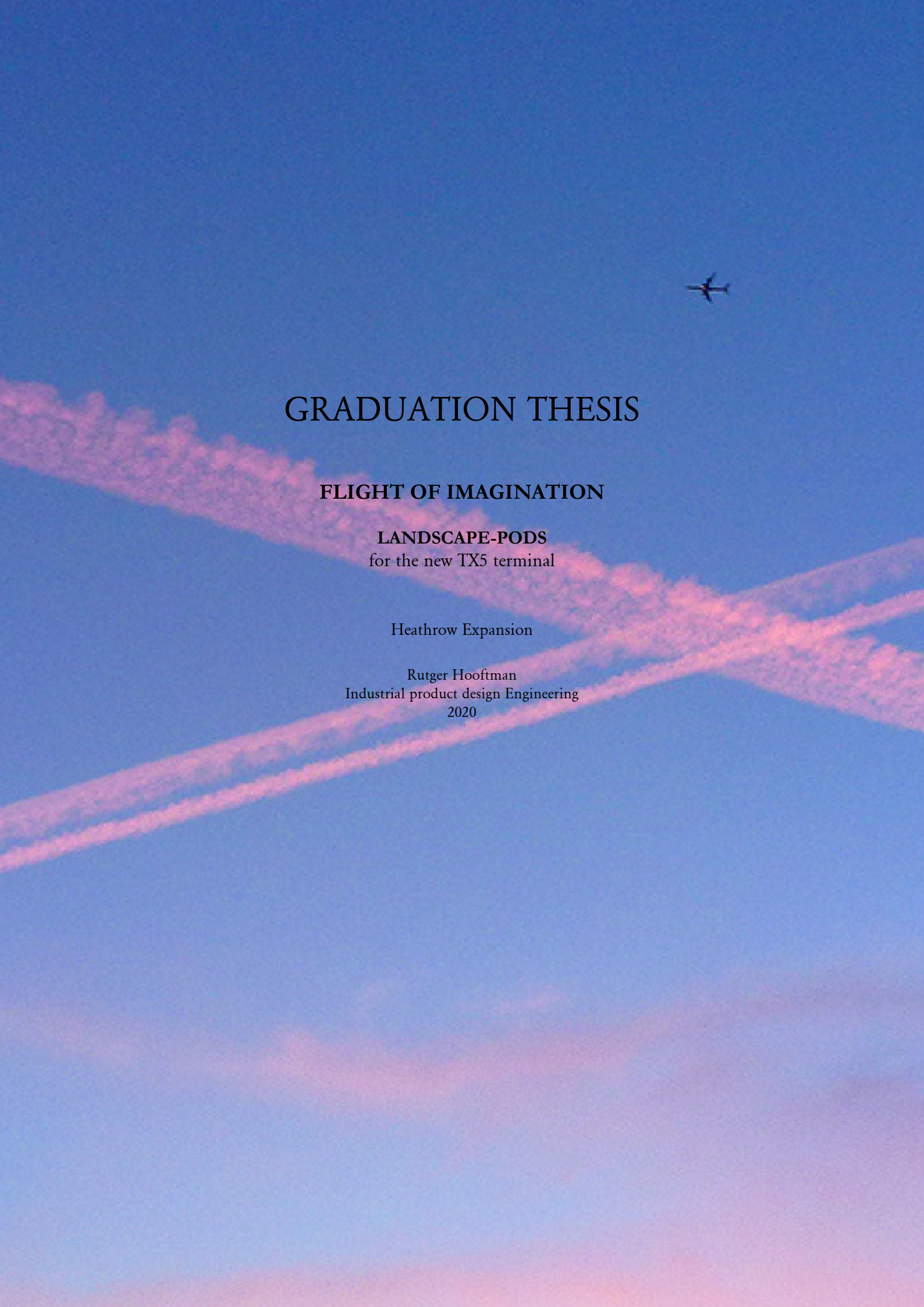

GRADUATION THESIS

FLIGHT OF IMAGINATION

LANDSCAPE-PODS
for the new TX5 terminal

Heathrow Expansion

Rutger Hooftman
Industrial product design Engineering
2020

2020

Rutger Hooftman

FLIGHT OF IMAGINATION
Third space concept for the new TX5 terminal:
LANDSCAPE-PODS
Faculty of GROSS. MAX.
HAN University of Applied Sciences

Thesis **Rutger Hooftman**, graduating report for the study **Industrial Product Design Engineering**
at the **HAN university of applied Sciences**.

June 2, 2020

Subject

Designing a product within the third space concept for Heathrow's new TX5 terminal.

Client

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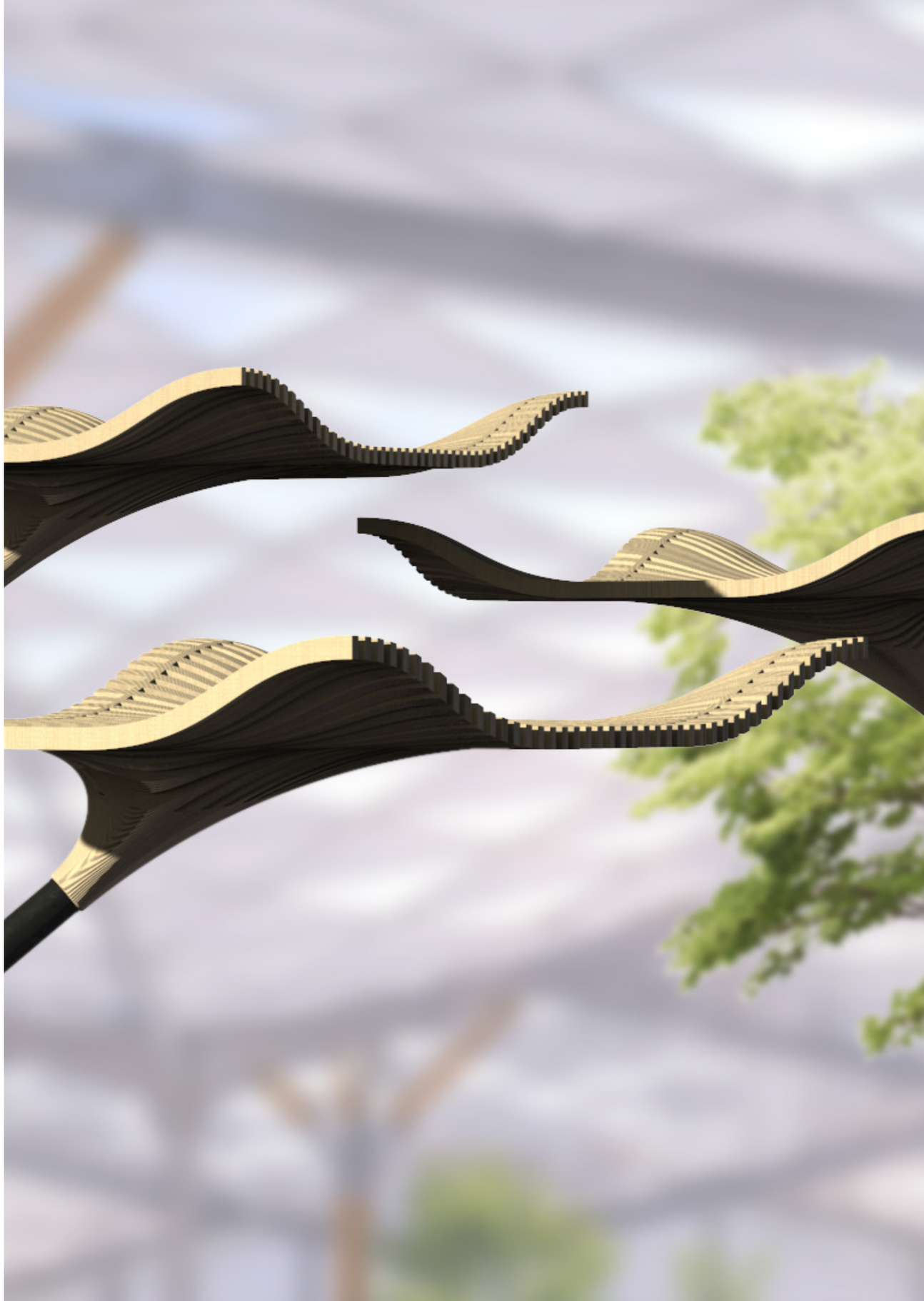
SUMMARY

Airports are reinventing themselves. A focus on passenger experience is of key importance. The expansion of Heathrow, one of the largest hub airports in the world, incorporates the design of a new terminal concept called the Third Space. This concept comprises of one large canopy roof providing daylight and a blurring between inside and outside and combining departing and arrival by creating in effect an expansive covered urban plaza. The thesis assignment was the design of a flexible and modular landscape pods to be incorporated within the terminal building. To develop such a product meant I had to critical position myself as a product designer within the other professional fields such that of architecture, landscape architecture and engineering in order to create an atmosphere of dialogue, review and feedback. The design process as being described and illustrated consists of a series of successive phases or stages, going from initial assignment to problem statement and program of requirement to design exploration to the final product and prototype development. The proposed final design of a canopy structure aims to resolve some specific aspects which may adversely result of the Third Space concept. The proposed product will alleviate stress on passengers by means of control of daylight and acoustics, sense of orientation/wayfinding and the provision of a sense of intimacy. The actual product form is the outcome of an elaborate design process with combines both the practical and theoretical. Its sculptural form is inspired by notion of biophilic design and the application of the method of biomicry. Whilst the canopy structure has been purposely designed for the Heathrow Third Space terminal concept; dialogue with various international manufactures indicate a genuine product interest for distribution and adaption to a larger market.

TABLE OF CONTENT

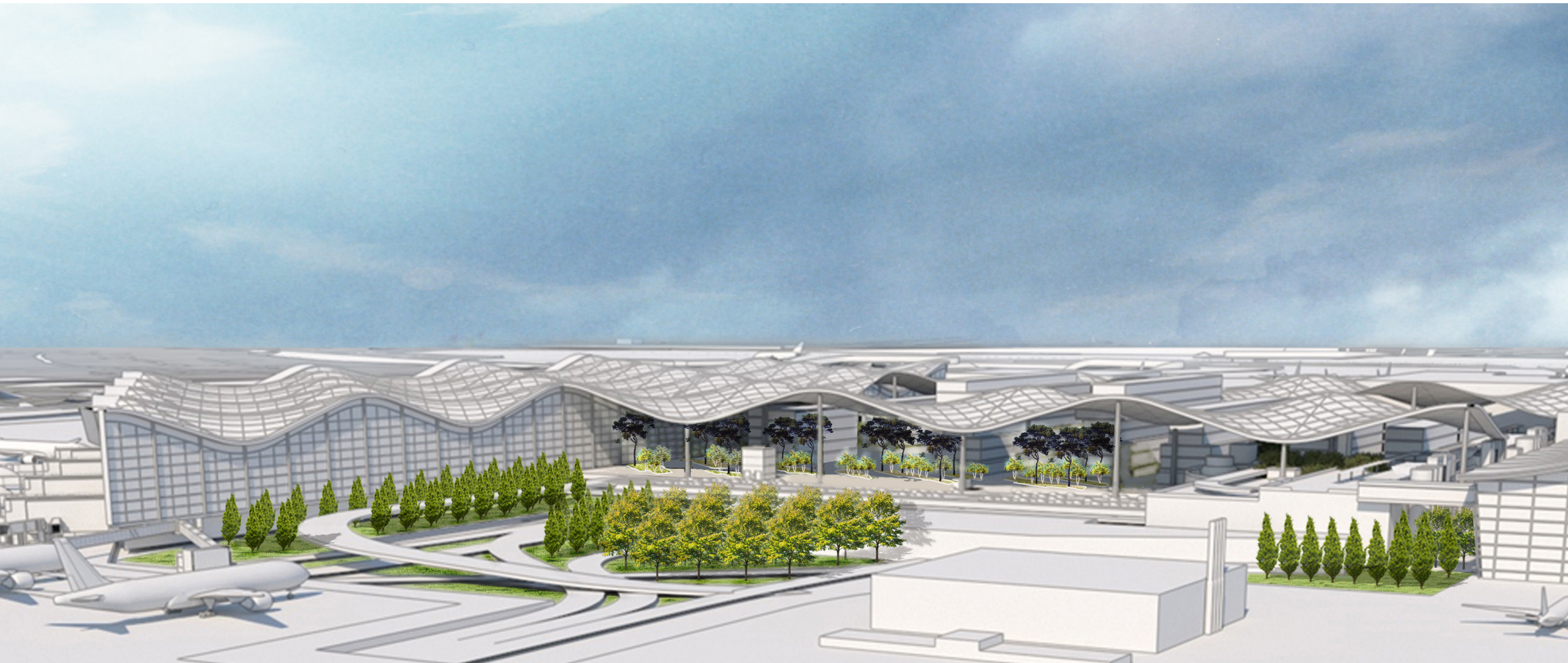


INTRODUCTION

This report presents the design-process of a product envisioned to optimize the passenger experience as integral part of the new TX5 terminal of the Heathrow Airport, London. The opportunity to engage as aspirant industrial product designer with the complex and interdisciplinary project of the expansion of one of the world's largest airport was both a challenging and rewarding experience. The choice of work place for this thesis project was motivated out of my interest in the interaction between man-environment-product. The opportunity to undertake my thesis project at GROSS. MAX. landscape Architects allowed me to continue and expand this field of interest. Their Edinburg based office of 15 landscape Architects is truly international both in terms of their staff and location of their projects. The project discussed with GROSS. MAX. prior from departure from 'low land to high land', was for me to collaborate and contribute towards the Heathrow Expansion Project. This project allowed me to engage with a wide range of disciplines; not just landscape but also architects of Grimshaw Architects and engineers from companies such as Atelier Ten. In dialogue with GROSS. MAX. and Grimshaw I defined and shaped my own project within the overall context of the new terminal proposal. The final choice of product has been motivated as result of a focus on the passenger experience and a critical appraisal of the proposed new terminal concept. As part of my journey I also encountered and exchanged ideas with a range of product designers, either working at Grimshaw or as part of my presentation and discussion to a range of (international) manufacturing companies.

The design process as being described and illustrated in this report consists of a series of successive phases or stages, going from initial assignment to problem statement and program of requirement to design exploration to the final product. Each of the key design stages form a separate part of this report. Part one focusses on defining a problem statement, part two describes the process of design exploration and part three focusses on the product development. Each part of the process is the result of analytic enquiry and makes references to specific design theories. As said, the design process as being discussed in this thesis study is argued as a series of rational decision, however it also contains moments when suddenly there is a spark – an inductive jump- so don't be distracted if you also will encounter some pages on ray fishes.

Finally, design is maybe better explained as a cyclical rather than linear procedure. The steps I took to develop my product proposal was very much the result of a sequence of conference meetings. These regular interim presentations to stakeholders acted as key milestones and valuable sources of feedback and review. Within the Appendix the record of those meetings can be found.



PART 1: PROBLEM STATEMENT

Predence

P. 14

Context

P. 18

Orientation

Target group Research

P. 20

Theory Prospect and Refuge

P. 26

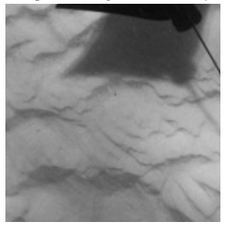
Environment Research

P. 28

Analyze

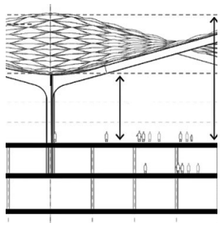
PART 2: DESIGN EXPLORATION

Biophilic design- Biomimicry



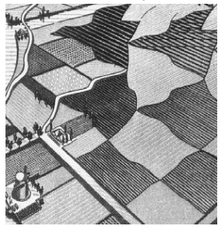
P. 54

Architecture



P. 52

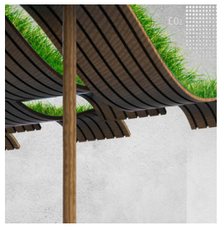
Modularity



P. 50

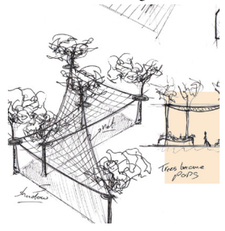
Form Study

Product Ideas



P. 44

Sketching



P. 42

Ideation

PART 3: PRODUCT DEVELOPMENT

Convergence of Form

P. 60

Concept testing

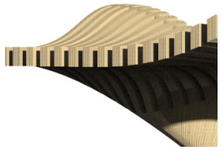
P. 66

Concept visualization/choice

P. 68

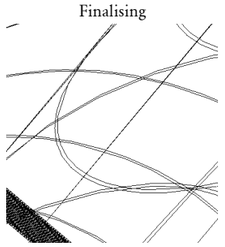
Conceptualization

Materiality



P. 92

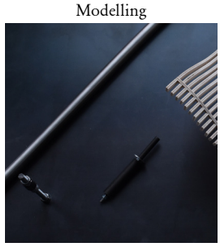
Finalising



P. 100

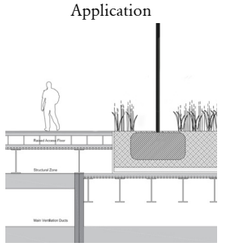
Finalising

Modelling



P. 104

Application



P. 116

RESULT

PART 1: PROBLEM STATEMENT

Heathrow Expansion
New TX5 terminal-
LANDSCAPE-PODS

APPROACH

The Heathrow expansion Project is one of the largest infrastructure projects in the U.K.
This large-scale project goes along with many design consultants, stakeholders and a complex system of planning and decision making. Furthermore, the project covers a long-time span, up to 2050 and therefore must be seen from a ***futuristic perspective***. Because of the complexity and scale parts of my research is approached from a ***top-down perspective***. It is important to understand the bigger picture. To distill and define out of the abstract and the speculative a distinct and manageable product proposal as part of my thesis project is equally important to focus on the concrete and the specific. For example, determining the complex interactive position of the product from the perspective of the main user e.g. the passenger. Therefor parts of the research are more zoomed-in and on a smaller scale, seen from a ***bottom-up perspective***. An important aspect in my research is a focus upon the passenger's wellbeing and human's connection with nature. In summary; an approach which reconciles the large-scale master planning of built environment (architecture, landscape, interior) with the specific experience of the user. The task is to make a fit between form, context and user.

THE TASK

The original task as discussed with GROSS. MAX. was the product design of a 'landscape pod'. The idea of integrating landscape and architecture in the new TX5 Terminal and blurring the boundaries between interior and exterior space demands close collaboration between the disciplines of landscape architecture, architecture and engineering. The idea was that the landscape pod would manifest the overall concept in a flexible and possible modular product design. To develop such a product meant I had to position myself as a product designer within the other professional fields and create an environment of dialogue, review and feedback. My product development could be compared to the art of acupuncture; where would you put the needle to have the most impact. In other words; could I come up with a product by which of minimal economy could reach a maximum result. As a product, it should be not a one off but in number should be able to be manufactured as part of an industrial production process. An important aspiration of Heathrow is to become one of the most sustainable hub airport in the world. The product must be integral and supportive to this vision.

PREDENCE

At the early stage of orientation in my thesis project I looked for precedence studies of where industrial designers have made an impact on the design of airport terminals. One of those precedence projects I found close to home at Schiphol Airport Amsterdam and one further away at O'Hare Airport Chicago.

During the 1960's the industrial designer Kho Liang Le made a great impact on the interior design of Schiphol Airport. His vision was based on clarity in lay-out with clear view lines and the use of glass in order to see the planes. In his design, he promoted notions of seclusion, hospitality, clean liness and simplicity motivated by the idea that passengers of an airport need a calm, stress-free environment. The original design of Schiphol is still widely seen as of the most successful and timeless terminal designs of all time (Bosma, 2013).

Kho Liang Ie stated:

"For me it was about the space, the calmness, the people not as many but as individual, projected opposite calm walls. With the primary objective of creating something people can find their way in."

Kho Liang Le, 1968

To achieve this Kho Liang Le did research on three main subjects:

- Walls: Module that is based on architectural structure.
- People: The passenger by doing field research and of what he was observing.
- Space: Using Calm, clear and simple forms and materials.

Lounge, serie 720, 1966
Kho Liang Ie
Photo: Jan Versnel

At O'Hare Airport Chicago, the design partnership between Charles and Ray Eames created the tandem seating in 1962. The sealed leather pads and polished aluminum frames expressed the jet age but has proven remarkable timeless as it is still produced after 50 years. It is furniture that looks good, feels good, wears well and scales well. The comfort and needs of the user were studied in minute detail. The simple modular system makes it possible to combine any numbers of units (see Fig. 1) (Eames & Eames, 2015)

Both precedence studies have the following in common:

- **Simplicity + Elegance**
- **Architectural Context**
- **Modularity**
- **Passenger Comfort**
- **Place Making**
- **Interdisciplinary Collaboration**

It is those listed aspects on the left which became important components and benchmarks in my further research as well assubsequent product development. I was inspired that the aim of my product should be to create cozy and functional spaces were passengers can feel a sense of calm while travelling.

See appendix 2 Booklet for more elaborate information regarding the precedence studies.

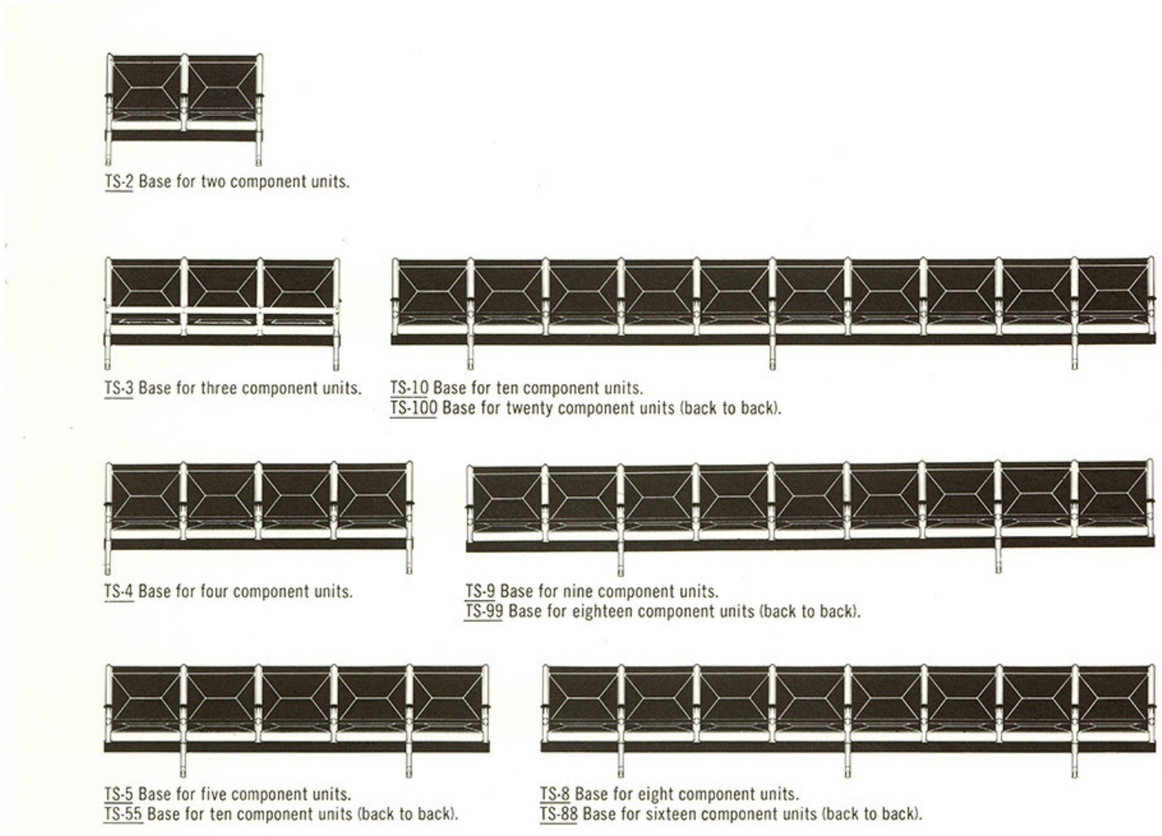


Fig. 1 - Tandem Seating system

ANALYSIS OF PROBLEM

My original precedence studies date from the more glamorous early days of aviation which arose in conjunction with the growing number of airline passengers. You could argue airports have changed when they became part of global mass transport. Since the enormous increase in scale, airports have become different altogether. Some architects, such as Rem Koolhaas, refer to them as "Non-Space' (Koolhaas & Mau, 1995). Airports are not just simple airport anymore and have become dynamic motors of urban development. With this also the particular problems connected with passenger movement changed.

With this in mind I started to outline a definition of a problem:

"International Airports like Heathrow are defined by large scale-architecture which no longer expresses a distinct sense of place. The world of flight has lost its former glamour and becomes problematic and controversial in times of climate change. Airports have become sprawling cities in their own right. The actual journey of passenger becomes mundane, hectic and prone to stress. Optimizing passenger experience is not only important for the well-being of the passenger but also for airport operation and reputation."

Towards the end of Part One, the problem description will become more defined in a problem statement. First I needed to do more in depth research into the phenomena of the contemporary airport in general and Heathrow Expansion specific. Also, the behavioral aspects of the passenger need close investigation.

AIRPORT ENVIRONMENT - Context

London Heathrow Airport is the busiest airport in Europe in terms of passenger numbers and one of the largest airports in the world. It currently operates at 99% capacity and in order to compete as a major international hub, it needs to expand with both a new runway and terminal capacity. The Heathrow Expansion programme proposals include a new northern runway situated to the north west of the current airfield and a new terminal (TX5) located to the west of the current Terminal 5 (Fig. 2). This expansion will provide the much needed additional capacity but in order to gain planning approval, the airport must meet stringent environmental and design standards. Heathrow Airport itself has also set ambitious environmental targets to become one of the most sustainable hub airports in the world. The new TX5 terminal will form a key part in meeting these environmental and design standards and contribute to the aspira-

Heathrow expect the number of passengers per year will be in the order of 130 million (Heathow Expansion, 2020). This is about 350 thousand passengers per day visiting the airport, equal to 87.5% of the total amount of the people who will be present at the airport. The amount of people that will work at the Heathrow airport will approximately be 50.000 people every day. Also, the airport will increasingly become an urban center and transport interchange for surrounding communities.

Fig. 2 - Heathrow Expansion Project size

Design principles

These are the Design Principles and Criteria for the Heathrow Expansion T5X Terminal written by Heathrow.

- Highly Integrated Public Transport Interchange & mixed-use landside commercial development
- Seamless movement between landside and terminal
- Pedestrian urban realm that provides a real sense of place

- A passenger focused terminal environment
- Unique spaces with a connection to the outside world
- Extensive natural planting to support health & wellbeing

- Dynamic climatic conditions which respond to functions
- Embedded sustainability and low energy features
- A highly transparent &lightweight structure and envelope
- A flexible and customizable modular system

THE PASSENGER- Target group

Airports serve a wide variety of passengers and they need to be carefully planned to cater to the demands of such a diverse user group. As my product design project is part of the expansion of an existing airport, my original intention was to do undertake field research and to observe and interview my key target group of the passengers at the airport. The plan was to ask about their experience at the airport and what they prefer to see and experience in the future. This would be interesting, especially if you considering passengers are all very different and therefore complicated to understand. In that sense using a method like Co-Design would have fit. Unfortunately, because of the Corona-crises I had to change my plans. So instead of bottom-up, I had to keep working from a top-down perspective and use reliable research instead.

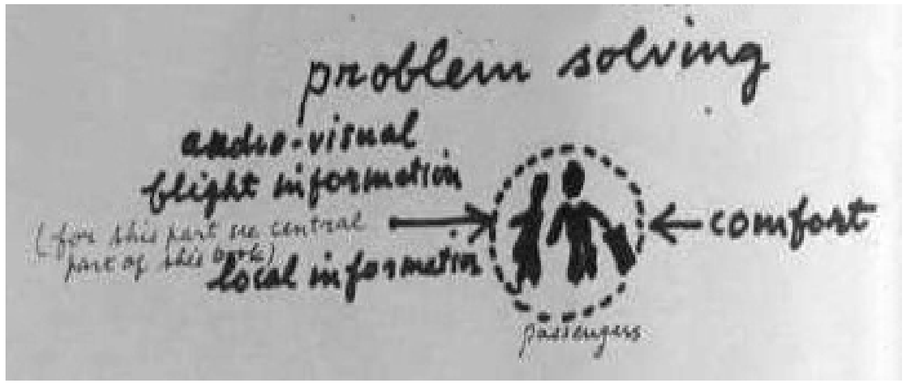
It can be said the product will probably be used by thousands of people every day.Therefor it can be concluded beforehand that the product has to withstand alot of use and unusual use which means it has to be:

- Sustainable
- Wear resistant
- Ergonomically responsible

“Wat ik vooral heb gezien, is hoe mensen zich in een luchthaven gedragen. Dat was bepalend voor mijn ontwerp. Luchtreizigers zijn nerveus en gespannen. Ik heb daarom geprobeerd helderheid en duidelijkheid aan de ruimte te geven. Ik heb grote aandacht besteed aan de bewegwijzering.

