAIL

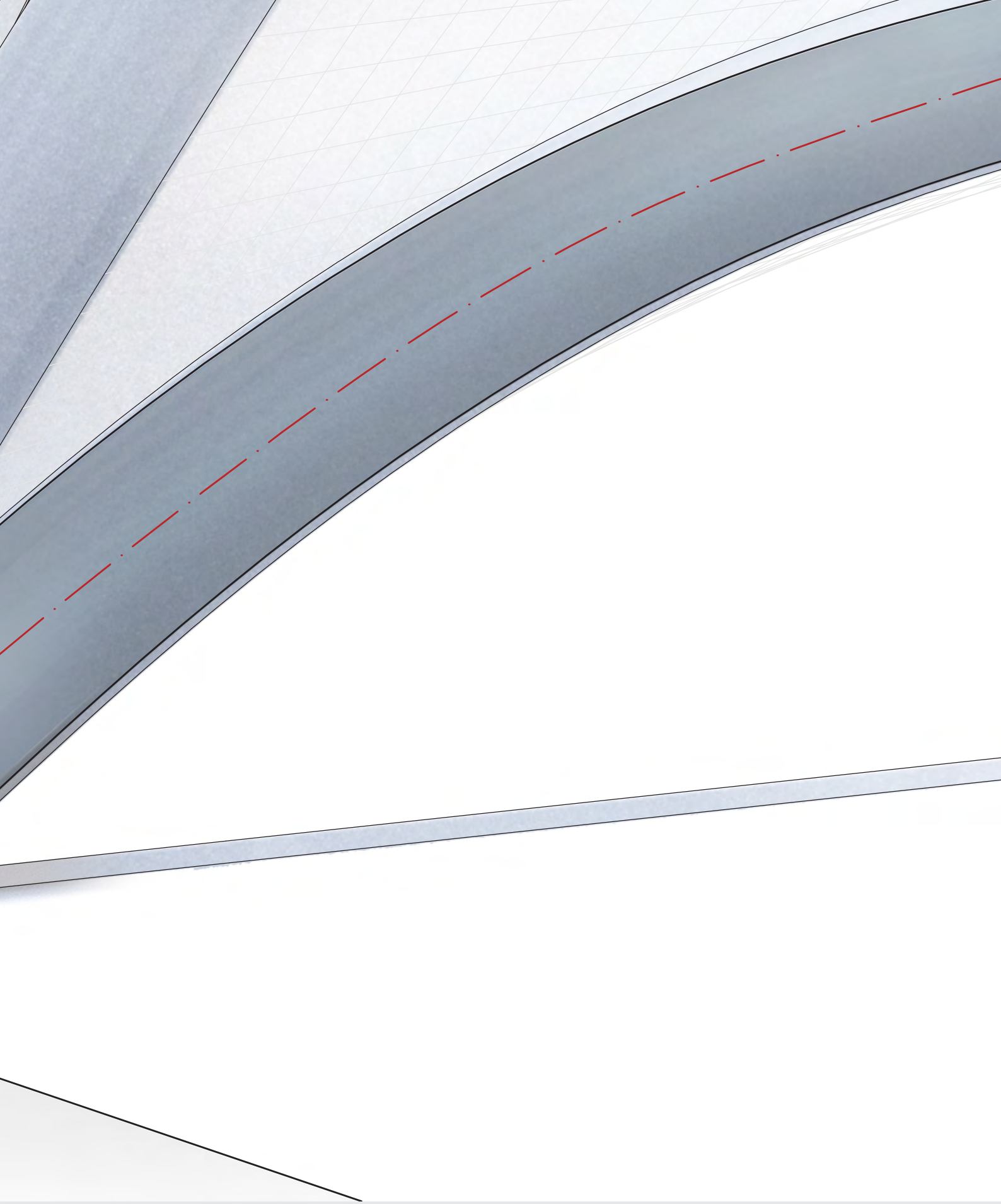




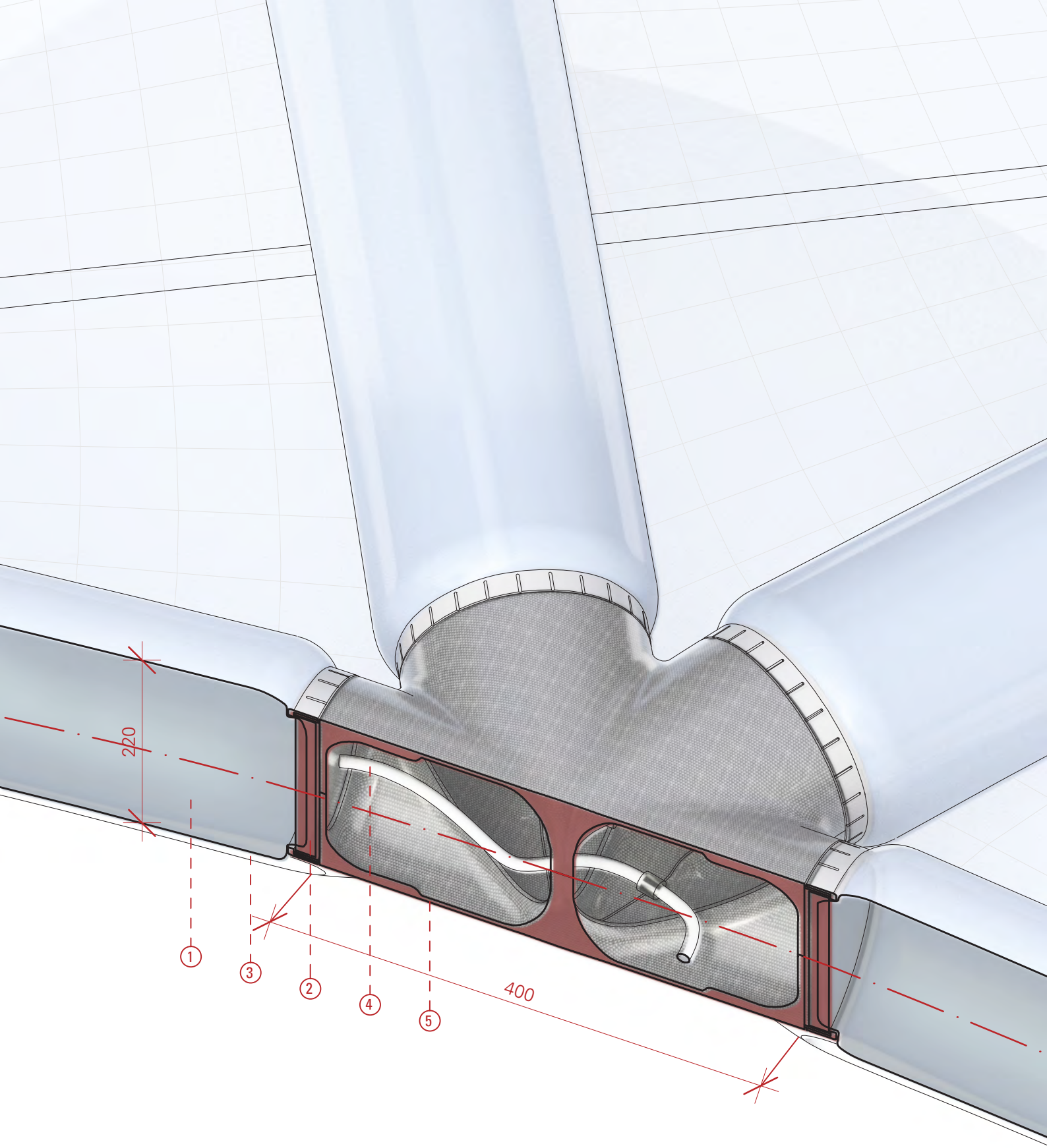




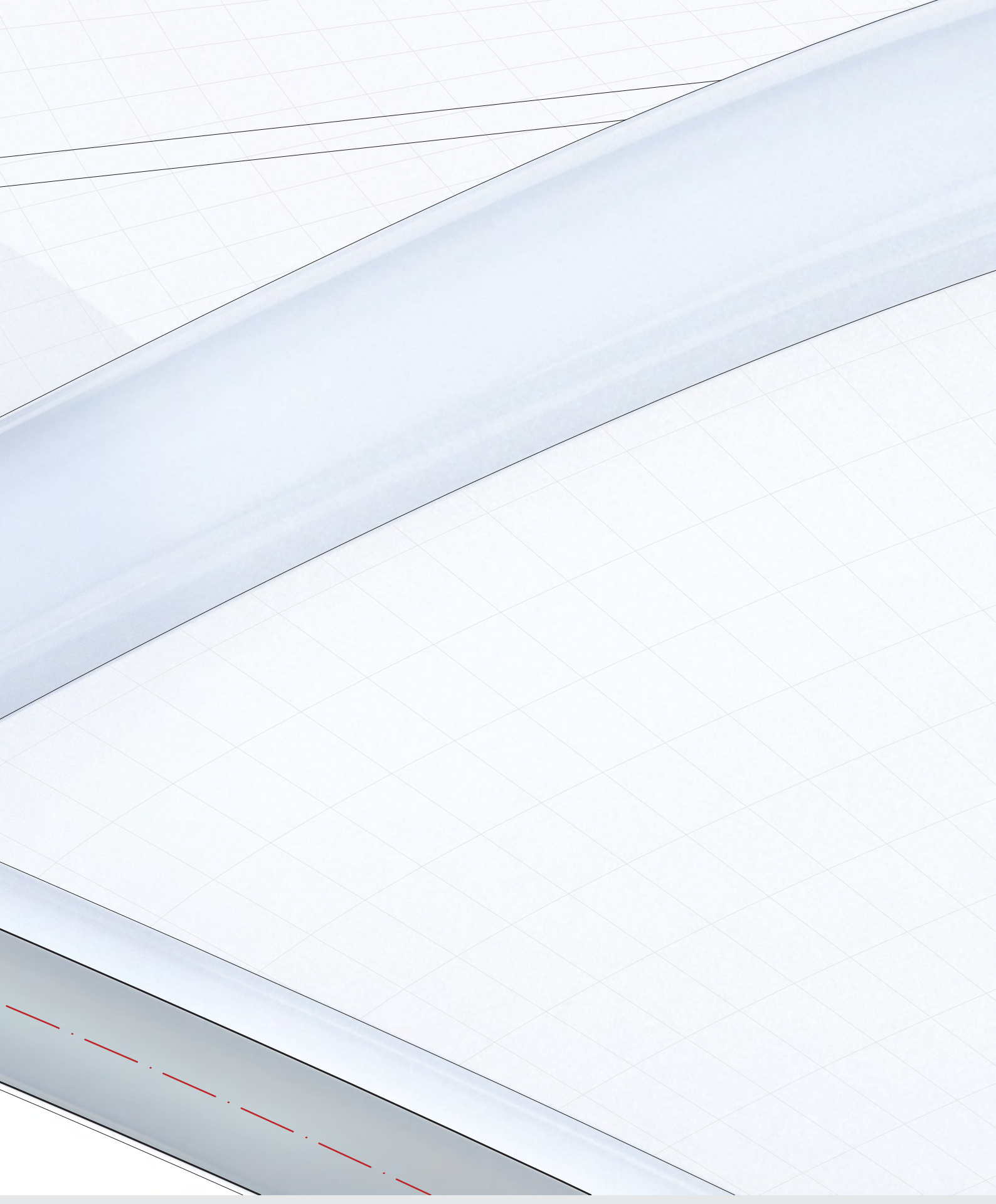
1. Air-pipe
2. Screw connection: air-pipe/base
3. Zip connection: air-pipe/membrane
4. Inflation cord: pressure supply
5. Steel ball joint
6. Steel plate: anchor



