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Executive summary

The purpose of *Task 7.4: Conceptualisation and Design exploration of Living@Sea* is to explore how living space at sea can be accommodated on modular floating platforms which are used for multiple functions at sea. The starting point for the exploration is to consider modular triangular platforms. It is soon concluded that triangular shapes are an option, but from the perspective of spatial distribution and usable space, far less efficient compared to platforms based on a rectangular geometry (e.g. squares). Therefore, it is decided to change the module shape from triangle to square.

Based on a square module of 45 x 45 m, explorations of urban layouts, functions and architectural designs are carried out. A parametric model is set up, integrating multiple urban functions and exploring design alternatives. For Living@Sea, input is gathered from the analysis of land developments and comparing them to ones on water. Using the parametric model script, a design with 2,000 inhabitants is elaborated and visualized through artist impressions. An alternative design with 90 x 90 m platforms is also presented. Such design would be more optimal for locations such as the North Sea because of the sea states occurring.

From the design exploration it can be concluded that a module of 45 x 45 m is suitable for the purpose of Living@Sea. Next to the design explorations, a general arrangement study and a weight analysis are performed. For the Living@Sea reference design (45 x 45 module) a platform height of 10 to 11 m is estimated. This height is necessary to make sure connector points are above the water level. A preliminary analysis shows that the module meets the intact and damage stability requirements during transit.

1. Introduction

The purpose of *Task 7.4: Conceptualisation and Design exploration of Living@Sea* is to explore how living space at sea can be accommodated on modular floating platforms which can be used for multiple functions at sea. During the design exploration, platform shape and dimensions were evaluated for the purpose of Living@sea. The findings of *T7.2 - Research current and future inhabitants and other stakeholders* and *T7.3 - Technical, comfort and safety requirements of Living@Sea* (D7.1 and D7.2) are used as input in the design of living space at sea. Based on the functional and technical requirements, a shortlist of promising design alternatives is developed.

1.1 Background

Due to the increasing population and scarce usable space on land, there is an increasing need for solutions to accommodate urban growth. Modular floating platforms (also referred as Modular floaters) such as the ones considered in Space@Sea could provide a solution to create space for various functions at sea, including urban development.

The main advantage of floating urban development is that it can adapt to variations in water level. Thanks to buoyant foundations, rising water due to climate change is no longer an impendence.

Since floating urban development consists of multiple platforms on which superstructures (buildings) are built, it provides greater flexibility compared to land development. On land, changes require demolishing or construction. On water there is the opportunity to relocate platforms and their functions if required. Since platforms and functions can be reconfigured or removed, a city can easily change its shape and dimensions. However, floating urban development is not completely free to grow and transform. As for cities on land, urban development on water is influenced by local characteristics. Aspects such as wave conditions, bathymetry and local ecosystems need to be considered into the design.

1.2 Objective and research questions

The vision for Living@Sea is to create a sustainable and flexible city on water considering the unpredictability of climate changes and future development. The main research question is the following:

What would living space look like on modular floating platforms which are used for multiple functions at sea?

The proposed shape of the reference platform is squared. In this report the platform shape is evaluated, and design explorations of Living@Sea are made.

1.3 Relevance and input for other work packages

The outcomes of Living@Sea analysis and explorations are used as input for other work packages, in particular:

- Cost and benefits analysis (WP 1)
- Motion and force analysis (WP – 4)
- Platform size, gap, etc (WP-4)
- Ecology (WP-8)
- Energy, food and transport (WP 6 and WP 9).

- Integration of applications (WP 10)

Impressions of Living@Sea design concepts provide input also for other tasks within WP7 (e.g. interviews T7.5).

1.3.1 Energy@Sea

About 5% of the functions within Energy@Sea consist of accommodations for workers. The goal for Living@Sea is to create a concept for a new Offshore Platform in two different scenarios: The North Sea and the Mediterranean Sea. Designs are made for an accommodation platform taking into account:

- "Space@Sea – WP6, List of requirements of the O&M hub".
- Bouwbesluit (Dutch Building Code) for the comparison with regulations of residential functions on land.
- D7.1 report, for understanding offshore worker's wishes.

Many of the interviewees (offshore workers) expressed the preference to increase the living space and also the possibility to receive family visits. Therefore, a higher number of people and more living space per person was considered in the building programme. Flats of 35 m² circa are envisioned, which could accommodate 1 or 2 people. Additionally, more space for outdoor activities and for leisure facilities is included in the overview.

In total, four concepts are explored for Energy@sea, two with triangular platforms and two with square ones. The designs were used as input for further work in WP6. More information about the accommodation design for Energy@Sea is included in *Appendix 5 – Energy hub at sea.*

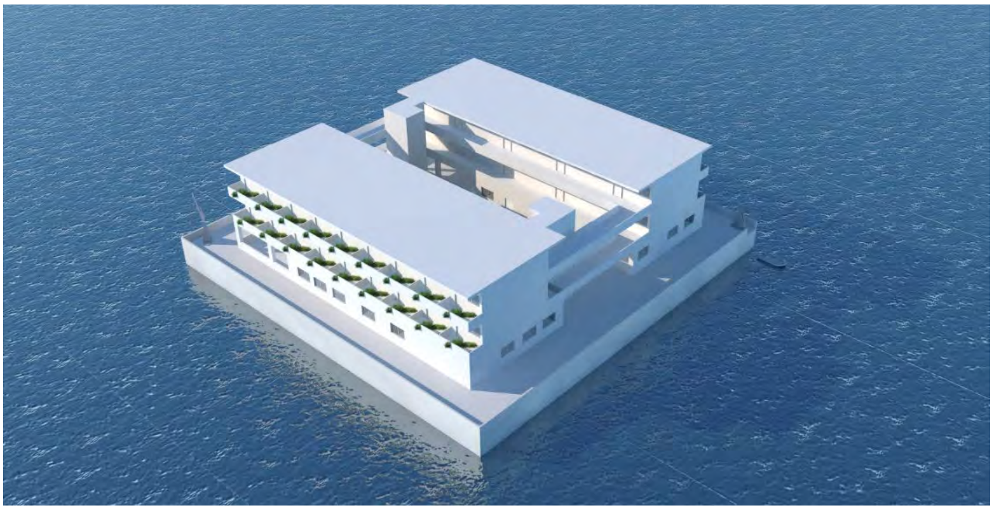


Figure 1.1: Impression of one of the design concepts for accommodating living functions within Energy@Sea

1.4 Structure of the report

This report includes the most relevant research and design decisions for Living@Sea. Next to the report, extensive appendices are provided, which illustrate various analyses and design explorations. The report is organized in 6 chapters. Chapter 1 outlines the background and scope for Living@Sea within the Space@Sea research. Relations of Living@Sea with other work packages are mentioned. Chapter 2 reports an evaluation of triangular platforms from the point of view of Living@Sea. Triangular modules are one of the starting points in the research but are found to be not optimal to accommodate various functions in a spatial-efficient way. The issue with triangular shaped platforms was presented to the rest of the consortium and the shape was re-evaluated from the perspective of different work packages. Based on the evaluation, a square platform of 45 x 45 m is chosen as the main module. Based on the new assumptions, explorations of urban layouts, functions and architectural designs are carried out. Chapter 3 includes more information on setting up a parametric model as a tool for integrating various design inputs and effectively comparing design options. In chapter 4, chosen designs are further elaborated and illustrated in more detail at the block scale. Based on the design of a reference Living@Sea block, weight analyses are performed in chapter 5. Utilities are integrated in the platform and the influence of the Living@Sea requirements on the 45 x 45 m module height is discussed. Finally, in Chapter 6 the main conclusions for Living@Sea are summarized.

2. Research on the optimal platform shape/ size and urban fabric

In this chapter the platform size and shape have been evaluated from the perspective of Living@Sea. At the beginning, the assumption was that equilateral triangle modules of 50 m side length could be used for all the functions researched within Space@Sea. In the process it was found that triangular platforms will not be so optimal, and the shape preference was shifted to squares. In this chapter the shape evaluation process is reported, comparing triangular platforms to rectangular/ square ones.

2.1 Design exploration of triangular platforms

The starting point for the design was to use triangular platforms, which measure 50 m at each side (equilateral). Design explorations were made, looking at the possible sizes and typologies of buildings, the quality of the open space, and the building footprint in comparison to the platform size. On a neighbourhood/city scale, possible development configurations were also explored.

2.1.1 Urban configurations

The analysis of urban configurations shows that triangular platforms allow a large variety of urban configurations. Many different development shapes can be created using the triangular platform as basic module. In comparison, shapes such as squares present less freedom in arranging the whole urban layout, on equal development area. More information on the study of triangular platforms is reported in *Appendix - 1 - City Fabric & Shape Study*.

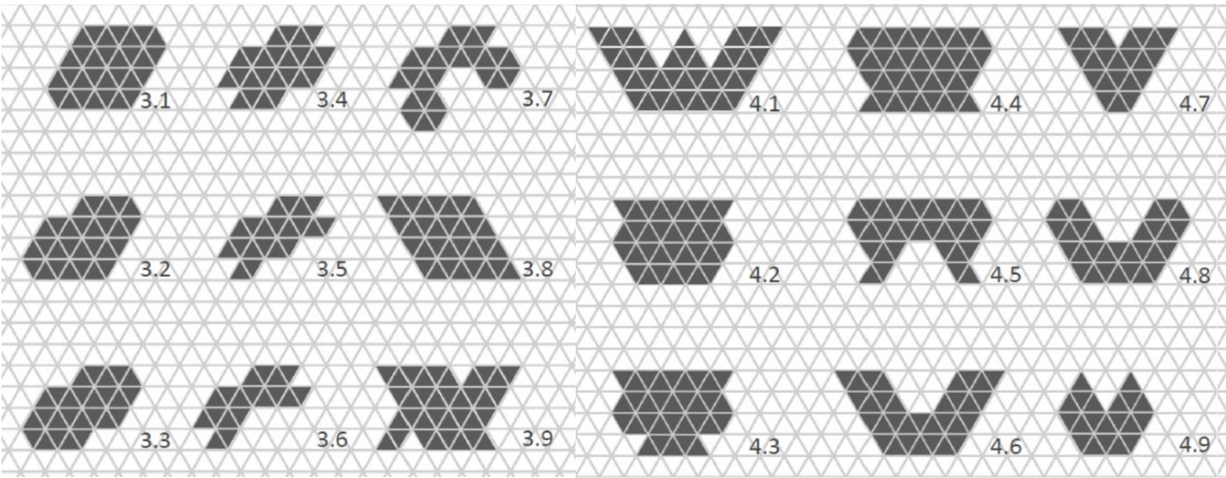


Figure 2.1: Study of urban layout possibilities with triangular modules

2.1.2 Block typologies

Next to looking into layouts on an urban scale, block typologies are also investigated. Block superstructures are designed and evaluated in terms of available real estate space and public space. The spatial qualities and the opportunities in terms of building typologies are also considered. An impression of the urban block study is included in Figure 2.2. Additional typologies are analysed and included in *Appendix - 1 - City Fabric & Shape Study*. Block typologies on triangular platforms are also compared to various typologies which may be possible on square shaped platforms (Figure 2.3).

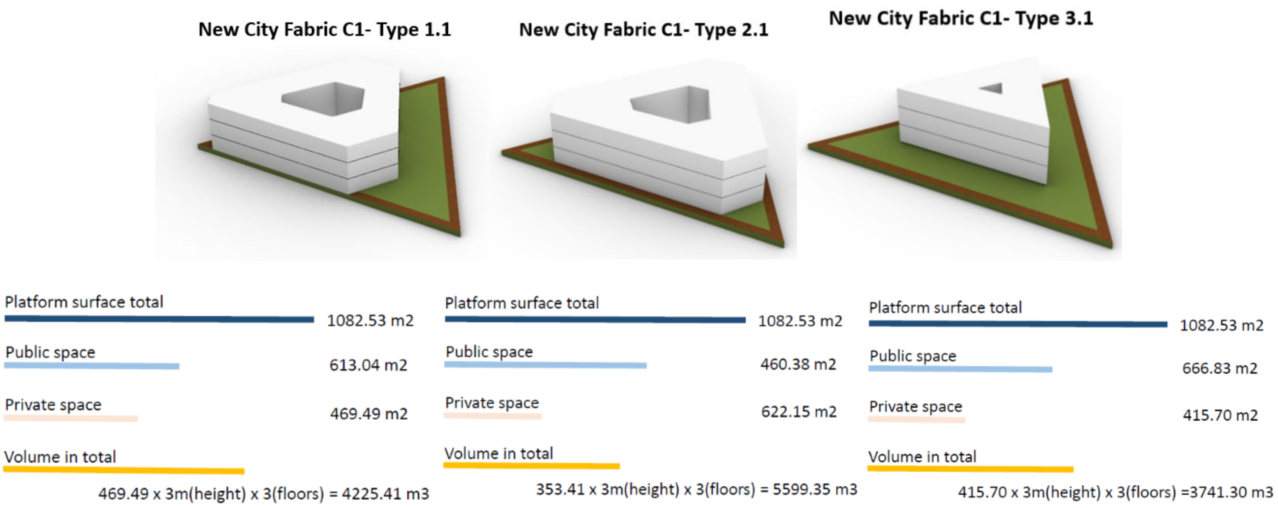
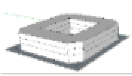
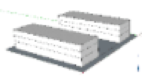
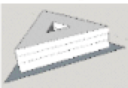


Figure 2.2: Study of block typologies on a triangular platform

	Platform			Open space		Building(s)						
	Polygon sides #	Side m	Area m²	Road m²	Green m²	Block length m	Floors #	Building depth m	Courtyard side m	Built-up area m²	Gross floor area (GFA) m²	Net floor area (NFA) m²
	4	50	2500	651	529	43	3	10	23	1320	3960	2772
	4	50	2500	701	529	43	3	10	23	1270	3810	2667
	4	50	2500	651	817	43	3	12	19	1032	3096	2167
	3	50	1082.5	461	45	38	3	8	10	576	1729	1211

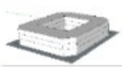
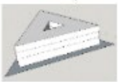
	Spacematrix			Land use %									
	Floor area Ratio FAR or FSI	Gross Space Index GSI	Spaciousness OSR	Buildings %	Road %	Green %	Total %	Apartments #	Residents #	Density ap./ha	Built volume m³	Façade surface m²	S/V
	1.58	0.53	0.30	52.8%	26.0%	21.2%	100%	44.00	88.0	176.0	13,200	2640	0.40
	1.52	0.51	0.32	50.8%	28.0%	21.2%	100%	42.3	84.7	169.3	12,700	2523	0.40
	1.24	0.41	0.47	41.3%	26.0%	32.7%	100%	34.4	68.8	137.6	10,320	2200	0.41
	1.60	0.53	0.29	53.3%	42.6%	4.1%	100%	19.2	38.4	177.5	5,765	1441	0.45

Figure 2.3: Analysis of block typologies on triangular and square platforms

2.2 Evaluation of triangular platforms in comparison to rectangle/square platforms

From the point of view of the building and urban block typologies, it is concluded that triangles are an option, but less efficient and more problematic compared to platforms based on a rectangular geometry (e.g. squares). Using triangular platforms, 20% less building footprint is achieved compared to square platforms with equal building depth and road width (Figure 2.4). This means that triangular platforms provide less opportunity for real estate space from the start. Moreover, choosing triangular platforms leads to building with pointy and difficult corners. Such corners are not only difficult to solve in floorplan, but they also make construction more complicated. One-of-a-kind buildings with the triangular geometry have been designed or exist (see for example the Flatiron building in New York, the Pyramids in Egypt or the Sundt house design by Frank Lloyd Wright, etc.). However, everyday buildings are mostly made using rectangular components of construction (e.g. windows, doors, bricks, tiles). This is one of the reasons why it is easier to design and construct buildings that are based on the rectangular geometry. In this respect, triangular platform geometry is also not preferable.

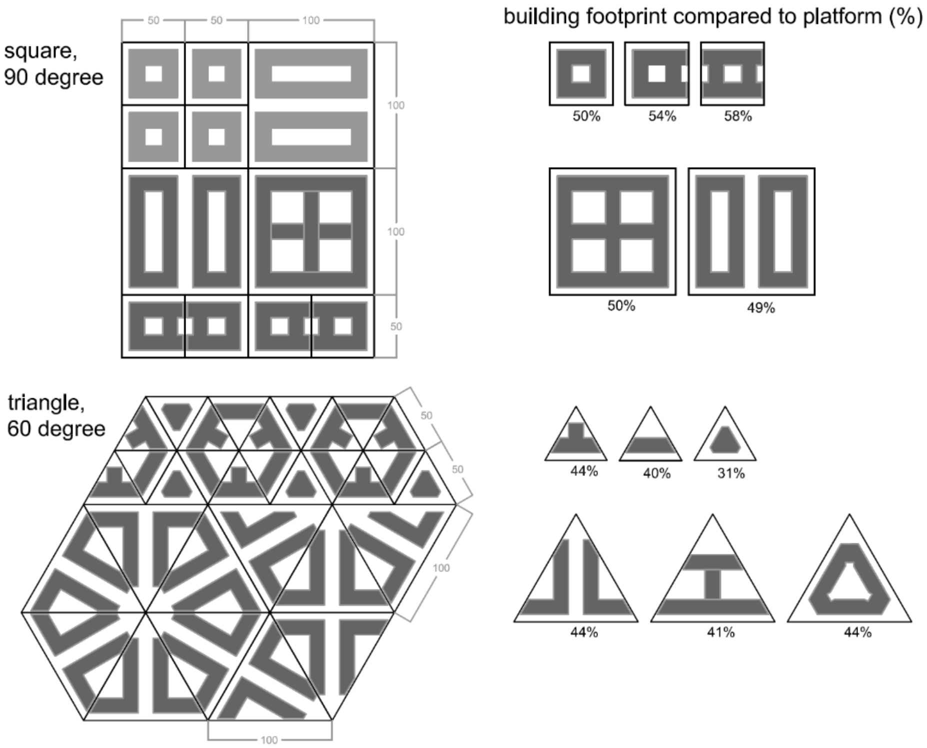


Figure 2.4: Study of urban configurations with triangular and square modules

The design exploration of triangular platforms pointed out some of the issues when using the triangular geometry as a basic module or grid for a city. Since the triangular geometry is one of the assumptions in the Space@Sea research, further assessment is required to determine how this shape performs in comparison to others.

Since the target is to work with shapes that have a maximum of two principle dimensions, equilateral triangles are compared with shapes as square, rectangle, right triangle, hexagon and circle. Different criteria are used for the comparison. As shown in Figure 2.5, the square and rectangular shapes perform the best on the selected criteria. Next to evaluating the most optimal shape, the most promising platform size is also assessed. The results indicate that a principle dimension around 50 m would be the most ideal (Figure 2.6). Platforms twice as large or bigger would be difficult to build at once, considering the available sizes of dry docks that can be found in Europe. More information about the platform shape and size evaluation is included in *D4.2-Basic design report*.

Shape	Buiding ease	Compliance and forces	Gaps	Aboard logistics	Score
Triangular	3.3	4.2	3.9	2.5	3.4
Right triangle	3.5	3.9	4.2	2.9	3.5
Square	5.0	2.9	4.3	4.6	4.1
Rectangle	4.7	2.9	4.4	4.7	4.0
Hexagonal	2.7	2.6	3.7	3.2	2.9
Hexagonal-triangle	2.8	3.7	3.6	2.9	3.2
Circular	1.2	2.0	1.0	1.4	1.6
Criteria weighing	*0.25*	*0.35*	*0.05*	*0.35*	

Figure 2.5: Results of module shape scoring (source: D4.2)

Principle dimensions [m]	Building possibilities	Transport and installation	Functionality	Flexibility	Costs	Score
12.5	4.5	2.5	1.1	3.9	2.7	2.4
25	4.6	3.1	1.6	3.9	3.2	2.8
50	4.2	3.9	3.1	4.0	4.3	3.8
100	2.6	3.5	4.0	2.8	3.7	3.6
200	1.6	3.2	4.5	2.1	2.9	3.3
Criteria weighing	*0.05*	*0.25*	*0.3*	*0.1*	*0.3*	

Figure 2.6: Results of platform dimension scoring (source: D4.2)

2.3 Conclusion: shift from triangular to rectangular platforms

Based on the evaluations of the ideal platform shape and size carried out by work packages 4, 6, 7, 8 and 9, square platforms of 50 m side are highlighted as the preferred module size. Results from the motion and forces analysis carried out in WP4 show significant differences between the performance of triangles and squares. Here the triangles perform better.

In the decision of the module size, the availability of dry docks for large platforms in Europe is considered. It is mentioned that a slightly smaller module size would provide more opportunities in terms of dry docks. Therefore, a base module size of 45 m is suggested instead of 50 m. If required, 45 x 45 m platforms could be rigidly coupled to form larger platforms of around 45 x 90 m, or even 90 x 90 m circa.

3. Urban design of Living@Sea using parametric modelling

In this chapter, the design of Living@Sea is discussed. The starting point for the design is to use modular platforms of 45 x 45 m. During the design process, concepts are developed for the urban layout, functional distribution and architectural design of the platform superstructure. Using Rhino Grasshopper, a parametric model is built, which enables integrating various design inputs and comparing design concepts.

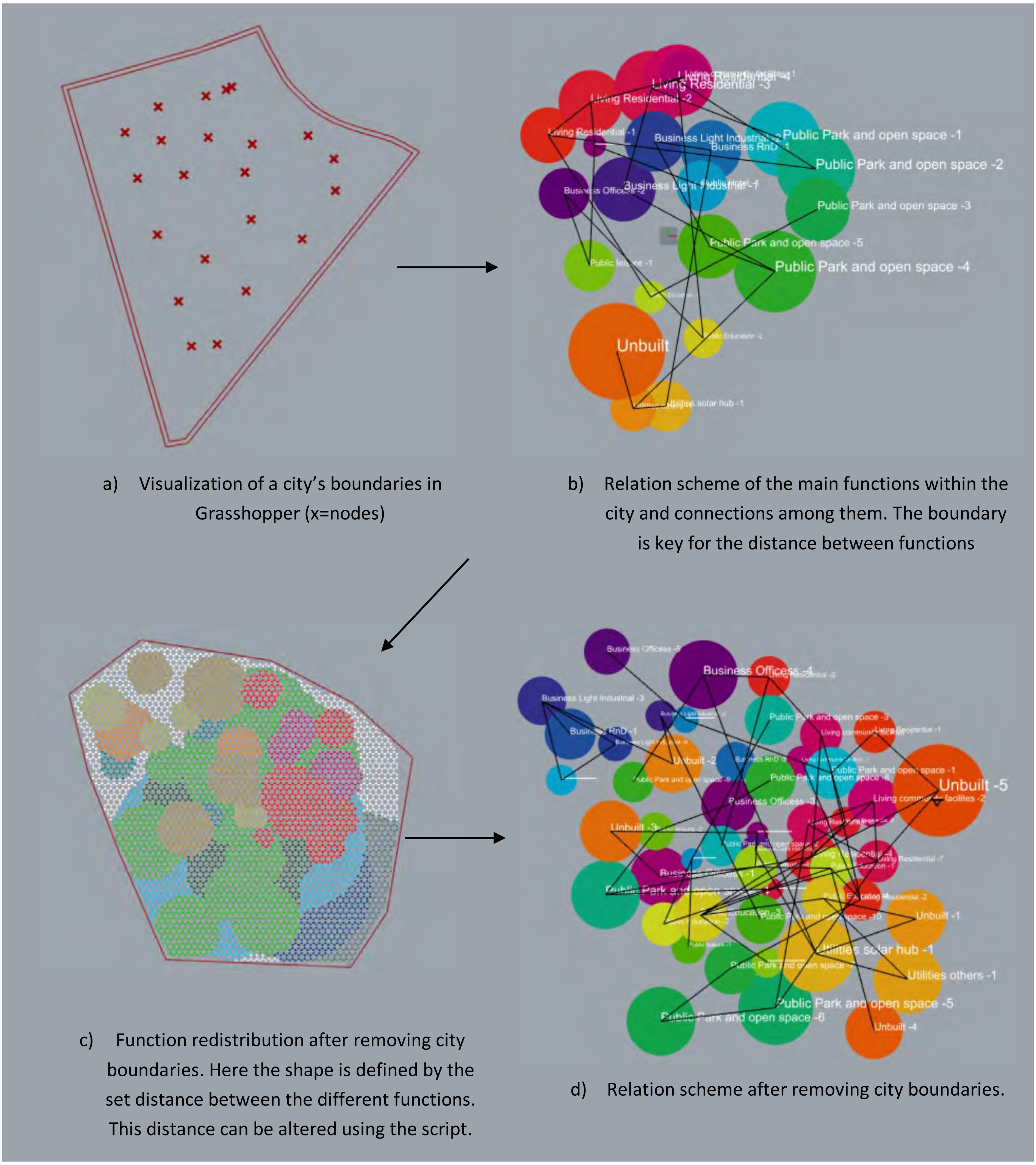
3.1 Parametric modelling

The planning and design of a new urban environment such as the one for Living@Sea has a high degree of complexity. It requires integrating different requirements and functions, establishing relationships among them. To be able to deal with complex urban phaenomena, planners and designers often seek the support of various tools, such as parametric design tools, to generate models of various design options. Parametric modelling is *the process of designing with parametric models or in a parametric model setting* [1]. Using parametric modelling for urban planning and design, urban patterns can be reduced into rule-sets and variables [2]. It is possible to create one model that consists of mathematical relations among elements and can be altered by changing input variables. This flexibility is very valuable in the design stage but could also be used during the lifespan of the city, to generate scenarios on how the floating urban environment could evolve, while maintaining the same ordering principles and aesthetic coherence. Considering that floating structures and functions can potentially be reconfigured, a flexible urban model provides great benefits.

For the design of Living@Sea, a parametric model is created to integrate multiple urban functions and explore design alternatives. This is done using Grasshopper, a plug-in for the modelling software Rhino. Grasshopper creates design outputs in Rhino, based on sets rules and parameters defined by users. All rules and parameters are integrated in one script. If necessary, new rules can be added to the script, and model variations are automatically generated. For Living@Sea a script is built starting from the analysis of land developments and comparing them to ones on water. On land, a city is mainly defined by its topography, which defines its boundary (Figure 3.1). On the water, a city's boundary is defined by the platform shape, size and by the local wave conditions. Most of the cities on land are program driven: a particular area addresses a particular function and all the other functions are built around it. It is not possible to depict the exact city planning strategies and layout for a floating city. The city has to develop its own typologies and planning strategies, considering various factors like cost, feasibility, natural constrains like depth of waters. For floating urban development, the expansion has to be strategically planned as it is built artificially from scratch.

Therefore, the study on using modular platforms for the purpose of Living@Sea, experiments with different design possibilities. How to organize platforms to meet the programme needs, which possibilities arise from reorganizing platforms, how much waterfront can be provided, etc. The starting point is to use modular platforms of 45 x 45 m.

Several studies are carried out using the parametric model. More information on the parametric model explorations in reported in *Appendix 3 - Parametric design & configuration study*.



a) Visualization of a city's boundaries in Grasshopper (x=nodes)

b) Relation scheme of the main functions within the city and connections among them. The boundary is key for the distance between functions

c) Function redistribution after removing city boundaries. Here the shape is defined by the set distance between the different functions. This distance can be altered using the script.

d) Relation scheme after removing city boundaries.

Figure 3.1: Reconfiguration of on land functional distribution by removing boundaries

3.2 Variable definition

To be able to build the script for the Living@Sea urban model, a set of key variables is defined. Such variables include:

1. Urban functions and distribution
2. Urban density
3. Platform dimensions
4. Ecological consideration (shading)

A schematic overview of all the variables and the relations among different variables within the script is illustrated in Figure 3.2. Input on urban functions, distribution and density is collected by analysing land-based cities. To be able to gain insight on the functional distribution in an urban context, three case studies are analysed. The results of this analysis are reported in the following chapter. Each input extracted from land-based cities is evaluated and adapted to the context of a floating urban development.

Variables such as platform dimensions and ecological considerations are also design inputs for Living@Sea. Platforms are modular and their dimensions are defined from the start as input from other work packages, which should be validated from the perspective of Living@Sea. In the script, basic ecological considerations are also added. This includes the effect of shading on primary production and makes sure gaps are left between the platforms to provide sufficient light access for photosynthesis.

The script built for Living@Sea design and analysis is also applied in other work packages. During the study of potential configurations for Logistics@Sea, additional criteria were added for the specific application. More information is included in *Appendix 3 - Parametric Design and Configuration Study*.

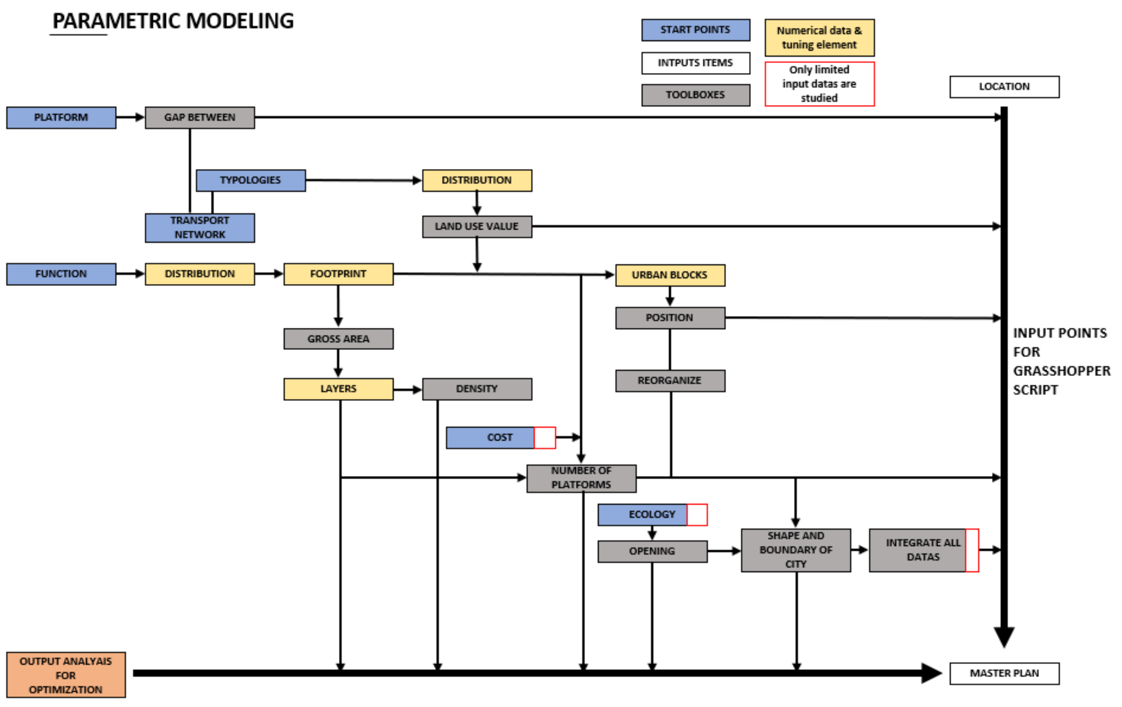


Figure 3.2: Scheme with parametric modelling relations

3.3 Analysis of urban settlements at different scales

An analysis of urban settlements is performed to gain insight on the functional distribution and density of cities. Case studied are selected based on the requirements defined for three different locations, which have been chosen for Energy@Sea, Logistic@Sea and Living@Sea in WP1 (Figure 3.3). For each of the three locations on the North Sea and Mediterranean Sea, a different ratio of living/urban functions is assumed in comparison to other functions at sea.

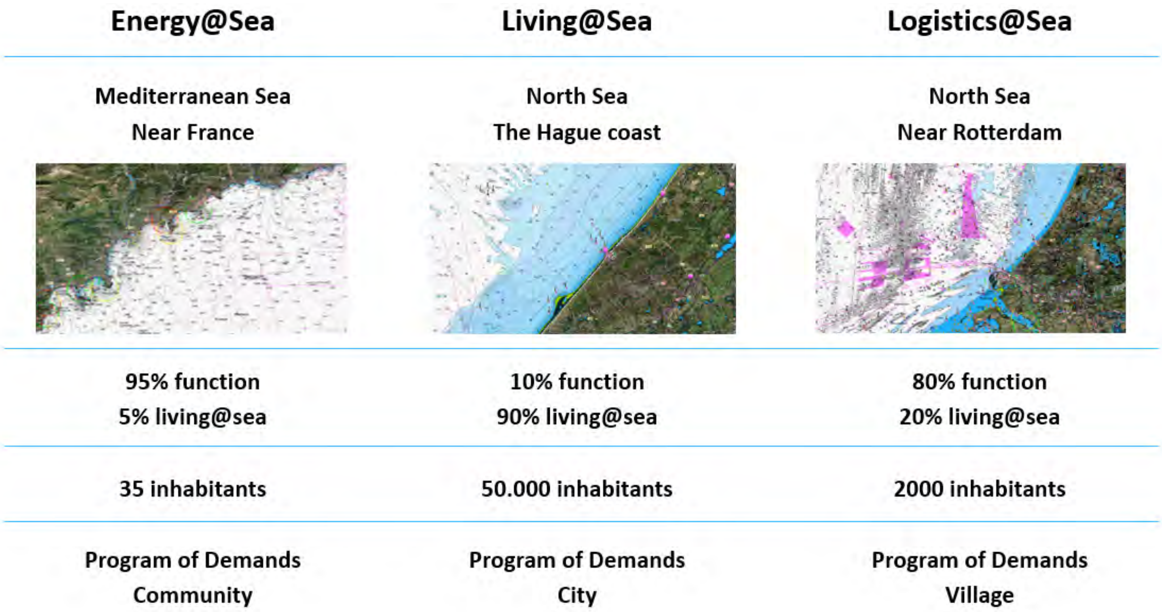


Figure 3.3 Overview three scenarios with Living@Sea

The choice of the case studies to analyse is based on the living/ urban space requirements defined for the medium and large scale Living@Sea scenarios (both in the North Sea). In the analysis, three case studies are considered:

1. Masdar City, a new, high tech city near Abu Dhabi
2. Rijswijk, a town near The Hague
3. Tollebeek, a village in Flevoland.

An impression of the three case studies is included in Figure 3.4. Masdar City is a planned city project near Abu Dhabi (United Arab Emirates). The new development is planned to host 45.000 inhabitants and has the functional distribution of a complete 'large' city. The city is designed to be pedestrian friendly and uses innovative forms of transportation. It relies on solar energy and other renewable energy sources. Rijswijk is a Dutch town situated near The Hague. The population of Rijswijk is around 50,000 inhabitants, similarly to the population planned for Masdar City. Both cities are compared in terms of functional distribution to gather input for the 50,000-inhabitant scenario (large scale). Finally, the Dutch village of Tollebeek (2,500 inhabitants) was selected to determine the functional distribution for the 2,000-inhabitant scenario (medium scale).

Figure 3.4: Impressions of the selected case studies

For each city an analysis is carried out based on functional distribution, land use and density. Analysed functions are presented in Figure 3.5. Sub-functions are specified for each urban function. The output of this analyses is formulated as a Program of Demands which is used as input for the Living@Sea design concepts. A detailed overview of the functional distribution for the three case studies is presented in Figure 3.6. In the table, each sub-function is expressed in percentage.

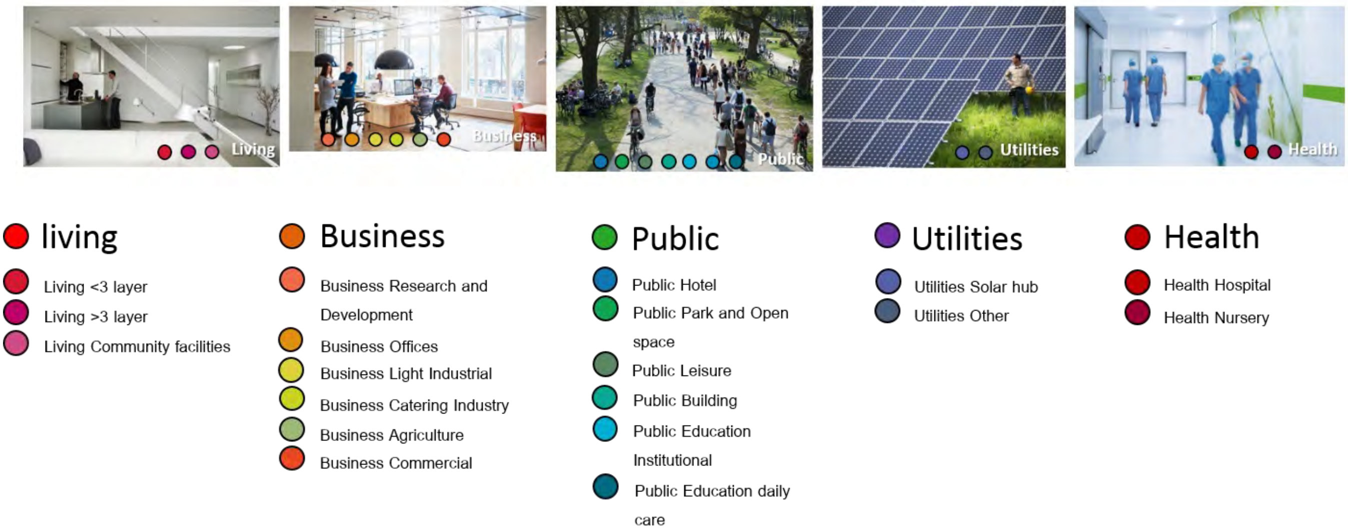
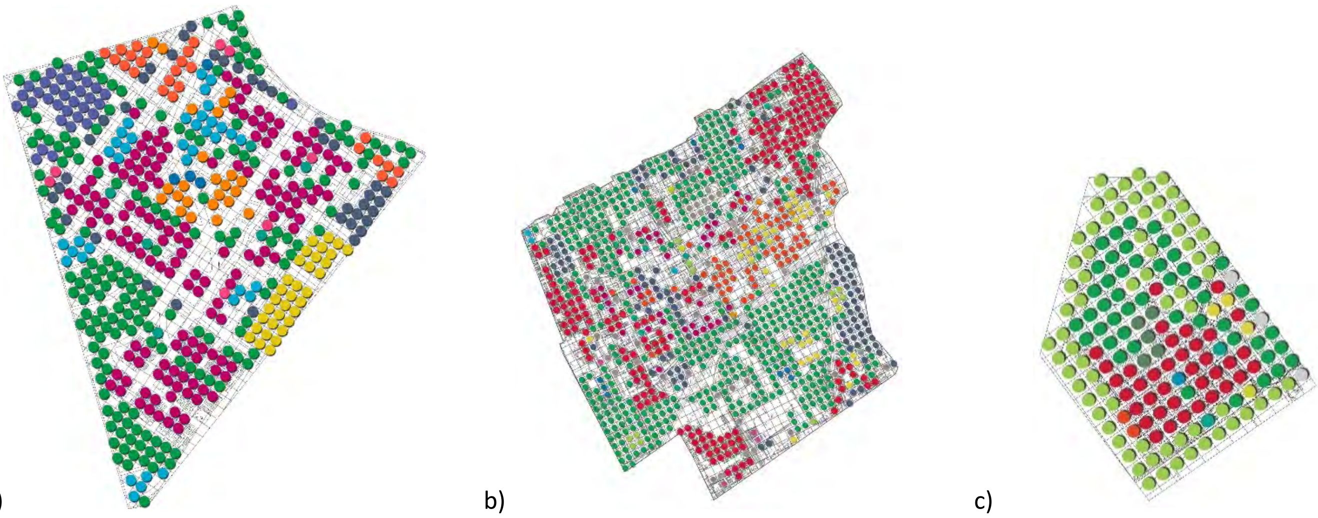


Figure 3.5: Function Categories considered in the analysis



a) b) c)

% of Built area	Masdar city	Rijswijk	Tollebeek
Living Residential <3 layers	0%	20%	22%
Living>3 layers	25%	3%	0%
Living community facilities	1%	1%	0%
Business Research and Development	4%	0%	0%
Business Offices	4%	1%	0%
Business Light Industrial	6%	4%	3%
Business Catering Industry	0%	1%	1%
Business Agriculture	0%	1%	41%
Business Commercial	0%	6%	1%
Public Hotel	1%	0%	0%
Public Park and Open space	31%	44%	28%
Public Leisure	12%	0%	0%
Public Building	0%	1%	1%
Public Education/Institutional	7%	1%	1%
Public Education daily care	0%	1%	0%
Utilities Solar hub	6%	0%	0%
Utilities Other	3%	11%	0%
Health Hospital	0%	0%	0%
Health Nursery	0%	0%	0%
Water	0	5%	2%
	100%	100%	100%

Figure 3.6: Function Distribution for Masdar (a), Rijswijk (b) and Tollebeek (c)

Table 3.1: Functional requirements at each scale (Own table based on data from [3]*)*

Urban scale levels	Population/ urban scale level (inh.)	Additional required functions at each scale
Block	200	
Residential neighbourhood	1,000	Nursery/ Play Lot/ Parent Education Spaces/ Social Space/ Convenience Shops/ Tertiary Transport links
Community Neighbourhood	5,000	Primary School/ Playgrounds/ Community Centres/ Social Spaces/ Shops/ Secondary Transport Links
District Neighbourhood	25,000	Highschool/ Play field/ Auditoriums/ Gymnasiums/ Social and Recreational Facilities/ Adult Education facilities/ Shopping Centres/ Primary Transport Links
Civic Section	50,000	College/ Cultural centre/ Social and Recreational facilities/ Civic Administration Centre/ Hospital

The need for additional functions at each neighbourhood level is considered in the urban design for Living@Sea. Table 3.1 shows different levels within the urban environment, from block to civic section. At each level, specific additional functions are required to support the needs of a larger population. More information about the urban analysis is included in *Appendix 2 - City Scenario and Analysis.*

The analysis of the three case studies helps to gain more insight on the functional distribution for urban areas of 50,000 and 2,000 inhabitants. For Living@Sea, it is decided to elaborate a design with 2,000 inhabitants. The size of the development is comparable to the village of Tollebeek. Therefore, the functional distribution of Tollebeek is considered in the design of Living@Sea and used as input for the parametric model. In the future, residential neighbourhoods could be added, and the development could grow into a larger city, adding functions as suggested in Table 3.1.

3.4 Urban composition

In this chapter urban design explorations are made for Living@Sea, taking into account:

- 45 x 45 m modular platforms (see chapter 2.3).
- Functional distribution of a 2,000-inhabitant urban settlement, based on Tollebeek.
- Performance considerations highlighted in *Task 7.3 - Technical, comfort and safety requirements* (summarised in *Appendix 7).*
- A list of requirements outlined in *Task 7.2: Research current and future inhabitants and other stakeholders* (summarised in *Appendix 6).*

The following key considerations are implemented in the design:

- Accessibility and proximity to green and public space
- Accessibility to platforms, waterfront accessibility and boat mooring facilities
- Creation of functional ‘zones’ and spatial integration among functions (e.g. schools in proximity libraries or sport areas)
- Density and Floor Space Index
- Wind Protection (tunnel-effect)
- Platform motions

3.4.1 Urban layout and functions

Different shapes were considered in the analysis. Since on water topography doesn't present constraints as for cities on land, there is more freedom to explore urban shapes and configurations. Both close and open city configurations are considered. If a city on water has an open layout, more waterfront area is created, increasing the access points from the sea. The view of the water and the possibility to directly access by boat are advantages of this type of layout. However, too much openness towards the water may make the city more difficult to protect from high waves. On the contrary, a city with a compact shape would provide less waterfront area but could be more easily protected from high waves.

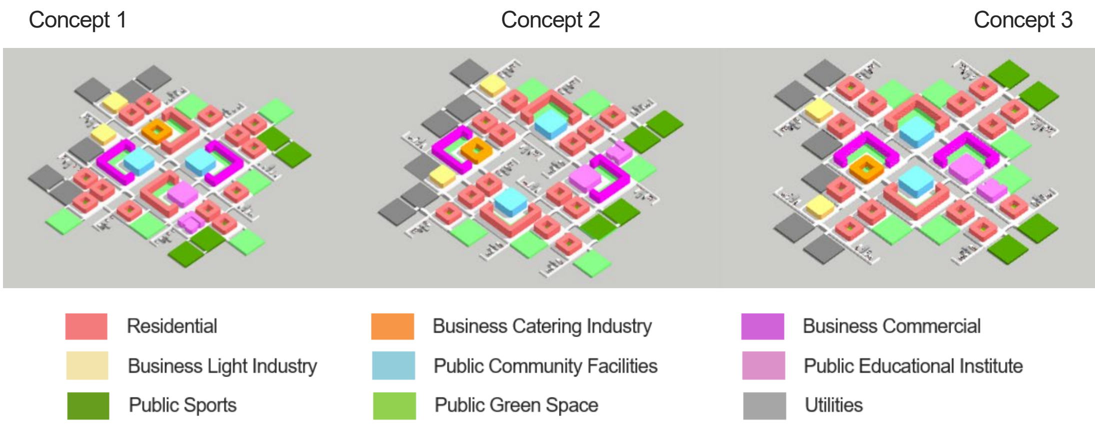


Figure 3.7: Overview of some 'open layout' concepts analysed during the design process

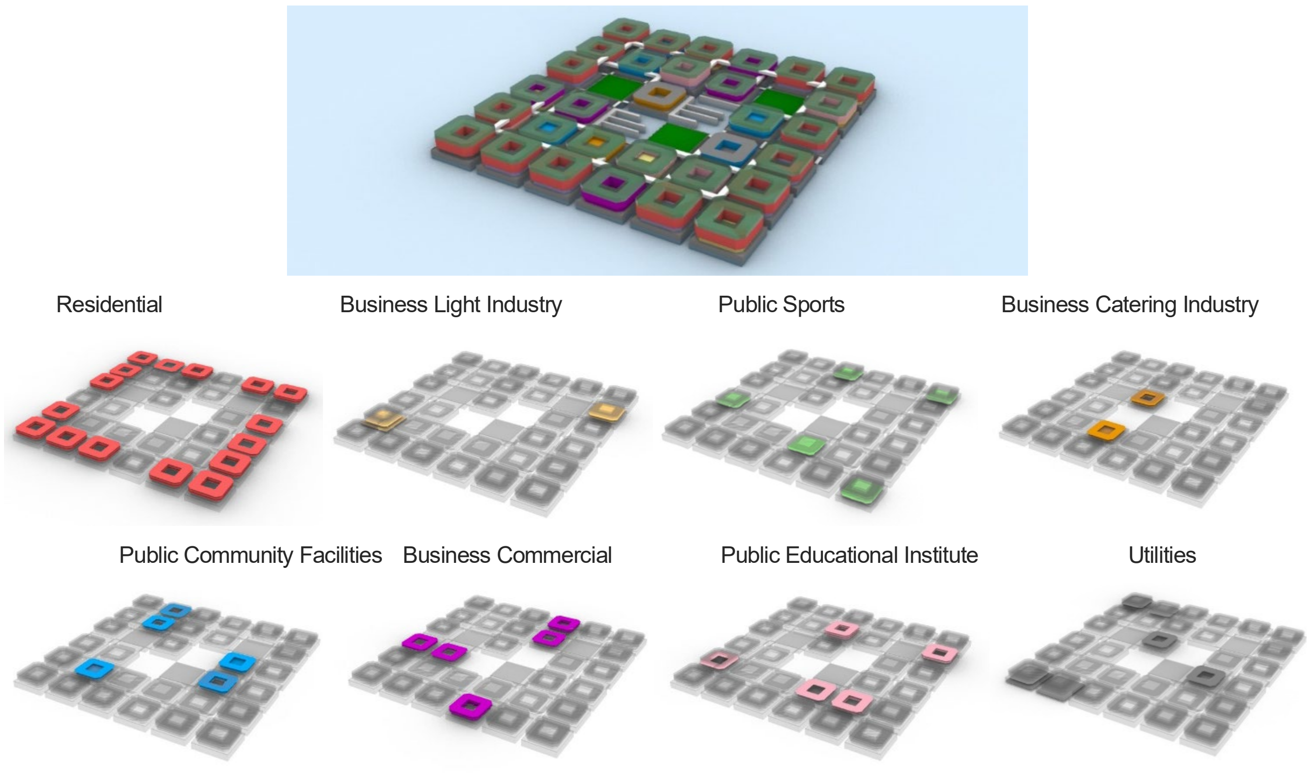


Figure 3.8: 'Closed layout' concept and functional distribution

Using the parametric model several layout options are analysed before giving a conclusion on the optimal number of platforms for a 2,000-inhabitant configuration. With the help of the model, built environment density is also verified. An example of an open layout is included in Figure 3.7. In this concept green space, marinas and utilities are located at the outer part of the floating development. Several options are analysed, with different functional distributions. In some of the concepts an internal marina is created in a sheltered area between platforms. In other concepts, higher density blocks are placed in the middle.

A compact and enclosed urban layout is also investigated. In this option, higher density is provided at the edge of the city. In the centre, protected areas are envisioned for recreation (Figure 3.8).

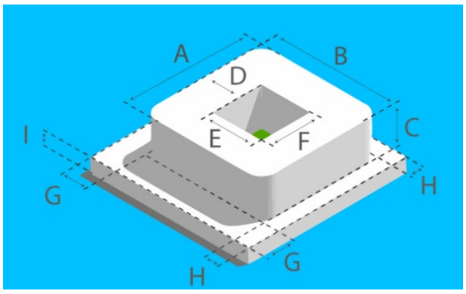
The two different layouts are compared and evaluated. Ultimately the compact, enclosed design is chosen to be further developed. Compared to a more open layout, a compact urban shape is easier to protect against high waves. In the design in Figure 3.8 blocks at the perimeter could be used as a protection towards waves and wind. In the blocks at the perimeter, systems could be installed on the façade, to close off the lower floors in case of heavy storms. This concept is further elaborated and illustrated in Chapter 4 on design.

3.4.2 Block typologies

Next to exploring possible urban configurations for Living@Sea, the urban block design is examined in more detail. Suitable building typologies and configurations are evaluated for the application of Living@Sea. Table 3.2 illustrates an exploration of block typologies for residential functions of Living@Sea. In the analysis, functions such as education, retail, business, etc. are also considered. The building volumes are designed following relevant building codes and standards, as well as example projects.

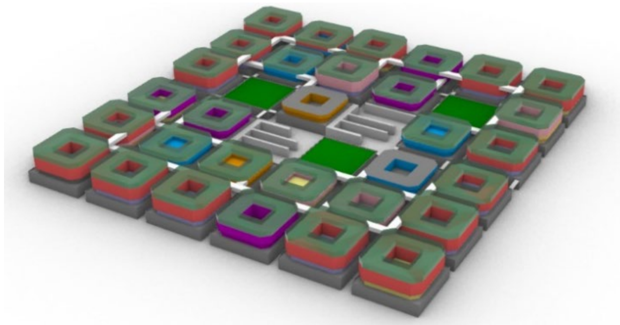
Table 3.2: Example of detailed exploration of block typologies with residential functions

Category	Residential	Function	Low Density
Shape	Courtyard Block	**No of Storeys**	3
A width (m)	33.75	**B width (m)**	33.75
C width (m)	10.90	**D width (m)**	10
E width (m)	13.75	**F width (m)**	13.75
G width (m)	7.5	**H width (m)**	3.25
I width (m)	4	**GFA per block (m²)**	2850
Interior Void (m²)		**Independent Platform**	✓



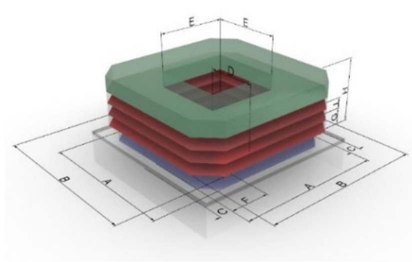
Distribution	(m²)	(%)
Total Plot	2025	100
Built	950	46
Green	189	10
Accessibility	886	44

Based on the volumetric study, 5 block typologies are defined for the 2,000-inhabitant design for Living@Sea, based on the compact layout design. Block typologies are illustrated in Figure 3.9. Typologies used for this design include mixed used perimeter blocks, with cut off corners and central courtyards. A detailed overview of the urban layout and block typology study is reported in *Appendix 4 - City Design-Square shaped platform*.

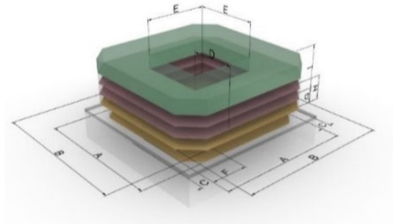


Function	Type	GFA (%)	Gross Floor Area (m²)	
Residential	Med Density	44	65,290	
Business Commercial	Offices	9	13,317	
Business Light Industry	Warehouse	4,5	6,718	
Business Catering Industry	Hotel	3,5	5,417	
Public Community Facilities	Cultural Centre	5	6,831	
	Theatre	3,5	5,417	
Public Educational Institute	Library and Learning Centre	5	7,070	
	School	3,5	5,364	
Public Sports		5	7,335	
Public Green Space		4	6,075	
Public Terrace Green		-	-	41,006
Public Amenities		6	8,802	
Utilities		7	10,210	
TOTAL		**100**	**147,846**	

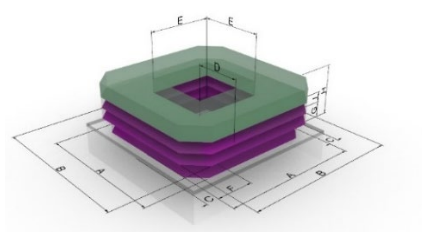
Type 1 – Residential + amenities



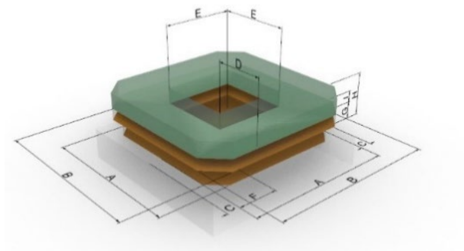
Type 2 – Mixed use (business, community, educational)



Type 3 – Mixed use (business, community and educational)



Type 4 – Mixed use (business, community and educational)



Type 5 – Mixed use (business, community and educational)

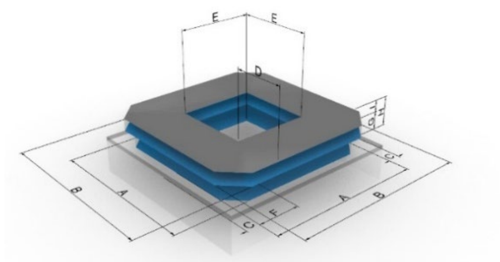


Figure 3.9: Overview of urban layout functions (left)t and block typologies (right)

4. Design of Living@Sea urban blocks

In this chapter the architectural design of the urban blocks is explored in more detail. Following the urban analysis and the exploration of different concept for the city layout, block typologies are defined. The architectural design of the blocks and their appearance within the urban context is illustrated with impressions.

4.1 Input

A compact urban layout concept is chosen to be developed further. In this concept, perimeter blocks directly face the waves and the inner part of the city experiences calmer conditions during bad weather. All the platforms are 45 x 45 m. Blocks are mixed used, combining residential, business and public functions. Platforms are considered to be moored separately and connected by bridges.

The design of the Living@Sea urban block considers the inputs from other tasks within WP 7:

- T7.2: Research current and future inhabitants and other stakeholders
- T7.3: Technical, comfort and safety requirements of Living@Sea

Based on these requirements, the compact concept with 45 x 45 m platform modules (Figure 3.8) is further elaborated and illustrated in the chapter 4.2.

Next to this concept, an alternative design is included, which assumes larger modules of 90 x 90 m. Compared to 45 x 45 m modules, 90 x 90 m platforms would be more suitable for North Sea conditions. Simulations by MARIN shows that 45 x 45 m platforms at the edge of the city would start resonating in waves that are common for the North Sea (between 10 and 21 seconds). If blocks are connected in a very flexible way, high differences up to 8m could be experienced between neighbouring blocks at the edge of the city. Therefore, to prevent platforms from starting resonating in the North Sea, 90 x 90 m platforms may be more suitable. It is important to mention that results from the numerical simulations were made available after the compact layout concept with 45 x 45 m platforms was already developed. Knowing the outcomes of the simulations earlier in the process would have probably led to different design choices. Based on the findings from MARIN work package 4 a concept including 90 x 90 m platforms is visualized in chapter 4.3

4.2 Concept 1 – 45 x 45 m platform

The floating modular settlement is designed as a ‘fortress’ to protect the inhabitants from the most extreme environmental conditions, such as the ones experienced in the North Sea (Figure 4.1). The urban configuration is designed for 2,000 inhabitants and consists of 34 modular platforms of 45 x 45 m. All the functions of a land-based city are provided: residential, business and commercial areas, community facilities, etc. A water transport network is created within the settlement.

In the development, around 500 apartments are planned, ranging from a minimum of 60 m² to a maximum of 105 m². The size of apartments is based on stakeholder preference (task 7.2). In the designed reference block (Figure 4.2), every residential layer has 14 units (Figure 4.3). Each block is characterized by the presence of rooftop greenhouses, which are shared within the community. Additionally, every block has a communal, centrally placed (courtyard). Figure 4.4 to Figure 4.8 include some impressions of the ‘fortress’ design concept.

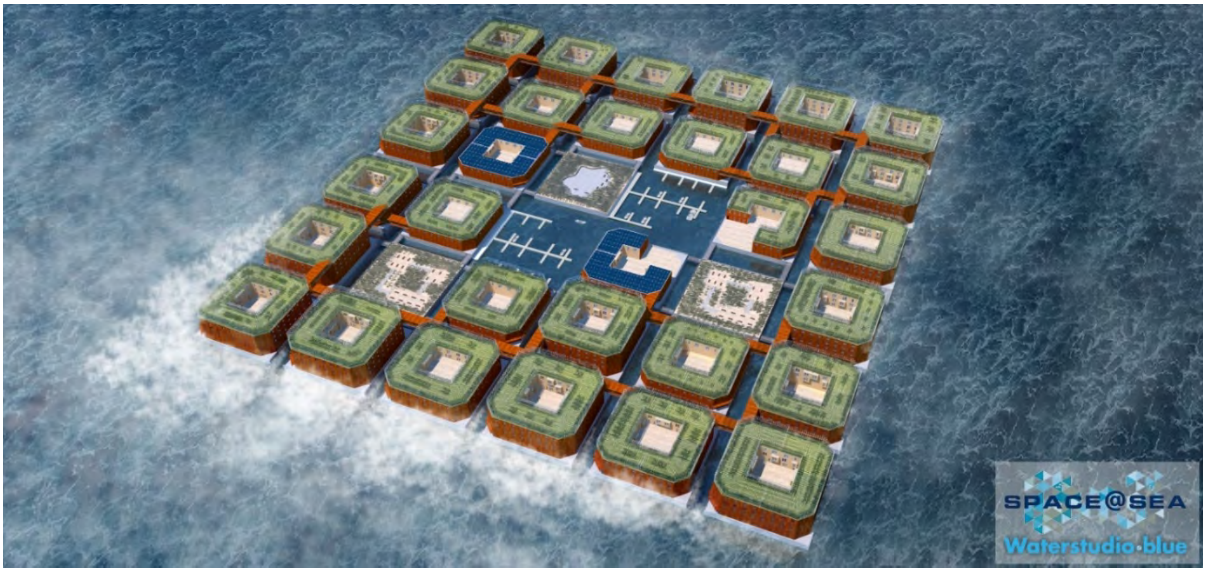


Figure 4.1: Aerial perspective of the compact 'fortress' concept with 45 x 45 m modules

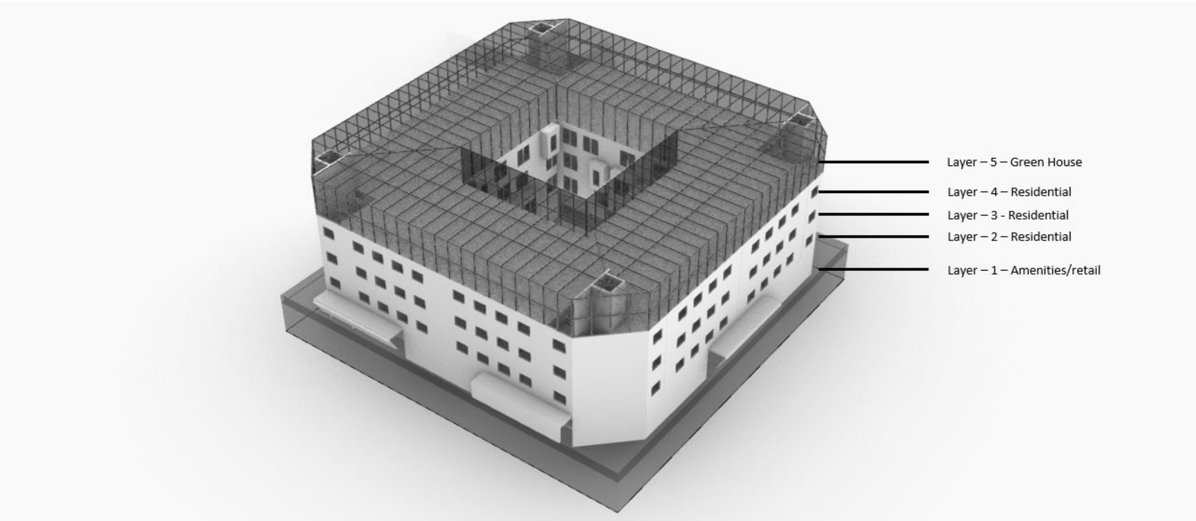


Figure 4.2: Architectural design of an urban block on a 45 x 45 m platform

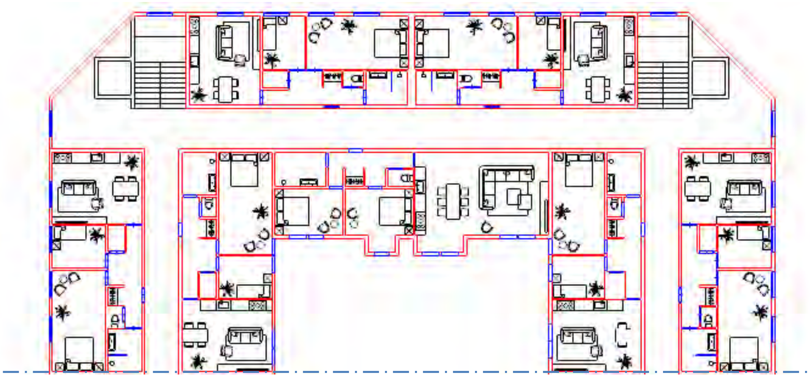


Figure 4.3: Half of the symmetrical floorplan of a residential level (layer 2,3 and 4).

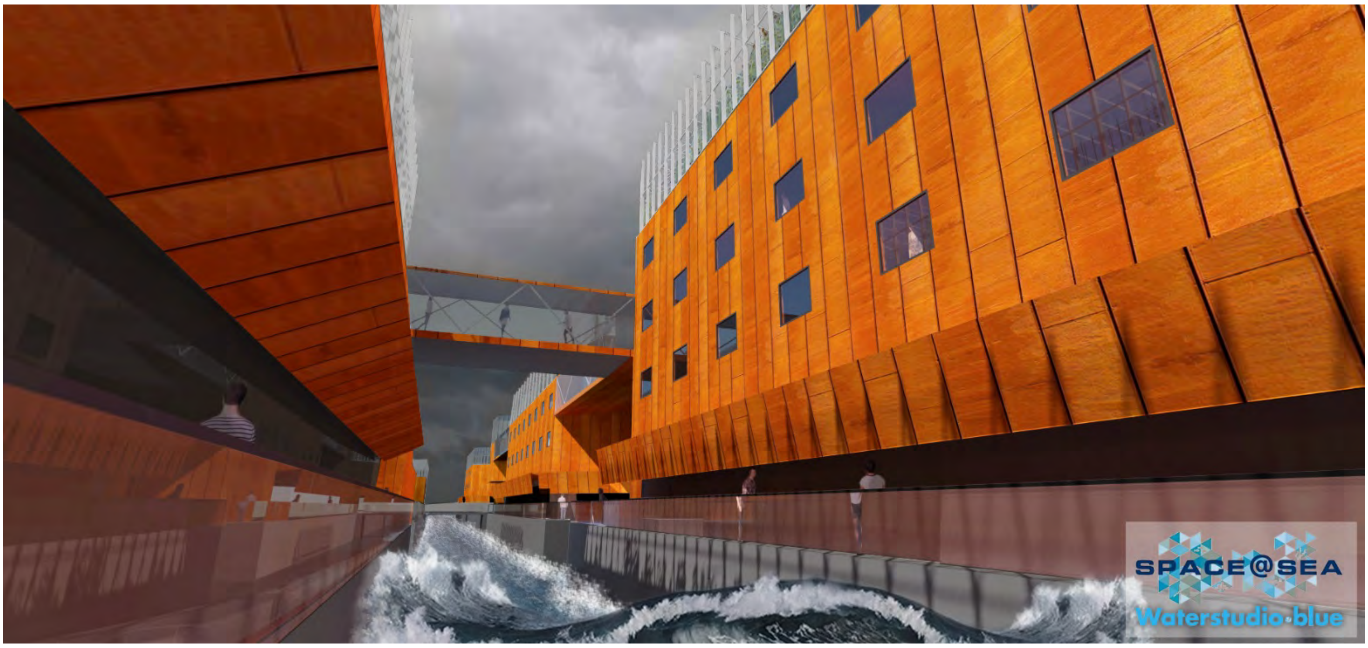


Figure 4.4: View of the gaps between platforms

Figure 4.5: Rooftop horticulture

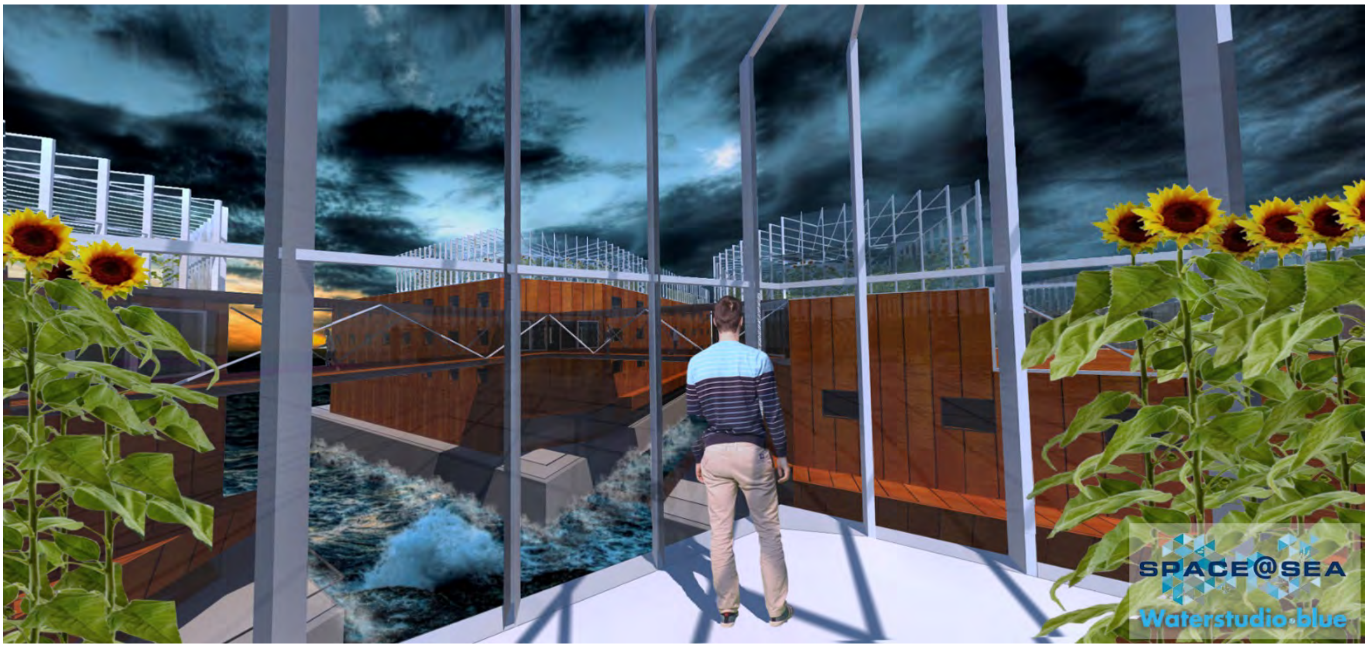


Figure 4.6: View of the blocks from a rooftop

Figure 4.7: Impression of the courtyard space

Figure 4.8: Visualization Harbour View

4.3 Concept 2 – 90 x 90 m platform

In some locations 45 x 45 m blocks may not be optimal and may lead to high motions. Therefore, the option to build large platforms of 90 x 90 m is considered. A design exploration is carried out considering larger platforms. Such platforms can be applied in moderate conditions such as the Mediterranean Sea and even more challenging locations such as the North Sea.

An artist impression of a floating urban area using 90 x 90 m platforms is included in Figure 4.9. The design considers mostly platforms of 90 x 90 m and includes L-shape platforms which consist of three rigidly connected 45 x 45 m modules. At the connection between 45 x 45 m blocks, gaps should be provided to cope with minor movements between the platforms.

In the visualization, a breakwater is built around the city, to reduce the motions in the inner blocks and the stresses at the connections. For the breakwater, modular 90 x 90 m platforms are used, submerging them partially. Behind the breakwater, urban blocks with different building typologies and densities are created. Access by boat is provided through canals, and a large, protected marina is created.

Figure 4.9: Impression of a floating urban area using 90 x 90 m platforms

4.4 Design evaluation

Several design concepts for Living@Sea are studied with systematic criteria. It can be concluded that modular platforms of 45 x 45 m are suitable for the purpose of Living@Sea. The most widespread functions within an urban development (e.g. residential, public space, retail, etc.) can be integrated in such block size. Where needed, platforms of 90 x 90 m could be used. But in terms of maintenance and life span of the connections, as well as still small movements present, the on top real estate should not have any structural impacts on the connection area.

Based on the evaluation of multiple case studies on land and the comparison with floating projects, it can be concluded that the design of floating urban space presents unique challenges and opportunities compared to developments on land. The main challenge comes from integrating urban design and maritime engineering, making sure that developments are safe and comfortable, as well as pleasant to live in and with enough amenities.

Besides its unique challenges, floating development presents opportunities to accommodate future urban growth in a flexible way. In comparison with building on land, buildings on water are not fixed to one place and can be reconfigured according to the demands. Specific typologies and planning strategies should be developed, considering various factors like cost, feasibility, natural constrains (e.g. water depth). Using flexible tools such as parametric model, it is possible to provide design alternatives on how a floating development could grow or shrink, keeping an overview of the functional distribution throughout the city. Also, different parts of the build-up space could be reused in other locations if necessary

5. Analysis of module design

In this chapter, the integration of utilities and structural requirements for Living@Sea are discussed. It gives a preliminary overview of a 45 x 45-meter residential living module from a mainly naval engineering perspective. The following subchapters try to give an overview on three main design aspects: space designation, weight estimation and resulting module draft/height and finally a preliminary stability evaluation of the design. One of the purposes is to be able to provide the input on the living at sea modules for the demonstrator design (work package 12).

5.1 Preliminary assumptions

The following design assumptions have been considered:

- The material of the hull and all internal delimiting walls is concrete
- The material of the superstructure/accommodation is CLT (Cross-Laminated Timber)
- The time period of platform self-sufficiency (fresh/wastewater capacities, etc.) is taken as 30 days.
- A "stand alone" case scenario has been analysed with regards to platform self-reliance of electrical supply (no shore connection), fresh/potable water generation (reverse osmosis plant compartment), sewage treatment (Advanced Water Treatment, AWT Plant) and Garbage management (Incinerator and garbage collection).
- The axes convention for all the following calculations is presented in the two figures below.

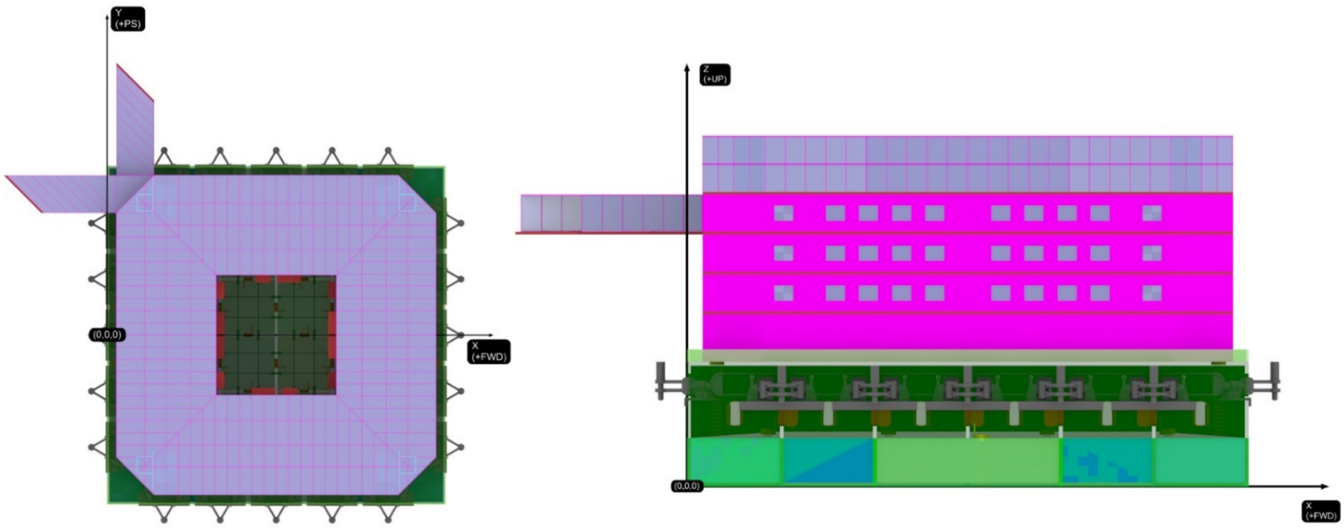


Figure 5.1: Living Module Axes: (left) top view, (right) elevation

5.2 Preliminary General Arrangement

The following figure shows the preliminary overview of the living module general arrangement. Each level is detailed below, in the following subchapters, starting from the lowest level.