Primair is, dat mensen hun weg kunnen vinden in dat grote bouwwerk”

Kho Liang Ie, 1967 (Bosma, 2013)



Sketch Passenger research- Kho Liang Le

PASSENGER STRESS - Interaction

Although each passenger perceives the world in a different way, as human beings they also share common natural behavioral reactions to certain situations/ events. Therefore it is more than logical ACI Europe (2014) mention stress free environment as top valued.

See appendix 3 Target Passenger experience

For this reason the ”passengers experience” will be looked at from a more p**sychological perspective** and be focused on the human natural instincts instead of the person needs.

It is worth mentioning the definition of ‘stress’ can be interpret differently and has diverse perceptions and expectations. According to Selye (1976) stress is triggered by a stressor, which is any nonspecific stimulus that creates stress reaction. In most cases, it is more than one stressor that makes the person feel stressed, the combination of multiple stressors of which the last stressor provokes the actual stress reaction. This activates the person who is in relaxation state. In brief, the objective is to find the right stressors to react on (Selye, 1976).

”The presence of the aircraft combined with its unreachability, the absence of another seat on a flight for forty-eight hours, the cancellation of a day of meetings in Tokyo, all these pushed the man to bang his fists on the counter and let out a scream so powerful that it could be heard as far away as the WH Smith outlet at the western end of the terminal. ”

Alain de Botton, 2009, pp. 33

For this reason, I used a model created by Stoop & Snelders (2017) called design for relaxation. This model can be used to develop future products to counter levels of stress. This model shows several stages in the stress process that are influenced by (multiple) factors. These factors can be addressed by design strategies. One strategy that fits the LANDSCAPE-PODS is ”acting on stressors”, which basically means when a person is aware of the stressors and their effect it becomes possible to act on the stressors and eliminated or re-evaluated them as non-threatening (Stoop & Snelders, 2017).

We also do know the LANDSCAPE-PODS will be in the environment of the airport and have influence on the passengers behavior. A good example of this is written in ‘Guidelines for passenger services at European Airport’s”, where they state that the physical areas and associated activities have strong connection with the passenger’s level of stress (ACI Europe, 2014). Censuswide has also done research on this topic. They surveyed over 1.000 UK residents. One of the questions they investigated was ”what part of traveling to or through an airport do people find the most stressful?”(Priority Pass, 2019).
These are the results:

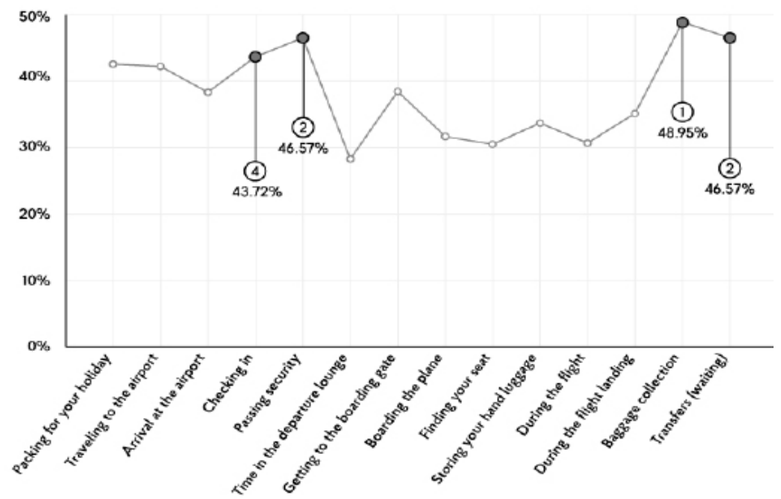


Chart: 1

Censuswide also mapped out a diagram related to the stressful acitivities:

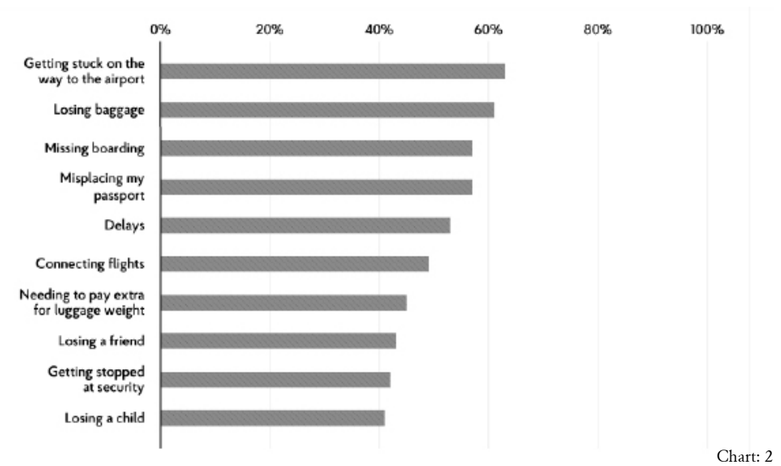


Chart: 2

This research not only shows the ”general” stressors that are present within the context of air traveling, but also shows the important relationship between stress-level and environment. A clear motive to interpret the concept of stress from a more environmental point of view.

Of interest to note is that the most stressful parts are usually at the start of the passenger path; coming to the airport, checking in at the security check. Once passengers get past security, they usually relax (Finavia, 2018).

” Stress has been defined as a state that occurs when people are faced with demands from the environment that require them to change in some way”

Veitch & Arkkelin, 1995

Importance is boosting passengers’ confidence levels and sense of control. Frequent travelers, on the other hand, will create their own routines and favorite spots which can reduce stress.

Large crowds make it difficult to control personal space and privacy and make people more prone to experience negative emotions.

Besides the environmental stressors, chart 2 shows two of the most stressful activities are getting stuck on the way to the airport and missing boarding. These two stressors are in strong relation with time. When the passengers miss their flight, it will have effect on their schedule and in most cases cost money. Because passenger want to avoid this, they experience a high level of stress. Acting on this stressor and creating a kind of ”time out” can potentially have a positive effect on the wellbeing of the passenger.

PROSPECT AND REFUGE- Theory

As we have seen, in large part, airport stress is related to a person's need to control his or her environment. From the perspective of environmental psychology, humans have a natural need to control their environment. Working in the context of a landscape architect's practice I came across an interesting landscape theory of "prospect and refuge". This theory describes why certain environments feel secure and thereby meets human needs. This theory is proposed by a geographer named Jay Appleton in 1975. Appleton (1975) states the following:

We humans seek out opportunities to prospect:

- Explore environments
- Find opportunities
- Perceive/acquire visual information

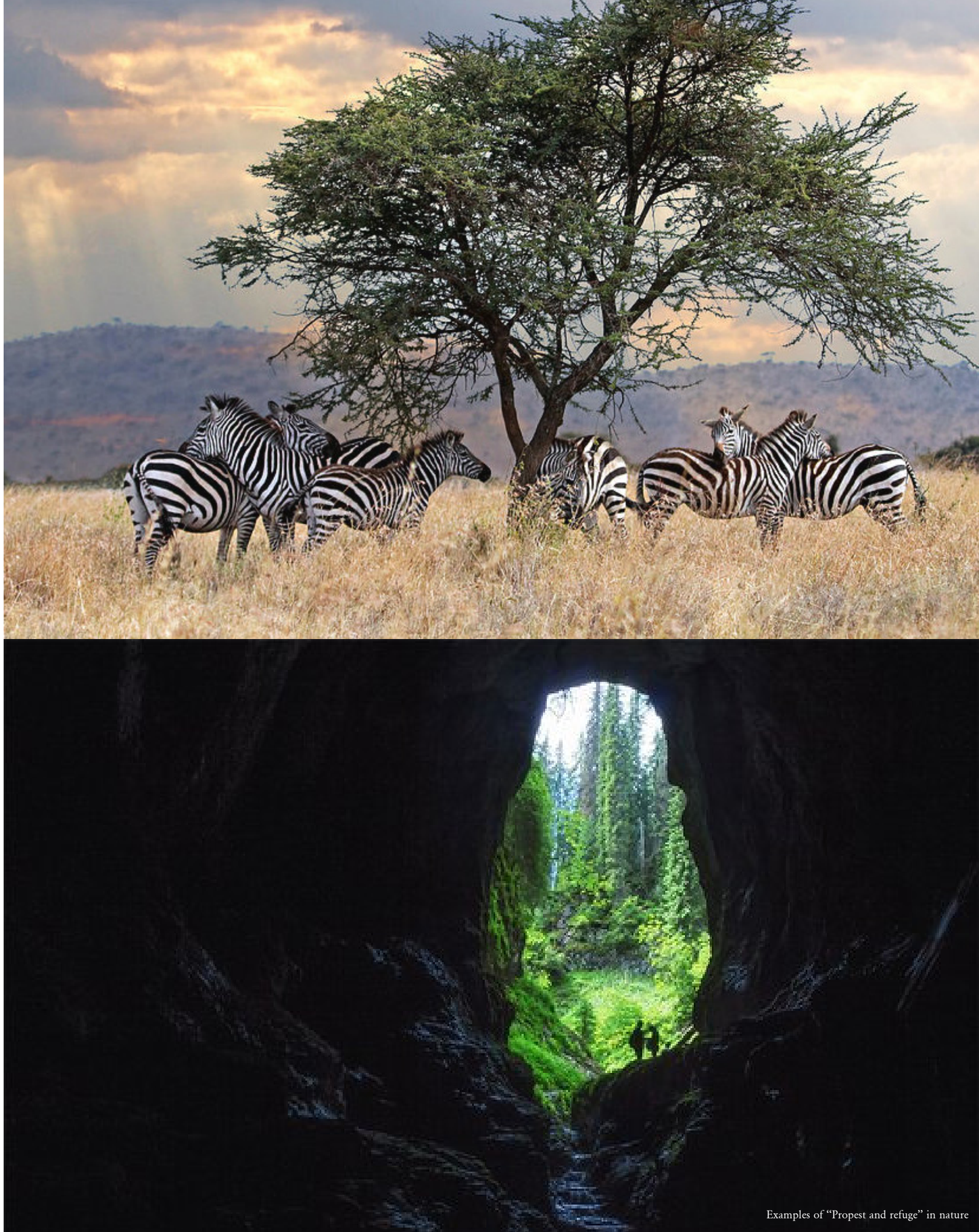
and to refuge:

- Protection
- Shelter
- Environments to hide away

This theory can be connected to architecture and the way they design space.
Prospect and refuge can have positive or negative affect on people's perception how "safe" the environment is and that we have a natural survival instinct as humans that suggest we choose environments we can see but not being seen. In this theory, it is the characteristics of the space that is held paramount e.g. the interrelationship the designed space and the physiological responses of the user (Appleton, 1975). This theory fits the project as it considers fundamental and universal aspects of human behavior. By applying this theory to this context, the LANDSCAPE-PODS are a form of refuge that create a secured environment within the vast openness of the terminal, which 'shelters' the passenger from feeling uncomfortable without losing the ability of viewing across the terminal and perceiving wayfinding elements and other visual information.

Conclusion

Creating a form of refuge and prospect within the vast terminal will introduce an element of intimacy and security.



Examples of "Propest and refuge" in nature

CRITICAL ASSESSMENT OF THIRD SPACE - Environment

Description of Third Space Concept

The dynamics of one of the largest international airports in the world require a flexible and modular approach. As part of the Heathrow Expansion the architects developed an innovative concept called 'Third Space' which comprises of one large canopy roof providing daylight and a blurring between inside and outside and combining departing and arrival by creating in effect an expansive covered urban plaza. The third space is intended to connect people to the outside world, celebrate seasonality and support health and well-being through biophilia and nature. The vision is to create a green landscape in which landscape creates a sense of fluidity between inside and out and integrate with the wider Heathrow landscape strategy.

Some key features of the architectural concept are:

- **A passenger focused environment with a dynamic climate & extensive planting**
- **A highly transparent & lightweight structure**
- **A modular, adaptable component based system**

The architectural design of the Third Space concept shows an elegant flowing roof supported by a gridded column achieving a long span structure. The columns will be a combination of high and shorter columns of steel and timber depending on their purpose. The height of the waving roof may vary between top and bottom between 38 and 24 meters. The transparency of the roof will be composed of opaque cushions of various transparency. The terminal is based on a 9 meters grid, with the columns on a 45-meter distance. The scale is large and extend over hundreds of meters.

Which specific environmental stressors are present in the new Third Space Concept?

By analyzing this concept and seperating the different concept elements and turning it around I manage to find some interesting results to hook on.

To be successful within the Third Space concept the LANDSCAPE-POD will need to resolve some specific aspects, which inversely may impact stress on passengers such as control of daylight and acoustics, sense of orientation/wayfinding and how to provide a sense of intimacy.

Wayfinding

One of the aims of Heathrow is to "provide airport journeys with are direct with minimal mode, level and directional changes to ensure easy and intuitive navigation". But how to enable wayfinding and ease of navigation in the vast open space provided by the third space? The concept of a 'horizontal' terminal building will create lengthy walking distances to travel through. The wide expanse of gridded columns may make orientation and controlling passenger flow difficult.

Scale

What is apparent in this is the enormous scale of the new terminal "building". The concept of the architects is to create a terminal that feels like an exterior space with the aspects of an urban public realm below one extended roof. The downside of something so open and vast can result in an environment with a lack of intimacy. Besides the need of intimacy, I realized the scale of this structure is something "we" are not used to. Something that might be too big to feel comfortable in, an environment that has the negative potential to feel overwhelming. Therefore, from my perspective the scale of the new Heathrow terminal might be too big to feel comfortable.

Light

The transparency of the roof allows the sunlight to go through, which results in a terminal that is lit up in a natural way (see Fig. 3). This will create a calming and relaxed atmosphere and will support the opportunity for extensive internal planting. Also, planting will help to reduce stress.
The downside of an abundance of daylight is the lack of controllability and related dependence. Controllability in the sense of the constant movement of light direction, quantity, temperature and difference between day and night. These aspects can cause problems when they are not controlled in a proper way and sunlight can become a stressor. This specifically might cause problems due to glare on electronic screens and handheld devices.

Noise

Acoustics play a large role in how stressful environments feel. A specific issue with the proposed lightweight structure could be the actual noise of the airplanes. In one large open space there will be a lot of ambient noise but little opportunity to control it. How to calm down admits large crowds and noise? What opportunities are available to reduce noise through design and material choices?

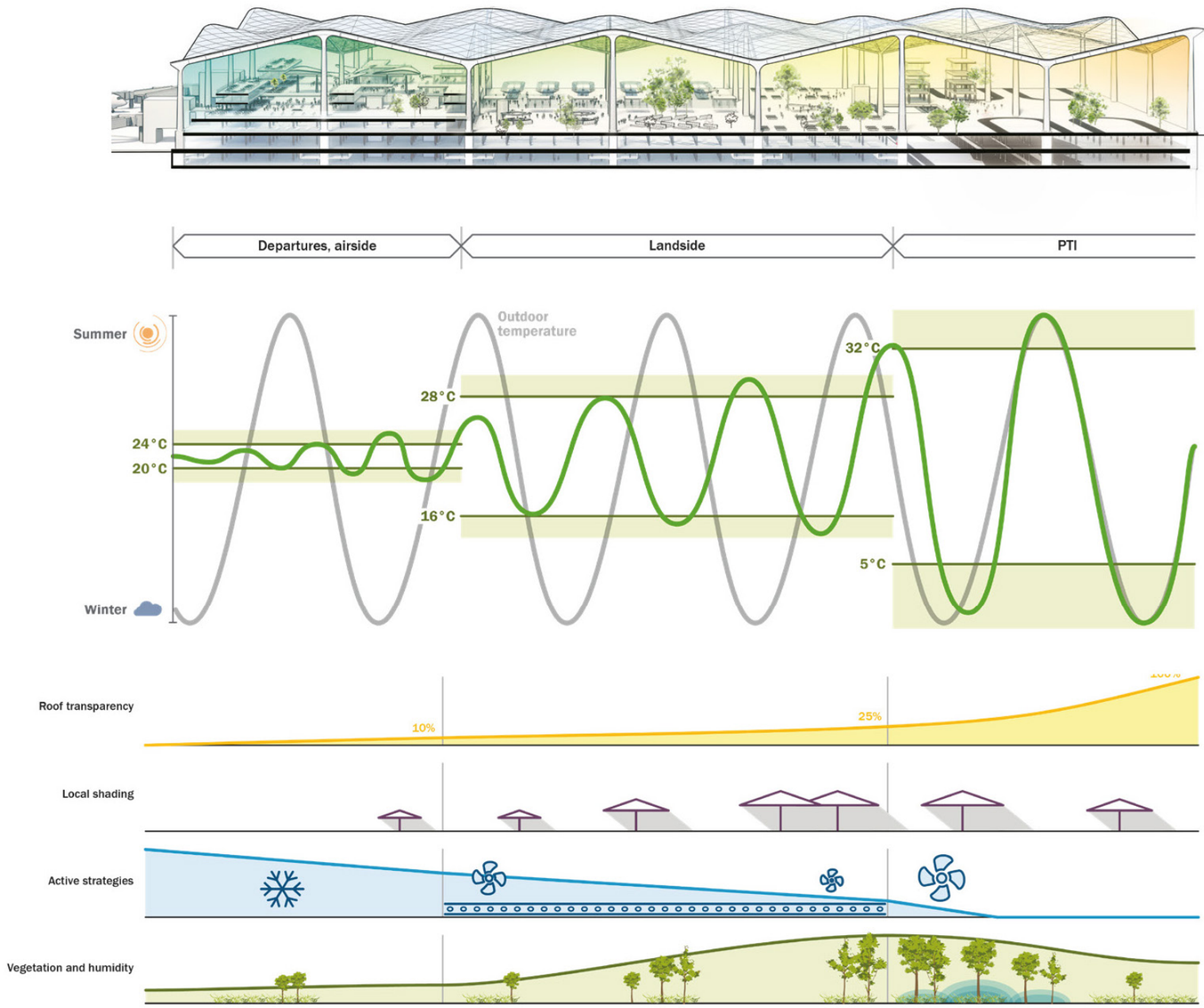


Fig. 3 - Climate control TX5 Terminal

FORMULATION OF PROBLEM

‘How to utilize innovative and interactive landscape product design which reduces passenger stress, enhance passenger comfort and provides an iconic passenger experience whilst facilitating airport operations and creating a ‘good fit’ sense of place for the Heathrow TX5 Third Space terminal concept?’

Some specific **sub-problems** are:

- How can can we design spaces where passengers can feel a sense of calm while travelling?
- How to provide local shading through product form?
- How to provide intimacy through product form?
- How can the product assist in way-finding?
- Can the product become acoustic?

CRITERIA - Heathrow Expansion

In numerous Heathrow Expansion Plan documents, there are references made to what is called 'Basis of Design'. Also the LANSCAPE-POD design should fulfil those criteria:

- **Visual Appearance:** **Good aesthetics**
- **Functionality:** **Fittness for purpose / durable / adaptable /modular**
- **Sustainability:** **Efficient in use of natural resources / low carbon / circular economy**
- **Cost** **Cost efficient / affordable**

Also, in respect to the passenger it is of importance that any design should not discriminate or have a negative mental or physical consequence on the user. Passengers are from different ethnicities and demographics. In the P2 Report of the Heathrow Expansion Program specific reference is made to the Equality Act (2010), which make it illegal to discriminate against anyone on the grounds of:

- **Age**
- **Disability;**
- **Gender reassignment;**
- **Marriage and civil partnership;**
- **Pregnancy and maternity;**
- **Race;**
- **Religion or belief;**
- **Sex;**
- **Sexual orientation**

PROGRAM OF REQUIREMENTS (PoR) - Constraints

Design specifications based on the conclusion made in part 1: Problem statement

Essential Requirements

Desirables

Technical

§	Requirement / Desirables	Type	Reference
1	**Context: Environment (New Heathrow Airport), Architecture (Third space)**		
1a	The LANDSCAPE-PODS fit the aesthetic architecture, landscape and interior of Heathrow's new TX5 terminal.	D	PREDENCE
1b	The LANDSCAPE-PODS do not interrupt the seamless movement between landside and terminal.	R	Airport Environment - Context - Design Principles
1c	The LANDSCAPE-PODS fit the Third space concept: help to provide a real sense of place.	R	Airport Environment - Context - Design Principles
1d	The LANDSCAPE-PODS fit the terminal module: based on a 9 meters grid, with the columns supporting roof on 54 meter distance.	R	PREDENCE CRITERIA - Heathrow Expansion
2	**Reducing Stress**		
2a	The LANDSCAPE-PODS fit the physical area of the terminal, based on the presence of stress.	D	THE PASSENGER - Target Group PASSENGER STRESS - Interaction
2b	The LANDSCAPE-PODS act on environmental stressors.	R	PASSENGER STRESS - Interaction CRITICAL ASSESSMENT OF THIRD SPACE - Environment
3	**Accessibility**		
3a	The LANDSCAPE-PODS do not discriminate and can be used by every passenger. (Children, older people, disabled people, different genders, pregnant women, race, religion or belief and sex.)	R	CRITERIA - Heathrow Expansion
3b	The LANDSCAPE-PODS can be used by multiple passenger's, public approach.	D	Airport Environment - Context - Design Principles

§	Requirement / Desirables	Type	Reference
4	**Interaction**		
4a	The LANDSCAPE-PODS are passenger focused.	R	Airport Environment - Context - Design Principles
4b	The LANDSCAPE-PODS help to provoke an iconic, inclusive and distinctive experience.	R	Airport Environment - Context - Design Principles
4d	The LANDSCAPE-PODS provide calmness, clarity and simplicity of space.	D	PREDENCE
5	**Safety**		
5a	The LANDSCAPE-PODS fit fire regulations.	D	GROSS. MAX.
5c	The LANDSCAPE-PODS stand out in time, to avoid passengers bump into it and get hurt.	D	THE PASSENGER - Target Group
6	**Production/installation**		
6a	The LANDSCAPE-PODS consist of a flexible and customizable modular system.	R	CRITERIA - Heathrow Expansion
6b	The LANDSCAPE-PODS could be combined to create a family of objects with various application depending on positioning within the terminal.	D	PREDENCE
7	The LANDSCAPE-PODS have little parts to assembly on location, to improve the time of installation	R	CRITERIA - Heathrow Expansion
7	**Sustainability**		
7a	Low carbon footprint	R	CRITERIA - Heathrow Expansion
7b	Impact resistant, every passenger with good intentions can use this product without damaging the LANDSCAPE-PODS.	T	THE PASSENGER - Target Group
7c	Abrasion resistant, the material which is in physical contact with the passenger is not sensitive to abrasion.	T	GROSS.MAX.

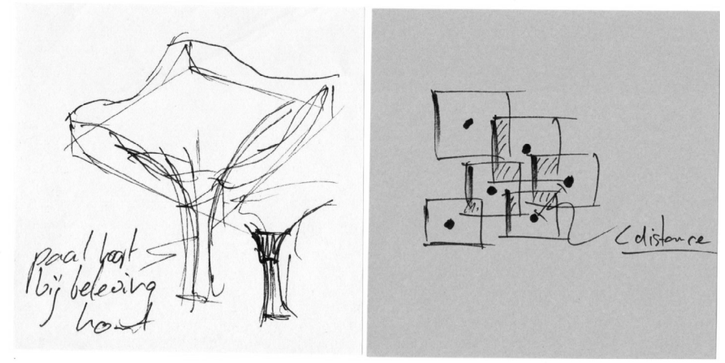
PART 2: DESIGN EXPLORATION

IDEATION AND CONCEPTS

Heathrow Expansion
New TX5 terminal-
LANDSCAPE-PODS

Still, with the general idea of a LANDSCAPE-PODS product-design which facilitates that passengers can feel a sense of calm while travelling, and which alleviates specific stress factors which might be caused as consequence of the Third Space concept, there are numerous design possibilities.

The key task as result of my problem statement is to resolve the mentioned stressors. During this design exploration, I kept the design principles in my mind but I did not particularly focused on the feasibility or technical aspect such as flexibility or modularity. I was focused on the effect of the ideas on the passenger and the relationship with the environment and its relationship to landscape. To validate the ideas I worked out several initial ideas and put them to test by giving design presentations to GRIMSHAW and GROSS. MAX.



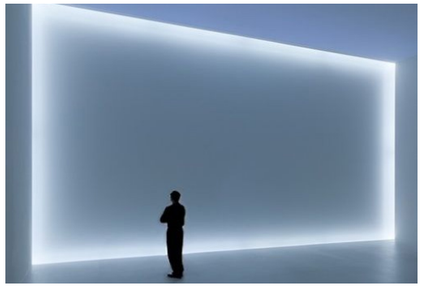
INSPIRATION

It was clear to apply the fitting method Prospect and Refuge, but not in what way or form.

I made an early collage of references to get inspired by product elements that would fit my product and help me to get closer to the actual physical form. How to correlate and fit the ideas and functions of the product?

Impressive structure; flexible, modular, connecting.

Holding the attention of the passenger without interrupting the clarity of the terminal.



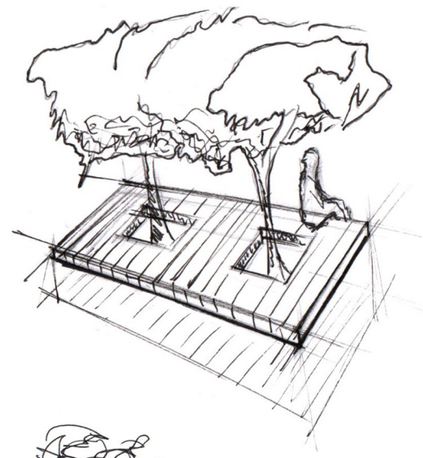
A product with a green element, like a green-wall, artificial tree, climbing plants etc.

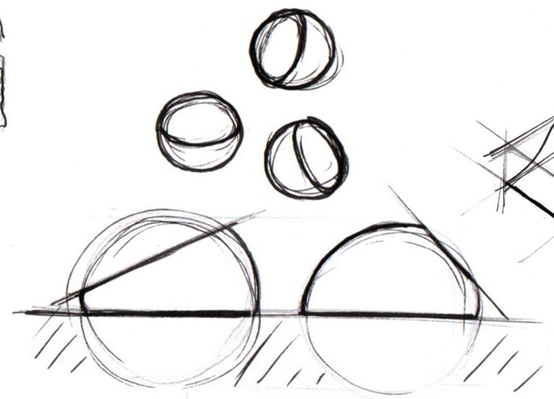
The original idea was making use of the specific environmental elements. Aspects to be considered were differentiation in climate, sunlight and architectural components.

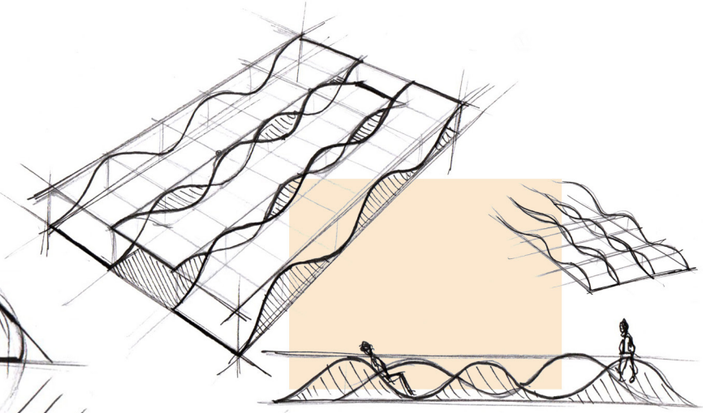
SKETCHING

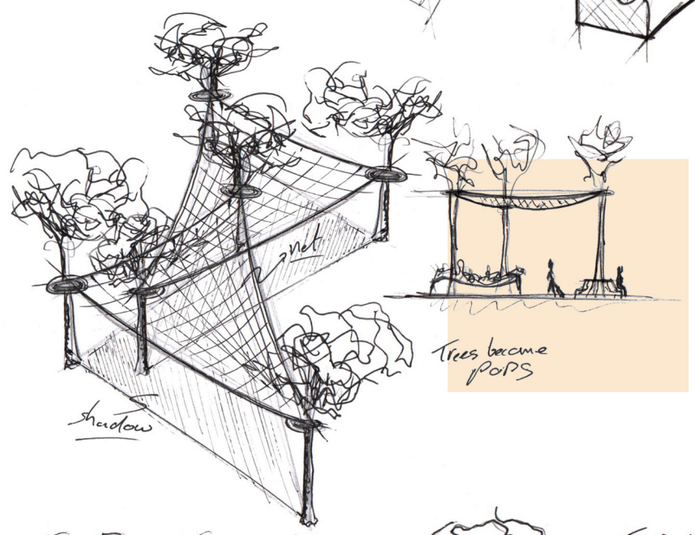
During this phase of design exploration, I was constant diverging and converging my ideas, such as the evolving ideas about interaction. I talk a lot within GROSS. MAX. and outside the office about the design process and my ideas. For this reason, I approach my ideation phase not only from visual perspective in the form of sketches but also by discussing different lines of thoughts and not only giving value to the idea by checking off all the requirements but by creating a rational narrative that opens entrepreneurial creativity that can be provoked by pitching.