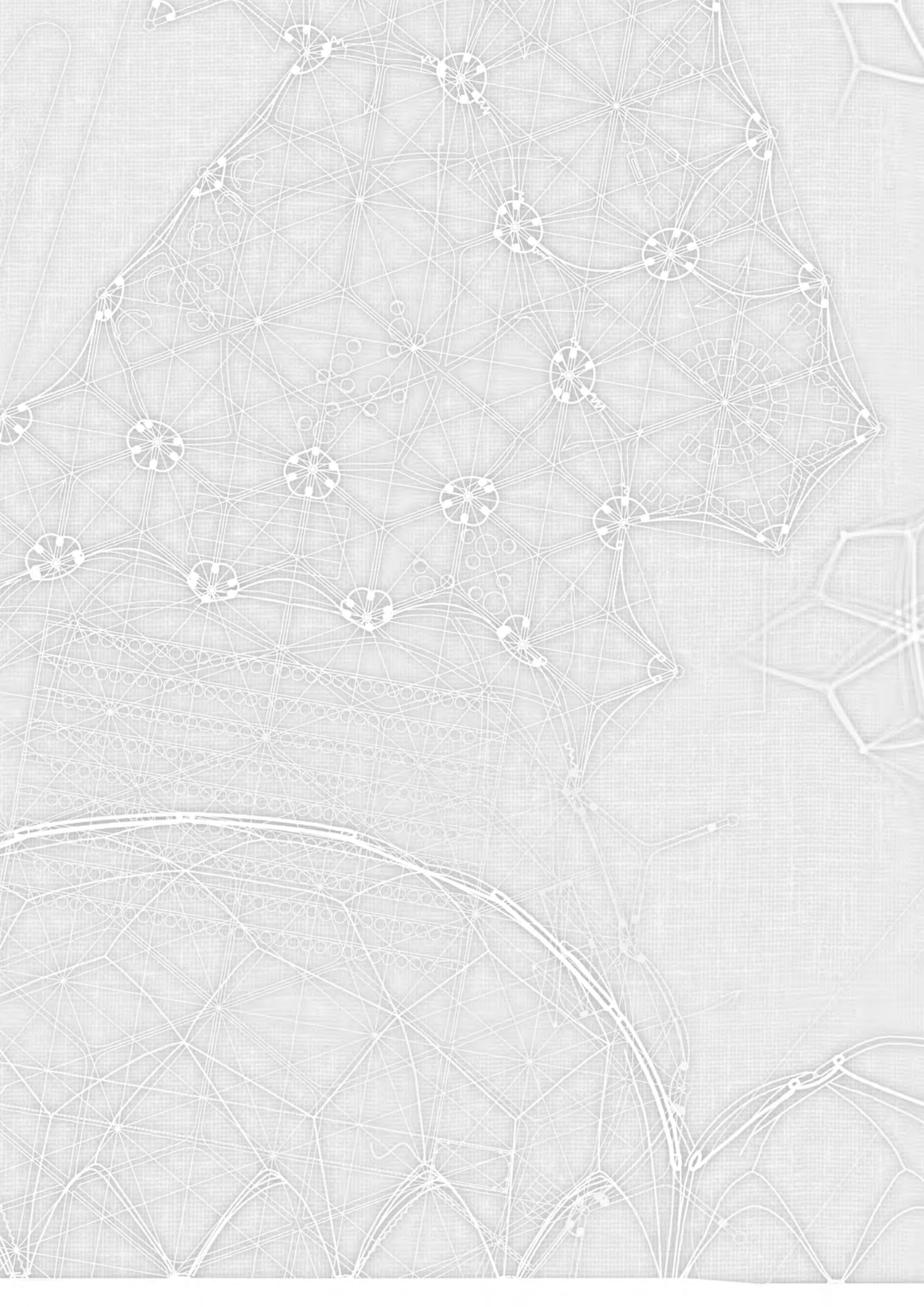
DETAIL A _ 1:5



1. Air-pipe
2. Screw connection: air-pipe/base
3. Zip connection: air-pipe/membrane
4. Inflation cord: pressure supply
5. Carbon fibre enclosre of the Knot