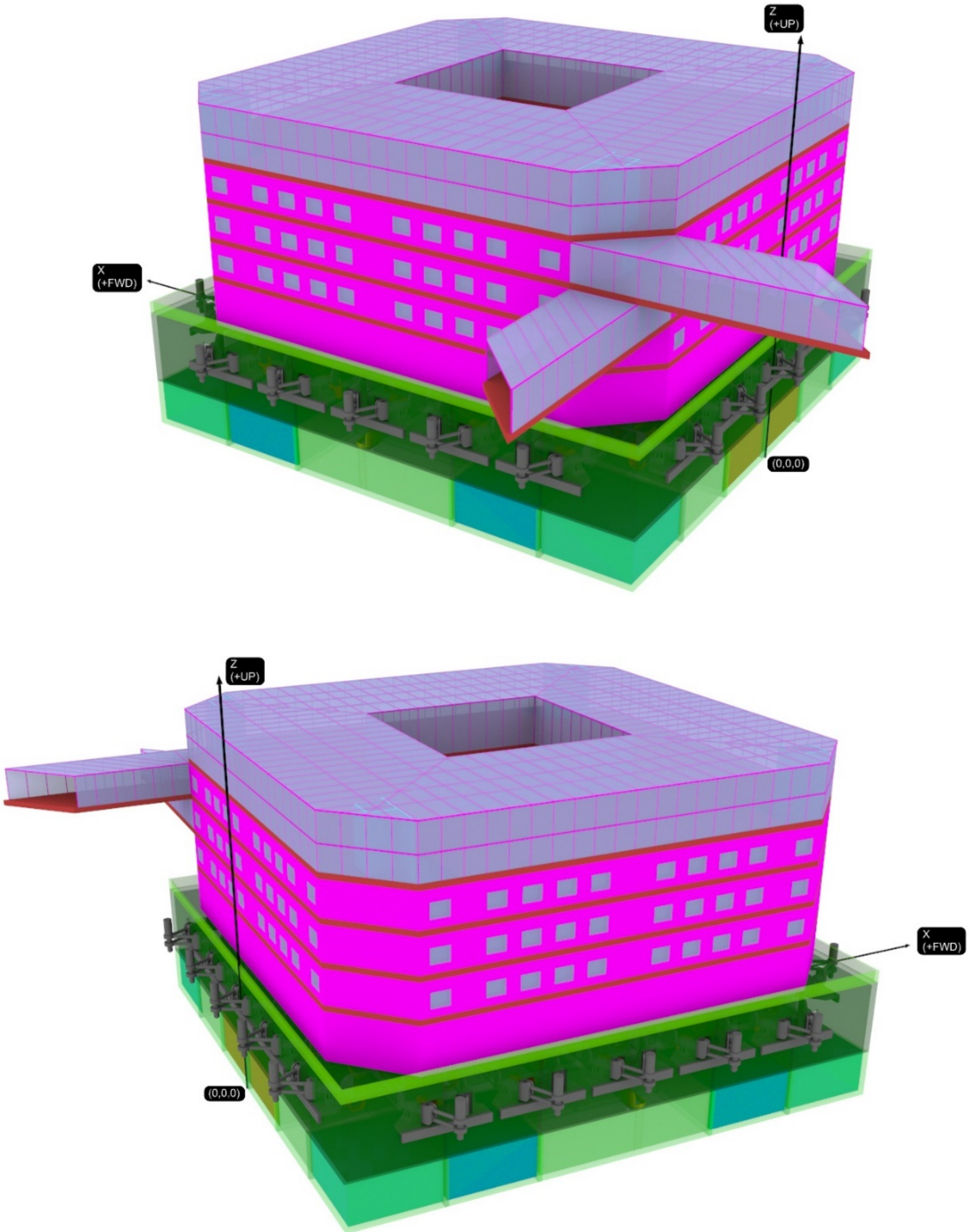


Figure 5.2 Living module General Arrangement

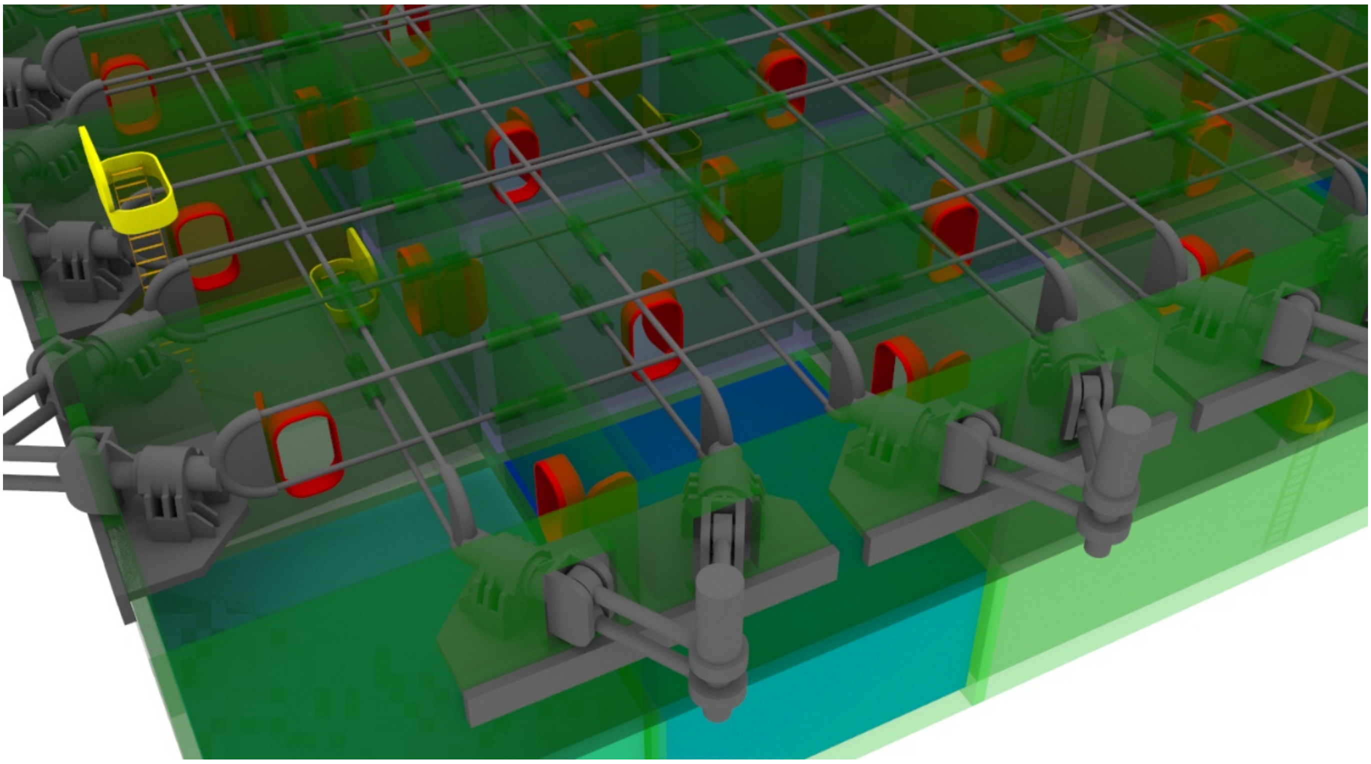


Figure 5.3 Living Module General Arrangement: 3D view of Level -1, where connectors are placed

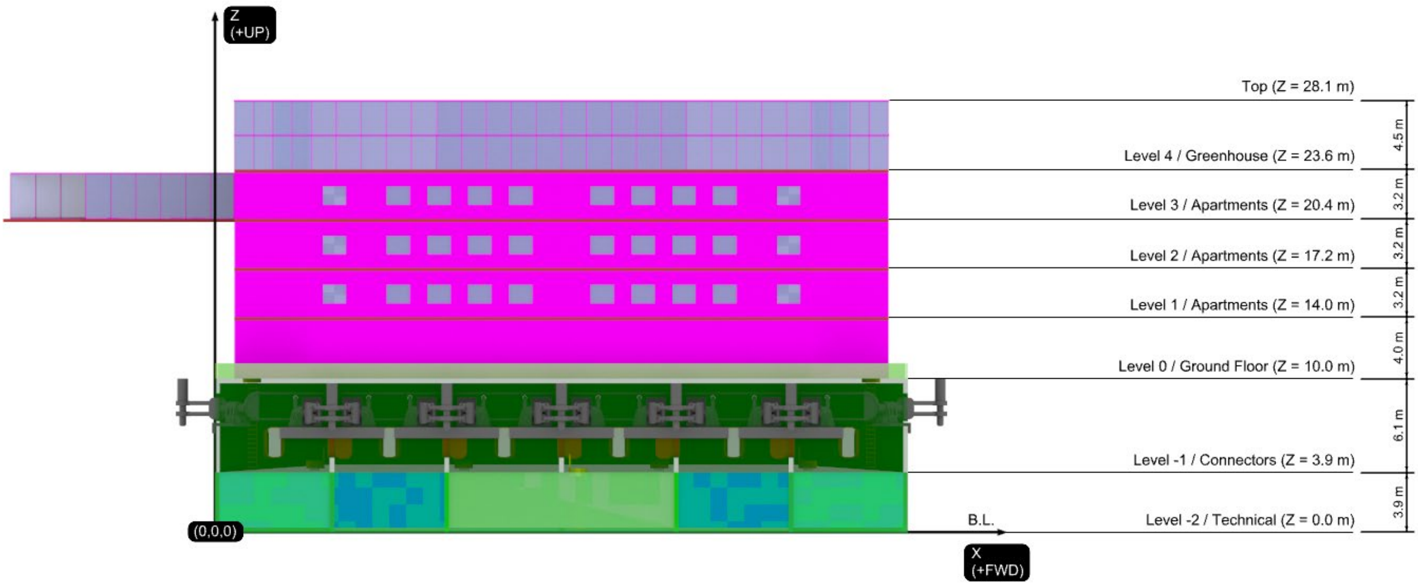


Figure 5.4 Living Module General Arrangement: elevation and Levels overview

5.2.1 Level -2 (Technical)

The lowest level of the module is reserved for technical compartments and tanks, as listed in Table 5.1.

Table 5.1: Overview of functions at Level -2

Technical Compartments	Tanks
Electrical Supply and Switchboard Fresh Water Generation Sewage Treatment Garbage Storage and Incineration	Fresh Water (FW) Grey/Black Water (G/BW) Ballast Water (BW)

The clear height of this level is about 3.9 meters, dictated by the overall dimensions of the equipment and necessary tank capacities. Exterior wall thickness is 0.3 m and interior wall thickness is 0.2 m. The preliminary layout of the technical floor is shown in Figure 5.5. The colour legend for Level -2 is included in the figure.

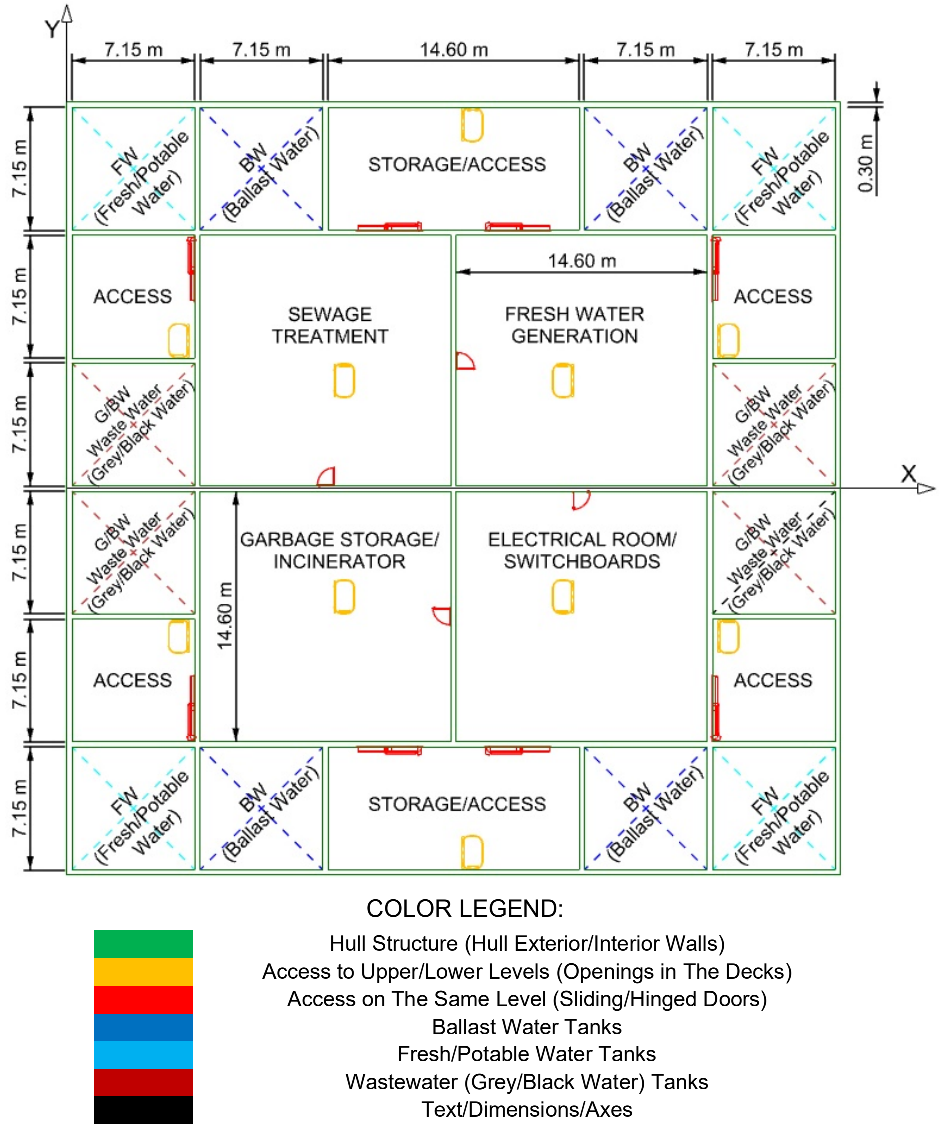


Figure 5.5 Level -2 (Technical) Preliminary Layout – Top View

5.2.2 Level -1 (Connectors)

The space between the main deck and the technical level is reserved for the connector's arrangement between modules. Exterior wall thickness is 0.3 m and interior wall thickness is 0.2 m. This space requires a height of about 6.1 meters for the following reasons:

1. The exterior part of the connectors needs to be above the waterline to function properly.
2. Access between compartments at this level should be clear of all obstructions, specifically to be clear of the connector cables that run through the whole length/breadth of the module.

The following two figures show the preliminary layout of the Connectors level.

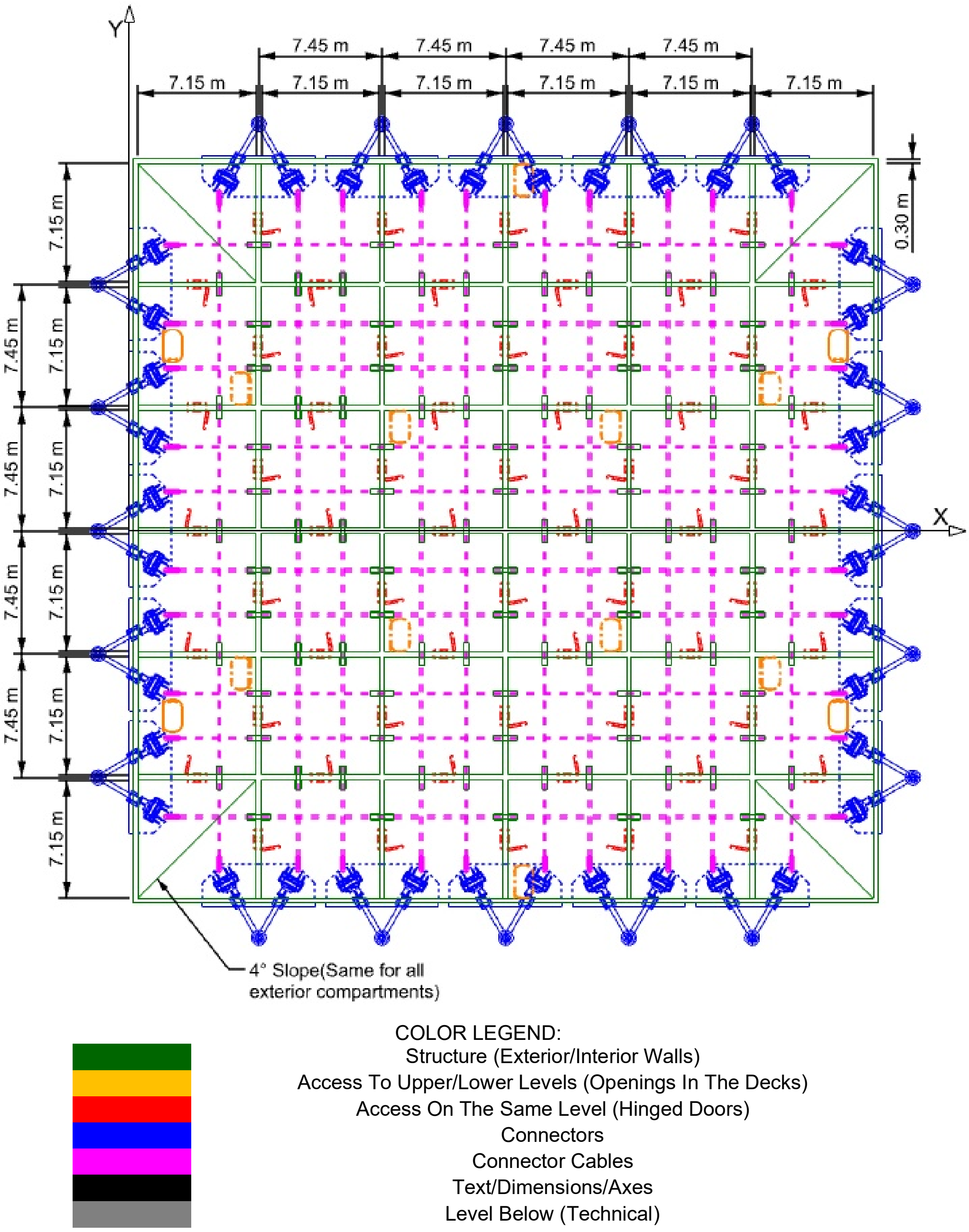


Figure 5.6: Level -1 (Connectors) Preliminary Layout - Top View

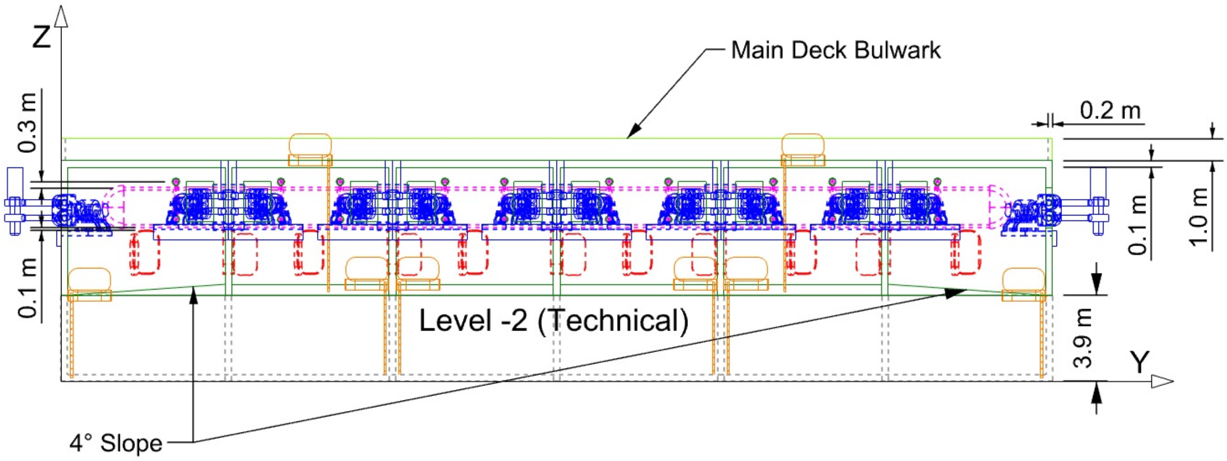


Figure 5.7: Level -1 (Connectors) Preliminary Layout - Section View

5.2.3 Level 0 (Ground Floor)

The ground floor level (about 4 m height) or main deck arrangement consists of:

- A weathertight exterior boundary. Weathertight means that it has parts that, in favourable weather can be opened and allow access to the exterior but this barrier cannot, in any circumstance, stay submerged under the waterline, even if closed.
- The module margins are delimited by a bulwark of about 1-meter height and 0.2-meters thick.
- The interior courtyard space is allocated for a garden and promenade area.
- There are four unassigned rectangular delimitations(walls) named "RESERVED SPACE" pending design evolution.
- Access to the higher levels is facilitated by 4 stair/lift trunks and access to the lower levels is made via 4 hatches.

Figure 5.8 shows the ground floor preliminary layout.

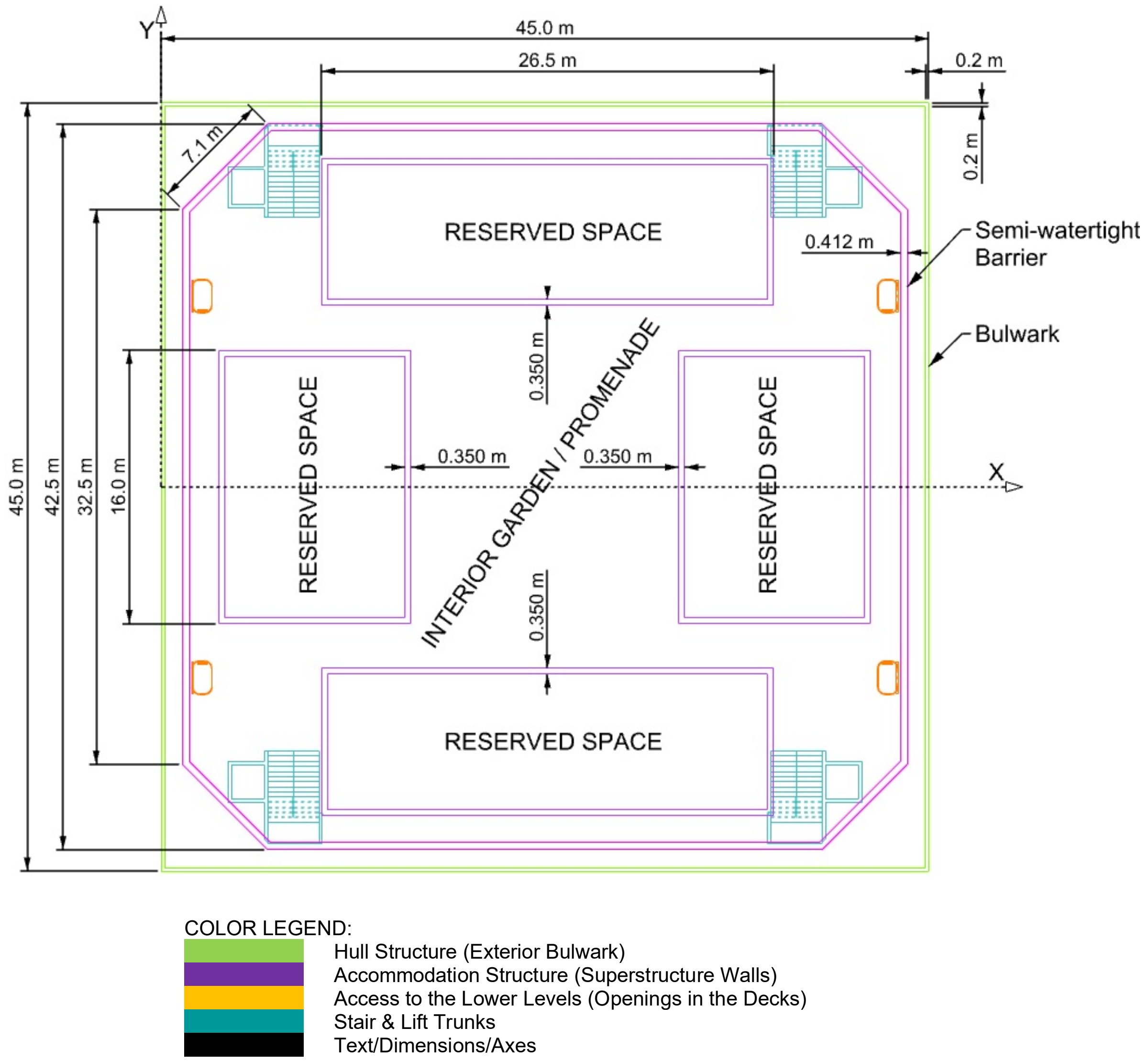


Figure 5.8: Level 0 (Ground Floor) Preliminary Layout – Top View

5.2.4 Level 1, 2 and 3 (Apartments)

Levels 1, 2 and 3 (about 3.2 m height each) are reserved for apartments. Levels 2 and 3 have panoramic walkways connecting to adjacent modules. The three levels are similar regarding the number and type of apartments per floor. For the purpose of this analysis a living block with two 'small' apartment sizes has been chosen. Each floor's apartments are split in two categories: 'Large' apartments, 2 per level, and Small apartments, 12 per level. The differences between the two is the surface areas (approx. 70 square meters for the Large apartment and approx. 60 square meters for the Small apartment) and that the Large apartment has a twin-bed secondary bedroom as opposed to a single-bed for the Small apartment. Therefore, the Large apartment was considered capable of accommodating 4 persons while the Small apartment only 3 persons. The layouts of each accommodation floor are shown in Figure 5.9 and Figure 5.10. The colour legend is the same for all levels.

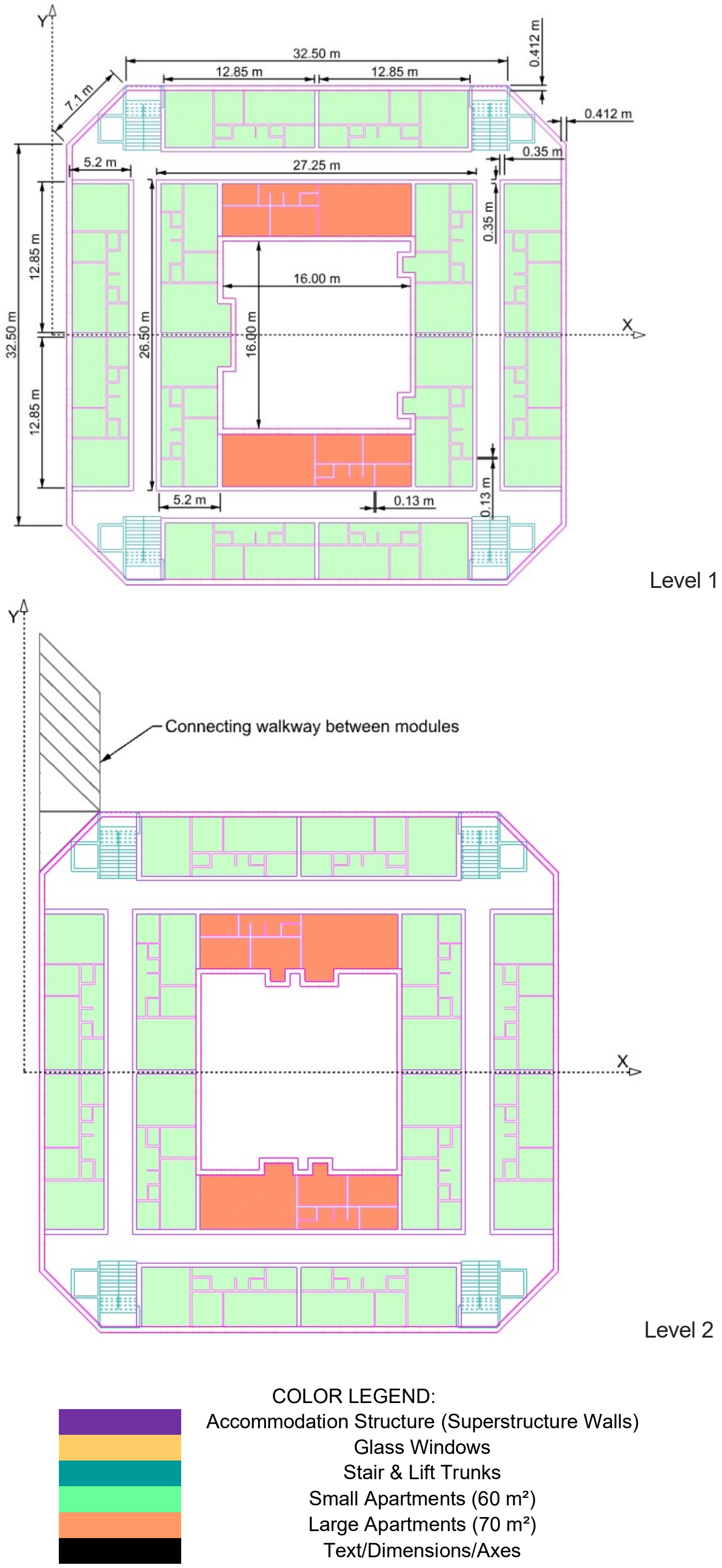


Figure 5.9: Level 1 and 2 (Apartments) Preliminary Layout – Top View

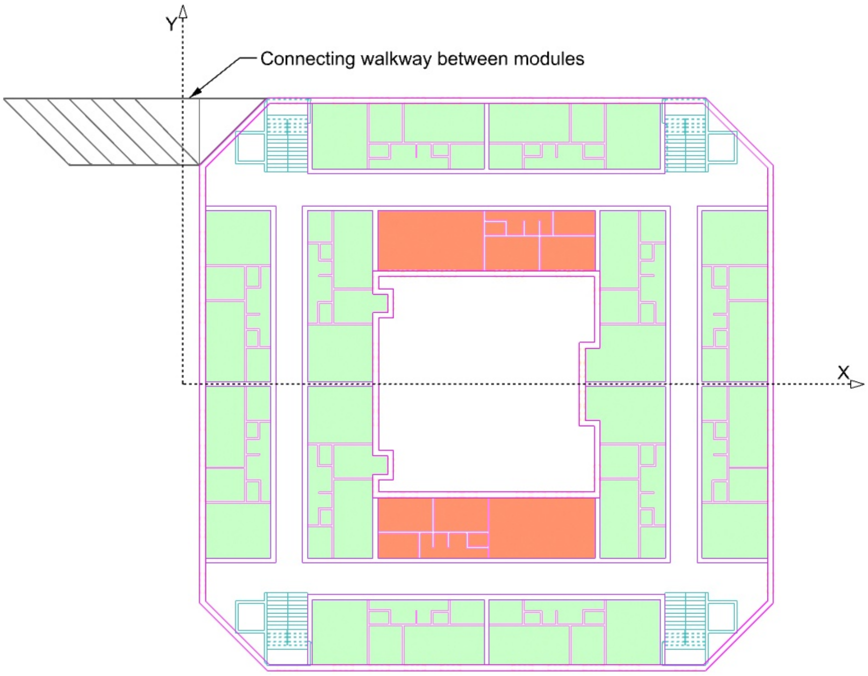


Figure 5.10: Level 3 (Apartments) Preliminary Layout – Top View

5.2.5 Level 4 (Greenhouse)

The top level of the platform is envisioned mainly as a greenhouse and promenade area. This level is made with primarily glass all around to maximize sunlight intake and allow for panoramic views. The greenhouse level layout is shown in Figure 5.11. The same colour legend as for levels 1, 2 and 3 applies.

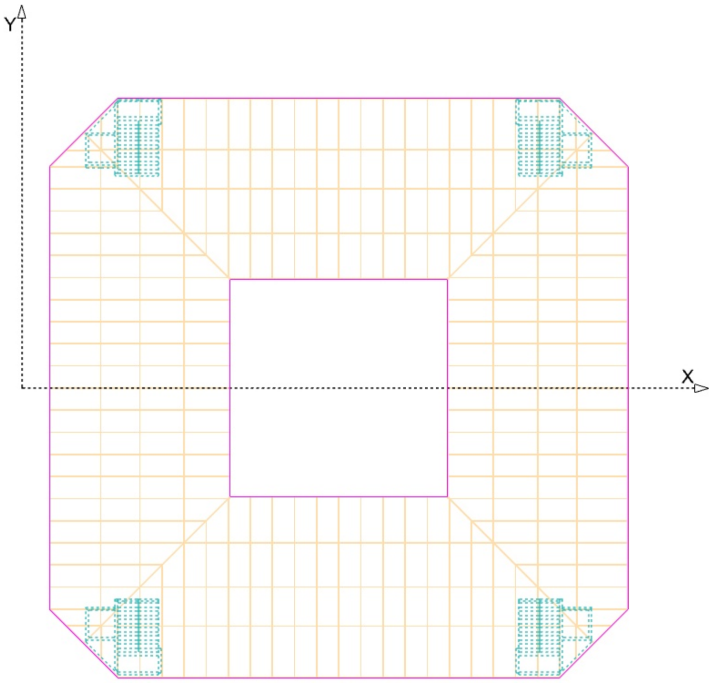


Figure 5.11: Level 4 (Greenhouse) Preliminary Layout - Top View

5.3 Weight Estimation

The living module weight estimation is based on the following:

1. The preliminary general arrangement detailed in Ch. 5.2
2. The total number of module inhabitants is 132 persons (see Table 5.2 and subchapter 5.2.4). This number shall include the technical personnel (crew) required for optimal functionality and maintenance of the technical equipment.
3. Tank capacities are based on:
    a. The number of inhabitants (132)
    b. The number of days of self-reliance (30 days), for fresh water/wastewater tanks
    c. Ballast water should be enough to correct eventual draft differences between modules and to correct trim/heel differences arising from variable loads (fresh water / wastewater / garbage, etc.)
4. A fresh/potable water consumption of 200 litres/person/day was assumed, taking as reference the *ISO 15748-2 International Standard, Ships and marine technology (Potable water supply on ships and marine structures – Part 2: Method of calculation, Annex A)* (Table 5.3):
5. Sewage (Grey/Black Water) capacity for the 30 days period has been estimated based on *EMSA/OP/02/2016, The Management of Ship-Generated Waste On-board Ships*. Based on the same reference document, other wastes (Plastics, Food Waste, Domestic Waste, Cooking Oil and Incinerator Ashes) have been estimated.
6. No margin was included to the estimated total weight.

Table 5.2: Module Inhabitants

Ap. Type	PAX/Ap.	Ap./Level	No. of Levels	PAX	Mass/PAX [t]	Mass [t]
Small Apartment (60 m2)	3	12	3	108	0.15	16.2
Large Apartment (70 m2)	4	2	3	24	0.15	3.6
TOTAL	-	-	-	132	-	19.8

Table 5.3: Guide values for potable water consumption in litre per person/bed and day

Type of ship		Group of persons embarked	Water consumption when fitted with	
			Flushing toilet system	Vacuum toilet system
Seagoing ship	Cargo ship	Crew/bed	220 l	175 l
	Passenger ship	Passenger/bed	270 l	225 l
	Luxury liner	Passenger/bed	—	275 l
	Ferryboat with cabins	Passenger/bed	205 l [a]	160 l [a]
		Passenger without bed	100 l	55 l
	Ferryboat without cabins	Passenger without bed	150 l	105 l
		Crew without bed	100 l	55 l
Inland waterway craft	Cargo ship	Crew/bed	Minimum 150 l	
	Passenger ship with cabins	Passenger/crew/bed	220 l	175 l
	Passenger ship without cabins	Crew/passenger	100 l	
Special-purpose ship	Research ship	per bed	220 l	175 l
	Federal armed forces tender and larger	Crew/bed	160 l	110 l
	Federal armed forces – smaller than tender	Crew/bed	100 l	55 l
Fishing vessel		Crew/bed	Minimum 150 l	
Offshore		Crew/bed	350 l	

[a] No shipboard laundry.

5.3.1 Weight summary Table

In Table 5.4 and Table 5.5 the weight summary is reported for each level.

Table 5.4: Living Module Weight Summary

Item	Mass [t]
Level -2 (Technical) Hull Structure	2,470
Level -1 (Connectors) Hull Structure	4,925
Level 0 (Ground Floor) Accommodation Structure	240
Level 1 (Apartments) Accommodation Structure	1,031
Level 2 (Apartments) Accommodation Structure	1,092
Level 3 (Apartments) Accommodation Structure	1,096
Level 4 (Greenhouse) Structure	1,118
Stair & Lift Trunks Structure	202
Level 0 (Ground Floor) Outfitting	2
Level 1, 2 & 3 Apartment Interiors Outfitting	36
Level 4 Interior Outfitting	26
Technical Equipment & Outfitting	1,917
PAX	20
TOTAL*	14,174

* no margin was considered

Table 5.5: Hull & Superstructure Weight Summary

Item	Mass [t]
Hull (Levels -2 & -1) & Technical Equipment & Outfitting	9,312
Superstructure (Levels 0, 1, 2, 3 & 4)	4,862
TOTAL*	14,174

* no margin was considered

5.3.2 Tank Capacities & Other waste/ garbage

Resulting estimated and actual capacities are presented in the following table(s).

Table 5.6: Tank Capacities Estimations

Persons		**132**	
Days		**30**	
Fresh/Potable Water (FW, ρ=1.000 t/m^3)	Potable Water/Person/Day	200	l
	Estimated Potable Water	792.00	m^3
	FW Tank Number	4	
	Actual FW Capacity	736.2	m^3
Sewage/Grey&Black Water (G&BW, ρ=1.000 t/m^3)	Estimated Sewage/Person/Day	0.2	m^3
	Sewage	792.00	m^3
	G/BW Tank Number	4	
	Actual G/BW Capacity	736.2	m^3
Ballast Water (BW, ρ=1.025 t/m^3)	BW Tank Number	4	
	Actual BW Capacity*	736.2	m^3

* This capacity can compensate about 0.4 m of draft variation.

Table 5.7: Other Wastes Estimation

Persons	**132**	
Days	**30**	
Plastics/Person/Day	0.008	m^3
Plastics (ρ = 0.07 t/m^3)	31.68	m^3
Food Waste/Person/Day	0.003	m^3
Food Waste (ρ = 0.5 t/m^3)	11.88	m^3
Domestic Waste/Person/Day	0.02	m^3
Domestic Waste (ρ = 0.5 t/m^3)	79.20	m^3
Cooking Oil/Person/Day	0.08	l
Cooking Oil (ρ = 0.9 t/m^3)	0.32	m^3
Incinerator Ashes/Person/Day	0.06	m^3
Incinerator Ashes (ρ = 0.6 t/m^3)	237.60	m^3

5.3.3 Structure

The structure of the living module is split in two main parts: Hull, substructure (Levels -1 and -2) and Superstructure (Levels 0, 1, 2, 3, 4). Both the interior and exterior hull structure is made of concrete (ρ = 2.4 t/m3) and both interior and exterior superstructure is made of wood (ρ = 0.7 t/m3 for the floors and 0.6 t/m3 for the walls and stair/lift trunks). Additionally, all superstructure windows have been assumed of glass (ρ = 2.5 t/m3). The structural weight estimation was volume based, see the following table for a weight breakdown on each level.

Table 5.8: CLT (Cross-Laminated Timber) Structures Overview of Weights

Item	Thickness (mm)	Weight (Kg/m²)
Floor*	460	450
External wall	412	150
Internal wall (between apartments)	350	124
Partition wall (between rooms of an apartment)	130	86

*type 4, with concrete, for better acoustic insulation performance
(Source: *CLT Handbook by Swedish Wood*)

Table 5.9: Living Module Structural Weight Estimation

Item	Volume [m³]	Density [t/m³]	Mass [t]
(Level-2) Hull (Technical) Exterior-300mm	801	2.400	1922
(Level-2) Hull (Technical) Interior-200mm	228	2.400	547
(Level-1) Hull (Connectors) Exterior-300mm	1595	2.400	3828
(Level-1) Hull (Connectors) Interior-200mm	457	2.400	1097
Stair & Lift Trunks	206	0.978	202
(Level0) Main Deck Bulkwark	36	0.978	35
(Level0) Walls-412mm	246	0.364	90
(Level0) Walls-350mm	324	0.354	115
(Level1) Floor-460mm	650	0.978	636
(Level1) Walls-412mm	203	0.364	74
(Level1) Walls-350mm	287	0.354	102
(Level1) Walls-130mm	117	0.662	77
(Level1) Windows	55	2.579	142
(Level2) Floor-460mm	689	0.978	674
(Level2) Walls-412mm	203	0.364	74
(Level2) Walls-350mm	286	0.354	101
(Level2) Walls-130mm	117	0.662	77
(Level2) Windows	64	2.579	165
(Level3) Floor-460mm	689	0.978	674
(Level3) Walls-412mm	200	0.364	73
(Level3) Walls-350mm	287	0.354	102
(Level3) Walls-130mm	117	0.662	77
(Level3) Windows	66	2.579	170

Item	Volume [m³]	Density [t/m³]	Mass [t]
(Level4) Floor-460mm	650	0.978	636
(Level4) Walls	12	0.662	8
(Level4) Windows	184	2.579	475
TOTAL	8769	-	12,172

5.3.4 Technical Spaces

The following technical spaces are considered, as listed in Table 5.10.

Table 5.10: Technical Spaces Weight Estimations

Item	Qty.	Weight/Item [t]	Weight [t]
Level -2 Electrical/Switchboard Compartment	1	17.0	17.0
Level -2 Fresh Water Generator Compartment	1	10.0	10.0
Level -2 Sewage Treatment Compartment	1	10.0	10.0
Level -2 Incinerator & Garbage Storage	1	196.6	196.6
Level -2 Sliding Watertight Doors	8	0.5	4.0
Level -2 Hinged Weathertight Doors	4	0.3	1.2
Level -2 Technical Stores Equipment	2	5.0	10.0
Level -1 Internal Doors (Access)	60	0.3	18.0
Level -1 Connectors	20	69.5	1,390.5
Level -1 Connector Cables	20	7.2	144.0
Level -2/-1 Vertical Ladders	14	0.2	2.8
Level -2/-1 Hatches	14	1.3	18.2
Level -2/-1 Other Outfitting (platforms, stairs, etc.)	-	-	95.0
TOTAL	-	-	1,917.4

5.3.5 Accommodation Levels

The accommodation outfitting and furniture weight estimations for levels 0, 1, 2 and 3 are shown in the following tables. Greenhouse interior (Level 4/ Top Floor) was estimated at about 26 t.

Table 5.11: Ground Floor Weight Estimation (Outfitting)

Item	Qty.	Volume [m³]	Weight [t]
Bench (Large)	8.0	2.3	0.3
Patio Umbrella	4.0	1.1	0.1
Plants (Large)	4.0	1.7	0.2
Sun Lounger	8.0	4.5	0.5
Trampoline	2.0	2.3	0.3
Retractable Sunsetter	4.0	2.8	0.3
Patio Table	4.0	2.8	0.3
TOTAL	-	17.6	2.0

Table 5.12: Small Apartment Interior Weight Estimation

	Item	Qty.	Volume [m³]	Weight [t]
LIVING ROOM	3 Seater Sofa	1	1.2	0.1
	Armchair	1	0.4	0.0
	Rug/Pad (Large)	1	0.3	0.0
	Flat Screen TV + Stand	1	0.7	0.1
	Wall Unit (Large)	1	2.4	0.3
	Dining Table (Small)	1	1.0	0.1
	Dining Chair	4	1.1	0.1
	Kitchen Cabinet	2	2.3	0.3
	Stove	1	0.7	0.1
	Dishwasher	1	0.6	0.1
	Plants (Large)	1	0.4	0.0
SMALL BEDROOM	Bed, Divan (Single)	1	1.1	0.1
	Bedside Table	1	0.4	0.0
	Plants (Large)	1	0.4	0.0
LARGE BEDROOM	Bed, Divan (King Size)	1	2.2	0.2
	Bedside Table	2	0.8	0.1
	Bedroom Chair	2	0.7	0.1
	Side Table	1	0.4	0.0
	Plants (Large)	1	0.4	0.0
BATHROOM	Room Divider	1	1.1	0.1
	Bathroom Sink	1	0.1	0.0
	Cabinet (Medium)	1	0.6	0.1
TOILET	Toilet	1	0.4	0.1
HALLWAY	Shoe Rack	1	0.3	0.0
	Interior Door	6	0.5	0.2
	Entrance Door	1	0.1	0.0
TOTAL		-	20.7	2.5

Table 5.13 Large Apartment Interior Weight Estimation

	Item	Qty.	Volume [m³]	Weight [t]
LIVING ROOM	Sofa Section (5 Piece)	1	5.2	0.6
	Coffee Table (Large)	1	0.4	0.0
	Armchair	1	0.4	0.0
	Rug/Pad (Large)	1	0.3	0.0
	Flat Screen TV + Stand	1	0.7	0.1
	Wall Unit (Large)	1	2.4	0.3
	Dining Table (Medium)	1	1.3	0.1
	Dining Chair	6	1.7	0.2
	Kitchen Cabinet	2	2.3	0.3
	Stove	1	0.7	0.1
	Dishwasher	1	0.6	0.1
	Plants (Large)	1		
BEDROOM 1	Bed, Divan (King Size)	1	2.2	0.2
	Bedside Table	2	0.8	0.1
	Bedroom Chair	1		
	Side Table	1	0.4	0.0
	Plants (Large)	1	0.4	0.0
BEDROOM 2	Bed, Divan (King Size)	1	2.2	0.2
	Bedside Table	2	0.8	0.1
	Bedroom Chair	2		
	Side Table	1	0.4	0.0
	Plants (Large)	1	0.4	0.0
BATHROOM	Room Divider	1		
	Bathroom Sink	1	0.1	0.0
	Cabinet (Medium)	1		
TOILET	Toilet	1	0.4	0.1
HALLWAY	Shoe Rack	1	0.3	0.0
	Interior Door	5	0.4	0.2
	Entrance Door	1	0.1	0.0
TOTAL		-	25.1	3.0

5.4 Draft calculation

An important note to take under consideration is that the weight estimation above has no margin for future (expected and unexpected) design alterations.

Considering the above weight estimation (with no margin) and platform dimensions a lightship (all tanks empty) saltwater draft of about 6.8 meters is expected. Calculation was made as follows:

Module hull length...	L	[m]	45.0
Module hull breadth...	B	[m]	45.0
Module hull depth...	D	[m]	10.0
Water density...	ρ_{water}	[t/m³]	1.025
Water Plane Area...	WPA=LxB	[m²]	2025.0
Saltwater Tons Per Centimeter immersion...	TPC= WPA/97.56	[t/cm]	20.8
Module Weight...	W_{module}	[t]	14173.4
Displaced water volume for the corresponding module weight...	$V_{saltwater}=W_{module}/\rho_{water}$	[m³]	13827.7
Resulting lightship draft...	T(lsw)	[m]	6.828
Corresponding lightship freeboard...	Fb(lsw)	[m]	3.172

The module has a TPC of 20.8 t/cm, meaning that adding 20.8 tonnes of additional weight submerges the module with 1 cm, i.e. increases the draft by 0.01 meters.

Therefore, considering the operational tank fillings as per Table 5.14, the final operational draft is calculated as: **T(actual)** = T(lsw) + DWT/(TPC*100) = 6.828 + 0.5 = **7.4 m**.

Table 5.14 Large Apartment Interior Weight Estimation

Tank Destination	Density [t/m³]	Tank Number	Filling per Tank [%]	Volume at Filling [m³]	DWT [t]
Fresh Water (FW)	1.000	4	95	710.6	710.6
Grey/Black Water (G/BW)	1.000	4	10	74.8	74.8
Ballast Water (BW)	1.025	4	50	374.0	383.4
TOTAL		-	-	1,159.4	1,168.8

Assuming a total hull height of 10 m would mean a resultant freeboard of 2.6 m. This freeboard height, however, is not sufficient to keep connector elements above the water (for details see Figure 5.12 below). Therefore, it can be concluded that the above operational draft of 7.4 m is not feasible. The following solutions are proposed to be investigated further:

1. Keeping the 10-meter living module height requires at the very least a 0.6 m draft reduction, or a weight reduction of about 1,250 t. Ideally, for the connectors to be fully out of the water requires a draft/freeboard of 6.5/3.5 meters or a weight reduction of about 1,875 t.
2. The connectors and their corresponding hull openings could be raised higher, closer to the main deck margin as far as practicable possible. At a first glance, this solution alone cannot resolve the issue, so at best, it can only limit the amount of weight to be removed.
3. Increasing the hull height further is another option, albeit should be combined with other solutions to keep it minimal.

Solutions could be combined to achieve sufficient draft. Two options are discussed in the paragraphs below.

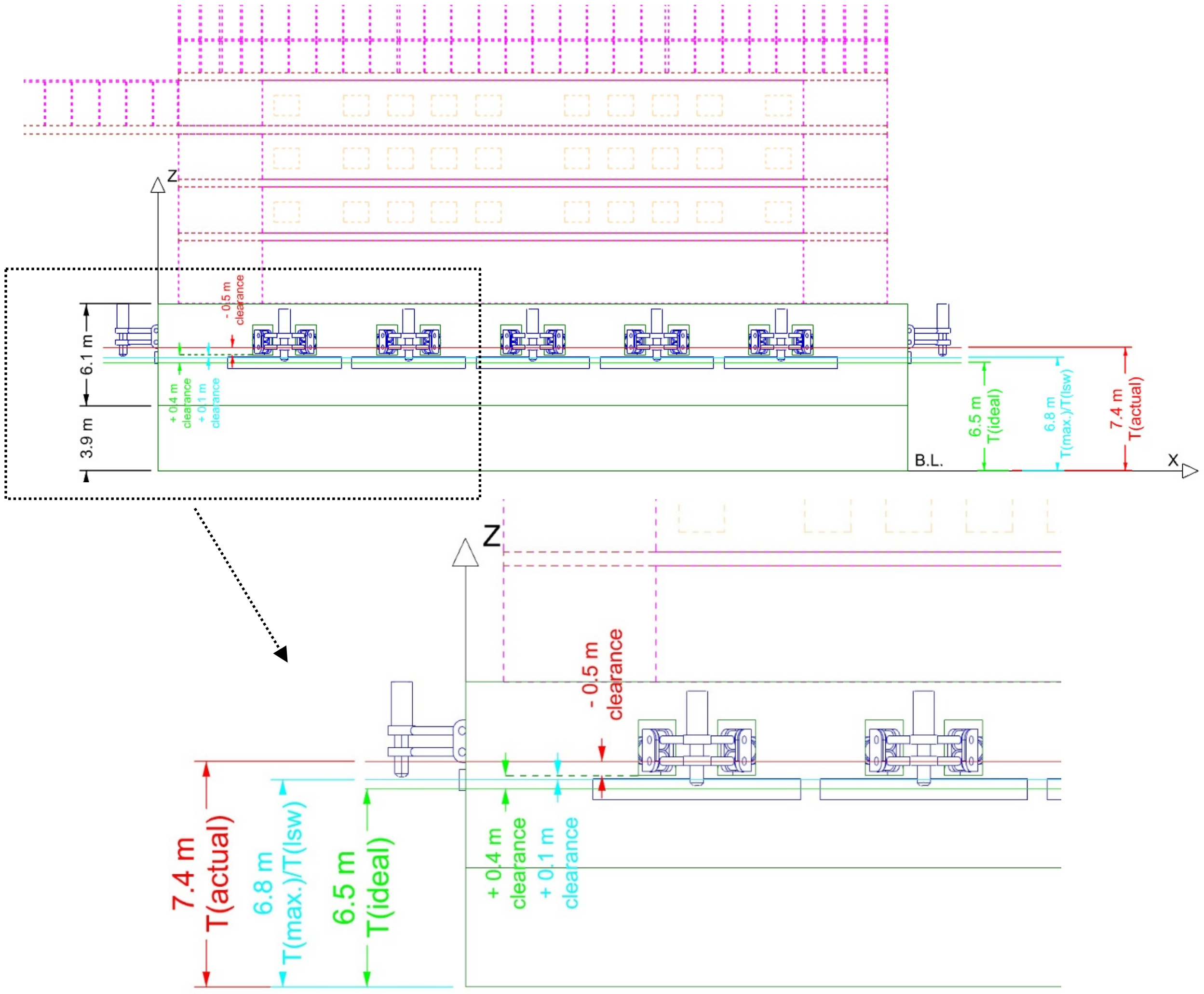


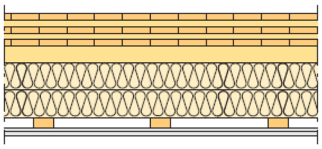
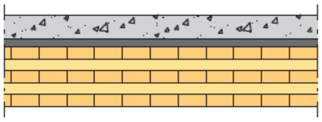
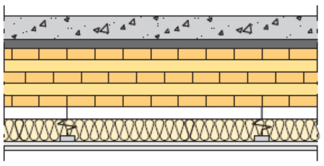
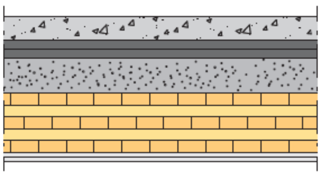
Figure 5.12: Draft Analysis (Connector Hull Openings Clearances; "- "/ "+" means below/above the waterline)

5.4.1 Option 1: reducing the superstructure weight

A larger draft could be obtained by reducing the weight of the superstructure. In the current design, floors with a weight of 450 kg/m² are considered (type 4 in Table 5.15). A larger mass is beneficial to provide good acoustic performances; however, it adds weight to the structure. Additionally, the large amount of glass on the roof is also adding quite some weight.

Choosing another type of floor such as type 3 in Table 5.15 instead of type 4 could reduce the floors density by about half (ρ = 0.500 t/m³) and still provide good acoustic performances. Opening parts of the Greenhouse Level or changing the material from Glass to Plexiglas (ρ = 1.180 t/m³) would also contribute reducing the superstructure weight. Adopting these changes would lead to a total weight reduction of about 1540 t (10,634 t instead of 12,172 t reported in Table 5.9). This would mean a draft reduction of 0.74 m. Such reduction would be enough to keep the module height at 10 meters height. The strategy to reduce weight could be combined with raising the connectors, to provide even higher, much needed, freeboard.

Table 5.15: Details and characteristics of CLT floors [4]

Floor structure type	Material (mm)	Total height (mm)	Weight (kg/m^2)	Vertical sound insulation (dB)	
				Impact sound level, *L*	Airborne sound insulation, *D*
	**Floor structure type 1** 110 CLT slab 220 fixed joists 2 × 95 insulation 34 battens 2 × 13 plasterboard	390	92	63 (+7)	56 (-6)
		Residential houses sound insulation class 2)		–	D
		Offices sound insulation class 3)		A	A
	**Floor structure type 2** 80 concrete 30 impact sound insulation, dynamic stiffness ≤: 9 MN/m^3 200 CLT slab	310	266	52 (+5)	63 (-8)
		Residential houses sound insulation class 2)		C	C
		Offices sound insulation class 3)		A	A
	**Floor structure type 3** 80 concrete 30 impact insulation, dynamic stiffness ≤: 9 MN/m^3 200 mm CLT slab 120 suspended ceiling joists 80 insulation 2 × 15 plasterboard, density ≥ 1050 kg/m^3	460	207	33 (+17)	79 (-14)
		Residential houses sound insulation class 2)		B	A
		Offices sound insulation class 3)		A	A
	**Floor structure type 4** 80 concrete 30 mm impact insulation, dynamic stiffness ≤: 12 MN/m^3 30 mm impact insulation, dynamic stiffness ≤: 12 MN/m^3 120 washed gravel 200 CLT slab 2 × 15 plasterboard, density ≥ 1050 kg/m^3	460	450	40 (+4)	75 (-7)
		Residential houses sound insulation class 2)		A	A
		Offices sound insulation class 3)		A	A

1) Value not available.
2) Space outside home to space inside home.
3) From space to space for private work or conversations.

Another option that may help reducing the weight is to exclude the Technical Level (-2) from the design. In this option, all tanks and utilities would be moved in the -1 (connectors) and/or ground floor level. Removing the -2 level provides the following weight reductions:

- (Level-2) Hull structure -2470 t;
- (Level-2) Technical Equipment & Outfitting 0-307 t;

Removing the -2 level would result in an actual/operational draft of about 6.0 meters. However, removing the -2 level would mean that the module height is also reduced by 3.9 meters, leading to a module hull height of 6.1 meters. Therefore, the resulting draft would be almost equal to the reduced module height, making this solution impractical.

5.4.2 Option 2: increasing the draft

If weight reduction is not an option, moving the connector holes slightly higher and increasing the draft could be alternatives to make sure connectors are kept above the water level. The following two options are proposed for the final design proposal to be further investigated:

1. Move the connector holes higher by 0.4 meters relative to their current position.
2. Increase the hull height by 1 meter, respectively only Level -2 (Technical) shall be increased by 1 meter.

These modifications bring these consequences:

1. A hull structural weight increase, highlighted in red in Table 5.16;
2. Increased tank capacities (Table 5.17);
3. Higher operational tank volumes/weights (Table 5.18).

Table 5.16 Living Module Structural Weight Estimation (+1-meter hull height increase)

Item	Volume [m^3]	Density [t/m^3]	Mass [t]
(Level-2) Hull (Technical) Exterior-300mm	854	2.400	2,050
(Level-2) Hull (Technical) Interior-200mm	291	2.400	698
(Level-1) Hull (Connectors) Exterior-300mm	1,595	2.400	3,828
(Level-1) Hull (Connectors) Interior-200mm	457	2.400	1,097
Stair & Lift Trunks	206	0.978	202
(Level0) Main Deck Bulkwark	36	0.978	35
(Level0) Walls-412mm	246	0.364	90
(Level0) Walls-350mm	324	0.354	115
(Level1) Floor-460mm	650	0.978	636
(Level1) Walls-412mm	203	0.364	74
(Level1) Walls-350mm	287	0.354	102
(Level1) Walls-130mm	117	0.662	77
(Level1) Windows	55	2.579	142
(Level2) Floor-460mm	689	0.978	674
(Level2) Walls-412mm	203	0.364	74
(Level2) Walls-350mm	286	0.354	101
(Level2) Walls-130mm	117	0.662	77
(Level2) Windows	64	2.579	165
(Level3) Floor-460mm	689	0.978	674
(Level3) Walls-412mm	200	0.364	73
(Level3) Walls-350mm	287	0.354	102
(Level3) Walls-130mm	117	0.662	77
(Level3) Windows	66	2.579	170
(Level4) Floor-460mm	650	0.978	636
(Level4) Walls	12	0.662	8
(Level4) Windows	184	2.579	475
TOTAL	8,885	-	12,451

Table 5.17: Tank Capacities Estimations (+1-meter hull height increase)

Persons	**132**	
Days	**36**	
Fresh/Potable Water (FW, ρ=1.000 t/m³)		
Potable Water/Person/Day	200.0	l
Estimated Potable Water	950.4	m³
FW Tank Number	**4**	
Actual TOTAL FW Capacity	960.0	m³
Sewage/Grey&Black Water (G&BW, ρ=1.000 t/m³)		
Estimated Sewage/Person/Day	0.2	m³
Sewage	950.4	m³
G/BW Tank Number	**4**	
Actual TOTAL G/BW Capacity	960.0	m³
Ballast Water (BW, ρ=1.025 t/m³)		
BW Tank Number	**4**	
Actual TOTAL BW Capacity*	960.0	m³

* this capacity can compensate about 0.5 m of draft variation

Table 5.18: Operational Tank Fillings (+1-meter hull height increase)

Tank Destination	**Density [t/m³]**	**Tank Number**	**Filling per Tank [%]**	**Volume at Filling [m³]**	**DWT [t]**
Fresh Water (FW)	1.000	4	95	912.0	912.0
Grey/Black Water (G/BW)	1.000	4	10	96.0	96.0
Ballast Water (BW)	1.025	4	50	480.0	492.0
TOTAL		-	-	1,488.0	1,500.0

Considering the above three (3) points a lightship (all tanks empty) saltwater draft of about 7.0 meters is expected. Calculation was made as follows:

Module hull length...	L	[m]	45.0
Module hull breadth...	B	[m]	45.0
Module hull depth...	D	[m]	11.0
Water density...	ρ_{water}	[t/m³]	1.025
Water Plane Area...	WPA=LxB	[m²]	2,025.0
Saltwater Tons Per Centimeter immersion...	TPC= WPA/97.56	[t/cm]	20.8
Module Weight...	W_{module}	[t]	14,451.8
Displaced water volume for the corresponding module weight...	$V_{saltwater}=W_{module}/\rho_{water}$	[m³]	14,099.3
Resulting lightship draft...	T(lsw)	[m]	<u>6.963</u>

Corresponding lightship freeboard...	Fb(lsw)	[m]	3.037

The module has a TPC of 20.8 t/cm, meaning that adding 20.8 tonnes of additional weight submerges the module with 1 cm, i.e. increases the draft by 0.01 meters.

Therefore, considering the new operational tank fillings as per Table 20, the final operational draft is: **T(actual)** = T(lsw) + DWT/(TPC*100) = 6.963 + 0.741 = **7.7 m** (see figure below). This draft is enough to keep connectors above the water level.

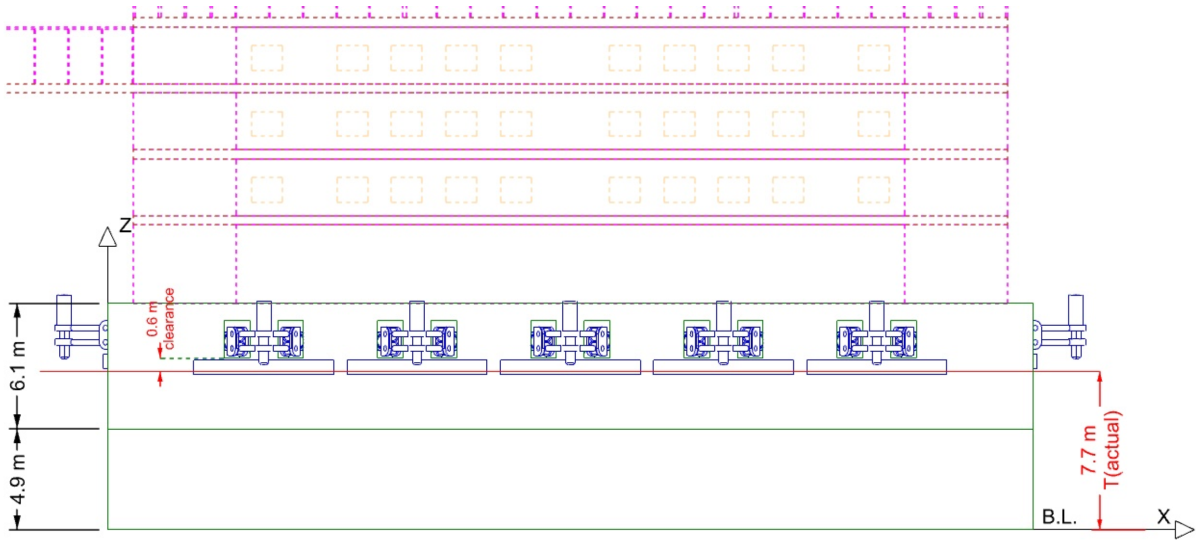


Figure 5.13: Draft Analysis - Final Design Proposal (+1-meter hull height increase)

5.5 Intact and damage stability

A preliminary stability analysis is made at this stage to assess the viability of the design when towing the living module from the construction yard to the site of operation assuming the following:

- The module structure, hull and superstructure, is finished in the construction yard and afterwards towed to the site. Only minor work is assumed to be done once arrived on site.
- When in transit, according to the applicable marine rules, the living module is treated as a pontoon, as defined by the *International Code on Intact Stability 2008, Ch. 2.2 Pontoons, 2.2.1 Application:* "The provisions given hereunder apply to seagoing pontoons. A pontoon is considered to be normally:
  1. non self-propelled;
  2. unmanned;
  3. carrying only deck cargo;
  4. having a block coefficient 0.9 or greater;
  5. having a breadth/depth ratio of greater than 3; and
  6. having no hatchways in the deck except small manholes closed with gasketed covers."

Calculations were made using GHS (General Hydro Statics) software by Creative Systems, Inc.

5.5.1 Intact stability

According to the *International Code on Intact Stability 2008, Ch. 2.2 Pontoons, 2.2.4 Intact Stability criteria*, the living module should satisfy the following criteria:

1. The area under the righting lever curve up to the angle of maximum righting lever should not be less than 0.08 metre-radians.
2. The static angle of heel due to a uniformly distributed wind load of 540 Pa (wind speed 30 m/s) should not exceed an angle corresponding to half the freeboard for the relevant loading condition, where the lever of wind heeling moment is measured from the centroid of the windage area to half the draught.
3. The minimum range of stability should be 20°.

Supplementary, it is necessary that the following criteria is satisfied (to give some measure of safety to in flooding through unprotected openings such as the connector holes):

4. The area under the righting lever curve up to the flooding angle should not be less than 0.08 metre-radians.

The stability axis makes an angle 'a' with the x axis on the XY-plane. This “a” angle is azimuth angle (deg.) and is positive towards the +y-axis (CW) and negative towards the -y axis. Wind blows perpendicular to the stability axis. The effect of existing underwater current is not considered for the stability axis. This convention is used within GHS calculation software, as per GHS User’s Guide.

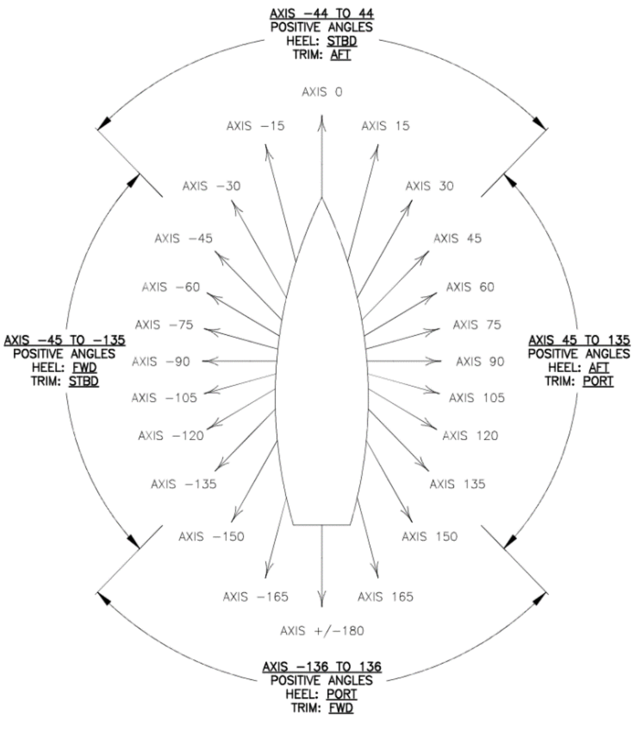


Figure 5.14: Axis Diagram Sign Convention

The intact stability assessment was made for 12 azimuth angles, from 0 to 180 with a 15° step. Summary of the results are shown in the following table.

Table 5.19: Intact Stability Calculation Report

Axis	Depth	Disp	Criteria (1)	Criteria (2)	Criteria (3)	Criteria (4)
deg	m	T	m.rad	deg	deg	m.rad
0	7.277	14451.820	2.162	68.902	27.915	2.040
15	7.277	14451.820	2.014	68.731	24.284	1.570
30	7.277	14451.820	1.944	68.610	23.443	1.440
45	7.277	14451.820	1.928	68.574	23.711	1.453
60	7.277	14451.820	1.945	68.616	23.447	1.441
75	7.277	14451.820	2.016	68.735	24.282	1.571
90	7.277	14451.820	2.163	68.921	27.915	2.040
105	7.277	14451.820	2.147	69.162	25.464	1.729
120	7.277	14451.820	2.084	69.441	24.420	1.573
135	7.277	14451.820	2.069	69.740	24.692	1.587
150	7.277	14451.820	2.094	70.038	24.782	1.612
165	7.277	14451.820	2.216	70.315	25.675	1.759
180	7.277	14451.820	2.383	70.552	29.533	2.290

All mentioned criteria are complied with. For detailed results see *Appendix 8 - Intact Stability Calculation - GHS Report*.

The following assumptions were taken into account during the Intact Stability calculation:

- Considering, the Intact Stability Calculation is made for the transit condition, all Operational Tanks are empty (Fresh Water, Grey/Black Water, Ballast Water).
- Also, the openings for connectors (Level -1) and windows - Level 1 are considered weathertight and windows - Level 2 are considered unprotected.

5.5.2 Damage stability

No regulatory body requires damage stability assessment for pontoons.

Although damage stability assessment in transit is not required, the following issues regarding damage (both from outside, i.e. collisions and inside, i.e. explosions/fires sources) on site should be taken into consideration in future design stages:

1. Damage to the living modules, especially on the outer layer, which is most prone to collisions, can lead to changes in the floating condition (even sinking) of mentioned module(s) and subsequently to high/breaking forces in the connector cables.
2. Flooding resulting from damage can have a cascading effect, leading from one module to another, so some measure of watertight integrity (watertight doors) should be provided on the exterior compartments of each living module.

3. In case of damage, especially fire and explosions, evacuation routes and escape plans must be carefully designed. Of note is the fact that most, if not all, of the living modules inhabitants is made of untrained personnel.

5.6 Conclusions

For the reference living module design, a two-storey 45 x 45 m platform is envisioned. The -2 level is used for utilities and the -1 level is reserved for reinforcement cables and connectors. In the design, several considerations are taken into account such as: 1) the need to keep connectors above water level, 2) the presence of cables running in two directions and linked to the connectors, 3) the spatial requirements of utilities and tanks, 4) the weight of the sub- and superstructure, of equipment and interiors.

According to the analysis, a platform height of 11 m is estimated for the Living@Sea module. A preliminary intact and damage stability analysis during transit is carried out, verifying that all the requirements are met.

Options to reduce the platform height are looked into. Using somewhat lighter floors and building the rooftop greenhouse space with lighter materials could help reducing the platform height from 11 to 10 m. Removing the -2 floor and integrating the equipment and tanks at the -1 or 0 level is also considered. However, this option would still require a large draft, around 6 m, due to the weight of the structure. On top of that, a freeboard of 3.5 m is required to keep connectors above the water level. Therefore, it was concluded it may be difficult to reduce the platform height to less than 10 m with the current living module design.

6. Conclusions and recommendations

In this chapter the main conclusions from the Conceptualisation and Design Exploration of Living@Sea are reported.

6.1 Conclusions

In the design exploration, a 45 x 45 m module is chosen and explored for Living@Sea. Several design concepts for Living@Sea are studied with systematic criteria. It can be concluded that modular platforms of 45 x 45 m are suitable for the purpose of Living@Sea. The most widespread functions within an urban development (e.g. residential, public space, retail, etc.) can be integrated in such block size. Where needed, modules of 90 x 90 m could be used.

According to the general arrangement study and weight analysis, a platform height of 10 to 11 m is estimated for the Living@Sea module of 45 x 45 m with the reference design. This height is necessary to make sure connector holes are above the water level. A preliminary analysis shows that the module meets the intact and damage stability requirement during transit.

6.2 Recommendations

Floating development presents opportunities to accommodate future urban growth in a flexible way. The main challenge comes from integrating urban design and maritime engineering, making sure that developments are safe and comfortable, as well as pleasant to live in.

References

[1] C. Barrios, “Transformations on Parametric Design Models,” in *Computer Aided Architectural Design Futures 2005*, Berlin/Heidelberg: Springer-Verlag, pp. 393–400.

[2] A. von Richthofen, K. Knecht, Y. Miao, and R. König, “The ‘Urban Elements’ method for teaching parametric urban design to professionals,” *Front. Archit. Res.*, vol. 7, no. 4, pp. 573–587, Dec. 2018.

[3] Y. Park and G. O. Rogers, “Neighborhood Planning Theory, Guidelines, and Research,” *J. Plan. Lit.*, vol. 30, no. 1, pp. 18–36, Feb. 2015.

[4] Swedish Wood, *The CLT Handbook. CLT structures – facts and planning*. 2019.

Appendix 1: Contribution to the Knowledge Portfolio

Background – Title / Responsible[1] Name	
Owner(s)	Partner Name(s)/third party rights, if applicable
Nature	Patent, design, software, etc.
Registration/Protection	Patent number or patent application number, copyright (year, etc), version N° (for s/w), etc.
Description	Description of background
Access conditions for research in the project / Limitations	Description of the access conditions, in particular: If a request in writing is needed and if access is conditional upon a specific licence agreement If limited to a WP
Access conditions for Use / Limitations	Description of the access conditions for use including for further research, internal usage and/or commercial usage
Licensees in the project	Names of the licensees – 1st set
	Date of allocation
	Type of licence/specific access rights granted
	Signature of parties (optional)
	Names of the licensees – 2nd
	Date of allocation
	Type of licence/access rights granted
	Signature of parties (optional)
Licensees for use	Names of the licensees – 1st set
	Date of allocation
	Type of licence
	Signature of parties (optional)
	Names of the licensees – 2nd set
	Date of allocation
	Type of licence
	Signature of parties (optional)

[1] Responsible means the organisation in charge of handling the IPR attached to the Background.