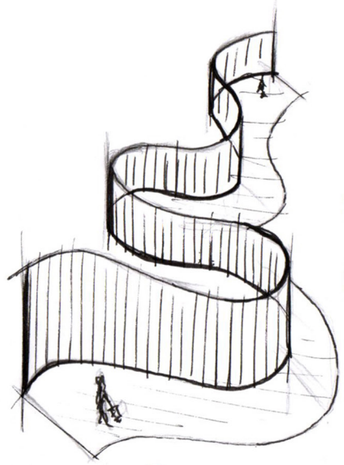
See Sketchook 1
for unedited sketches

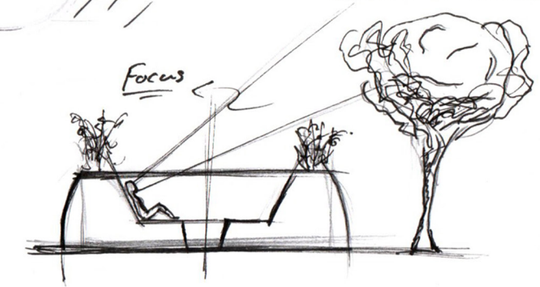


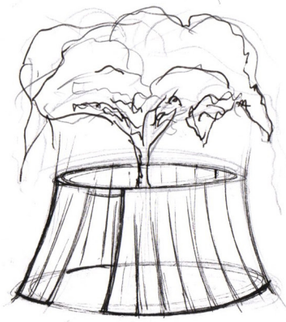


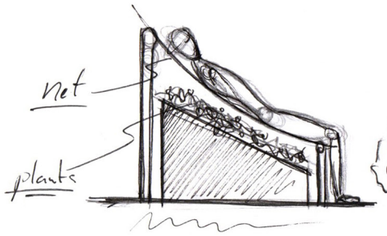


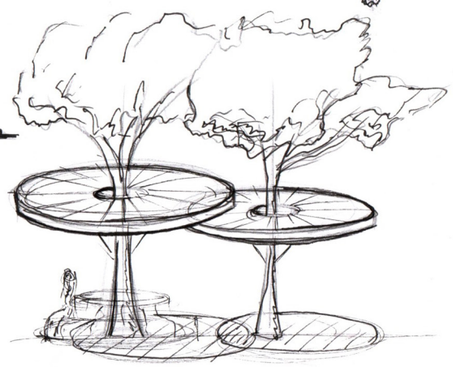


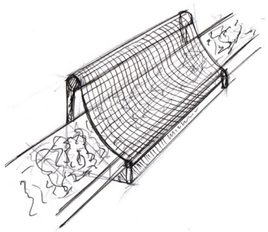


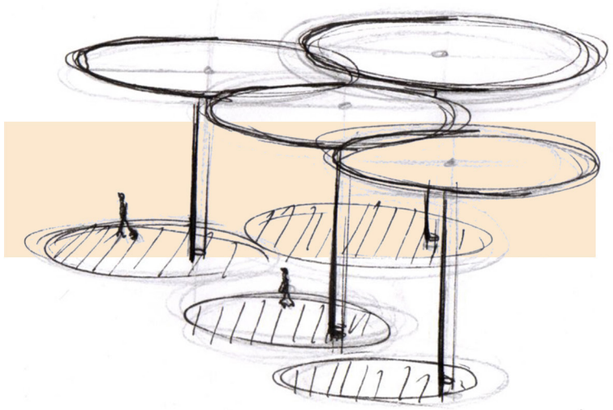


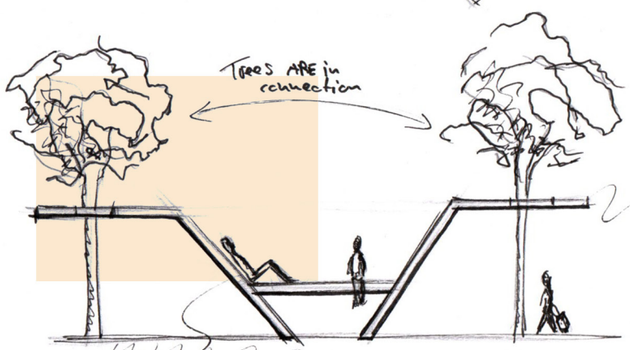


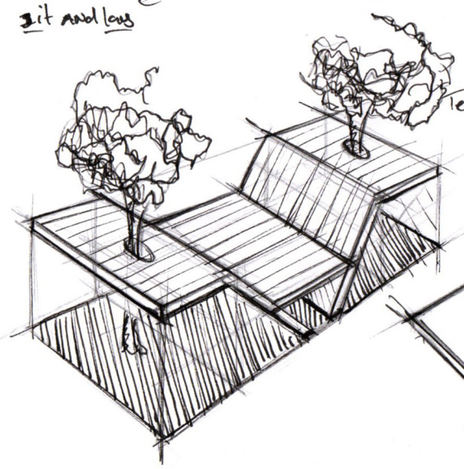


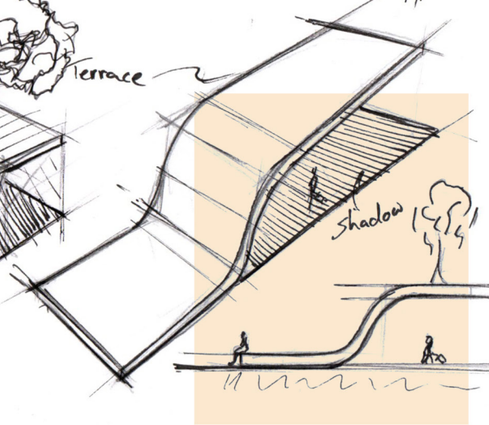


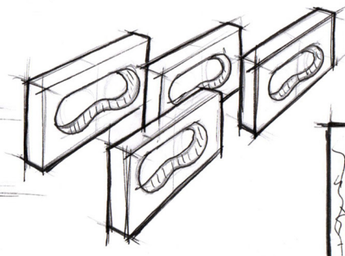


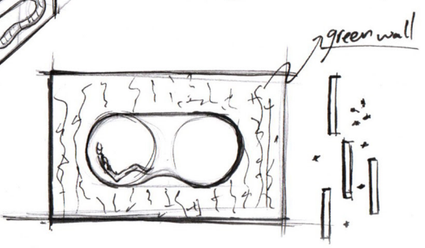












IDEAS

To present my ideas to GRIMSHAW I had to create some rapid visual concepts. I worked out my two most promising ideas. The ideas here are present as different designs, but in reality, they are an iteration of the same idea of acting on the previously mentioned environmental stressors.

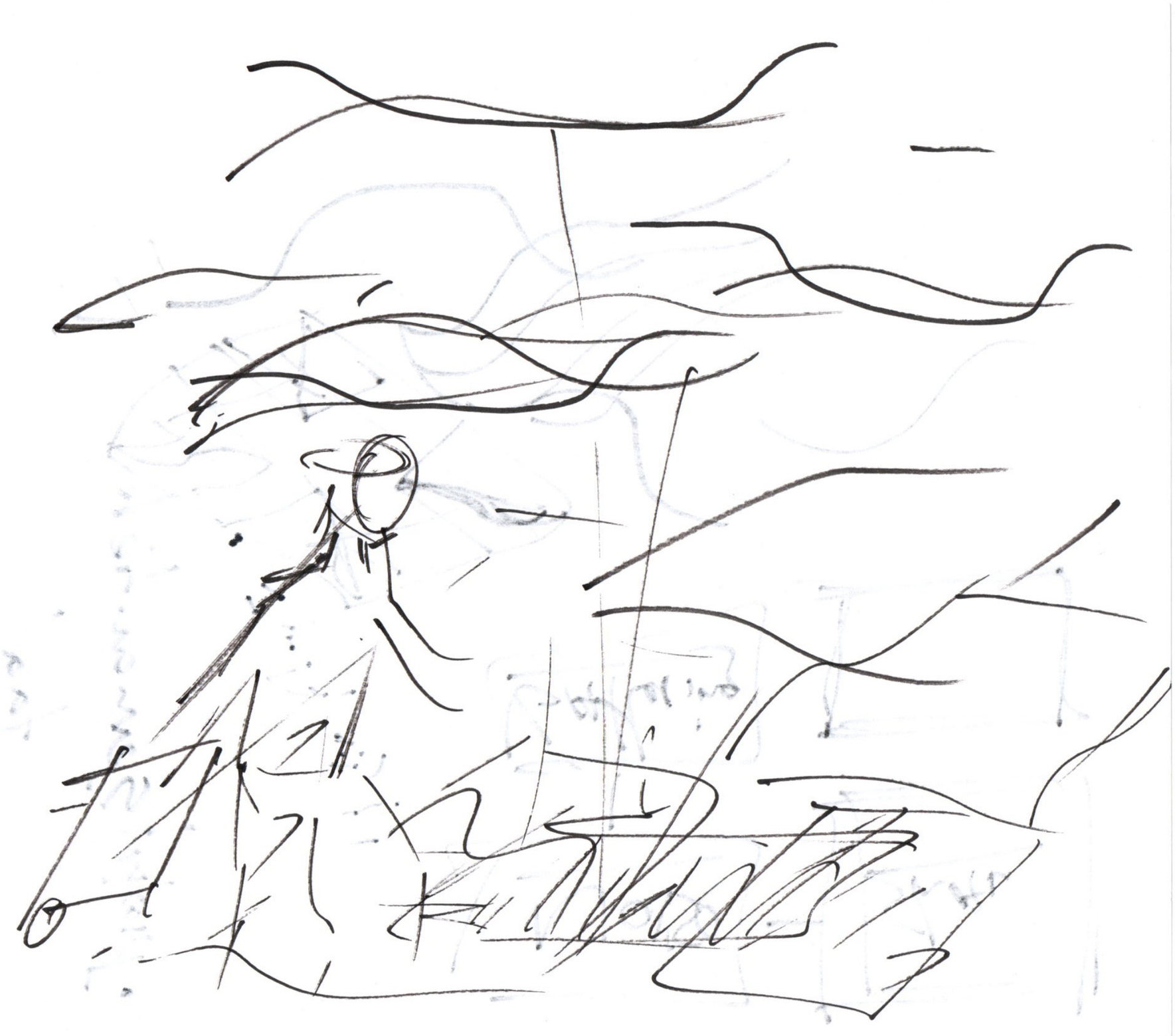
1. Navigating the focus of the passenger

This concept proposes a break-out space that physically helps the passenger to direct his or hers gaze across the environment of the Third space by blocking a part of the field of vision. The assumption of navigating the focus of the passenger, they will be less distracted by other passengers/impressions and to connect more to the beauty of the terminal instead.

2. Horizontal Curtain

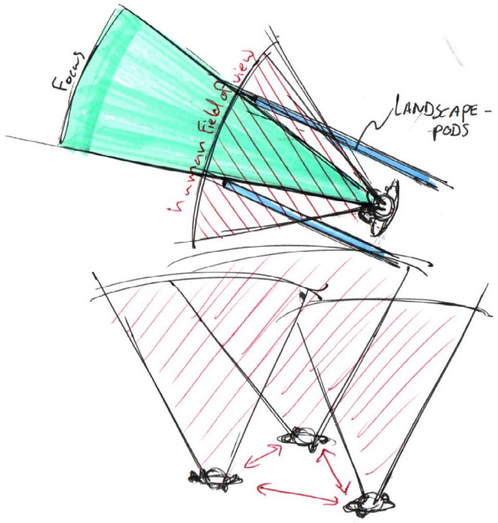
The second idea was to create a "horizontal curtain", basically a small roof under the big terminal roof. The idea was to lower the large scale of Heathrow and making it easier to control environmental elements on local level.

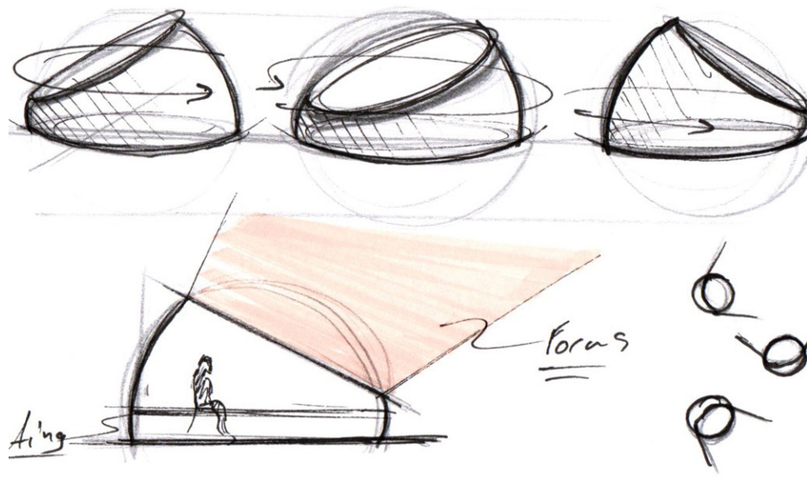
The two conceps were to be presented in a design-review with GRIMSHAW and GROSS.MAX. in order to facilitate discussing and descision making.



CONCEPT I

In brief, the idea is inspired by the principles of a cave. It is basically a globe that aesthetically merges into the ground and has been "sliced open" which creates a focused opening slot. The pods can be placed facing in different directions and thereby changing the view of the passengers that are making use of the product. Because the passenger is mostly enclosed, the pods can be blocking sound and light and providing intimacy. A downside of this seating element is the lack of space efficiency and therefore possible interruption of passenger flow. On the other hand, it could be enjoyable to walk through, because they look different from the rest of the environment, which might possibly distract the passenger from feeling stressed.





CONCEPT 1: VISUAL PRESENTATION

CONCEPT II

The proposal consisted of sculptural modular canopy structure with a green roof-scape that helps to purify the air and a wooden underside to act as acoustic barrier. The canopy provides shadow and is therefore an attractive place to work or wait under without being annoyed by light or reflection. Because of its height the canopy can function as a landmark/way-finding element and creates a place of intimacy because passengers are attracted to the same spot.

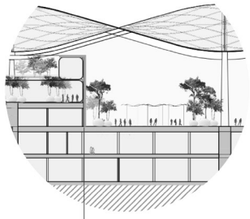
The key reaction was positive. The architect and product designers in attendance appreciated the focus on passenger experience and well-being. They stressed the ideas of the Third Space concept, e.g. daylight to create a calm serene atmosphere, the importance of green and the concept of biophilic design. The idea is that the third space feels like an exterior space with the aspects of an urban public realm below one extended roof. I was complemented that the idea of canopy structures would fit the overall concept very well. The chief architect in charge, Andy Barnes, responded: "the concept is absolute capable with the idea!'. I was advised to further study aspects of biophilic design to explore how the canopy structure could 'mimic' nature and natural conditions.

Conclusion:

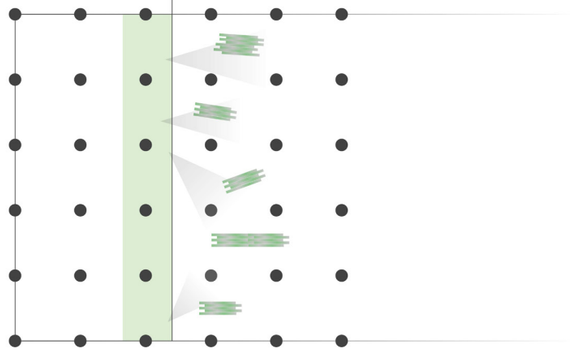
The physical form of the product will be a canopy inspired by the idea of a horizontal curtain.

See appendix Minutes of meeting A to read more about the discussed items

Shape: Product becomes part of the total architecture and interi-



Concept fits the specific Heathrow "wall of security" and connects Land-side with Air-side.



Passengers can see the green roof-tops from balcony.

CONCEPT 2: VISUAL PRESENTATION

FORM STUDY

Modular System

The choice to design a canopy still would give me ample of opportunity to evolve the design of the actual shape of the product. It was time to get back to the design principles, one of those referred to the perfectly tuned architecture as 'a flexible and customizable modular system'. The LANDSCAPE-PODS canopy should answer the following question:

"How to design a modular canopy system that fits the aesthetics of the Heathrow's TX5 terminal environment?"

According to the Cambridge Dictionary "modular" means "Consisting of separate parts that, when combined, form a complete whole".

Method: Plane tessellation

Serrentino & Özkar (1999) state (inspired by Escher's art) a regular plane tessellation is composed copying the same shape again and again and therefore theoretically covering the whole plane.

Monohedral: All tiles are the same size and shape. If the tiling is monohedral, we should call it a prototile (see Fig. 4).

Composed prototile: When a prototile is congruent to another of the same prototile and form a new composed tile covering the plane it is called a composed prototile (see Fig. 5)(Serrentino & Özkar, 1999).

Both, simple prototile and composed prototiles might fit the canopy.

M.C. Escher was a real pioneer in the use of this method. He worked with modular shapes like fishes, birds, lizards, sea and landscape.

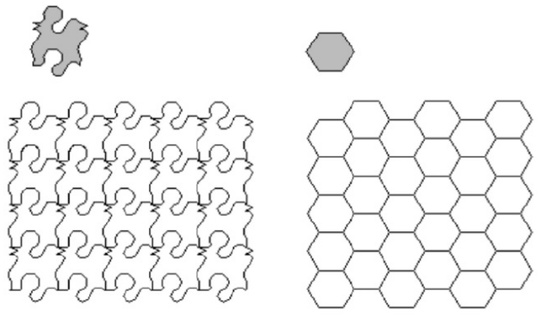


Fig. 4 - Simple Prototiles

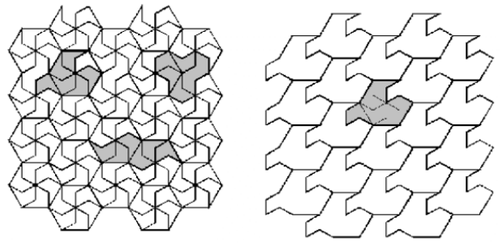


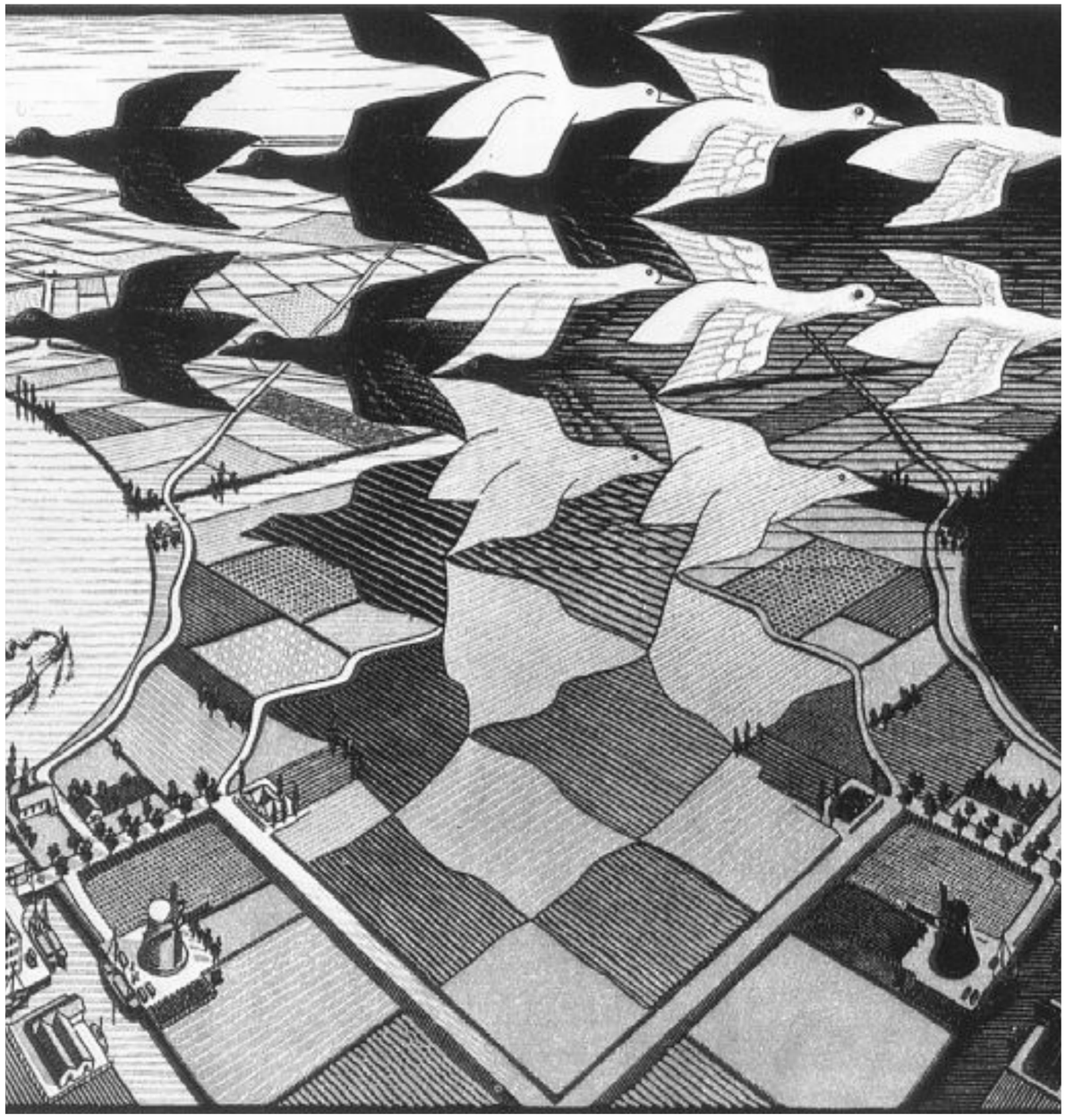
Fig. 5 - Composed prototiles

Application

Such methods might be applicable as the LANDSCAPE-PODS are (aesthetically) connected with the wider landscape of the Third Space and beyond. An artwork made by Escher that supports this vision, which shows modular shaped geese overflowing with the modular shaped landscape and gradually blurring into one other. This property of becoming ones gives a certain feel of calmness and clarity to the piece of art.

The idea emerged that I could create something similar by designing canopies that aesthetically become one with the architecture though modularity.

Fig. 6 - "Day and Night", 1938



FORM STUDY
Relation With Architecture

The roof (see Fig. 7) of the TX5 Terminal is the architectural eye-catcher and the most dominant shape of the environment. It is therefore interesting to use its shape as reference point for the design of the canopies. The wavy shape of the roof reminds of the DNA strand (see Fig. 8). When these two lines overlap, they create different visual surfaces. The overlap characteristic is interesting for the canopies because it can provide a group system without the parts being in physical contact and still form a group, in contrast to the tessellation method. From this point on I call this "optical modularity".

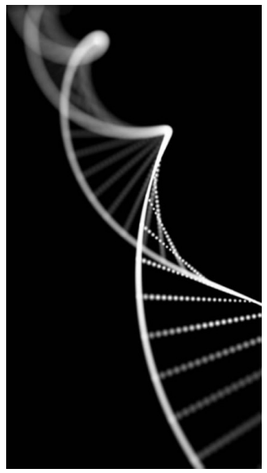


Fig. 8 - DNA

Optical modularity can be seen/applied from different views. Even if the different lines do no over-lap or are in physical connection, the side view can give a certain feel of aesthetic relation between two different elements (See Fig. 9)

Because the canopies stand under an enormous roof, the depth of the product can be a benefit. So, instead of using the ground space like done above, the height of the canopies can vary and therefore be functional to create optical modular clusters (3.) instead of physical groups (2.).

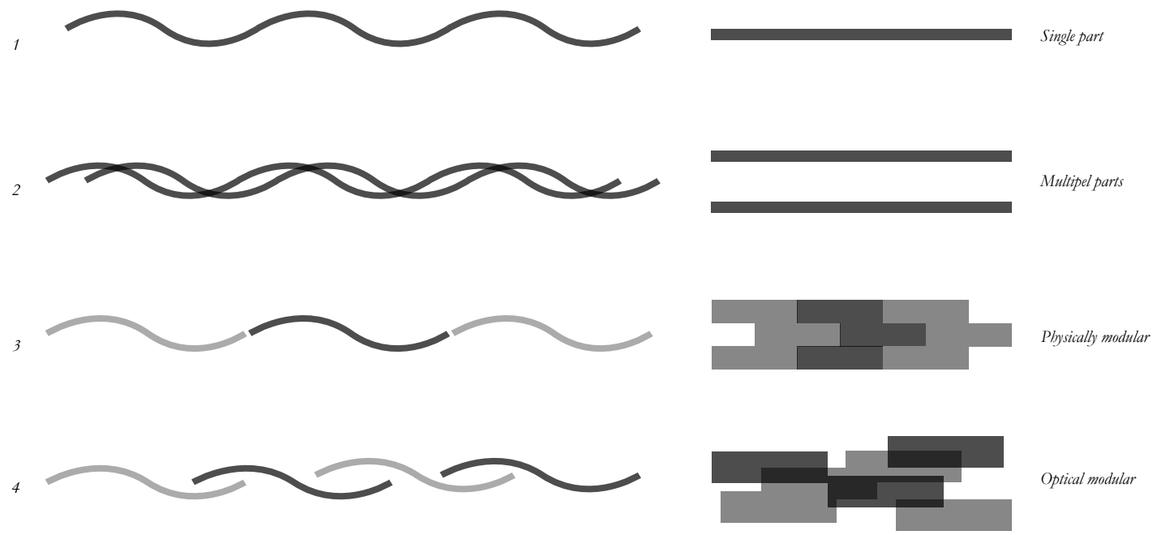


Fig. 9 - Modularity

Conclusion

- **The canopies can become a modular shaped system by using plane tessellation. Besides being physically in contact the canopies can form a group by overlapping (optical modularity).**
- **The canopies are shaped so they are in line with the wavy pattern of the terminal roof with the aim of providing calmness and clarity.**

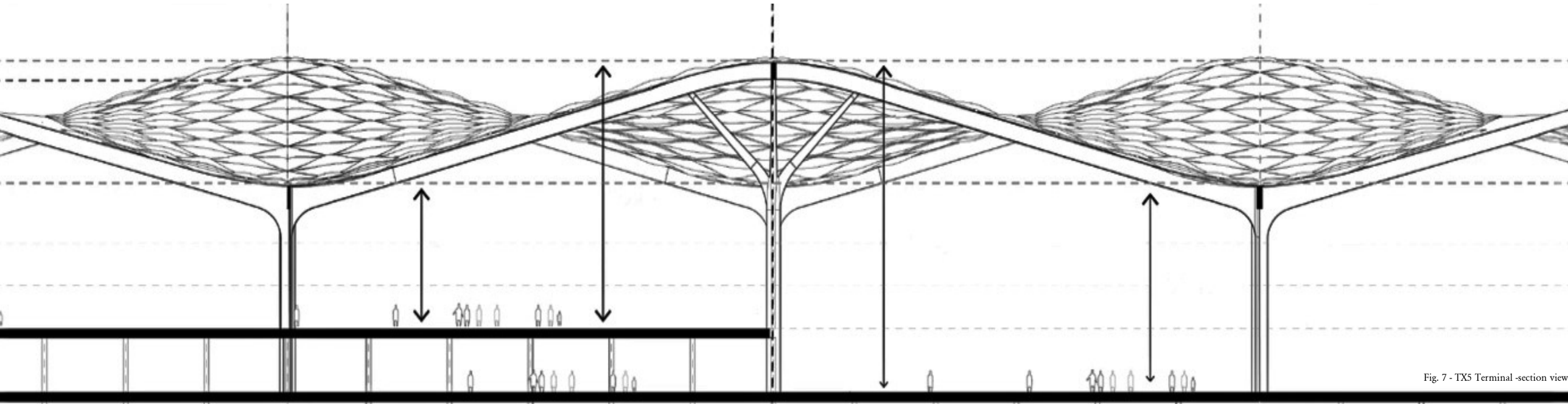


Fig. 7 - TX5 Terminal -section view

FORM STUDY
Mimic Nature

Besides the idea of giving the canopies a modular and flexible shape, the overall shape must fit the aspiration of the architects. I was advised to look further into the notion of biophilic design.