DETAIL B _ 1:5



VISUALIZATION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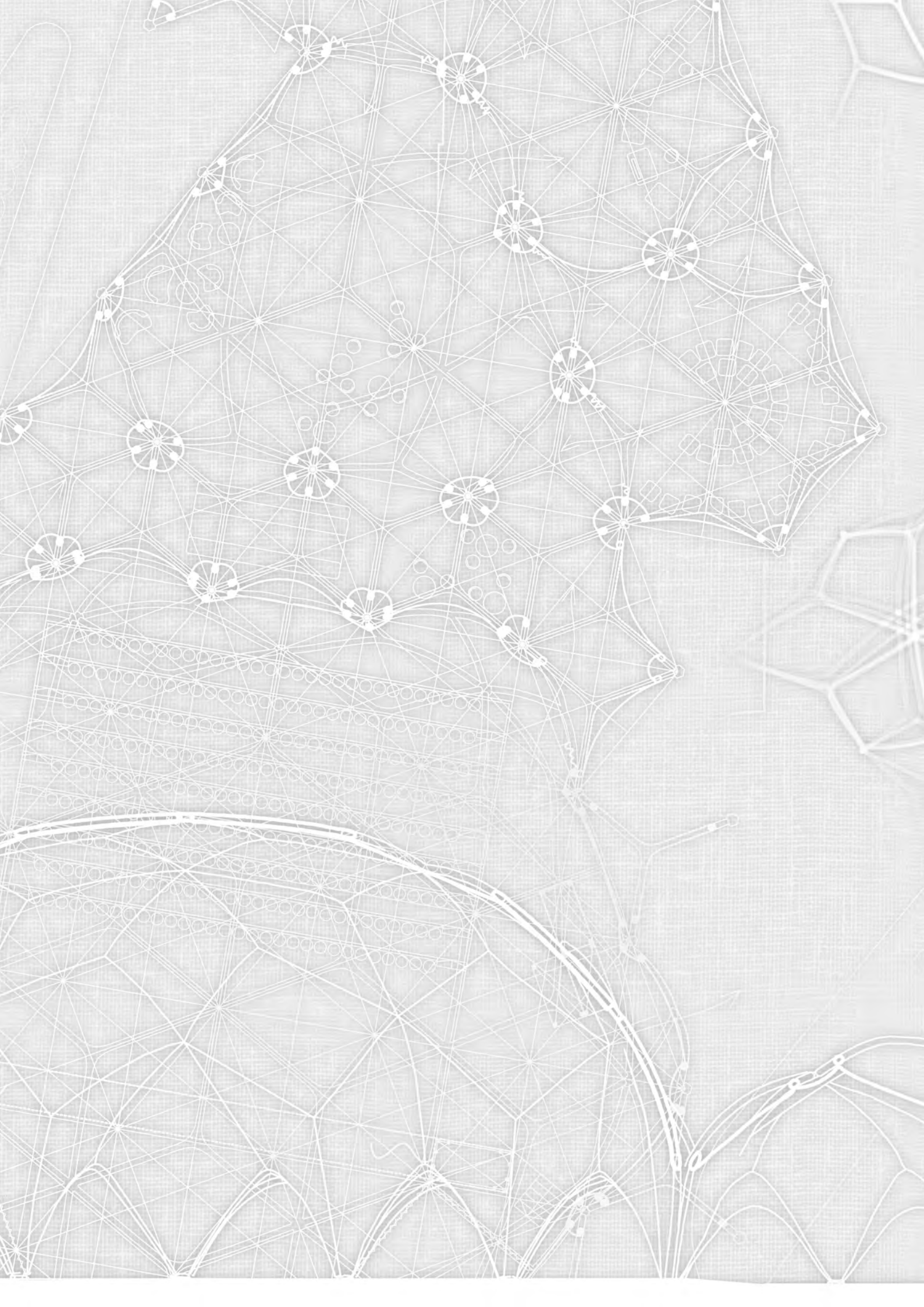