Exploitable Foreground	
Type of exploitable foreground	
Exploitable Foreground (description)	
Confidential	
Foreseen embargo date	
Exploitable product(s) or measure(s)	
Sector(s) of application	
Timetable for commercial use or any other use	
Patents or other IPR exploitation (licenses)	
Owner & Other Beneficiary(s) involved	

Patents, Trademarks, Registered designs, etc.	
Type of IP rights*	
Application reference(s) (e.g. EP123456)*	
Subject or title of application*	
Confidential*	
Foreseen embargo date	
Applicant(s) as on the application*	
URL of application	

Appendix – 2 City Fabric and Shape Study

Table of Contents

1. WHAT – Vision and References
2. HOW – Research and Concepts
3. PROPOSAL – Form and Function

WHAT – Vision and References

Vision

Our vision is creating sustainable and flexible city above the water considering the unpredictability of climate changes and future development. As given structure module is equilateral triangle, we study all possibilities of developing floating city with systematic criteria. Through multiple case studies already done in urban design and other projects, we have seen the need to find new architectural language. Since living condition is different from the ground, the floating city should embrace marine engineer technologies in design concept. For these reasons, we are searching for ideal design results to meet all these needs so that the platform itself can be independent but also easily be combined with others. The size of the floating city also should be controlled because of its flexibility to extend and shrink. In our research process, we constantly compare with other existing cities in different living conditions in order to imagine how these ideas can be realized. Cityscape is also important in terms of social acceptance to live on the water. The floating city should be beautiful and comfortable at the same time so that people don't have to fear constantly living above or under the water.

Basic Module

50 m X 50 m equilateral triangle platform

Waterstudio studied the possibilities of creating city with the presumed dimension of 50m equilateral triangle platform. Each platform not only floats independently but also easily combined with other plats because of its geometrical features. As each edge measures the same, it is easy to assemble all together and disassemble separately. Its platonic geometry also gives strong visual impact on the water scenery.

Task 7.4 Living@Sea

Proposal

Task 7.4: Conceptualisation and Design exploration of Living@Sea (M17-M25)[WS (20), DS(8), ICE(8)]
Based on the functional and technical requirements, a shortlist of promising design alternatives will be developed. The proposed shape of the reference platform is triangular. It will be analysed in what shape and dimensions are suitable from the perspective of Living@sea.
The findings of T7.2 and T7.3 are used as input in the design of living space at sea.
- Research on spatial design, testing different configurations and studying different combinations of functions. Focussing on both the floating platforms and various types of superstructures.
- Integration of technical requirements (such as accessibility, utilities and supplies)
- Research on urban fabrics for acquiring ideal platform size related to block size
- Integration or connection to the other main functions (energy, food, transport) WP 10
- Analyse and evaluate design alternatives; which will be further tested WP 10
- Preparation for input WP 1 on costs and benefits.
- Preparation of visualisation / virtual reality / augmented reality in order to increase social acceptance (T7.5)

Role of Partner: WS will provide two design alternatives for WP10 (Energyhub@sea,and Transport@sea) ICE will be involved in the 3D modelling related to platform shape improvement and structural integration of various living spaces configuration.

Task 7.4 Living@Sea

Research on urban fabrics for acquiring ideal platform size related to block size

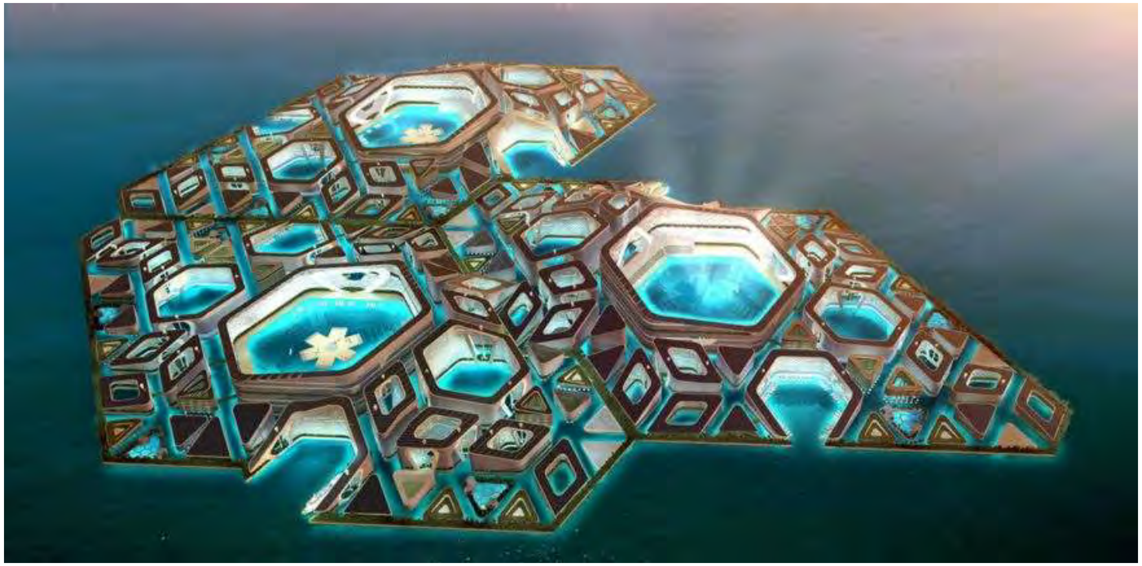
Research on spatial design, testing different configurations and studying different combinations of functions. Focussing on both the floating platforms and various types of superstructures.

Waterstudio decided to start the study for the research on spatial design of the living@sea task before it was planned in the process.

Creating a floating city gives the possibility to rethink the shape of urban fabric.

Random research on urban fabric and shape possiblities in order to get a grip on shape possiblities.

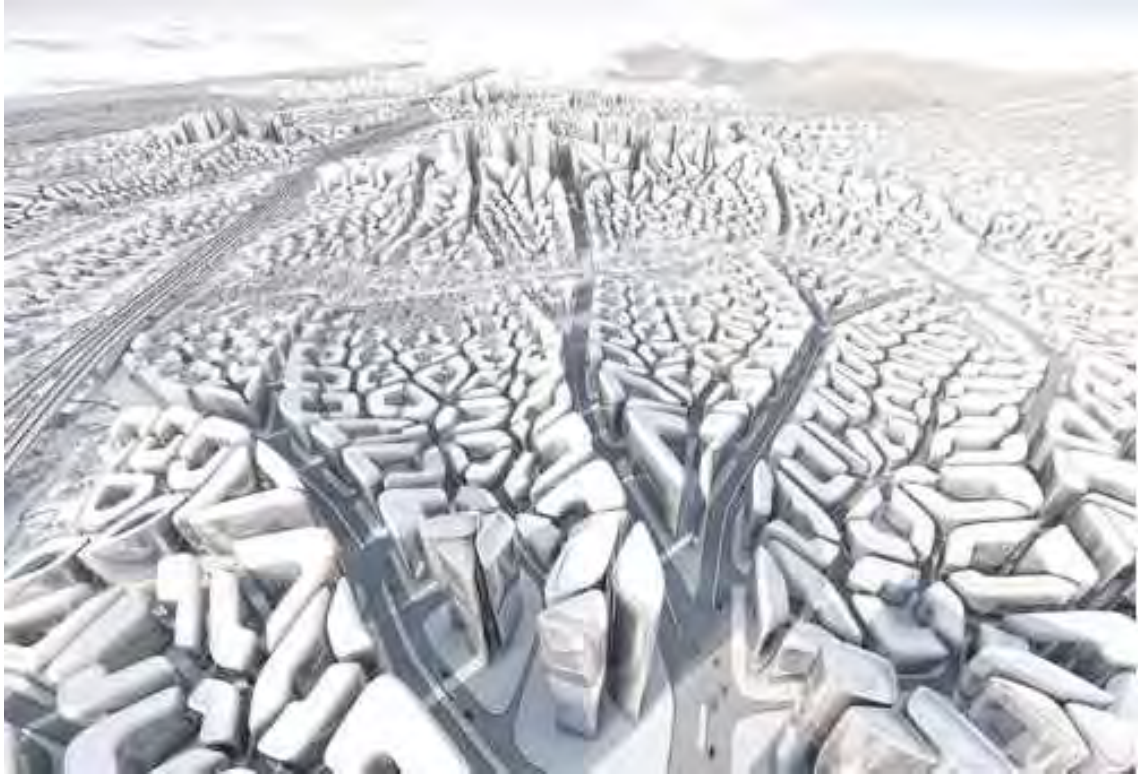
References



[Floating City concept by AT Design Office features underwater roads and submarines]

This reference shows the geometrical clearance of floating city with large scale. Its tilting slope and watery canals connecting each building show the new possibility of city transportation. Also it shows new and simple architectural language to easily be grasped. The city is equally distributed without existing strong axis to define city fabric which shows there is no hierarchy to access to the city in the middle of ocean.

References



Adaptive urban fabric Patrik Schumacher, Partner at Zaha Hadid Architects

The parametric design approach for building of cityscape reflects the architect's intention to make visible social and ecological aspects of the city. Thanks to permission of digitalization of city information, the architectural scenery gives the city a new identity. All these consideration of creating bottom-up city matches to Space@sea philosophy: flexibility of floating city and digitalization of infrastructure engineering.

References

A floating self-sustaining city. Aleksandar Joksimovic and Jelena Nikolic

Successive rings covered by green roof provide not only protection from natural disaster but also energy supply for the city. The form is adaptable for attracting natural resources such as wind, solar and wave energy. Also underneath the water, 64meter tunnel connected to the mainland is thought for aquaculture creating new ecosystems. Its shape also makes possible to combine with other ring leading to flexible and extended city on the ocean.

References

Pier55, Park on New York’s Hudson River. Thomas Heatherwick

Connected to New York’s Hudson Harbor, the project is developed by one mushroom-shaped pile to create open public space. Repetitive module makes extensive green park above the water. Mainly it is for recreative use and also its shape makes it possible to vary height for hill-shaped area.

References

Size of city : Amsterdam

Triangle - shaped platform based city can be compared with the existing city such as Amsterdam, The Netherlands. Each side measured 1km eventually ended up an hexagonal shape covering the heart of Amsterdam. It shows the possible dimension of floating city and makes think the circulation inside the city.

References

Size of city : Flevoland

Flevoland is one of the provinces in the Netherlands located in the centre of the country. As the world's largest artificial island, a dividing dike in the middle keep one polder safe if the other is flooded. Instead of enormous input for creating artificial island, floating city is more flexible and less damaging its surrounding ecosystem. As the hexagonal platform reaches up to 5km at each side, it is easily to be imagined the size of city.

HOW – Research and Concepts

Introduction

- The research is about how the super structure will be formed, and how different programs are networked with each other. It gives an insight on how much of public and private space play a role in a cityscape.
- It's a study to understand the type of language which the city is going to express. A design pattern is the re-usable form of a solution to a design problem.
- The elements of this language are entities called patterns. Each pattern describes a problem that occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice. — Christopher Alexander
- Documenting a pattern requires explaining why a particular situation causes problems, and how the components of the pattern relate to each other to give the solution.
- The study on floating base is experimenting with the different possibilities by which platforms can be oriented and organized to meet the program needs and also its about how easy to de-organize if needed. It also creates a possibility of how much waterfront(perimeter) is required for each function. The individual floating structures should be uniform shaped. - The platforms should be connected in such a way that a dimensionally stable cluster is created. - The shape of the individual platform should enable easy configuration for future growth. - There must be enough water experience in the floating community. - The form of a single floating platform must be such that the single floating platform is statically and dynamically stable on its own.

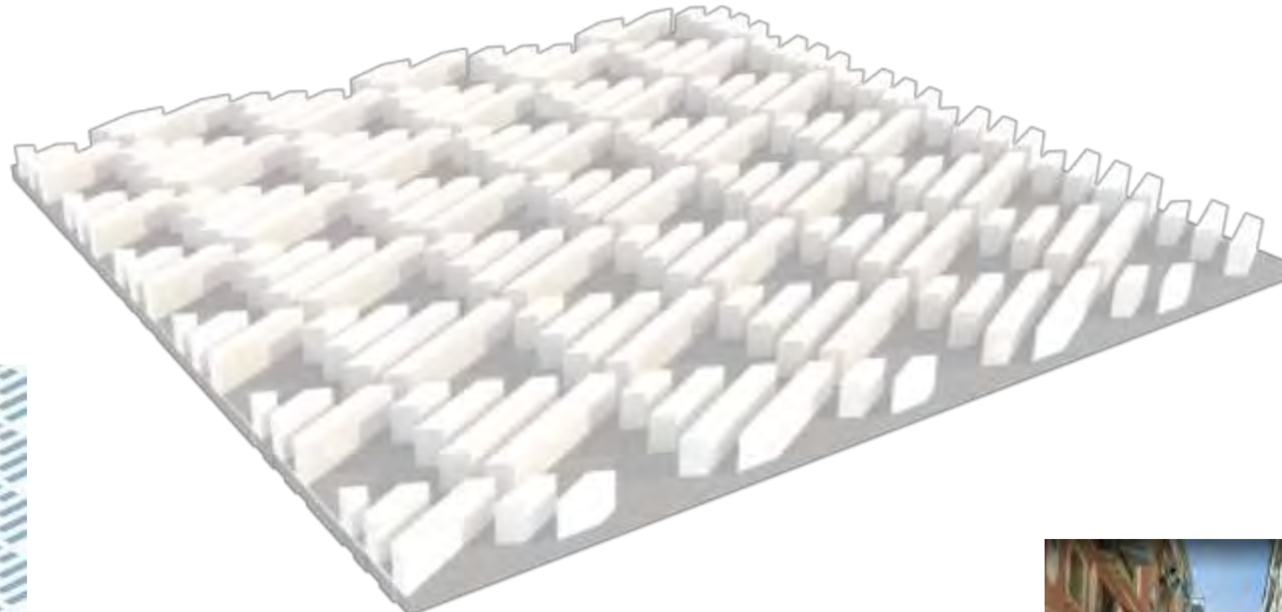
Research Method

- Triangle grid gives lots of opportunities to think about city fabric. We explored various shapes of triangle patterns and transformed each of these into tri-dimensional model. This method lead us to imagine how it will be sensation to be inside of the city. Also we can easily see the interaction between building blocks and public spaces. Starting from pattern also gives us possibilities to transform it easily and combine with other.

- Playing Japanese origami is also our inspirational design method to study repetitive pattern and turn to 3d model. Its mathematical and structural aspects of Japanese origami has been used several times in architectural design concept. The more there are connecting edges with various planes, the more complicated will be the model.

City Fabric Study

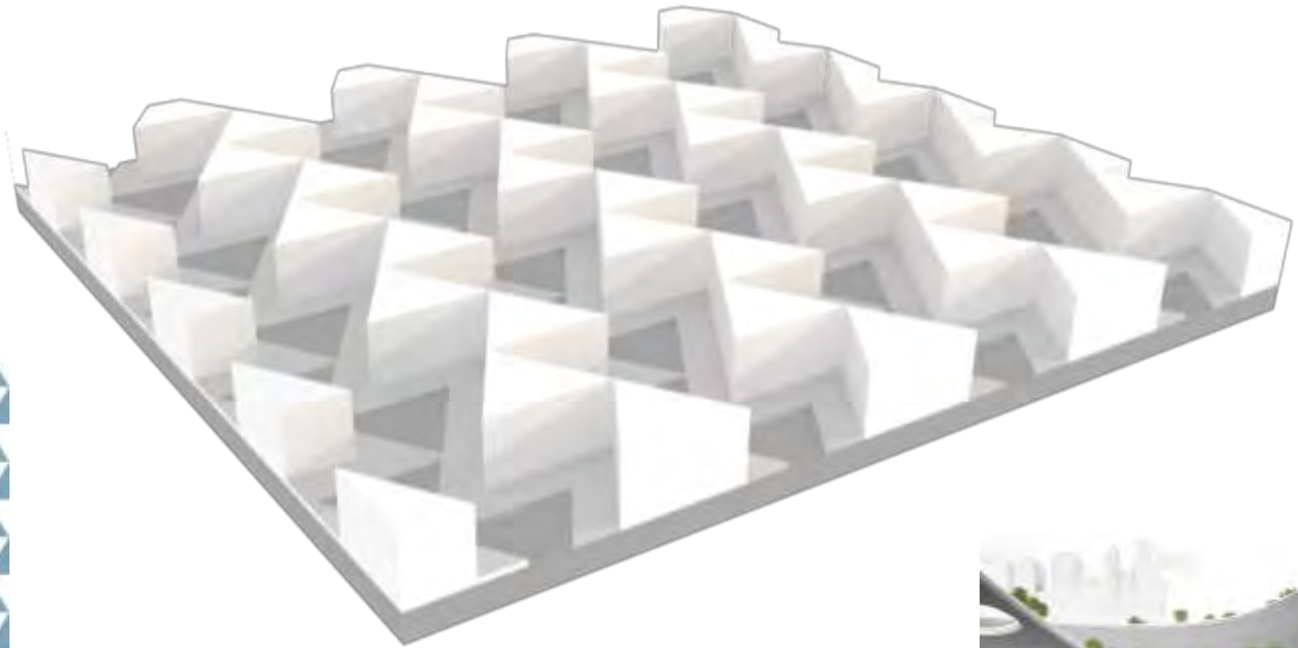
Patterns (1)



It creates a contrast on narrow streets between the tall building blocks and has a huge pubic squares where it brings in more interaction between public and private spaces. All streets opens out to huge public spaces.

City Fabric Study

Patterns (2)

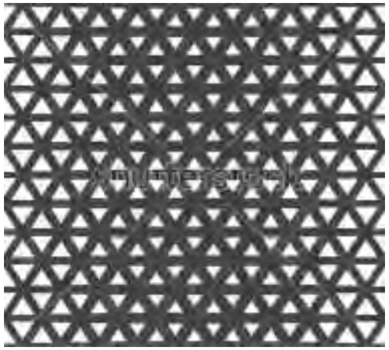


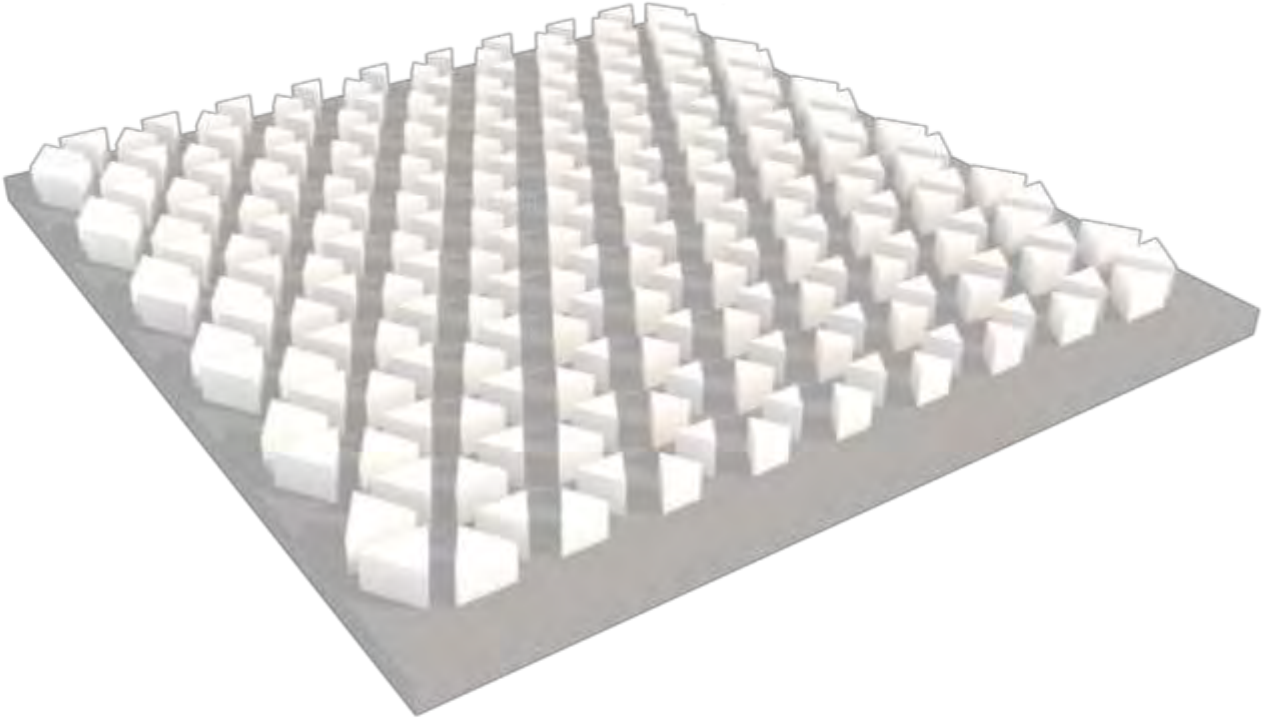
The pubic spaces are constantly disconnected, and a continues urban terrace-(green terrace) flows at an higher level, bringing out leisure activities.

SPACE@SEA

City Fabric Study

Patterns (3)

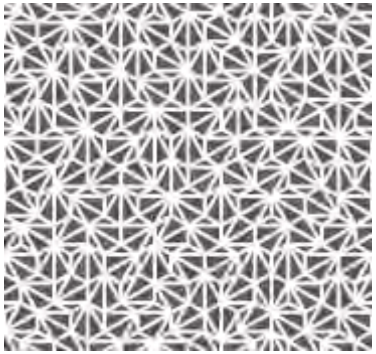


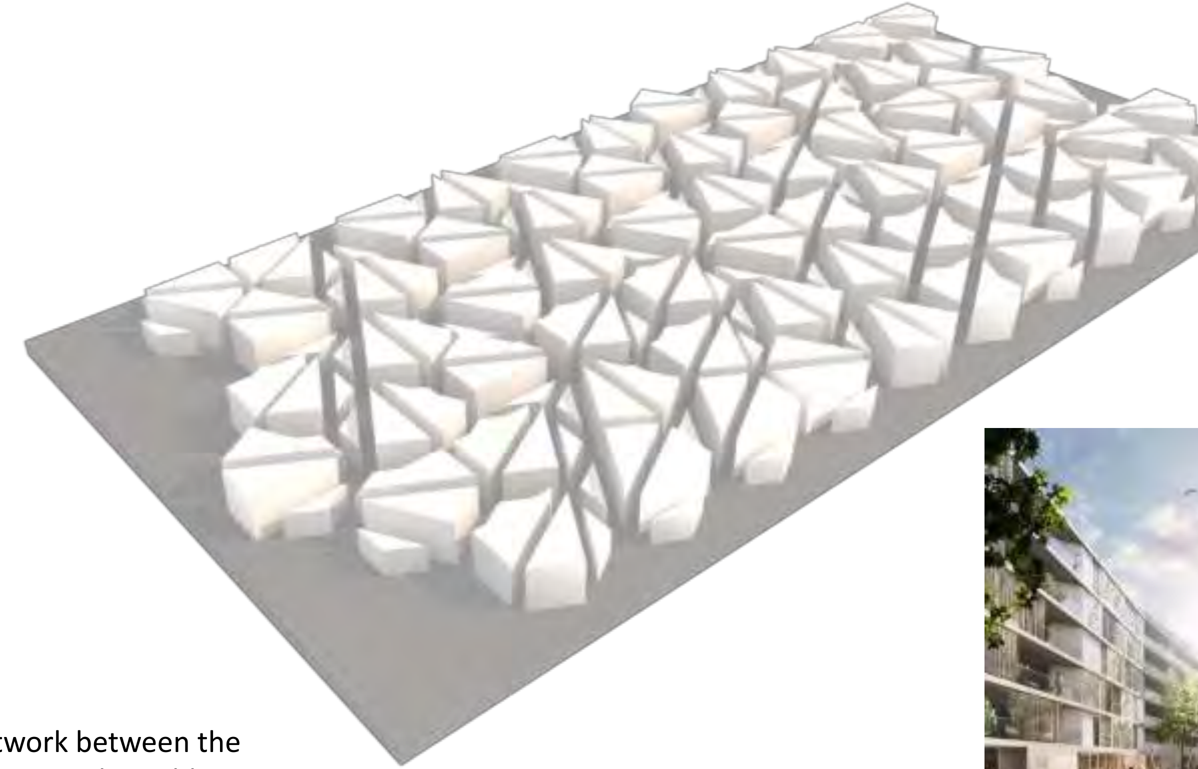


The public spaces are wide and have a strong axis.

City Fabric Study

Patterns (4)

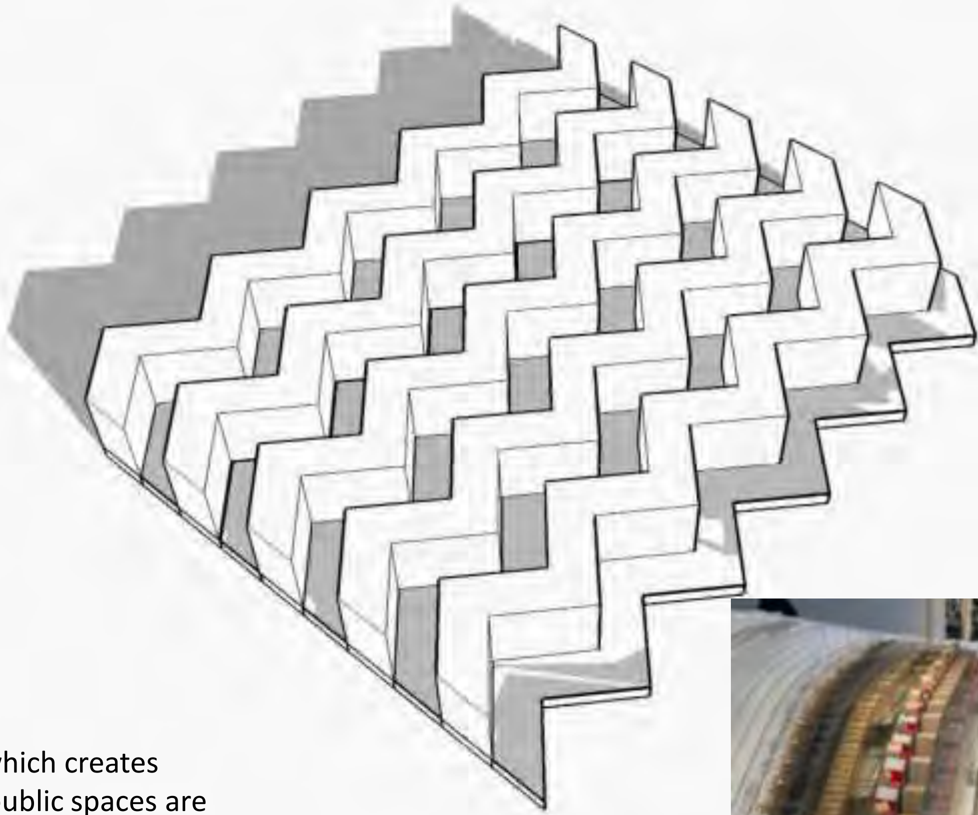




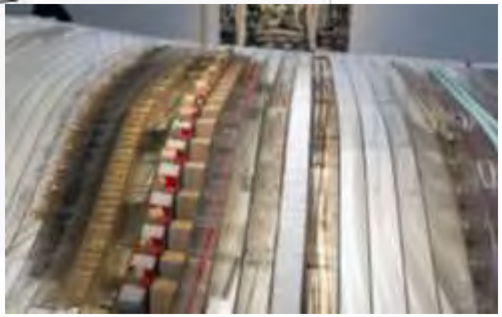
This creates much organic network between the functions. This triangulation creates the public spaces with a shortest distance between.

City Fabric Study

Patterns (5)

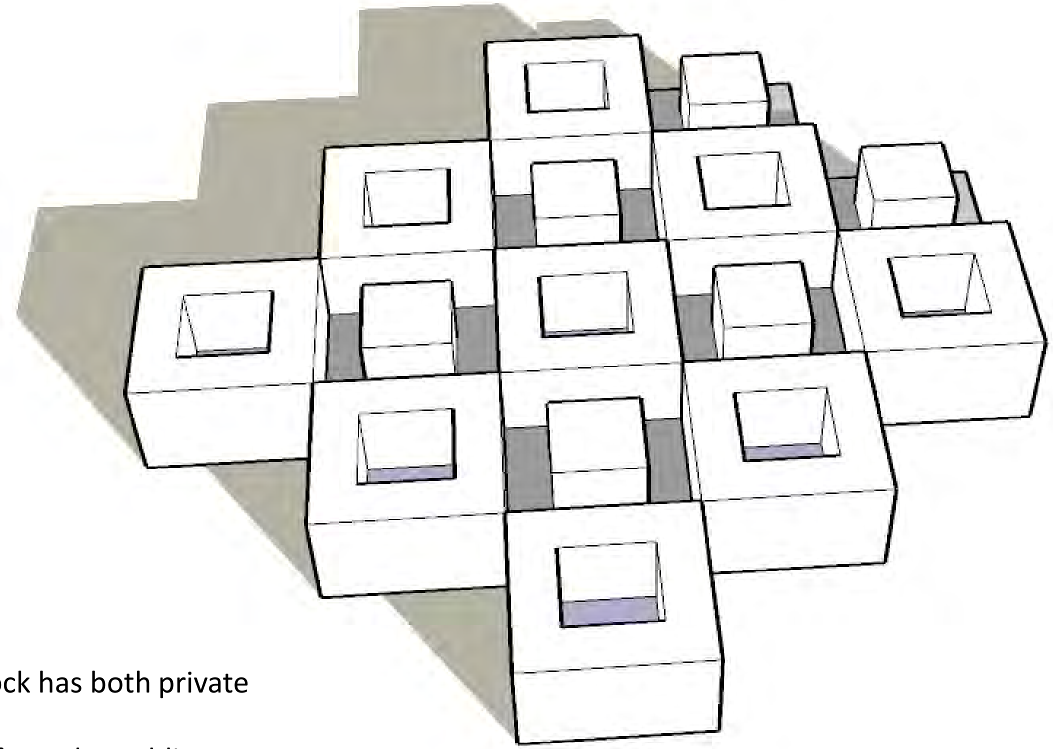


There is a continuous connectivity, which creates parallel streets throughout and the public spaces are disconnected at each street level.



City Fabric Study

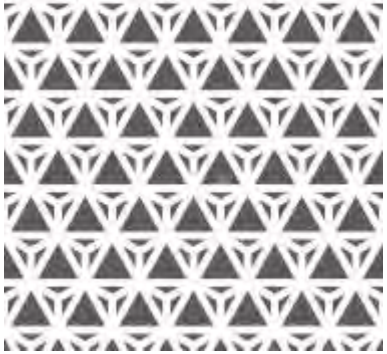
Patterns (6)

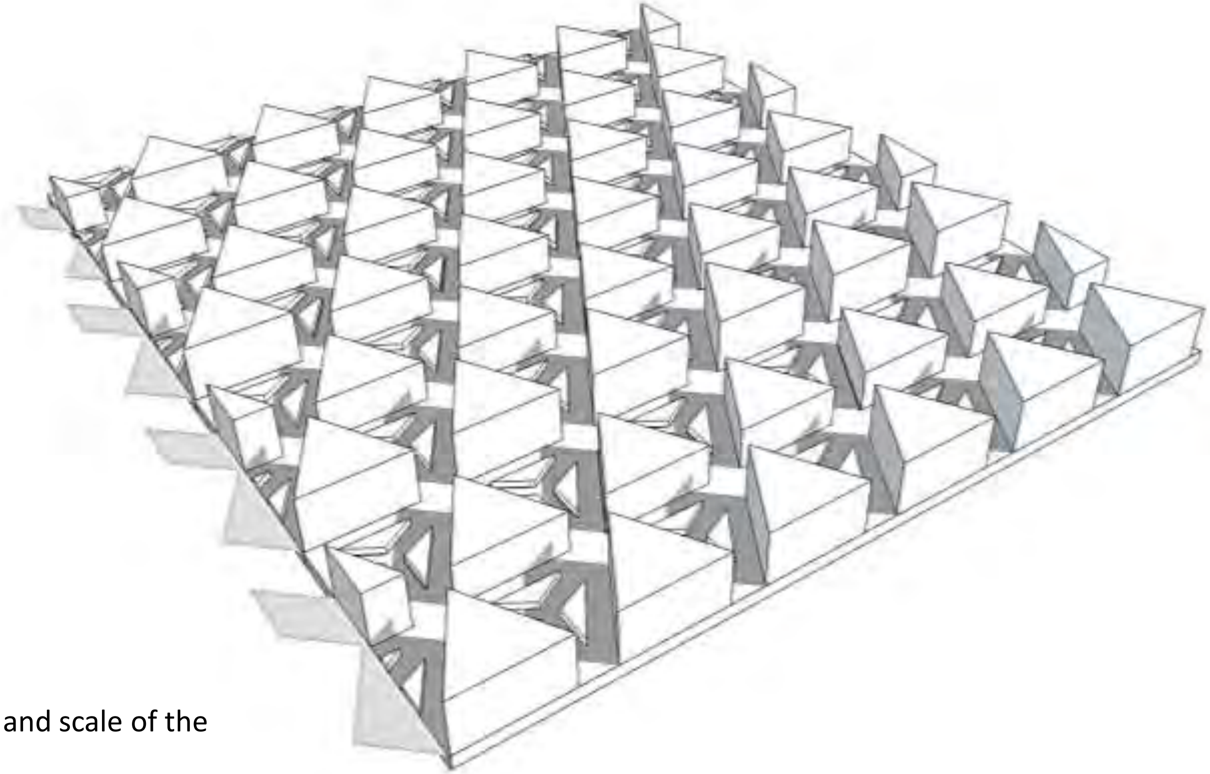


A regular grid pattern of organization. Each block has both private and public faces.
And each private space is distinctly separated from the public space, there is no connection between each public and private spaces.

City Fabric Study

Patterns (7)

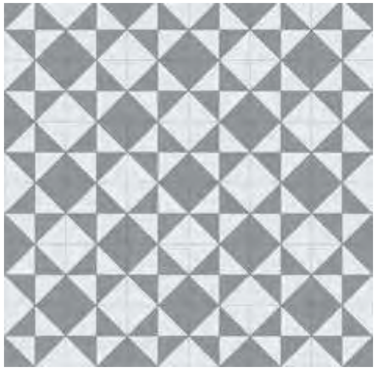


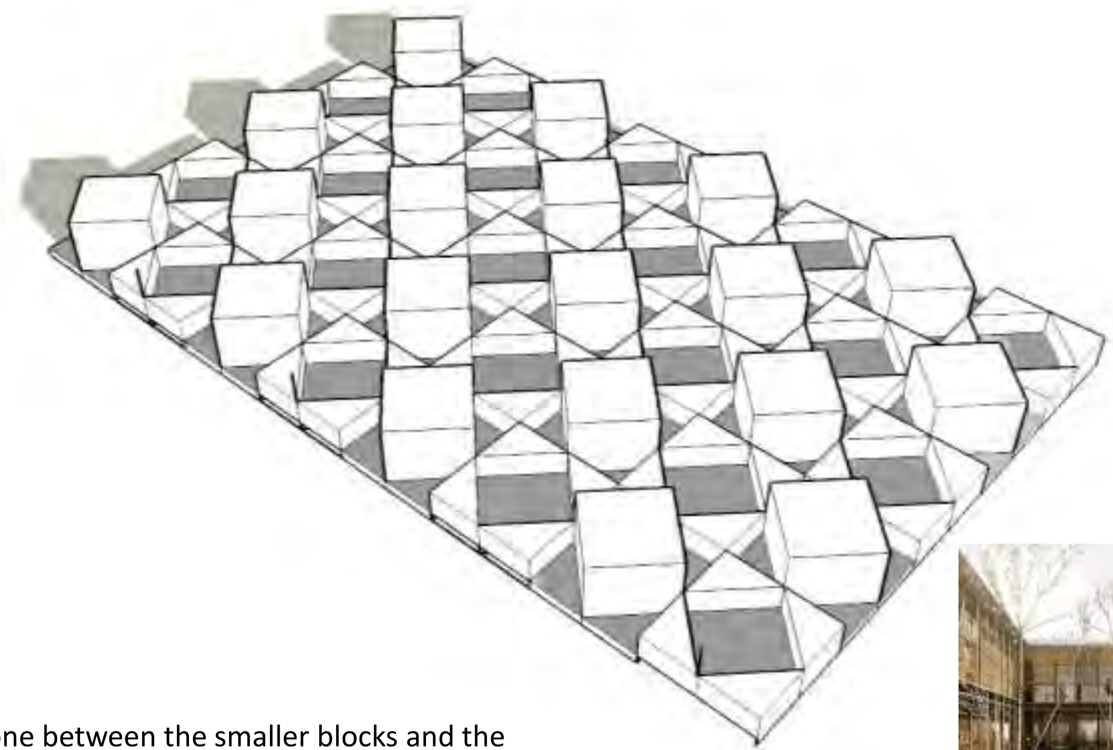


Proportionally this pattern has wider streets and scale of the blocks are at different extremes.

City Fabric Study

Patterns (8)

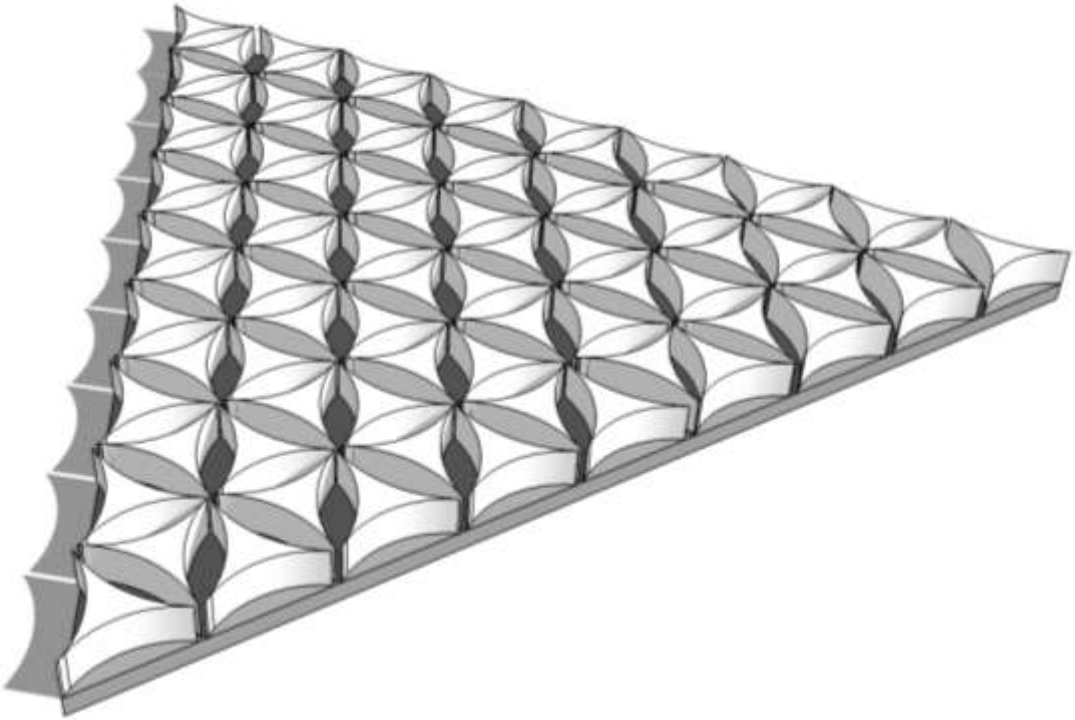




There are two level of public spaces one between the smaller blocks and the other on the intersection with a huge block. The terrace of the small blocks can be used as green terrace. The public spaces are disconnected.

City Fabric Study

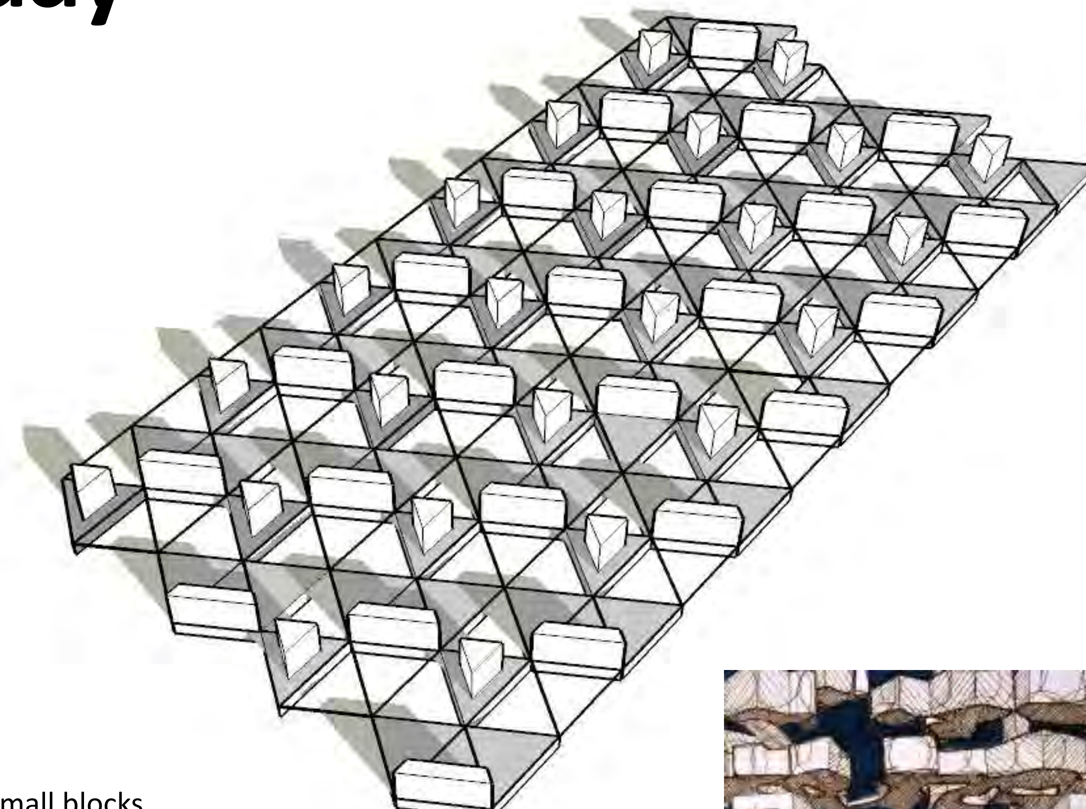
Patterns (9)



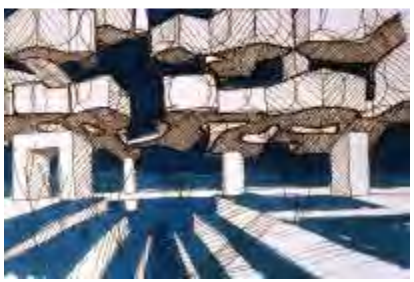
This pattern leaves a less footprint and maximum area is open for pubic spaces.
From each central public space, the connectivity radials out to another public space.

City Fabric Study

Patterns (10)

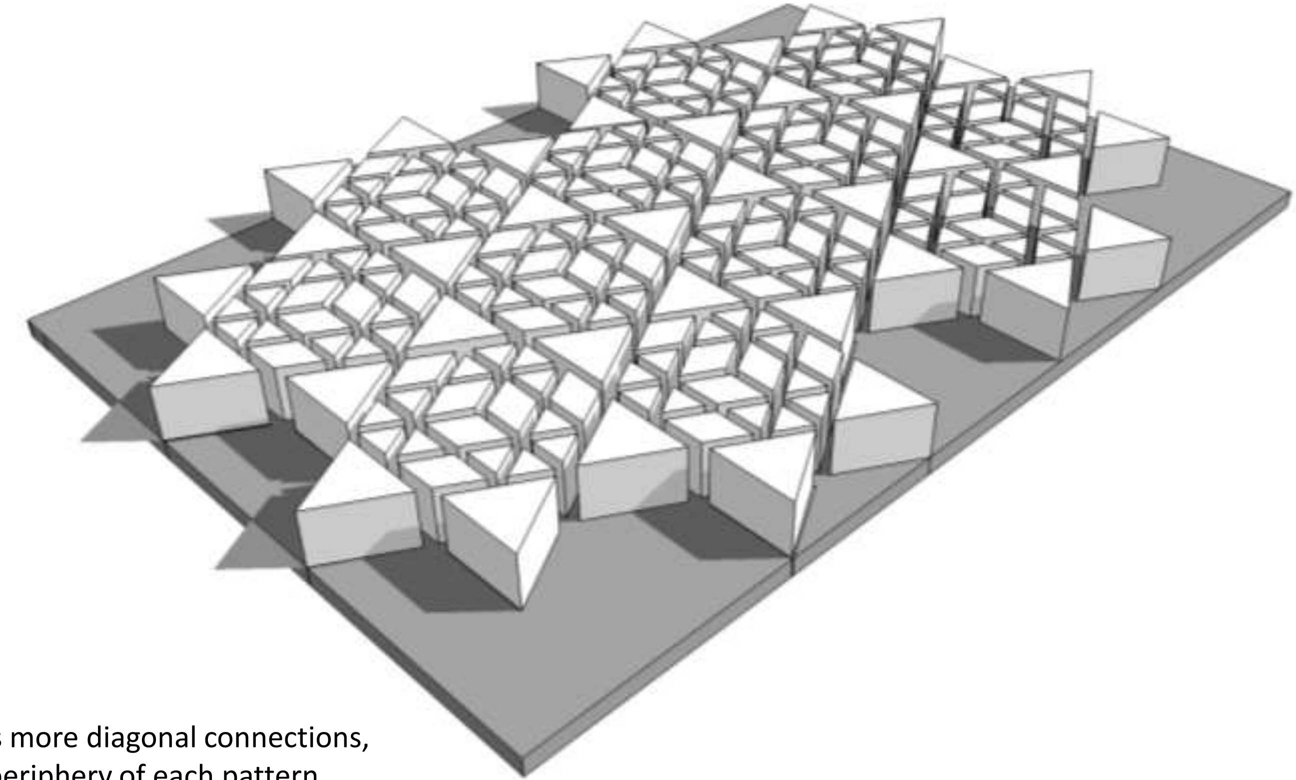


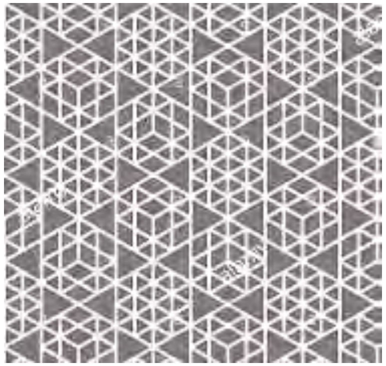
There s a continuous green space over the small blocks, connected with a huge public space at street level. The super blocks create a contrast to the spread area, linear and tall.



City Fabric Study

Patterns (11)

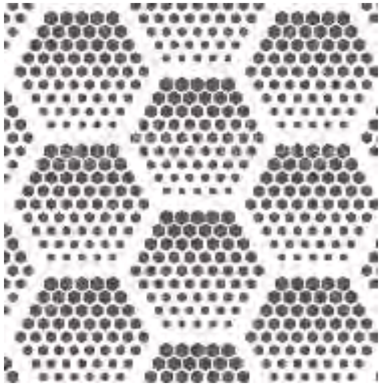


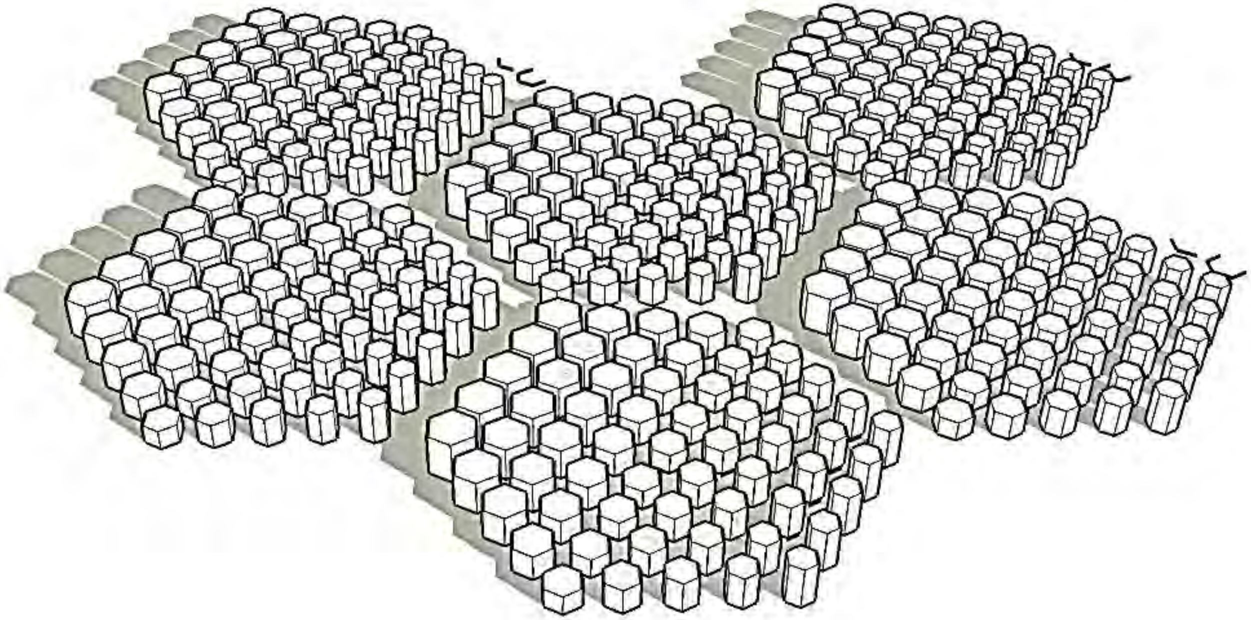


This hexagonal pattern creates more diagonal connections, with the huge super bocks in periphery of each pattern.

City Fabric Study

Patterns (12)

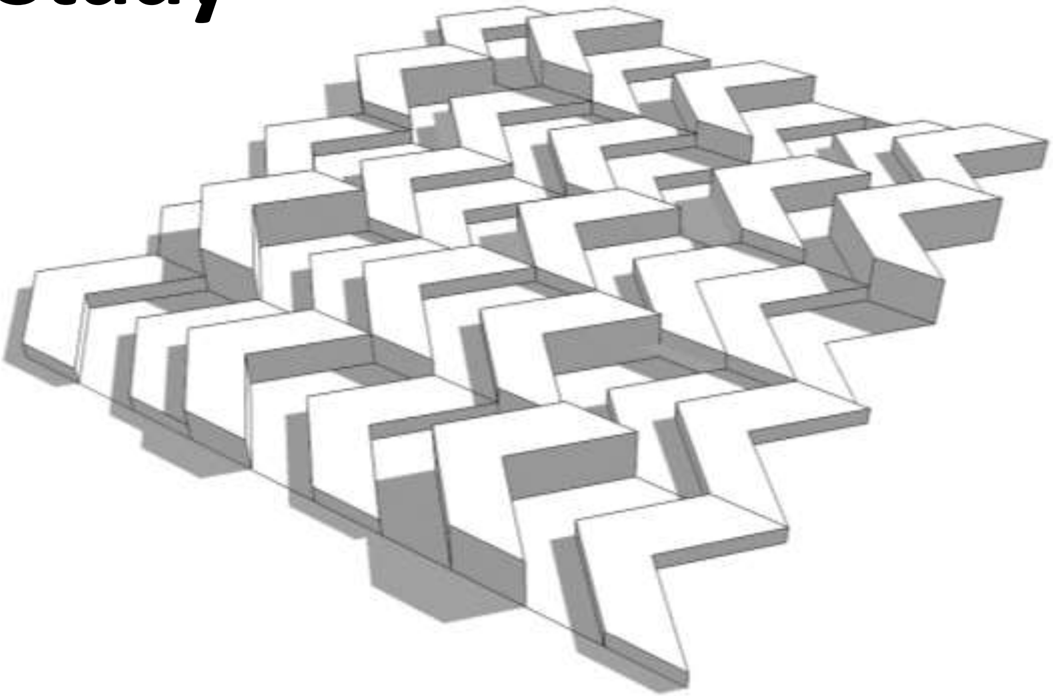




This pattern has the efficient planning pattern, allowing enough area for connectivity, between each clusters. The public area within a cluster has a mix feel of narrow street to wider one, with the difference on the blocks height.

City Fabric Study

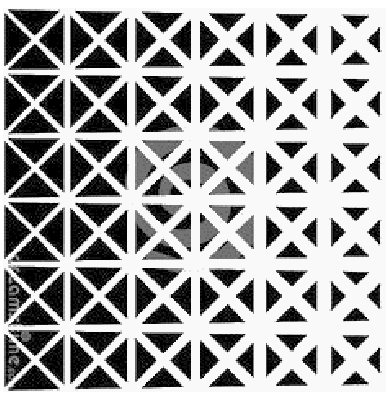
Patterns (13)

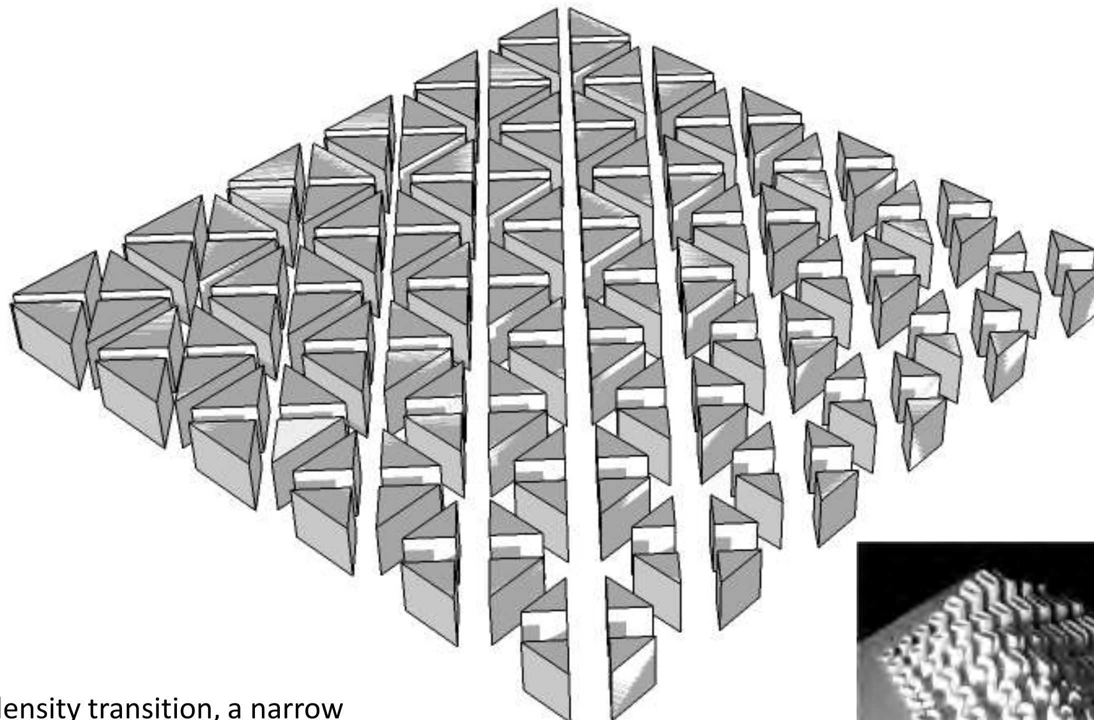


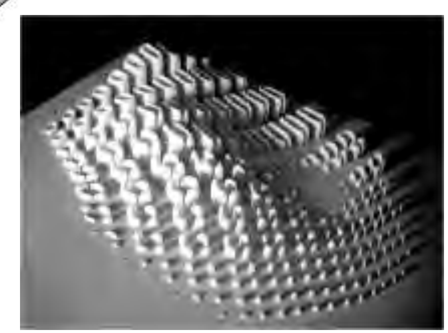
This brings a strong connectivity between the blocks, and disconnected public space.
The level difference at each block creates spaces for green terrace. Corresponding bocks opens to that spaces

City Fabric Study

Patterns (14)



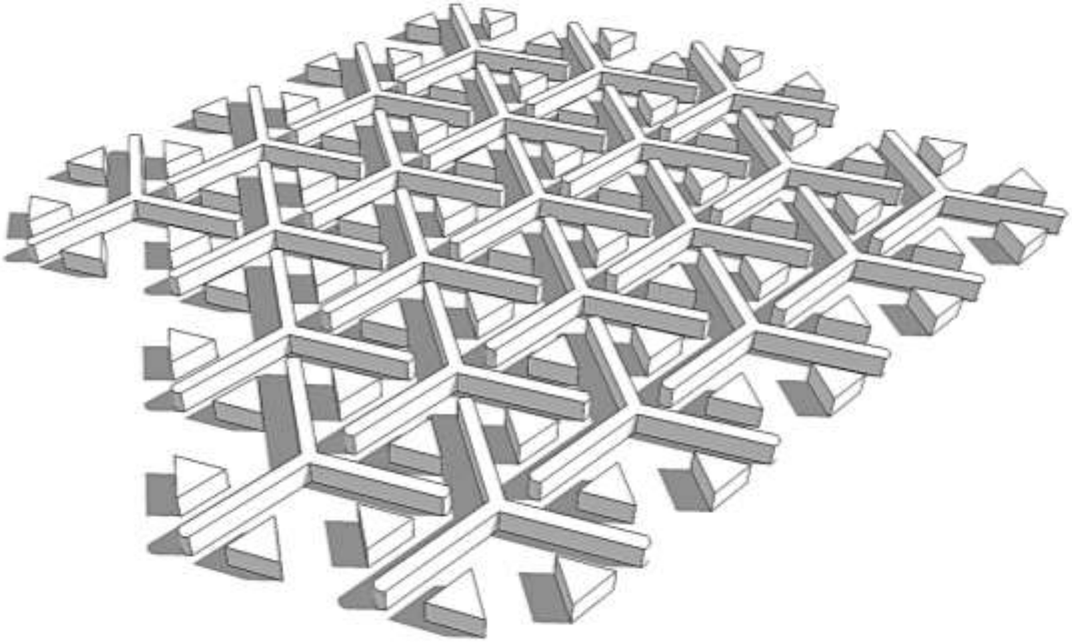




This shows high-density to low density transition, a narrow street between huge blocks and a wide street in a smaller blocks, the pattern shows a contrast in the spaces. The streets are aligned to particular axis and the intersections acts as a public space.

City Fabric Study

Patterns (15)



This has a long linear blocks with small independent blocks. This opens more public and private interactive spaces.

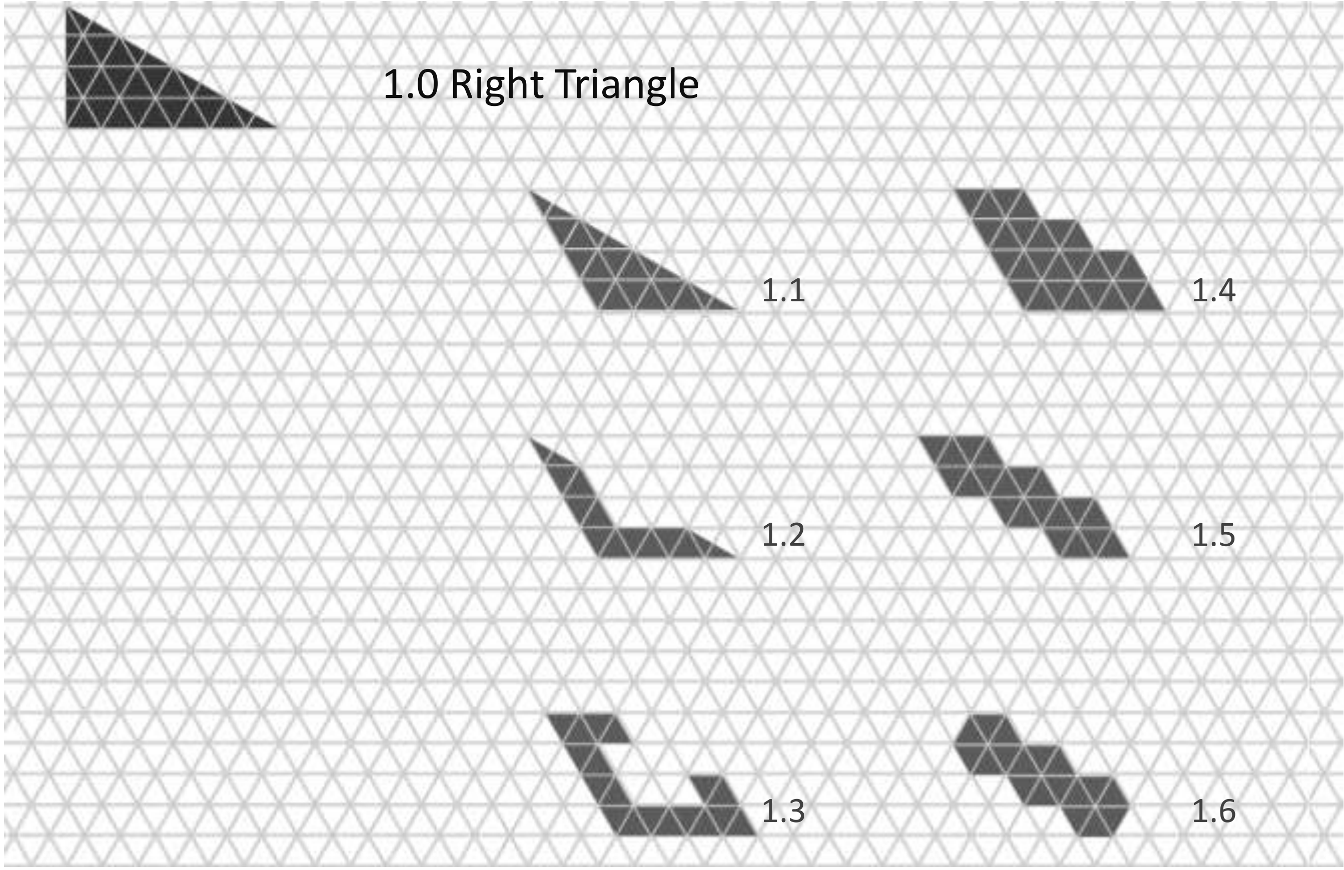
Floating Base Study

- At first, we limit the size of city to study further transformations of each shape. Considering there aren't limits to define border of cities and being surrounded by sea, we have possibilities to close or open the city shape. If the city has open shape, it creates more access points from the ocean which makes it more vulnerable to the outside. On the contrary, closed shape-city has more barrier to protect city and contains more stability to sustain on the water.

- We start from basic forms such as triangle, rectangle, hexagon, 6 point star and circle. And by subtracting and adding elements we can get diverse forms.

Floating Base Study

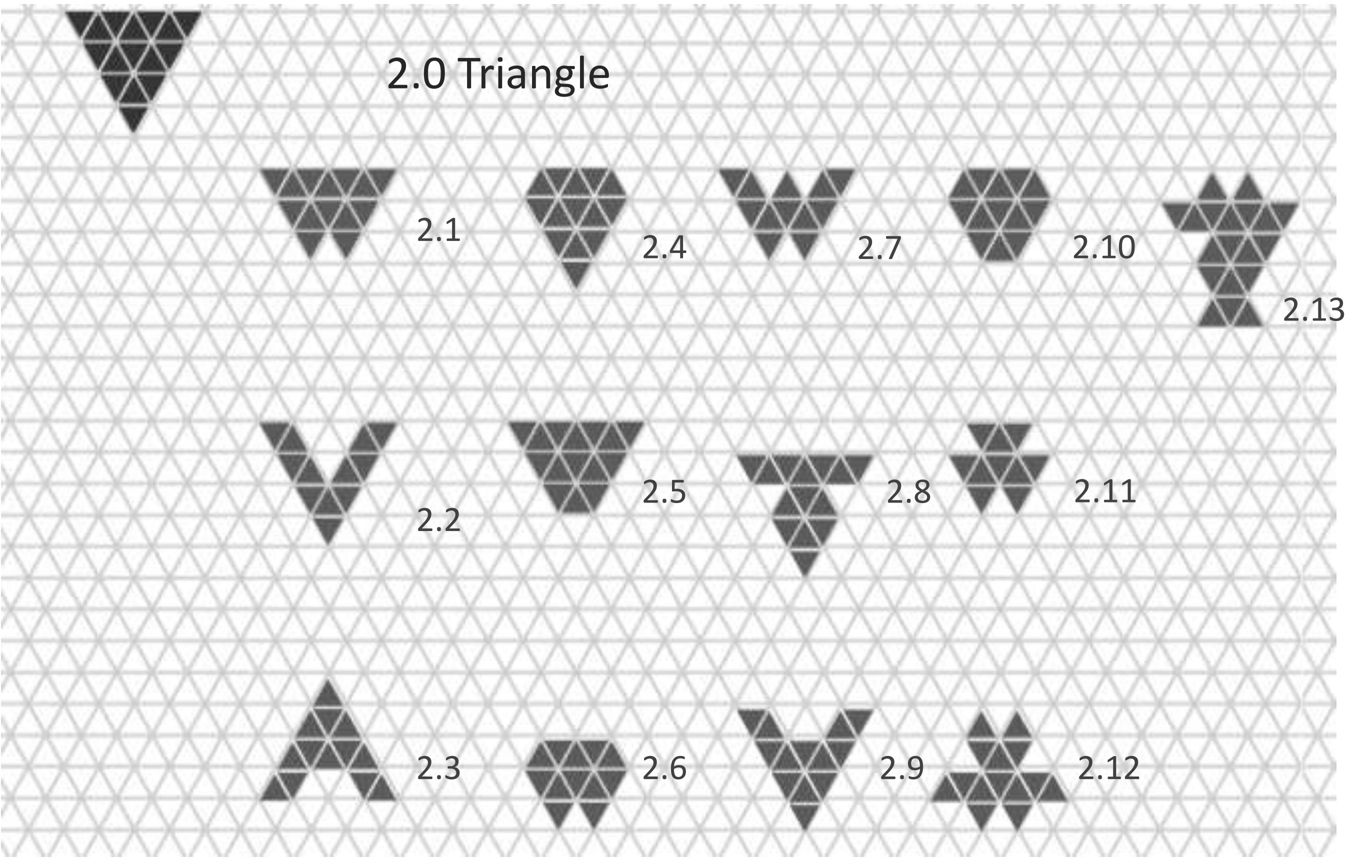
Base shapes and possibilities



All the edges are straight and these give strong axis to define city. However, it is difficult to make one platform independent from others since its shape would be cut. The shape 1.6 shows its transformation into 3 combined hexagons which provide more stability to float on the water and independency to be separated.

Floating Base Study

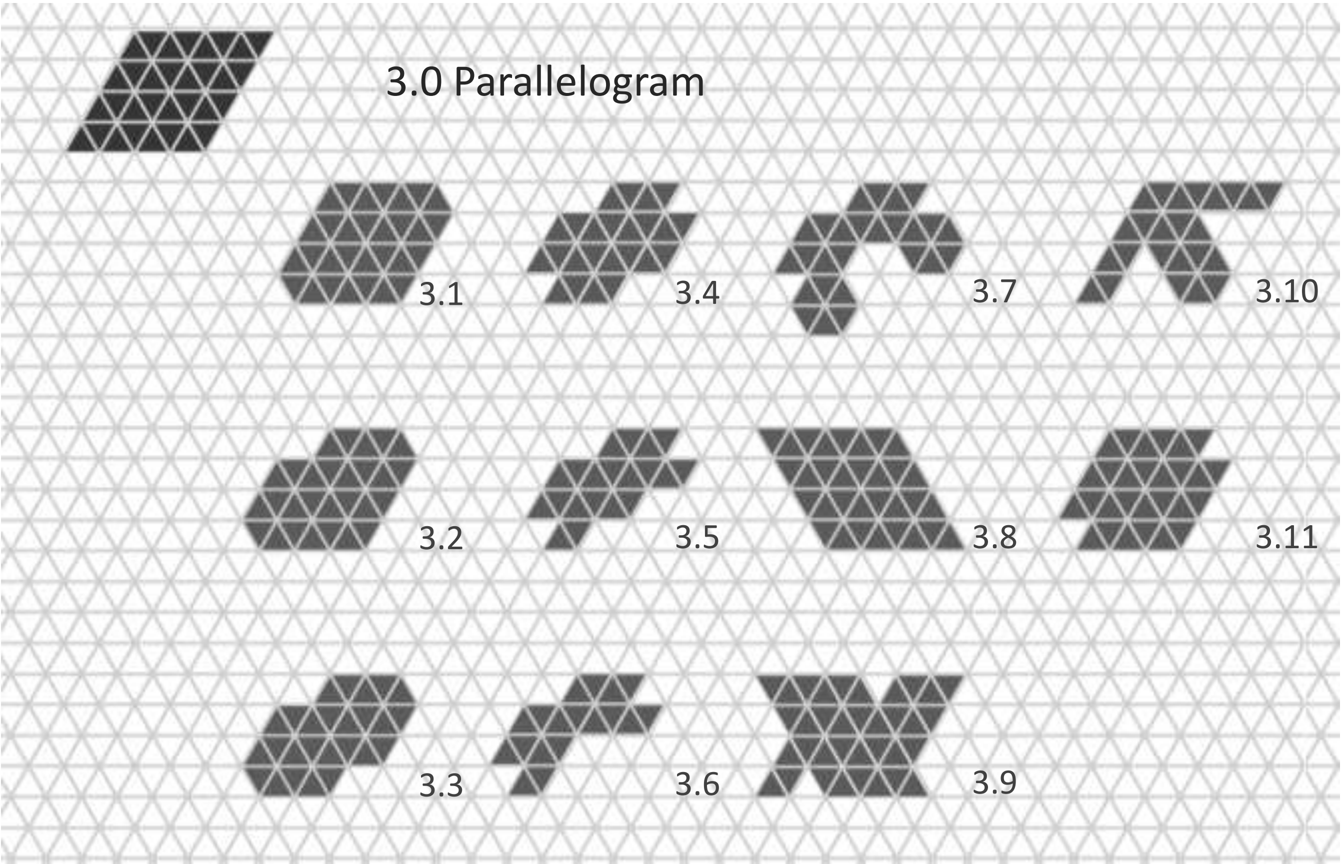
Base shapes and possibilities



It is completely symmetrical based on axis passing through its centre of gravity to 3 defining points of triangle. By these three axis, there will be several transformed shapes and ended up 2.12 completely different figure.

Floating Base Study

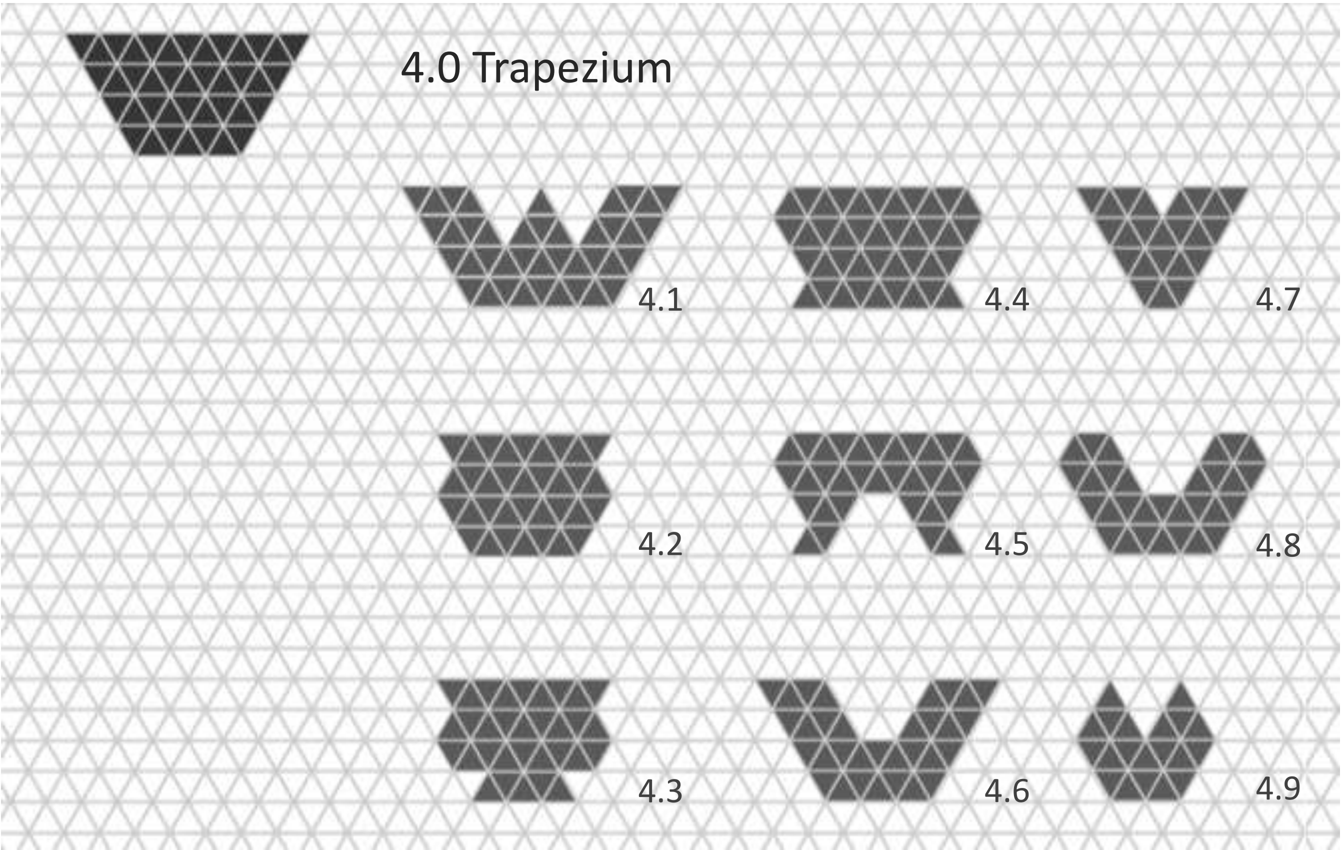
Base shapes and possibilities



It always creates parallel edges, formed with a combination of two triangles. Fig 3.9 is a attempt to create more open edge by eliminating few triangles.