Concept: Biophilic design

Learning from nature is not a new concept, but with the development of technological advancement, it is a re-emerging approach within a wide range of disciplines. Kellert and Calabrese (2015) suggest that biophilic design derives from the idea that connection with nature is a basic human need and should be integral as part the built environment. Design inspired by nature allows the individual to connect with the nature as part of our daily environment we live in (Kellert & Calabrese, 2015). By mimicking natural environments through product, the LANDSCAPE-PODS can provoke positive emotional experiences.

Method: Biomimicry

There are many ways to connect the passengers with nature, although this research is particularly focused on the appearance of the product it is interesting to mimic the nature through imitating, this method is called ***Biomimicry***.

See appendix 4 how this theory is approach.

"Thus, man who used to gain experience through observation of nature have begun to take lessons from nature as a means of comparison and an instructor beyond taking it a model"

Benyus, 1997

The ray fish

Studying animals that cluster together and also make use of different height to group the ray fish came out as the most corresponding ‘system’. The swimming technique of the ray fish is a special wave motion (Fish et al., 2016). By looking at the morphology of the stingray and estimated amplitude (Fig. 10) , the fish is in line with the shape of the new roof. By mimicking this shape, the canopies will most likely be in symphony with the architecture, not dissimilar like Escher has done (Fig. 6).

Besides the floating motion effect, rays do group by swimming under and above each other and therefore form a surface based on different layers, which creates depth. Just like the canopies they create shadow in a manner it can expand by increasing the elements. On top of that, the romantic thought of the rays clustering together as well as they are searching their way in the big ocean is comparable to the “way-finding” and ‘gathering” experience of the passenger and therefore provided a suitable analogy for application in the canopies.

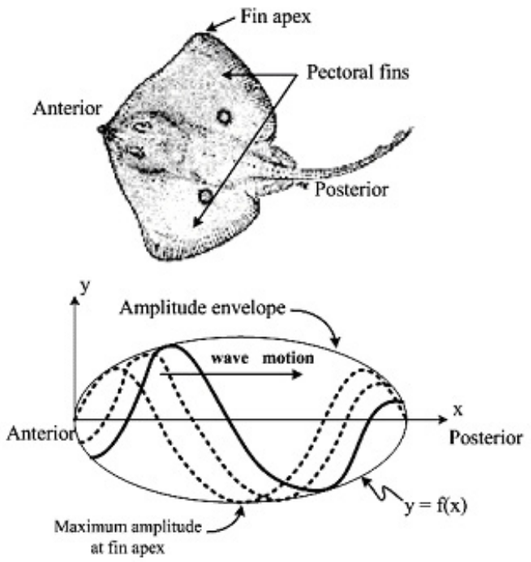
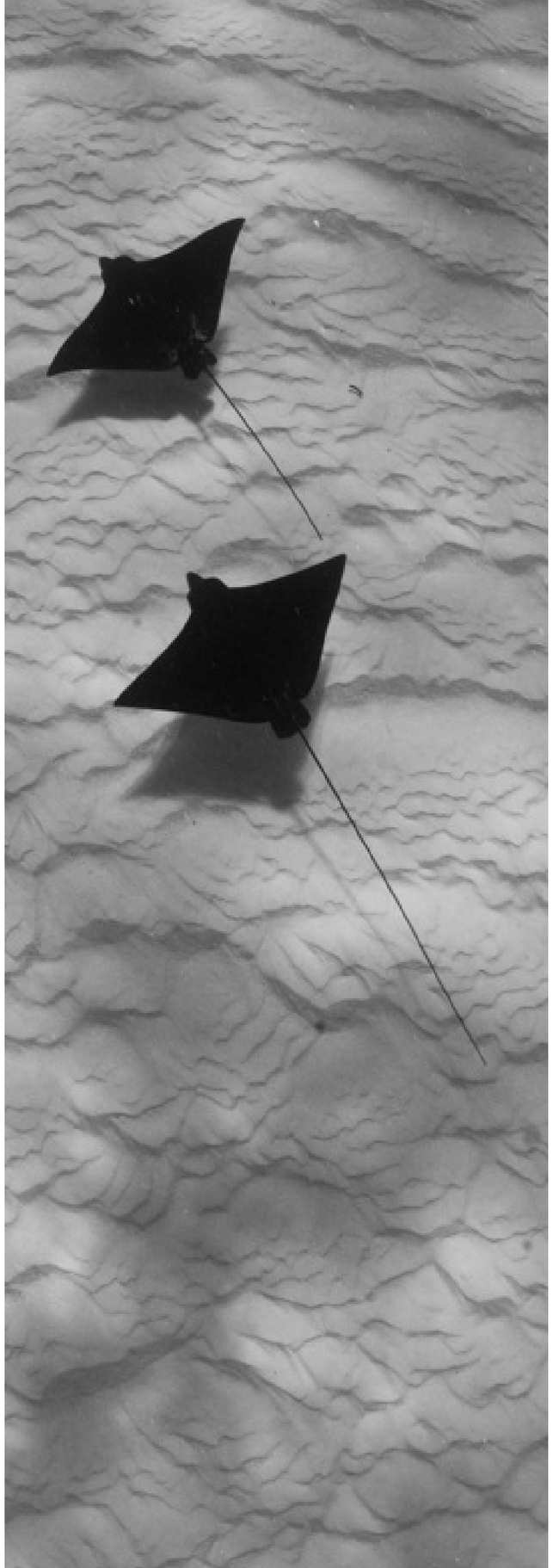


Fig. 10 - Ray fish motion



What makes this shape the most interesting is the way it overlaps. Besides the functionality of creating shadow and being modular, the different crossovers create fascinating shapes. As shown Figure 11 you can see the wave motion of a ray in steps. I overlapped them in horizontal in line or at different heights, this results in the lines of the fins keep being in symphony and form a sea of waves. This is not because of the motion but also due the fact the top of the ray has a different color than the bottom. Which is comparable to the planes of the canopy, the top surface is covered by sunlight and the bottom has a darker tint because of the shadow.

The connecting thought of this all was that of connecting the passenger with nature through form of the canopy. I therefore considered it of interest to mimic the crucial element of the ray fish, which are the wave motion fins. By applying this inspiration –not literally but figuratively-
I could create the same floating effect with the help of sunlight and shadow.

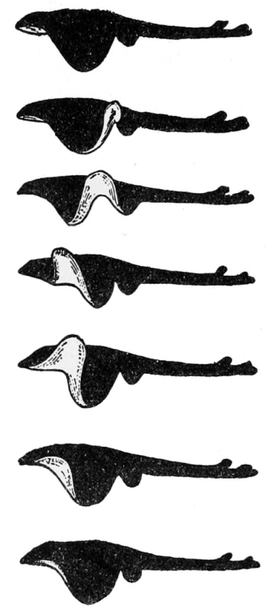
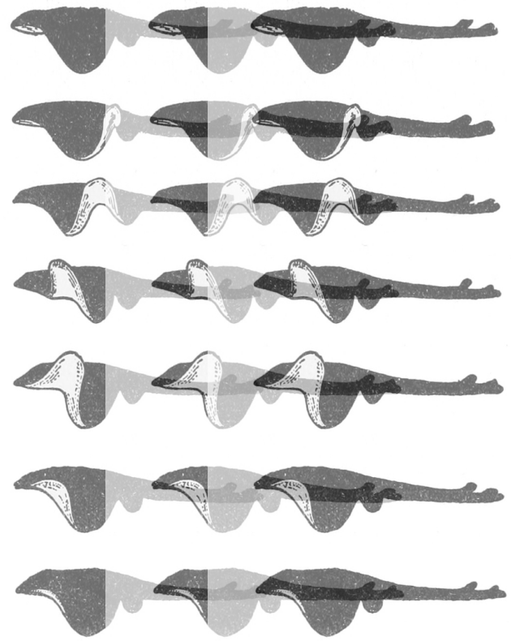
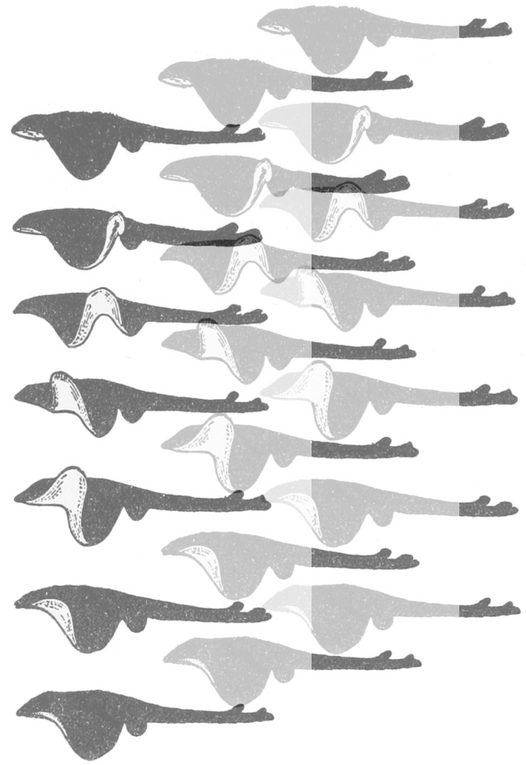


Fig. 11- Steps of motion





FORM STUDY
Convergence Of Form

From this point on I had to converge back to sketching and de-compose the fins of the ray and find answer to the question:

"How to convert the floating effect of a ray fish to a modular canopy roof surface?".

To achieve this the objective is to create a modular pattern based on the plane tessellation method and combine this with the biophilic results.

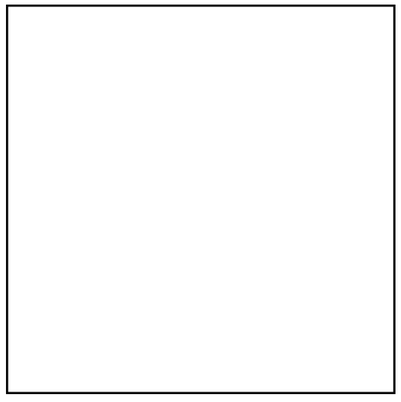
Inspired by the grid as underlying design rational of Kho Liang Le (see booklet) created a prototile that fits the pattern of the architectural structure. Because a prototile is approached as a flat plane and not as something 3 dimensional, I took the column grid (54mx54m square) as starting point.

This results in the **conclusion**:

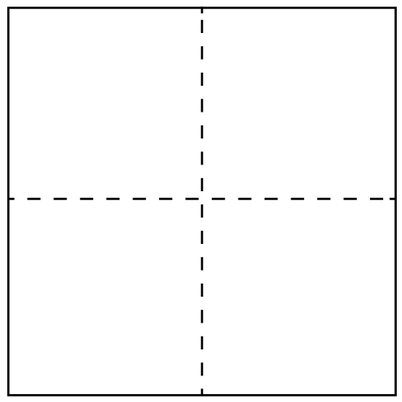
The base top view of the canopy structure will contain of a simple prototile pattern of squares.

By using symmetric lines within the shape of the square the shape does not change when turning around, which means the canopy pieces physically fit each other from every side.

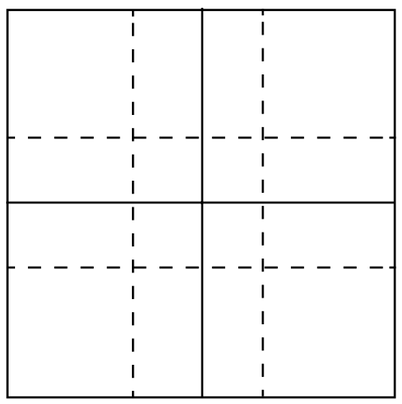
To avoid losing this property the square is split in "leading lines", which created a pattern with in the center a flat surface and in the corners "flexible" smaller squares that can be changed in depth and vertical form. The flat surface is chosen because it creates a strong appearance of layers and depth when overlapping.



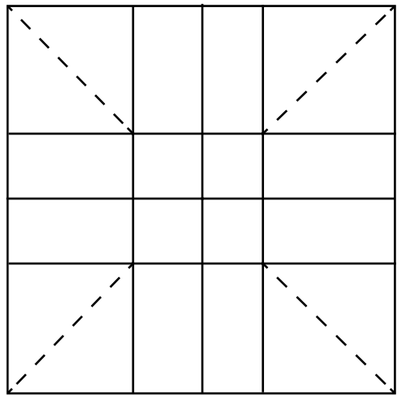
Square



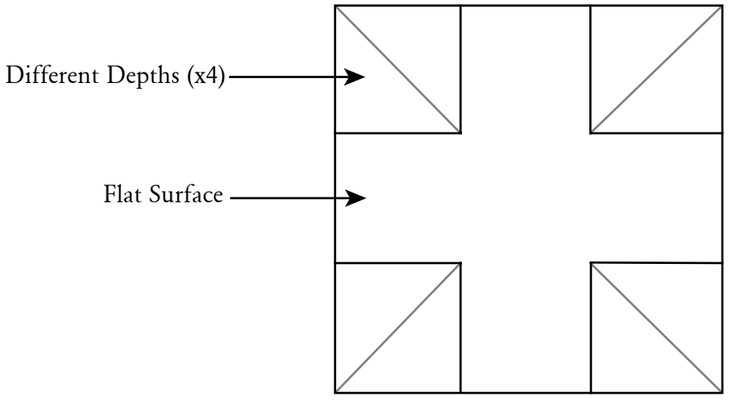
Symmetrical line step 1



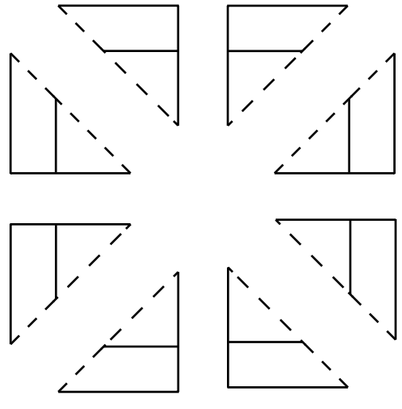
Symmetrical line step 2



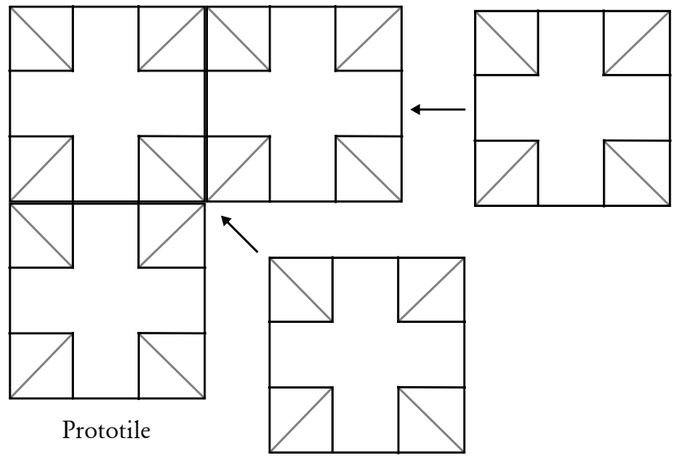
Symmetrical line step 3



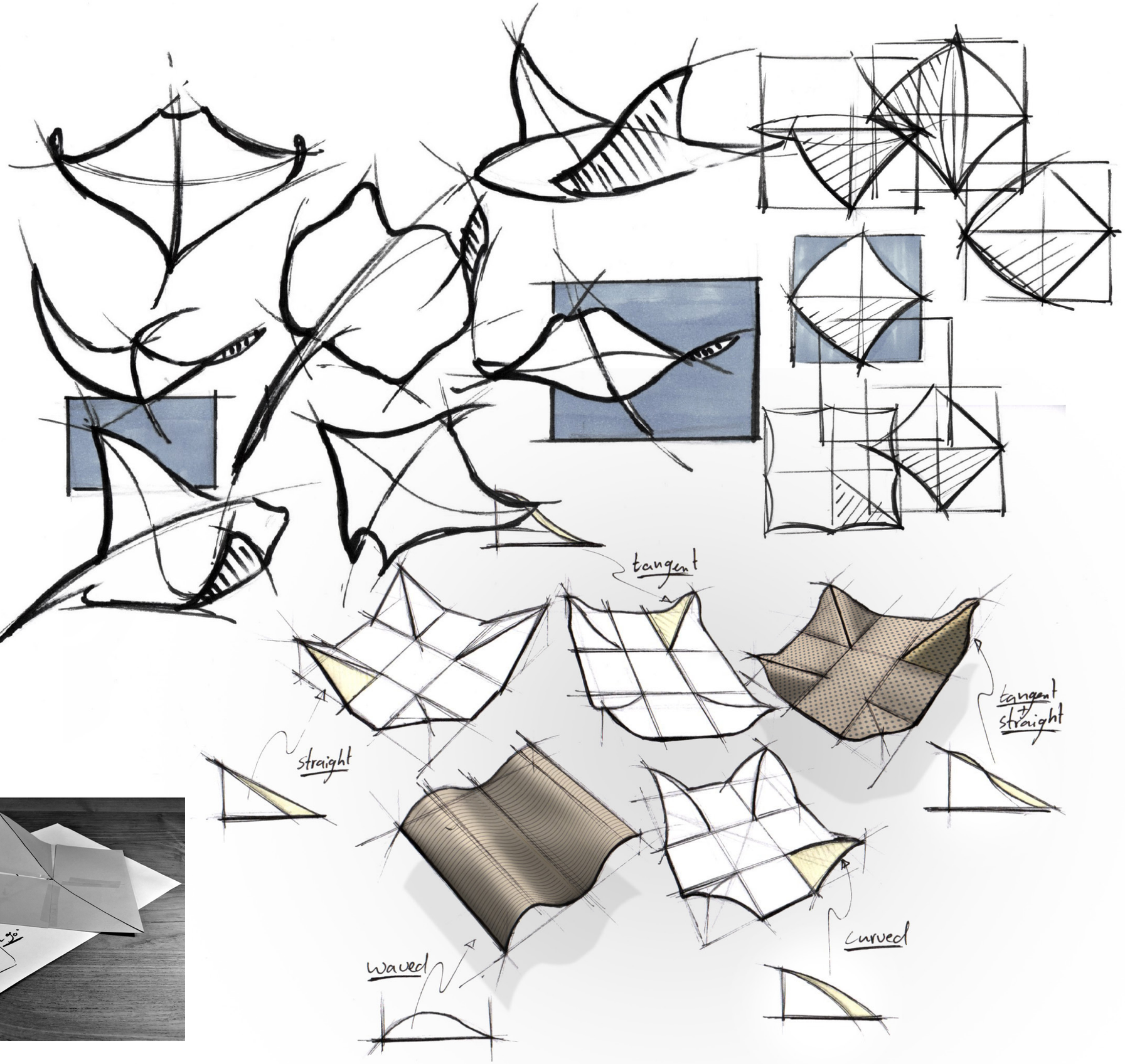
Leading shape lines Canopy

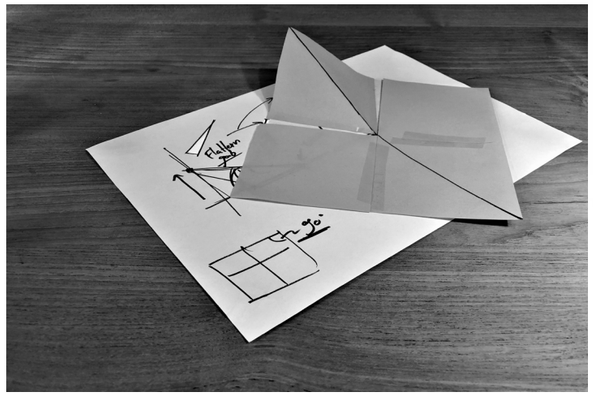


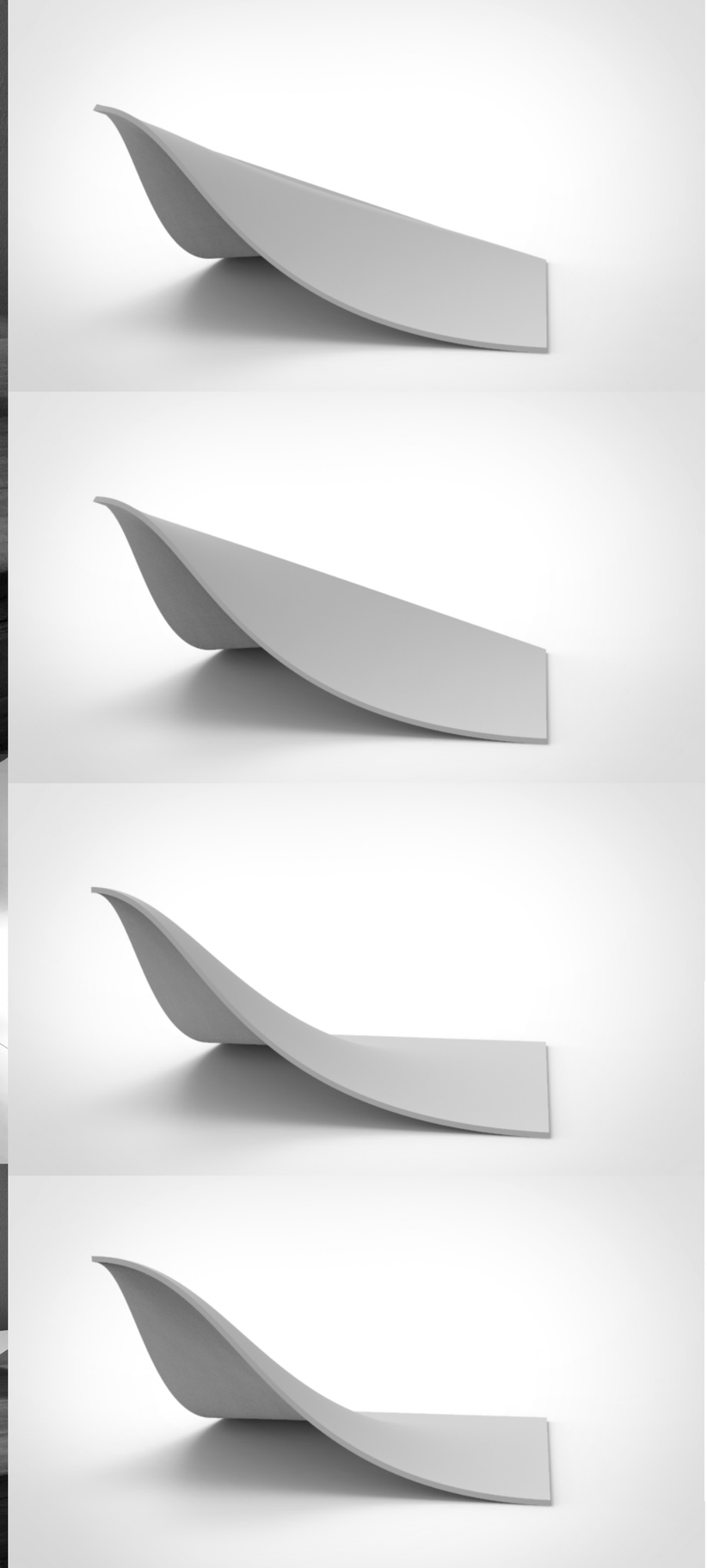
Decomposed mirror parts



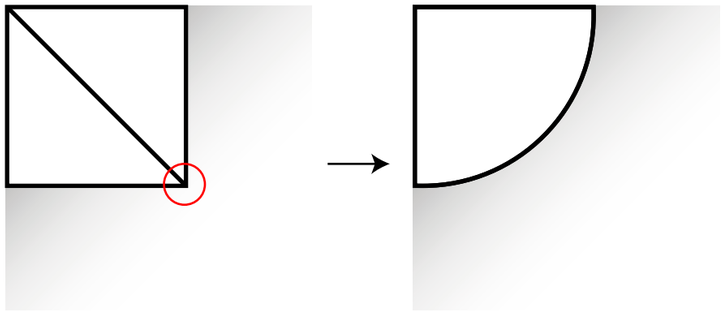
Prototile


tangent
straight
tangent + straight
waved
curved



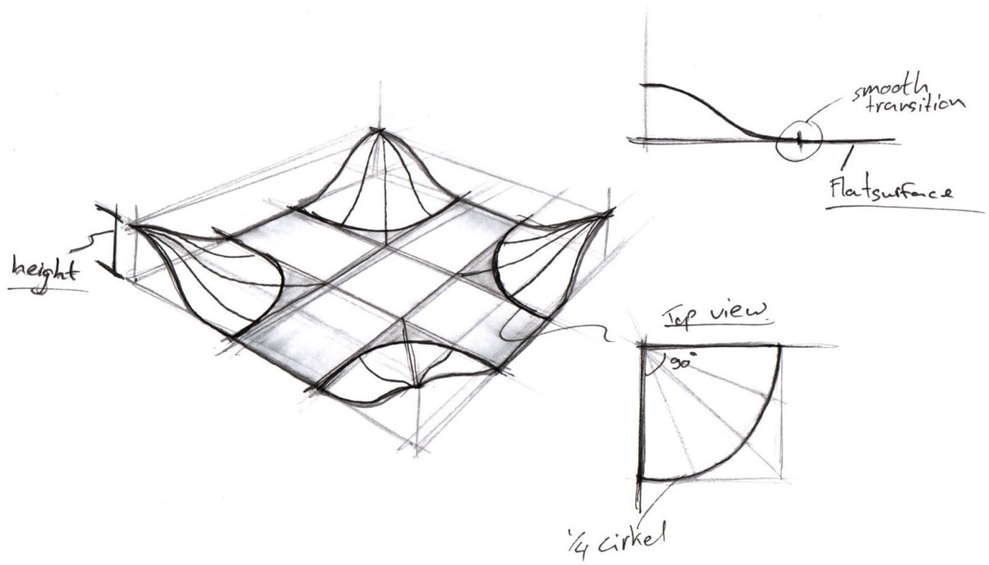


To get a better understanding and feel of the overall proportion and the way the corners will bend a quick physical model is made from paper. This gave insights how the corners meet the flat surface. The results are that the shape of corners have a gradient that encounter the flat surface in a disrupt way. By changing this to a quart circle the transition becomes smooth.



Conclusion:

The roof shape of the canopy is there and can be slightly adjust during the next process without losing the main features, the next step is to translate it to 3D context.



FORM STUDY

Context

Grimshaw suggested that the product could be combined with various terminal applications and highlighted the importance of green (trees and plants) in relation to the canopy. Two visual scenarios are created to test how this shape concept reacts on the environment and how it works in the form of groups.

1. Information exchange (e.g. Check-in, Security Threshold / Rest zone)

2. Lounge (e.g. Departure lounge, Arrivals)

1,

2.

FORM STUDY
Form meets function

Now, the general shape of the canopy is approved. The next step is to analyse this canopy on its properties that react on the environmental stressors and convert these to three potential concepts.

The following objectives are together with GROSS.MAX.

See Sketchbook 2.2 for addition information why these objectives are formulated.

Objectives:

- Creating a canopy roof with an acoustic property.
- Supporting the Canopy Roof element without disrupting the passenger flow or flexibility.
- Creating a transparent canopy roof that creates shadow.
- Transfer the canopy to a more 3-dimentional shape.
- Scaleup the dimentions.

The aim at this stage is to keep clarity of the design by transfering the canopy to a more 3-dimensional form that follows the functions and not by adding elements to it.

Therefore, I was interested to explore the material properties of exciting timber construction in relation to light (see Fig. 12) and acoustics (see Fig. 13).