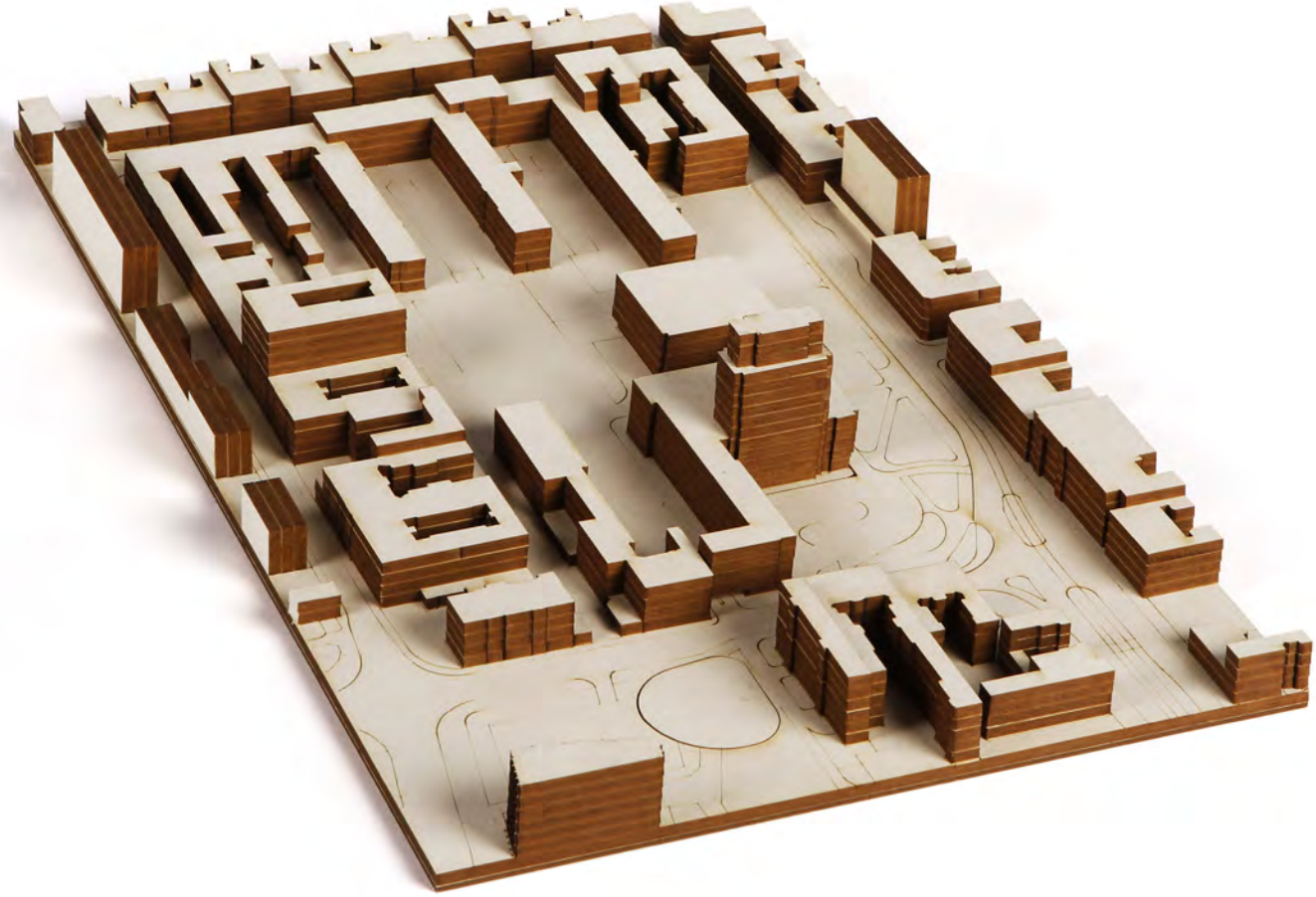
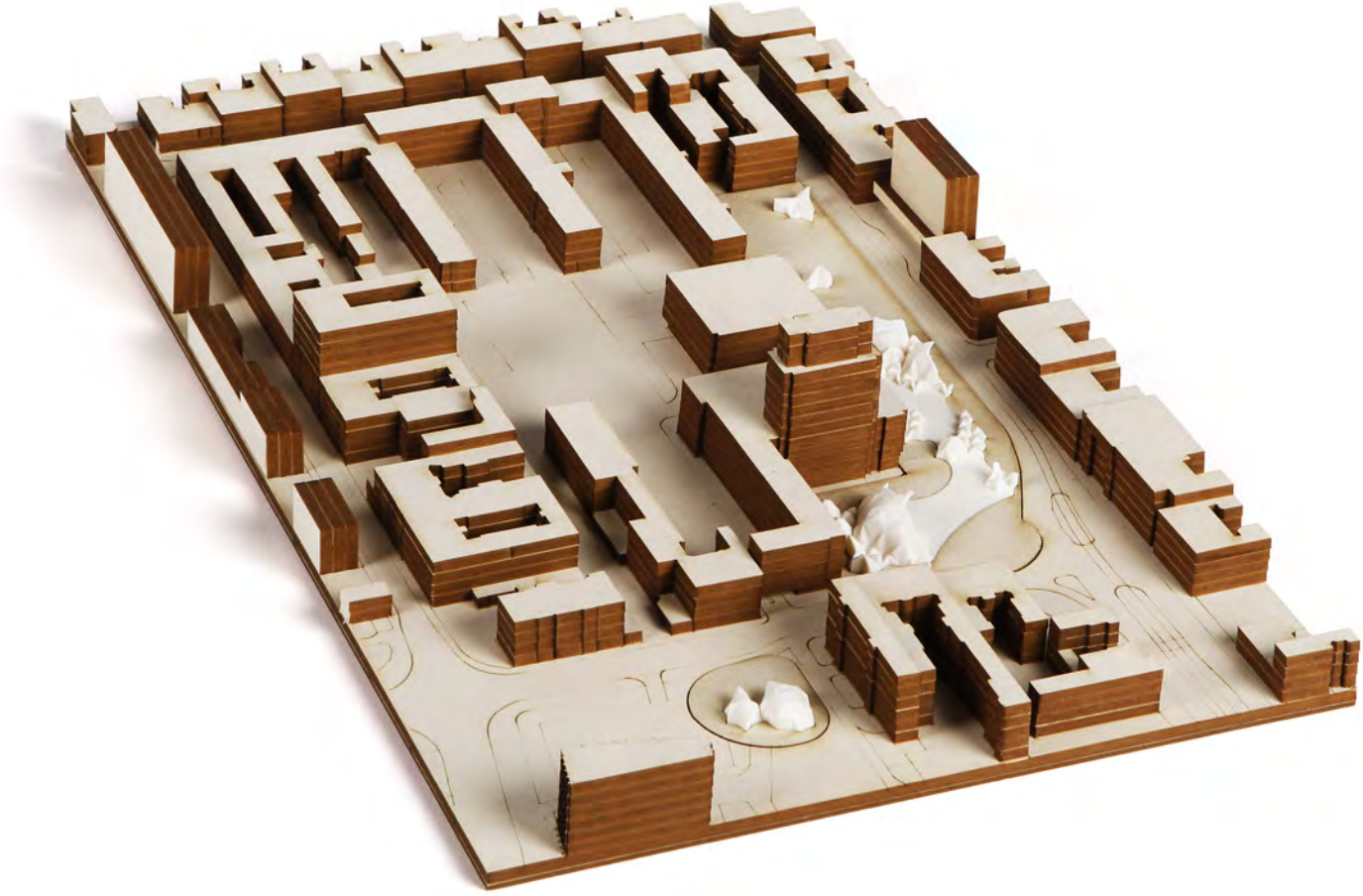