Floating Base Study

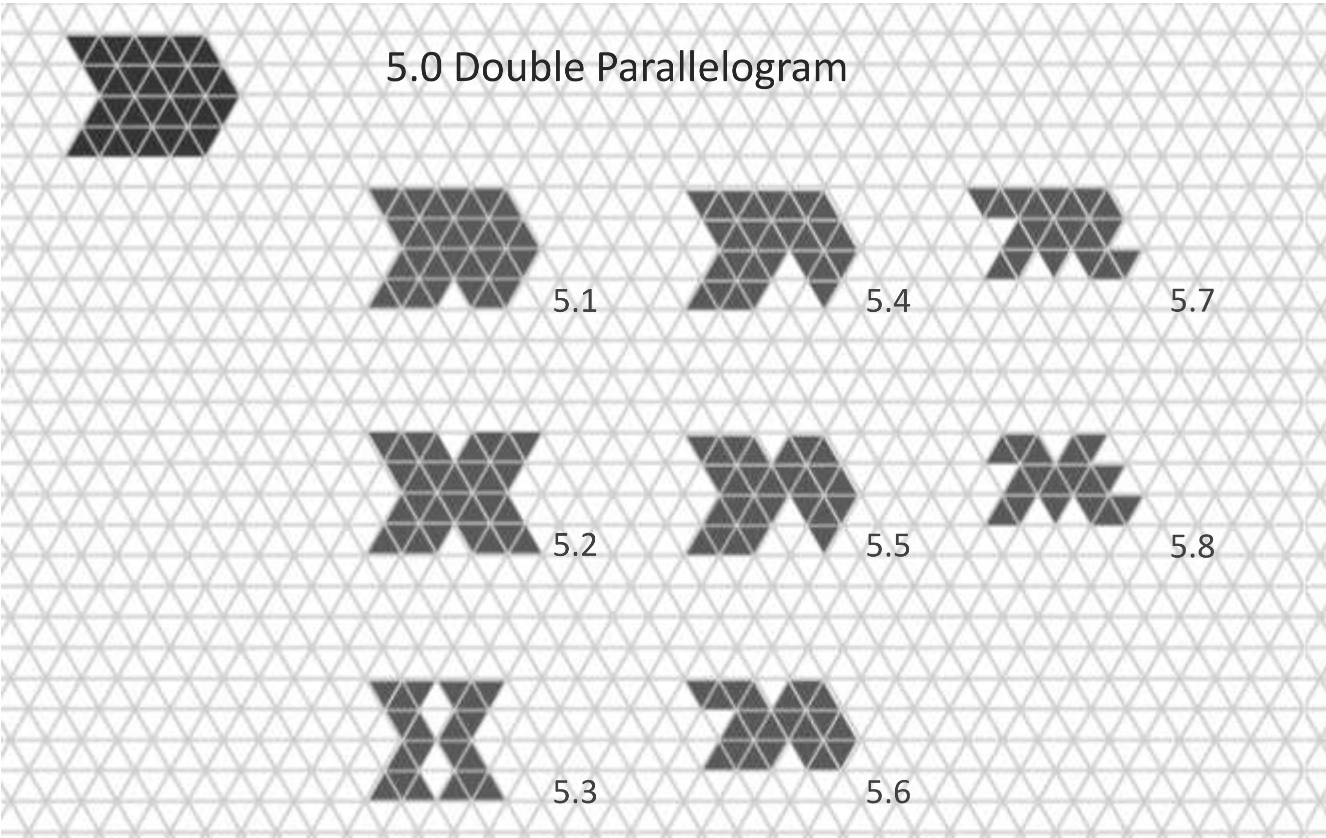
Base shapes and possibilities



The two edges always converge to a point. Transformation of this from is always related to those axis.

Floating Base Study

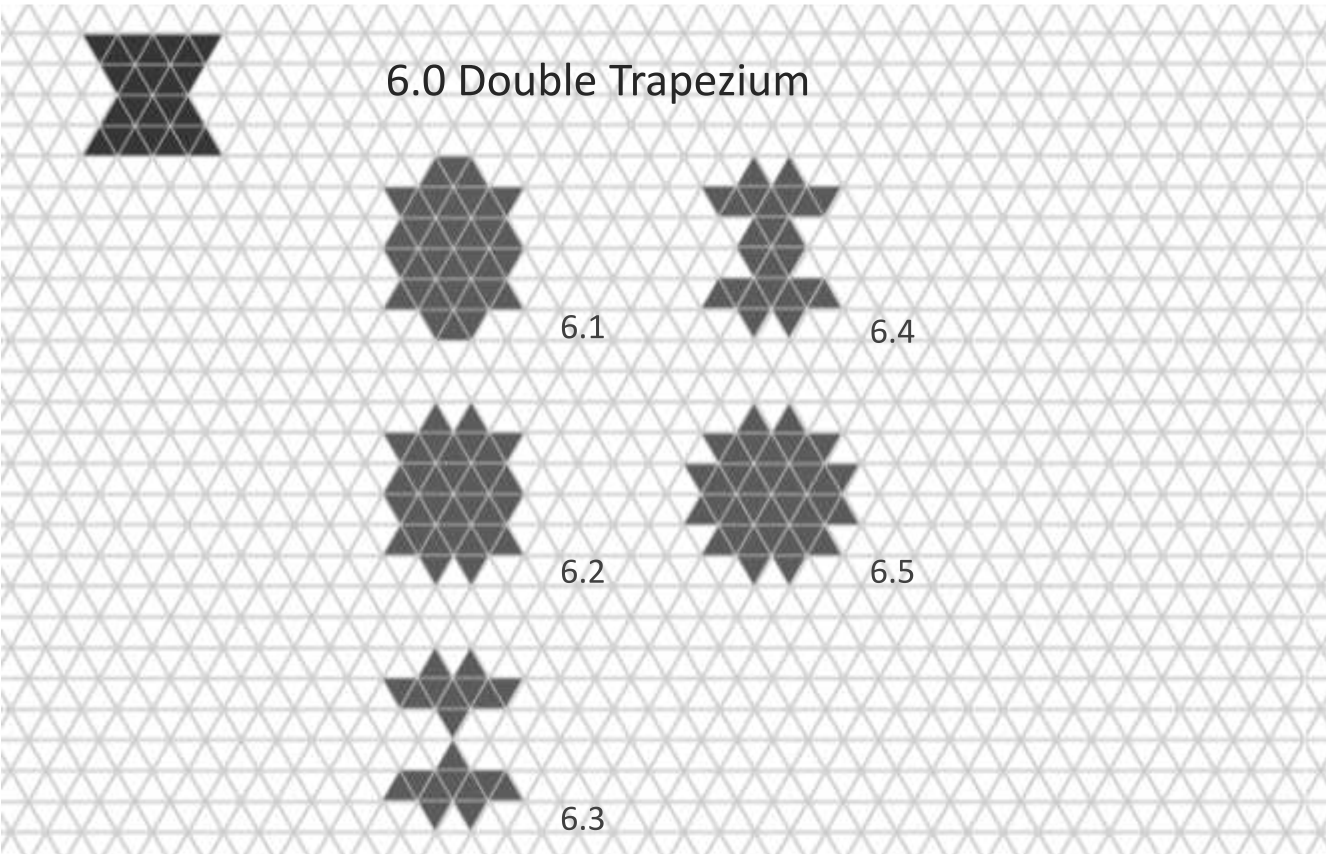
Base shapes and possibilities



This form creates two independent parallel edges converge to a point.

Floating Base Study

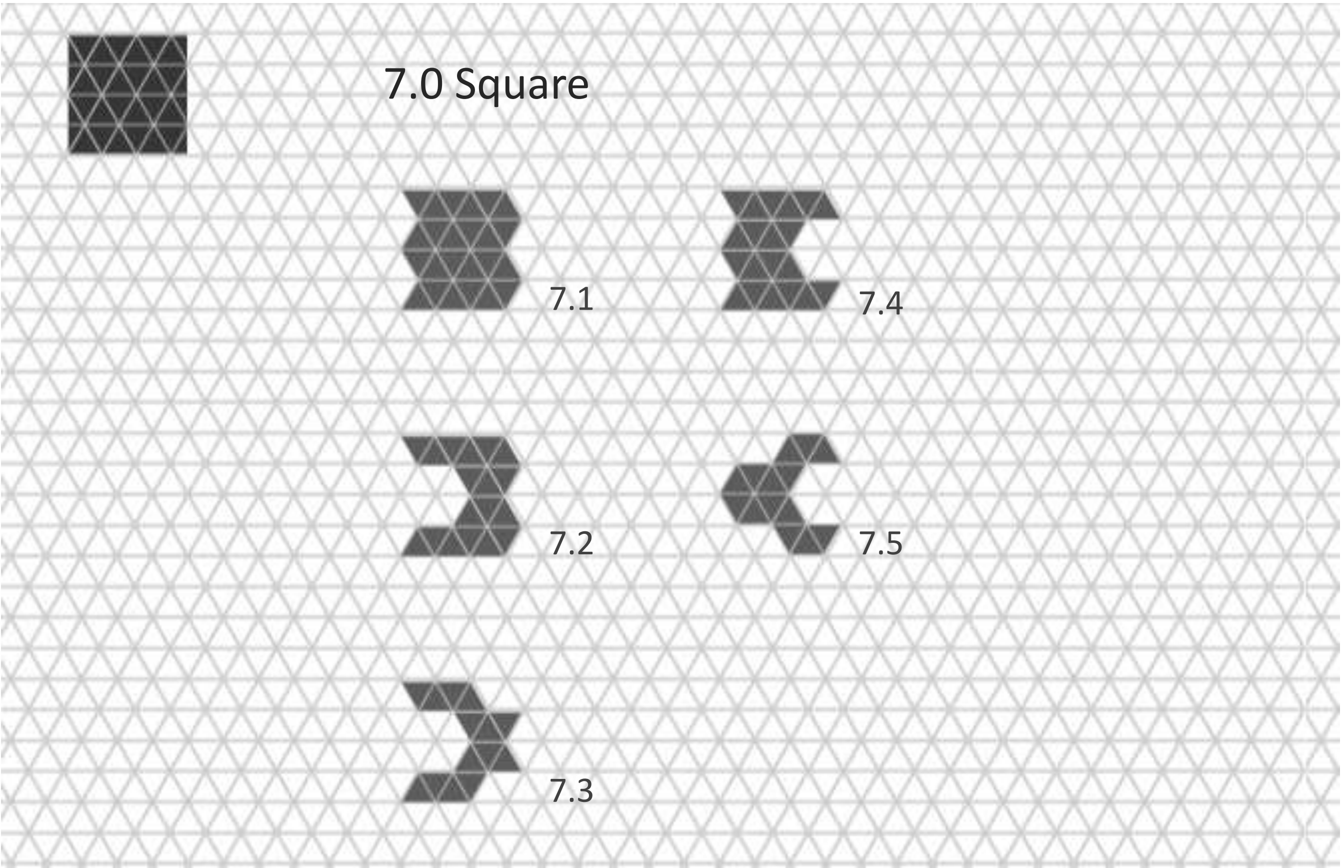
Base shapes and possibilities



In this form two alternative parallel edges are created, and converging to a point. This creating a complex outer edge throughout.

Floating Base Study

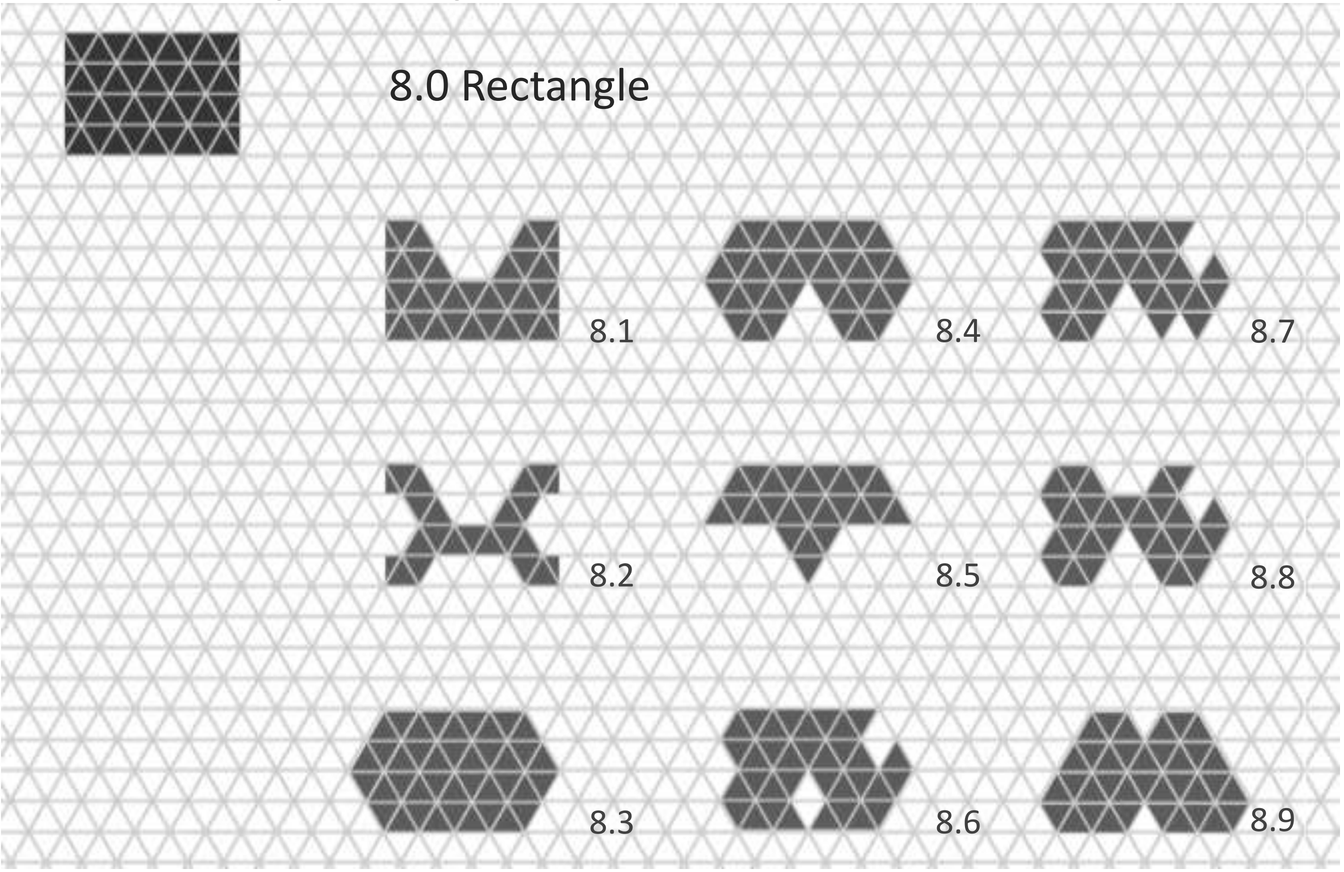
Base shapes and possibilities



Due to the equilateral triangle base, it s not possible to create a square, so all iterations start from truncated square.

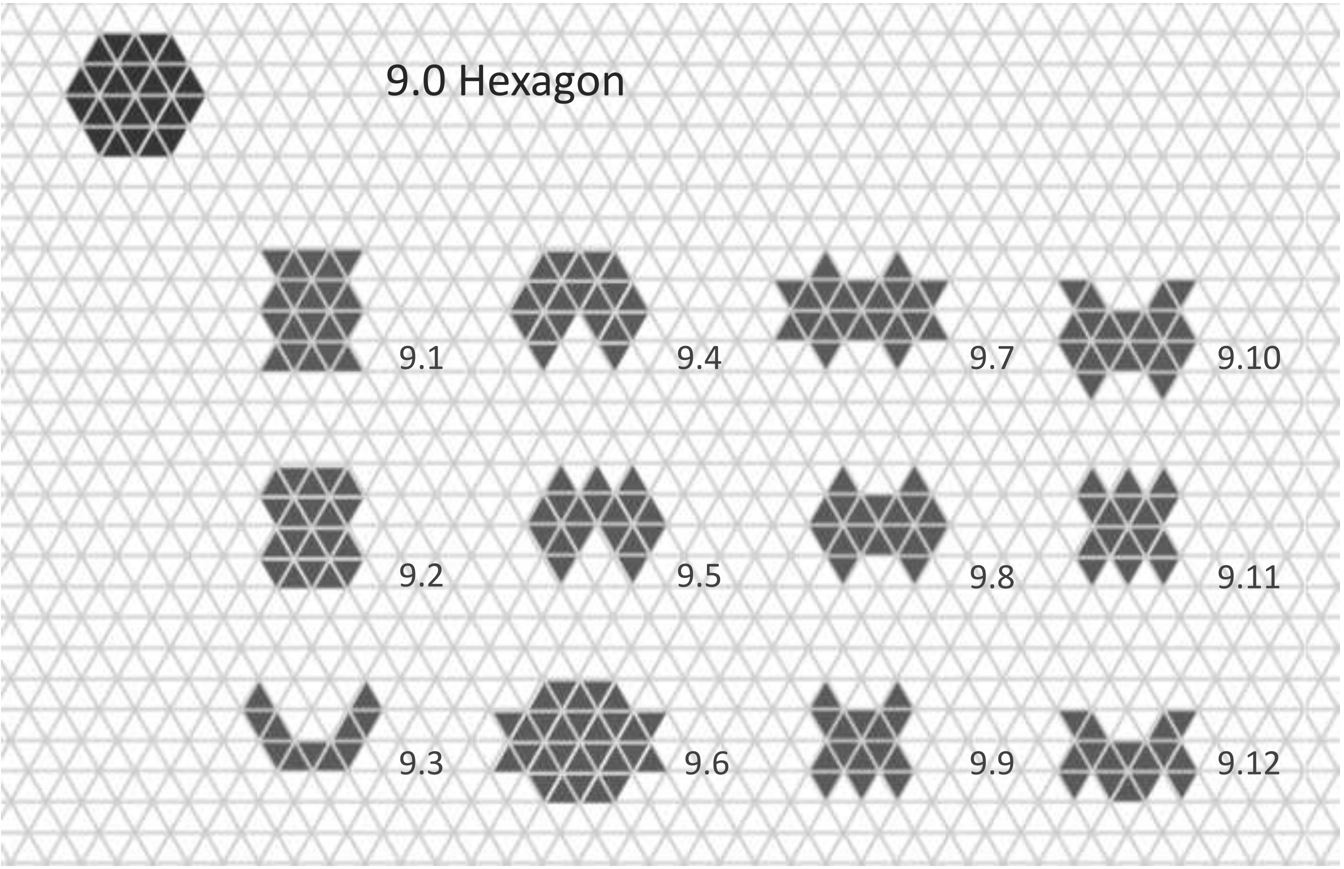
Floating Base Study

Base shapes and possibilities



Floating Base Study

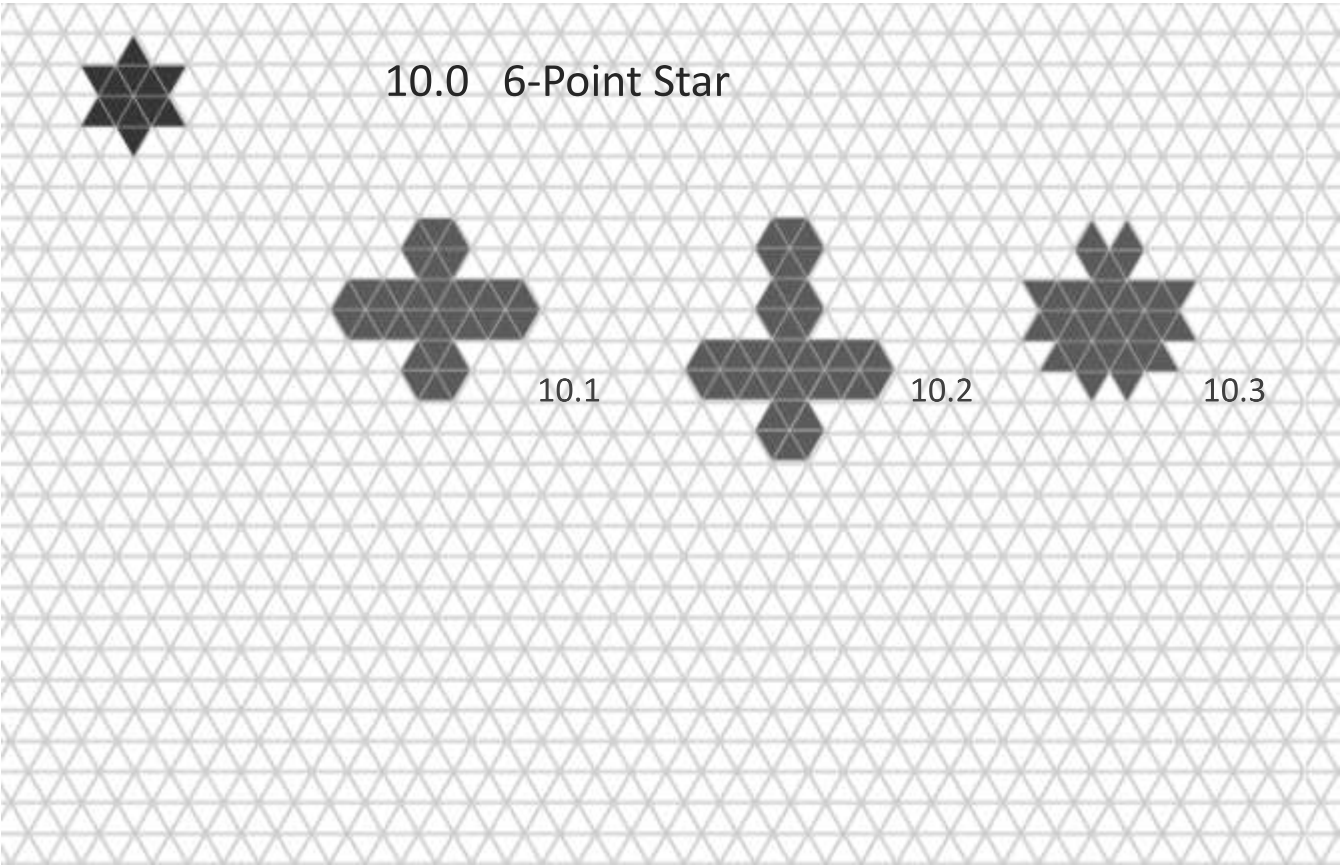
Base shapes and possibilities



This figure is completely symmetrical with 6 same edges. By adding or subtracting elements it is possible to create various shapes. It can be more open or more closed to the ocean.

Floating Base Study

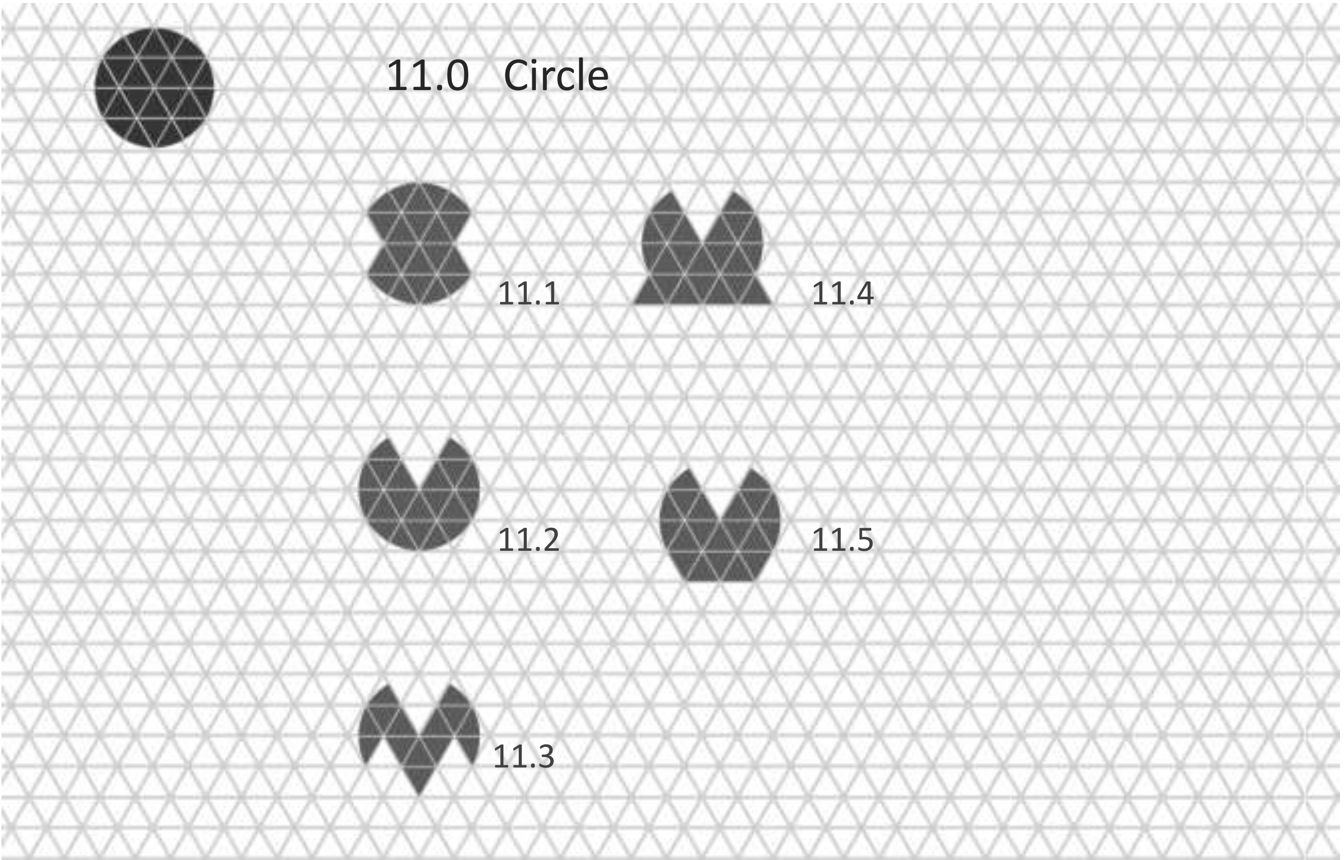
Base shapes and possibilities



It is completely symmetrical with the possibilities to be separated in 6 same figures. Its transformation leads to completely different shape from each other and has symbolic meaning.

Floating Base Study

Base shapes and possibilities



It is completely symmetrical in all angles and its centre of gravity matches with the centre of the city. For its geometrical feature, it is difficult to combine between circles. There comes possibilities to be connected with others giving edges by cutting along with the triangle grid.

New City Fabric Creation

Based on the studies, the standardized multi-use floating platforms are 50m equilateral triangle. Further continuing to create different combination of elements developed from the basic shape, we study the multiple relationship with public and private spaces, green and blue area, the circulation and the shadow factors. Its an insight on the volumetric study based on the programs. These modular combinations give n- number of ideations , catering to the program needs.

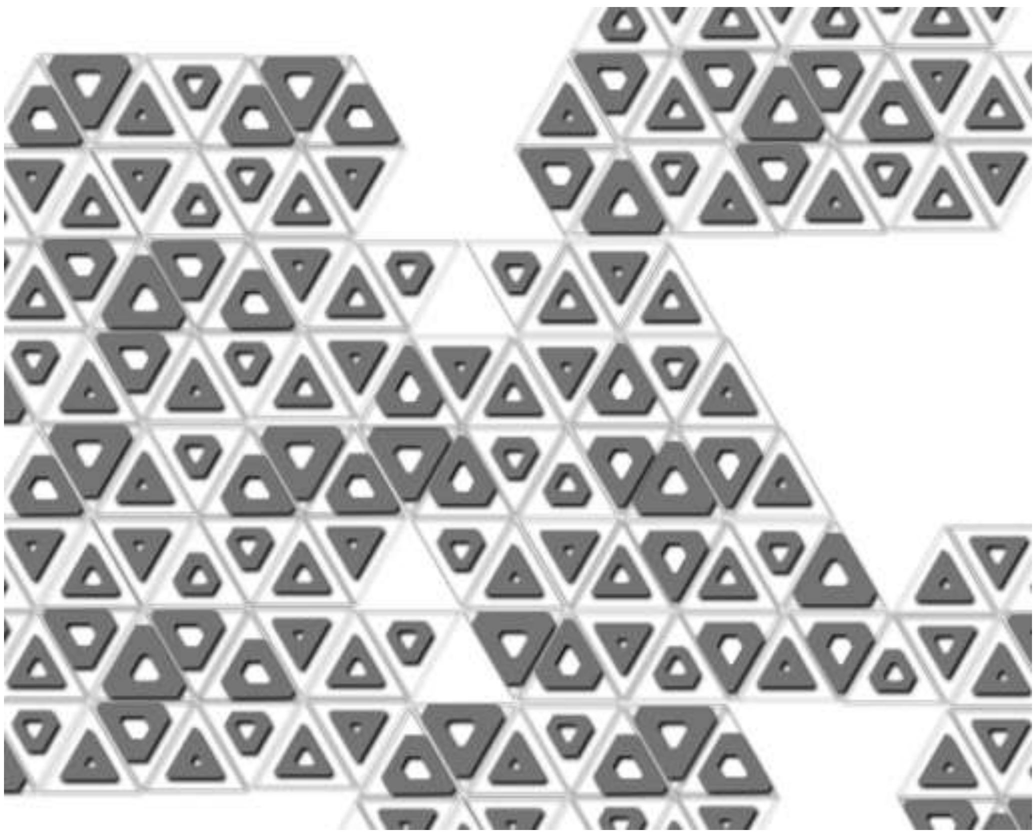
Given that the geometry of platform is an equilateral triangle, we situate the building block in the gravitational centre of triangle. This strategy is taken to gain more extensive public space besides the building and more stability on the water. We study the relational ratio between public and private spaces taking the 3 parallel axis to 3 edges. Connecting 3 points of triangle with its centre of gravity, we have 3 imaginary axis. With these axes, diverse cases of floating islands can be created. We decide to limit 3-5 examples and combine them randomly to see general functioning of city fabrics.

When it comes to public spaces, we classify them into 3 categories: circulation, green space and blue space. The circulation is mainly considered for access path from ocean to city. Green & Blue spaces are principal source of food & energy supply. We simplify the smallest number of parameters for the further study into details.

Various ideations on the foot prints of urban blocks and the connectivity is studied in the following chapter. Plug in and out depending on the requirement of the program is also experimented.

New City Fabric

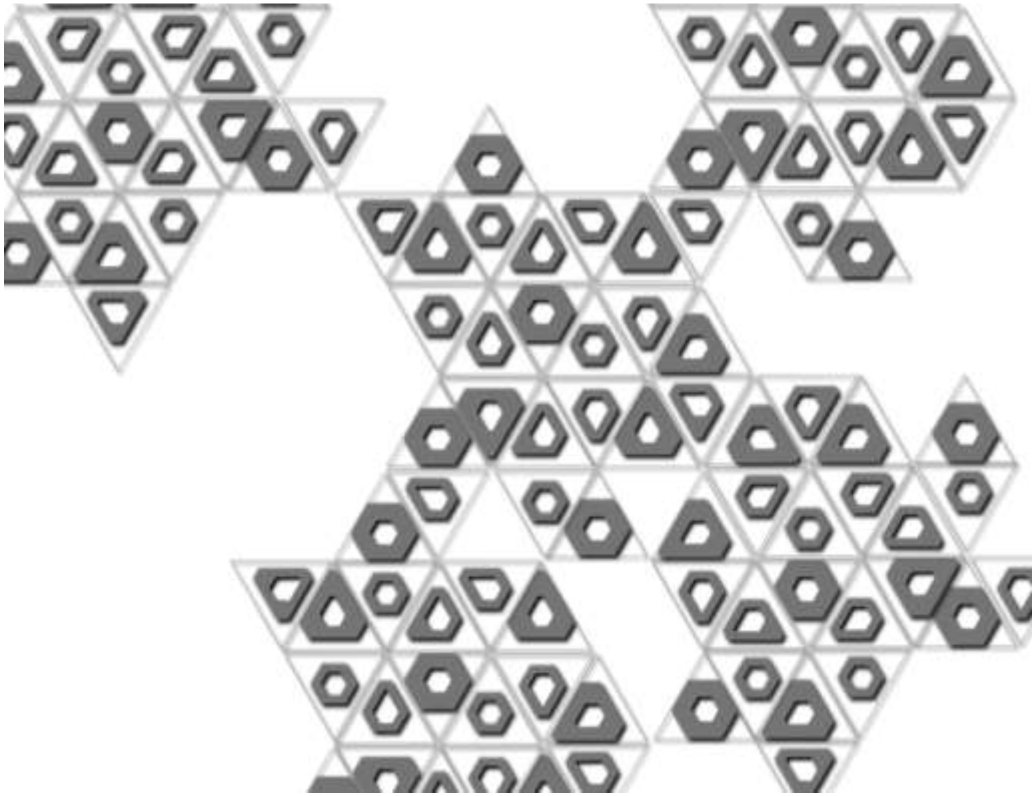
Concept 1



The gradually proportional relationship between private and public spaces creates 4 different elements. Building's form resembles the shape of platform leaving triangle green space in 3 points. The surface of blue space is proportional to the private area.

New City Fabric

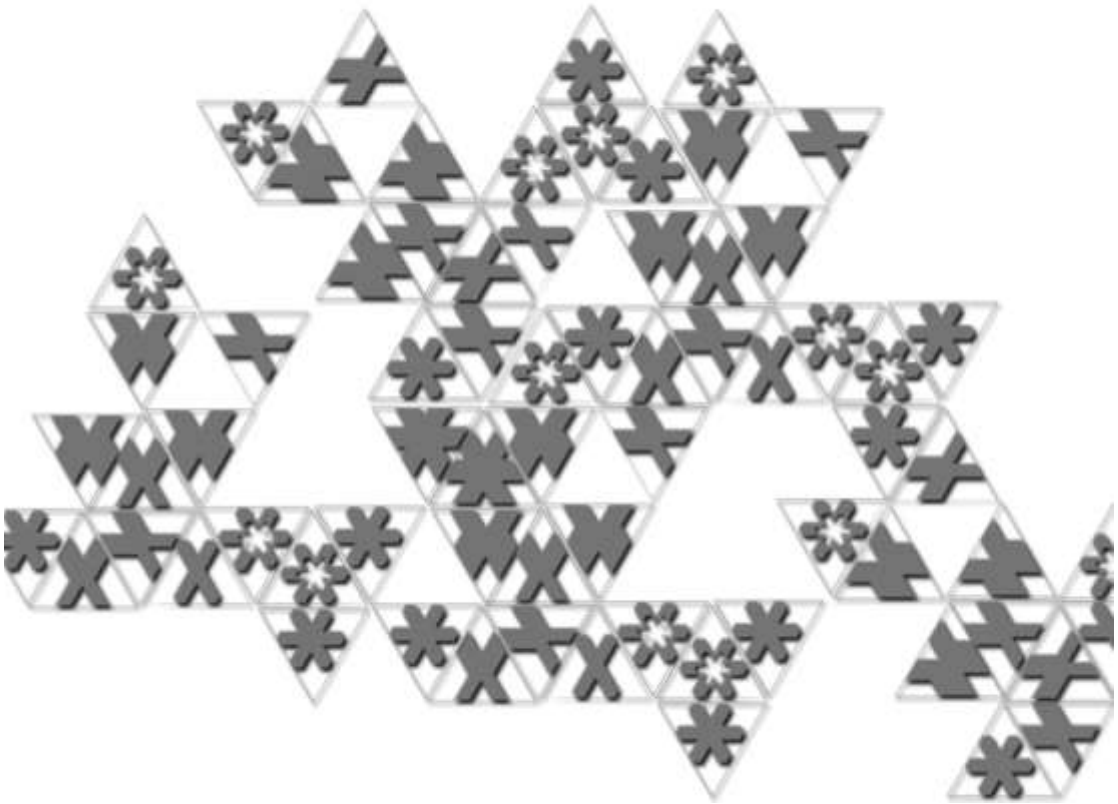
Concept 2



Building shape remains hexagonal which creates more standard-rooms in each floor. In relation to it, blue space also takes hexagonal form along with the building's inner façades. In the second case, the building takes up the whole triangle leaving 3 triangle green spaces. As building footprint shrinks, the surface of green spaces increases.

New City Fabric

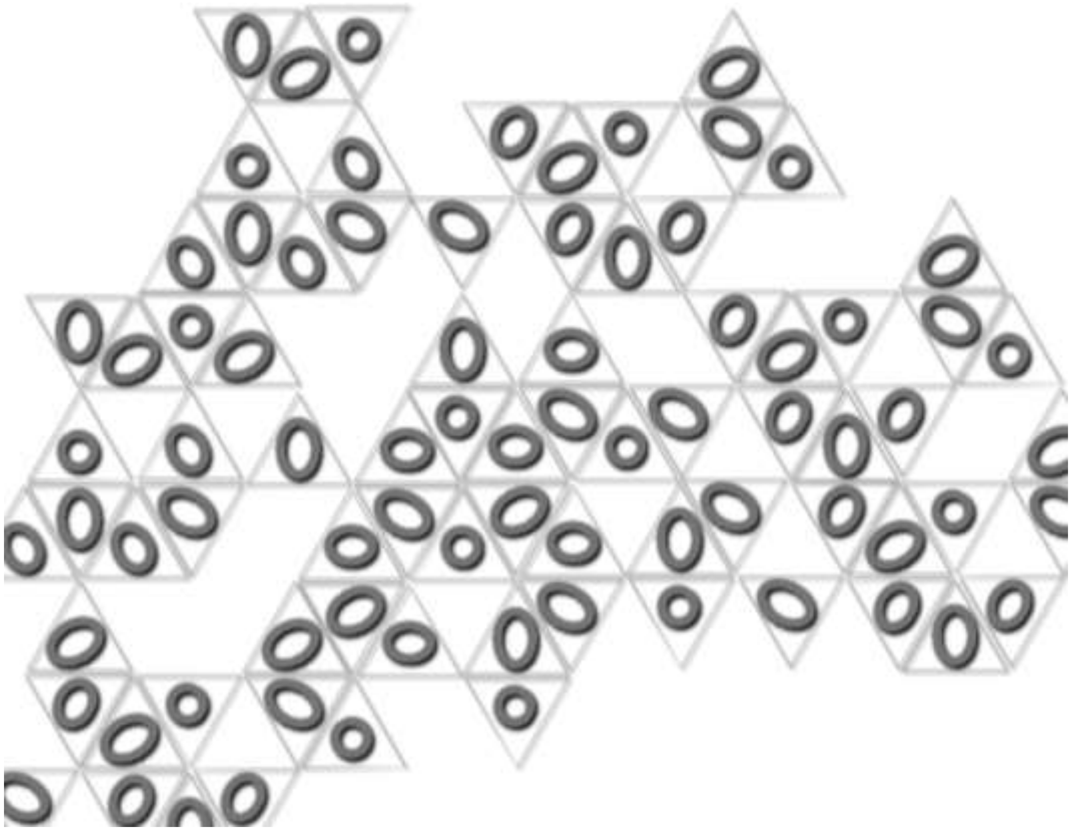
Concept 3



Building blocks intersect themselves and create communal space between them. As creating more intersection between them, the shape become more complex. It leads to multiple facets in the building's façades and less connectivity between public spaces.

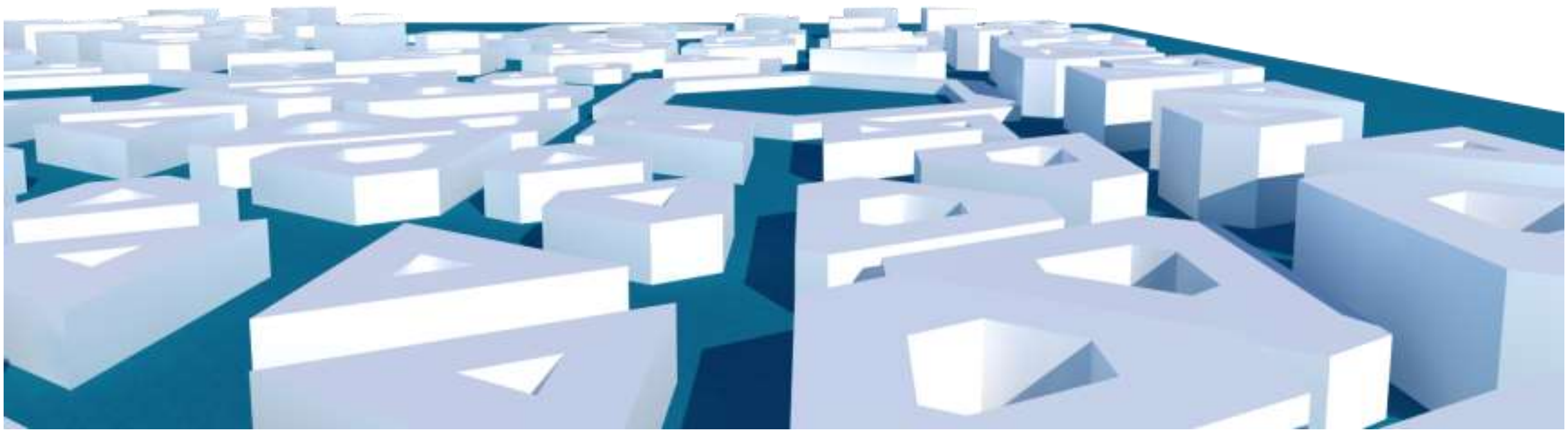
New City Fabric

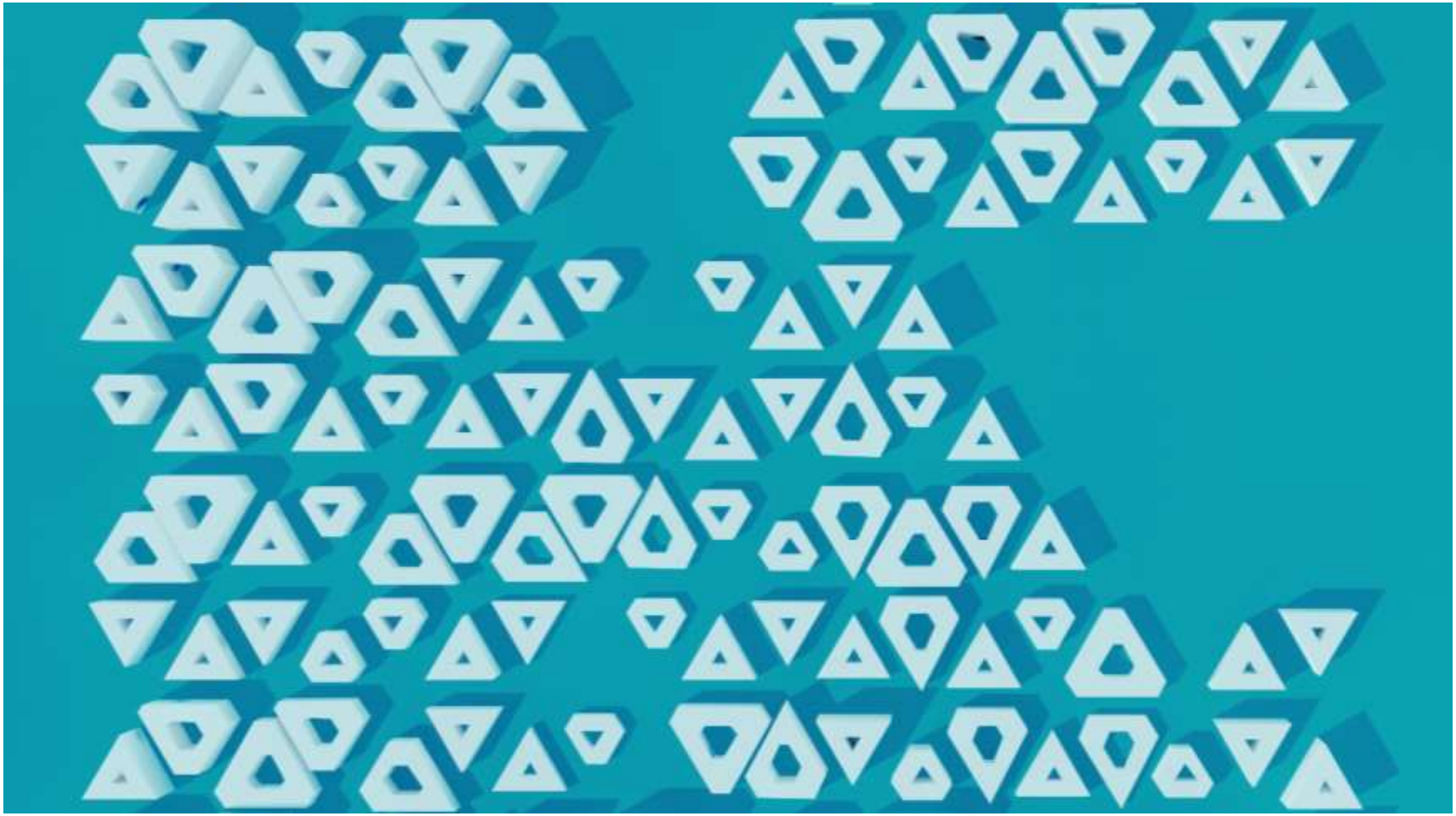
Concept 4

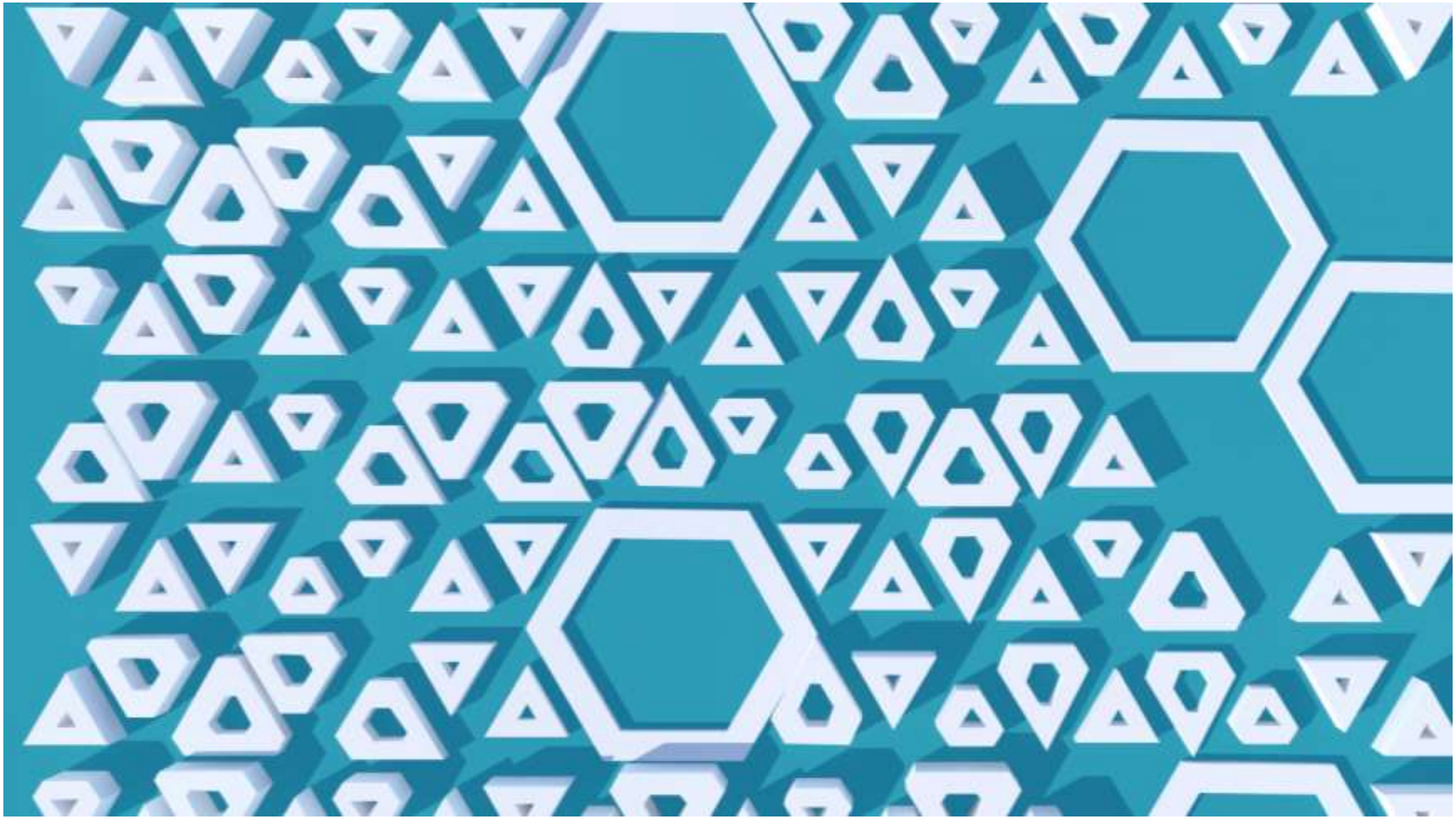


Circular form of building leaves no directional path to the entrance. The circle can be stretched or shrink leaving open green space in its surrounding. The blue space has oval or circle shape leading to embracing space without edge.

Shadow study on one such ideal urban footprint. The relation between the public squares and building blocks.







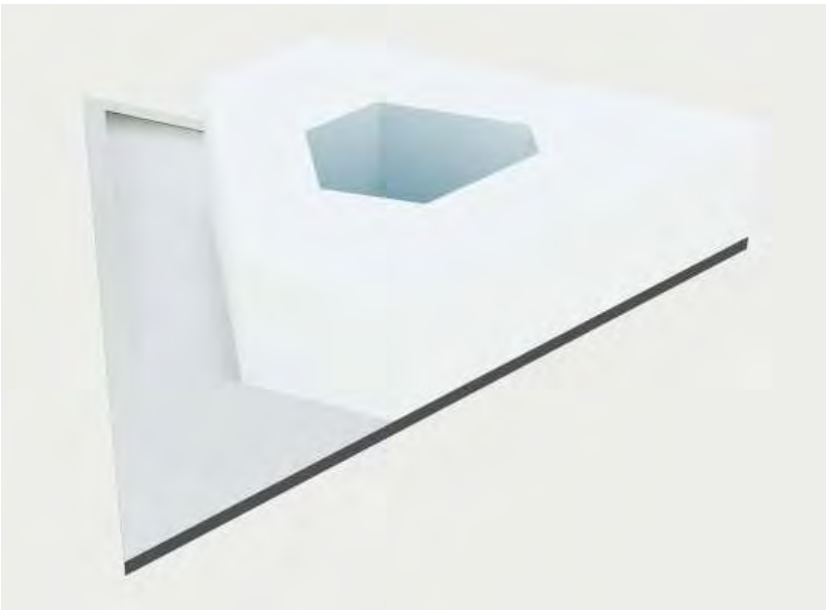
HOW – New City Fabric Concept -1

Criteria

- Based on the city fabric created in concept 1, we build tridimensional model and calculate the possible surfaces and volumes that can be created. We set up its building height as 3 floors primarily considering that floating city's density should be low.

- Transformations in building shape show its advantages and disadvantages.

New City Fabric C1- Type 1.1



- Rigid form from the offsets of the platform, creating a linera green space.
- It is only possible to access to the blue area through the building

Platform surface total 1082.53 m2

Public space 613.04 m2

Private space 469.49 m2

Volume in total

469.49 x 3m(height) x 3(floors) = 4225.41 m3

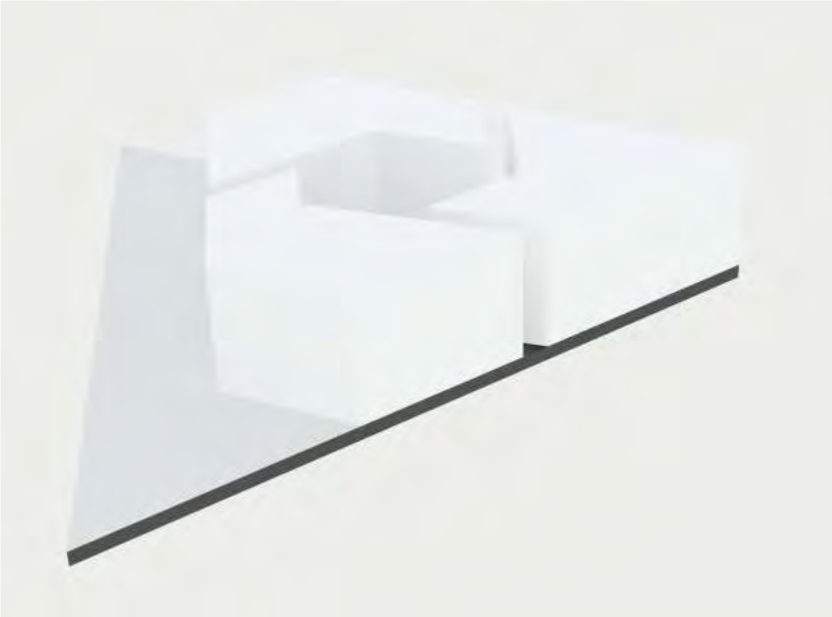
Green space 350.41 m2

Blue space 136.73 m2

Circulation 125.91 m2

Access 5 + 2 + 2 = 9m perimeters (3 sides)

New City Fabric C1- Type 1.2



- Radialing access, creating more visually connecting to the outer space.

Platform surface total — 1082.53 m2

Public space — 646.85 m2

Private space — 435.68 m2

Volume in total

435.68 x 3m(height) x 3(floors) = 3921.12 m3

Green space — 384.22 m2

Blue space — 136.73 m2

Circulation — 125.91 m2

Access — 5 + 2 + 2 = 9m perimeters (3 sides)

New City Fabric C1- Type 1.3

- Creating voids opens out to the public space and green space, the threshold between the private and public is less.
- Increases sunlight to inner façades of the building

Platform surface total 1082.53 m2

Public space 671.09 m2

Private space 411.45 m2

Volume in total

411.45 x 3m(height) x 3(floors) = 3703.05 m3

Green space 408.45 m2

Blue space 136.73 m2

Circulation 125.91 m2

Access 5 + 2 + 2 = 9m perimeters (3 sides)

New City Fabric C1- Type 1.4

- Building is seperated in 2parts.
- It is possible to give different functions in each building

Platform surface total 1082.53 m2

Public space 729.13 m2

Private space 353.41 m2

Volume in total

353.41 x 3m(height) x 3(floors) = 3180.69 m3

Green space 466.49 m2

Blue space 136.73 m2

Circulation 125.91 m2

Access 5 + 2 + 2 = 9m perimeters (3 sides)

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New City Fabric C1- Type 1 - Variations

Increase access to the bulding : Organised circulation
Roof shape varies – create less shadow
Different sensation

Roof shape varies – create less shadow
Possible to use the roof as an open public space
Better permission of sun light.

New City Fabric C1- Type 2.1

- More solid and higher foot print, accomodating more volume for different program.
- Closed basic shape of building surrounded by minimal green area
- More protection from wind and better exploitation of land

Platform surface total 1082.53 m2

Public space 460.38 m2

Private space 622.15 m2

Volume in total

353.41 x 3m(height) x 3(floors) = 5599.35 m3

Green space 94.65 m2

Blue space 152.42 m2

Circulation 213.31 m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

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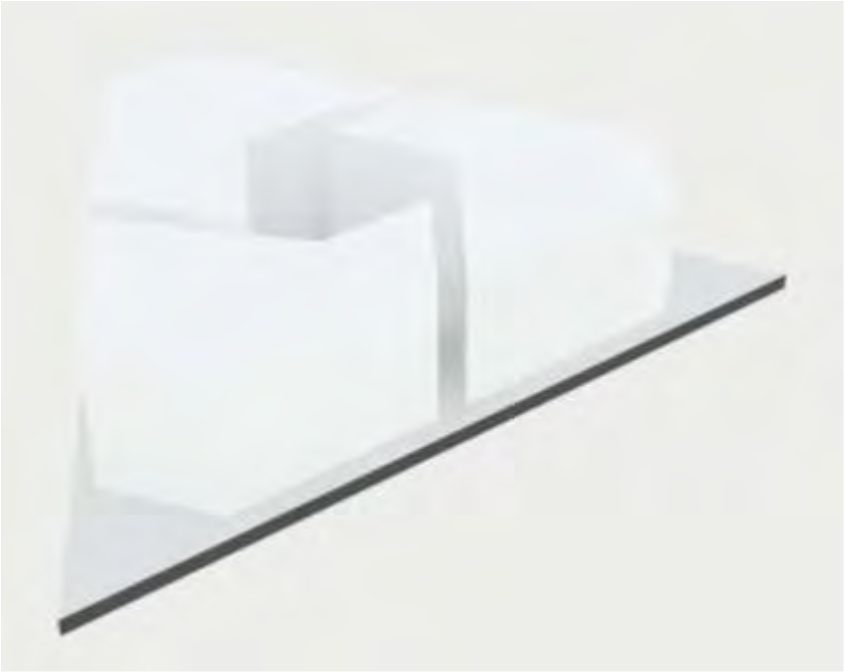
New City Fabric C1- Type 2.2



- Partially opened the public area
- Direct conection to the blue area from circulation path

Platform surface total 1082.53 m2

Public space 646.85 m2

Private space 577.34 m2

Volume in total

577.34x 3m(height) x 3(floors) = 5196.06m3

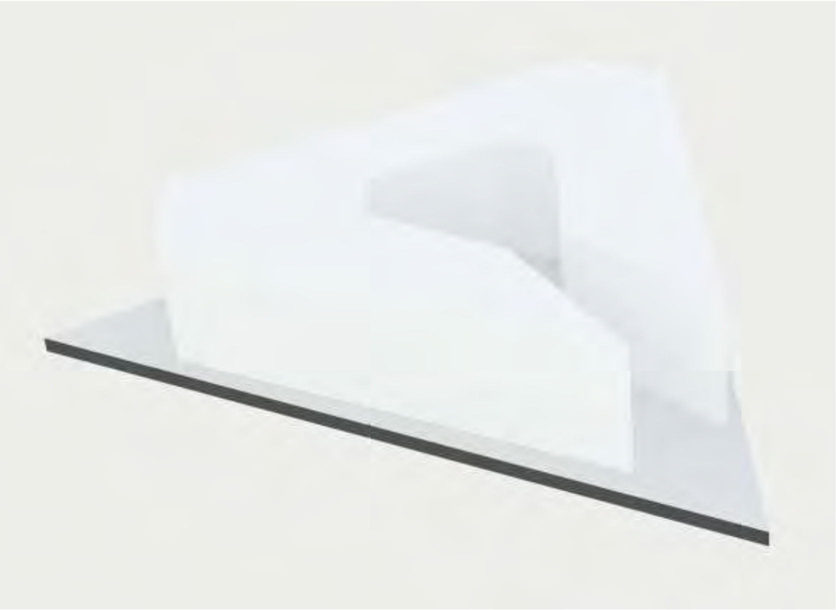
Green space 103.78 m2

Blue space 152.42 m2

Circulation 213.31 m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C1- Type 2.3



- Gives orientation to the main entrance of building

Platform surface total 1082.53 m2

Public space 503.97 m2

Private space 545.23 m2

Volume in total

545.23x 3m(height) x 3(floors) = 4907.07 m3

Green space 110.32 m2

Blue space 152.42 m2

Circulation 213.31 m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C1- Type 2.4

- Creates three seperate buildings

Platform surface total
1082.53 m2

Public space
591.15 m2

Private space
491.38 m2

Volume in total
491.38x 3m(height) x 3(floors) = 4422.42 m3

Green space
225.42 m2

Blue space
152.42 m2

Circulation
213.31 m2

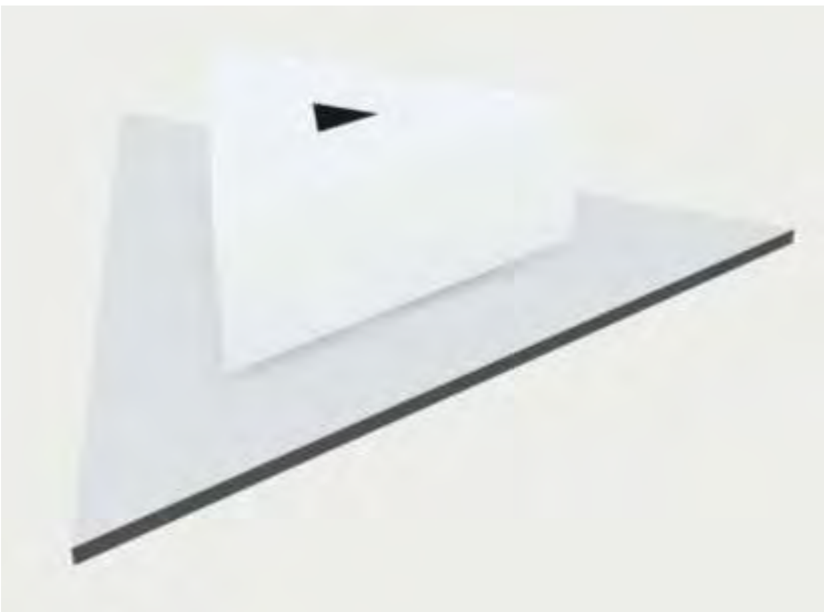
Access
50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C1- Type 2 - Variations

- Differentiation of communication box
- Less visual barrier
- Faciliate visual orientation

- Roof shape varies – more open space
- Less visual barrier

New City Fabric C1- Type 3.1



- Lesser footprint and a compact block.
- Maximum surface of public space

Platform surface total
1082.53 m2

Public space
666.83 m2

Private space
415.70 m2

Volume in total
415.70 x 3m(height) x 3(floors) =3741.30 m3

Green space
425.81 m2

Blue space
27.71 m2

Circulation
213.31 m2

Access
50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C1- Type 3.2

- Open path from green area to blue area

Platform surface total

1082.53 m2

Public space

703.60 m2

Private space

385.76 m2

Volume in total

385.76x 3m(height) x 3(floors) = 3471.84 m3

Green space

589.72m2

Blue space

27.71 m2

Circulation

213.31 m2

Access

50 + 50 + 50 = 150m perimeters (3 sides)

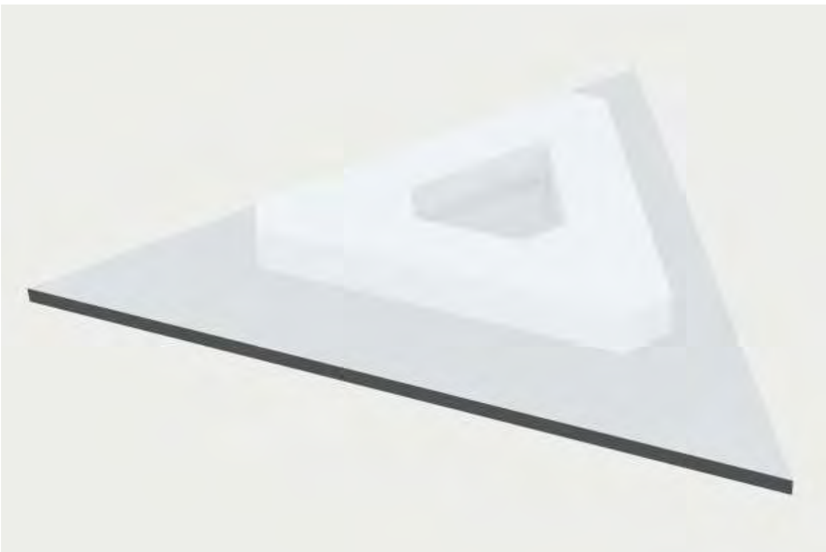
New City Fabric C1- Type 3 - Variations

- Visual cogeherence
- More open and pedestrian space

- Roof inclination moves rain drops into the center

HOW – New City Fabric Concept -2

New City Fabric C2- Type 1.1



Platform surface total 1082.53 m2

Public space 735.11 m2

Private space 347.42 m2

Volume in total

347.42 x 3m(height) x 1(floor)= 1042.26 m3

Green space 438.57 m2

Blue space 83.22 m2

Circulation 213.30 m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

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New City Fabric C2- Type 1.2

Platform surface total 1082.53 m2

Public space 763.89 m2

Private space 318.64 m2

Volume in total

318.64 x 3m(height) x 1(floor)= 955.92 m3

Green space 488.93 m2

Blue space 61.66 m2

Circulation 213.30 m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C2- Type 1.3

Platform surface total 1082.53 m2

Public space 769.75 m2

Private space 312.78 m2

Volume in total

312.78 x 3m(height) x 1(floor)= 938.34 m3

Green space 500.23 m2

Blue space 83.22 m2

Circulation 213.30 m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C2- Type 1.4

Platform surface total 1082.53 m2

Public space 761.70 m2

Private space 320.83 m2

Volume in total

320.83 x 3m(height) x 1(floor)= 962.49 m3

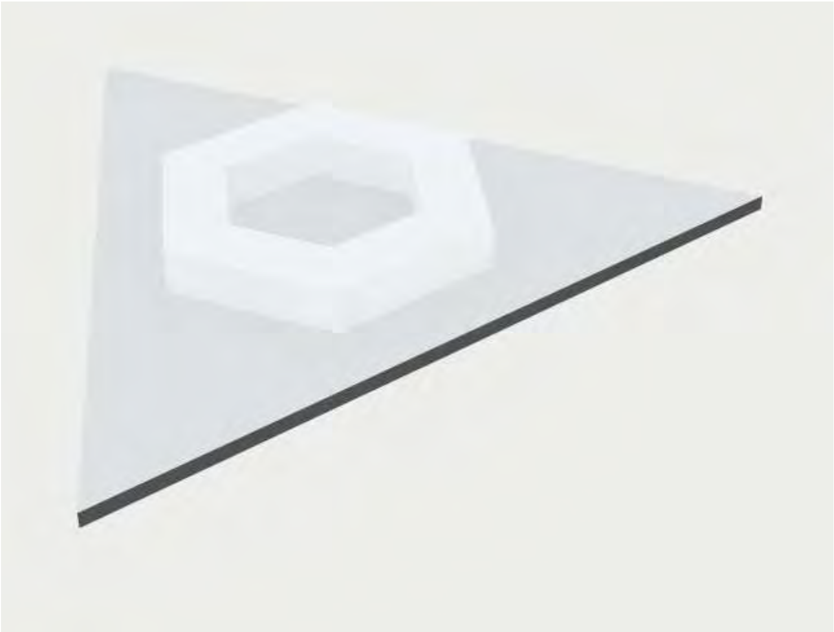
Green space 465.18 m2

Blue space 83.22 m2

Circulation 213.30m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C2- Type 2.1



Platform surface total 1082.53 m2

Public space 862.67 m2

Private space 219.86m2

Volume in total

219.86x 3 m (height) x 1 (floor)= 659.58 m3

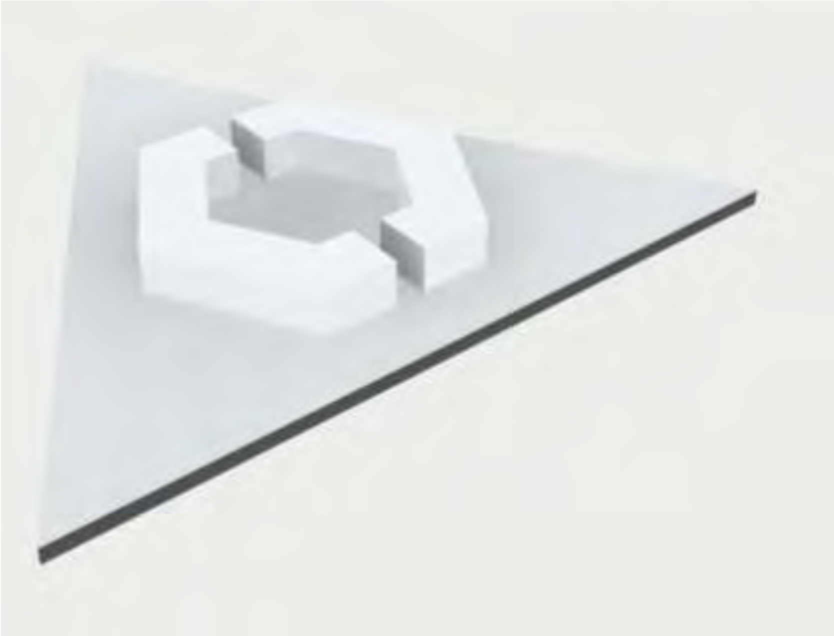
Green space 527.38 m2

Blue space 121.96 m2

Circulation 213.30 m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C2- Type 2.2



Platform surface total

1082.53 m2

Public space

878.67 m2

Private space

203.86 m2

Volume in total

203.86 x 3 m (height) x 1 (floor)= 659.58 m3

Green space

543.41 m2

Blue space

121.96 m2

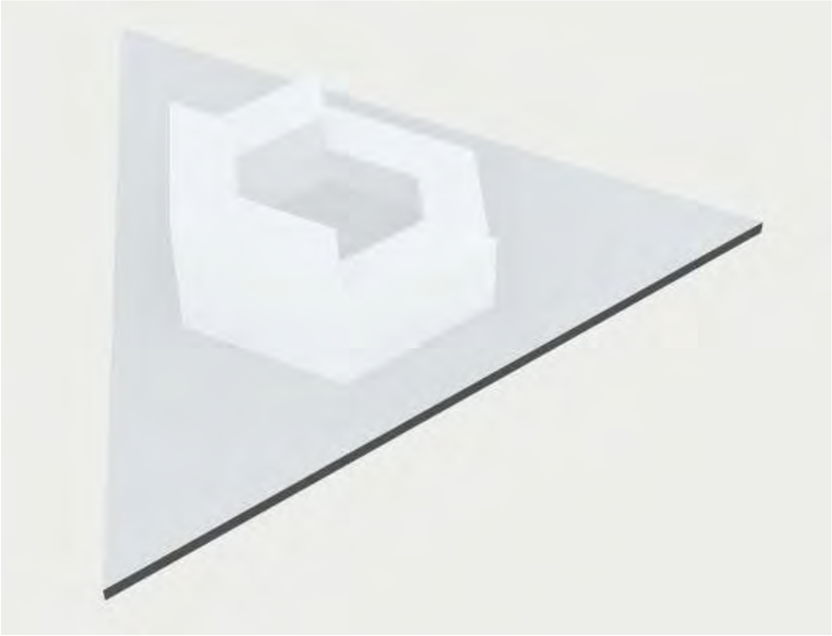
Circulation

213.30 m2

Access

50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C2- Type 2.3



Platform surface total

1082.53 m2

Public space

862.67 m2

Private space

219.86m2

Volume in total

219.86 + 146.57 + 73.28 x 3m (height) = 1319.13 m3

Green space

527.38 m2

Blue space

121.96 m2

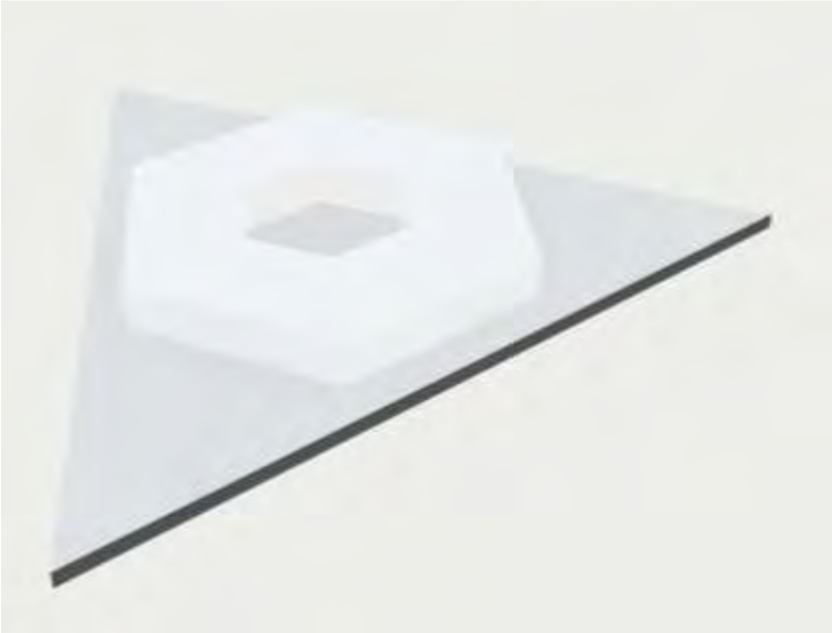
Circulation

213.30 m2

Access

50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C2- Type 3.1



Platform surface total 1082.53 m2

Public space 673.52 m2

Private space 409.01 m2

Volume in total

409.01 x 3m(height) x 1(floor)= 1227.03 m3

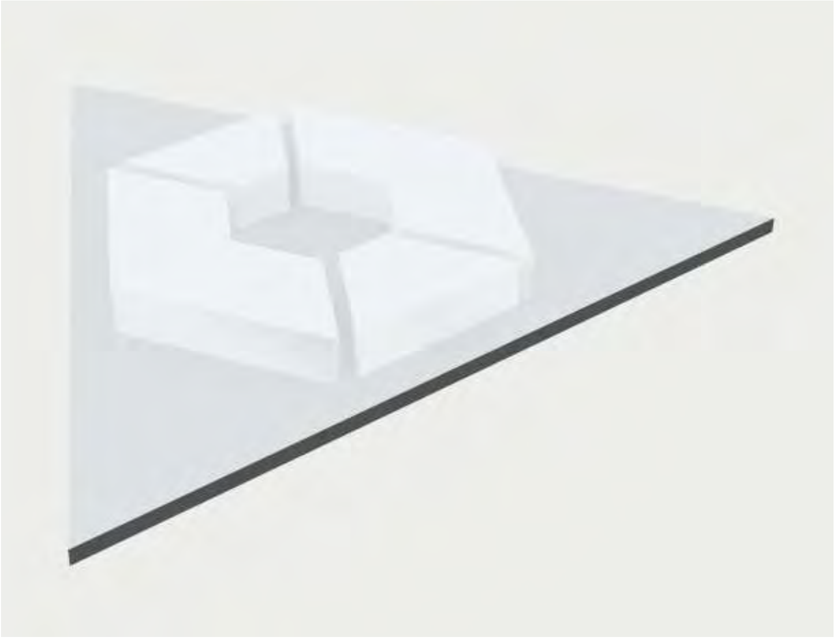
Green space 378.90 m2

Blue space 84.32 m2

Circulation 213.30 m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C2- Type 3.2



Platform surface total 1082.53 m2

Public space 702.6 m2

Private space 379.93 m2

Volume in total

379.93 x 3m (height) x 1 (floor) = 1139.79 m3

Green space 407.98 m2

Blue space 84.32 m2

Circulation 213.30 m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

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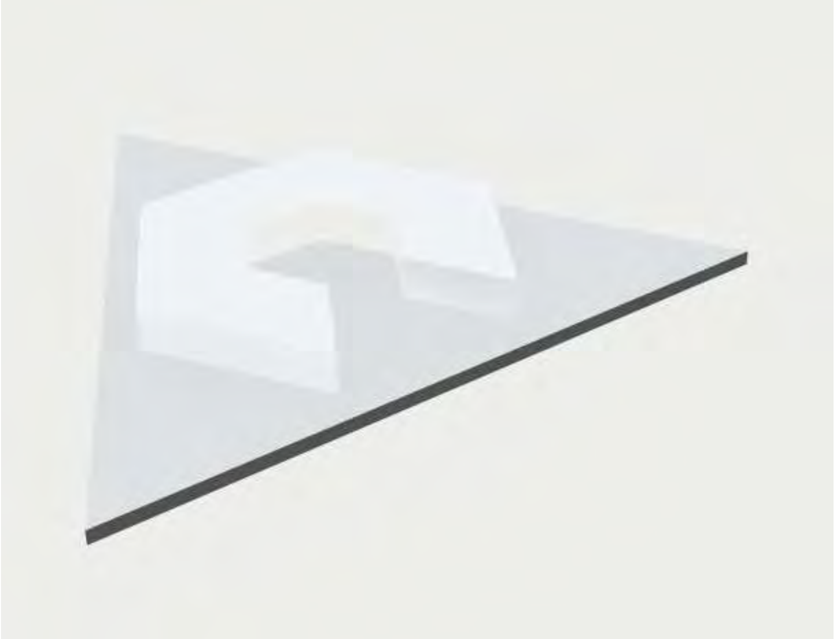
New City Fabric C2- Type 3.3



Platform surface total
1082.53 m2

Public space
741.69 m2

Private space
340.84 m2

Volume in total
340.84 x 3m(height) = 1022.52 m3

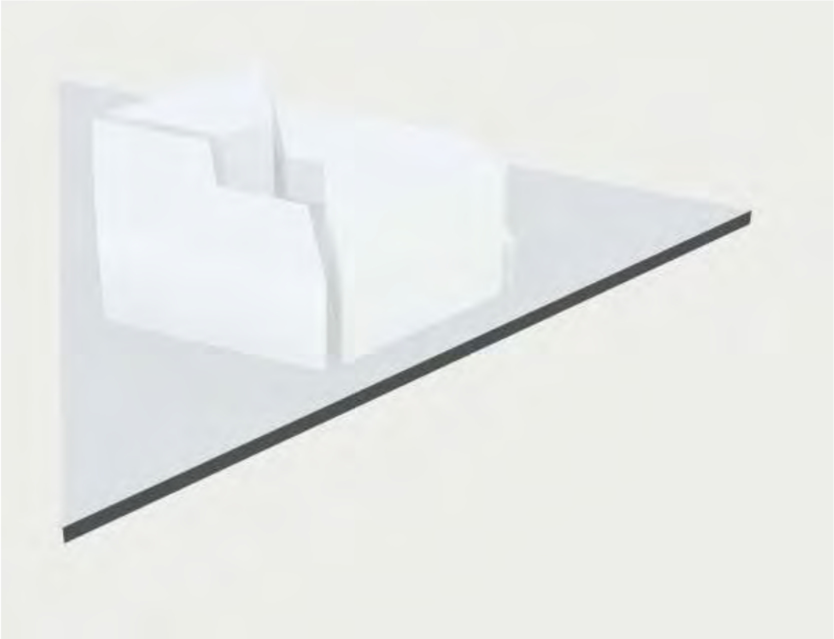
Green space
444.07 m2

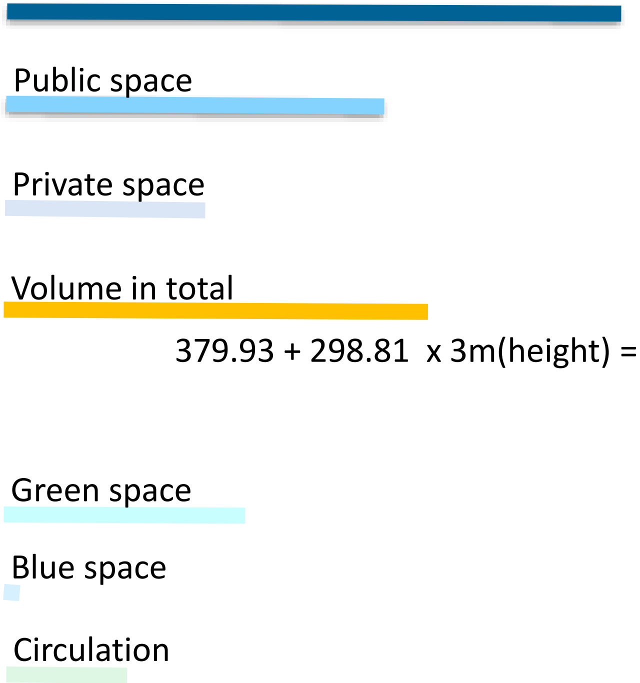
Blue space
84.32 m2

Circulation
213.30 m2

Access
50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C2- Type 3.4





Platform surface total 1082.53 m2

Public space 702.60 m2

Private space 379.93 m2

Volume in total

379.93 + 298.81 x 3m(height) = 2036.22 m3

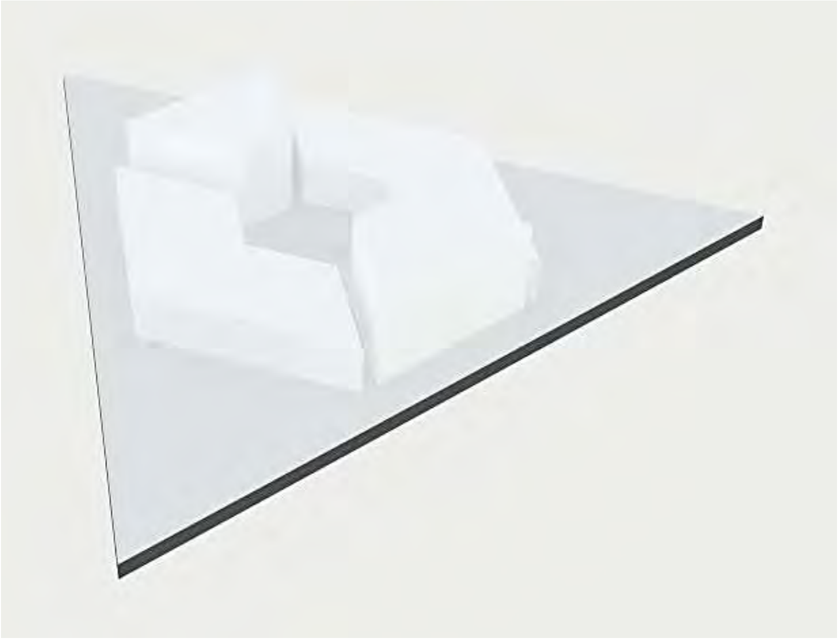
Green space 407.98 m2

Blue space 84.32 m2

Circulation 213.30 m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

New City Fabric C2- Type 3.5



Platform surface total 1082.53 m2

Public space 702.60 m2

Private space 379.93 m2

Volume in total

379.93 +107.25 x 3m(height) = 1139.79 m3

Green space 407.98 m2

Blue space 84.32 m2

Circulation 213.30 m2

Access 50 + 50 + 50 = 150m perimeters (3 sides)

HOW – Public Spaces

The study about superblocks gives an insight on the volume proportions between the public and private spaces.