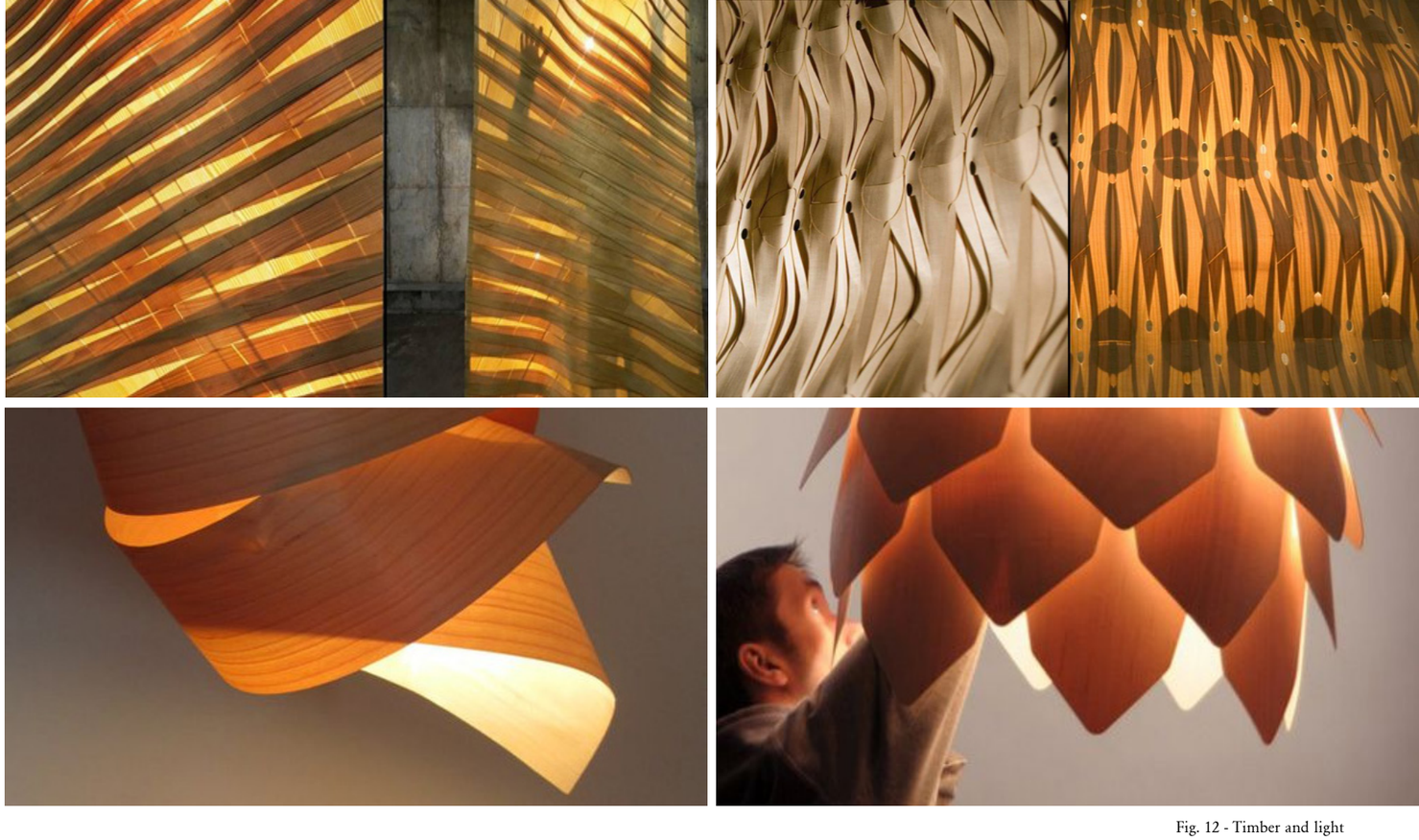


Fig. 12 - Timber and light

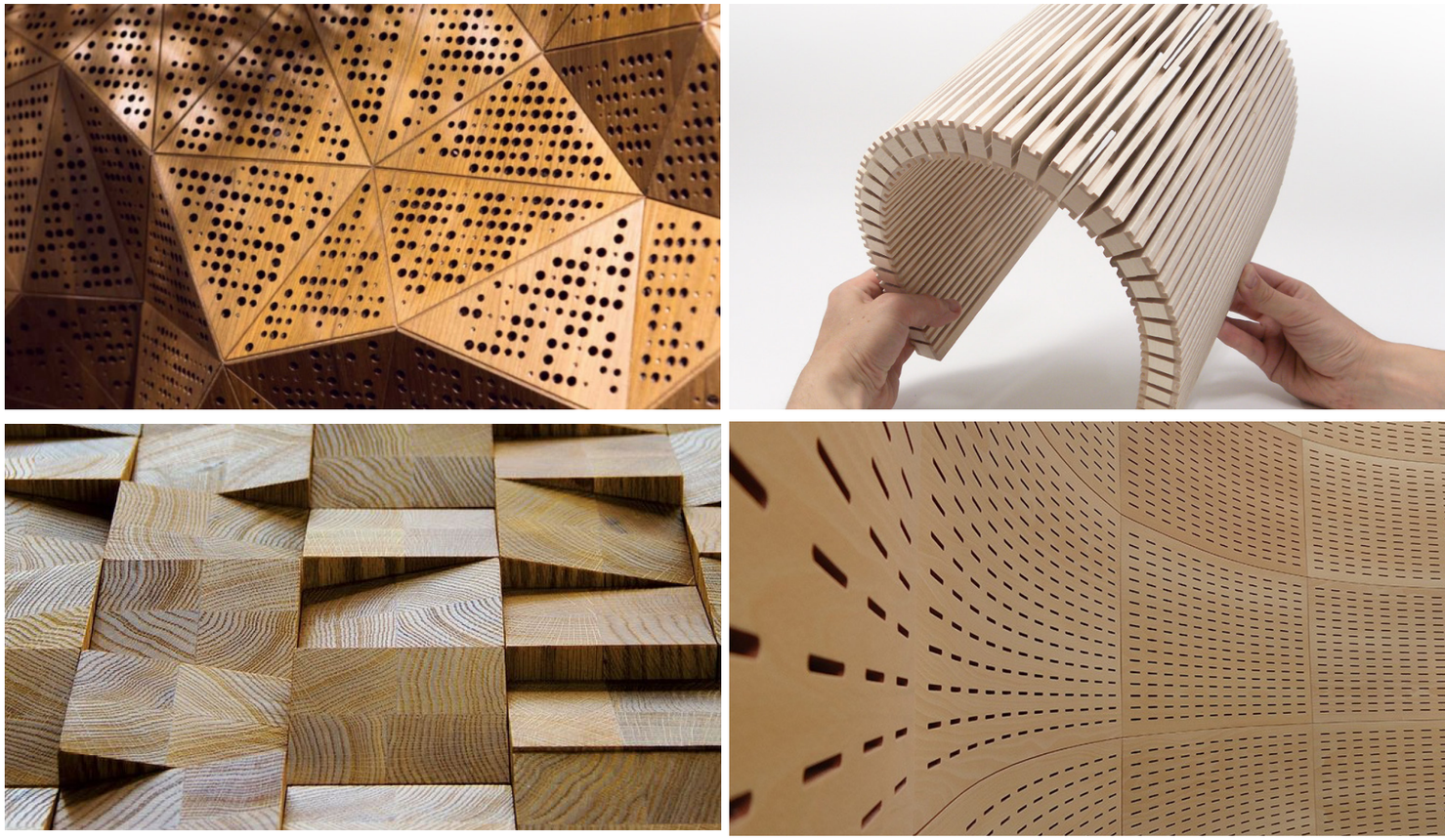


Fig. 13 - Timber acoustics

The first step was to thicken the flat surface of the first concept to something more 3-dimentional. The second step was to make the solid piece transparent by creating gap lines (inspired by the skeleton of the rayfish and products with similar build) (see Fig. 14).

This resulted in a pattern of slabs that functions as my starting point for all of my new concept (see Fig 15). The last step was to find the right support and the connection between the ribs and the support.

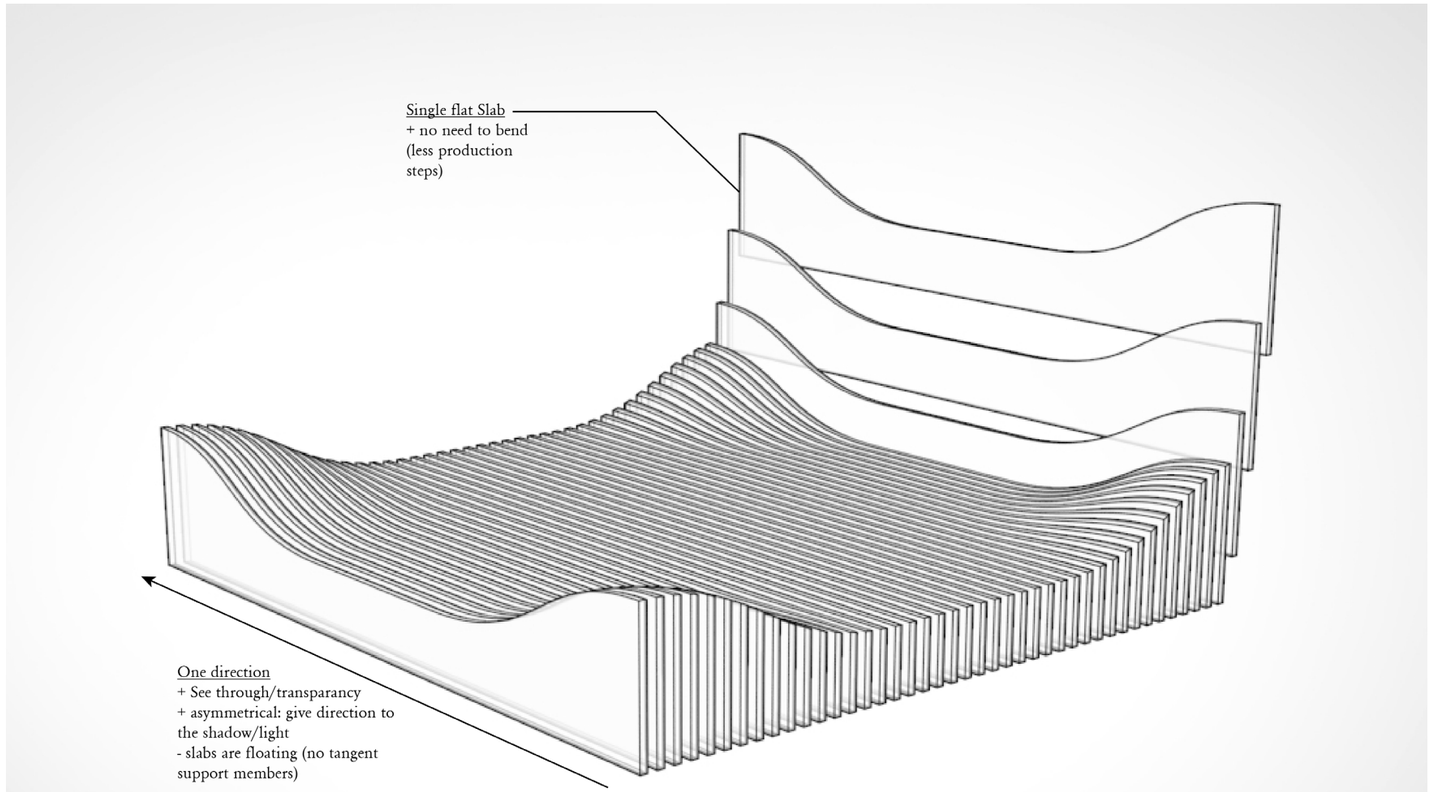


Fig. 15 - 3D build Canopy

See Sketchbook 2.4 for concept development process and comparising.

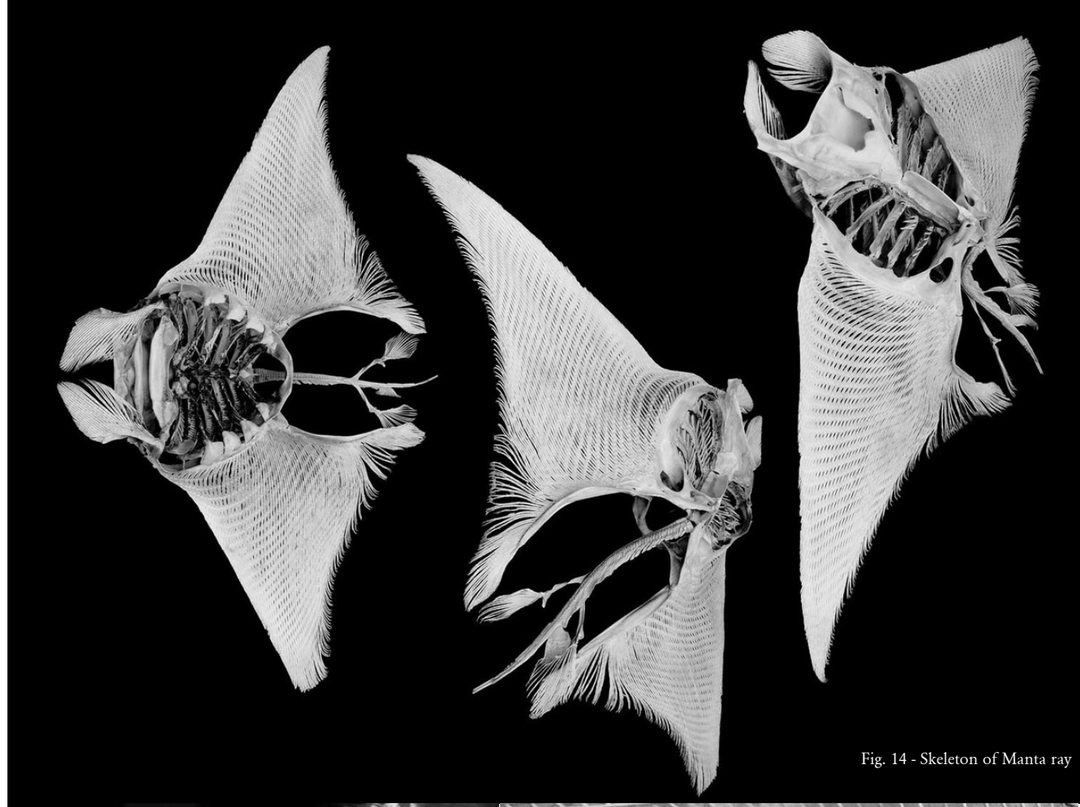
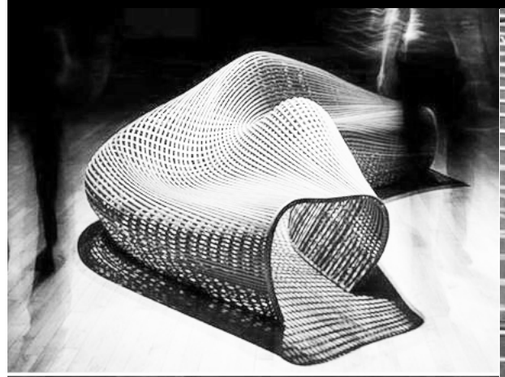
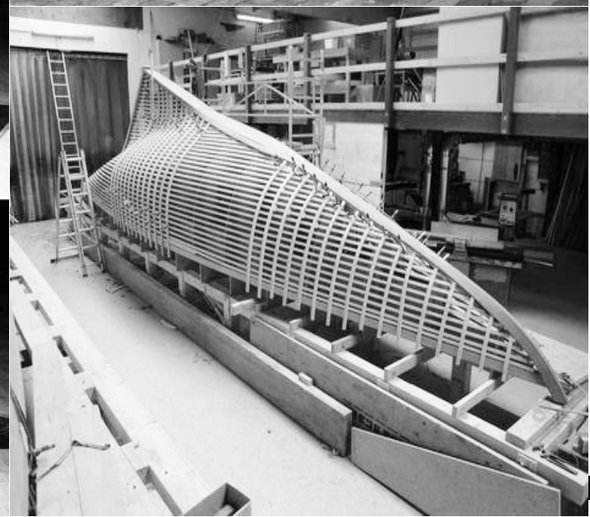
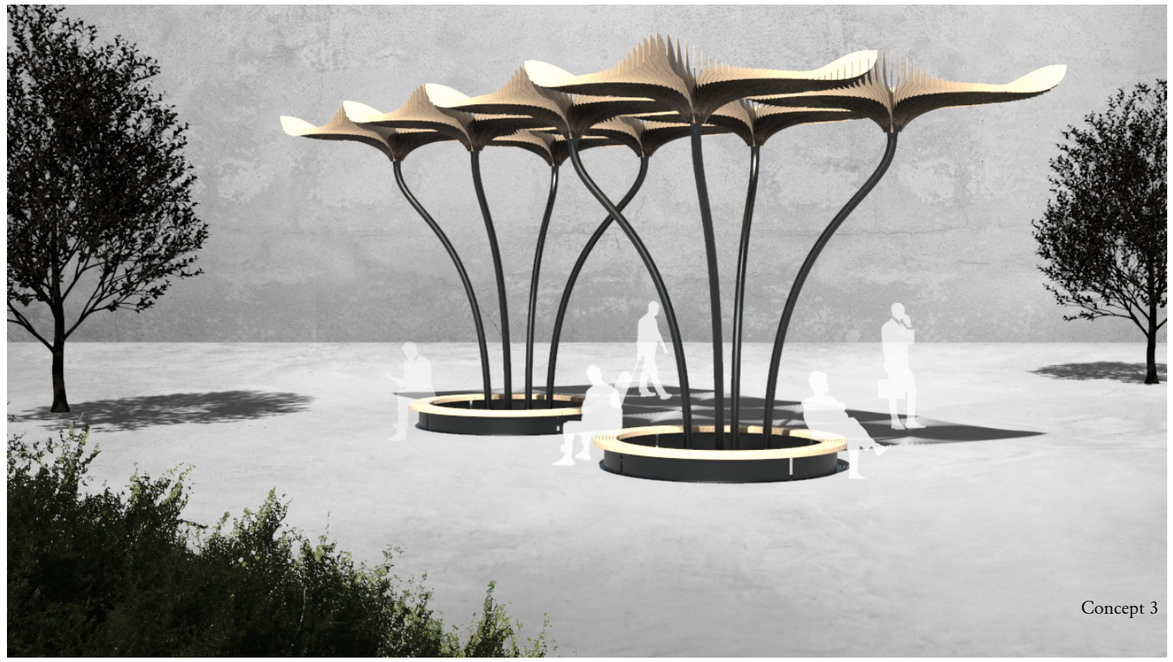


Fig. 14 - Skeleton of Manta ray

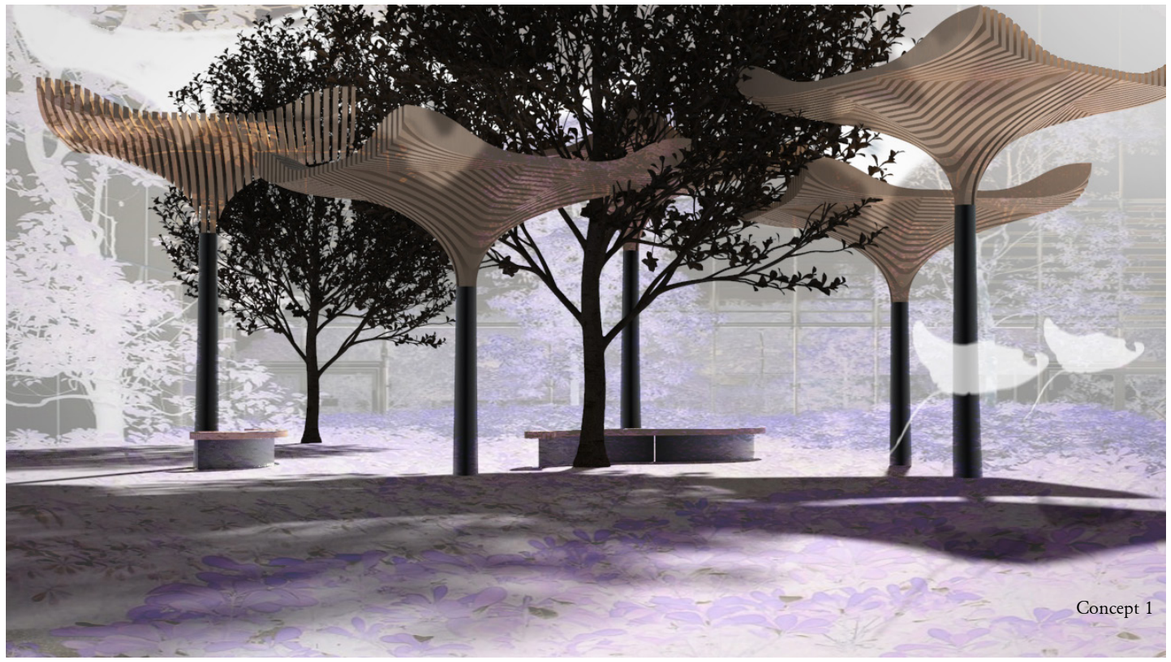




CONCEPTS



Concept 3



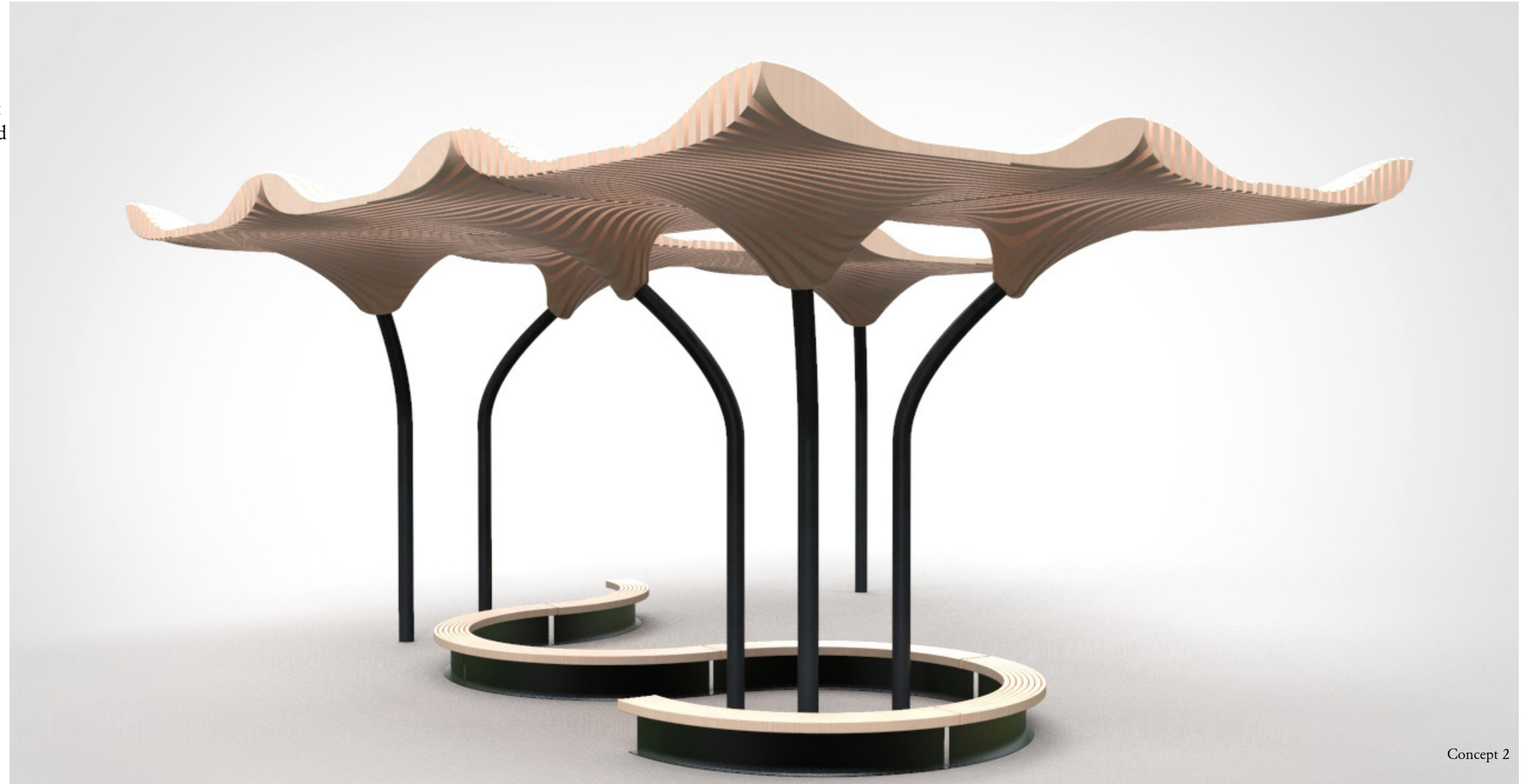
Concept 1

All these concepts were presented to GRIMSHAW Architects and discussed with GROSS. MAX. .Based on the opportunities it creates and the overall fit within the terminal concept number two is preferred by GROSS. MAX. and GRIMSHAW Architect as the most suitable concept.

Conclusion:

Concept two will be developed in the next chapter.

See appendix for Pitch results GRIMSHAW architects



Concept 2

PART 3: PRODUCT DEVELOPMENT

LANSCAPE-PODS

Heathrow Expansion
New TX5 terminal-
LANDSCAPE-PODS

During this chapter many decisions are based on the knowledge of engineers, architects, product designers and manufacturers that are spoken with. The calls are all chronologically documented in the appendix: Minutes of Meetings. These calls give additional information why certain steps are taking in this phase and for this reason recommended to read.

THE LANDSCAPE PODS - Product

Form

The form of LANDSCAPE-PODS can be split in two main shapes; the roof consisting of timber slabs and the column that support this rooftop. The aim is to create a canopy based on biophilic aspects that are in line with the third space, which mean the whole shape of LANDSCAPE-PODS need to feel natural and organic. To achieve this the connection between these two, must be a natural smooth transition. This transition is based on many form factors. The first factor and most decisive one is the answer to the question:

"How the column is shaped and in what way does it interacts with the roof?"

To give a better understanding these two elements will be discussed separately.

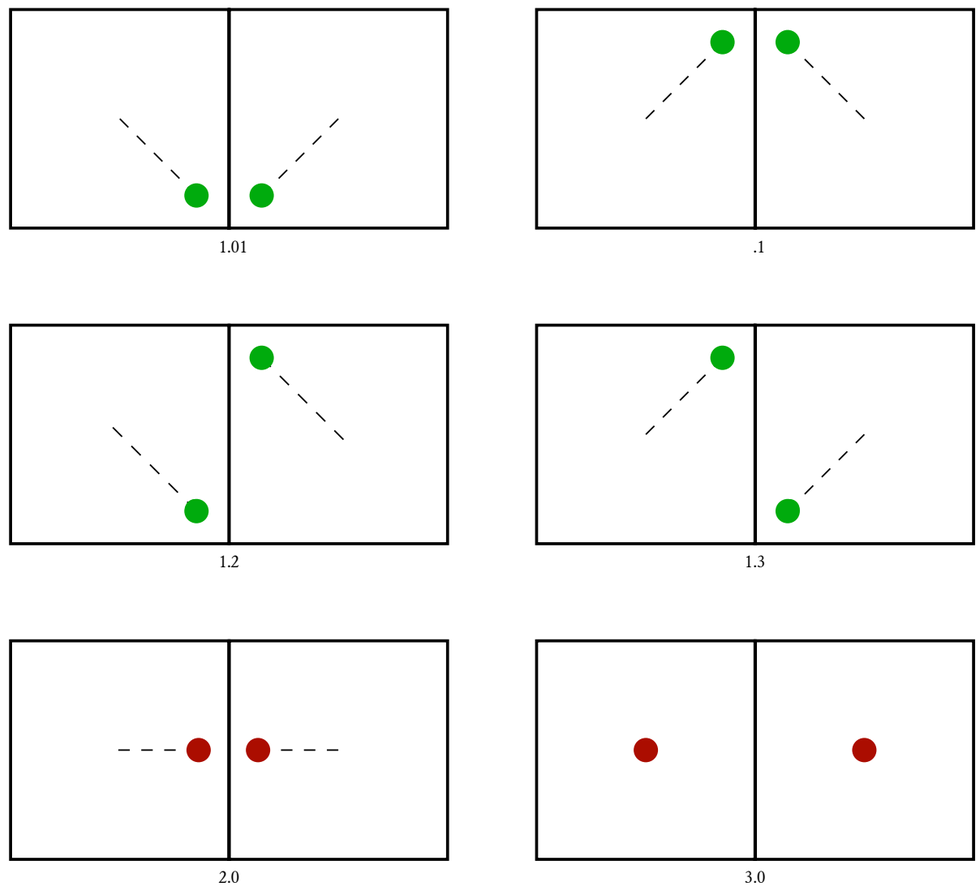
Column

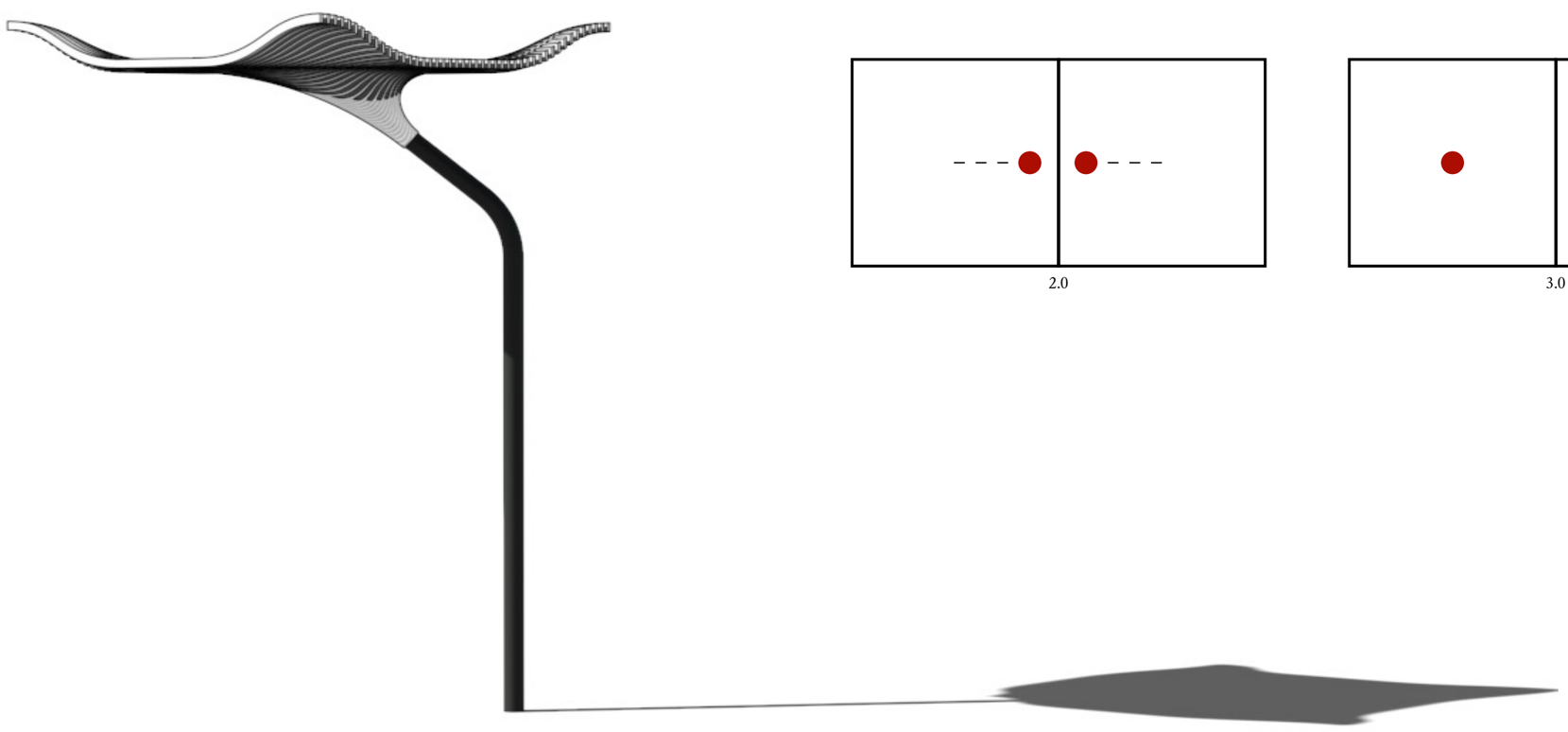
One of the goals during is exploration is to find the right balance between the shape, realization and flexibility. Flexibility in the sense of increasing the different options of using/placing the LANDSCAPE-PODS in context. The most logic step from a physical perspective would be to place a straight pole in the center of the roof. Because this requires the least counterweight due the centered balance-point. The downside on the other hand is the lack of flexibility because you could only create one kind of grid when you cluster them together. The option that gave the most variety is to fix the column on the diagonal of square towards one corner (see Fig. 16) . This is tricky because the diagonal line of the column meets and crosses the vertical lines of the slabs and could cause fixing problems.