MODEL PHOTO

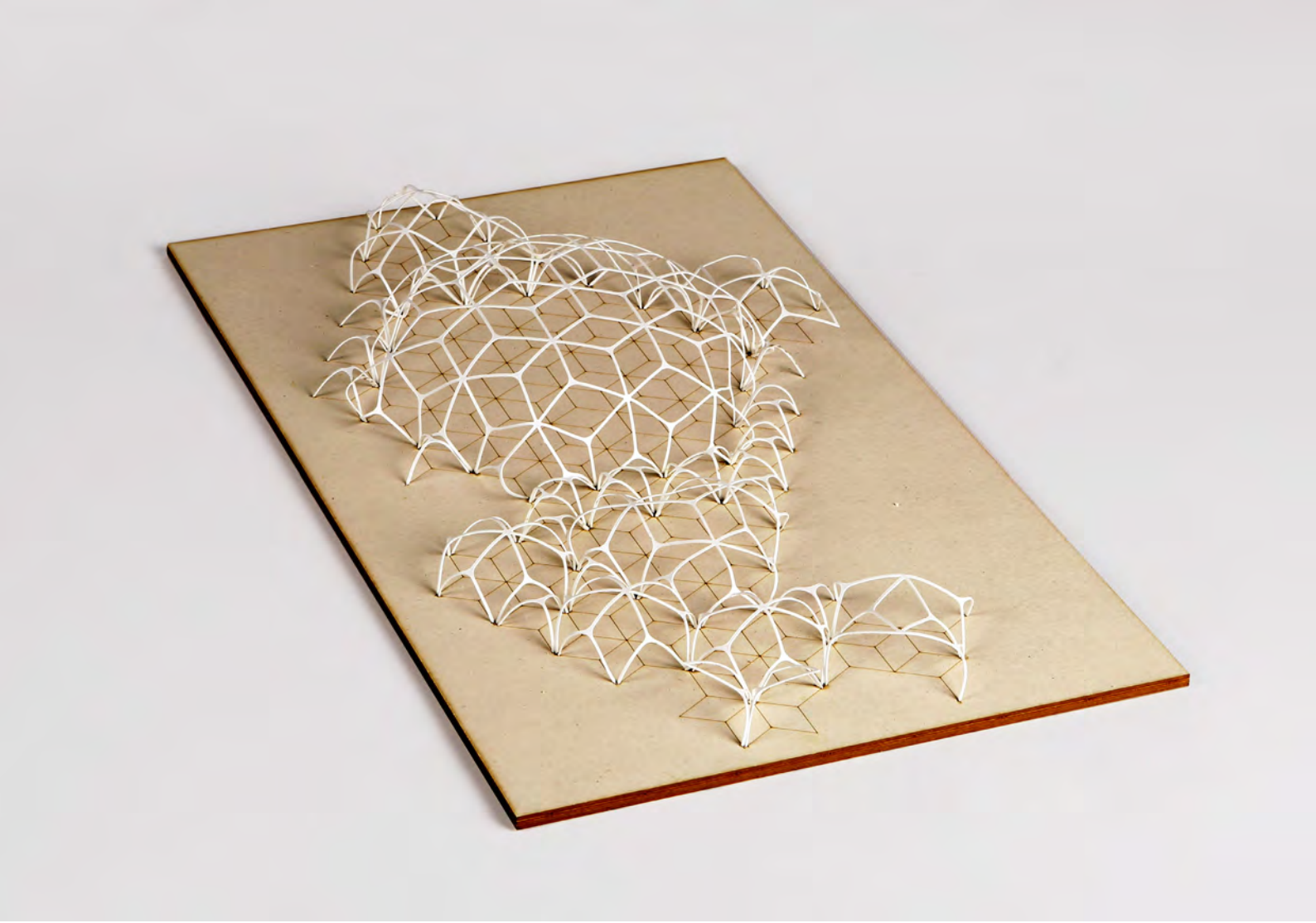


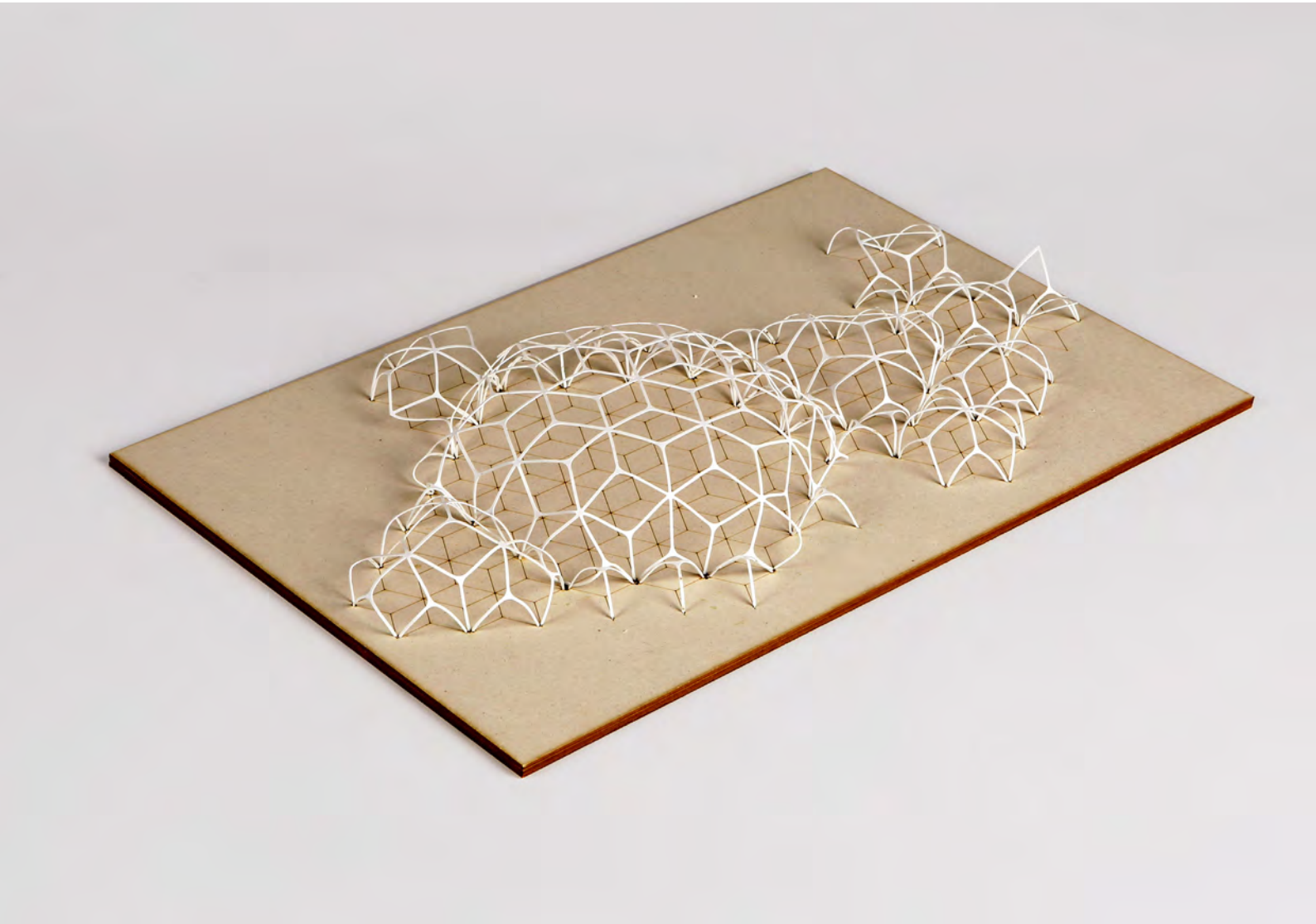
CONTEXT 1_1000