Finding new uses for the streets and intersections will provide an opportunity to rethink communities, from cultural spaces to urban agriculture.

Public Spaces

Reference to other cities

Amsterdam, The Netherlands

Amsterdam city fabric is created by cannal rings and its connecting bridges.In public space lots of urban and maritime activities happen at the same time.

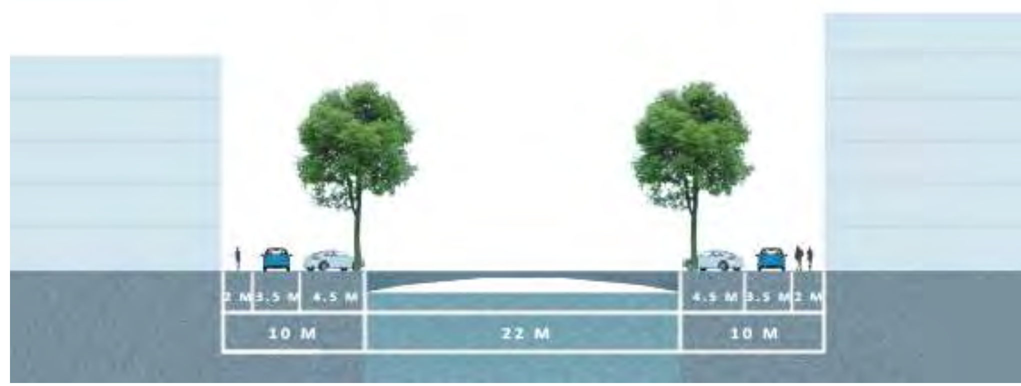
Barcelona, Spain

Created by ortogonal with diagonal axis, the composition of superblocks vary.Study of Urban density: the proportion between private and public space

Public Spaces

1.1 Amsterdam - Canal

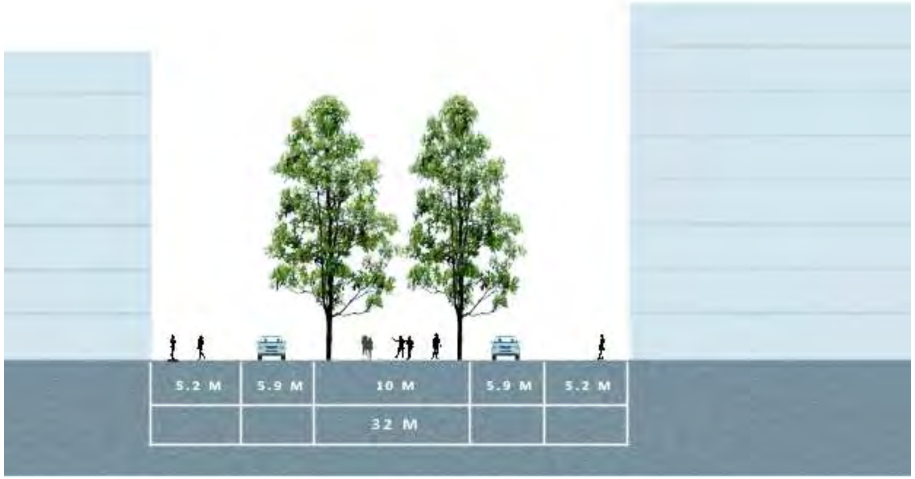
Diverse cityscape with canal. It leads to diverse urban activities : cruise ships, fishing, floating houses
Creating different microclimate : water absorbs urban heat and makes rich surrounding ecosystem.
Building density is low: most of historical buildings and the number of floors is from 4 to 6.



Public Spaces

1.2 Barcelona – La Rambla

Wide bulevar area with strong axis to connect city.
The center of roads is pedestrian area allowing citizens to enjoy the city. It increases spaces for activities and interactions of the local community and tourists.
It is common to see public square where cultural activities are happening.
Building density is higher than Amsterdam.



Public Spaces

1.3 Barcelona – Avenida Diagonal

It increases spaces for activities and interactions of the local community and tourists. Improving city congestion seperating public transportation and vehicle lines.
Wide pedestrian area and green path make pleasant walking around and enjoy the city.
Building density is high

Public Spaces

Introduction

The study covers –

Volume and spacial composition with the public and private spaces.

Shows how solid and void areas are created.

All blocks has blue space in them, where all leisure and water related activities happen.

Public Spaces

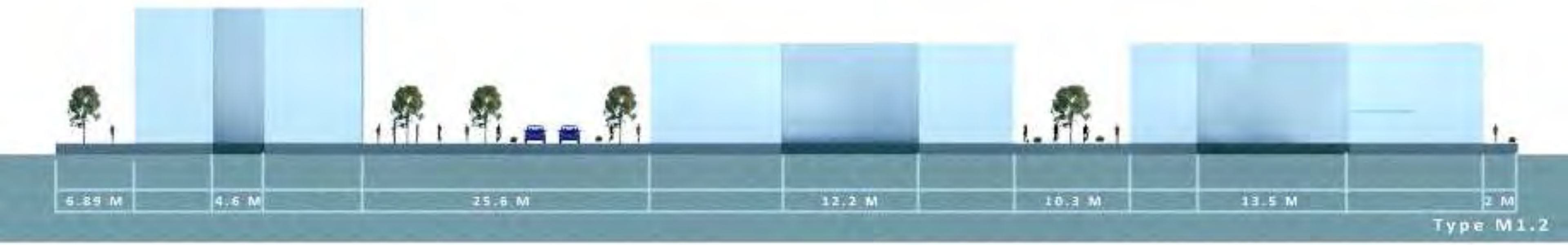
Concept 1 – Public Space Section 1

Low building density and green pedestrian area.
Seperation of vehicle lane with evergreen broad-leaved trees.
The main public network is in between the building blocks, showing the study of proportions.

Public Spaces

Concept 1 – Public Space Section 2

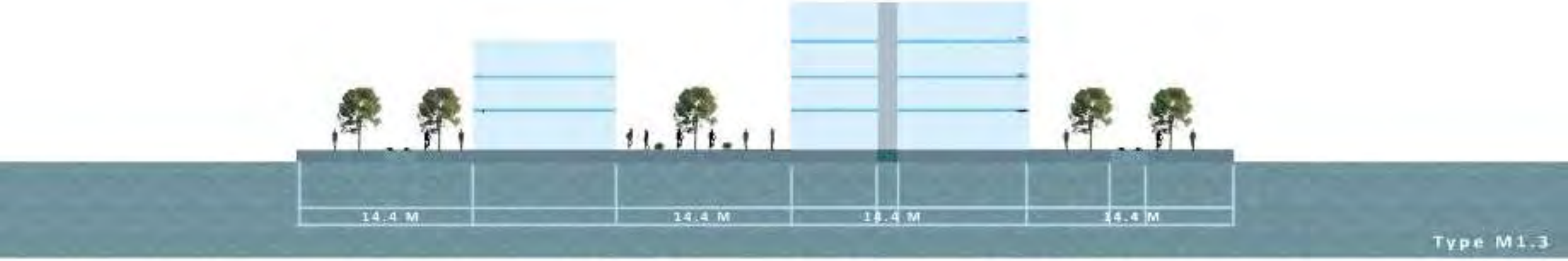
The main transportation networks, with more public spaces – creating interactive spaces for the community.



Public Spaces

Concept 1 – Public Space Section 3

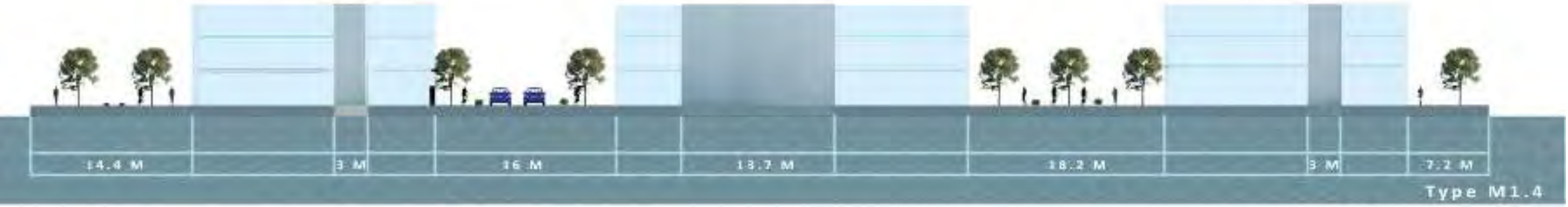
Public pools for recreation and neighbourhood activities.



Public Spaces

Concept 1 – Public Space Section 4

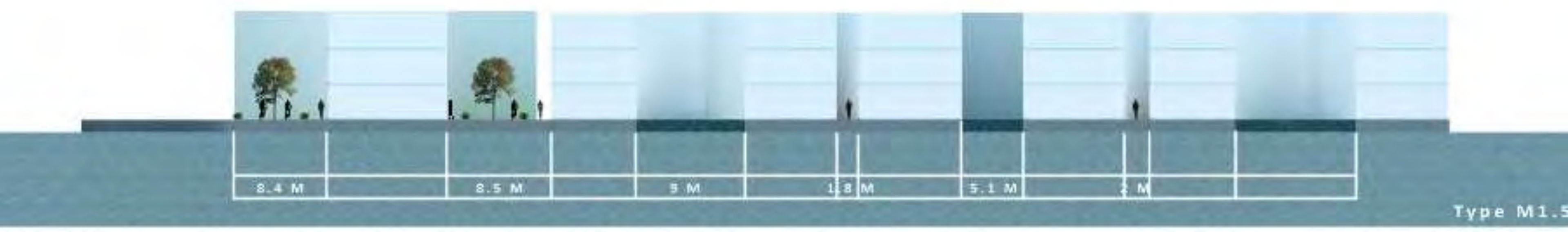
Interactive pedestrian spaces on the waterfront.



Public Spaces

Concept 1 – Public Space Section 5

This shows a complete pedestrian network between the blocks.



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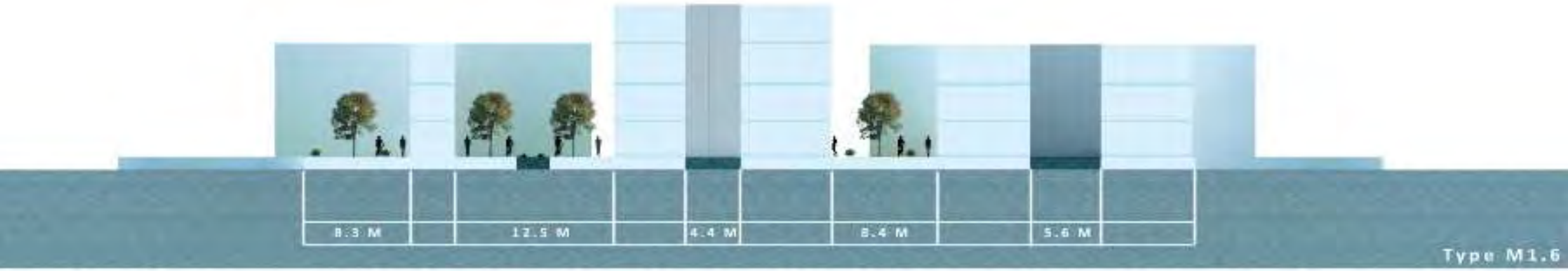
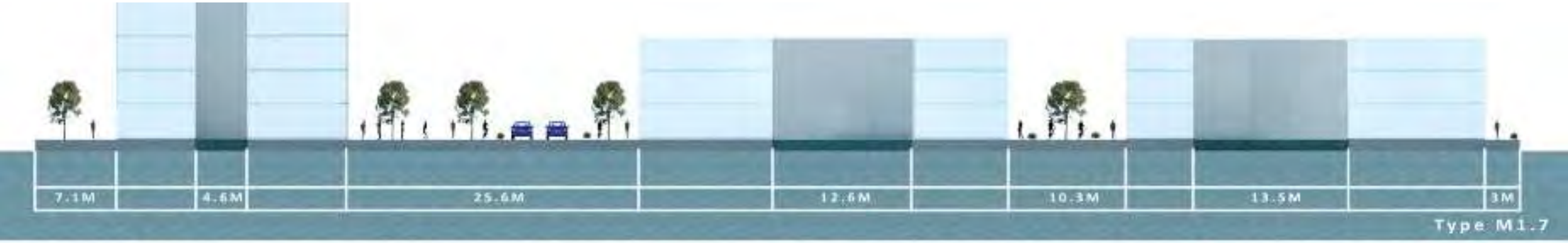
Public Spaces

Concept 1 – Public Space Section 6



Public Spaces

Concept 1 – Public Space Section 7



PROPOSAL –
Form & Function

Introduction

With the base platform, an equilateral triangle the possibilities of orientations have been explored in the previous chapter.

The main idea behind the form and the function both should be flexible in terms of future requirements. The system should enable many different variations to keep open future possibilities for the floating community. It should be also responding to the present needs. It should be flexible enough to eliminate certain spaces. The flexibility level should not only limit to the built form, it should be integrative till the end of functional spaces.

Our attempt is to find possibilities of deriving the form and the program which is flexible and self-sustaining.

“The language of materials and patterns seen in radical architecture transform as the nomadic city walks endlessly, adapting to the environments” - Matt Pyke

References

City upper the water

Different city composing elements - Independent buoyant structure for each function. This makes the city more flexible in terms of their program needs and it’s always expandable due to its modular nature.

References

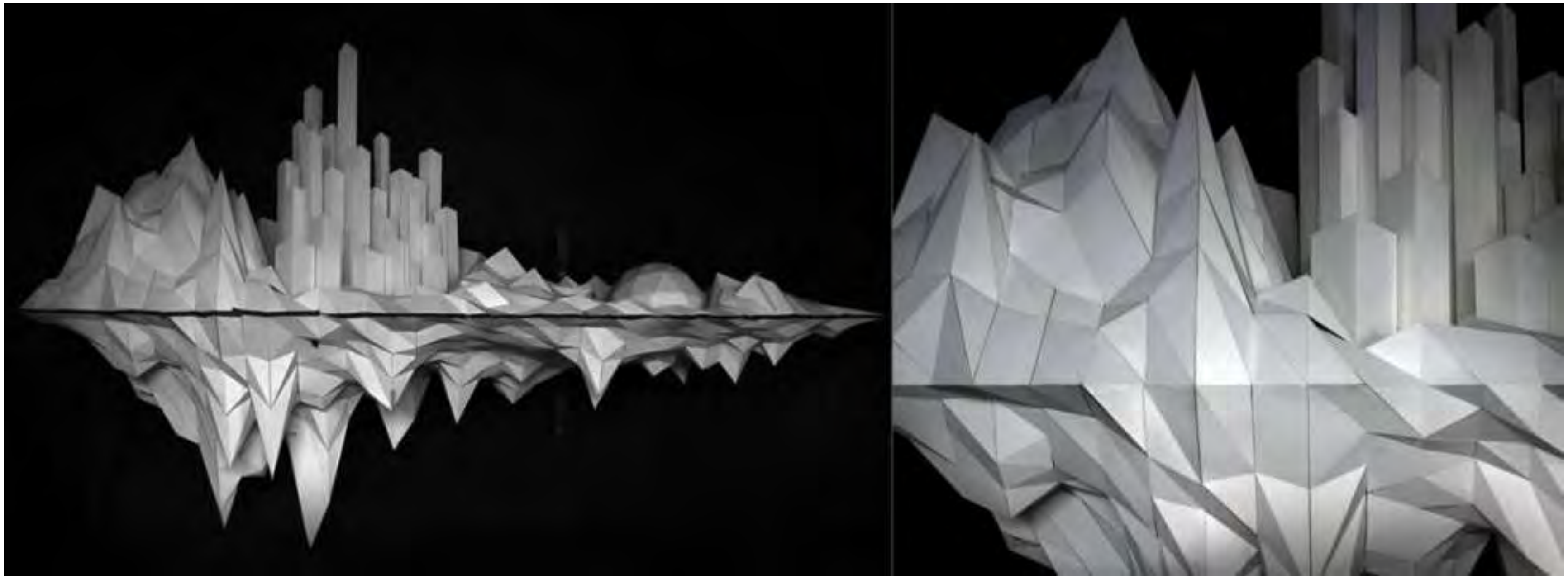
City upper the water

Closer relationship between public space and private space, this triangulation form creates a closer proximity between different hot spots in a urban context link a voronoi application - as a surface discretization method and a way of creating structural elements or spatial forms

References

City upper and under the water

General visual impact is a floating iceberg – as we build above the floating platform, we have enough space under water to create different spaces.



References

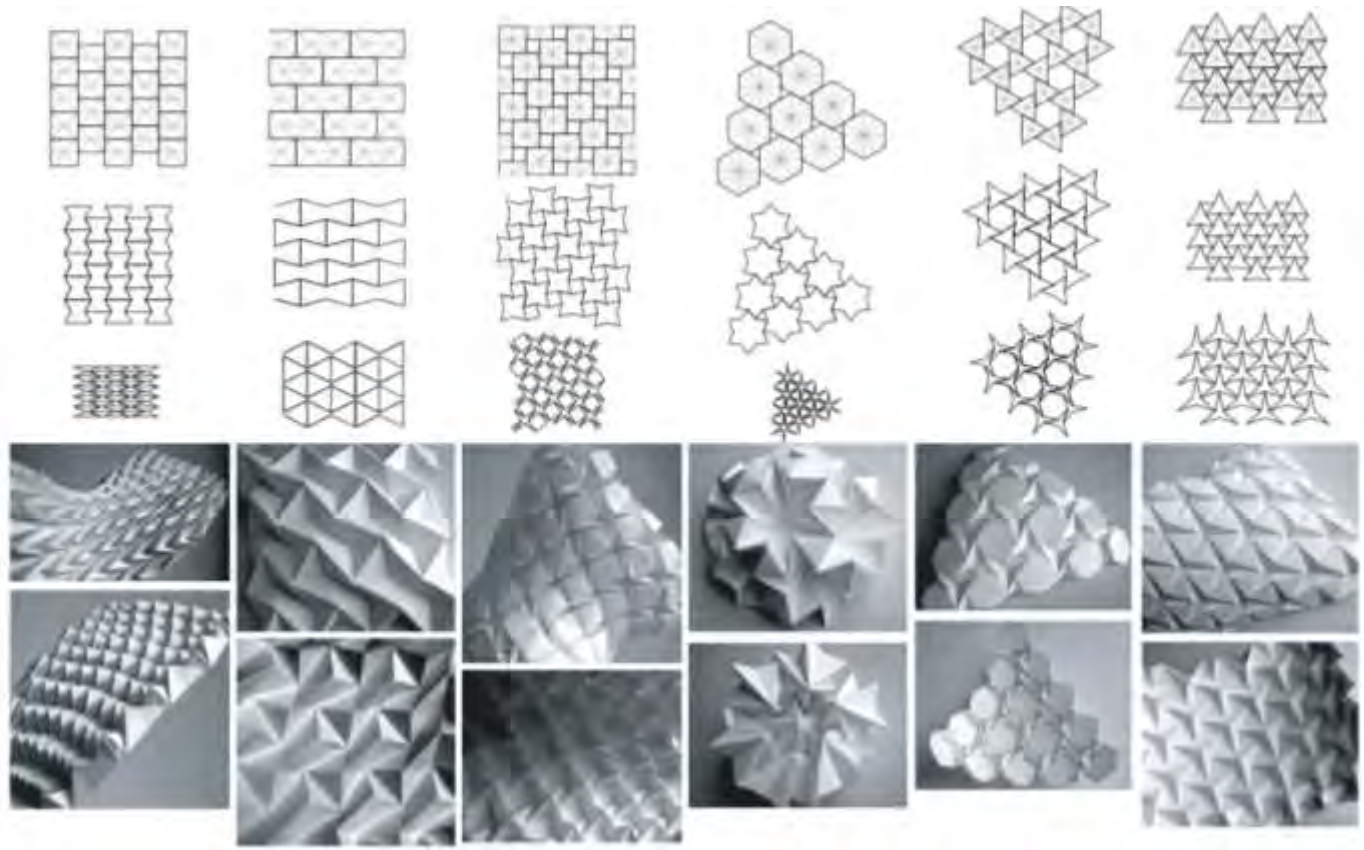
City above and under the water

Construction idea – the idea of constructing under water will help giving more buoyant force making the platform stable to hold more weight over it.

References

City above and under the water

Possibility to create city landscape

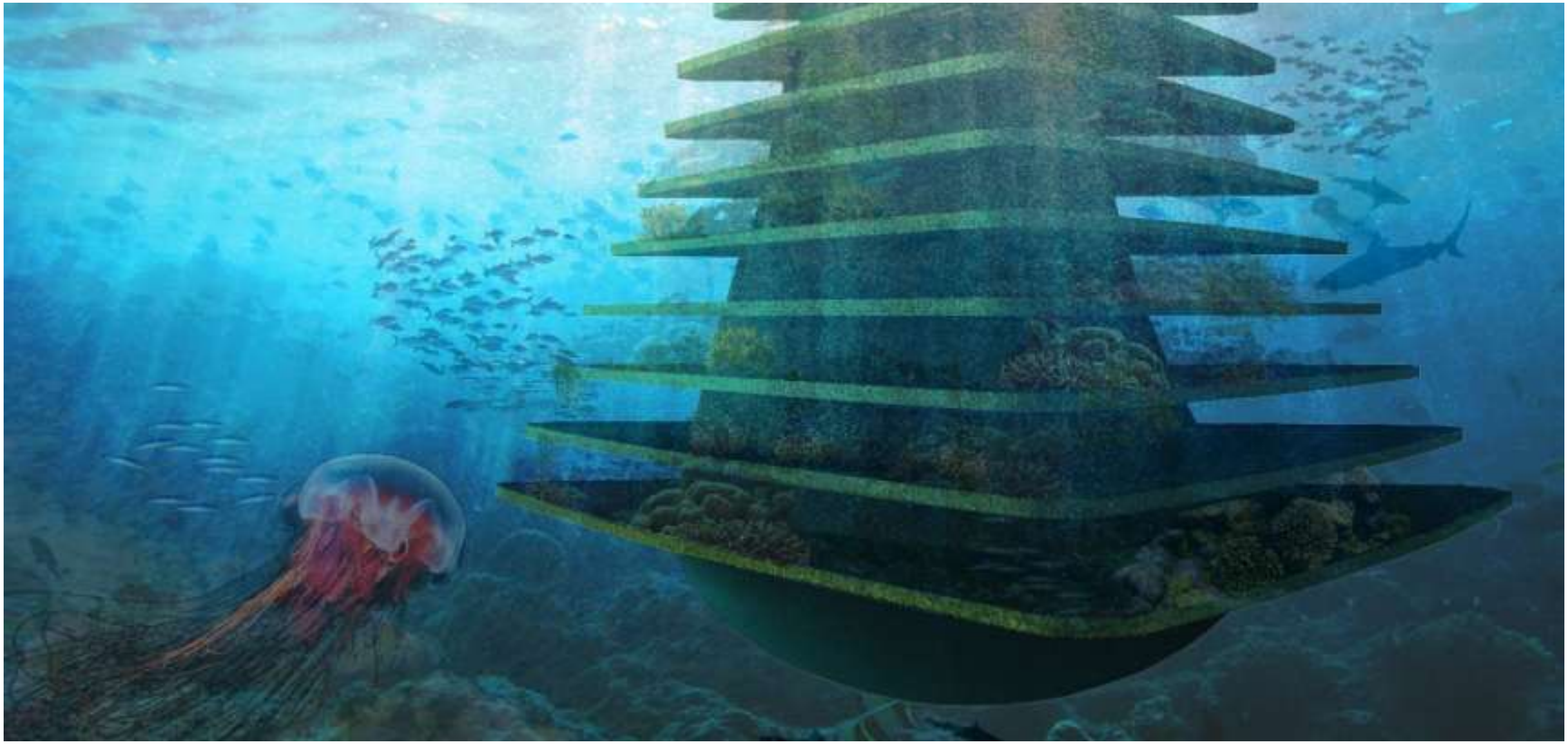


References

City under the water

References

City under the water



Program

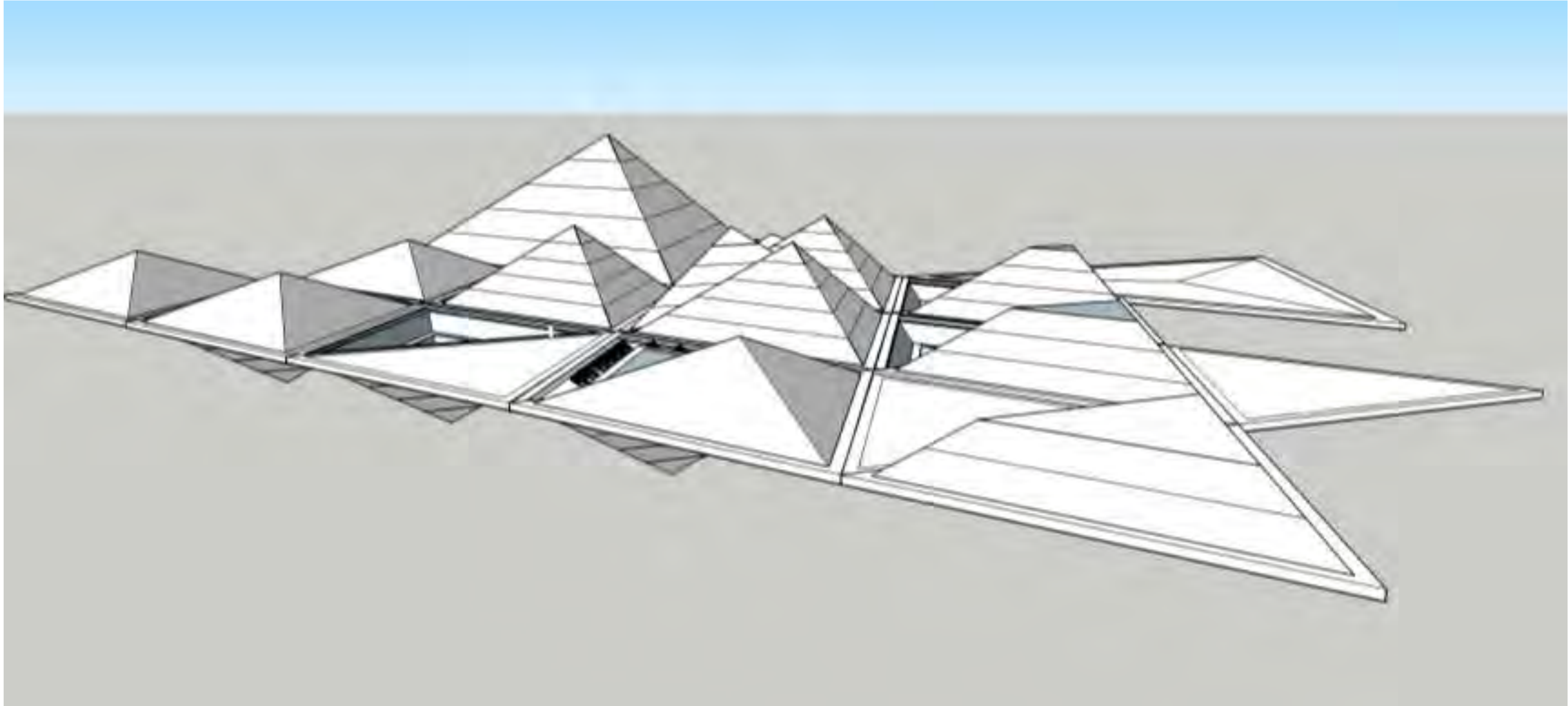
The city module is a self- sustainable module -

- Production: aquaculture industry- growing seaweed, fish and microalgae at an offshore location.
- Energy can be harvested as bioenergy from crops grown offshore while these crops can also add to the food production. Also fish farming further offshore is becoming feasible.
- Recreation: leisure activities- mostly in the blue space in a block.
- Living: quarters for workers and their family as a step up to communities at sea
- Protection: filtering water and recycling
- Research:
- Rehabitation
- Ecosystem and planting – individual platforms can become floating marshes- which develops marsh habitate, fish and plant community.
- CO_2 reduction and energy consevation – wave power generator, water cooling system, carbon chain, thermal and solar energy. The structure can itself process CO_2 in the atmosphere and absorb it into its titanium dioxide skin.
- Recycling – waste.
- The concept of blue revolution - The output of one system becomes the input for the other system.

Construction System

- The basic construction unit is a prefabricated block- platform -50m equilateral triangle. The modular parts are floated to the site after pre-fabrication in the factory.
- The floating community is realized by connecting all the modular floating platforms to each other. This way, the individual platforms will not move relative to each other, preventing collisions and/or platforms drifting away from the floating community.
- Construction of offshore structure- with triangular base – framed honeycomb structure works efficiently. Its an efficient packing system and has more faces to interconnect each other making the structure more stable.
- A close loop connection brings higher stability.
- A mooring system is necessary to ensure that the floating structure is kept in position and prevented from drifting away under critical sea conditions and storms.
- Clean technology : Algae for energy production- Able to produce electricity and biofuel without emit CO2 or other polluting substances, the hydrogen especially is nowadays such as a very promising clean energy source.
- Algae : fertilizer in proudction of shrimp and oyster
- Energy: Sea weed-the green seaweeds recycle our carbonated waste , other sea plants – Autosufficient
- Transportation: the main inter-connection between the islands of platform via seaways.
- The construction system could be a network of steel membars and tensile cabels to erect the pyramidal structure.

Visualization

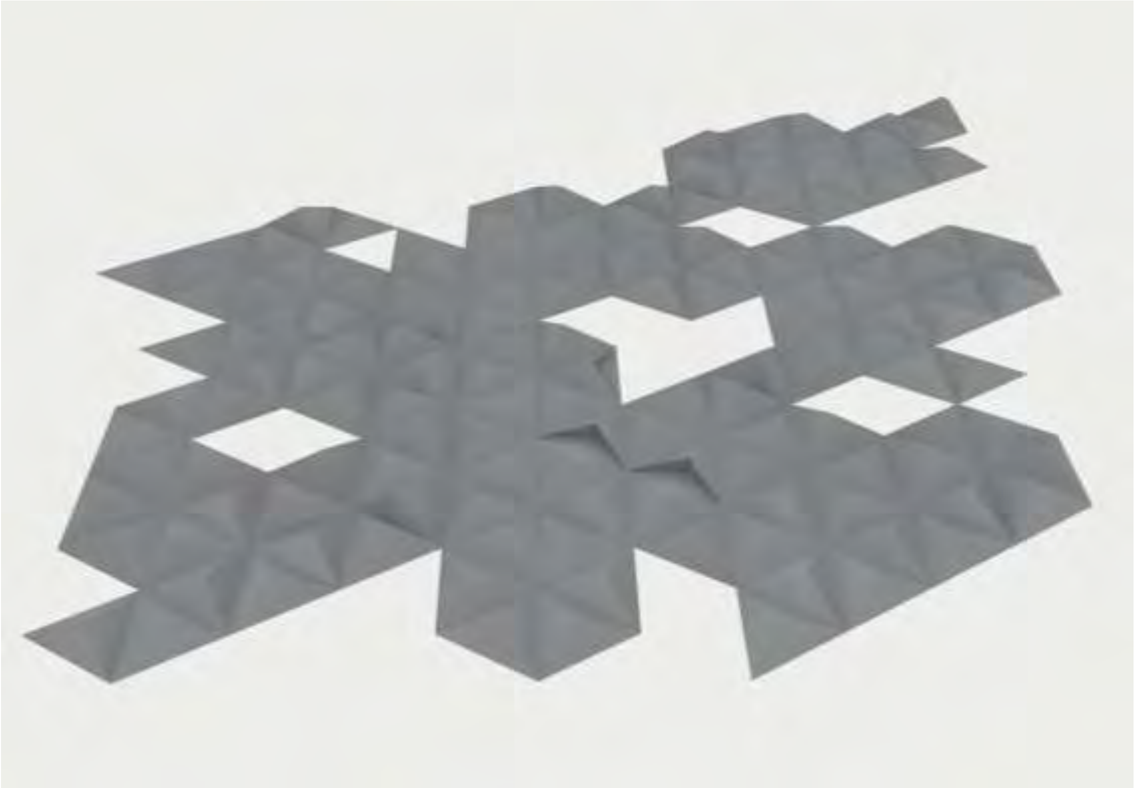


Building block restrained by 3 sides - communication roads : building's sizes vary
Public spaces divided by its funtion – Open green area/Aquaculture area under the sea/Yatch parking area

Visualization

The basic geometry is used to create the building blocks, the triangle form is the most flexible geometry. This form increases the higher possibilities of combining different functions. This form creates lot of opportunities to interlink different spaces, it doesn’t distinctively separate each spaces. The modular form of built spaces makes the form and functions more flexible. It’s creates a plug-in city language.

Visualization



In comparision with the square base prymidal shape, the triangular base creates more interactive spaces around the junctions.

Visualization

This form gives continuous transition from one space to other spaces. It creates pockets of open spaces which will create an interactive space in the local neighborhoods.

Conclusion

- The study has come with conclusion about space@sea
- Development of large floating platform – 50m equilateral triangle –for constructing different configurations.
- Comparing the different pattern which the city can exhibit as a spatial experience- relation between the public space and private spaces.
- City fabric concepts – exhibiting different building block configuration and spacial connectivities.
- The modular nature of the entire city from the form of the building blocks to the functional spaces.
- In this study we arrive at the possibilities of starting a cityscape from a triangle grid. Which influences the form of the building blocks.

SPACE@SEA

THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

HORIZON 2020

Appendix – 3 City Scenario and Analysis

Table of contents

1.Task 7.4 - Locations
- Program

2. City Scenario
   Masdar City
   Rijswijk
   Tollebeek

7.4 Locations

The Hague coast

Stand-alone business case for Living@Sea prospectively close to the coast of the Netherlands in front of The Hague

Mediterranean Sea

Energyhub@Sea offshore in the Mediterranean Sea in combination with Living@Sea for housing purposes of the workers and their families mainly

North Sea

Logistics@Sea offshore in the North Sea between Amsterdam and Antwerp in combination with Living@Sea for housing purposes of the workers and their families mainly

7.4 Program

Energy@Sea	Living@Sea	Logistics@Sea
Mediterranean Sea Near France	North Sea The Hague coast	North Sea Near Rotterdam
		
95% function 5% living@sea	10% function 90% living@sea	80% function 20% living@sea
35 inhabitants	50.000 inhabitants	2000 inhabitants
Program of Demands Community	Program of Demands City	Program of Demands Village

City Scenario

A division is made for different kind of cities. This because every city scenario has different program of demands.

- Masdar city Abu Dhabi (High tech city)
- Rijswijk (City near The Hague)
- Tollebeek (Small village)

City Scenario

City Scenario

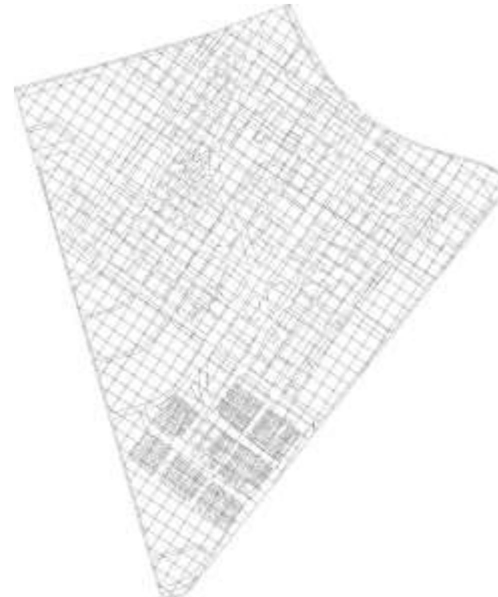
Grid

The grid is based on the required triangular platform size of 50x50x50m. For a rectangular platform with the same m2 a squared platform of 33x33m is needed. Based on the functions sizes in the case cities, we have chosen to triple this platform size (99x99m).

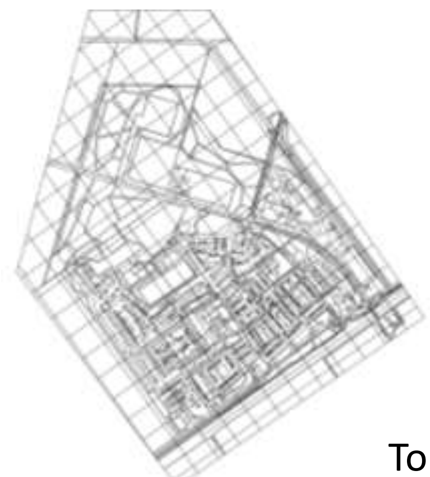
City Scenario

Grid

Rijswijk



Masdar City



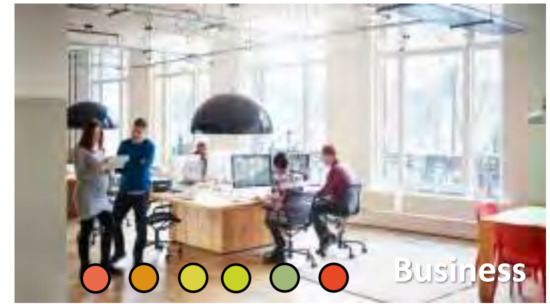
Tollebeek

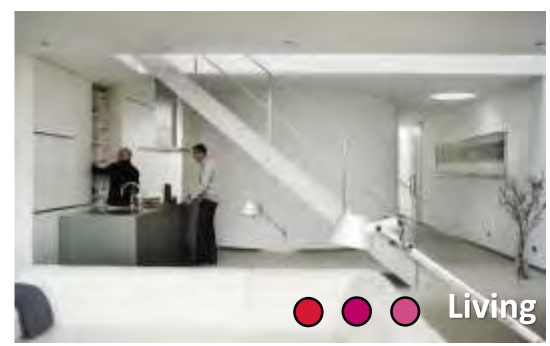
City Program

Functions

Every city has a scale of functions. In this analyses
we limited the functions to the followoing function groups:

- Living
- Business
- Public
- Utilities
- Health





City Program

Functions

Living

- Living <3 layer
- Living >3 layer
- Living Community Facilities

Business

- Business Research and Development
- Business Offices
- Business Light Industrial
- Business Catering Industry
- Business Agriculture
- Business Commercial

Public

- Public Hotel
- Public Park and Open Space
- Public Leisure
- Public Building
- Public Education Institutional
- Public Education Daily Care

Utilities

- Utilities Solar hub
- Utilities Other

Health

- Health Hospital
- Health Nursery

MASDAR CITY ABU DHABI

Masdar City is a planned city project in Abu Dhabi, in the United Arab Emirates. Its core is being built by Masdar, a subsidiary of Mubadala Development Company, with the majority of seed capital provided by the Government of Abu Dhabi. Designed by the British architectural firm Foster and Partners, the city relies on solar energy and other renewable energy sources. Masdar City is being constructed 17 kilometers east-south-east of the city of Abu Dhabi, beside Abu Dhabi International Airport.

Masdar City hosts the headquarters of the International Renewable Energy Agency. The city is designed to be a hub for cleantech companies. (Wikipedia)

MASDAR CITY ABU DHABI

High Tech City

Location and Facts

MASDAR CITY ABU DHABI

High Tech City

Location and Facts

MASDAR CITY ABU DHABI

High Tech City

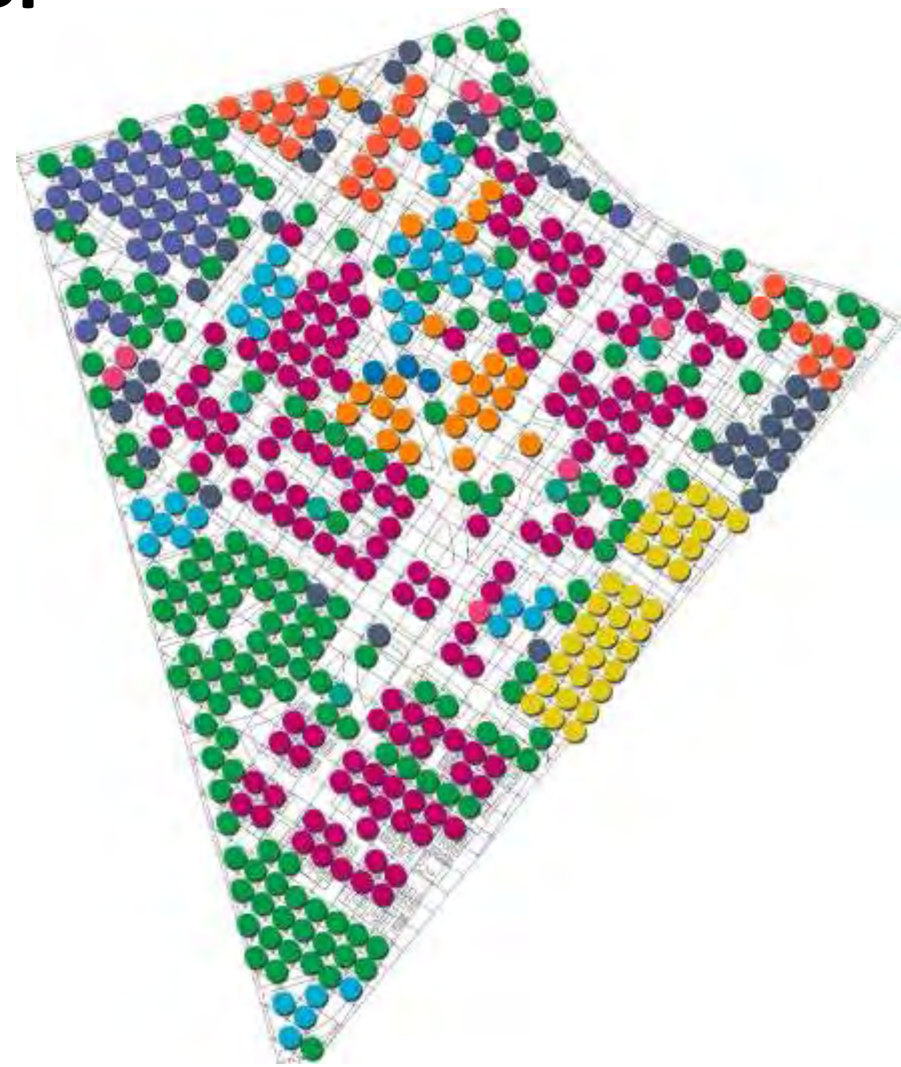
Location and Facts

MASDAR CITY ABU DHABI

- 45.000 inhabitants
- 62% of plot area is dedicated to residential properties
- 10% of the plot area is dedicated to corporate office properties
- 40% less energy and water consumption than conventional cities of comparable size
- 100% pedestrian friendly

MASDAR CITY ABU DHABI

- Living Residential
- Living Community facilities
- Business Offices
- Business Light Industrial
- Business Research and development
- Public Park and open space
- Public Hotel
- Public Leisure
- Public Education Institutional
- Utilities solar hub
- Utilities other



SPACE@SEA

MASDAR CITY ABU DHABI

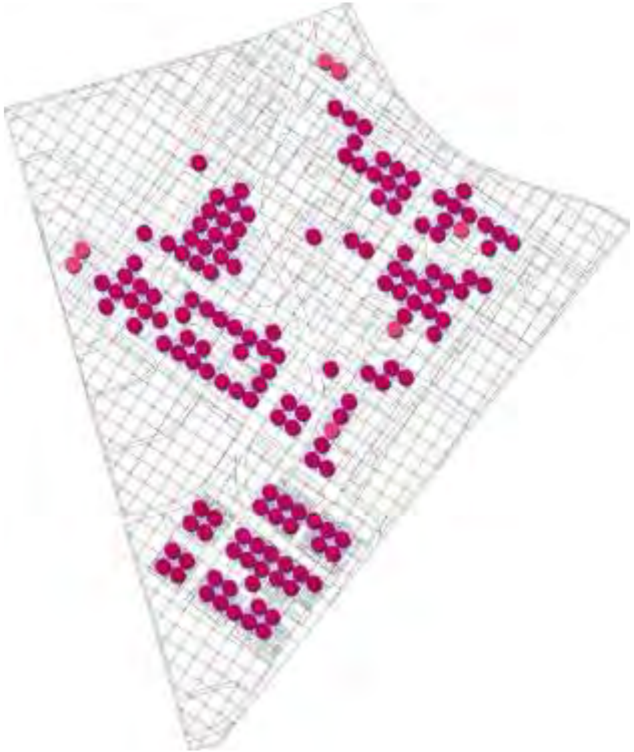
	m2 Footprint	% of total built area
Living Residential	1.565.620	25
Living Community facilities	78.195	1
Business Offices	225.161	4
Business Light Industrial	340.128	6
Business Research and development	258.717	4
Public Park and open space	1.913.031	31
Public Hotel	41.185	1
Public Leisure	731.136	12
Public Education Institutional	444.079	7
Utilities solar hub	360.622	6
Utilities other	181.383	3

MASDAR CITY ABU DHABI

Function Living

	m2 Footprint	% of total built area	% of total area
Living Residential	1.565.620	25	20
Living Community facilities	78.195	1	1

- Estimated 75% of the plot area is dedicated to the footprint of the function Living
- 75% is equal to 7.351m2 of total grid footprint of 9801m2 (platform)
- In Masdar City the estimation of the total footprint for living and community facilities is 1,247.861m2 of the total area



MASDAR CITY ABU DHABI

Function Business

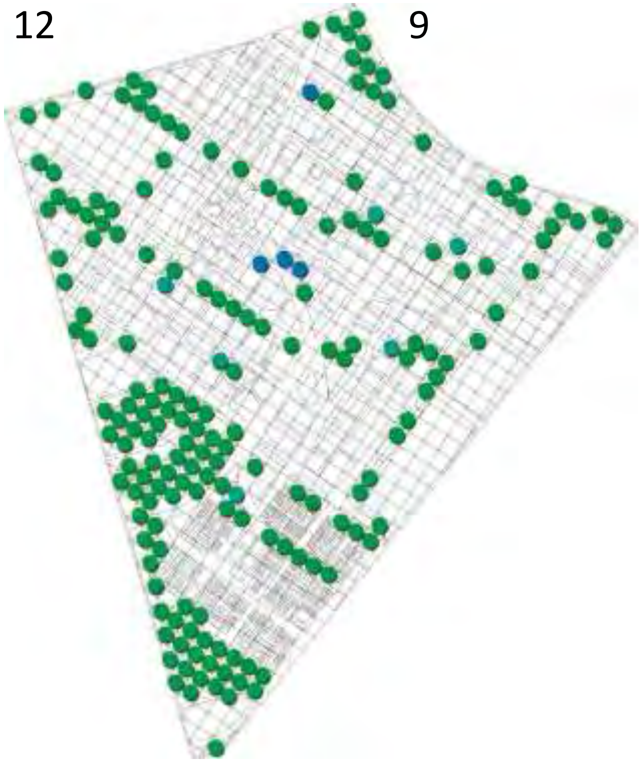
	m2 Footprint	% of total built area	% of total area
Business Offices	2.55.161	4	3
Business Light Industrial	340.128	6	4
Business Research and development	258.717	4	3

- Estimated 21% of the plot area is dedicated to the footprint of the function Business
- 21% is equal to 2.058 m2 of total grid footprint of 9801m2 (platform)
- In Masdar City the estimation of the total footprint for Business is 173.041m2 of the total area

MASDAR CITY ABU DHABI

Function Public

	m2 Footprint	% of total built area	% of total area
Public Park and open space	1.913.031	31	24
Public Hotel	41.185	1	0,5
Public Leisure	731.136	12	9



- Estimated 25% of the plot area is dedicated to the footprint is Public area
- 25% is equal to 2.450m2 of total grid footprint of 9801m2 (platform)
- In Masdar City the estimation of the total footprint for public is 2.001.768 m2 of the total area

MASDAR CITY ABU DHABI

Function Educational

	m2 Footprint	% of total built area	% of total area
Public Education Institutional	444.079	7	6

- Estimated 29% of the plot area is dedicated to the footprint is Institutional
- 29% is equal to 2.842m2 of total grid footprint of 9801m2 (platform)
- In Masdar City the estimation of the total footprint for public is 2.322.050 m2 of the total area

MASDAR CITY ABU DHABI

Function Utilities

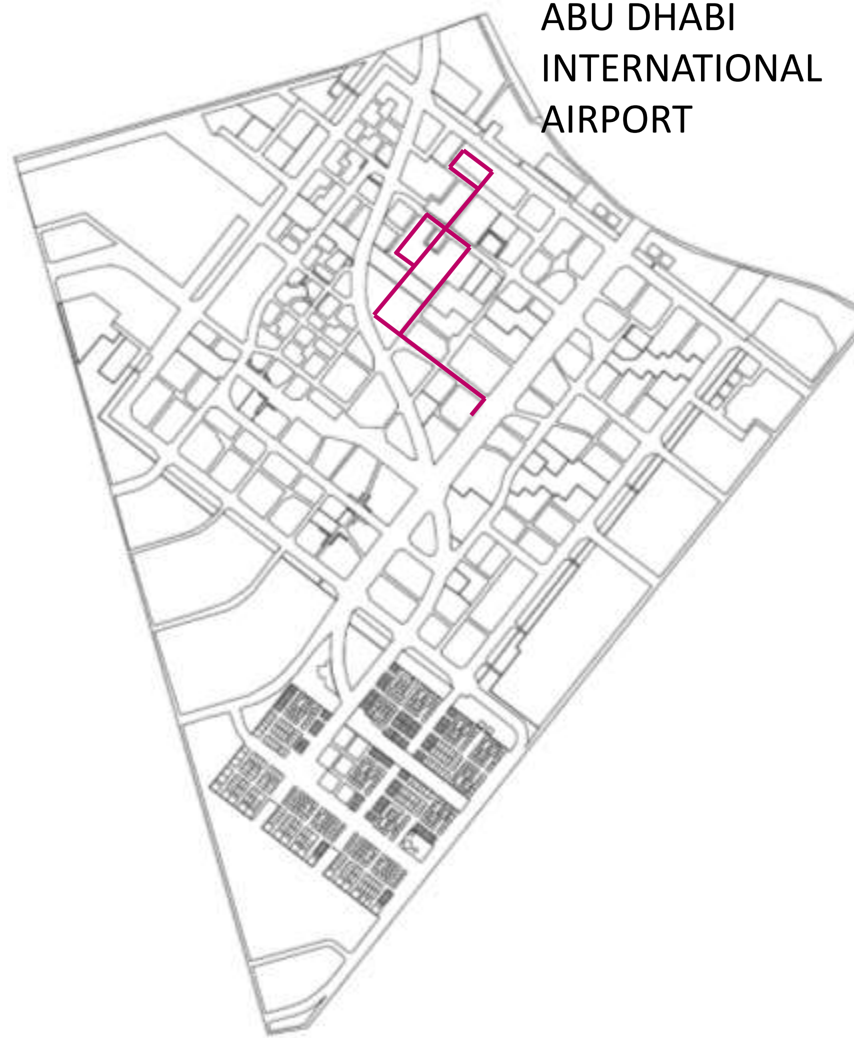
	m2 Footprint	% of total built area	% of total area
Utilities solar hub	360.622	6	4,5
Utilities other	181.383	3	2

- Estimated 18% of the plot area is dedicated to the footprint is Institutional
- 18% is equal to 1.764m2 of total grid footprint of 9801m2 (platform)
- In Masdar City the estimation of the total footprint for public is 1.441.273 m2 of the total area

MASDAR CITY ABU DHABI

Function Connectivity
Personal Rapid Transit

2.8km track



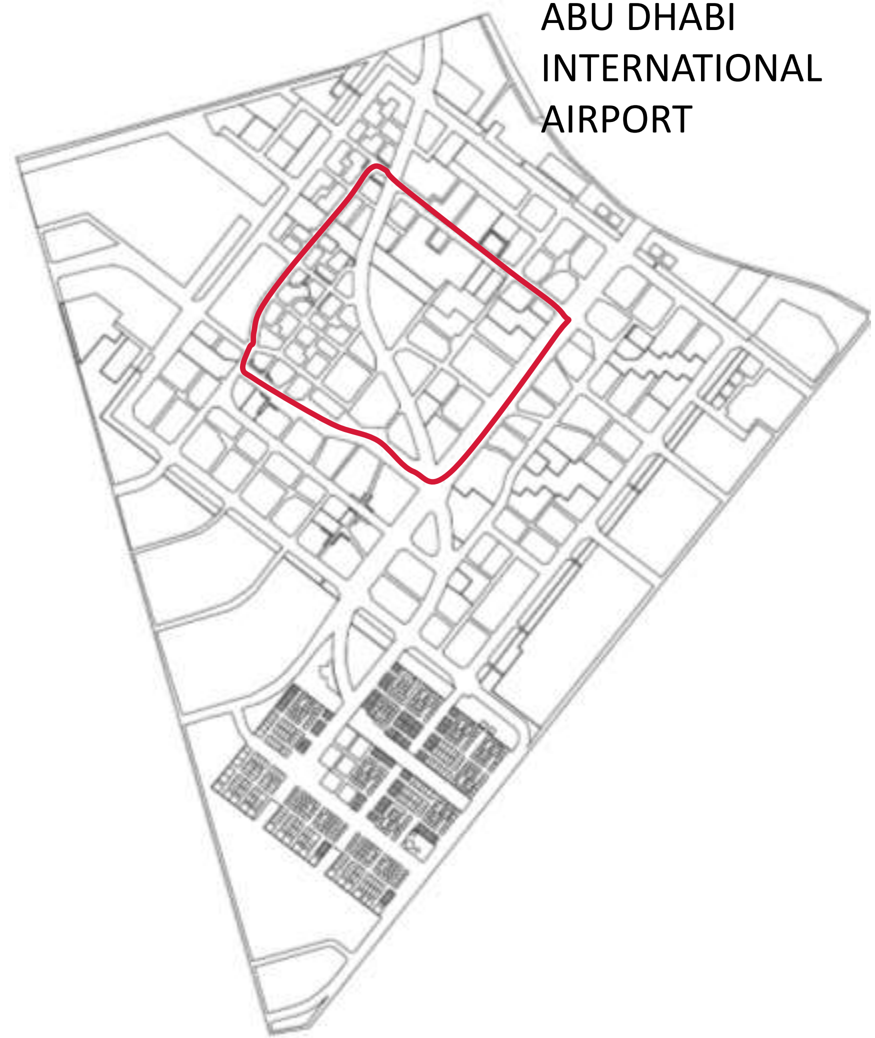
SPACE@SEA

MASDAR CITY ABU DHABI

Function Connectivity
Group Rapid Transit

4.0km track

ABU DHABI
INTERNATIONAL
AIRPORT



MASDAR CITY ABU DHABI

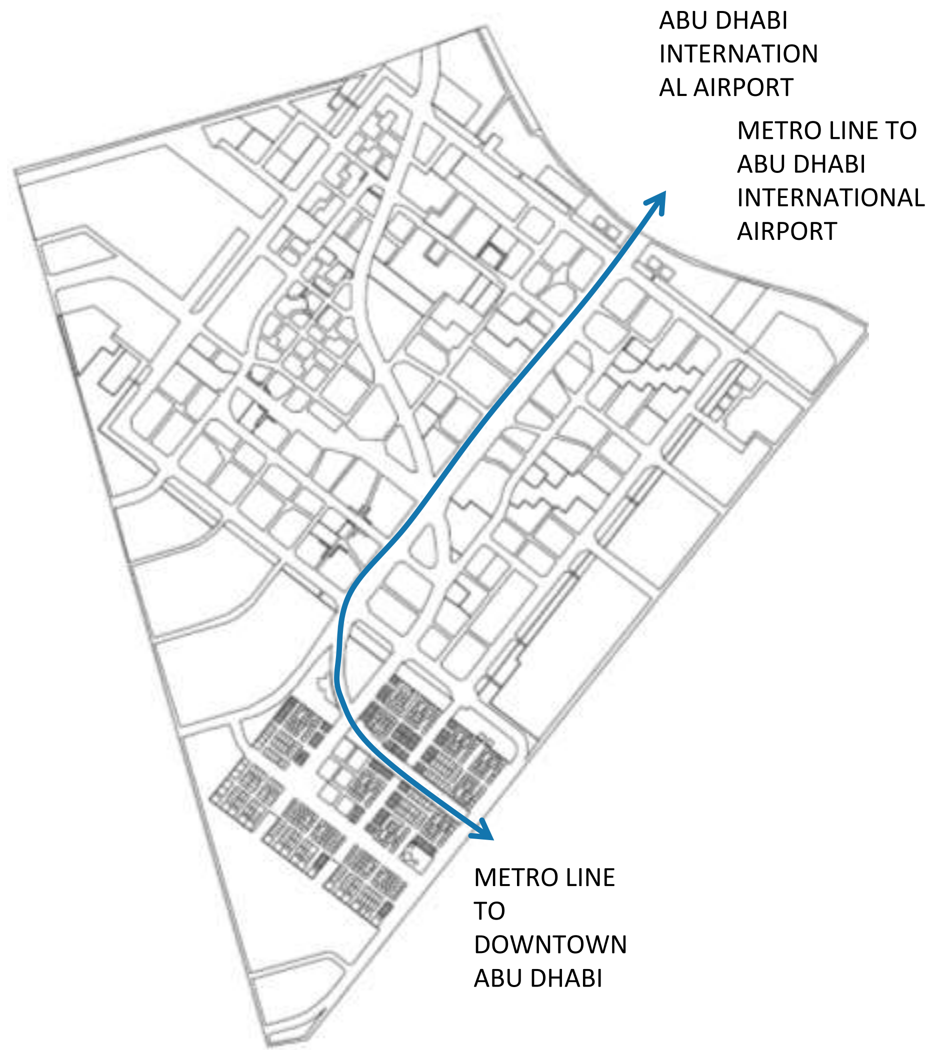
Function Connectivity
Public Bus Route

4.1km track

MASDAR CITY ABU DHABI

Function Connectivity
Metro Line

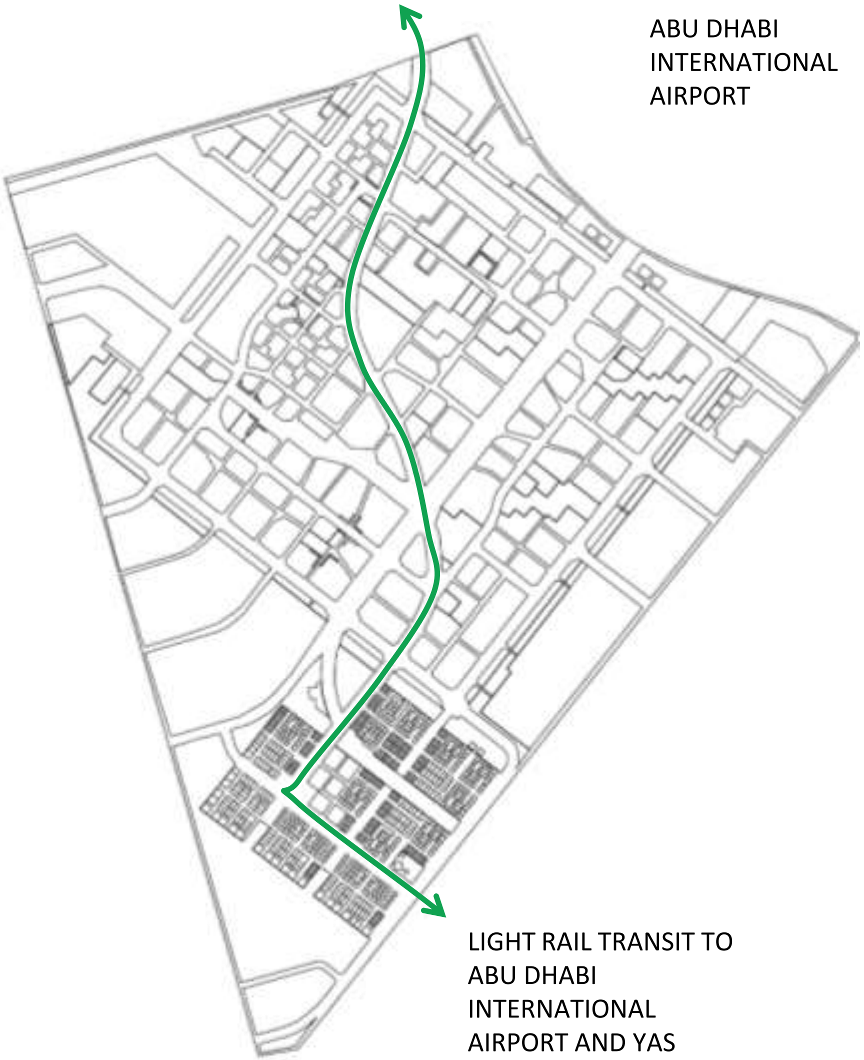
3.1km track



MASDAR CITY ABU DHABI

Function Connectivity
Light Rail Transit

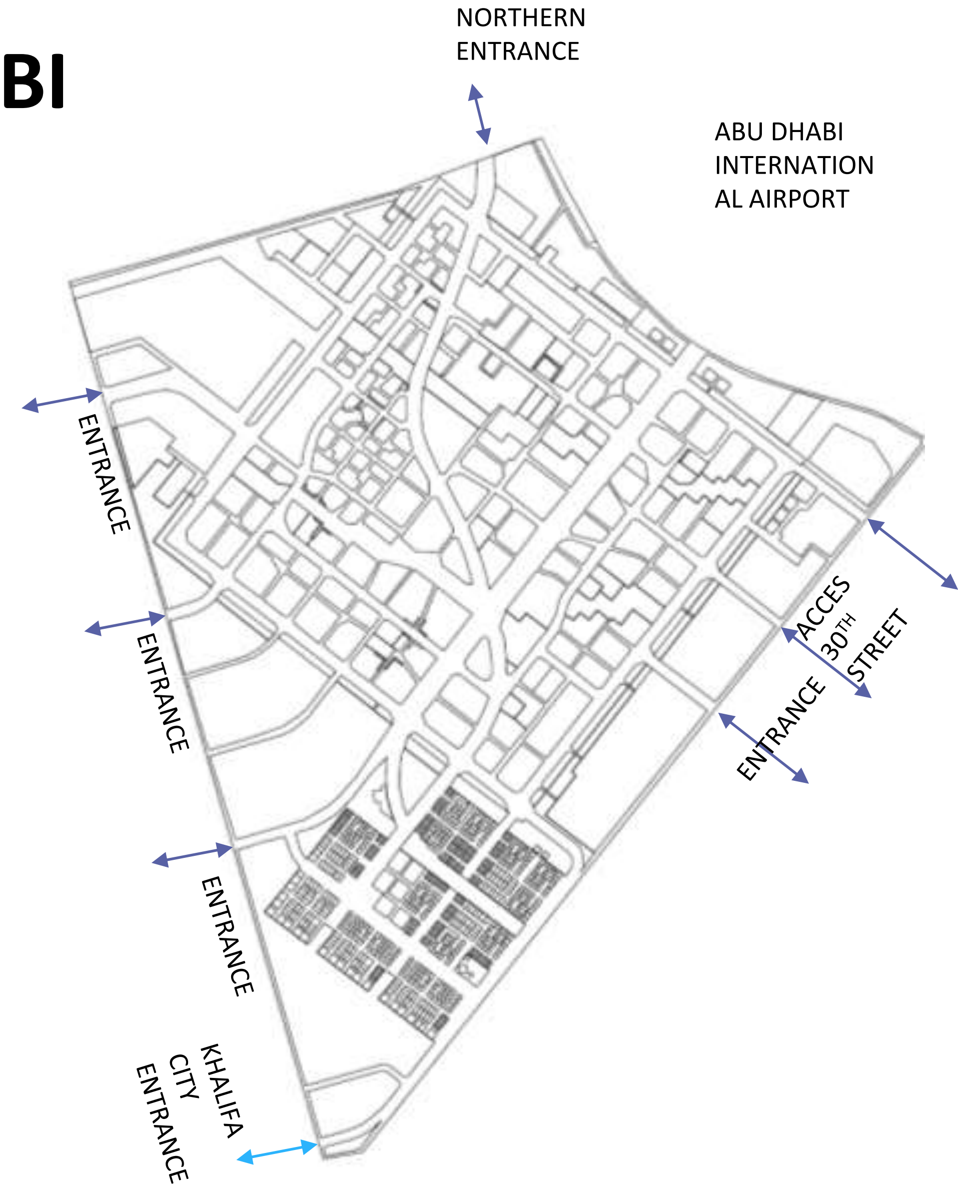
4.2km track



MASDAR CITY ABU DHABI

Function Connectivity
Entrances

8 main entrances



RIJSWIJK

Rijswijk is a city in the coastal area of the Netherlands located next to the city of The Hague.