The Column is basically a straight tube bended towards the middle point of the roof. The choice of making the column straight at the bottom is to minimalize the change of passenger's pump into and to avoid the column being in contradiction with other terminal elements/dimensions. It also makes it easier to attach elements to it, for example a heater.

Fig. 16- **Column Combinations with 2 canopies.**

Dot: column meets the ground.



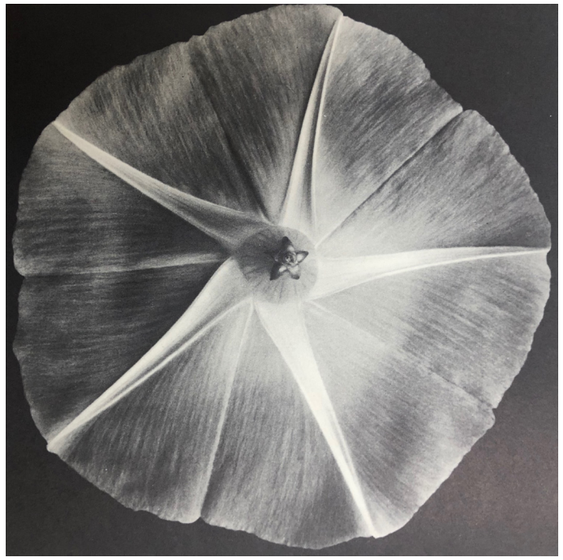


Roof

The other factor is the shape of the roof and can be summarized as a square surface that tapers to a circle profile that meets the column in an organic and smooth line. The idea behind the LANDSCAPE-PODS is to create a form that looks pleasing from every angle without any line disruptions.

The LANDSCAPE-PODS are shaped in a sense they show a different appearance from every angle (see Fig. 17). This means when they are clustered it looks like the group consist of differently shaped canopies, but that is not the case. This property keeps the LANDSCAPE-PODS interesting, because of variation as seen in different configurations.

Another interesting aspect of the roof is the timber slabs are getting thinner the closer they get to the edge. From a mechanic perspective this is the most logical considering the fact that when the distance increases the mass of the slabs have more effect on the moment, which requires more force support you want to avoid. To stay with biophilic design this also happens in the well-known structures of plants, trees and flowers . Alongside from this, it also accentuates the overall waviness of the LANDSCAPEPODS.



Bottom view Flower

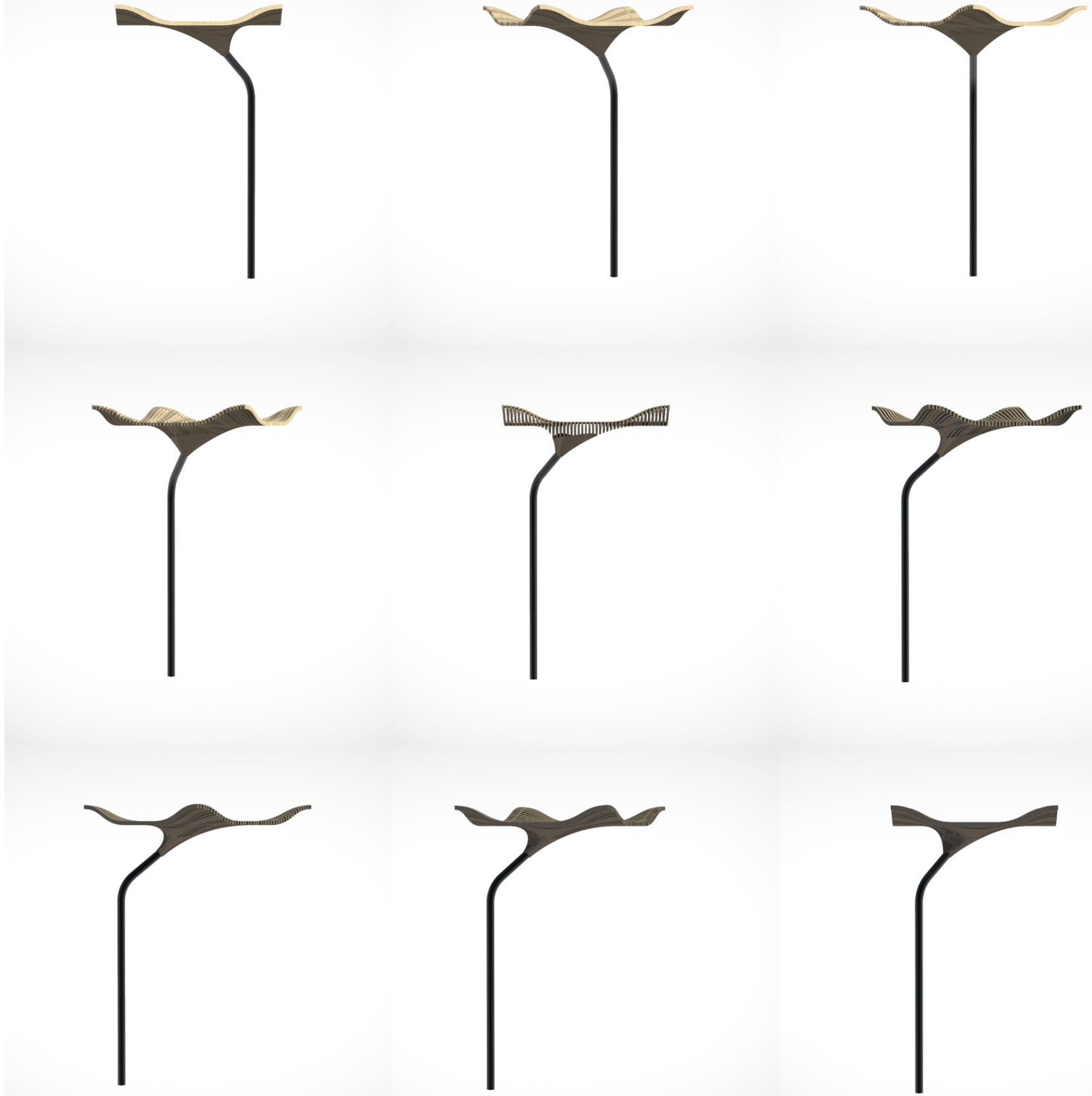


Fig. 17 - LANDSCAPE-PODS from different perspectives

FORM APPLICATION

The form of the product is highly connected to the function of the product. The LANDSCAPE-PODS are designed in way they are as flexible as possible and can be placed and used in many ways. The main functional characteristics ain relation to the form are wayfinding, modularity and light.

Wayfinding

Because they are above eye level and easy to recognize from a far distance and to distinguish from the rest of the terminal, the LANDSCAPE-PODS play a big role in natural wayfinding, which is considered as the primary objective of an airport (see Fig. 18). Because Airports in general expect natural wayfinding and not just signage. The PODS can function as landmarks that gives the passenger directions to terminal elements like check-in kiosks. The part of the PODS that provides this is the column, because of the column's form language the passenger's eye is guided to one place. This characteristic becomes even stronger when the PODS are clustered.

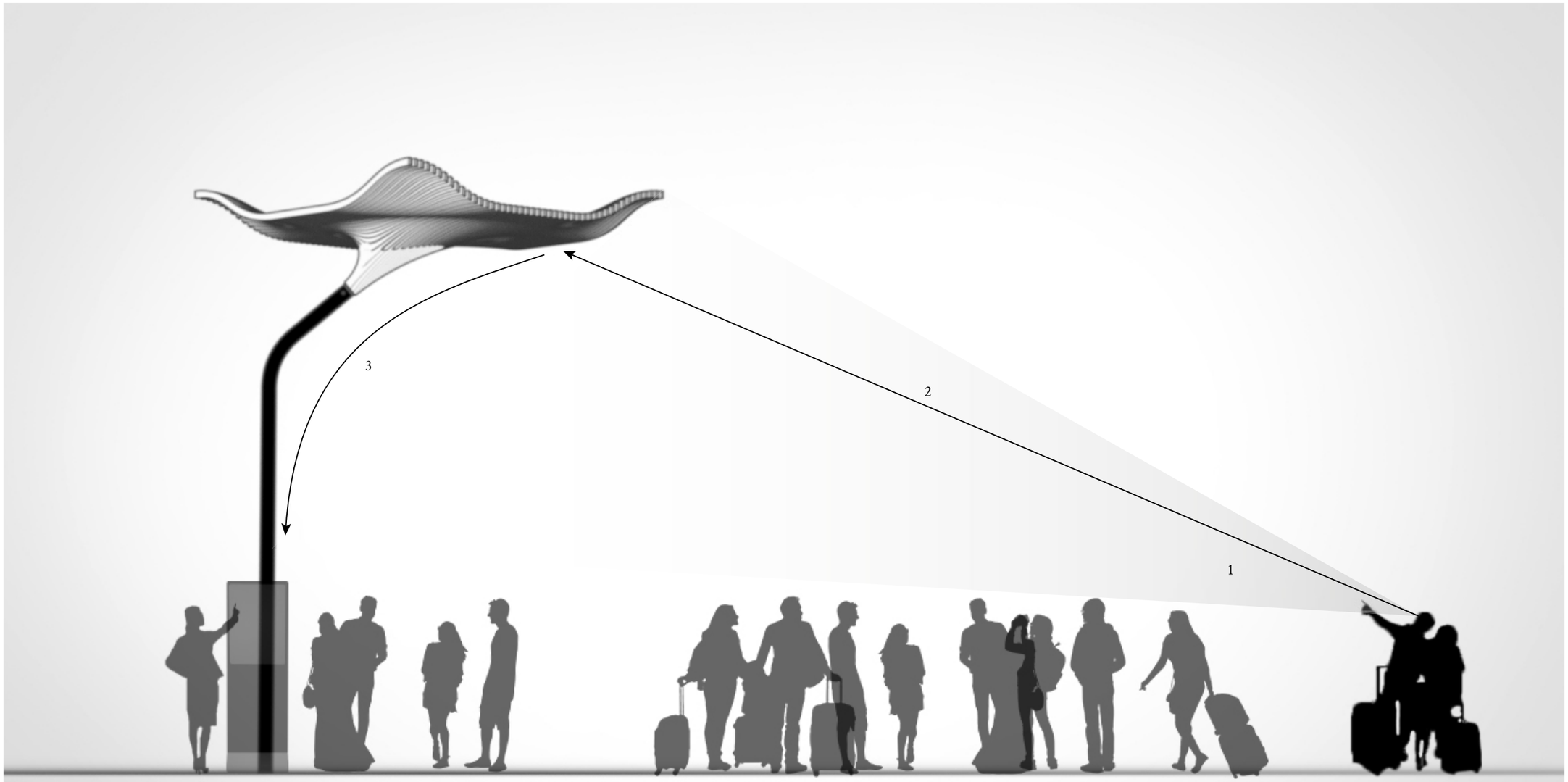


Fig. 18 - LANDSCAPE-PODS as Landmark

Modularity

One characteristic of the product is modularity. The LANDSCAP-PODS can be grouped in infinite ways and are easy to combine with other terminal applications like seating elements and can follow the lines of the landscape because of the different variety in column placements (Fig. 19). This gives Heathrow the change to group the LANDSCAPE-PODS in preferred rhythms, symmetries and properties based on the terminal area. On top of that the LANDSCAPE-PODS do also function as single products and can be combined with the present green nature and trees in the terminal or be clustered by overlapping them and using different kind of heights (see Fig. 20).

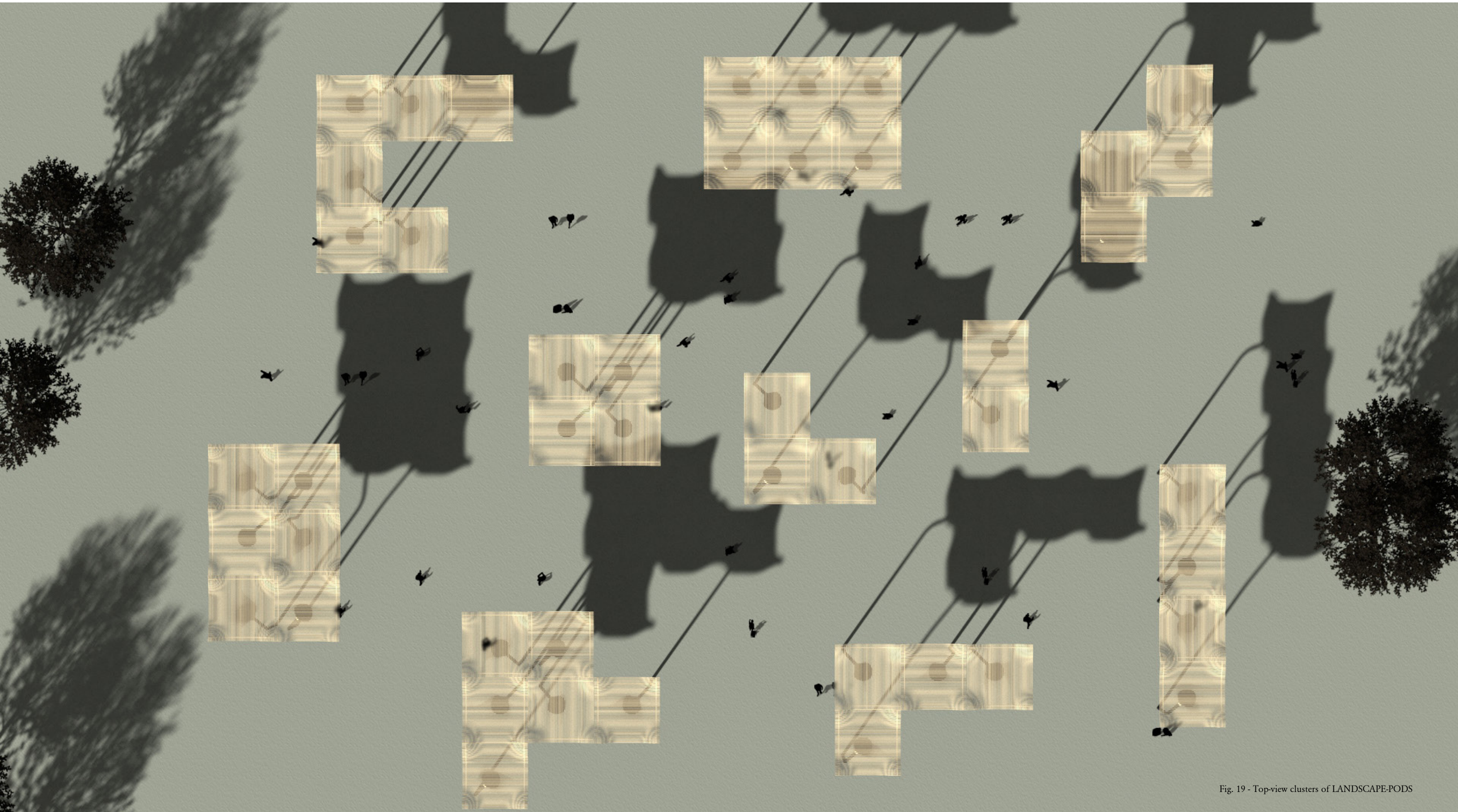


Fig. 19 - Top-view clusters of LANDSCAPE-PODS

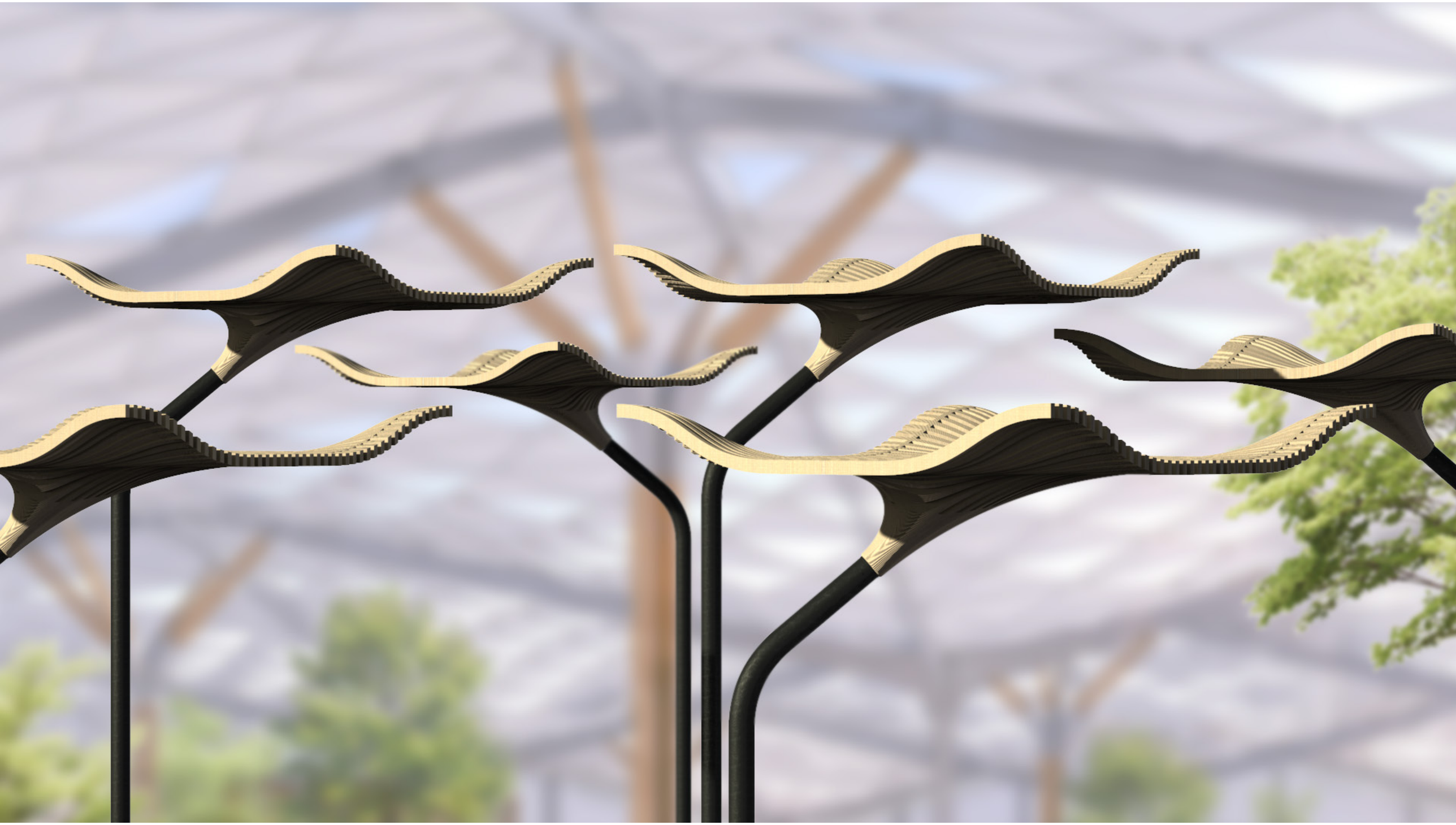
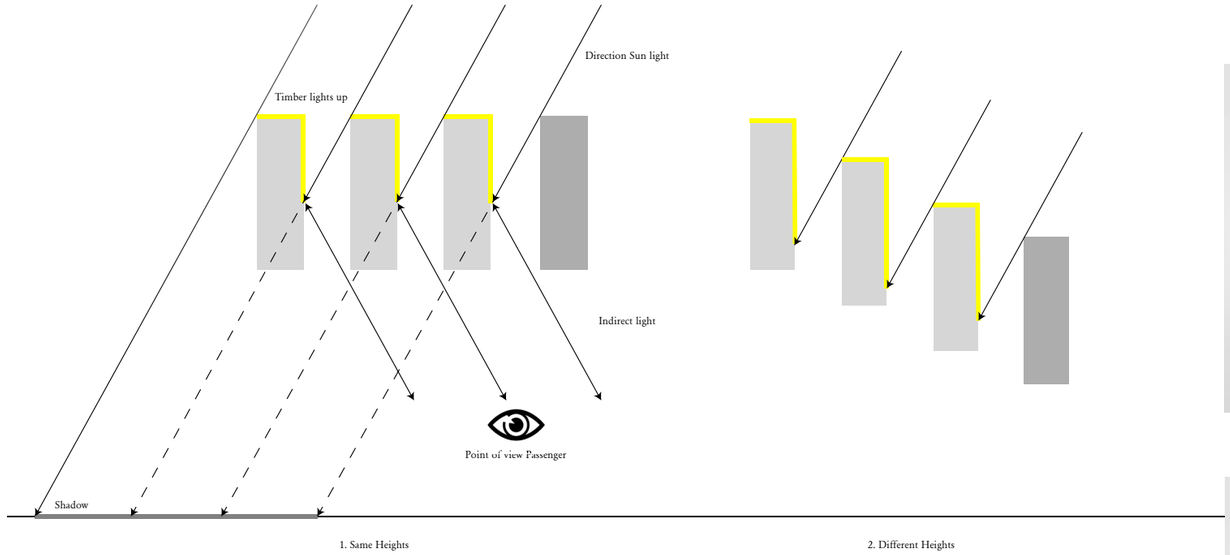
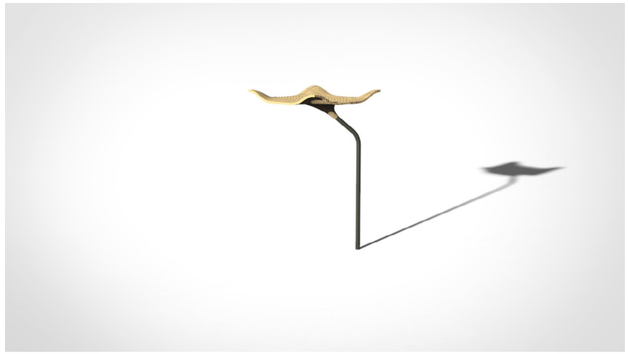


Fig. 20 - Overlapping LANDSCAPE-PODS in Third-Space

The Timber slabs have a horizontal pattern with similar sized gaps between them. Because the PODS work with sunlight it is interesting to see the different interaction of shadow and surface color grade between these two, because it keeps changing during the day and the year (Fig. 21). The direction of the sun in London (Heathrow) is most of time not directly above the LANDSCAPEPODS, which means the sun beams hit the slabs from a certain angle that create a closed shadow.

But more interesting is the light bouncing of the surface slabs, forming an indirect source of light. Hence instead of fully blocking the sunlight, the direct source is changed to indirect. The slabs in the corner are thin and curved and therefor collecting the most visible sunlight. This creates an interesting interplay of lines, light and shadow (see Fig. 22).





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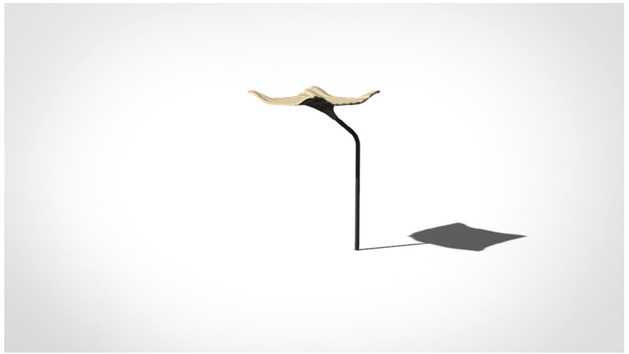

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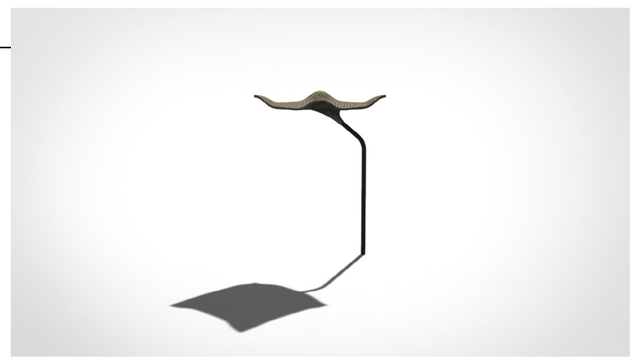

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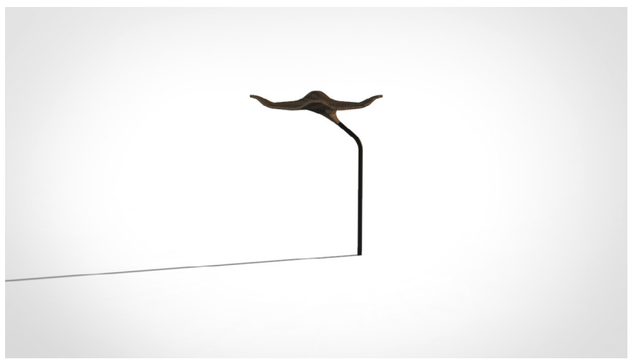

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Location: London
Coordinates: 511,32ºN, 0,5º E
Date: 15 May

Fig. 21 - LANDSCAPE-PODS daylight-study

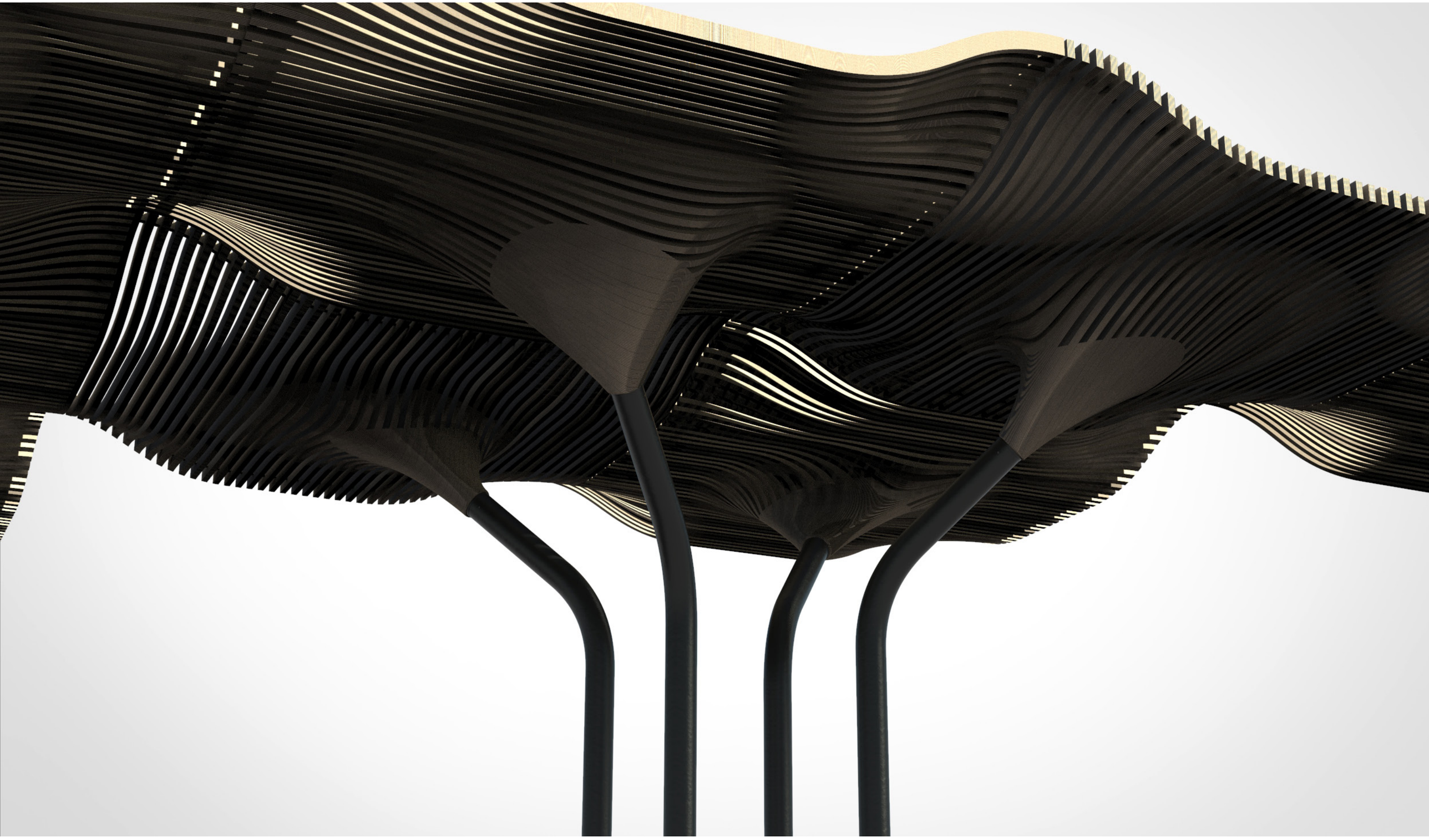


Fig. 22 - Passenger under PODS perspectieve

MATERIALITY

The LANDSCAPE-PODS can be split up three main parts that can be assembled; the roof, connector and-column.