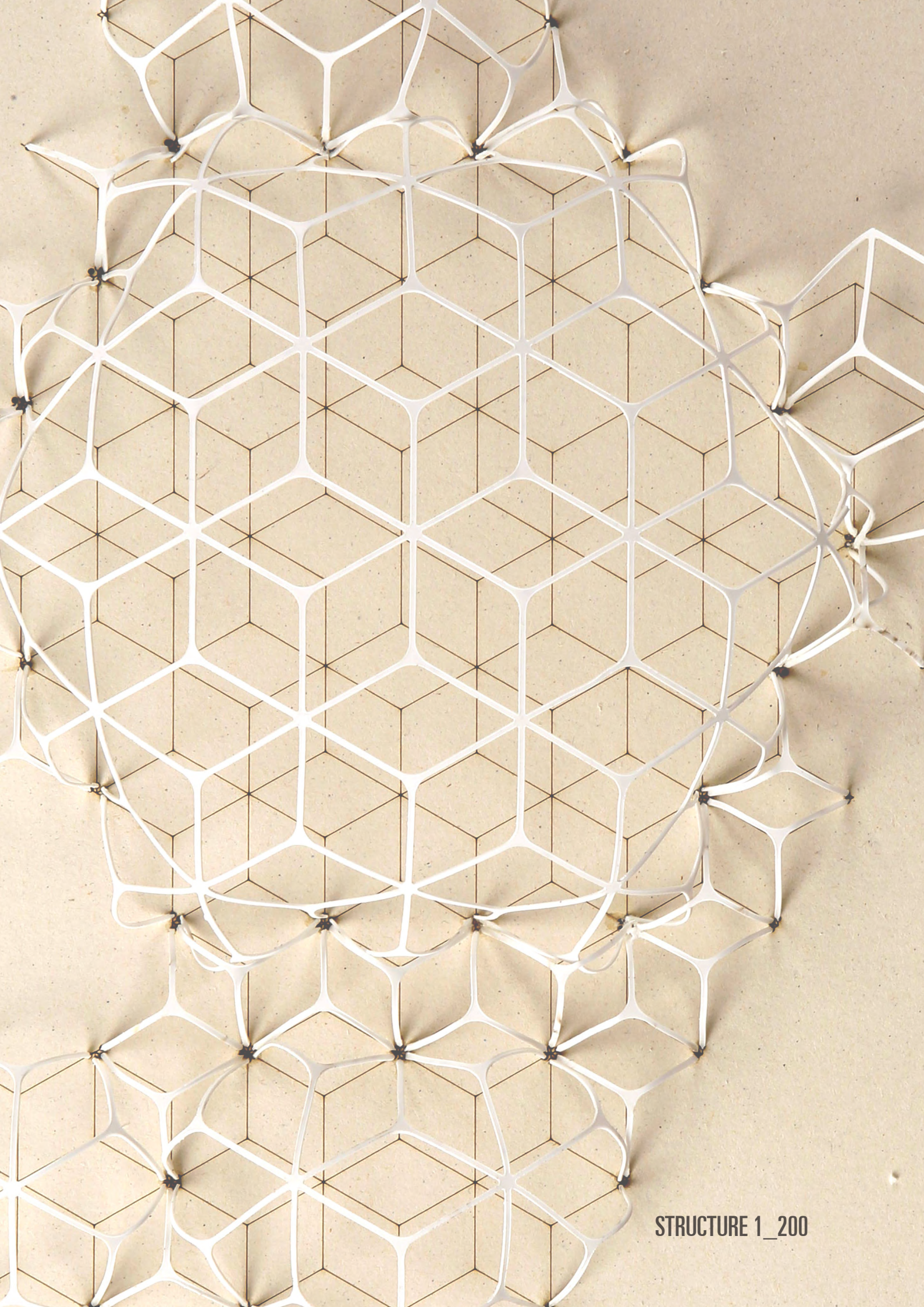
SCENARIO A 1_1000



SCENARIO B 1_1000







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