RIJSWIJK

Subcity

Location and Facts

RIJSWIJK

Subcity

Location and Facts

RIJSWIJK

- 51.742 inhabitants

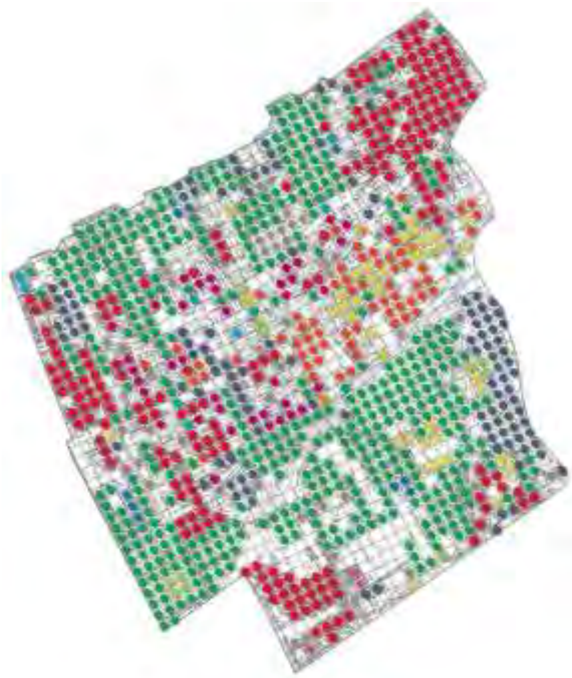
RIJSWIJK

- Living Community Facilities
- Living < 3 layers
- Living > 3 layers
- Business Commercial
- Business Offices
- Business Light Industrial
- Business Agriculture
- Business Catering Industry
- Public Park and open space
- Public Building
- Public Education Institutional
- Public Daily Care
- Utilities
- Water

SPACE@SEA

RIJSWIJK

	m2 Footprint	% of total built area
Living Community Facilities	40.000	1
Living < 3 layers	2.050.000	20
Living > 3 layers	370.000	3
Business Commercial	620.000	6
Business Offices	30.000	1
Business Light Industrial	360.000	4
Business Agriculture	90.000	1
Business Catering Industry	30.000	1
Public Park and open space	4.430.000	44
Public Building	70.000	1
Public Education Institutional	90.000	1
Public Daily Care	30.000	1
Utilities	1.130.000	11
Water	560.000	5



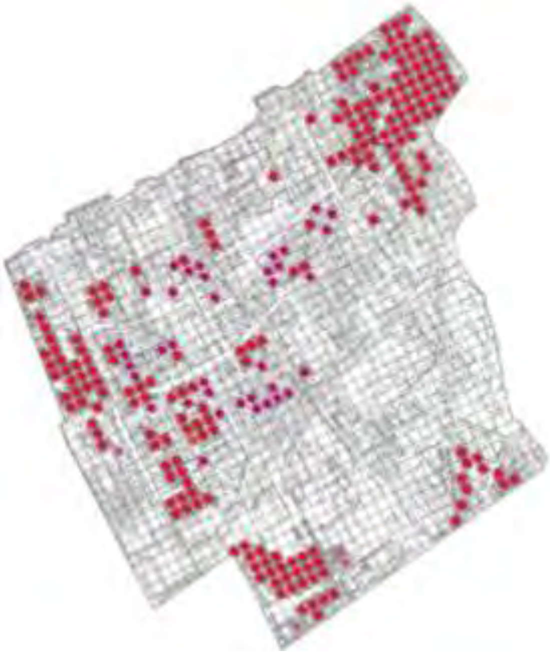
SPACE@SEA

RIJSWIJK

Function Living

	m2 Footprint	% of total built area	% of total area
Living Community facilities	40.000	1	1
Living < 3 layers	2.050.000	20	18
Living > 3 layers	370.000	3	1

- Estimated 23% of the plot area is dedicated to the footprint of the function Living
- 23% is equal to 2.219m2 of total grid footprint of 9801m (platform)
- In Rijswijk the estimation of the total footprint than wil be 565.800m2

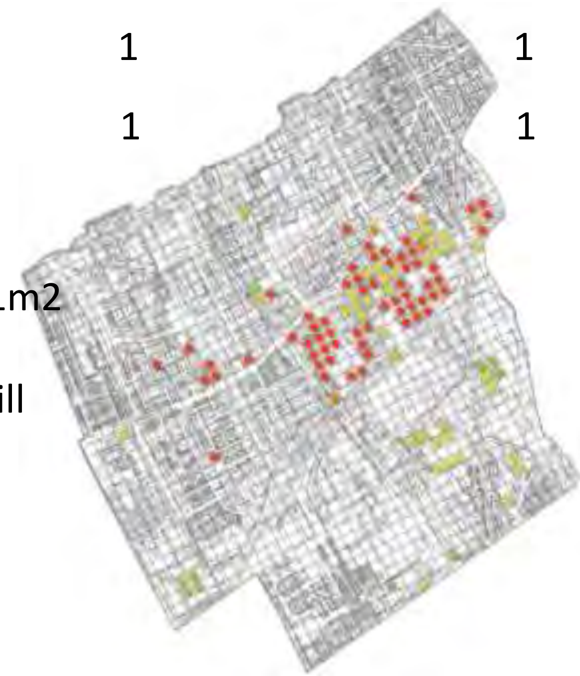


RIJSWIJK

Function Business

	m2 Footprint	% of total built area	% of total area
Business Commercial	620.000	6	14
Business Offices	30.000	1	1
Business Light Industrial	360.000	4	2
Business Agriculture	90.000	1	1
Business Catering Industry	30.000	1	1

- Estimated 44% of the plot area is dedicated to the footprint of the function Business
- 44% is equal to 4.312m2 of total grid footprint of 9801m2 (platform)
- In Rijswijk the estimation of the total footprint than will be 497.200m2



RIJSWIJK

Function Business

	m2 Footprint	% of total built area	% of total area
Business Commercial	620.000	6	14
Business Offices	30.000	1	1
Business Light Industrial	360.000	4	2
Business Agriculture	90.000	1	1
Business Catering Industry	30.000	1	1

- Estimated 44% of the plot area is dedicated to the footprint of the function Business
- 44% is equal to 4.312m2 of total grid footprint of 9801m2 (platform)
- In Rijswijk the estimation of the total footprint than will be 497.200m2

RIJSWIJK

Function Public

	m2 Footprint	% of total built area	% of total area
Public Park and Open Space	4.430.000	44	35
Public Building	70.000	1	1
Public Education	90.000	1	1
Public Daily Care	30.000	1	1

- Estimated 17% of the plot area is dedicated to the footprint of a public building (excluding the parks and sport facilities area which consist mainly of land)
- 17% is equal to 1678m2 of total grid footprint of 9801m2 (platform)
- In Rijswijk the estimation of the total footprint than will be 32.300m2 (excluding parks and sport facilities)

RIJSWIJK

Function Water

	m2 Footprint	% of total built area	% of total area
Public Park and Open Space	560.000	6	4

RIJSWIJK

Function Connectivity
Main Road Transit

14.7km track

RIJSWIJK

Function Connectivity
Public Bus Transit

8.1km track

RIJSWIJK

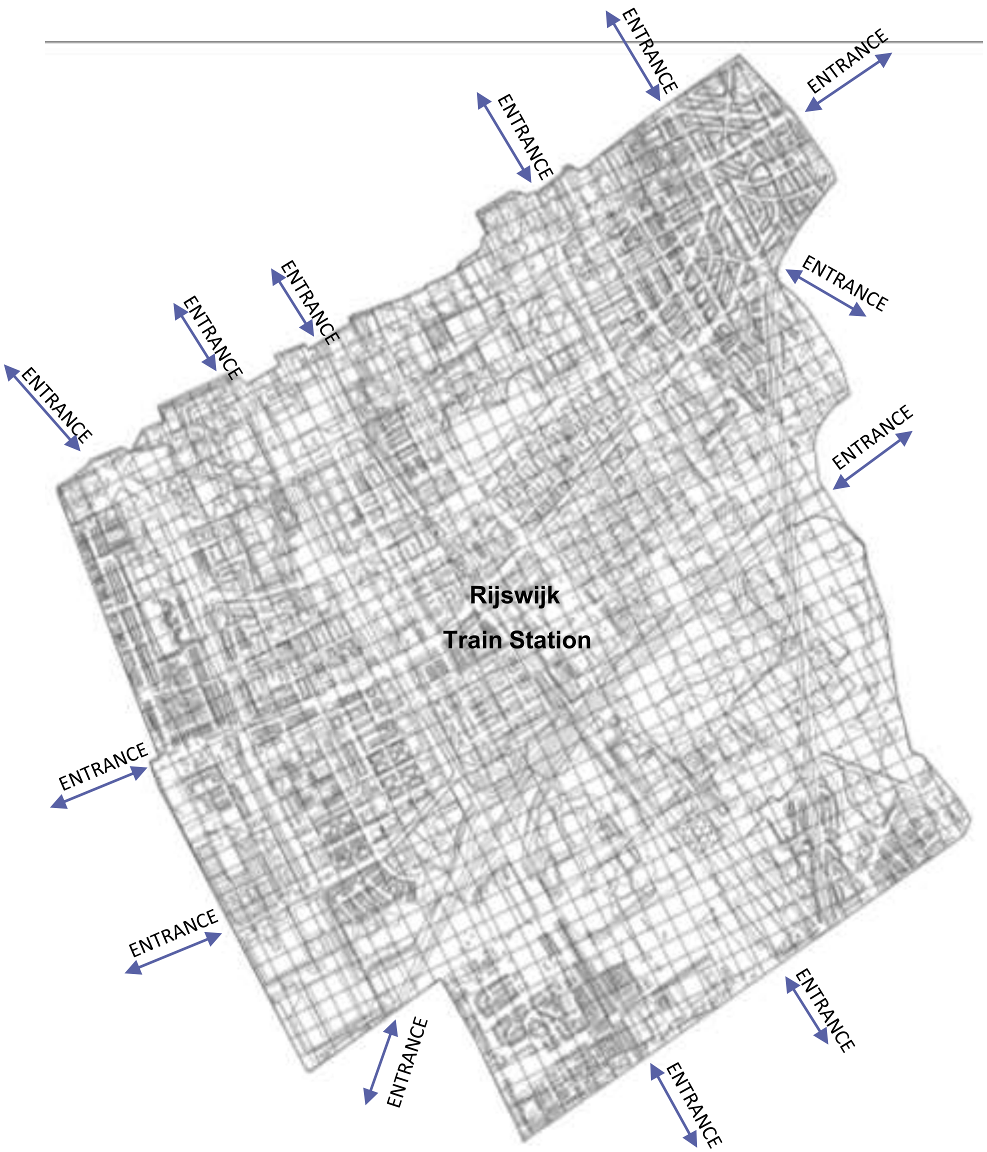
Function Connectivity
Railway

4.5km track

RIJSWIJK

Function Connectivity
Entrances

13 Main entrances



TOLLEBEEK

Tollebeek is founded in 1957 after the land was drained in 1942. The village is located at the east embankment of the Ijselmeer in the province of Flevoland.

TOLLEBEEK

Small Village

Location and Facts

TOLLEBEEK

Small Village

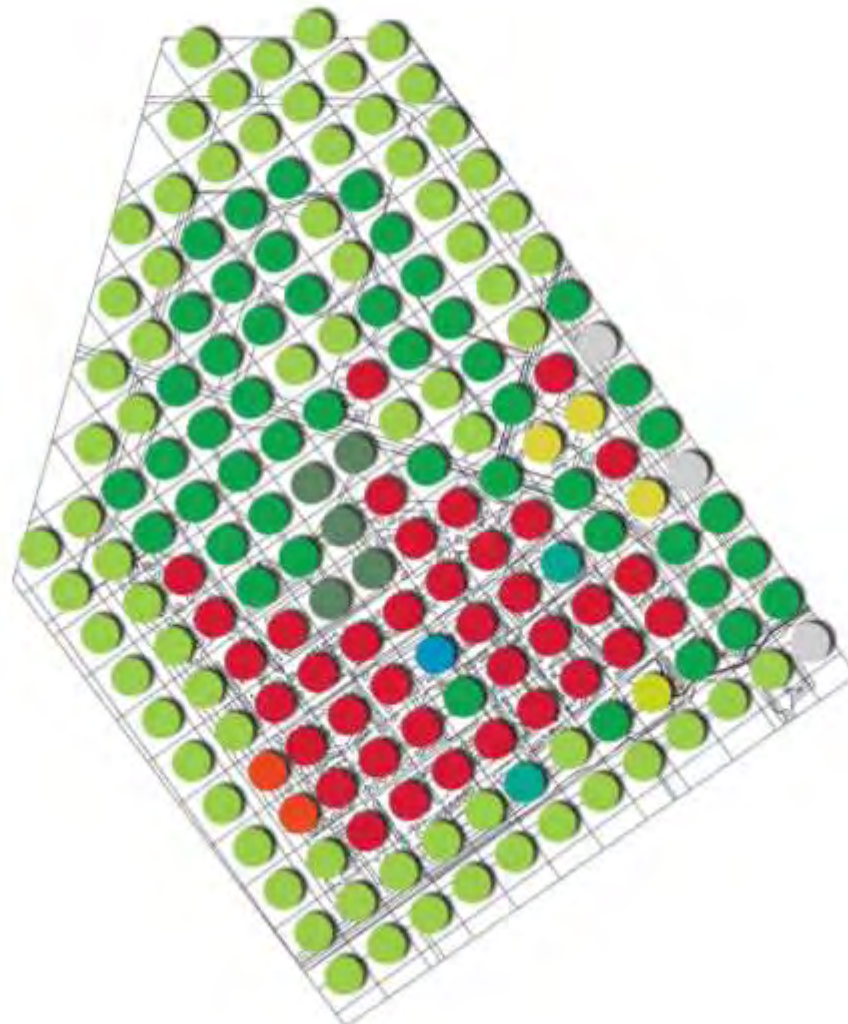
Location and Facts

TOLLEBEEK

- 2.450 inhabitants

TOLLEBEEK

- Living < 3 layers
- Business Commercial
- Business Light Industrial
- Business Agriculture
- Business Catering Industry
- Public Park and open space
- Public Building
- Public Educational Institutional
- Water



SPACE@SEA

TOLLEBEEK

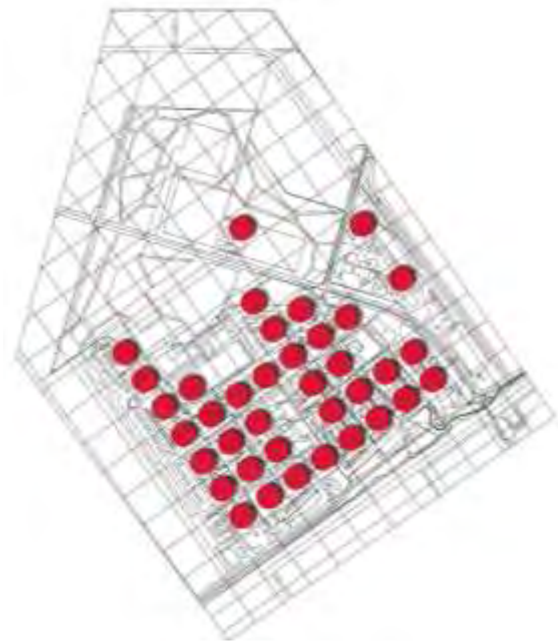
	m2 Footprint	% of total built area
Living < 3 layers	362.637	1
Business Commercial	16.602	20
Business Light Industrial	29.403	3
Business Agriculture	686.070	6
Business Catering Industry	9.801	1
Public Park and open space	460.640	4
Public Building	19.602	1
Public Educational Institutional	9.801	1
Water	29.403	2

TOLLEBEEK

Function Living

	m2 Footprint	% of total built area	% of total area
Living < 3 layers	362.637	22	21

- Estimated 26% of the plot area is dedicated to the footprint of the residential housing
- 26% is equal to 2.468m2 of total grid footprint of 9801m2 (platform)
- In Tollebeek the estimation of the total footprint than will be 164.458m2



TOLLEBEEK

Function Business

	m2 Footprint	% of total built area	% of total area
Business Commercial	19.602	1	1
Business Light Industrial	29.403	3	2
Business Agriculture	686.070	41	39
Business Catering Industry	9.801	1	1

- Estimated 9% of the grid area is dedicated to the footprint of a commercial building (excluding the agricultural area which consist mainly of farmland)
- 9% is equal to 842m2 of total grid footprint of 9801m2 (platform)
- In Tollebeek the estimation of the total footprint than will be 5.052m2

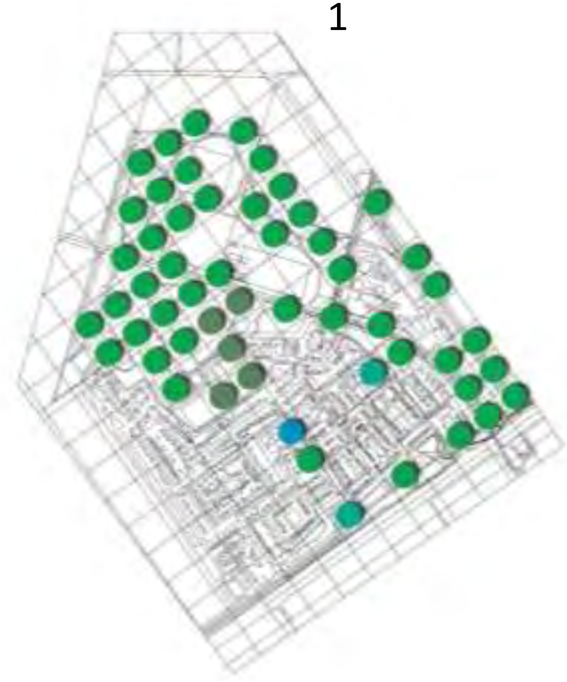
SPACE@SEA

TOLLEBEEK

Function Public

	m2 Footprint	% of total built area	% of total area
Public Park and Open Space	460.647	28	27
Public Building	19.602	1	1
Public Sports	49.005	3	3
Public Education Institutional	9.801	1	1

- Estimated 8% of the plot area is dedicated to the footprint of a commercial building (excluding the parks and sport facilities area which consist mainly of land)
- 8% is equal to 786m2 of total grid footprint of 9801m2 (platform)
- In Tollebeek the estimation of the total footprint than will be 4.716m2 (excluding parks and sport facilities)



SPACE@SEA

TOLLEBEEK

Function Water

	m2 Footprint	% of total built area	% of total area
Water	29.403	2	2

TOLLEBEEK

Function Connectivity
Main Roads Transit

2.0km track

TOLLEBEEK

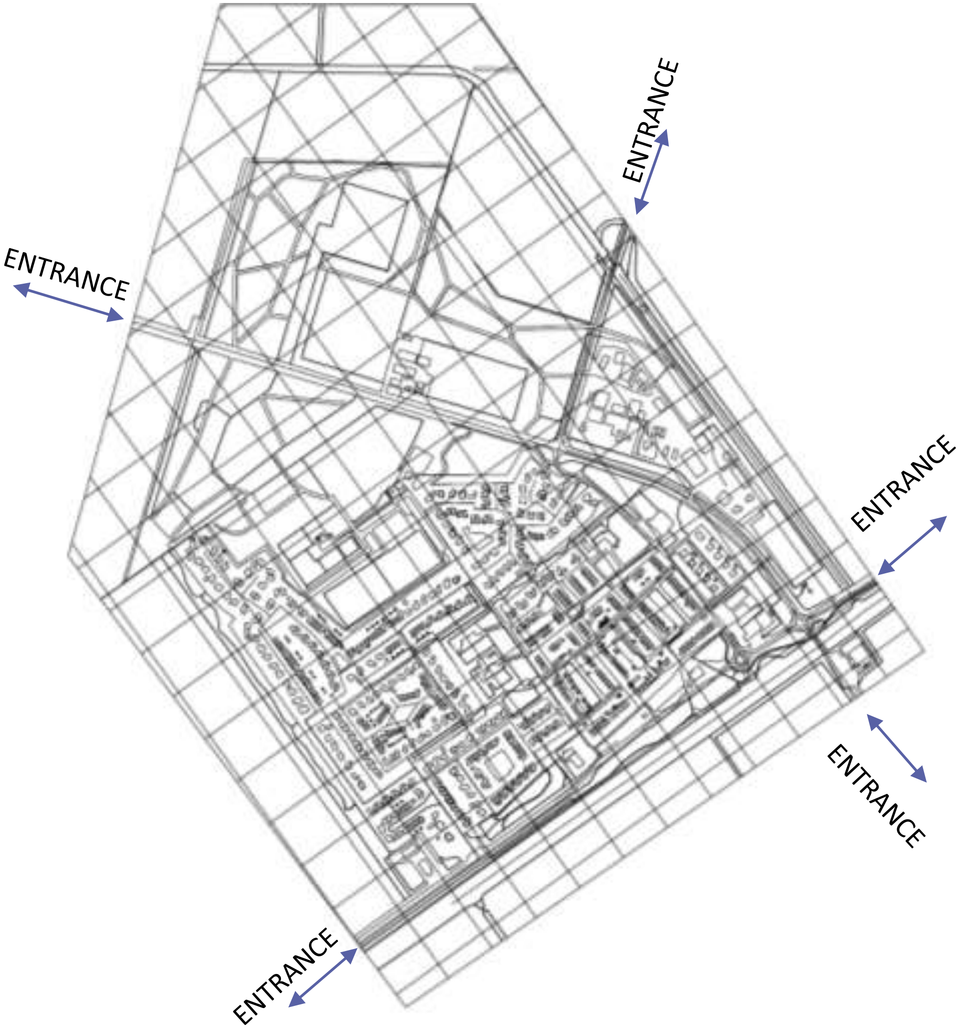
Function Connectivity
Public Bus Transit

1.2km track

TOLLEBEEK

Function Connectivity
Entrances

5 Main Entrances



WRAP UP

% of Built area	Masdar city	Rijswijk	Tollebeek
Living Residential <3 layers	0%	20%	22%
Living>3 layers	25%	3%	0%
Living community facilities	1%	1%	0%
Business Research and Development	4%	0%	0%
Business Offices	4%	1%	0%
Business Light Industrial	6%	4%	3%
Business Catering Industry	0%	1%	1%
Business Agriculture	0%	1%	41%
Business Commercial	0%	6%	1%
Public Hotel	1%	0%	0%
Public Park and Open space	31%	44%	28%
Public Leisure	12%	0%	0%
Public Building	0%	1%	1%
Public Education/Institutional	7%	1%	1%
Public Education daily care	0%	1%	0%
Utilities Solar hub	6%	0%	0%
Utilities Other	3%	11%	0%
Health Hospital	0%	0%	0%
Health Nursery	0%	0%	0%
Water	0	5%	2%
	100%	100%	100%

Appendix – 4 Parametric Design and Configuration Study

Table of Contents

1. HOW
2. WHY
3. Script trials
4. Comparision of platform geometries
5. Platform Design
   Concept -100m
   Concept -50m
6. Studies
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8. Optimum platform numbers
9. Input for simulation
10. Configuration concepts

HOW –

- Searching of different urban scenarios: A, B, C, D, E, Etc. each with specific characteristics.
- Program selection, of this different urban scenarios.
- Carrying different studies with grasshopper scripts, to obtain outputs and observations based on the rules and parameters.
- Output performance : how well functioned city at comfort, technique, ecology, feasibility.
- Output tuning.

WHY –

Grasshopper

- Grasshopper – computational tool helps to arrive at a design output based on rules and parameters.
- Once we define rules and parameters – the script can be used for any conditions. We will obtain the respective outputs based on our inputs for the rules and parameters.
- We can keep adding new rules – it becomes a cumulative script.
- We can study more outputs in a time frame and produce better results.

Script trials

Introduction

With the studies in our previous presentation. We started generating the city pattern and fabric.

We are defining the space @ sea through scripts in grasshopper.

These scripts will be the source code for the cities in varies condition and senarios. The design methods are approached with systematic algorithmic scripts.

These algorithms will be the data sources for the future – floating cities. This data collection helps us in gathering and measuring information on targeted variables in an established systematic fashion, which then enables one to answer relevant questions and evaluate outcomes.

The algorithms will helps us find a better solution and configuration, based on the flexibility tools. The city could be tuned and will make it adaptable.

Trial -1

Starting with triangular floating platform. In this we are understanding how platform can be eleminated on the need for creating blue spaces for the neighbourhood.

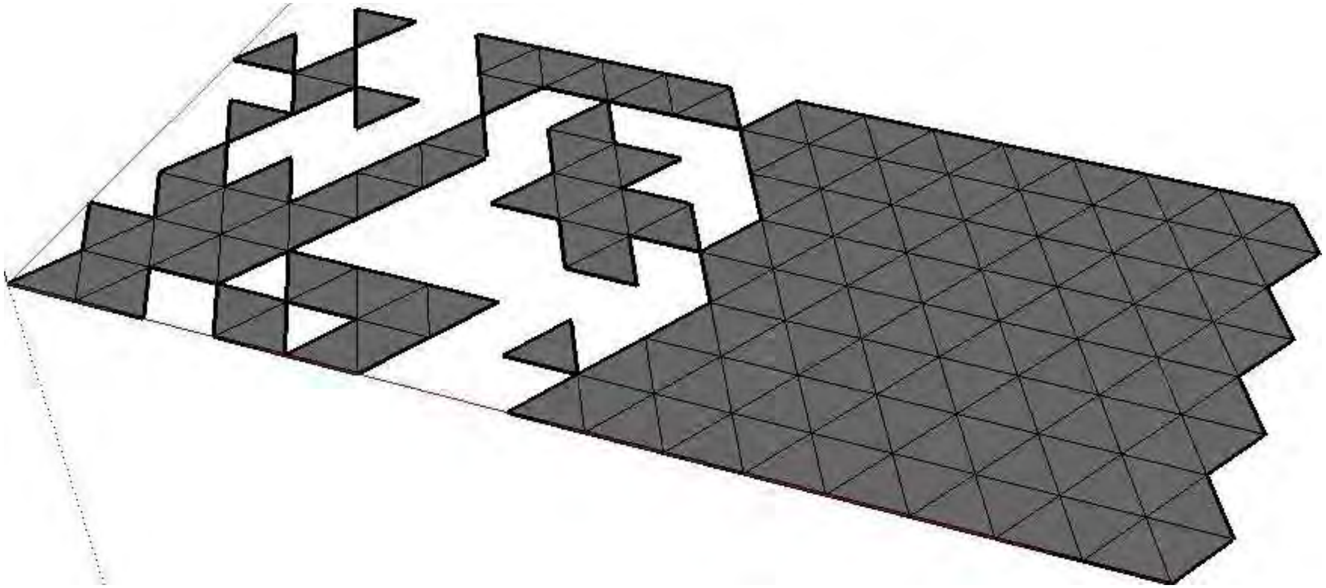
We define the points or we define a path along which blue spaces needs to be created.

Different parameters -

1 - Number of points or points along a path.

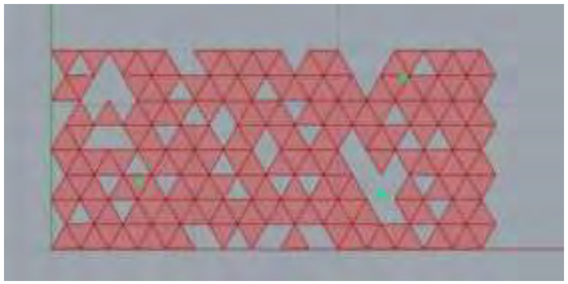
2 - The distance range between them.

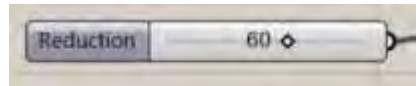
3 - Numbers of units to be eliminated.

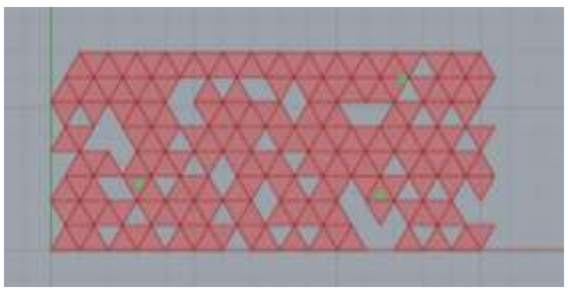


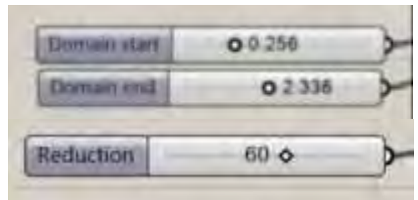
Trial -1

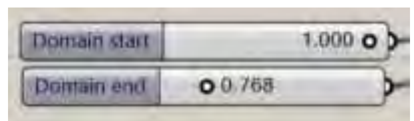
The defined points in the neighbourhood.

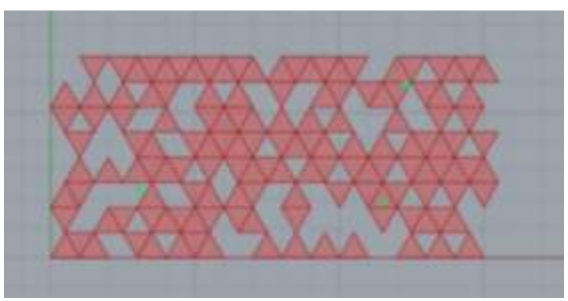


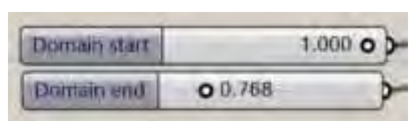












The domain help to group the distance limit from the defined points.

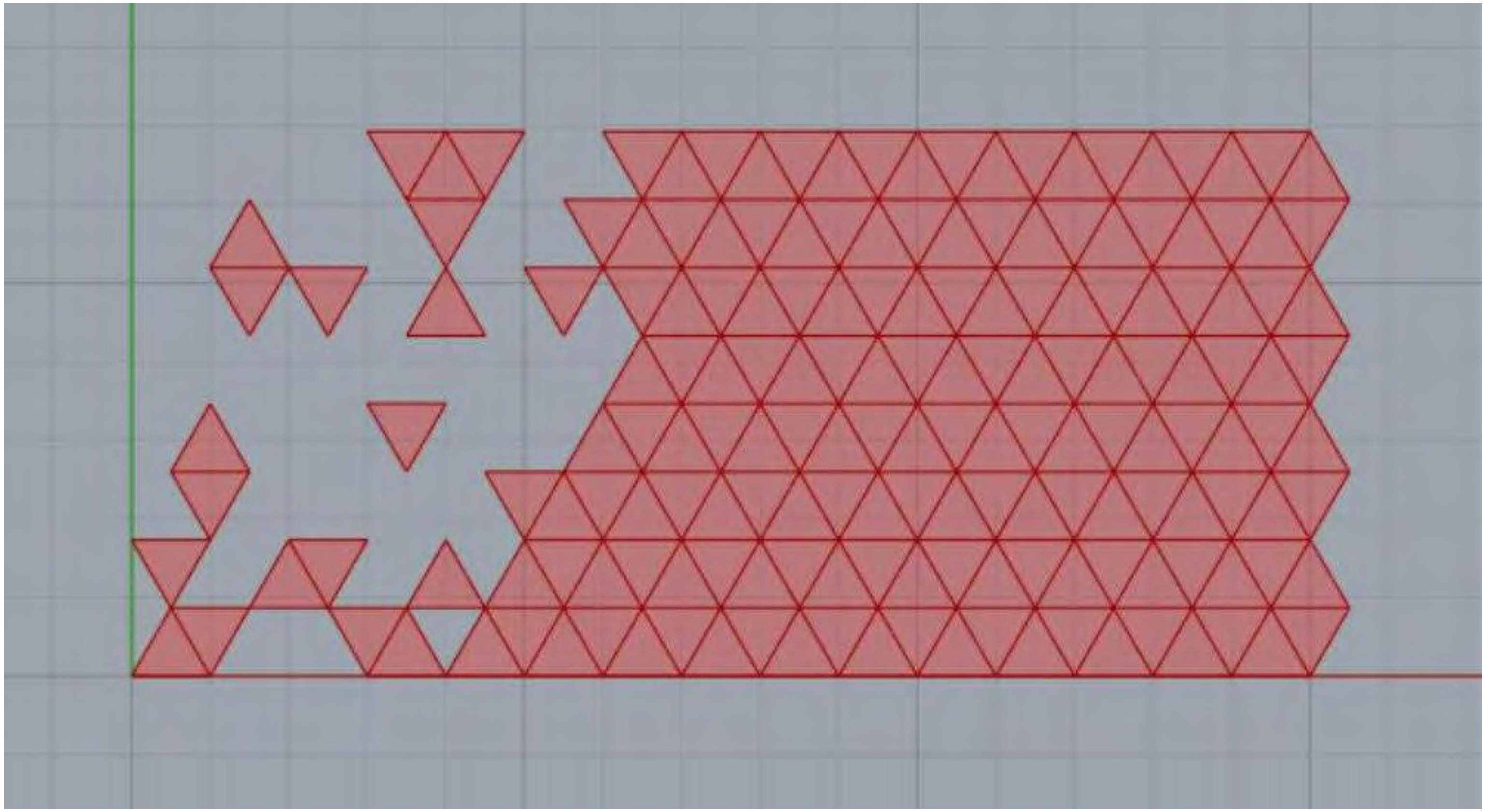
This helps us to set the limit or the distance range, where we want to create blue space.

This helps us to create more open face towards water.

Trial -1

Definition for points along a curve.

This helps in creating more opportunities for functions like dock yards, local recreational spaces, or a transportational terminal.



Trial -2

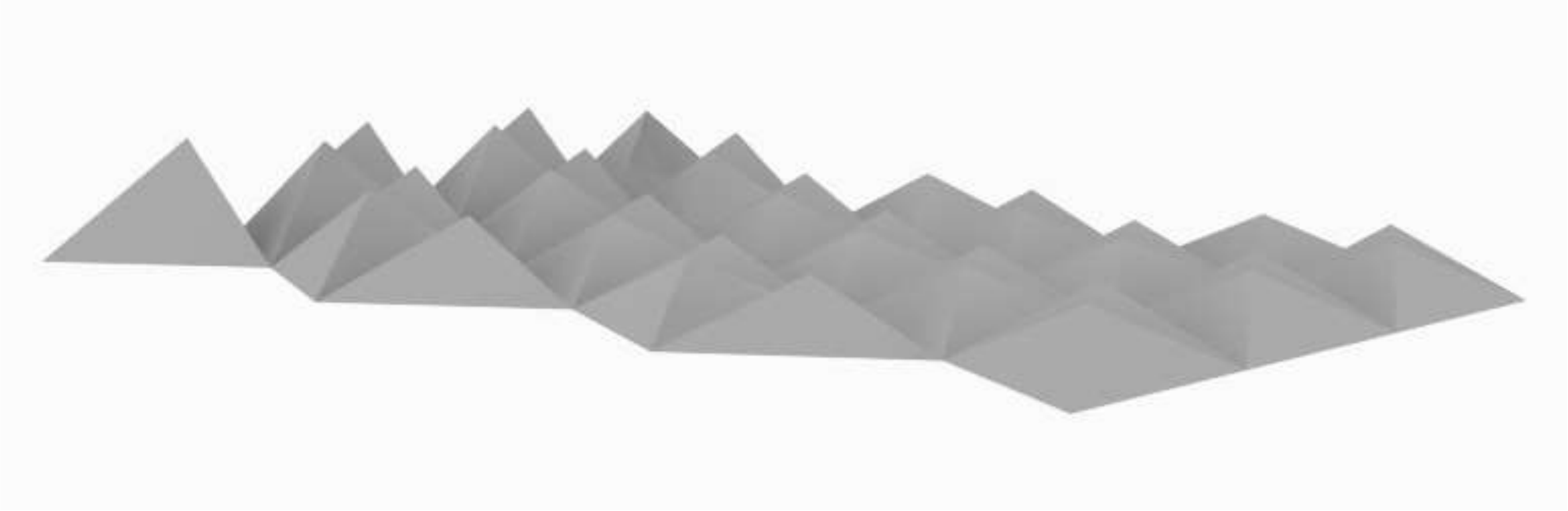
The idea of a built form should respond to the platform profile. So we attempeted to create triangular prymide. Inorder to define it for different functions, we attempted to vary each built forms height.

In this the height of the built form responds to a functional graph. Through this, we also attempted an iteration – if all built form have same height and the functional graph trims the existing form. We got much open space on a higher level, which gives a different perspective of the surrounding.

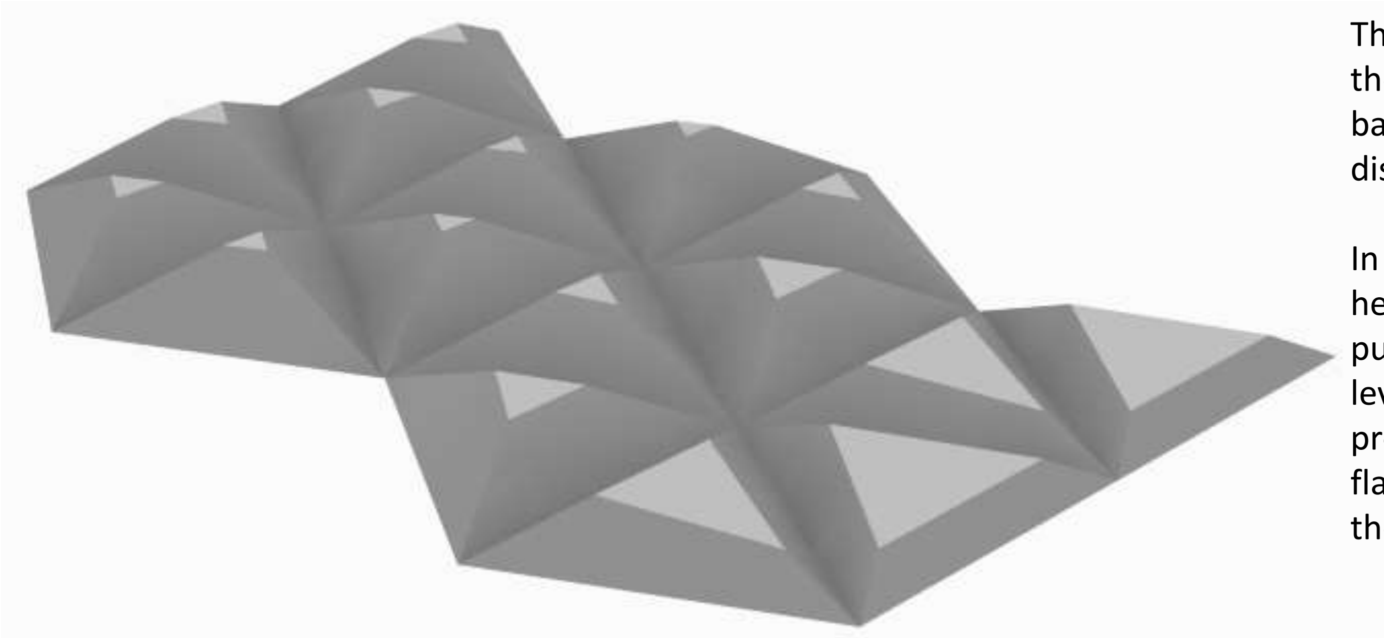
Parameters –

1 - Extrusion value (height).

2 - Graph defining the height based on the functional need.

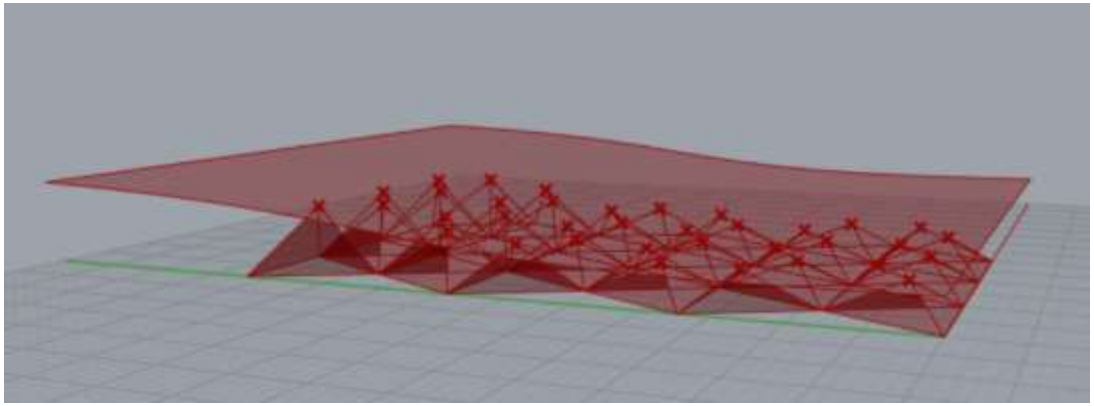


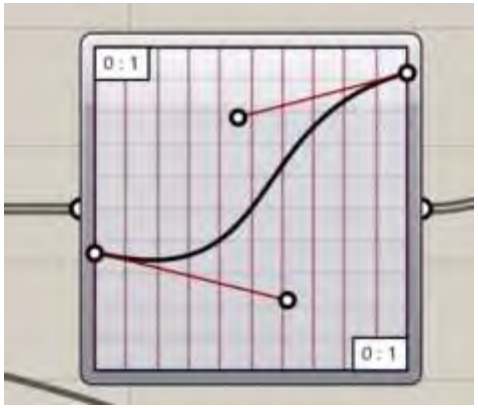
Trial -2



This helps in defining the heights of the form based on the functinal distribution.

In the second iteration it helps us to think about a public space at a higher level and relation / proportion between the flat surface on top with the functional graph.





Trial -3

From the previous attempt,In this we study how relatively the public spaces on higher level can be defined with different massing of each block. Based on the defined form.

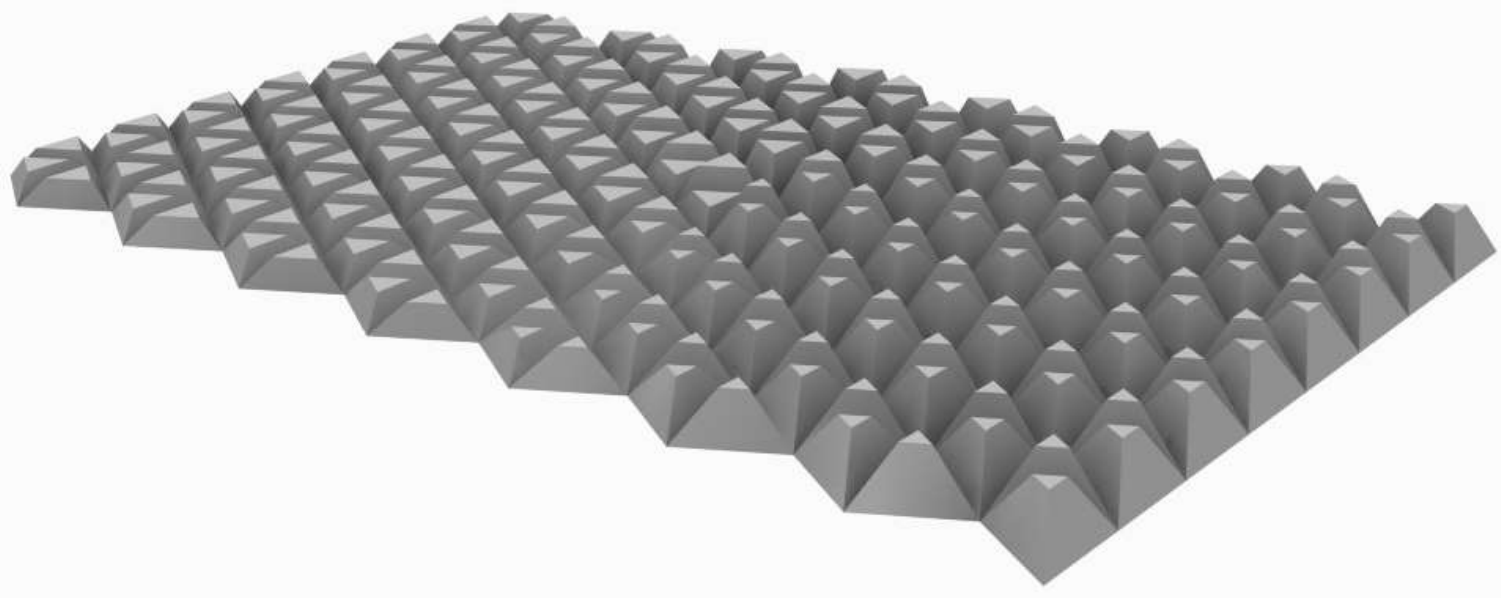
Parameters –

1 - Functional spots / points.

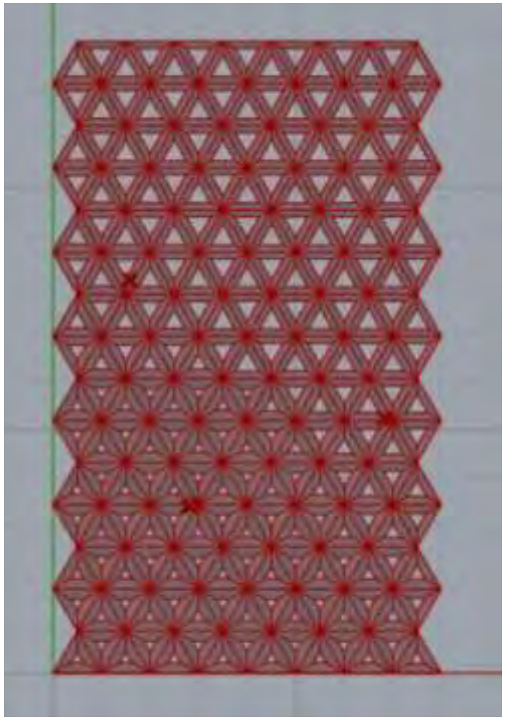
2 - Scale factor for the higher level spaces.

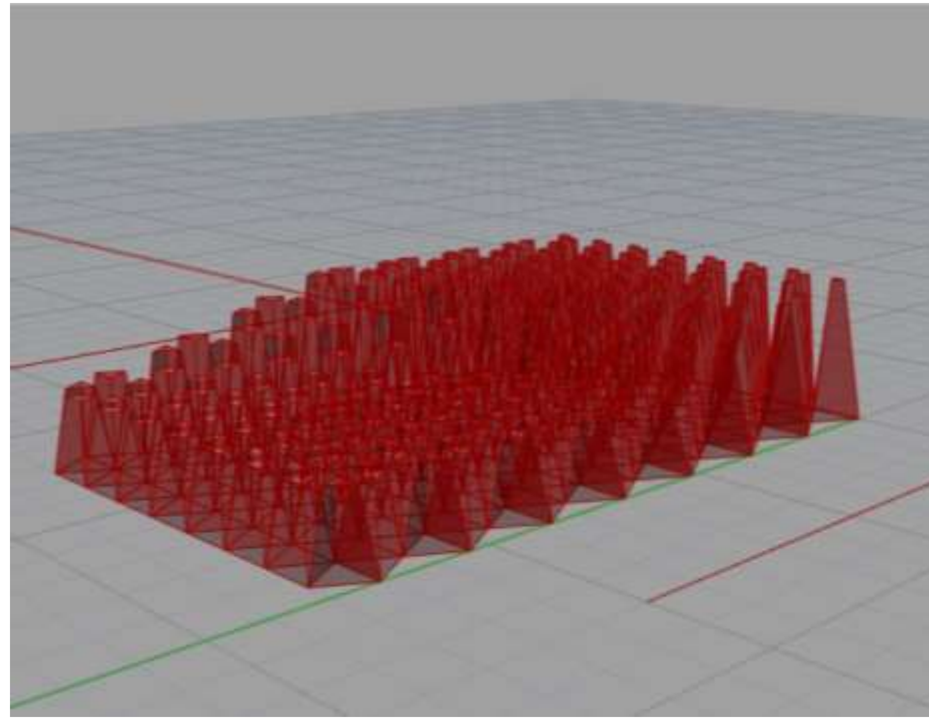
3 - Extrusion value.

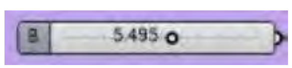
4 – Slope.

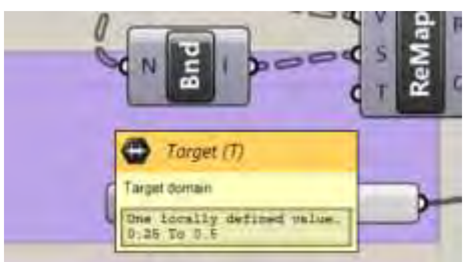


Trial -3







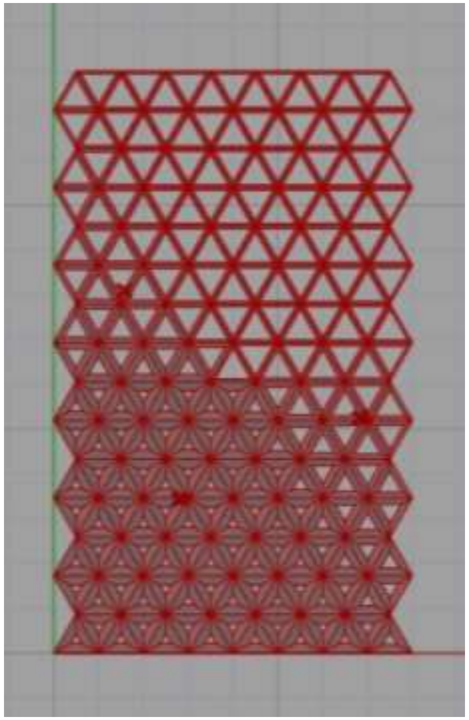


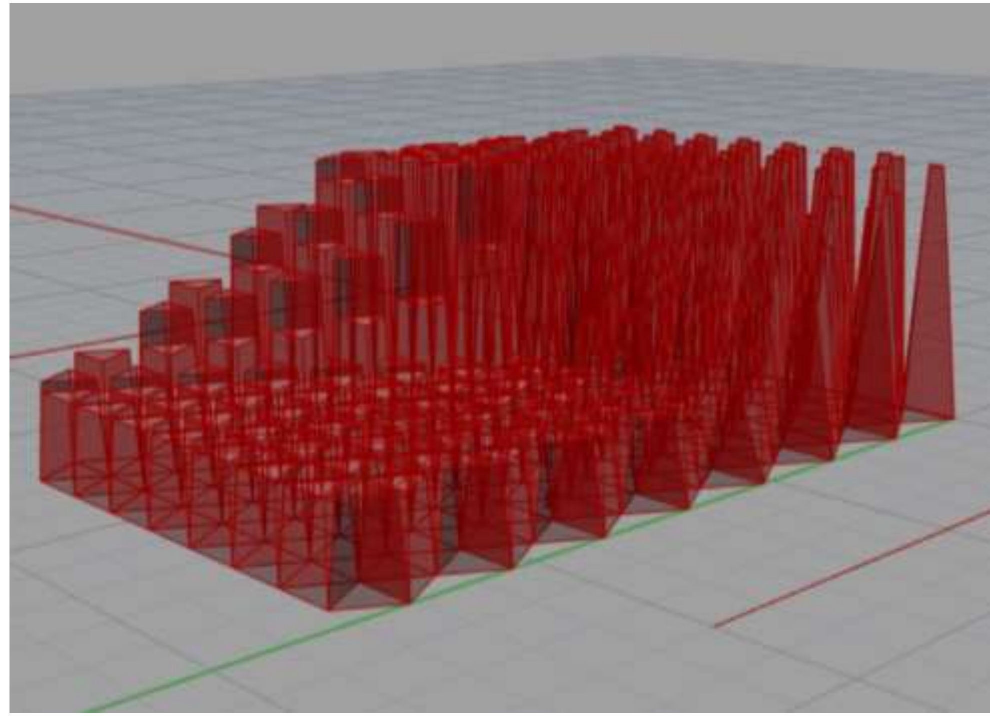
The extrusion factor is fixed.

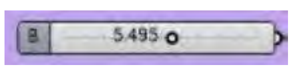
But when the scale factor or the slope factor is varied. This influence the form of the building.

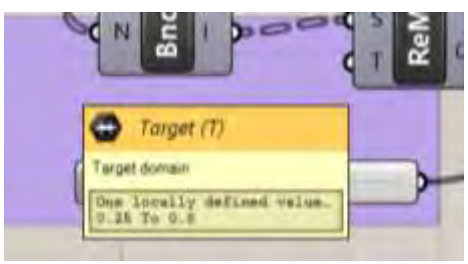
The plan shows the open space on top, in relation to the height.

Trial -3







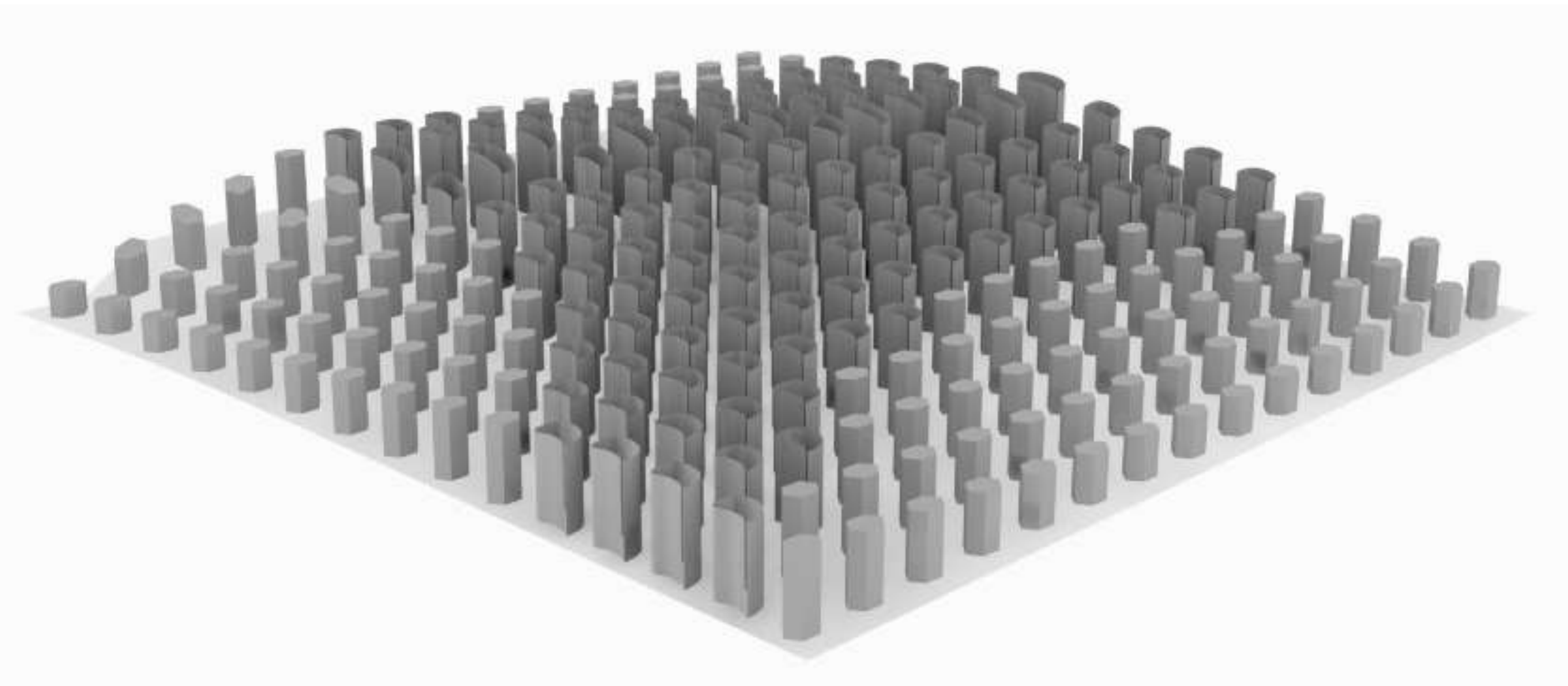


This helps in finding the relation between the flat area on top with the slope of the built form. Also it helps in determining the height factor of the form.

Trial -4

In this we are trying to distribute specific built form, for specific function zones.

Here a grid pattern is used to have grip on the idea of distributing building forms.



Trial -4

The built forms are predefined. Based on the functional points or the nodes, the area is divided based on the influencial region and accordingally the built forms are packed.

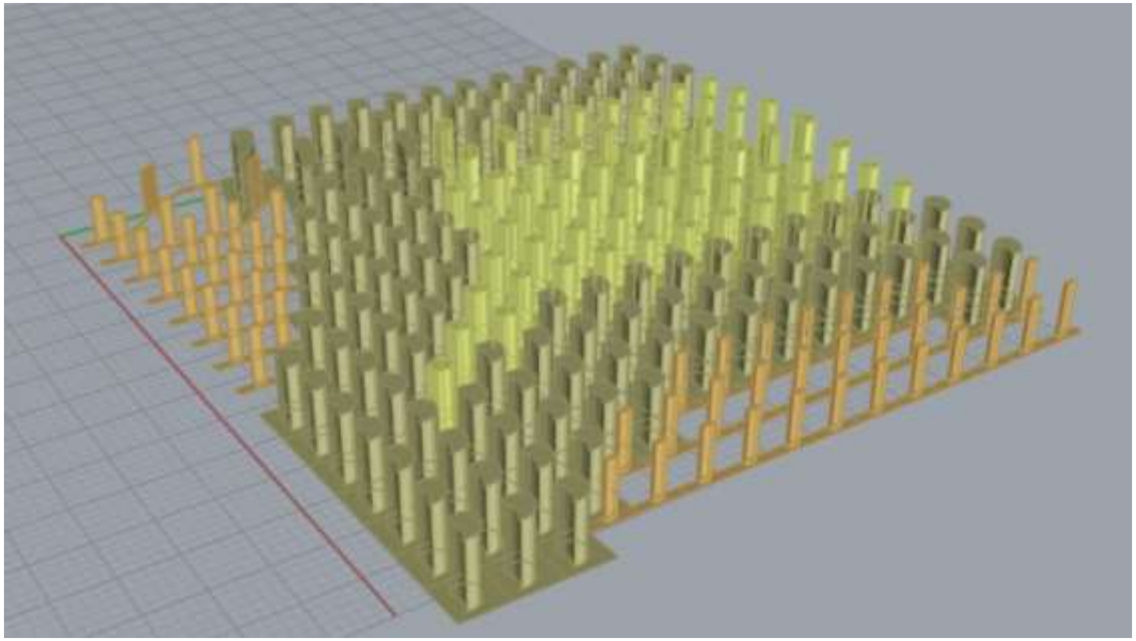
Parameters –

1 - Functional spots / points.

2 - Height for the built form.

3 - Area of influence.

This will help us in organising each building typology based on the functional need.



Conclusion

In the previous session, we tried to get an understanding on relation between the functional nodes and the built form and the platform.

In an urban planning, the built form is mostly dependent on the function, it's catering. Each function demand its own form but there is a connection or slow transision between two.

The idea of having open public spaces on the higher level will bring in a different spacial quality for the city, with multilevel of different functions performing together. It creates a mixed use pattern – adaptable form.

Trial -5 City growth parameters

In this chapter, we take an attempt to script the city growth pattern.

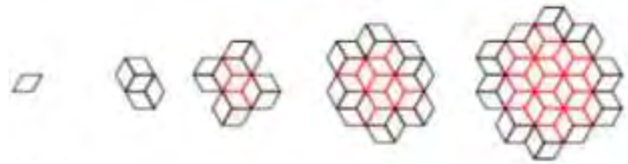
It becomes a necessery tool to study the growth pattern of the floating city. There is no defined boundary conditions or topographical constraints.

A set of rules has to be defined for the floating platform to develop, which is functionaly driven.

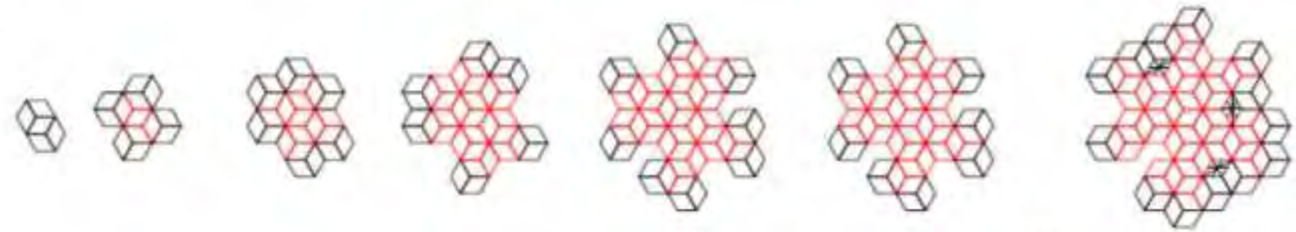
This will help in understanding on orign of a city and dynamics of it's configurations.

Trial -5 City growth parameters

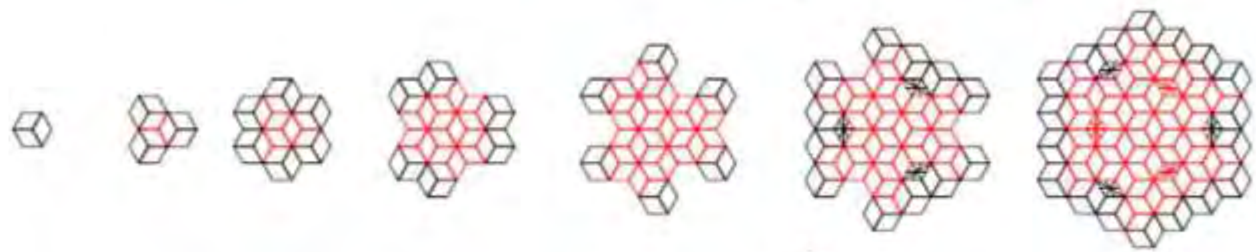
Mirror on all open edge



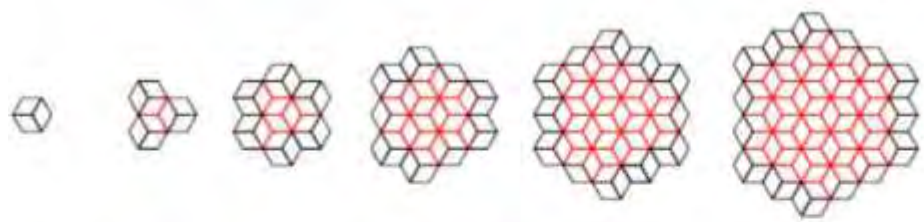
Mirror only when two sides are open



Mirror on all open edges – When 2 edges are open



Mirror on all open edges



Moving along a point

Trial -5 City growth parameters

The growth pattern along the different points of the given base form, gives more flexibility of growth compared to other growth pattern.

This helps us to have more control over the program, functions of the city and the city blocks.

In all other growth pattern- the platform are developed on the periphery.

Being a floating city, it gives us an opportunity to develop from the inner core. The algorithm to move along the points will help in bringing this growth form. Where the shortest open ends will be reconfigured to accommodate new platforms in the central spaces. Which doesn't change original functional configuration and also allows us to easily reorganise functionally, (for adaptability) because of more open ends.

Parameters –

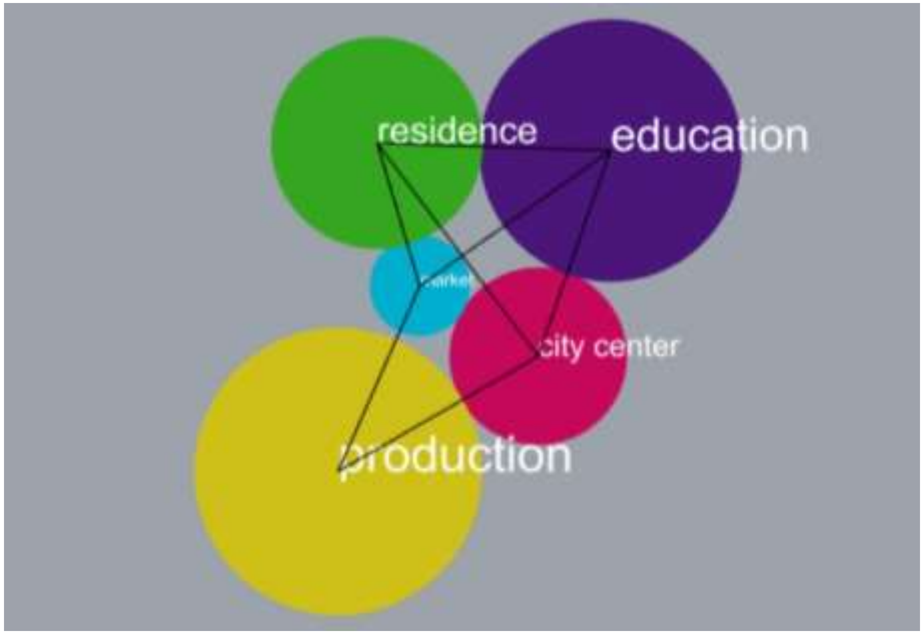
1 - City functions.

2 - Area per.person variable.

3 - Near growth.

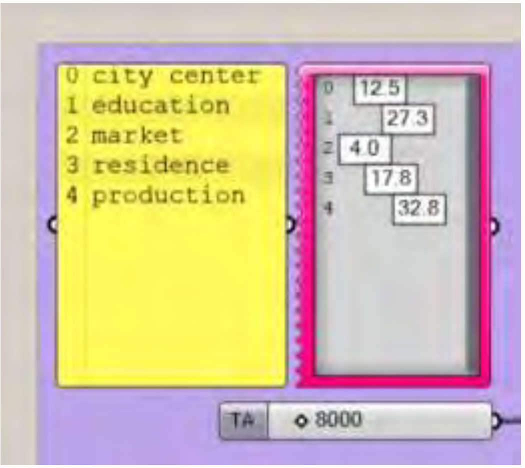
4 - Deform the equilateral triangle.

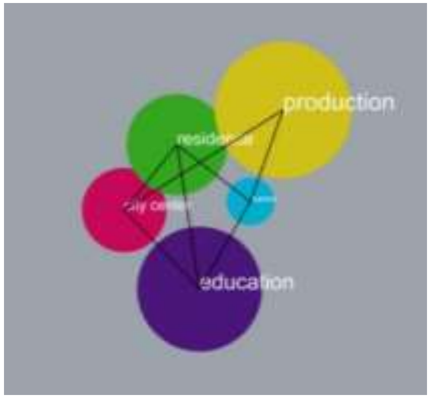
Trial -5 City growth parameters

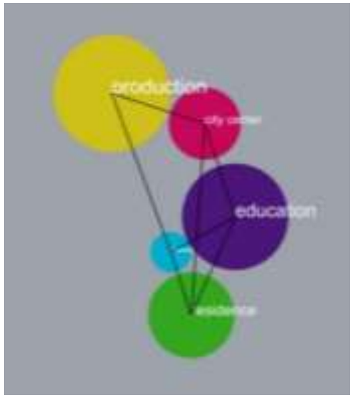


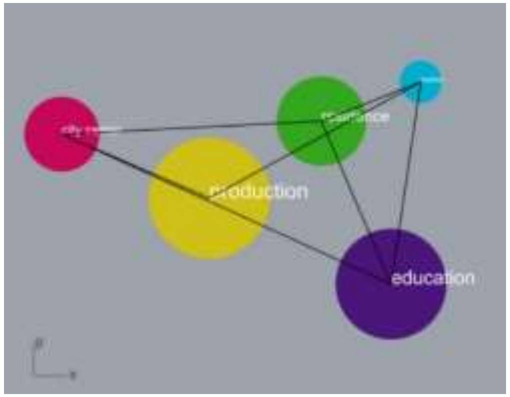
Initial city functions are defined and the best configuration is opted, out of the lot.

The area for each function is also defined.





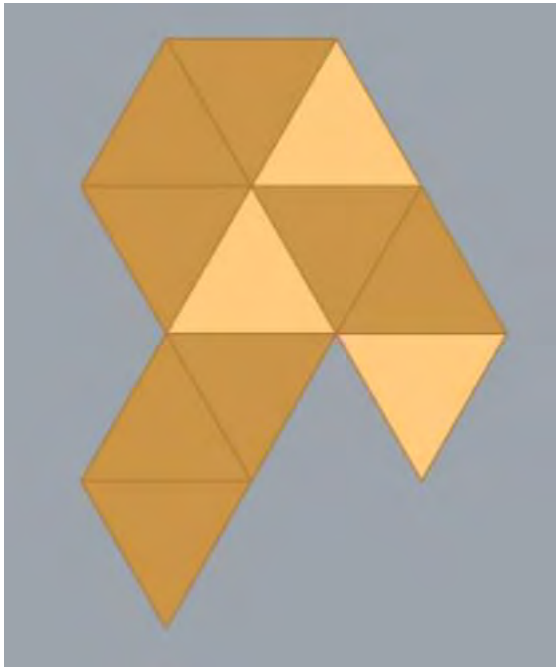




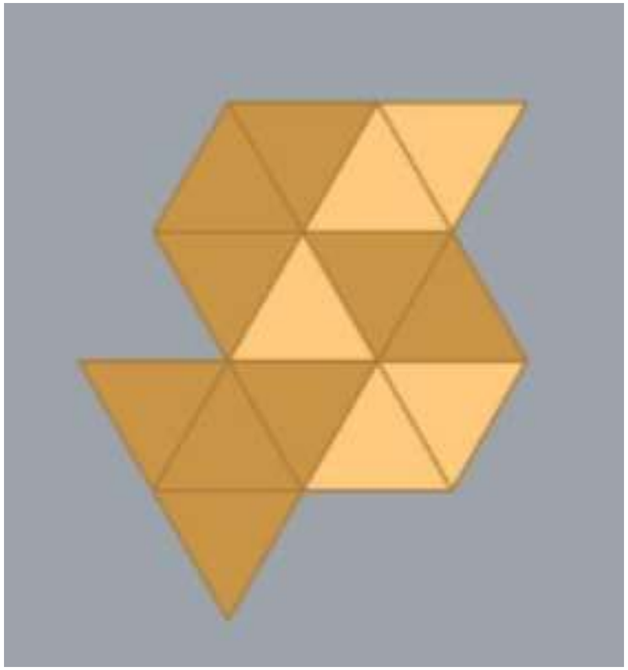
Trial -5 City growth parameters

Initial city structure – with given area and the functions

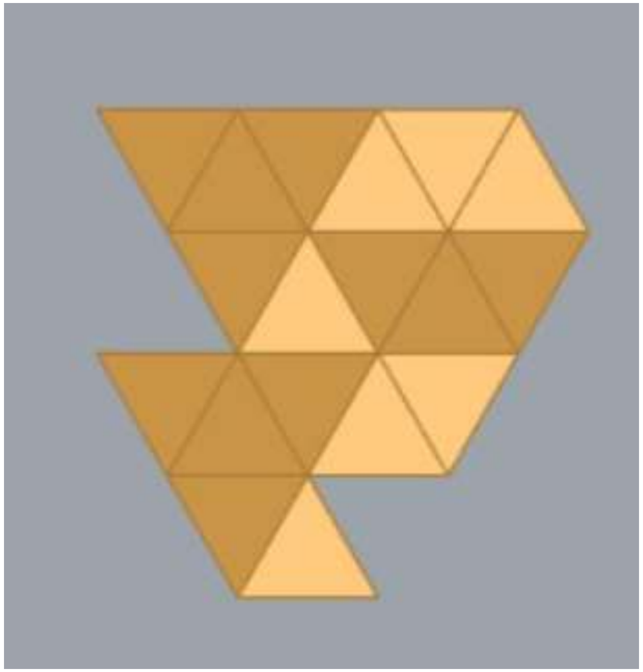
It forms equilateral triangle with 50m as one of its edge.