See appendix Minutes of meeting H

1. Roof

The Rooftop part is made completely from Laminated Veneer Lumber (LVL) panels. Based on the conversations with specialists the most fitting timber composition for this rooftop element for many reasons. Despite the fact this was the most recommended material, there was still an interest to compare different kinds of wood (Appendix: Materialisation), but this did not result in anything special.

One of the most successful producers of this LVL is the company Metsäwood, they are strong in Europe and make use of 100% traceable sustainable raw wood from northern forests and have done impressive projects like one of the largest wooden buildings; the Metropol Parasol in Sevilla. It was definitely worth trying to contact MetsäWood and they were in. They agreed with the choice of material and recommended the Kerto LVL Q-panel as the best option. It is known for its strength, straightness and dimensional stability.

Fig. x - Appearance LVL: surface and grain

The Rooftop element can be split up three LVL parts.

1.1 The pattern of 45 ***slabs/ribs***

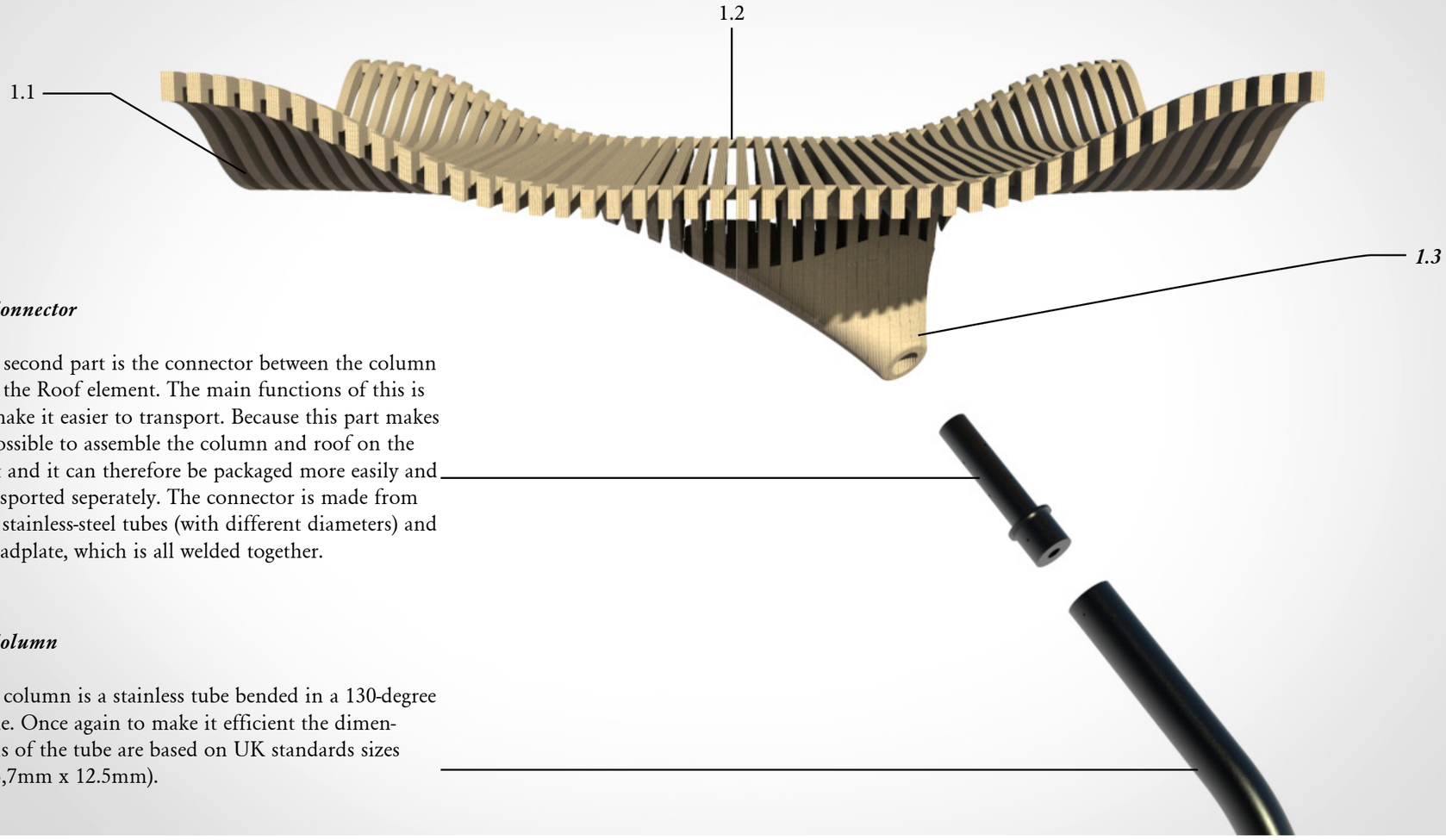
These LVL panels have an available stock size dimension of 45mm, a 4000mm length and are separated by a 44,88mm gap. This result in tuned 4mx4m square. (These dimentions are not avalaible in the material that comes the closest to LVL: plywood)

1.2 Two ***support members*** that keep the slabs together and provide them from floating (see Fig. 23).

These are straight two (45mm) LVL slabs perpendicular to pattern above. Because the support members interlock with the slabs, they do not interrupt overall smoothness of the LANDSCAPE-PODS. The interlocking system provide the slabs from friction and shear stress. Because this part is cut in particular interlock dimensions, which makes it easy to keep the right gap distance between the slabs. Many options are tried during this process, but most of them where in contradiction with the form or "transparancy".

1.3 ***Solid piece***, the transitions part from roof to column.

Seen from a top view perspective this part is tricky because of the diagonal column that meets the vertical slabs in a 22.5-degree angle. On top of that the slabs have open gaps between each other and are not locked together. When the column must be fixed to the roof this is far from ideal, because this result in a structure that has no proper force transition from the roof into the column. This is crucial if you do not want the structure to break on particular point or lose stability. Therefore, a solid piece is designed made out of multiple glued LVL, this larger thickness can be produced by Kerto LVL production lines. This piece can be glued (polyurethane or melamine) together by a vacuum press or glulam press. These multiple glued Kerto Products are CE-marked. The shape of the solid piece had to big enough to divide the force of gravity and wind load, but at the same time could not be too big. Because this would block the transparency and the organic looks of the canopy. The solid piece is designed in a way to minimalize the transition between solid and "transparent".



2. Connector

The second part is the connector between the column and the Roof element. The main functions of this is to make it easier to transport. Because this part makes it possible to assemble the column and roof on the spot and it can therefore be packaged more easily and transported seperately. The connector is made from two stainless-steel tubes (with different diameters) and a headplate, which is all welded together.

3. Column

The column is a stainless tube bended in a 130-degree angle. Once again to make it efficient the dimensions of the tube are based on UK standards sizes (193,7mm x 12.5mm).

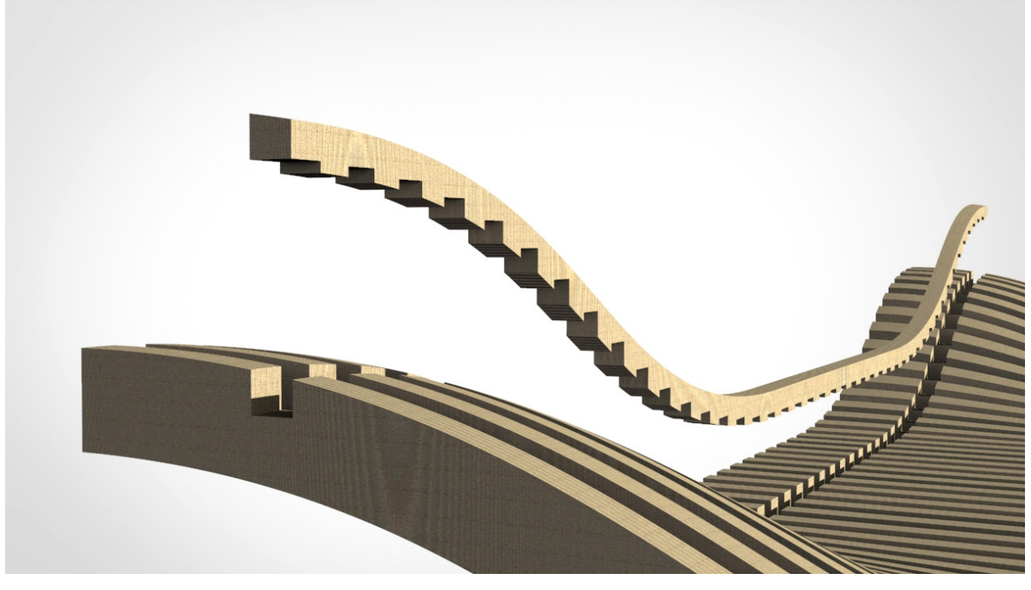
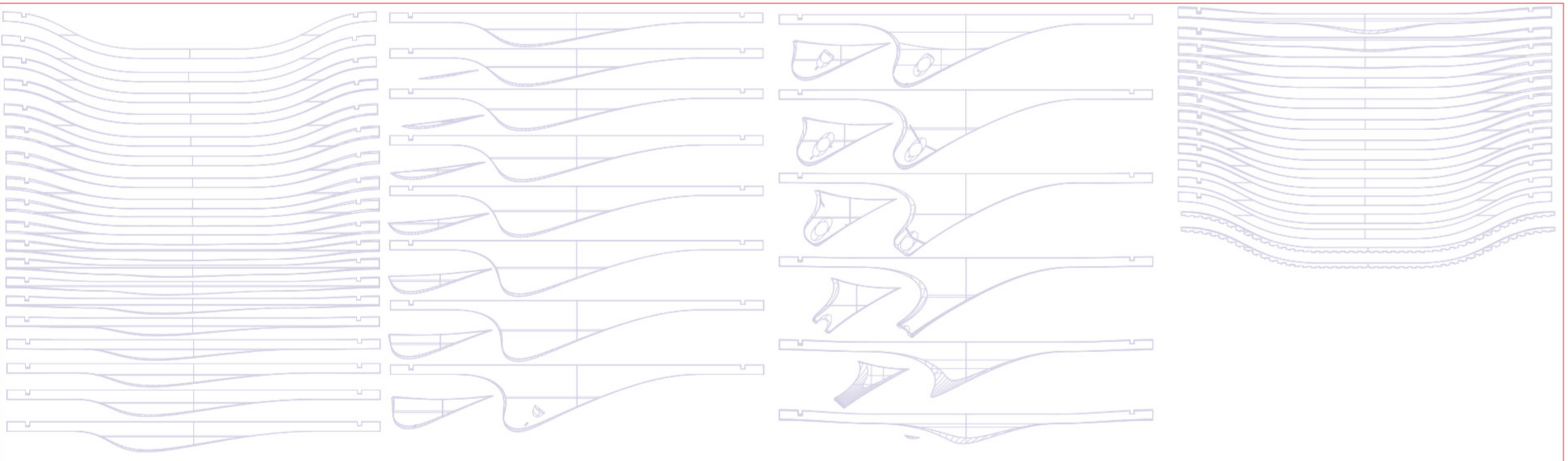


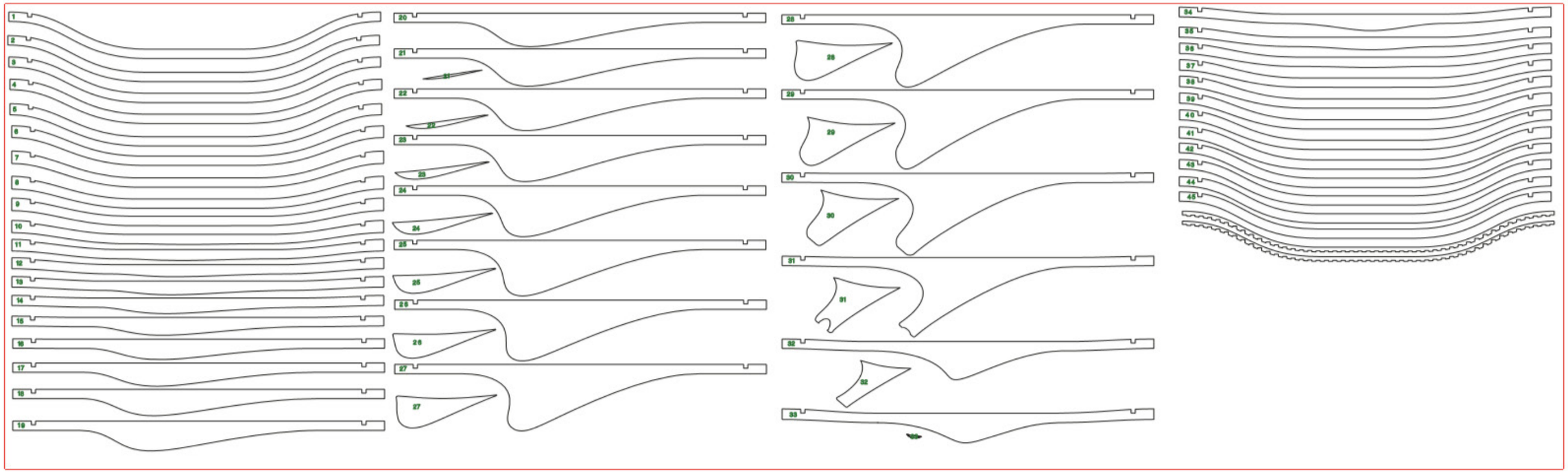
Fig. 23 - Support members

What makes this Rooftop element efficient and practical is the fact they can all be cut from the same kind of Kerto LVL Q-panels and be glued in the factory with non-toxic water-based glue. The most efficient cutting way of cutting the slabs out the sheets can be found below in three steps.

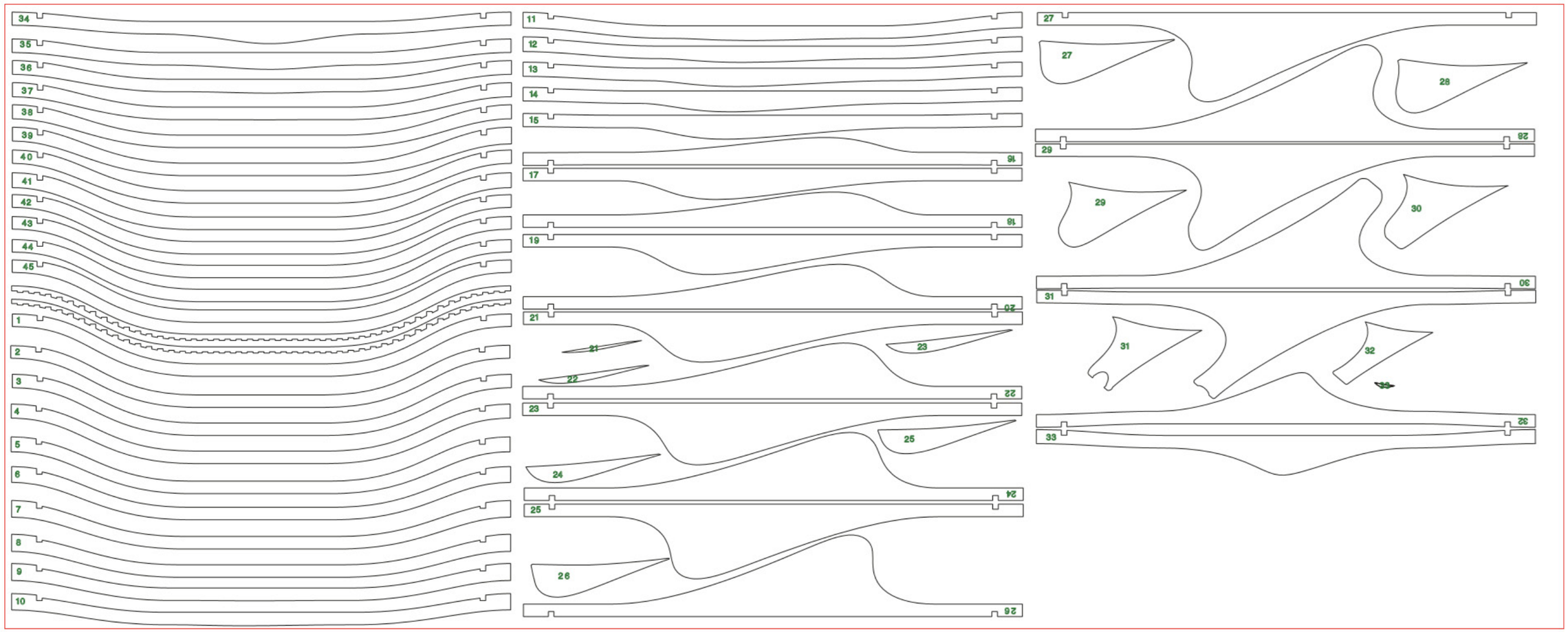
The actual edge profiling can be done by a CNC machines by companies MetsäWood work with, like Züblin. This all will result in a low amount of wastage. The visual appearance of the roof element can ben improved by optical sanding, only to make it more natural (removing glue).



1:Roof converted to different layers/slabs of LVL



2: Edge profiles are thickened to the surface of the slabs, so these can be profiled after cutting.

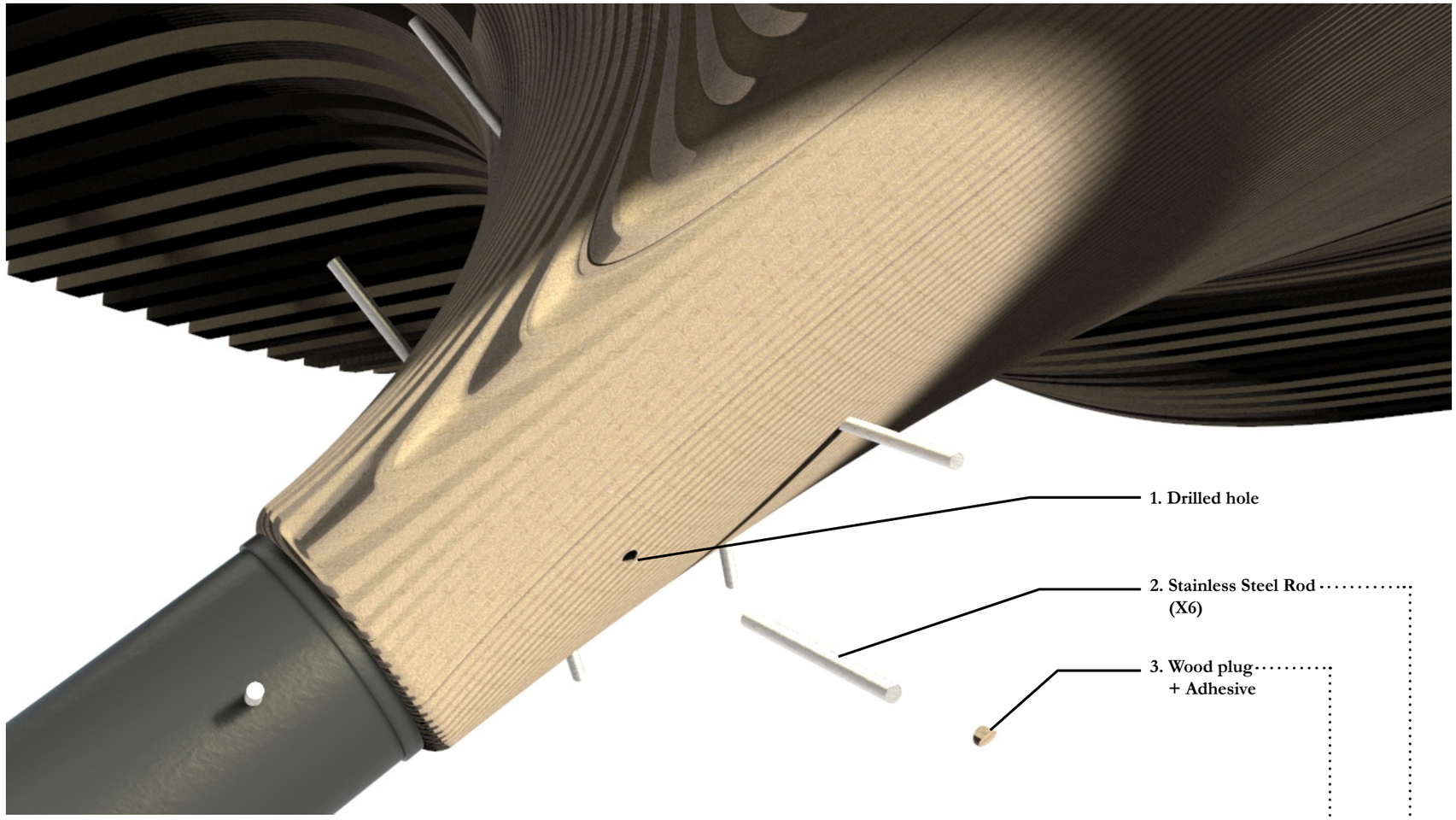


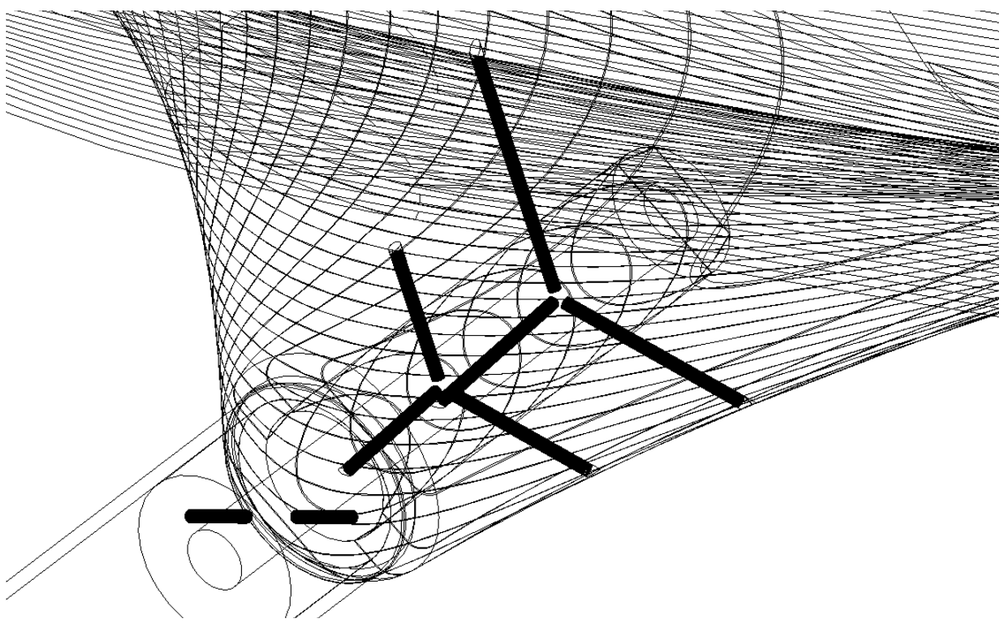
3: The slabs are ordered/devided in a way the lowest amount of LVL Panels is needed; less wastages and more efficient

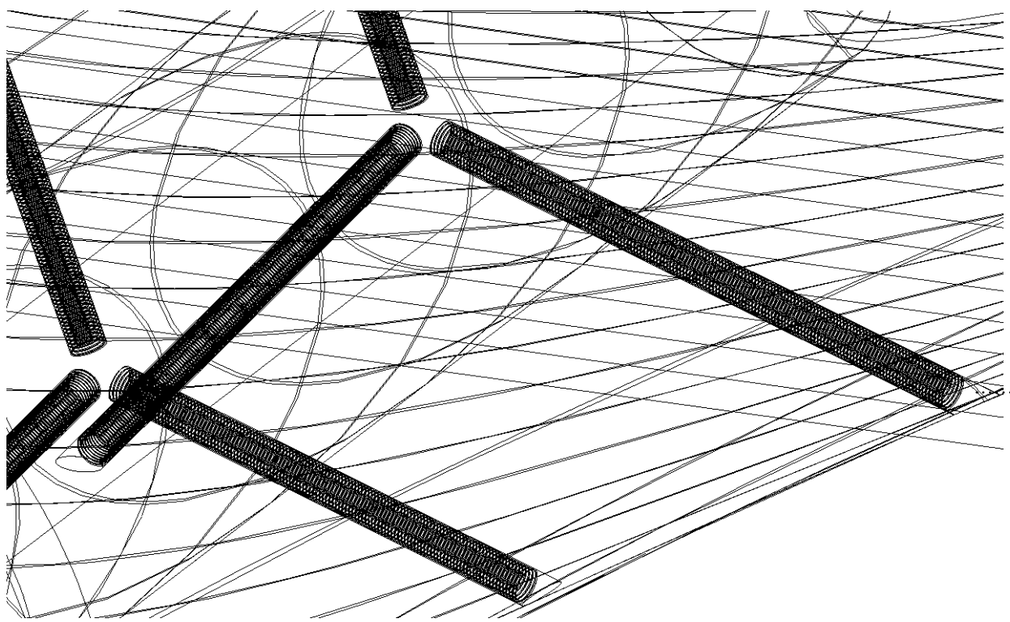
FIXING AND FIXTURES

Connection Steel / Timber

The technique by which the parts are fixed together is related to the order of manufacturing steps. Daniel Kreissig from MestäWood stated in our call that the whole product would be very likely done by a 4D CNC machine than anything else. They will glue it all together and would than set it up and machine it round to get the rough finish. Then to finish it off completely, the drilling for the rods will have be done with precision, because the machine can determine the exact points for the drill to be exactly in the right place (if needed pilot holes can be drilled). The hole where the post goes in can be realized by making a rough cut and machine it from the inside (Daniel Kressig). The connector is shoved in the hole and fixed to the timber by pre-treated stainless-steel rods (x6) that meet the inner tube perpendicular and are screwed tight to the treated holes in the inner tube (see Fig. 24). These rods in general are known for their construction performance. In this case they are used to reinforce the solid timber piece and to increase the stability. To make this fixing invisible for the outside, the holes are covered with glued wood plugs. The connector can be slid over the steel column on location and fixed with two steel screws with the same diameter as the rods.