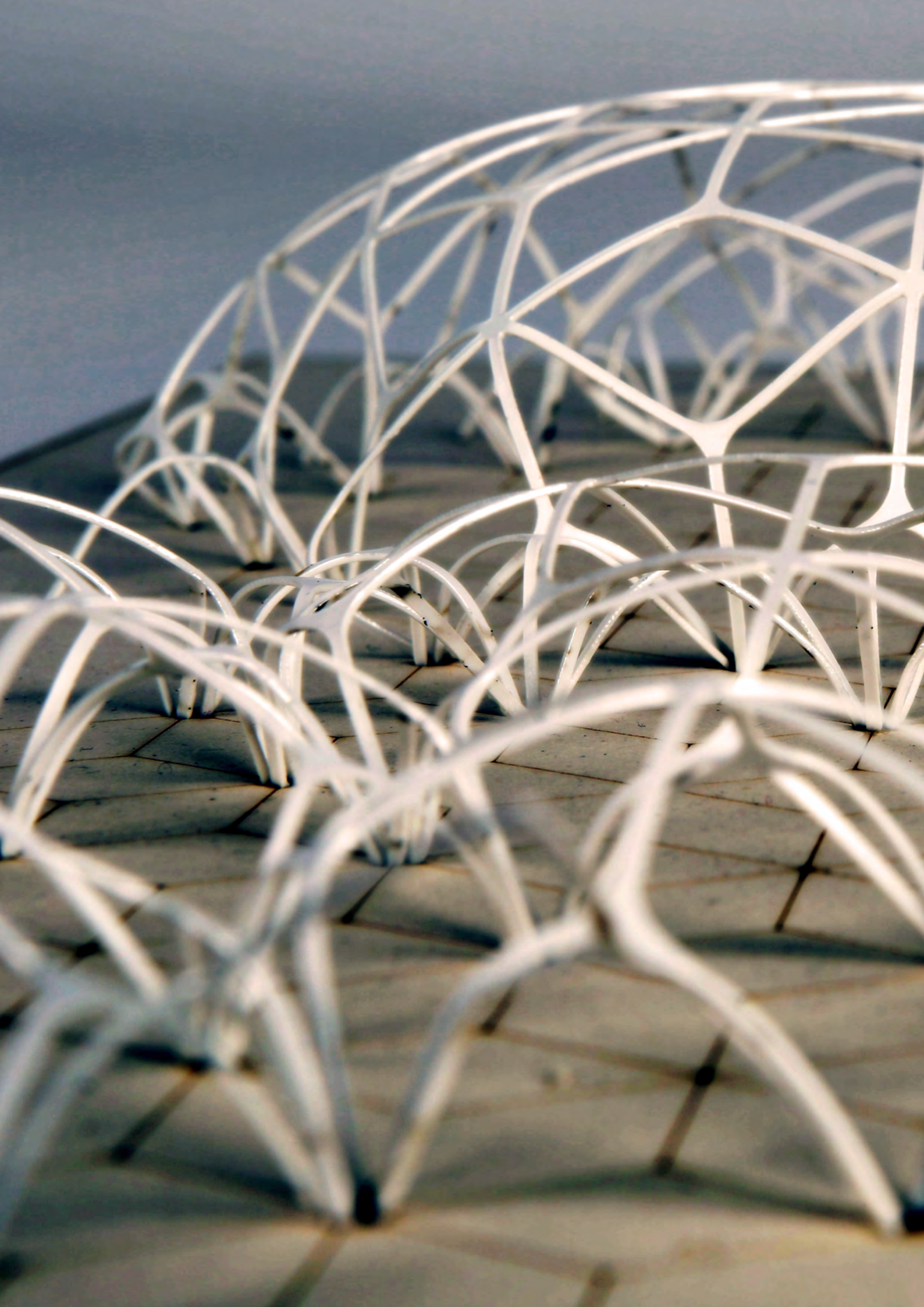

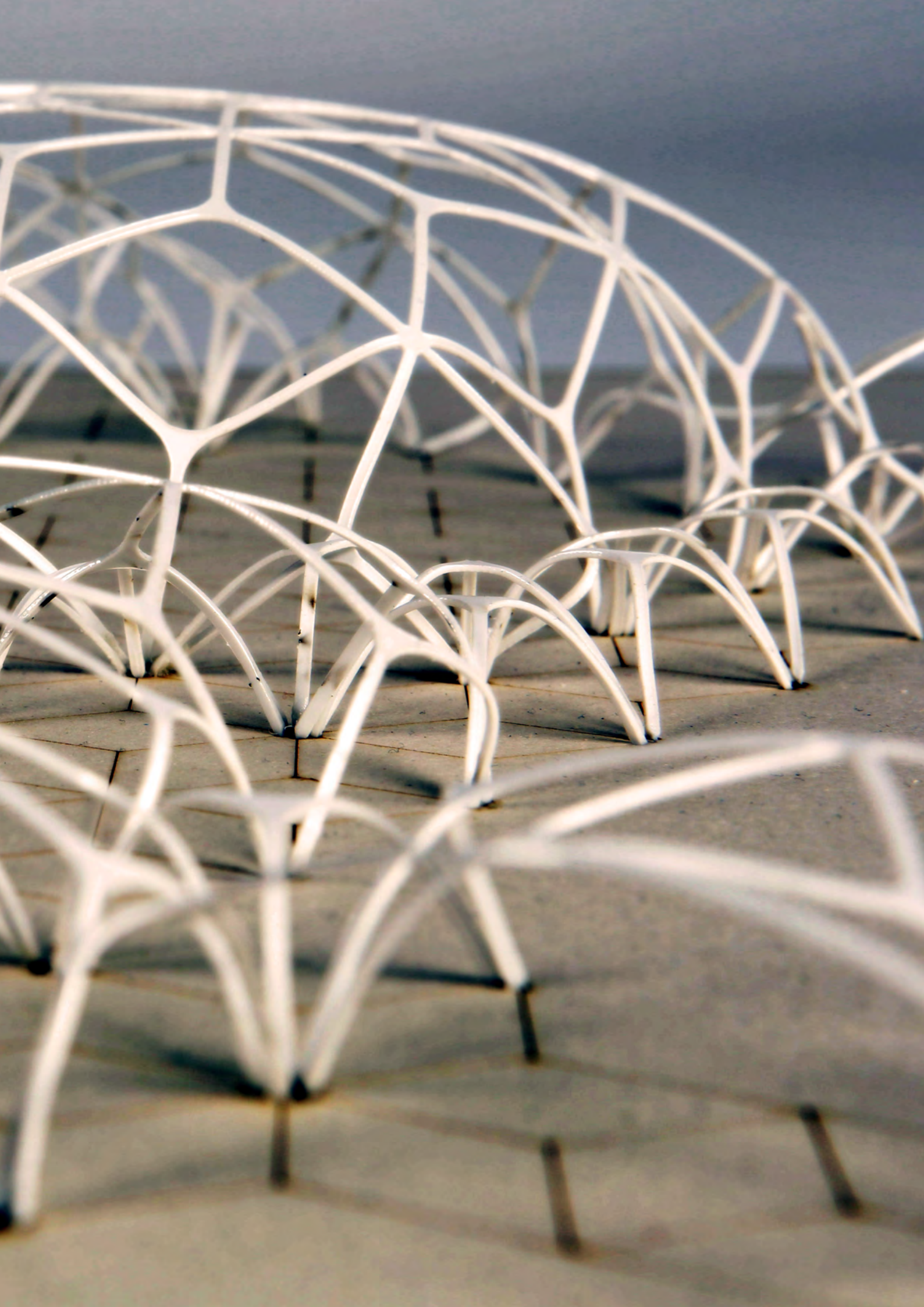

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