Initial form



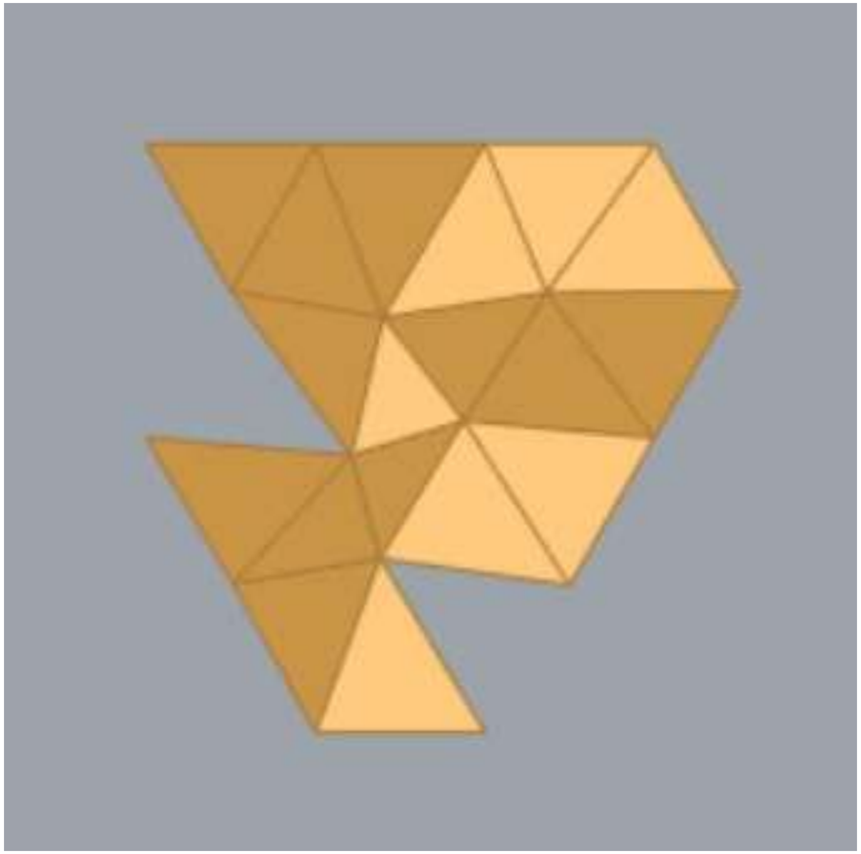
Step -1 increase in per person area

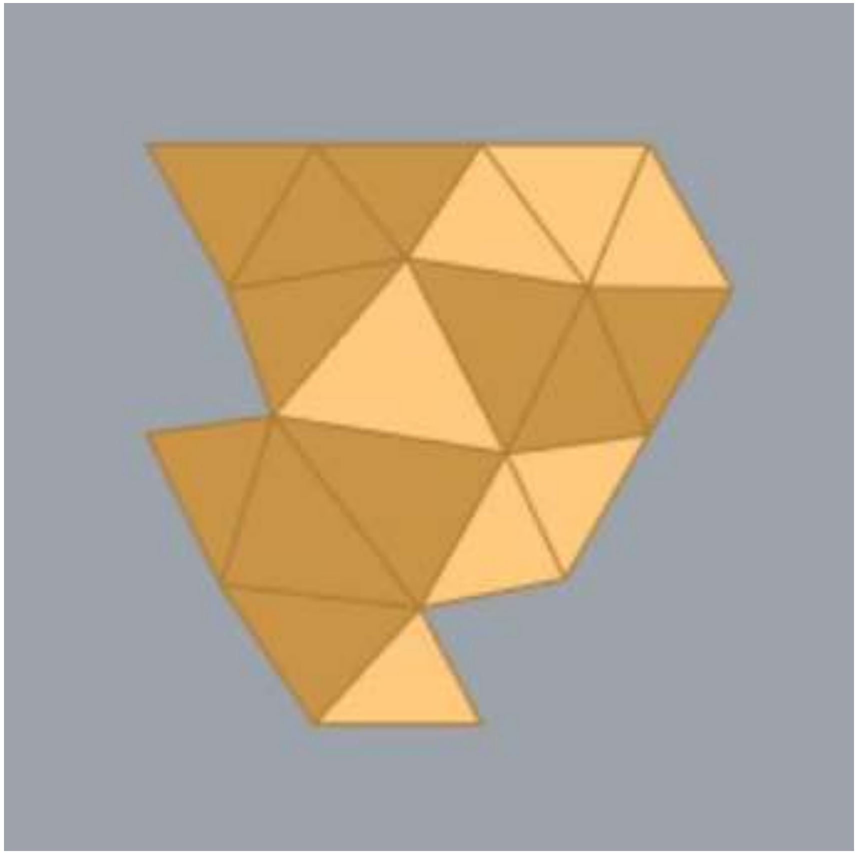


Step -2 increase in per person area

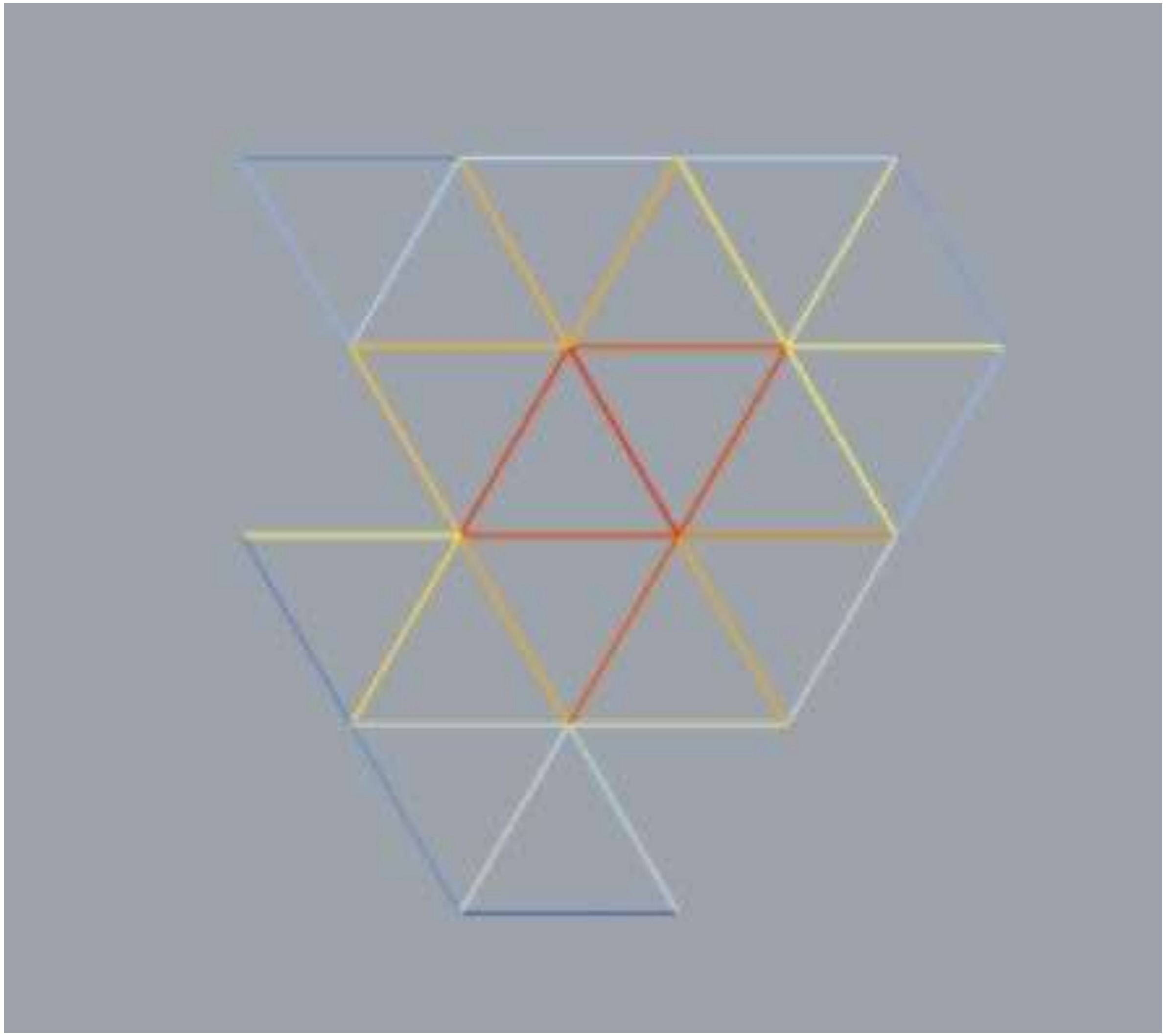
Trial -5 City growth parameters

We start deforming the equilateral platform on the basis of increasing the area or decreasing the areas of platform closer to the functional nodes.





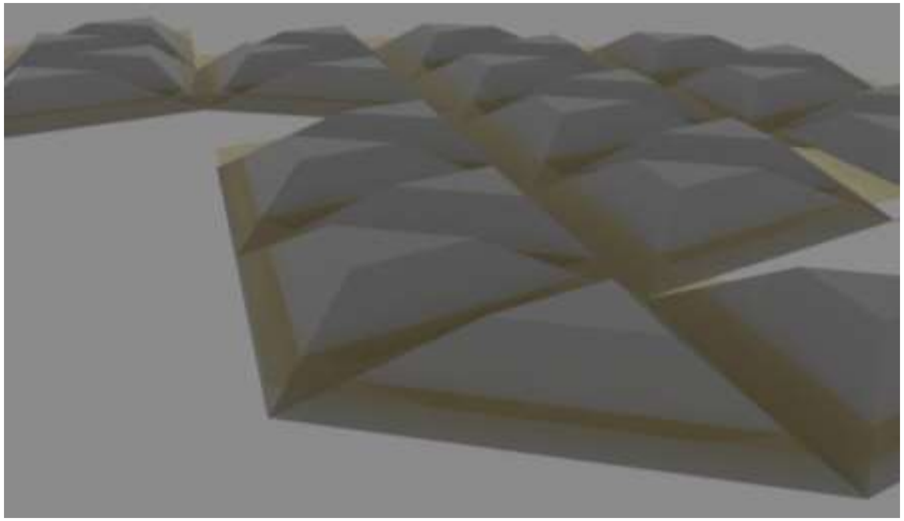
Trial -5 City growth parameters

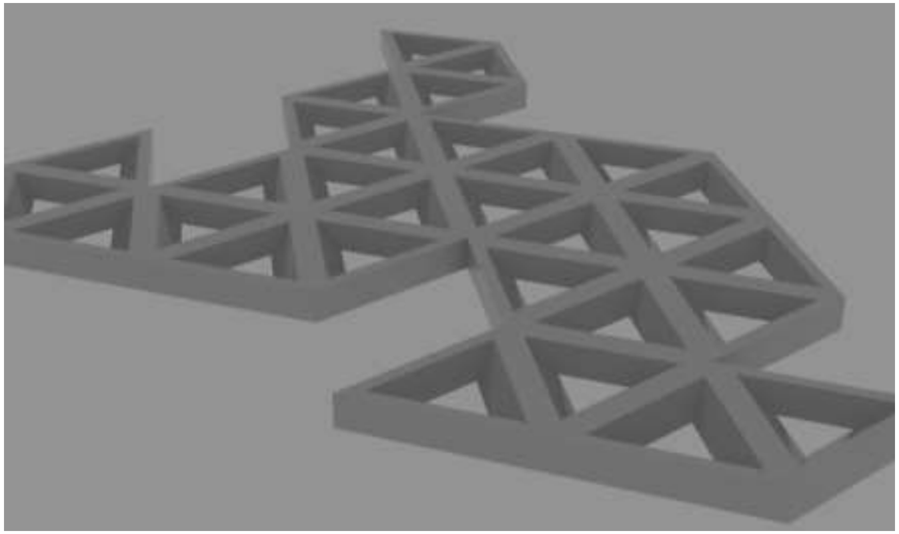


Study on the street movements based on the formed network.

The study is only for the peripheral movement.

Trial -5 City growth parameters



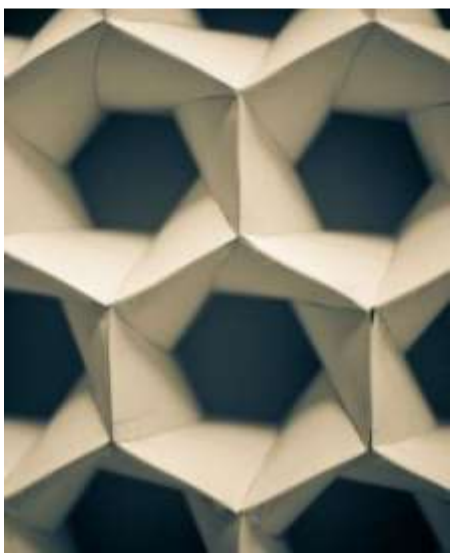


From the formed cluster, we tried different movement pattern and building blocks.

With the triangular pyramid form and a mid layer for network and top layer of open spaces.

An idea of perimeter blocks with central open spaces.

References



Conclusions

The city developes in an organic pattern.

The algorithm defined along the points provides the flexiblity to look for better configurations for both functional nodes and platforms.

Periphral movement and different levels of open space and movement pattern improves the city functions.

Trial -6 Waterfront grid

In this study we are attempting the possiblities of giving additional flexible spaces to the existing city.

This plugin can generate through the existing water channels, or to the city fabric.

This module extends the existing network of movement and adds water ways also. The city blocks gets connected with water canals.

Its opens out more public interactive spaces.

Each block has both faces- one towards the city network and the other to the water – creating different spacial experiences.

Trial -6 Waterfront grid

Initial attempt to work out the combination of spaces. Visual creation.

Trial -6 Waterfront grid

Scripting the visual creation

With the initial visual, we started scripting in grasshopper.

We will be generating a source code which can be tuned to different situations and conditions.

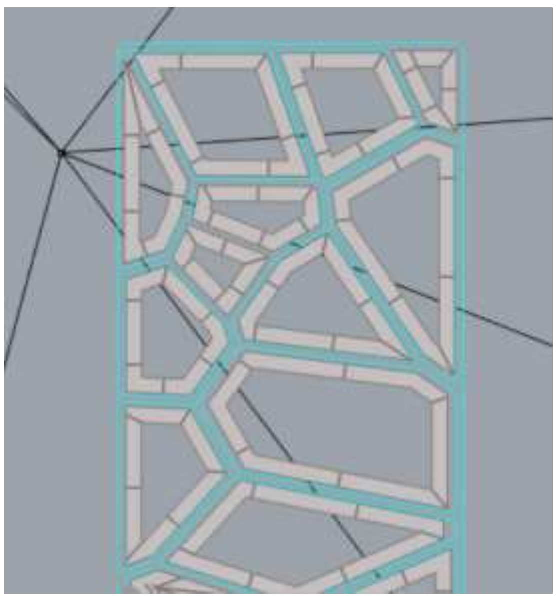
This source code will be the DNA for more waterfront grids system to come up in the future.

Trial -6 Waterfront grid

Attempt - 1

We started defining it with number of block – we want to create and the connectivity within them.

We generated the city block within a defined region and parallel street networks and internal water network.



Parameters –

1 - Number of blocks.

2 - Areas of each block.

3 - Street width.

4 - Building block width.

5 - space in-between blocks.

6 – blocks height.

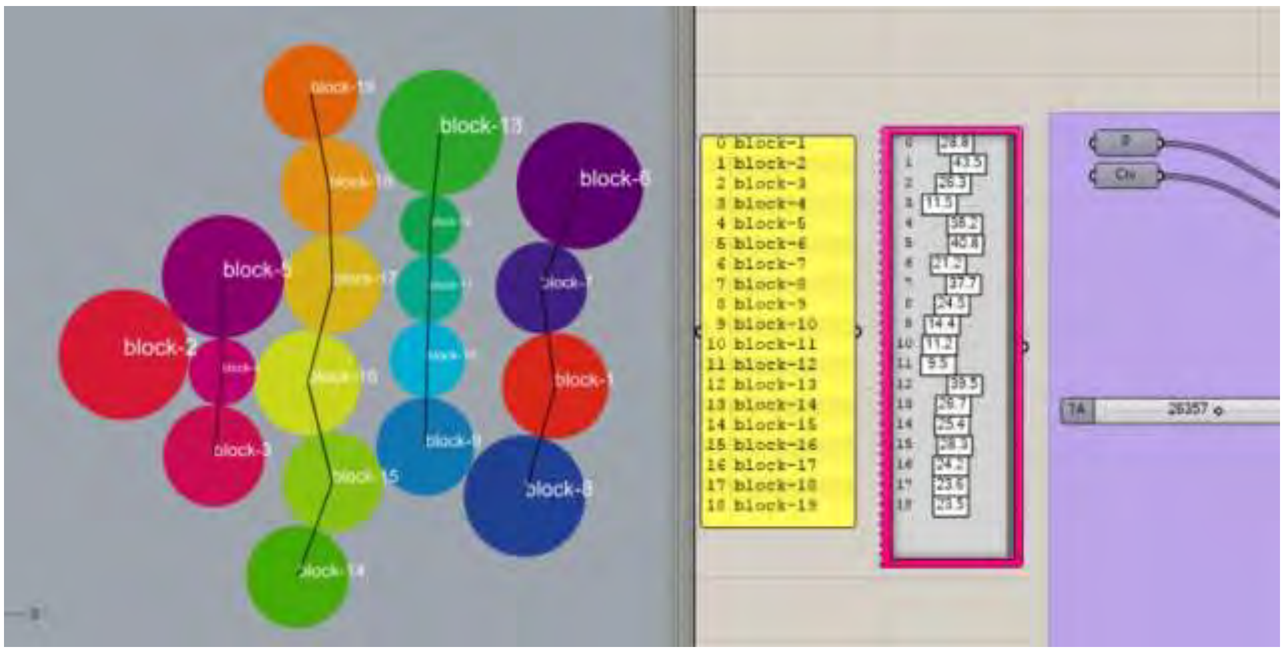
Trial -6 Waterfront grid

Attempt - 2

In this we gave more characters to the sorce code.

Worked out a generative growth factor for the city fabric. Which will enable the city to grow in the near future.

We created more characters to the streets. By opening canals and interconnecting the city network and the water.



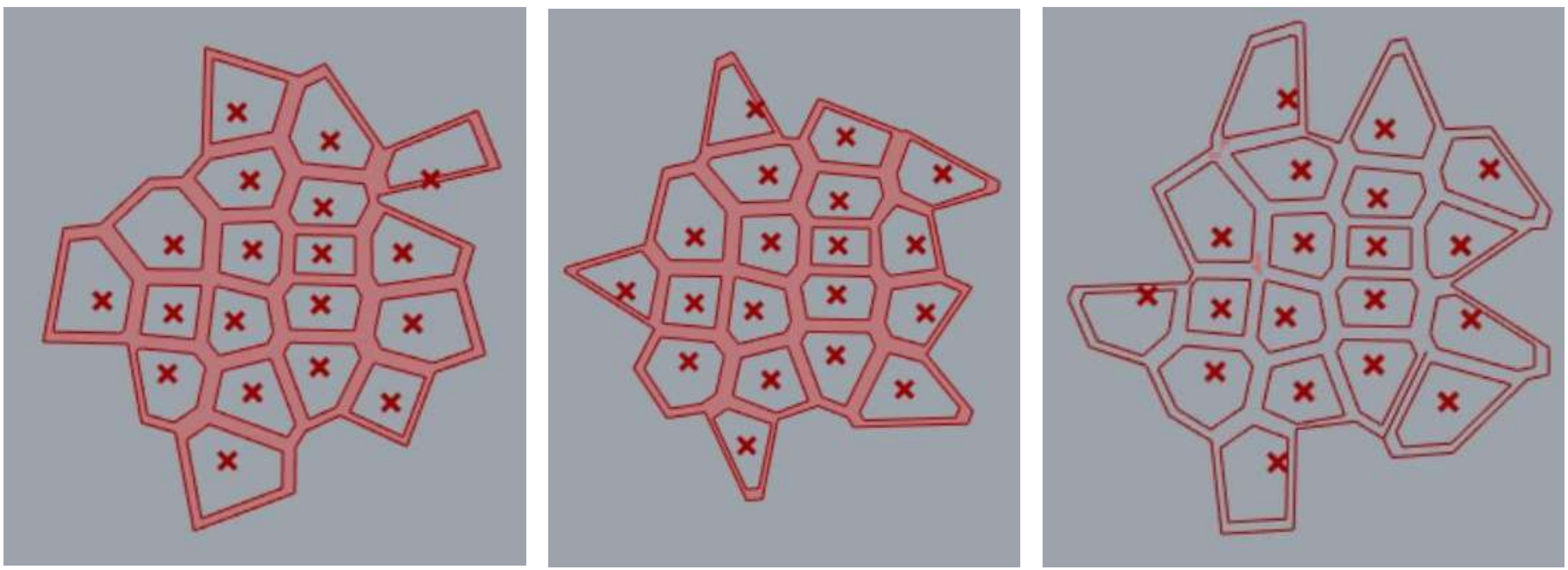
Define the urban blocks and configure the arrangement.

Trial -6 Waterfront grid

Attempt - 2

With the defined configurations. The script will develop the network of streets, set the limits to get the better peripheral combination.

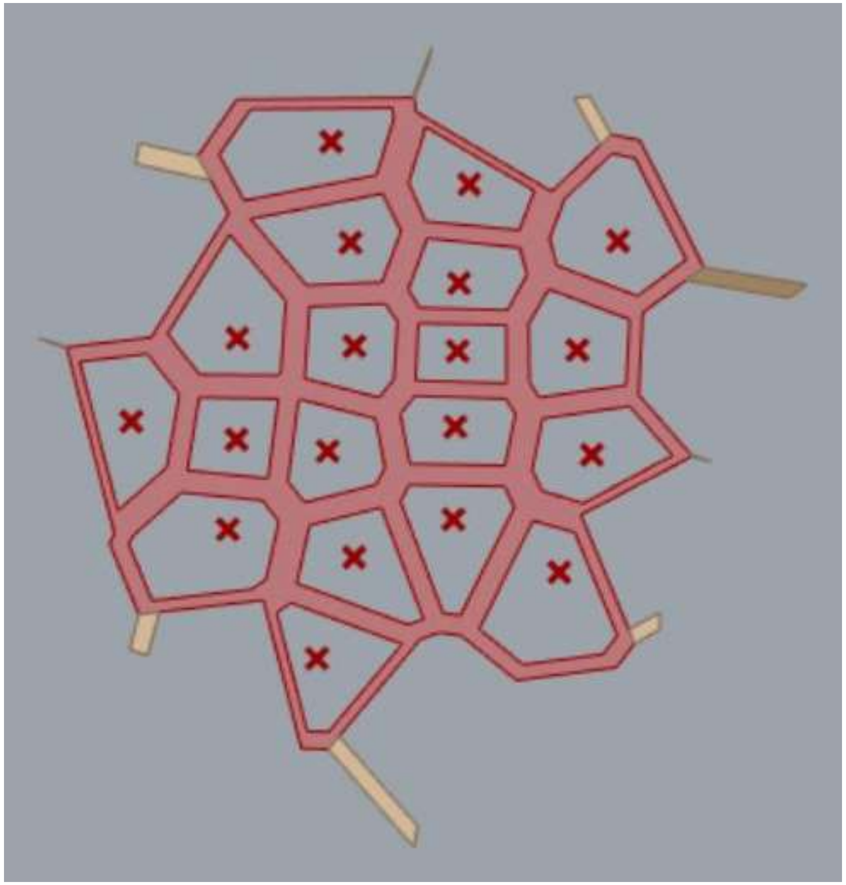
The extended streets will act as a dock space, later if the city grows this will transform to a block by itself.

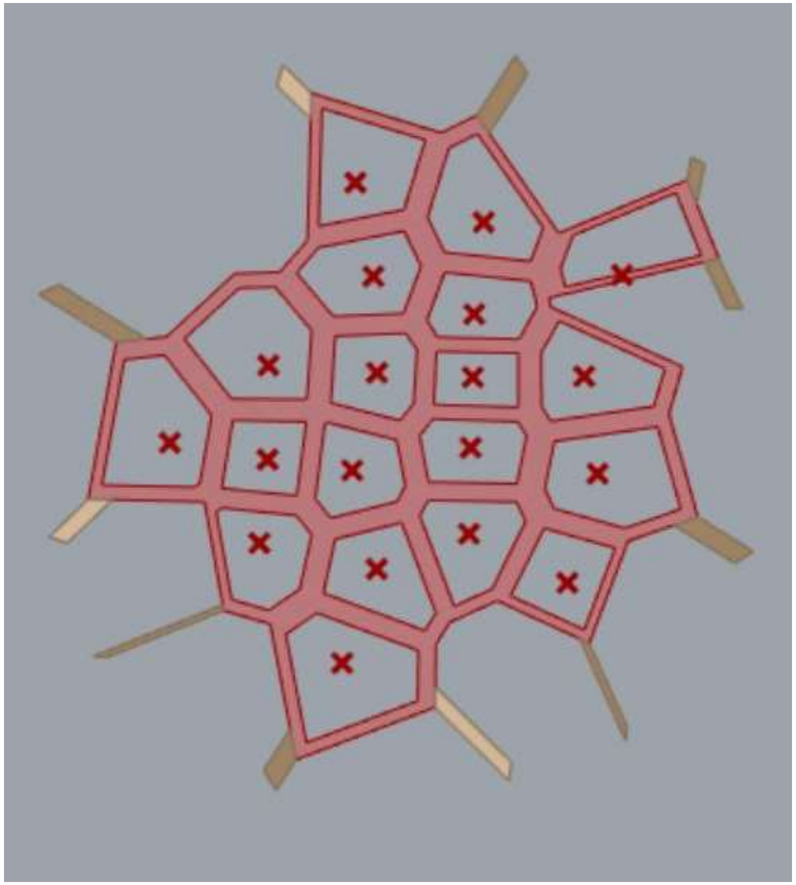


Trial -6 Waterfront grid

Attempt - 2

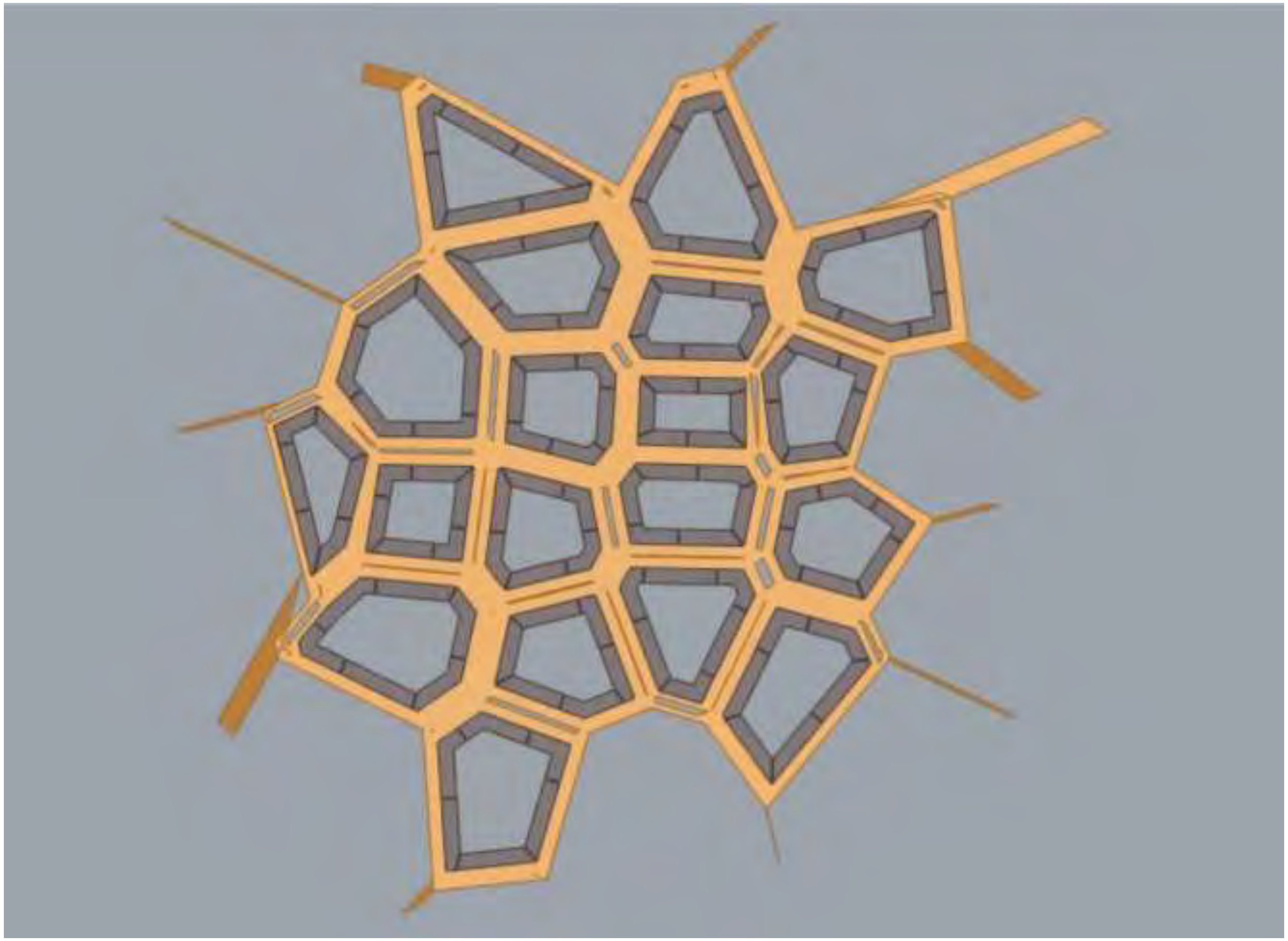
The extended streets will act as a dock space, later if the city grows this will transform to a block by itself.





Trial -6 Waterfront grid

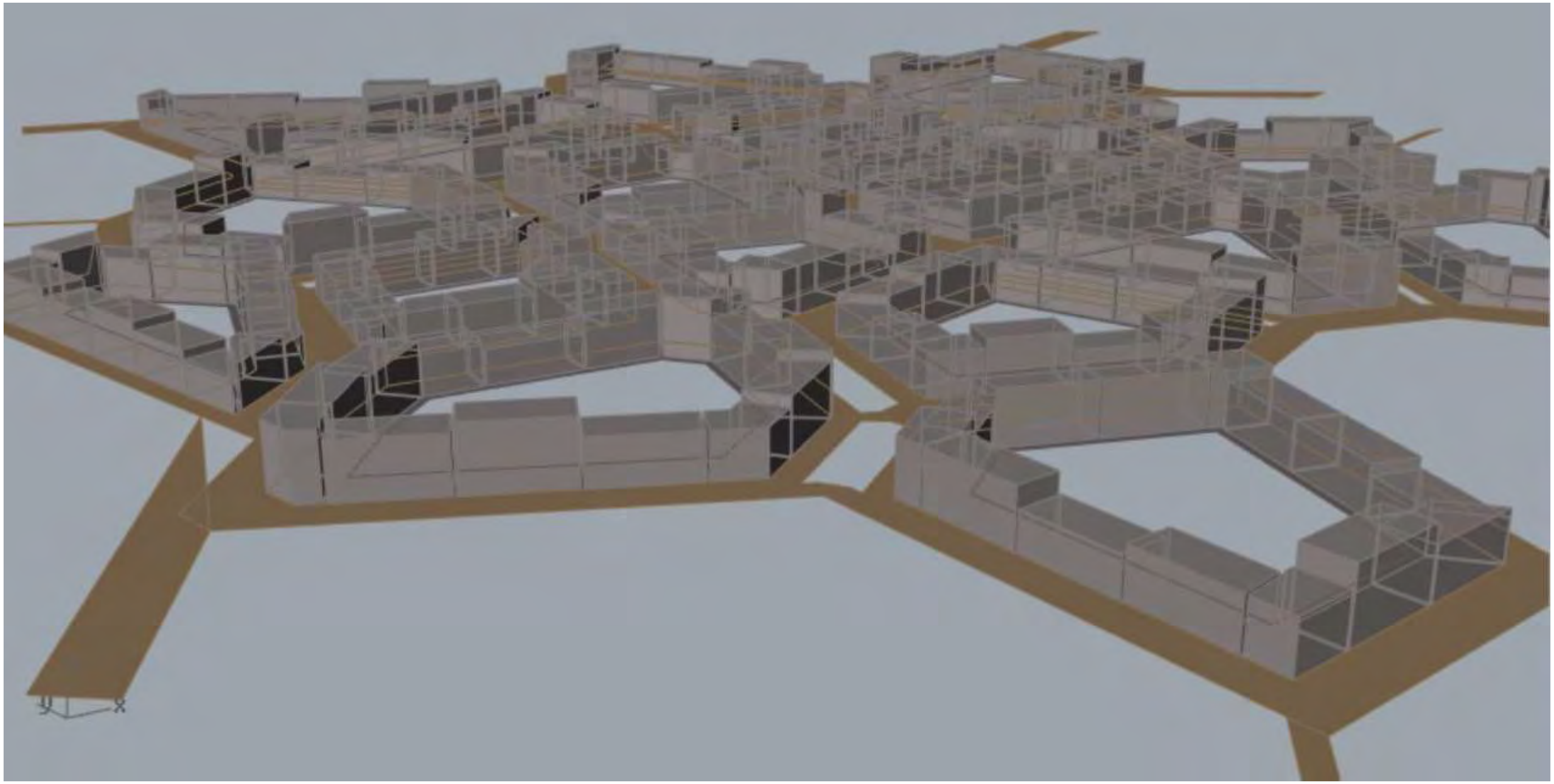
Attempt - 2



Trial -6 Waterfront grid

Attempt - 2

More numbers of building blocks, gives more opportunity for a mixed use function.



Trial -6 Waterfront grid

Attempt - 3

This is an understanding, of the scales between the existing and the new water front grid.

Each existing urban fabric will demand its own proportions of the blocks and urban network.

Conclusions

The previous attempts explain the different spatial experience and the connectivity between water and land. The attempt explains how we could continue carrying the language of the city into water.

The city might demand an organic growth line we have shown in the attempt – 3.

There are cities which will demand regular gird pattern or a radial pattern or an hexagonal grid pattern. Depending on the requirements the scripts can be derived accordingly.

The bigger picture is about how the city is changed to a flexible module with the development in water.

Trial -7 Open Spaces

Green spaces / Open spaces - capacity by flexibility

Increases the connectivity – more local movement (pedestrian)

Increases green space

The platforms can be combined to create interactive spaces.

open market

public gatherings – events

pavilion

Possibilities of increasing urban farming

Water front walkways.

Trial -7 Open Spaces

Attempt -1

Once the site is defined –

With the boundary region we can define the primary street network and define the open space. Forming the network of pedestrian movements.

Parameters-

1 - Number of entry points.

2 - Length of the walkways.

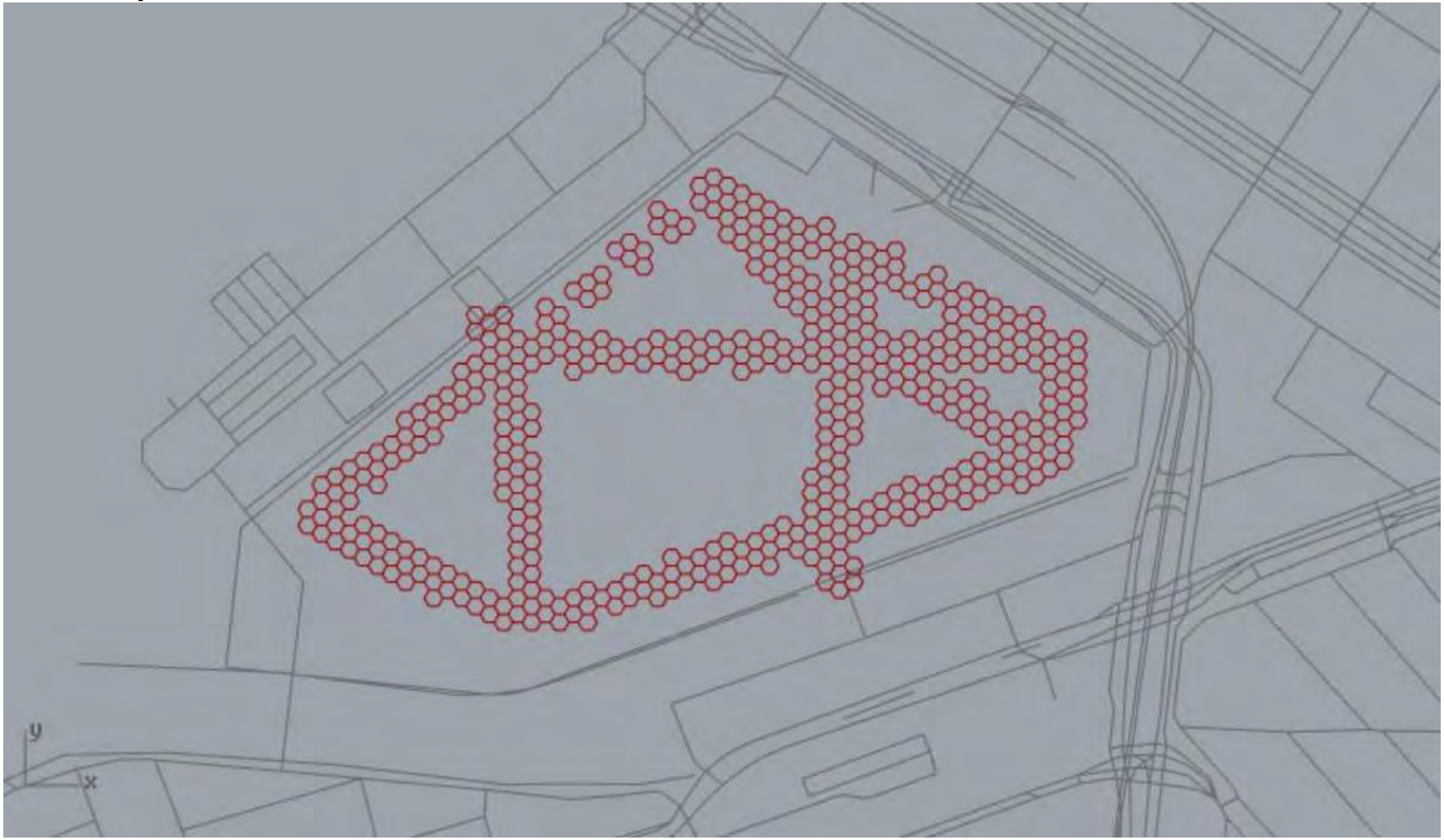
3 - Interconnectivity.

4 - Size of the platforms.

5 - Number of platforms.

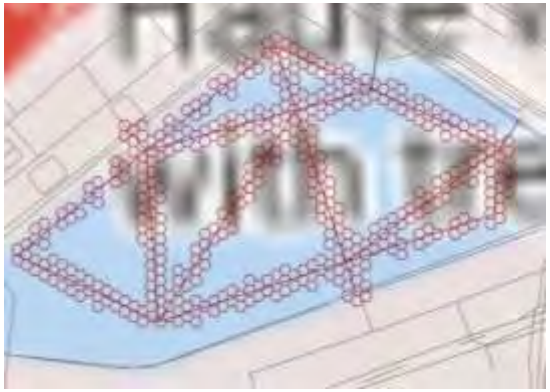
Trial -7 Open Spaces

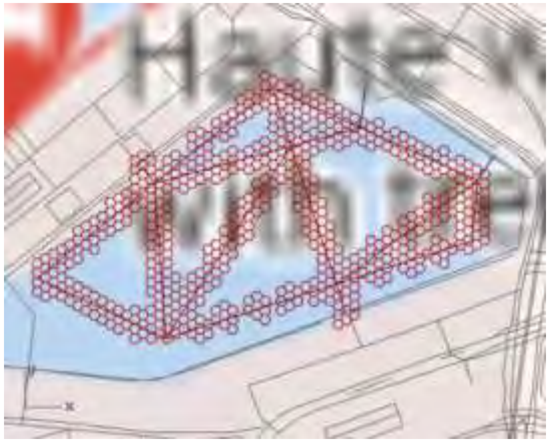
Attempt -1



Trial -7 Open Spaces

Attempt -1





Initial step, the boundary and the access points area defined.

The script then generates the internal network, based on the max. and min. street length provided.

Hexagon modules are used to create the platform. Similarly any quadrant can be created.

Have control over number of modules along the path. Which increases area per person ratio.

Trial -7 Open Spaces

Attempt -2

We cab generate island of open spaces with defined area to occupy.

Parameters –

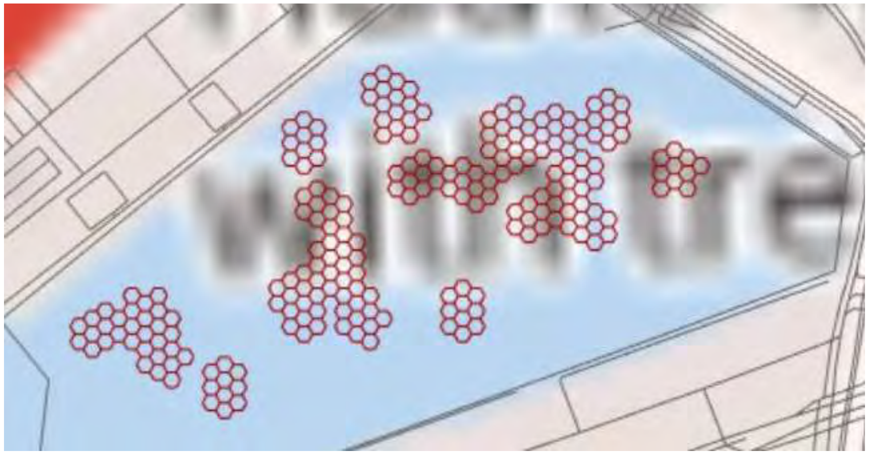
1 - Number of islands to be formed

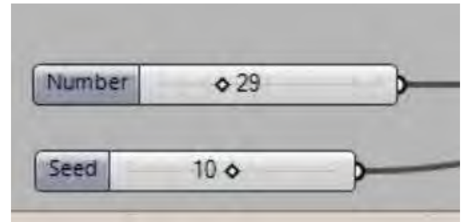
2 - Size of the islands

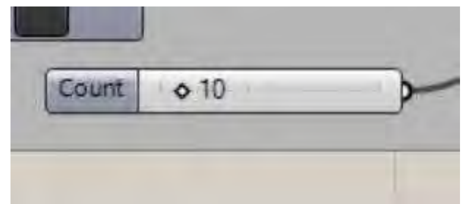
3 - Iterations of different forms.

Trial -7 Open Spaces

Attempt -2

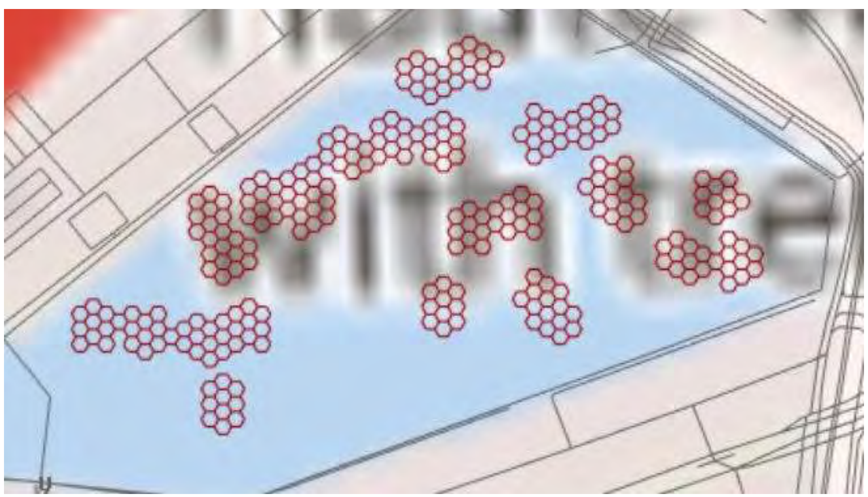


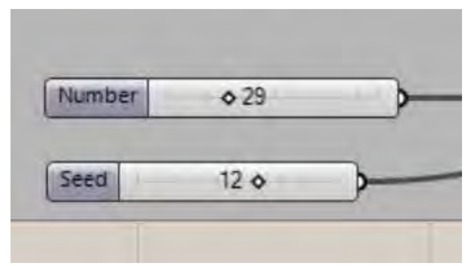


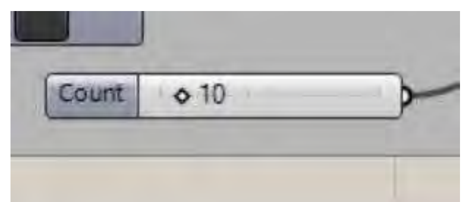


The numbers denote number of islands to be created. The island has constant number of platforms.

Seed – gives us number of iterations based on the required configuration, within the region defined.

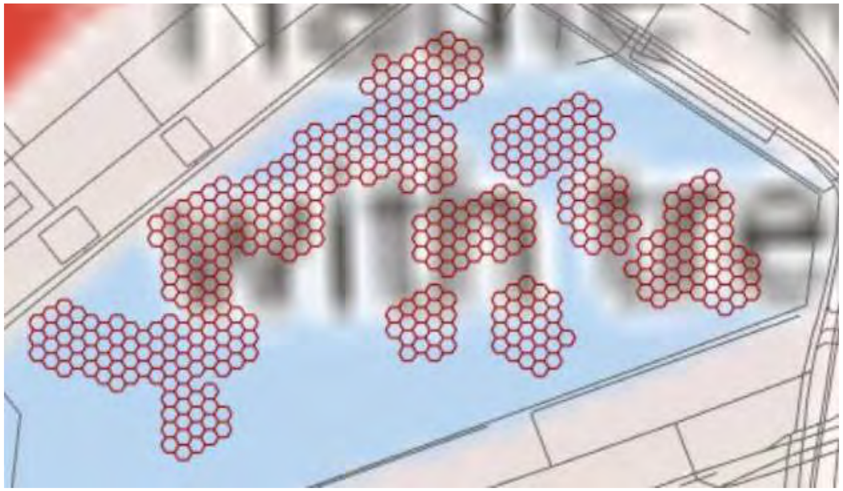


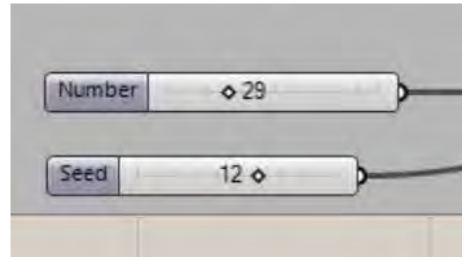


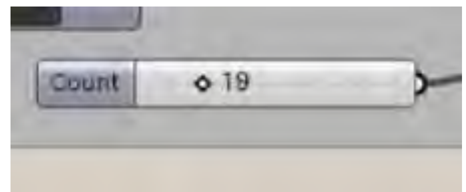


Trial -7 Open Spaces

Attempt -2





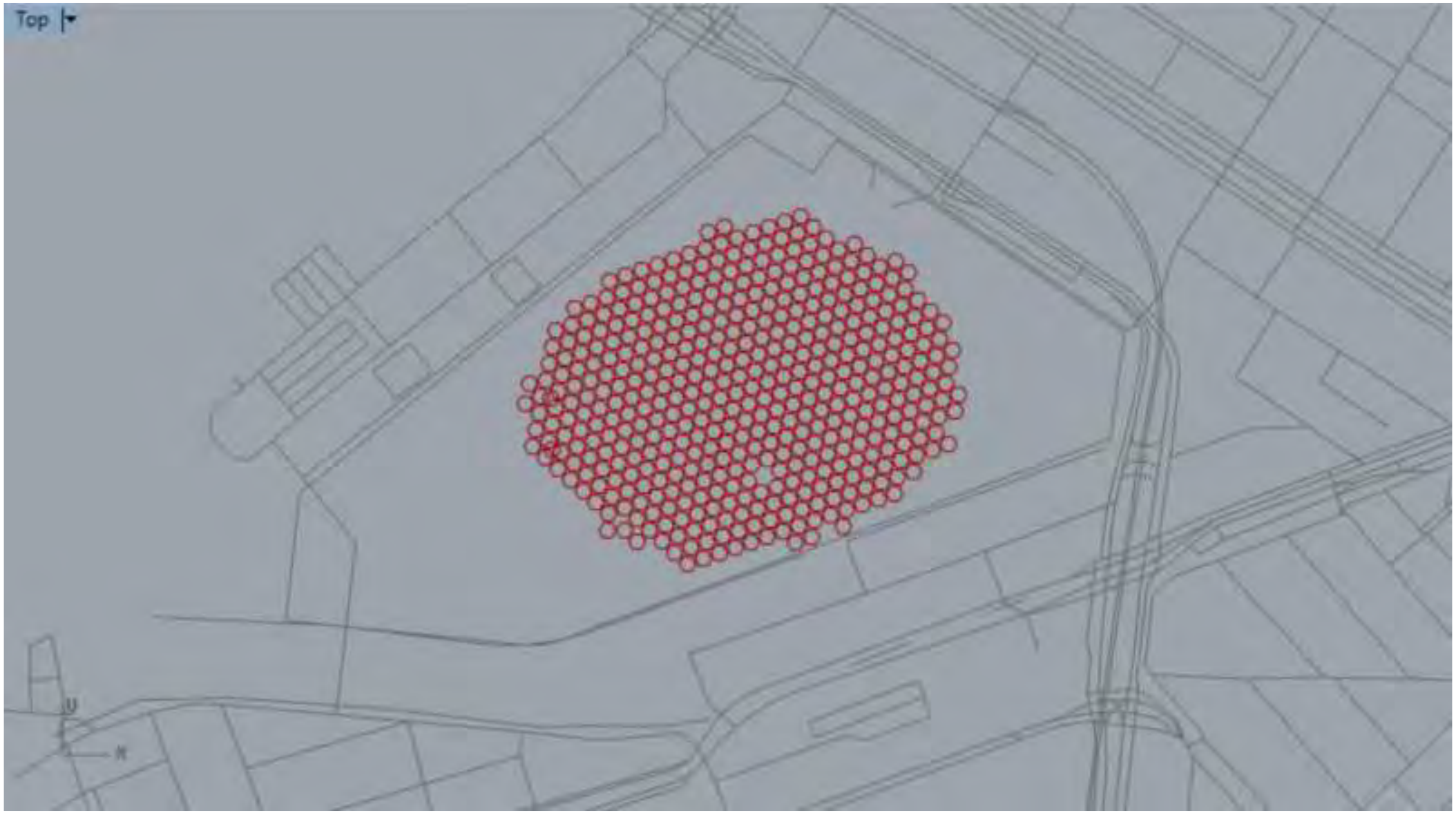


Number of modules per island is increased.

Trial -7 Open Spaces

Attempt -3

With the set of platforms defined, we can collect all to a point or points or boundary to create gathering spaces.



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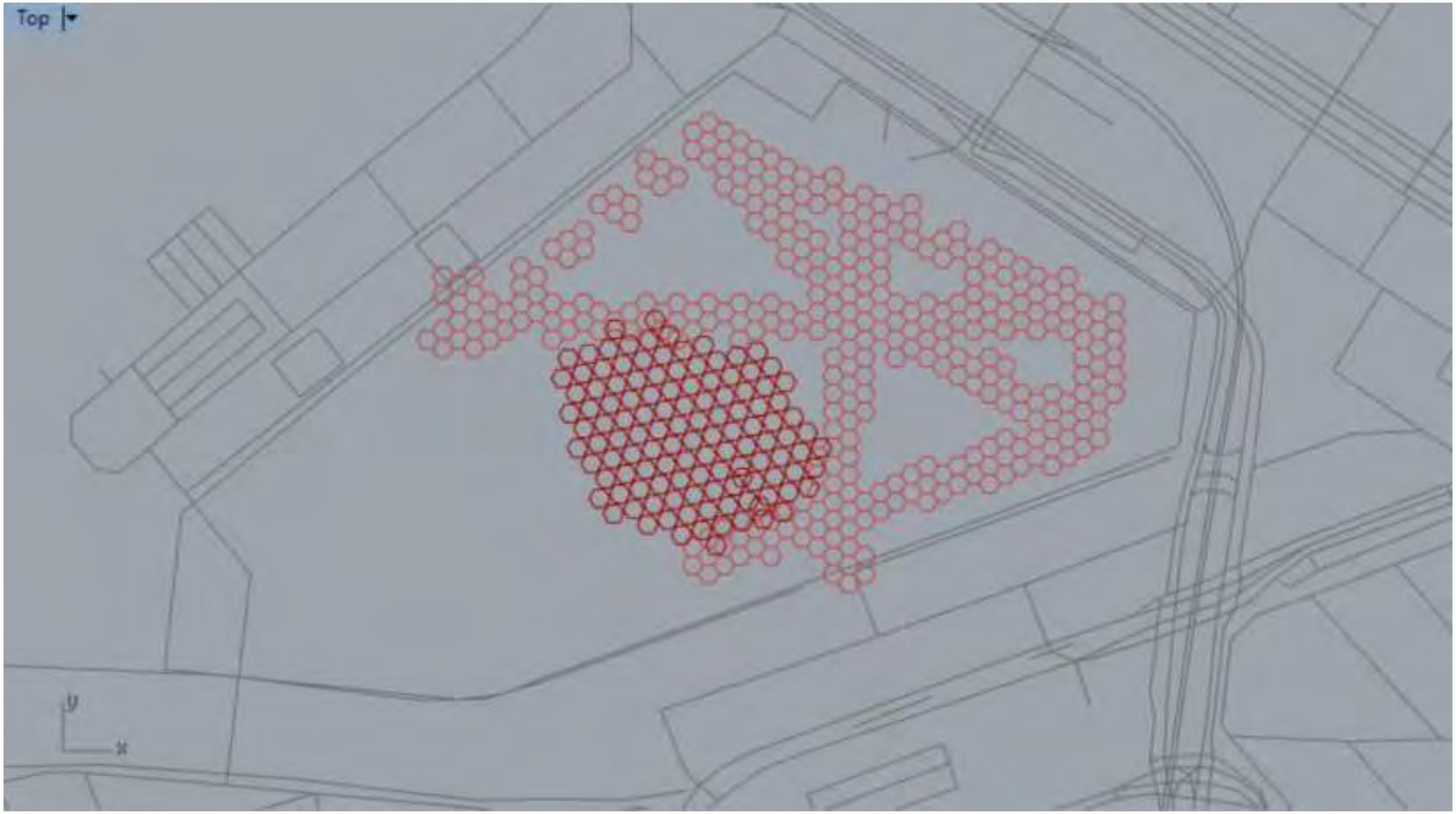
Trial -7 Open Spaces

Attempt -3

We temporarily collect part of open space and convert to a bigger platform.



Trial -7 Open Spaces

Attempt -4

Walkways using the existing cuboids – 240 X 80 X 80 cm and 80 X 80 X 80 cm

This provides more green space to the neighborhood.

It also connects two end destinations – creating a walkway on water with green and open areas.

Here we define the path and then the script generates the form.

Parameters-

1 - Number of horizontal elements.

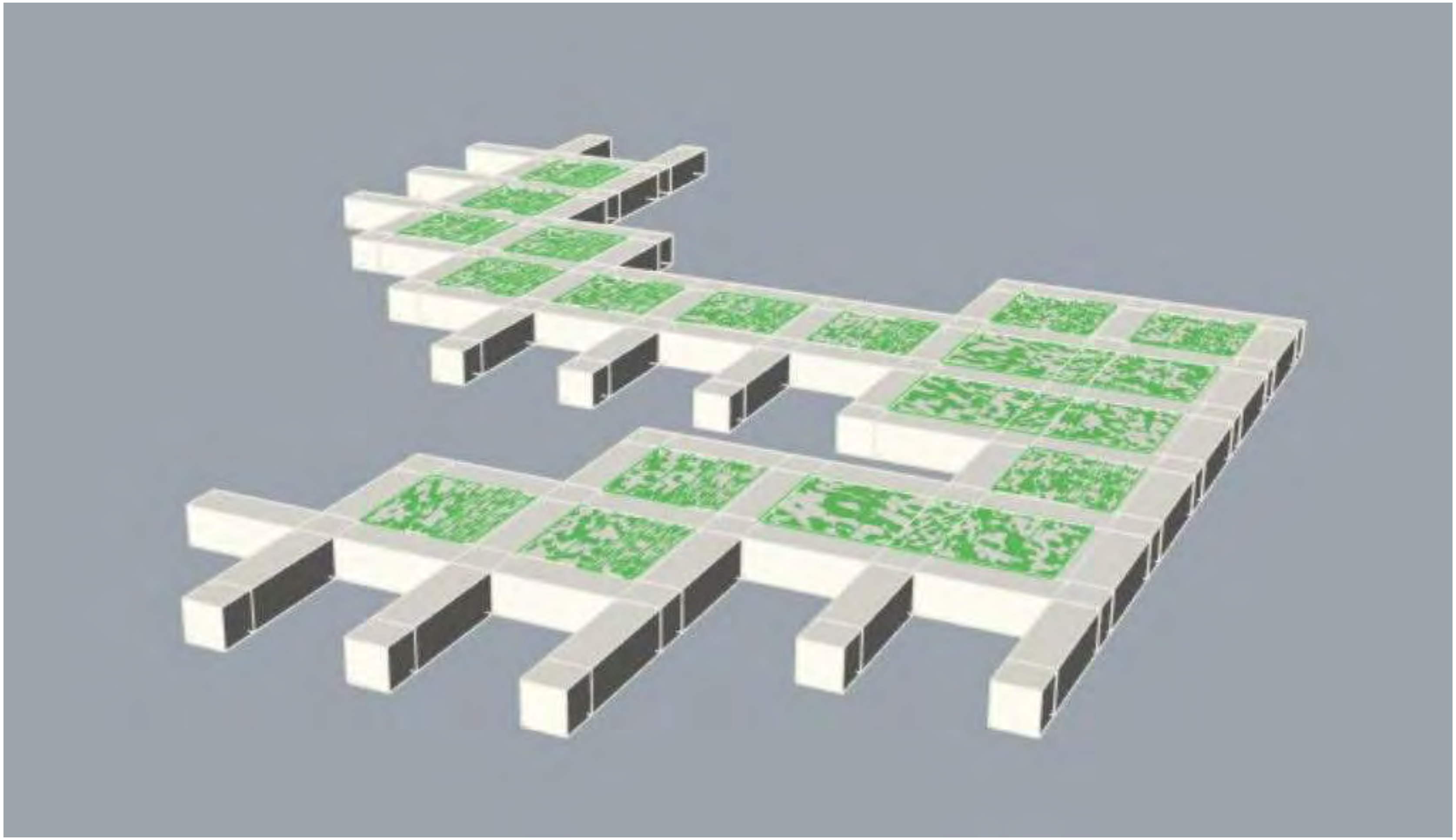
2 - Number of vertical elements.

3 - Combine to form bigger grid area.

4 - Split the square area with percentage.

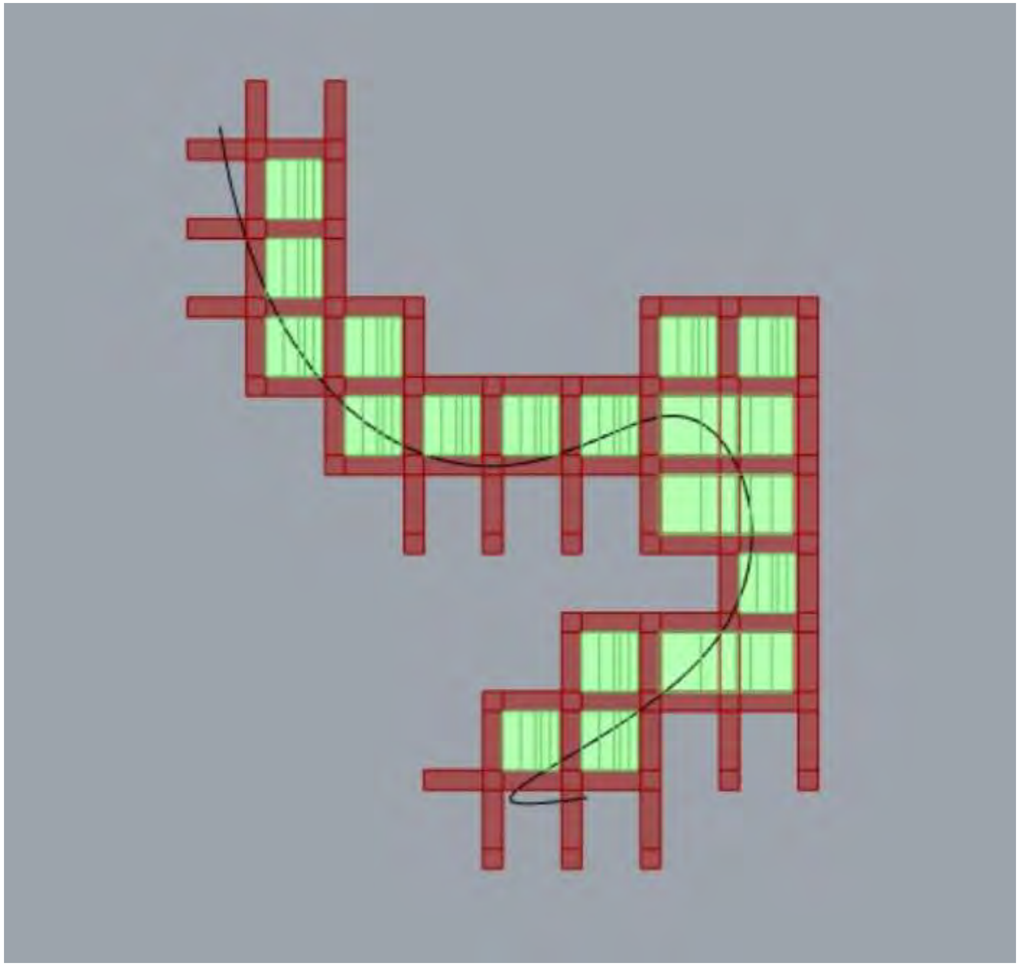
Trial -7 Open Spaces

Attempt -4



Trial -7 Open Spaces

Attempt -4

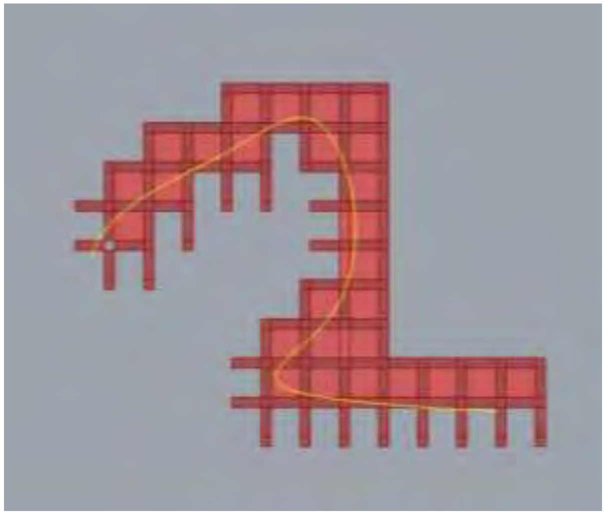


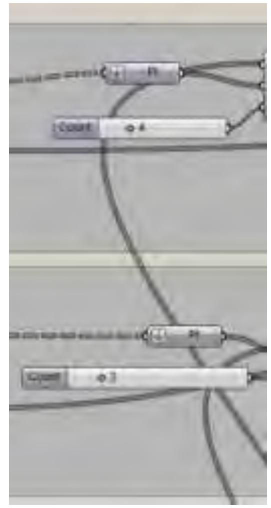
In this part of the script, we can define how each central space can be divided based on different purposes.

It's possible to combine the central spaces on the requirement.

Trial -7 Open Spaces

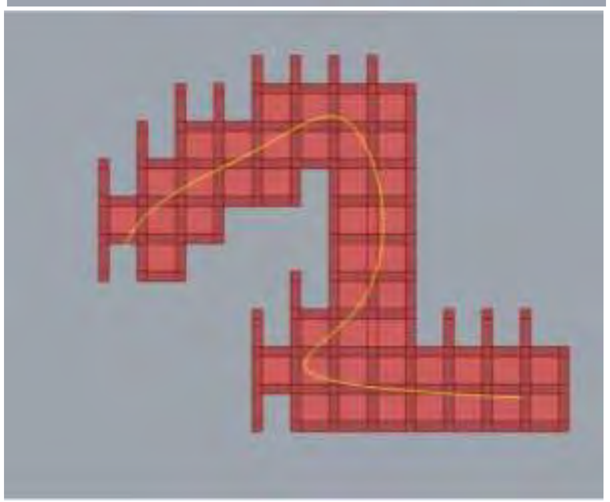
Attempt -4

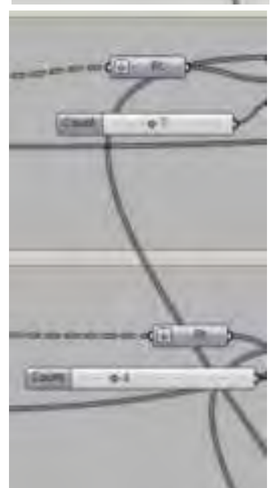




When a new path is defined, the script generates the walkway between the start to end.

We have the flexiblity of determining or increasing the horizontal and vertical members individually based on our needs.





Trial -8 Affordable Housing

Attempt -1

From the script made for waterfront grid – an attempt to see the organic growth of the residential spaces.

Trial -8 Affordable Housing

Attempt -2

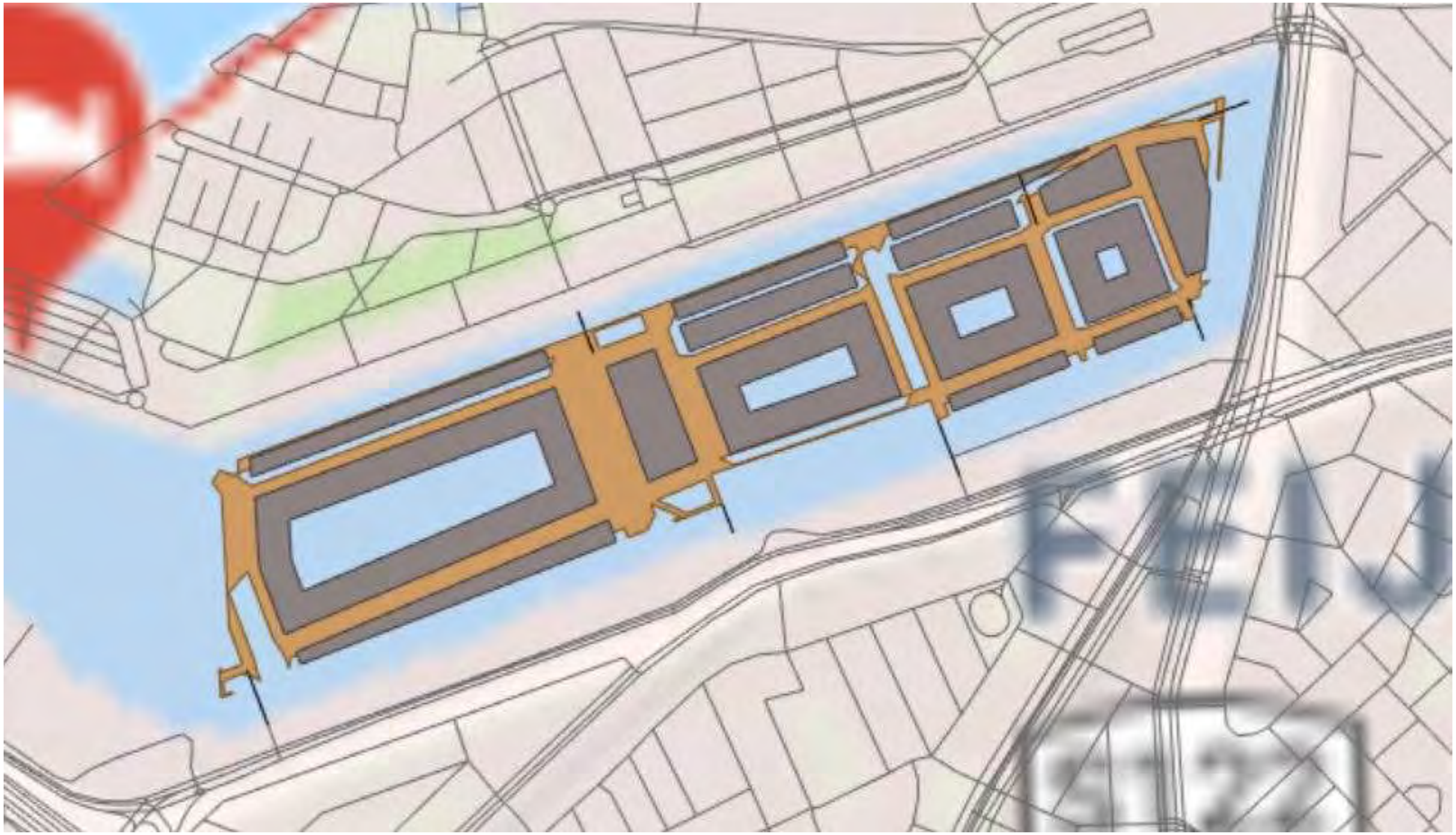
In this we have tried to maintain the grid pattern in the waterfront grid. The access points are defined.

With the access points – the internal network is defined and the perimeter block system is carried out.

Trial -8 Affordable Housing

Attempt -2

This approach addresses the existing urban language.



Conclusions

In the initial studies – we have created an understanding on how the platforms can configure with respect to the function based on the need.

The flexibility is, it can reconfigure the platforms based on the other criteria's.

The open spaces responds to this flexibility - they can be a walkway for a particular period of time and can reorganize to form huge area for public market and event spaces.

The change period of each function on a public space is maximum scaled on weekly basis.

The change period for a work space or a residential space, maximum scaled for 1-2 years.

So, the built form also, with the platform should be able to reconfigure, without disturbing the urban fabric.

Defining Parameters

- Platform.
- Height for the built form.
- Density distribution.
- Program / Functional distribution.
- Under water spaces.
- Open area and Built area.
- Geometry of the built form.
- Functional modules – typologies.
- Reconfiguration.
- City mobility – interconnectivity and mode of travel.
- Alignment of built form – wind factor.
- Open surface for energy – sunlight orientation.
- Weight.
- Growth factor of the city.
- Sustainability – key sustainable elements.

Capacity by flexibility

The flexible approach to urban planning should enable variability in the totality and particulars of urban functions because it is the only way to adapt to the changes that are difficult to predict (Knežević, 1980)

Contemporary practice of design and planning should target the flexibility and transformability.

All the existing city constantly work on adaptable spaces and minor components of flexible space with the built form.

We are looking into the possibilities on how we increase the capacity of flexibility.

The system will permit the generation of alternative solutions to respond to changes in the context during the legal lifespan of the plan, while maintaining the same ordering principles and aesthetic coherence.

Capacity by flexiblity

The impact of accelerating change on the physical form of the city is radical.

Architecture that responds to change.

Functional architecture that is moveable, adaptable, transformable, and capable of disengagement and reassembly – multiple activities in one space.

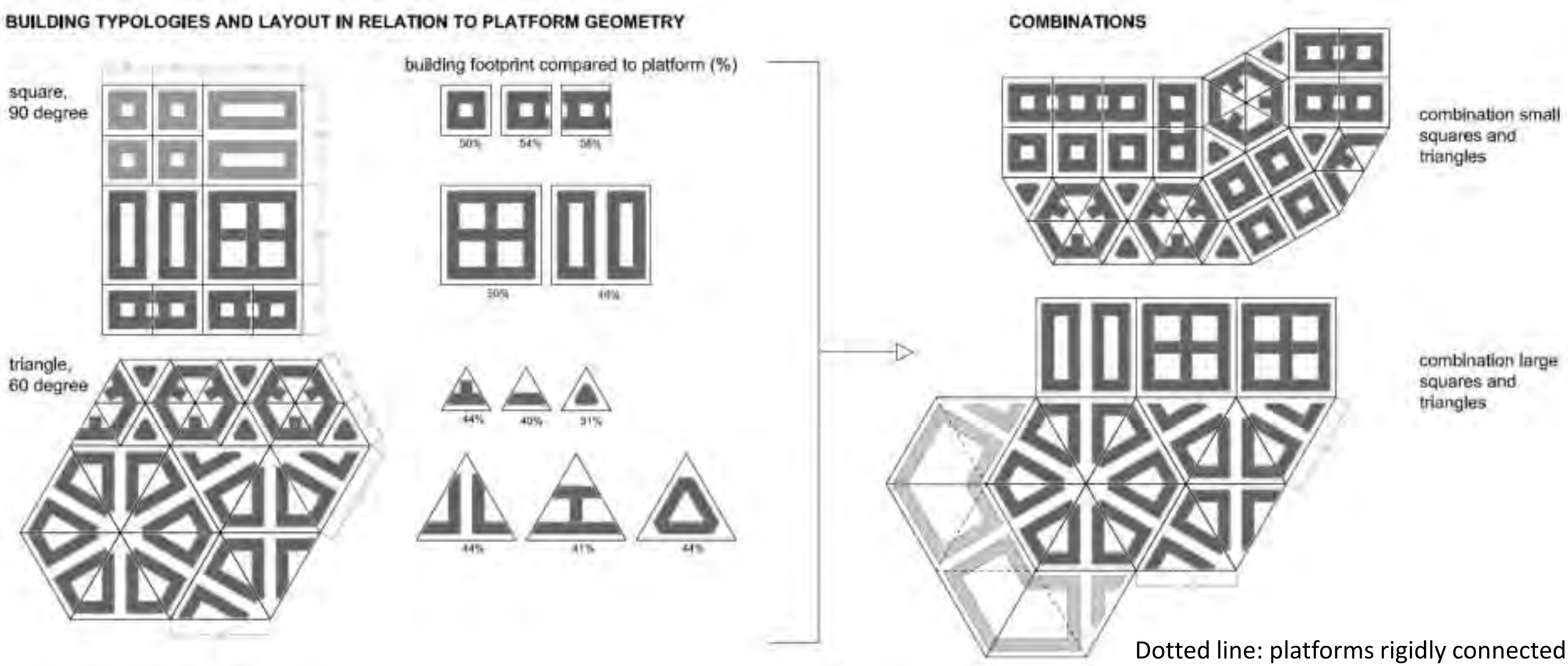
Flexible master planning,

Flexible building design,

Flexible building management.