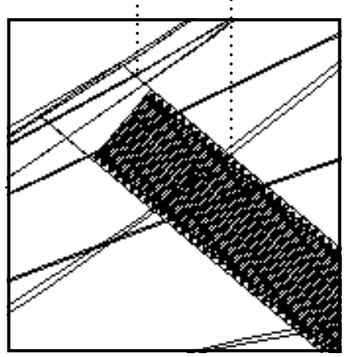
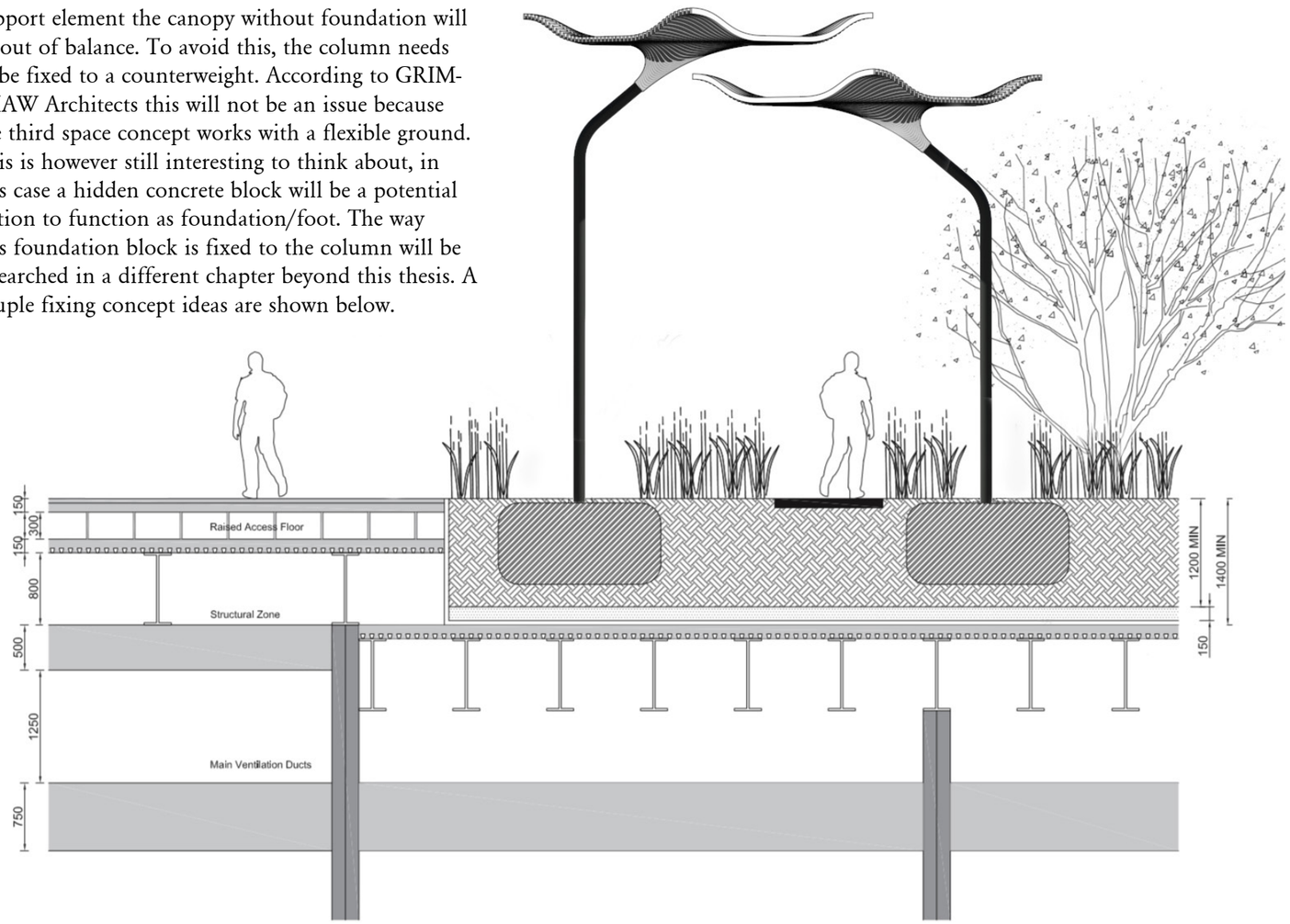
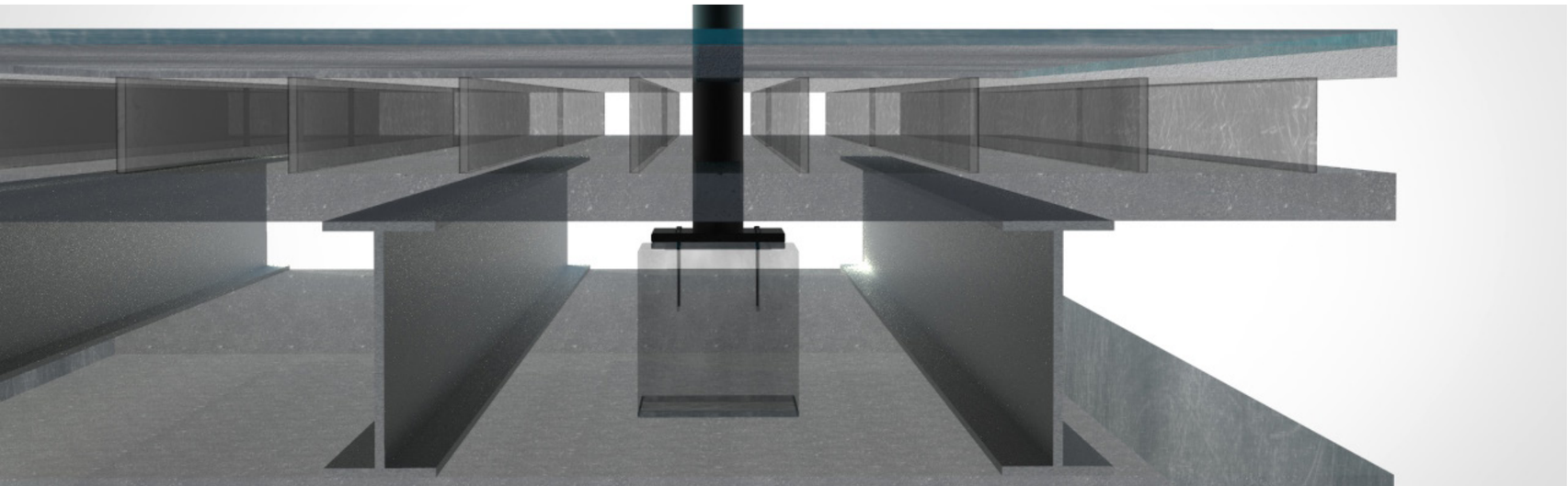


Fig. 24 - Transpart view POD, location of rods

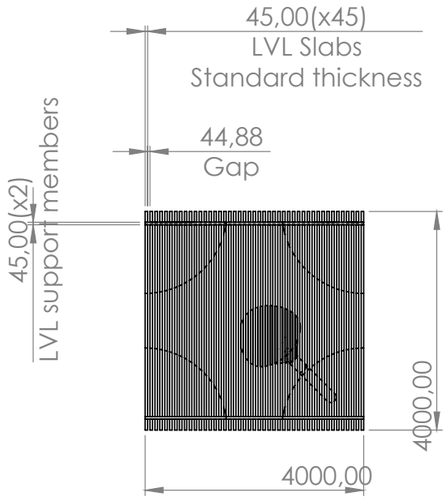
Floor fixing

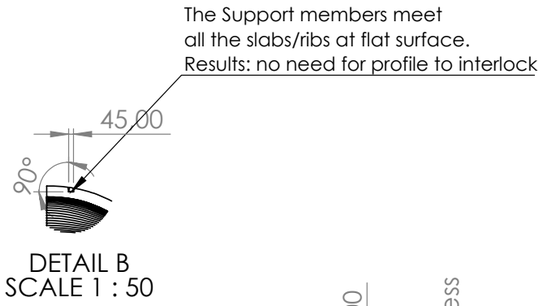
The LANDSCAPE-PODS will be integrated to the flexible floor system of the Third Space.
Because there is a distance between the center and the support element the canopy without foundation will be out of balance. To avoid this, the column needs to be fixed to a counterweight. According to GRIM-SHAW Architects this will not be an issue because the third space concept works with a flexible ground. This is however still interesting to think about, in this case a hidden concrete block will be a potential option to function as foundation/foot. The way this foundation block is fixed to the column will be researched in a different chapter beyond this thesis. A couple fixing concept ideas are shown below.



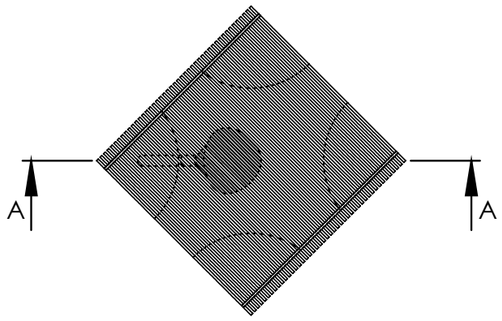


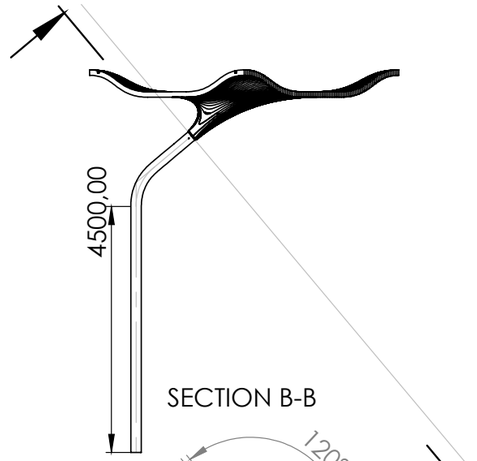
TECHNICAL DRAWING

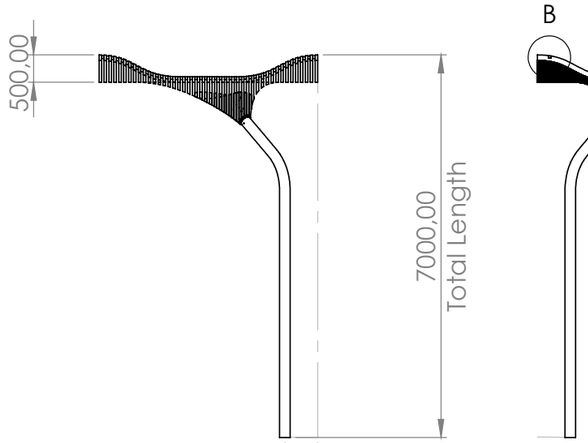


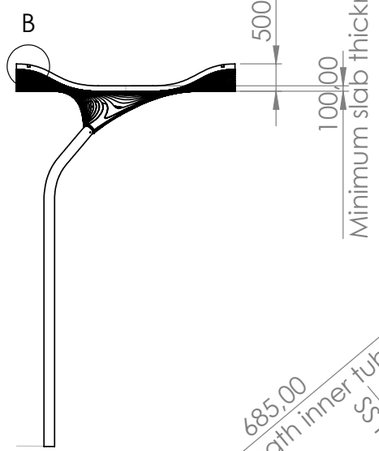


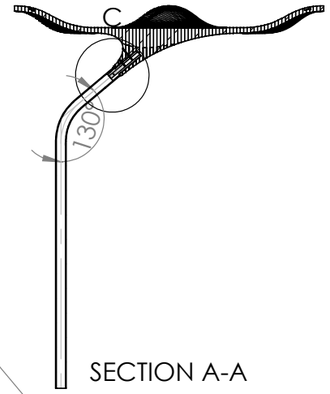
DETAIL B
SCALE 1 : 50





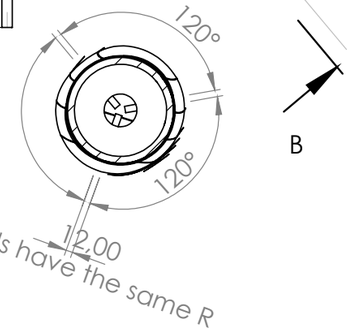


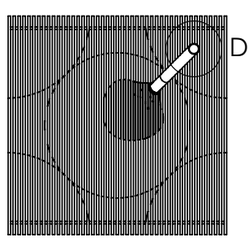


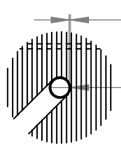


SECTION A-A

SECTION B-B

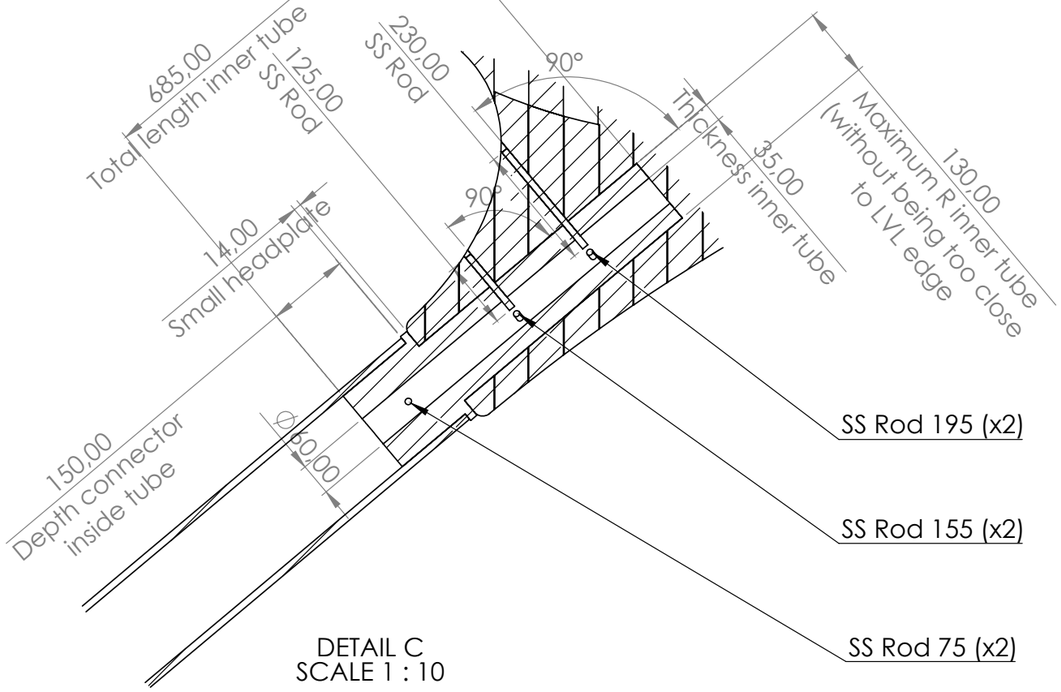






DETAIL D
SCALE 1 : 50

12,50
Uk stock standards
∅193,70
UK stock standards



DETAIL C
SCALE 1 : 10

PROTOTYPE

Due to the fact that building a real prototype was not feasible due to the actual scale of the product and the timewindow of this thesis, I decided to follow two routes. One was that of building a physical scale model and secondly by using the advantages of contemporary computer technology. The interaction between digital and physical modelling for getting the final form would have been ideal, but now this is a recommendation for next steps. Such form finding process might produce the most efficient and feasible structure at the end.

Computer simulation

I experimented to transfer the drawings generated by Solid Work computer programme into a form we could combine the model with Grasshopper. This would allow us testing the axial forces and structural efficiency and if necessary, go through a process of size optimisation of the various components in order to reduce the internal stresses.

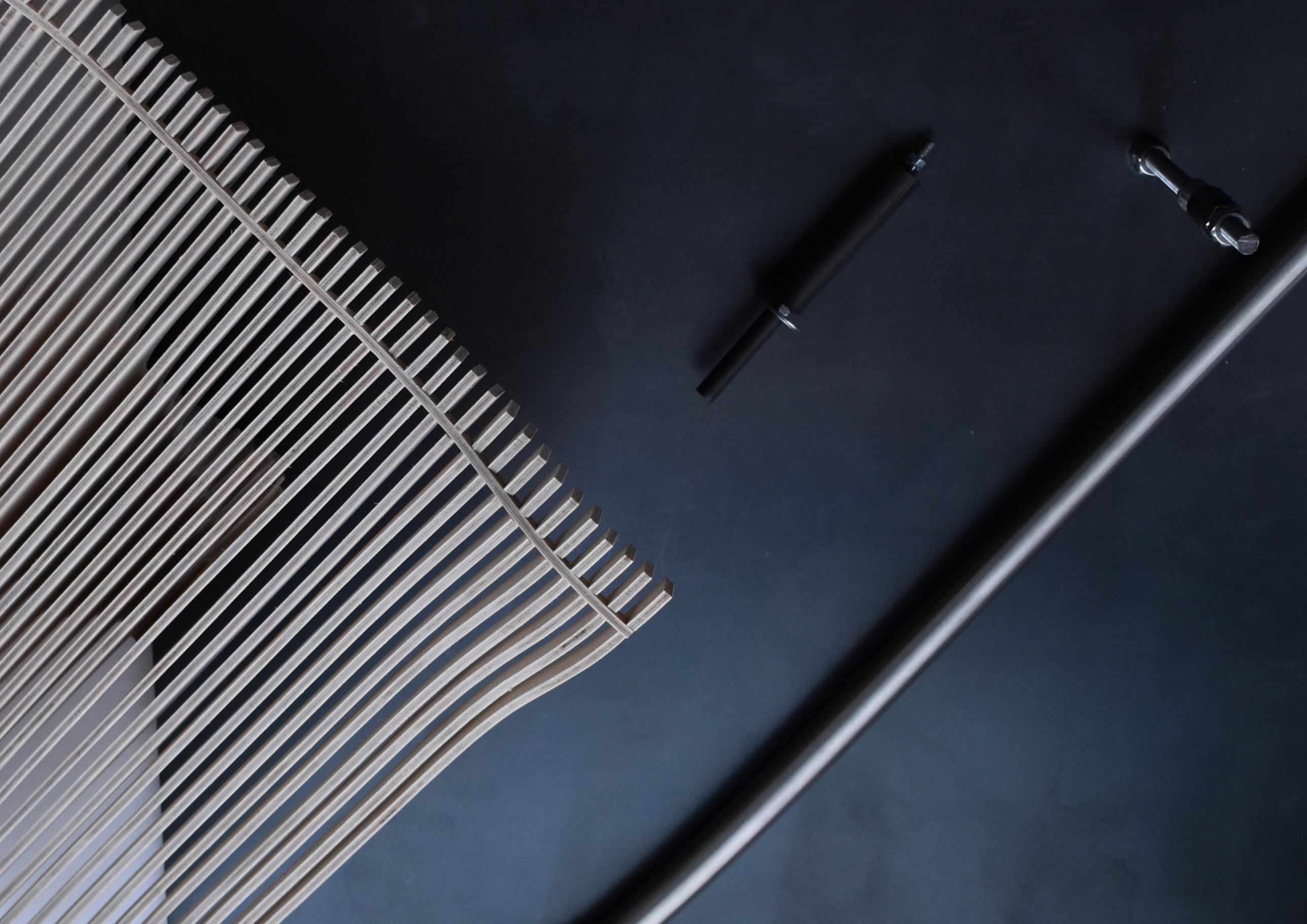
See appendix X to
see first force simulations.

Scale Model

For the construction of the scale model the actual ‘cutting sheet’ can be considered a prototype for the manufacturing process of the various wooden ribs. The physical scale model helped me to understand the actual stress behaviour and to confirm my original assumptions and calculations. Two scale models are made:
1:50 and 1:10
See photos below.

Scale
1:50

Scale
1:10



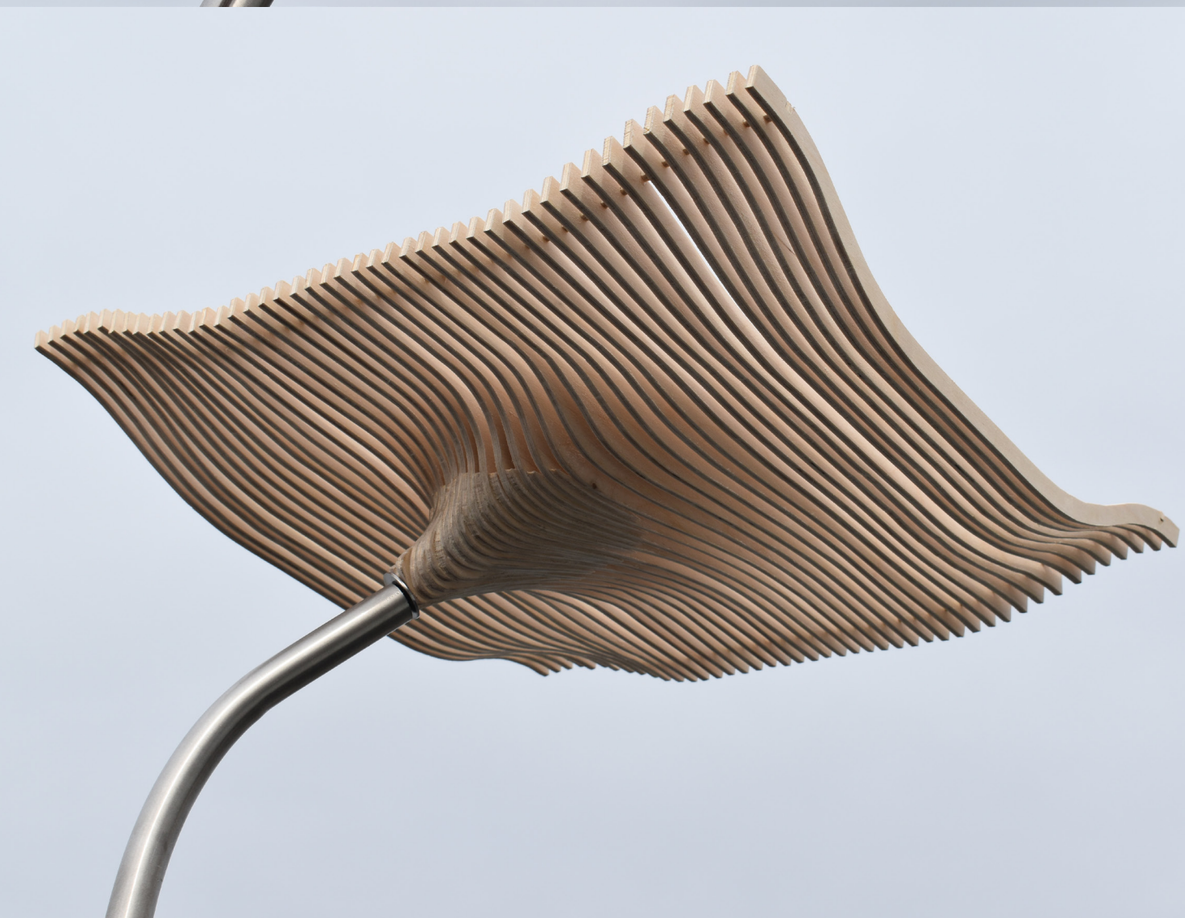


Fig.- LANDSCAPE-PODS in context - Nighttime

Fig.- LANDSCAPE-PODS in context - Daytime

DISTRUBUTION LANDSCAPE-PODS WITHIN THIRD SPACE CONTEXT

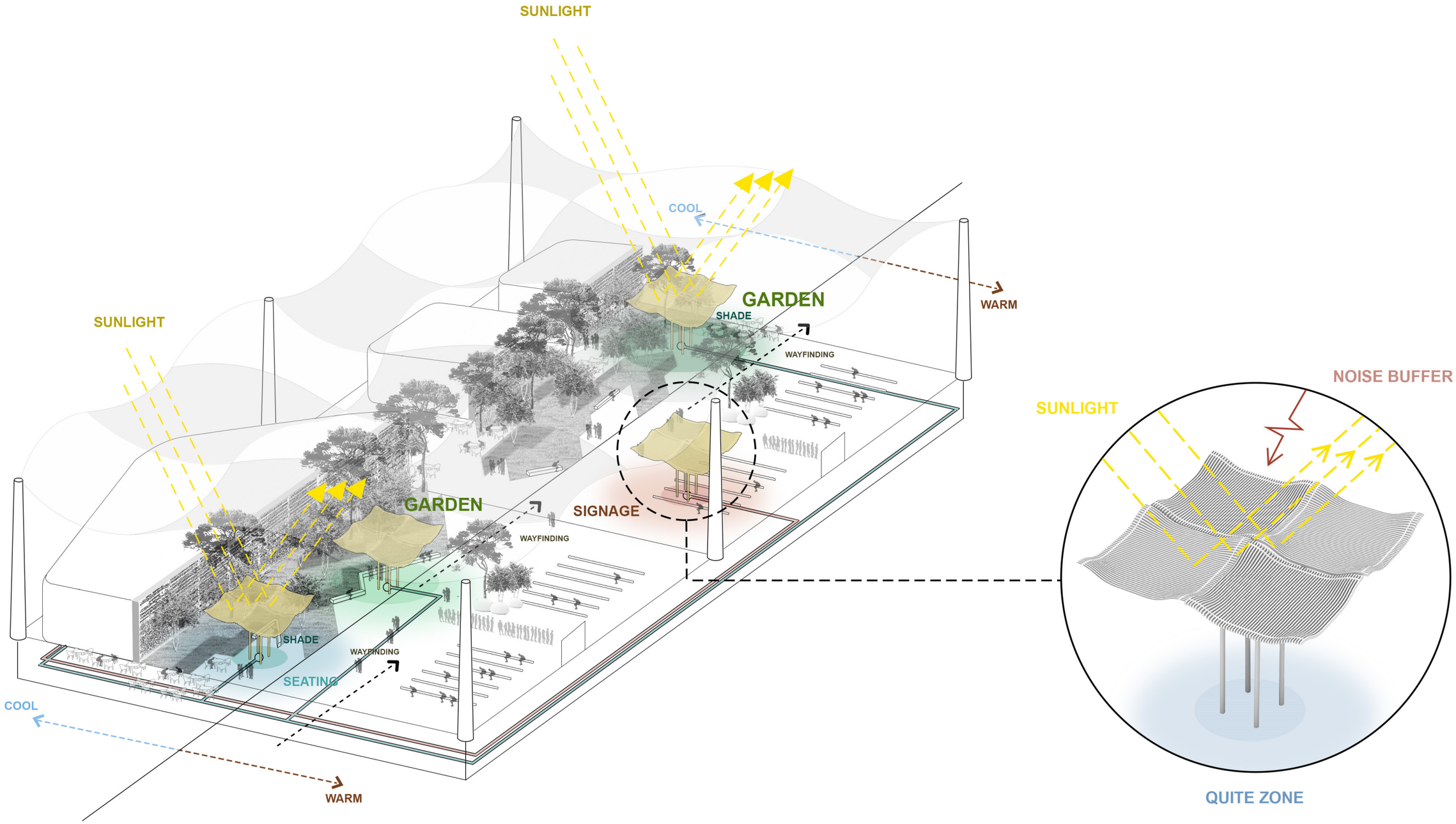


Fig.- Diagram of PODS distribution within Third Space

RECOMMANDATION

The project does not stop after the thesis is finished. The timescale of the Heathrow Expansion is long term and currently the project has been delayed due to both juridical challenges and the impact of the corona crises. However, the canopy project has been well reviewed both by the designers working on the new TX5 Terminal as well international manufacturers of public realm furniture. The product has potential to become fully integrated to ameliorate specific environmental conditions of the third space. For example, it has been suggested that the idea of providing variation in thermal condition created by the concealed heating and cooling pipes in the floor could be linked with the canopy structures which can act as 'markers' for either hot and cold spots. Also, the canopy structures have great potential to be combined with uplighters to create a reflective light illumination of the third space during nighttime which would be both atmospheric and resource efficient. The possibility of acoustic properties could be further developed in relation to an overall approach of acoustic objects / interventions within the third space. Further integration with application such USB chargers or information devices and building services might be considered. Finally, it has been suggested that a variation in height e.g. both a larger and a smaller version could increase the product's versatility. An XL version could provide an iconic landmark within the TX5 terminal.

To fully test the canopy structure, the development of a full scale prototype would be necessary. Companies such as mmCite have shown potential interest and have the capacities to facilitate such workshop testing.

Currently, the canopy is designed as interior product. Talking to the industry there could be interest for a scaled-up production and application of external use. This would require revisiting the structural properties to design for potential wind loading and outdoor use of LVL need careful consideration.

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APPENDIX

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