Comparison of platform geometries (1/2)

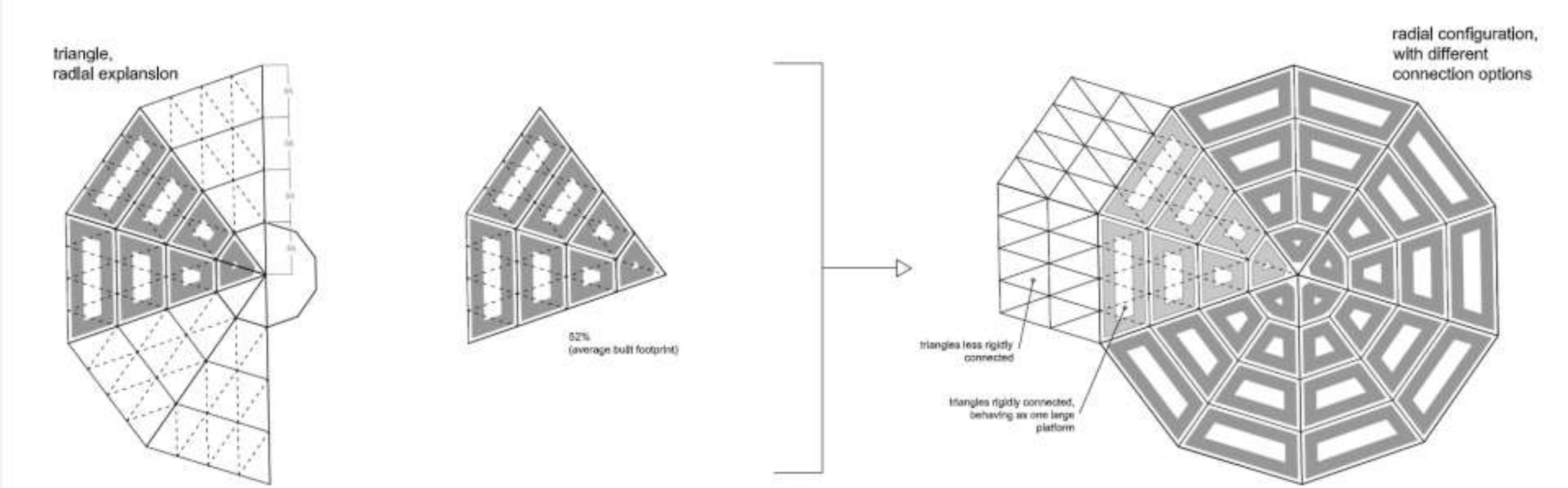
Square and equilateral triangle



Dotted line: platforms rigidly connected

Comparison of platform geometries (2/2)

Isosceles triangle, radial expansion

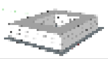
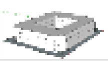
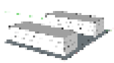


Dotted line: platforms rigidly connected

Comparison of platform geometries: evaluation

- **Using triangular platforms, 20% less building footprint is achieved compared to square platforms** with equal building depth and road width -> less opportunity for real estate space from the start.
- **Choosing for triangular platforms leads to building with pointy and difficult corners**. Such corners are not only difficult to solve in floorplan but also make construction more complicated.
- **With larger triangles it is easier to create perimeter blocks and optimize the built space on the platform.** However, there is a limit to the size of platforms we can build. A possible way to circumvent having a large amount of pointy buildings and to make more efficient use of the space on the platform is to connect multiple triangular platforms in a rigid way, so that they behave as one large platform

Comparison of platform geometries: evaluation

	Platform			Open space		Building(s)							Spacematrix			Land use %									
	Polygon sides #	Side m	Area m^2	Road m^2	Green m^2	Block length m	Floors #	Building depth m	Courtyard side m	Built-up area m^2	Gross floor area (GFA) m^2	Net floor area (NFA) m^2	Floor area Ratio FAR or FSI	Gross Space Index GSI	Spaciousness OSR	Buildings %	Road %	Green %	Total %	Apartments #	Residents #	Density ap./ha	Built volume m^3	Façade surface m^2	S/V
	4	50	2500	651	529	43	3	10	23	1320	3960	2772	1.58	0.53	0.30	52.8%	26.0%	21.2%	100%	44.00	88.0	176.0	13,200	2640	0.40
ers 	4	50	2500	701	529	43	3	10	23	1270	3810	2667	1.52	0.51	0.32	50.8%	28.0%	21.2%	100%	42.3	84.7	169.3	12,700	2523	0.40
	4	50	2500	651	817	43	3	12	19	1032	3096	2167	1.24	0.41	0.47	41.3%	26.0%	32.7%	100%	34.4	68.8	137.6	10,320	2200	0.41
	3	50	1082.5	461	45	38	3	8	10	576	1729	1211	1.60	0.53	0.29	53.3%	42.6%	4.1%	100%	19.2	38.4	177.5	5,765	1441	0.45

PLATFORM DESIGN

Concept

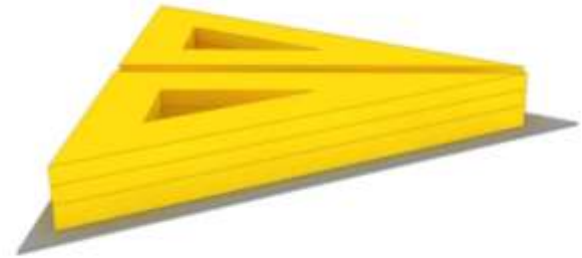
- A parallel analysis was done on the built typologies on the triangle platform.
- Through this we get inputs for the script, the built percentages, density analysis etc.
- Also comparisons between 50m platform and 100m platform.

PLATFORM DESIGN

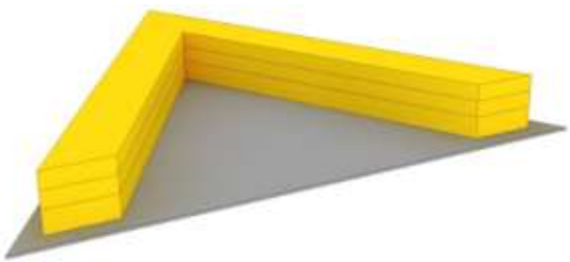
Concept 100m

Triangular courtyard

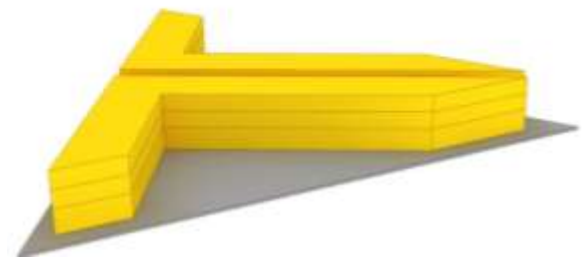
Triangular courtyard
Chamfered corners



Triangular courtyard
Split in two



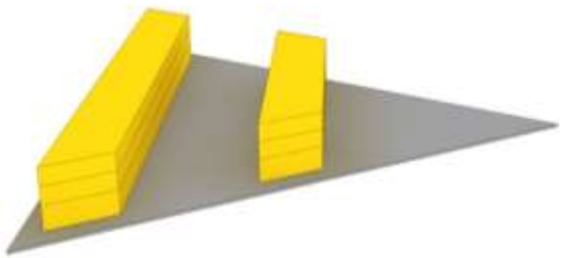
Triangular courtyard
Open side



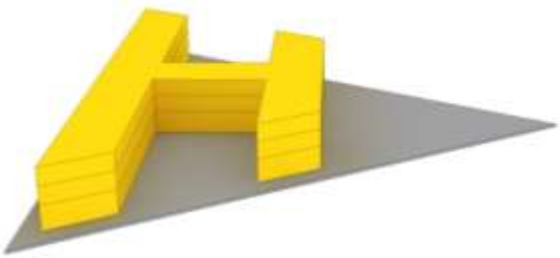
Triangular courtyard
Split in two and open side

PLATFORM DESIGN

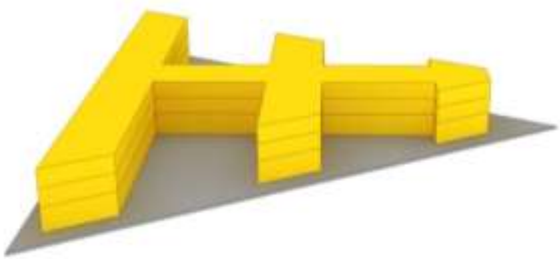
Concept 100m



Linear blocks
Two linear blocks



Linear blocks
Two linear blocks
With connecting block

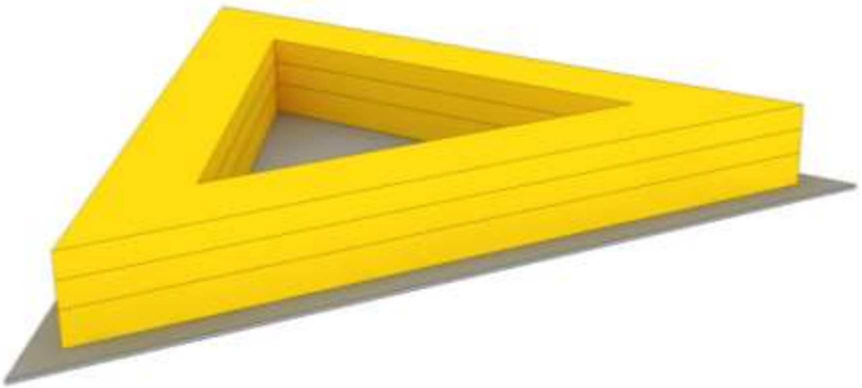


Linear blocks
Three linear blocks
With connecting block

PLATFORM DESIGN

Concept 100m

Triangular Courtyard



Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Buildings	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
3	**100**	**4330**	**986**	**1228**	**88**	**3**	**10**	**53**	**2116**	**6348**	**4444**	**1,47**	**0,49**	**0,35**	**48,9%**	**22,8%**	**28,4%**	**100%**	**70,5**	**141,1**	**162,9**	**1270**	**-42**	**70,5**	**21.160**

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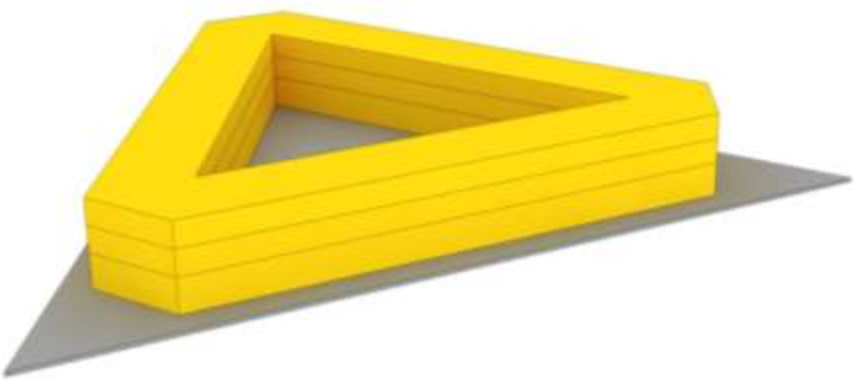
PLATFORM DESIGN

Concept 100m

Triangular Courtyard with Chamfered Corners



Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Buildings	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
3	100	4330	1160	1227	88	3	10	53	1943	5802	4061	1,34	0,45	0,41	44,9%	26,8%	28,3%	100%	64,5	128,9	148,9	1160	67	64,5	19.430

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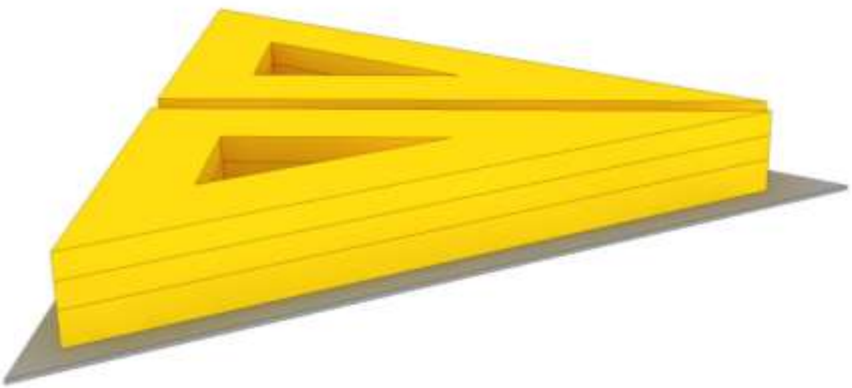
PLATFORM DESIGN

Concept 100m

Triangular Courtyard Split in Two



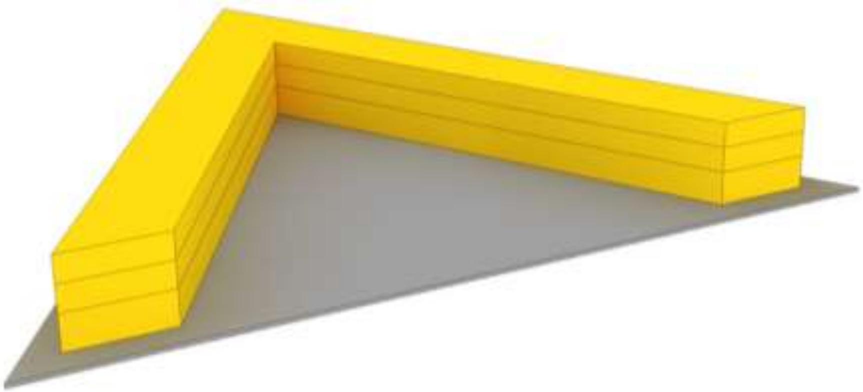
Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Buildings	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
3	100	4330	1247	383	88x73x42	3	10	25	2700	8100	5670	1,87	0,62	0,20	62,4%	28,8%	8,8%	100%	90,0	180,0	207,9	1620	-1237	90,0	27.000

SPACE@SEA

PLATFORM DESIGN

Concept 100m

Triangular Courtyard Open Side

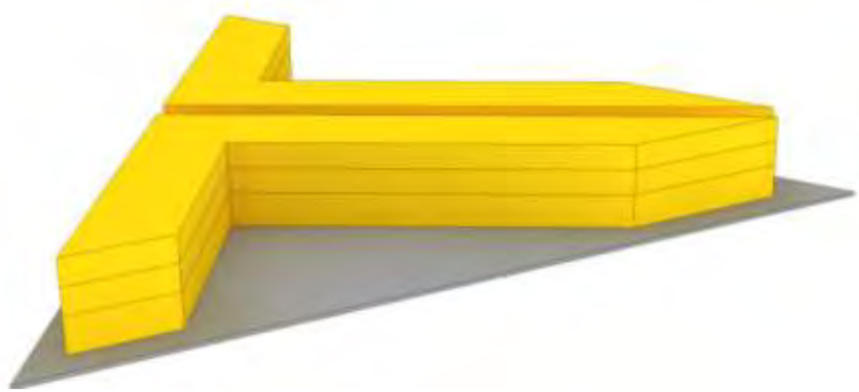


Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Buildings	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
3	100	4330	986	1818	88	3	10	53	1526	4578	3205	1,06	0,35	0,61	35,2%	22,8%	42,0%	100%	50,9	101,7	117,5	916	902	50,9	15.260

PLATFORM DESIGN

Concept 100m

Triangular Courtyard Split in Two and Open Side



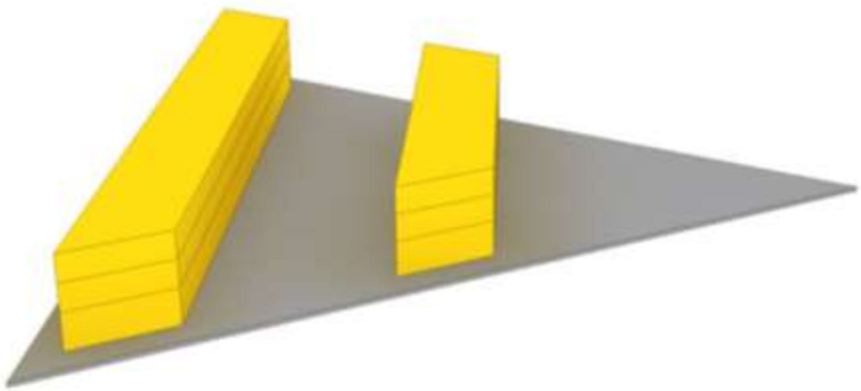
Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Buildings	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
3	100	4330	1247	1209	73x42	3	10	46	1874	5622	3935	1,30	0,43	0,44	43,3%	28,8%	27,9%	100%	62,5	124,9	144,3	1124	85	62,5	18.740

SPACE@SEA

PLATFORM DESIGN

Concept 100m

Linear Blocks Two Linear Blocks

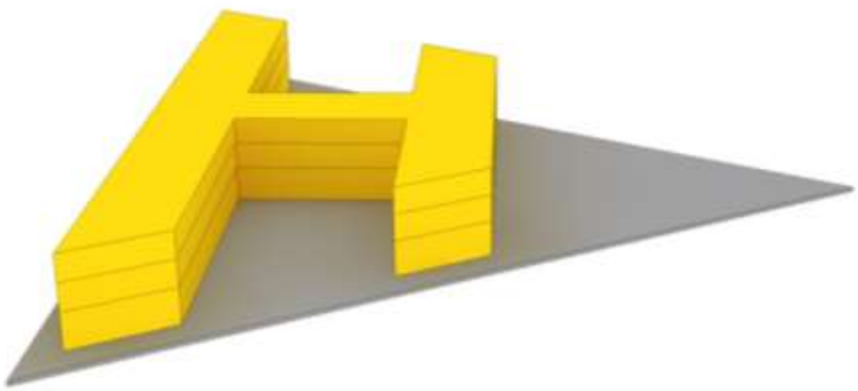


Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Buildings	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
3	**100**	**4330**	**1579**	**1456**	88 & 53	3	10	20	**1295**	3885	2720	0,90	0,30	0,78	**29,9%**	**36,5%**	**33,6%**	100%	43,2	86,3	99,7	777	679	43,2	12.950

PLATFORM DESIGN

Concept 100m

Linear Blocks Two with Connecting Block



Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Buildings	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
3	100	4330	1600	1235	88&53	3	10	20	1495	4485	3140	1,04	0,35	0,63	34,5%	37,0%	28,5%	100%	49,8	99,7	115,1	897	338	49,8	14.950

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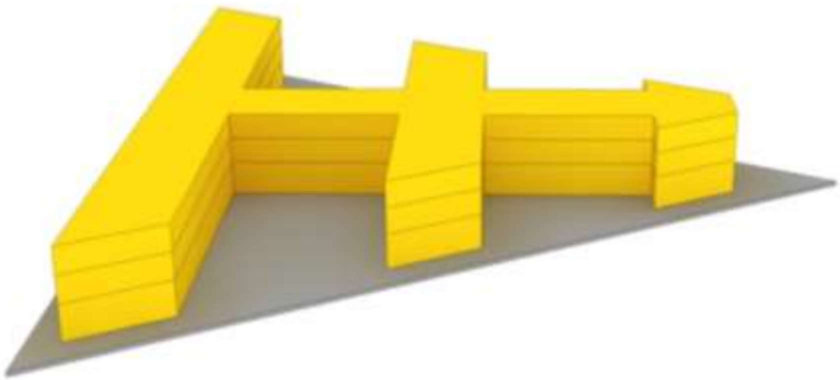
PLATFORM DESIGN

Concept 100m

Linear Blocks Three Linear Blocks with Connecting Block



Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Buildings	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
3	**100**	**4330**	**1693**	**814**	**88&53&19**	**3**	**10**	**20**	**1823**	**5469**	**3828**	**1,26**	**0,42**	**0,46**	**42,1%**	**39,1%**	**18,8%**	**100%**	**60,8**	**121,5**	**140,3**	**1094**	**-280**	**60,8**	**18.230**

PLATFORM DESIGN

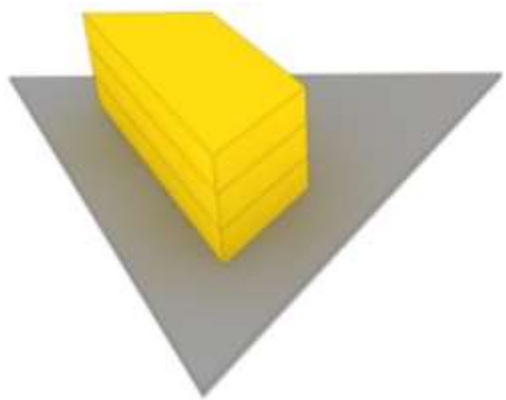
Concept 100m - Wrap up

		Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
		Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Building	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
Building typology	Variation	#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
Triangle courtyard		3	100	4330	986	1228	88	3	10	53	2116	6348	4444	1,47	0,49	0,35	48,9%	22,8%	28,4%	100%	70,5	141,1	162,9	1270	-42	70,5	21.160
Triangle courtyard	chamfered corners	3	100	4330	1160	1227	88	3	10	53	1943	5802	4061	1,34	0,45	0,41	44,9%	26,8%	28,3%	100%	64,5	128,9	148,9	1160	67	64,5	19.430
Linear blocks	2-linear blocks	3	100	4330	1579	1456	88 & 53	3	10	20	1295	3885	2720	0,90	0,30	0,78	29,9%	36,5%	33,6%	100%	43,2	86,3	99,7	777	679	43,2	12.950
Linear blocks	2-linear blocks with a connecting block	3	100	4330	1600	1235	88&53	3	10	20	1495	4485	3140	1,04	0,35	0,63	34,5%	37,0%	28,5%	100%	49,8	99,7	115,1	897	338	49,8	14.950
Linear blocks	3-linear blocks with a connecting blocks	3	100	4330	1693	814	88&53&19	3	10	20	1823	5469	3828	1,26	0,42	0,46	42,1%	39,1%	18,8%	100%	60,8	121,5	140,3	1094	-280	60,8	18.230
Triangle courtyard	open structure	3	100	4330	986	1818	88	3	10	53	1526	4578	3205	1,06	0,35	0,61	35,2%	22,8%	42,0%	100%	50,9	101,7	117,5	916	902	50,9	15.260
Triangle courtyard	splited in two	3	100	4330	1247	383	88x73x42	3	10	25	2700	8100	5670	1,87	0,62	0,20	62,4%	28,8%	8,8%	100%	90,0	180,0	207,9	1620	-1237	90,0	27.000
Triangle courtyard	spited and two with open side	3	100	4330	1247	1209	73x42	3	10	46	1874	5622	3935	1,30	0,43	0,44	43,3%	28,8%	27,9%	100%	62,5	124,9	144,3	1124	85	62,5	18.740

PLATFORM DESIGN

Concept 50m

Triangular block
Chamfered corners



Linear block

Linear block
Two elements combined

PLATFORM DESIGN

Concept 50m

Triangular block, Chamfered corners

Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Buildings	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
3	**50**	**1083**	**712**	**34**	**20**	**3**	**10**	**0**	**337**	**1011**	**708**	**0,93**	**0,31**	**0,74**	**31,1%**	**65,7%**	**3,1%**	**100%**	**11,2**	**22,5**	**103,7**	**202**	**-168**	**11,2**	**3.370**

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PLATFORM DESIGN

Concept 50m

Linear block

Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Buildings	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
3	50	1083	712	174	29	3	10	0	197	591	414	0,55	0,18	1,50	18,2%	65,7%	16,1%	100%	6,6	13,1	60,6	118	56	6,6	1.970

PLATFORM DESIGN

Concept 50m

Wrap up

		Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
		Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	**Building**	**Road**	**Green**	**Total**	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
Building typology	Variation	#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	**%**	**%**	**%**	**%**	#	#	ap./ha	m²	m²	#	m³
Trianglar block	chamfered corners	3	50	1083	712	34	20	3	10	0	337	1011	708	0,93	0,31	0,74	**31,1%**	**65,7%**	**3,1%**	**100 %**	11,2	22,5	103,7	202	-168	11,2	3.370
Linear block		3	50	1083	712	174	29	3	10	0	197	591	414	0,55	0,18	1,50	**18,2%**	**65,7%**	**16,1%**	**100 %**	6,6	13,1	60,6	118	56	6,6	1.970
lLinear block two	element combined	3	50	1083	712	88	29	3	10	0	283	849	594	0,78	0,26	0,94	**26,1%**	**65,7%**	**8,1%**	**100 %**	9,4	18,9	87,1	170	-82	9,4	2.830

SPACE@SEA

PLATFORM DESIGN

Concept for 100m and 50m platforms

- The built form is majorly effected with road % based on what dimension we pick for their width – depends on what type of transport system we choose.
- We maintain a peripheral transport system so not to effect the built form.
- On average the built% on each platform is 42,65 % for 100m and 41 % for 50m.
- We have more options with 100m platform than 50m because of the its size is 4 times bigger and the possibilities of built forms are many.

STUDIES

By the use of grasshopper scripts, we carry out certain studies to understand and have a grip on city designs. We understand the rules and parameters, which helps in creating a script for various situations.

STUDIES

The studies always overlap each other in various stages. Each study outputs and understand helps improving a step ahead on the final output. The script is an integrated DNA.

Study - 1 – One to one translation of a city from land to water. In this we compare various stands on how we can translate an existing city and the result outputs based on our stands. The functions location remains same.

Study - 2 – Density comparison with 50m platforms and 100m platforms.

Study - 3 – How transportation network effect the arrangements of the platform and its effect on the density and other stands.

Study - 4 – How we arrive at a planning layout based on the rules and the connectivity between each functions. How functions are organized to each other and where its placed.

Study - 5 – Update any parameter or new rule into to path of the script – e.g. - change in the platform shape.

WHY

- We build our study from comparing a city form land to water.
- On land, a city is defined by its topography – which defines its boundary.
  In water the boundary is defined by the platform shape, size, analytical data's of the waters, etc.
- Most of the cities are program driven – they address a particular function and rest all functions build around it.
- We cannot depict exact city planning strategies and layout for a floating city, it has to develop its own typologies and planning strategies. Due to various factors like cost, feasibility, natural constrains like depth of waters.
- The easy availability of land helps city to easily develop on land for future.
  For floating cities the expansion has to be strategically planned as we are building it artificially from the bottom line

STUDIES

- We analyzed three cities: Masdar City, Rijswijk and Tollebeek.
- By adding gaps between the platforms, the existing city boundary scales up.

Platforms are without slope edge.

For 100m equilateral triangle platform

Distance between	Scaling factor
2.5 meters	1.0433
5 meters	1.0866
7.5 meters	1.1299

For 50 mequilateral triangle platform

Distance between	Scaling factor
2.5 meters	1.0866
5 meters	1.1732
7.5 meters	1.2598

STUDIES

With the grasshopper script prepared we can consider situations with the platform having sloped edges

This table helps in quickly arrive to an idea how big the city is going to be with a set of condition, on distance between the platforms with an existing scale on land.

Scaling table –
Platform between distance 2.5 meters   Size – 50 m equilateral triangle

Depth in --------mts. / Angle Deg.	1	1.5	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7	7.5	8	8.5	9	9.5	10
0	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866	1.0866
5	1.878497	2.274446	2.670395	3.066343	3.462292	3.85824	4.254189	4.650138	5.046086	5.442035	5.837984	6.233932	6.629881	7.025829	7.421778	7.817727	8.213675	8.609624	9.005573
10	1.479518	1.675977	1.872436	2.068895	2.265354	2.461813	2.658272	2.854731	3.05119	3.247649	3.444108	3.640567	3.837026	4.033484	4.229943	4.426402	4.622861	4.81932	5.015779
15	1.345164	1.474446	1.603728	1.73301	1.862292	1.991574	2.120856	2.250138	2.37942	2.508702	2.637984	2.767266	2.896548	3.02583	3.155113	3.284395	3.413677	3.542959	3.672241
20	1.276951	1.372126	1.467302	1.562477	1.657652	1.752828	1.848003	1.943179	2.038354	2.13353	2.228705	2.32388	2.419056	2.514231	2.609407	2.704582	2.799757	2.894933	2.990108
25	1.235176	1.309464	1.383752	1.458039	1.532327	1.606615	1.680903	1.755191	1.829479	1.903767	1.978055	2.052343	2.126631	2.200918	2.275206	2.349494	2.423782	2.49807	1.572358
30	1.2066	1.2666	1.3266	1.3866	1.4466	1.5066	1.5666	1.6266	1.6866	1.7466	1.8066	1.8666	1.9266	1.9866	2.0466	2.1066	2.1666	2.2266	2.2866
35	1.185545	1.235017	1.28449	1.333962	1.383435	1.432907	1.48238	1.531852	1.581325	1.630797	1.68027	1.729742	1.779215	1.828687	1.87816	1.927632	1.977105	2.026577	2.07605
40	1.169167	1.210451	1.251734	1.293018	1.334301	1.375585	1.416868	1.458152	1.499436	1.540719	1.582003	1.623286	1.66457	1.705853	1.747137	1.78842	1.829704	1.870988	1.912271
45	1.155882	1.190523	1.225164	1.259805	1.294446	1.329087	1.363728	1.398369	1.43301	1.467651	1.502292	1.536933	1.571574	1.606215	1.640856	1.675497	1.710138	1.744779	1.77942
50	1.144735	1.173802	1.202869	1.231936	1.261004	1.290071	1.319138	1.348205	1.377273	1.40634	1.435407	1.464474	1.493542	1.522609	1.551676	1.580743	1.609811	1.638878	1.667945
55	1.135112	1.159368	1.183624	1.20788	1.232135	1.256391	1.280647	1.304903	1.329159	1.353415	1.377671	1.401927	1.426183	1.450439	1.474694	1.49895	1.523206	1.547462	1.571718
60	1.1266	1.1466	1.1666	1.1866	1.2066	1.2266	1.2466	1.2666	1.2866	1.3066	1.3266	1.3466	1.3666	1.3866	1.4066	1.4266	1.4466	1.4666	1.4866
65	1.118907	1.13506	1.151213	1.167367	1.18352	1.199674	1.215827	1.23198	1.248134	1.264287	1.28044	1.296594	1.312747	1.328901	1.345054	1.361207	1.377361	1.393514	1.409667
70	1.111817	1.24425	1.137033	1.149641	1.16225	1.174858	1.187466	1.200075	1.212683	1.225291	1.2379	1.250508	1.263116	1.275724	1.288333	1.300941	1.313549	1.326158	1.338766
75	1.105164	1.114446	1.123728	1.13301	1.142292	1.151574	1.160856	1.170138	1.17942	1.188702	1.197984	1.207266	1.216548	1.22583	1.235113	1.244395	1.253677	1.262959	1.272241
80	1.098816	1.104924	1.111033	1.117141	1.123249	1.129357	1.135465	1.141573	1.147681	1.15379	1.159898	1.166006	1.172114	1.178222	1.18433	1.190438	1.196547	1.202655	1.208763
85	1.092611	1.095692	1.098723	1.101753	1.104784	1.107815	1.110846	1.113876	1.116907	1.119938	1.122968	1.125999	1.12903	1.13206	1.135091	1.138122	1.141153	1.144183	1.147214

STUDIES

Platform

Triangle size

- 50m platforms.
- 100m platforms.

Space in between

- 2,5 meters.
- 5 meters.
- 7,5 meters.

Scripts help to constantly compare the output of what the size of the city will be with the settings of the used parameters and rules

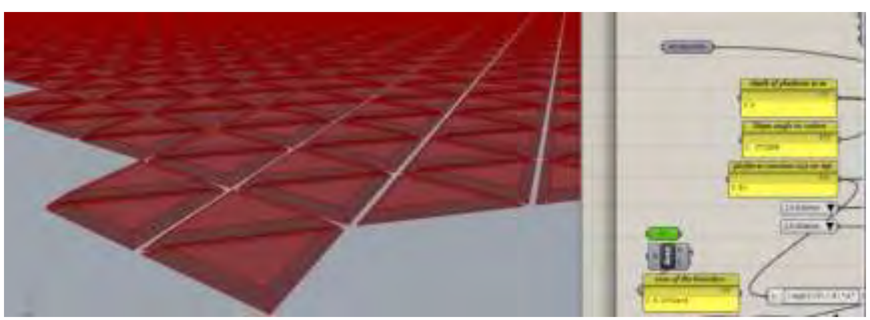
PLATFORM

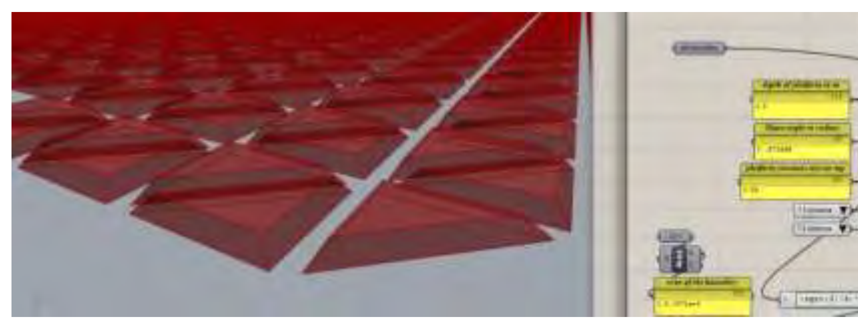
PARAMETERS

- Depth of platform
- Slope in radian
- Distance between each platform
- Platform constant size on top

RULES

- Top face is always constant area
- Set boundary or obtain boundary





SPACE@SEA

STUDIES

Conclusion

- Due to the gap between the platforms, the city boundary will occupy more space compared to land
- The gaps can be efficiently used for recreational purposes and water transportation network

We start with Tollebeek to get a grip on the script.
The list of functions are specific and this can be used as a basic model. The next step will be to change the conditions of the script and derive output for other cities.

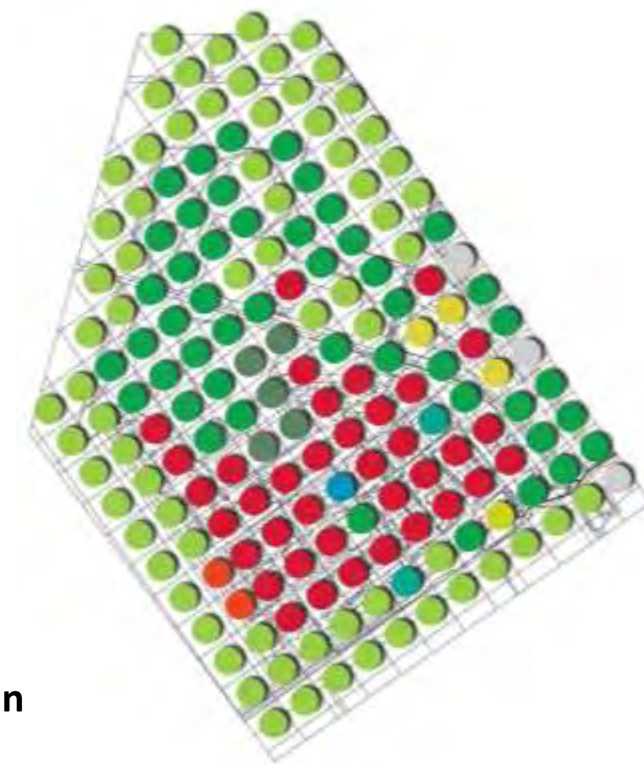
STUDIES

Tollebeek

Study on the existing city on land
This shows the distribution of functions

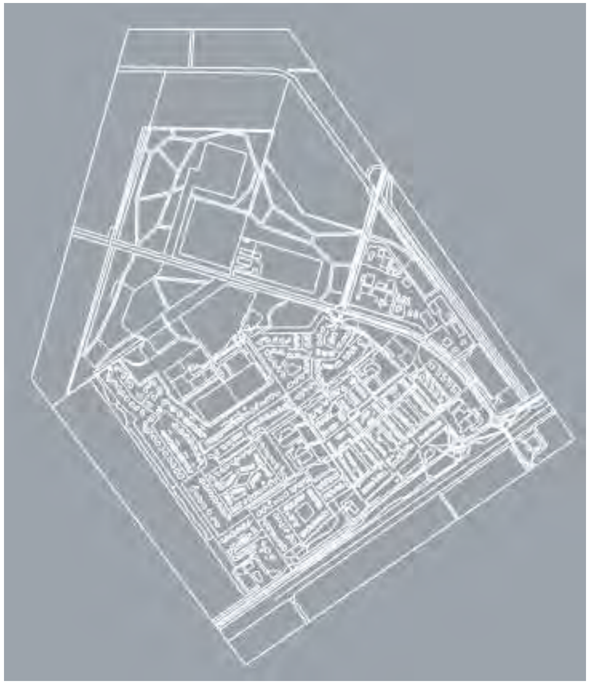
Function	**Area**	**Percentage on Boundary area**
Living Residential	362.637	20.8
Business Commercial	19.602	1.1
Business Light Industrial	29.403	1.6
Business Agriculture	686.070	39.4
Business Catering Industry	9.801	0.6
Public Park and open space	460.647	26.4
Public Building	19.602	1.1
Public Sports	49.005	2.8
Public educational Institute	9.801	0.6
Water	29.403	1.6
Total area	**1.675.971 m2**	**96**
Total boundary area:	**1.740.240 m2**	

4 % is unused or doesn't have any specific functional distribution

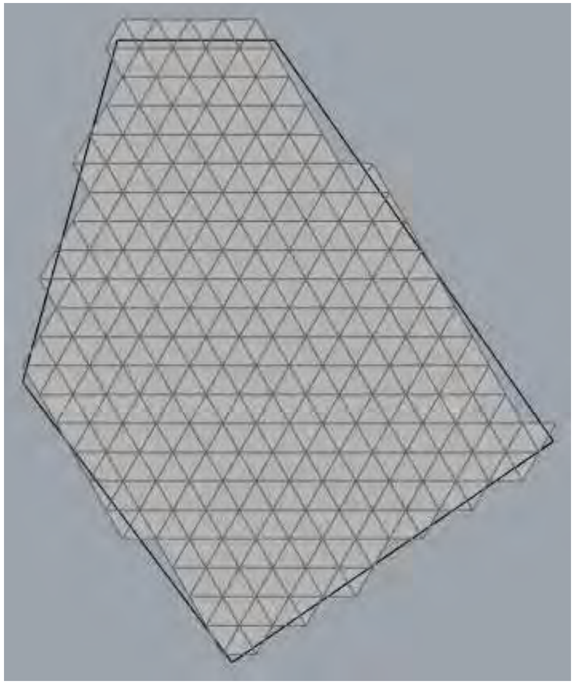


STUDIES

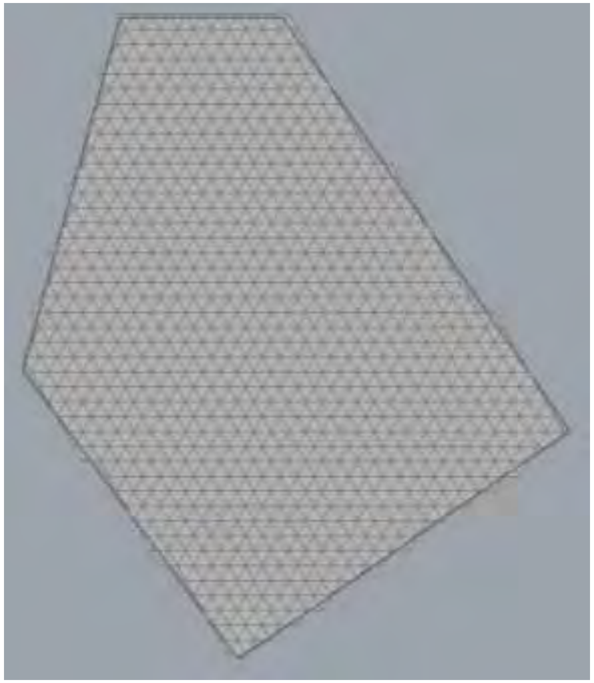
Considering without gaps between the platform gives an exact picture on the number of platforms. (literal translation from land to water)



On land
Total boundary area:
1.740.240 m2



Platform size	100 m
Total boundary area:	1.745.000 m2
Total platform area	1.745.000 m2
Scaling factor 1.06955	
Total number of platforms	403 units

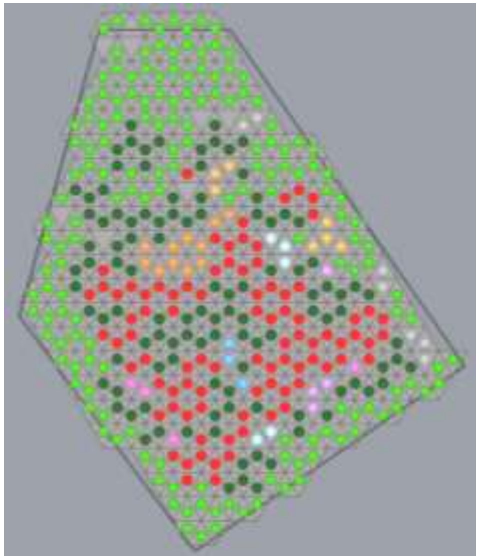


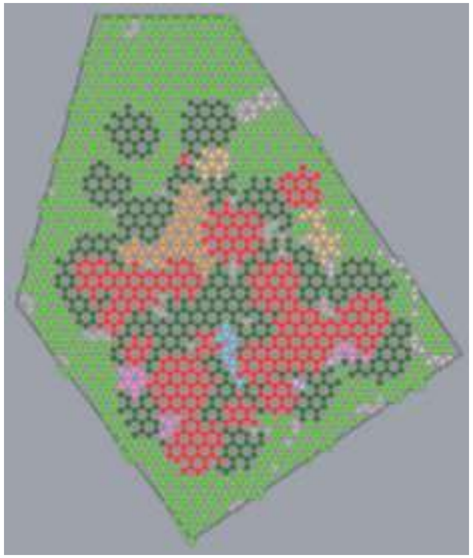
Platform size	50 m
Total boundary area	1.741.800 m2
Total platform area	1.741.800 m2
Scaling factor	1.03620
Total number of platforms	1609 units

STUDIES

Platform with no gap between platforms

Function	Number of units required 100 m platform	Number of units required 50 m platform
Living Residential	87	350
Business Commercial	5	19
Business Light Industrial	7	27
Business Agriculture	165	660
Business Catering Industry	2	9
Public Park and open space	110	442
Public Building	5	19
Public Sports	12	46
Public educational Institute	3	10
Water	7	27
Total	**403**	**1609**

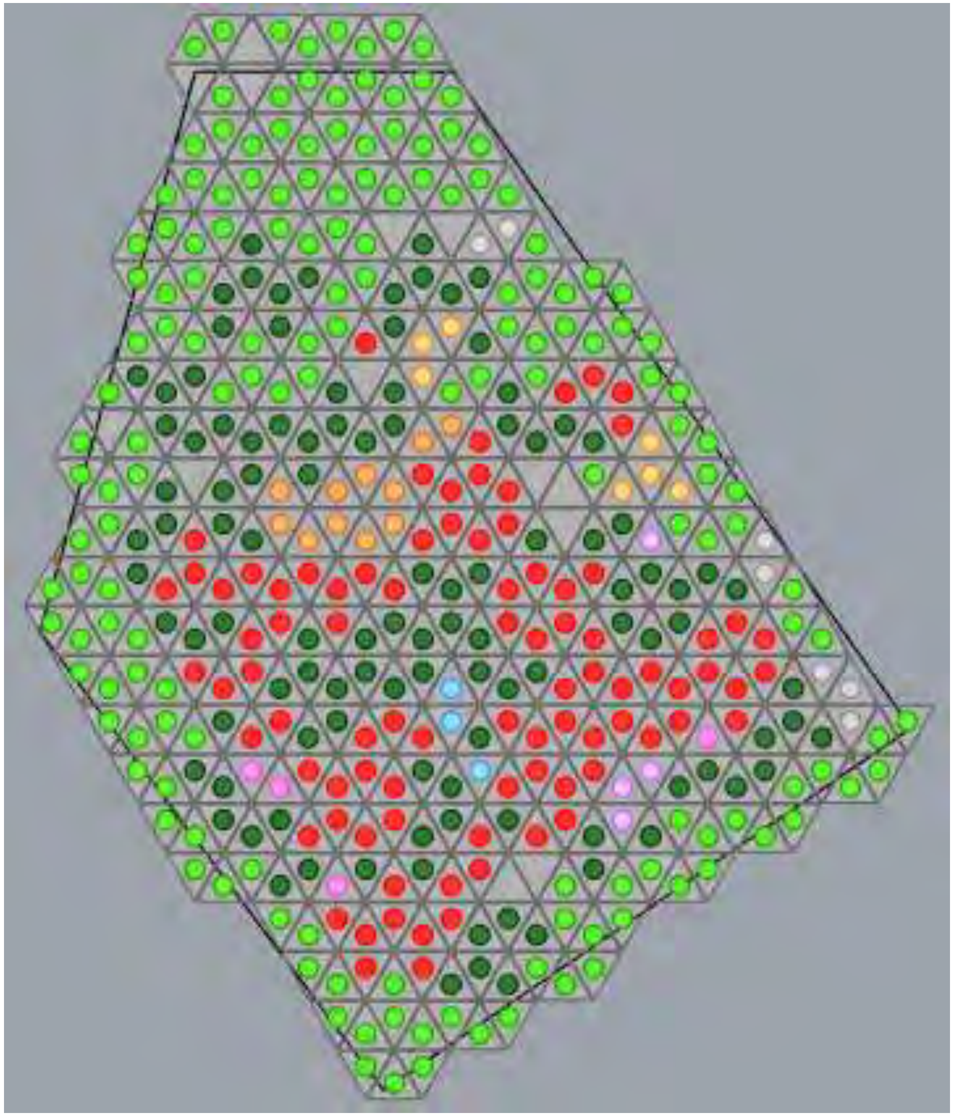




STUDIES

Rules

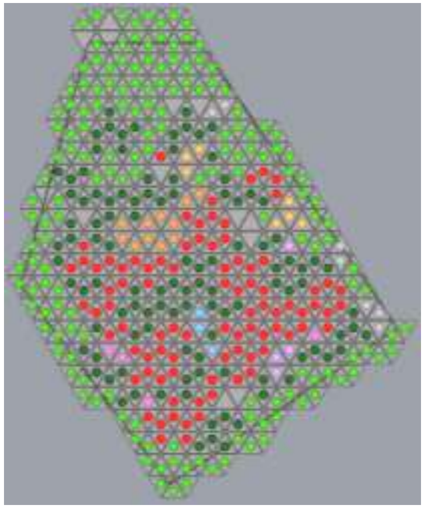
Platform	100 m
Platform depth	4 m
Slope of platform	0
Gap between	2.5 m
Area occupied on water	1.899.400 m2
Total area of platforms	1.745.000 m2
Scaling of boundary	1.1159
Scaling of program	1.0433

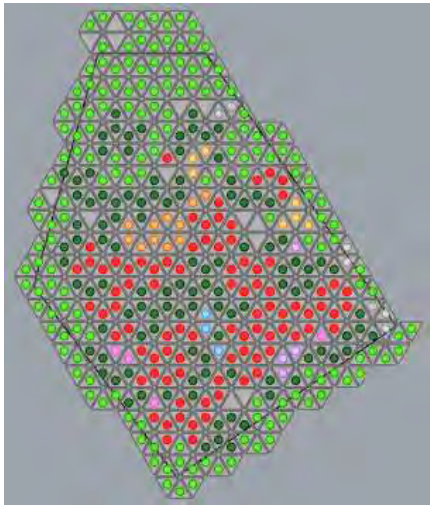


STUDIES

Rules

	Gap of 5.0m	Gap of 7.5m
Platform	100m	100m
Platform depth	4m	4m
Slope of platform	0	0
Gap between platforms	5.0m	7.5m
Area occupied on water	2.060.400m2	2.227.800m2
Total area of platforms	1.745.000m2	1.745.000m2
Scaling of boundary	1.1622	1.2085
Scaling of program	1.0866	1.1299

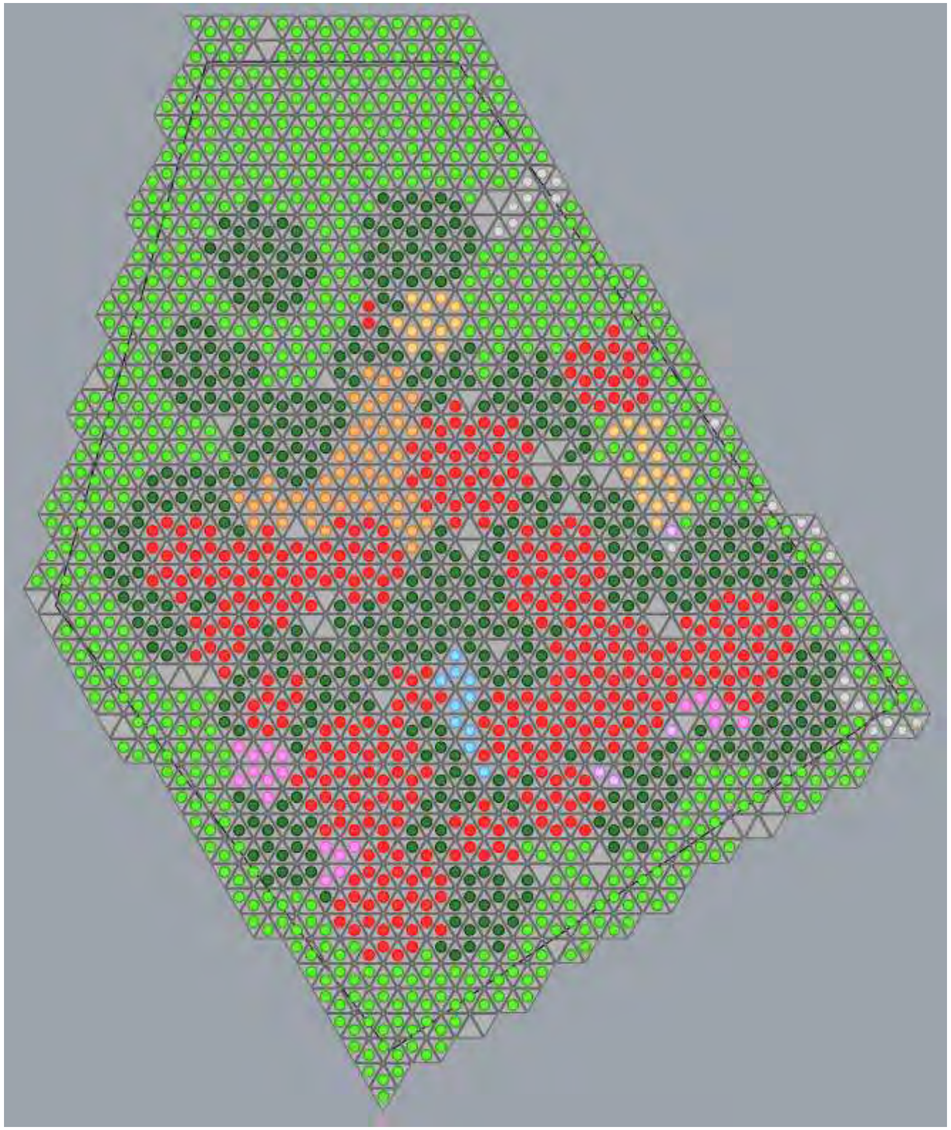




STUDIES

Rules

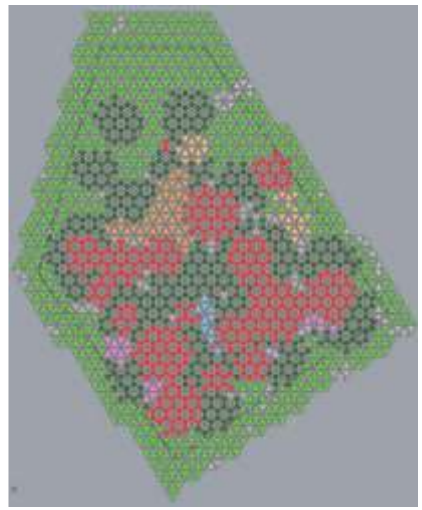
Platform	50 m
Platform depth	4 m
Slope of platform	0
Gap between	2.5 m
Area occupied on water	2.056.500 m2
Total area of platforms	1.741.800 m2
Scaling of boundary	1.126
Scaling of program	1.0866

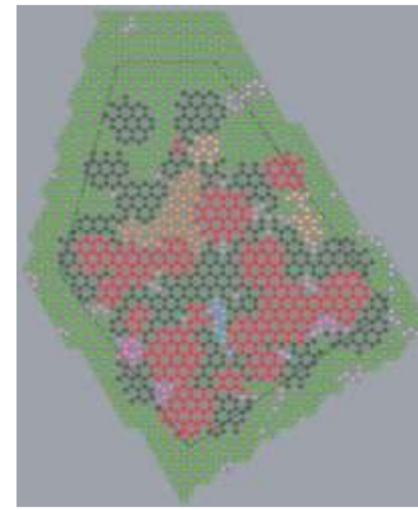


STUDIES

Rules

	Gap of 5.0m	Gap of 7.5m
Platform	50m	50m
Platform depth	4m	4m
Slope of platform	0	0
Gap between platforms	5.0m	7.5m
Area occupied on water	2.397.400m2	2.764.400m2
Total area of platforms	1.741.800m2	1.741.800m2
Scaling of boundary	1.2165	1.306
Scaling of program	1.1732	1.2598





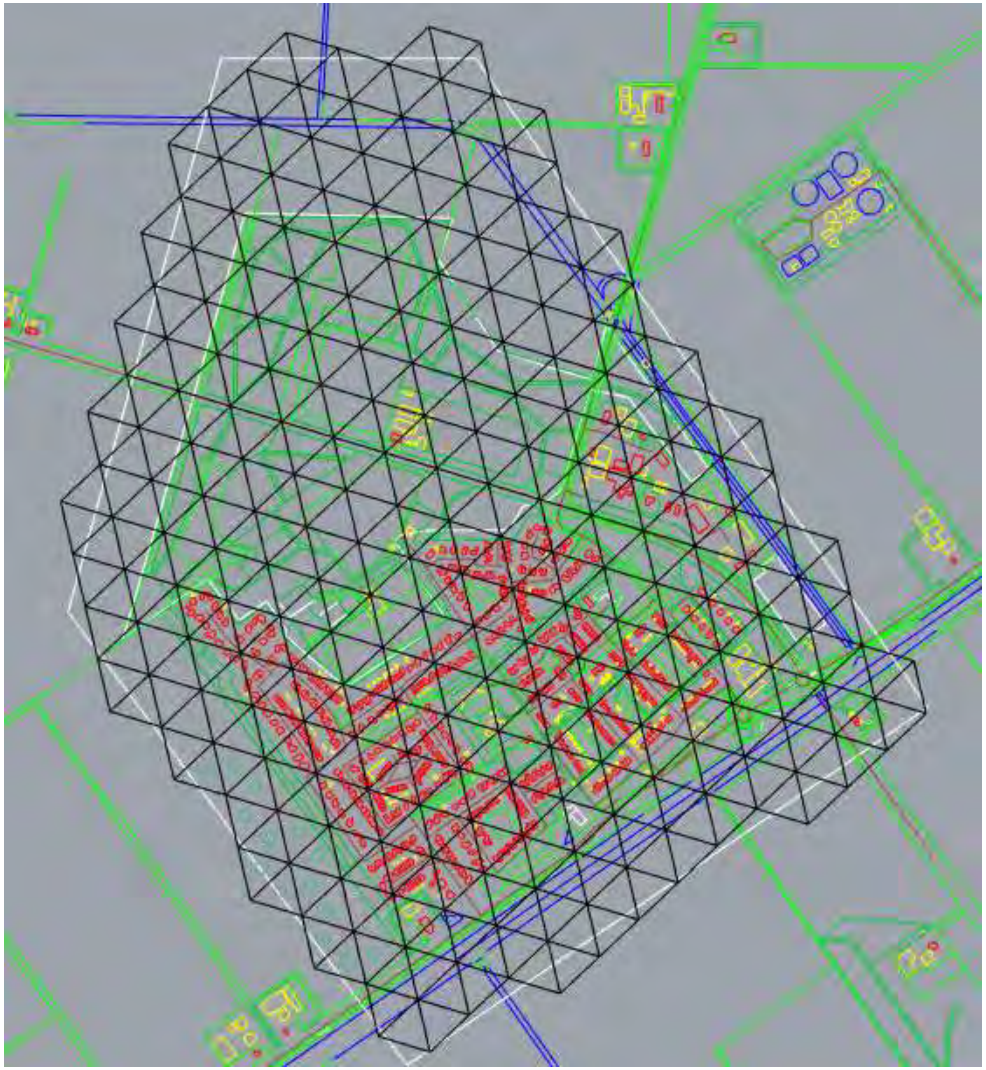
Number of platforms dedicated to a particular function remains the same
We see a constant change on the area occupied on water based on the rules

STUDIES

To study the built area on a platform

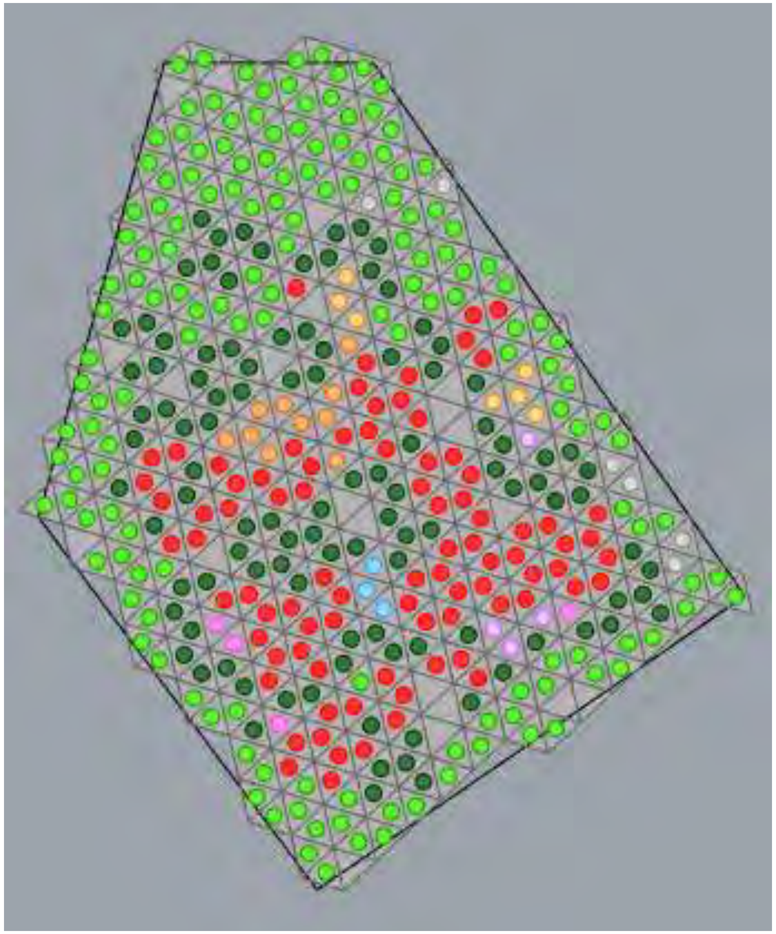
The platforms are aligned to the road network
The platform size is 100 m

With this, we studied the built area of each platform.
And the proportion to the transportation system etc.,.



This is a parallel to study 3. trying to understand how we can replicate a same network from land to water.

STUDIES



Basic ideation on how primary transport network can work.

STUDIES

Functions

Residential	less then 3 layers 21 – 25 % built 15 % road 53 – 57 % open and lawn area	
Commercial	21 – 25 % built 60 % open and lawn area	
Light Industry	35% built 55 % open and road	
Agriculture	type1	100% agri land
	type 2	12-15% road or walk ways balance agri land
	type 3	10 % water 10% open or green

.

Catering	30 % built open green lawn
Park	6-10 % pedestrian
Public	15% built open and green area road
Sports	15 % built 45 % sports field
Education	15 % built

We have to efficiently redefine the space – because we have lot of open spaces on land.
When we look in terms of exact footprint of a particular function we can reduce number of platforms.
And we can redefine number of platforms towards a function.
Each function can have different occupancy percentage on each platforms.

STUDIES

Function	Area (m2)	Footprint (m2)
Living Residential	362.637	55.248
Business Commercial	19.602	13.596
Business Light Industrial	29.403	14.074
Business Agriculture	686.070	561.210
Business Catering Industry	9.801	3.520
Public Park and open space	460.647	571.705
Public Building	19.602	4.821
Public Sports	49.005	20.284
Public educational Institute	9.801	1.375
Water	29.403	74.225
Total area	**1.675.971 m2**	**1.320.058 m2**

- We can see a drop in numbers when we just consider exact required footprint.
- Also the road network and the sizes vary from the existing (in land), to the triangle grid system, so its better to begin with exact foot print.
- We try to optimize on number of platforms.

STUDIES

Now we know the exact amount of foot print to be addressed for.
We have already done studies on different types of built form on a triangle platform.

With those studies we get the set of outputs.
These analysis becomes a toolbox to the script, we define things based on this analysis

Toolbox

Type	1	2	3	4	5	6	6	7
Side	100 m	100 m	100 m	100 m	100 m	100 m	100 m	100 m
Area	4330 m2	4330 m2	4330 m2	4330 m2	4330 m2	4330 m2	4330 m2	4330 m2
Land use %								
Buildings	48,9%	44,9%	62,4%	35,2%	43,3%	29,9%	34,5%	42,1%
Road	22,8%	26,8%	28,8%	22,8%	28,8%	36,5%	37%	39,1%
Green	28,3%	28,3%	8,8%	42%	27,9%	33,6%	28,5%	18,8%

Manual calculations to understand the difference in number of platform when a particular type is picked.

STUDIES

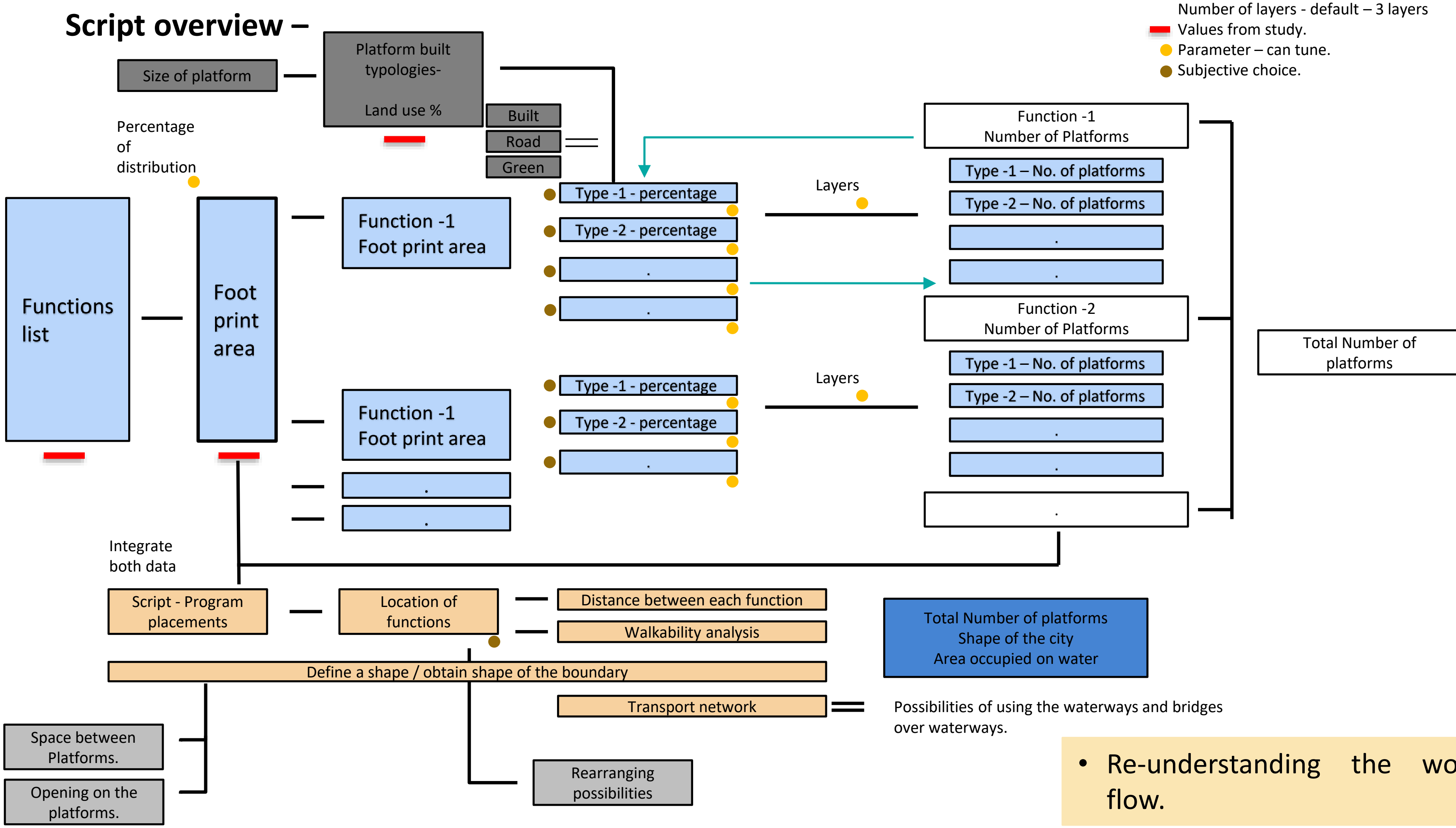
Remodeling the city

Total area of all built structure	111.170	Forest	325.726
Grass	245.979	Agriculture	561.210
Total	**1.244.085**		

	Type 1 **100 m** size	Type 3 **100 m** size	Type 7 **100 m** size	Type 1 **50 m** size
Built-up area	2116	2700	1495	576
Green	1230	383	1234	45
Road	984	1247	1602	461
Agriculture – Platform	3346 + 984	3680	3680	920
Number platform	**168**	**153**	**153**	**610**
Built Number	**53**	**42**	**75**	**193**
Green utilized	65190	16086	92550	8685
Balance green and forest	506515	555619	571705	563020
15% for walkways	650	650	650	
Number walkway	**138**	**151**	**156**	**612**
Total number	**359**	**346**	**384**	**1415**

STUDIES

Script overview –



- Re-understanding the work flow.

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STUDIES

Scenario 1 –

Function	Foot print	platform typology	Percentage	Built-%	Road-%	Green-%	blue or cut on platform-%	No. Of layers	Number of platforms	Total Platform
Living Residential	**55248**	Type -7	60	42,1	39,1	18,8		4	14	
		Type -6	40	29,9	36,5	33,6		3	17	**31**
Business Commercial	**13596**	Type -7	100	42,1	39,1	18,8		3	7	**7**
Business Light Industrial	**14074**	Type -7	100	42,1	39,1	18,8		3	8	**8**
Business Agriculture	**561210**		100	85	10	5			152	**152**
Business Catering Industry	**3520**	Type -7	100	42,1	39,1	18,8		3	2	**2**
Public Park and open space	**571705**		100	92	8	0			121	**121**
Public Building	**4821**	Type -7	100	42,1	39,1	18,8		4	2	**2**
Public Sports	**20284**	Type -7	20	42,1	39,1	18,8		3	2	
			80	100	0	0			4	**6**
Public educational Institute	**1375**	Type -7	100	42,1	39,1	18,8		3	1	**1**
Water	**74225**		100	0	0	4	96		18	**18**
	1320058									**348**

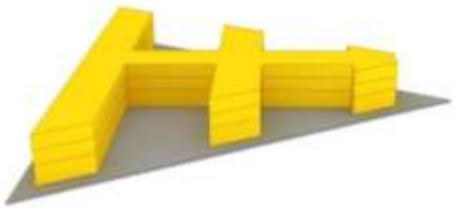
Platform size – 100 m.

- Idealy if we pick different type and compare. For the required amount of footprint we get the exact number of platforms. Still transportation has to be integrated.

STUDIES

Comparatively studying the results with 2 different sets of typologies of built form on the platform.
One function is considered and the exact same foot print is evaluated for both the sets.

Set 1 –



Type -1

Type -2

In this scheme the road transportation is not considered. The dimension for the road is 3,5 meters – accommodating complete pedestrian – walkability.

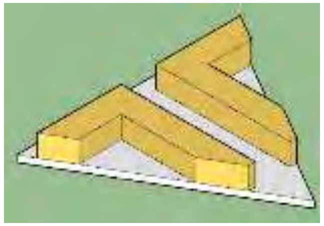
- Picking which typology is going to be used in what proportions.

STUDIES

Set – 2

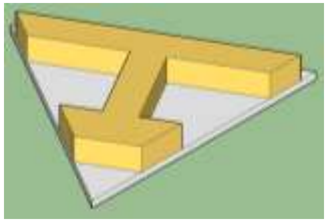
Type -1

Platform	– 100 m.	
Area	– 4330 m2	
Built	– 1891 m2	– 43,7 %
Road	– 1773 m2	– 41 %
Green	– 666 m2	– 15,3 %



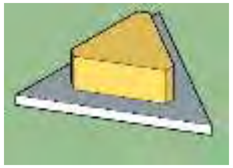
Type – 2

Platform	– 100 m	
Area	– 4330 m2	
Built	– 1925 m2	– 44,4%
Road	– 788 m2	– 18,6 %
Green	– 1617 m2	– 37 %



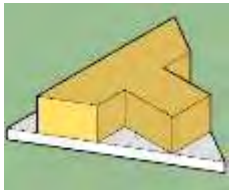
Type -3

Platform	– 50 m	
Area	– 1083 m2	
Built	– 358 m2	– 33 %
Road	– 725 m2	– 67 %



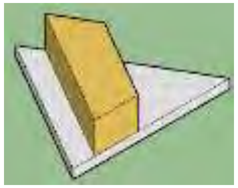
Type-4

Platform	– 50 m	
Area	– 1083 m2	
Road	– 279 m2	– 25,7 %
Built	– 613 m2	– 56,6 %
Green	– 191 m2	– 17,6 %

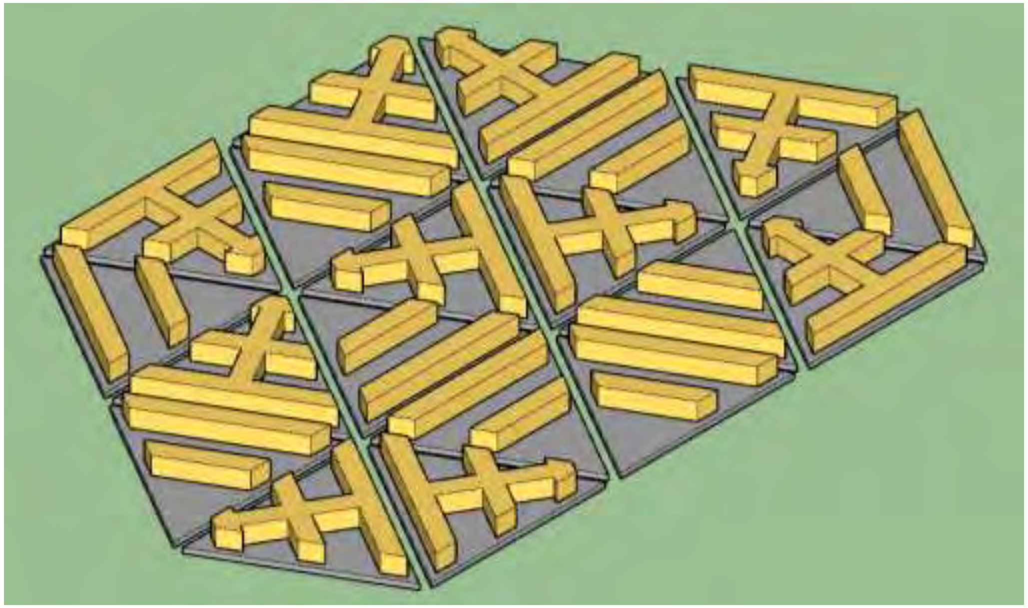


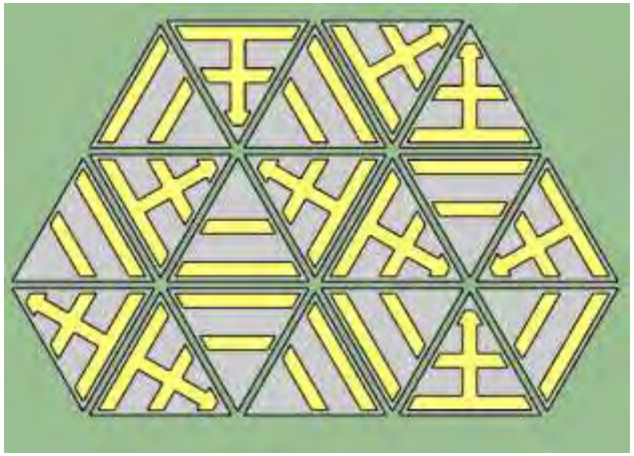
Type-5

Platform	– 50 m	
Area	– 1083 m2	
Road	– 279 m2	– 25,7 %
Built	– 434 m2	– 40 %
Green	– 370 m2	– 34,1 %



STUDIES



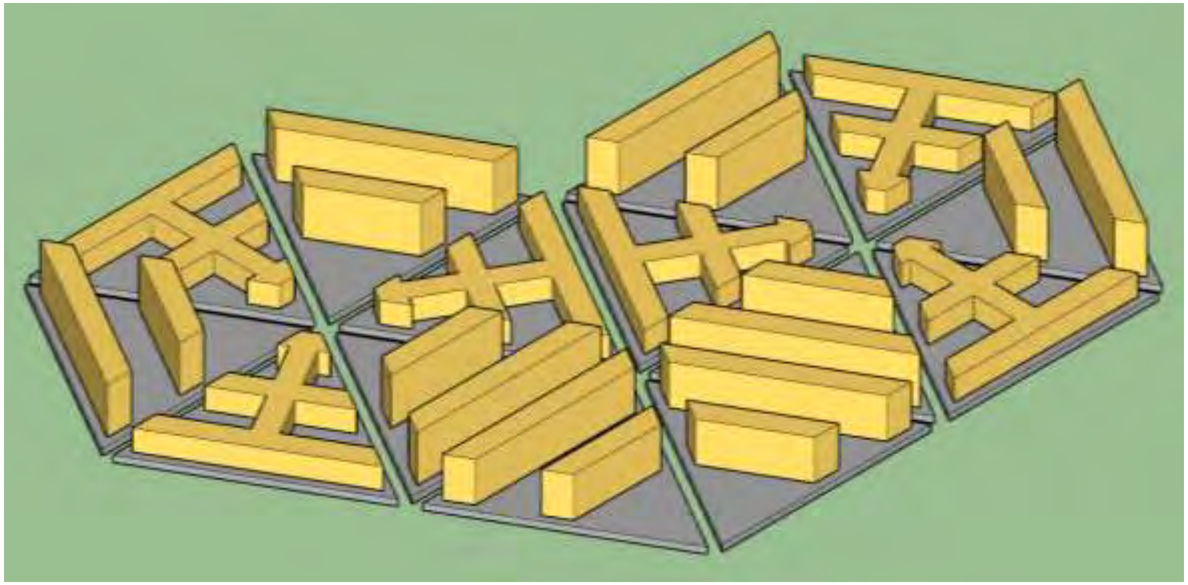


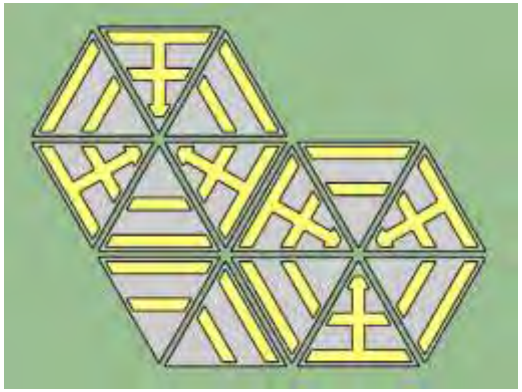
Function	Foot print	platform typology	Percentage	Built-%	Road-%	Green-%	blue or cut on platform-%	No. Of layers	Number of platforms	Total Platform
Living Residential	**29535**	Type -1	60	42,1				3	10	
		Type -2	40	29,9				3	9	**19**

- By changing the percentage of a type and the number of layer - we can control the density.

SPACE@SEA

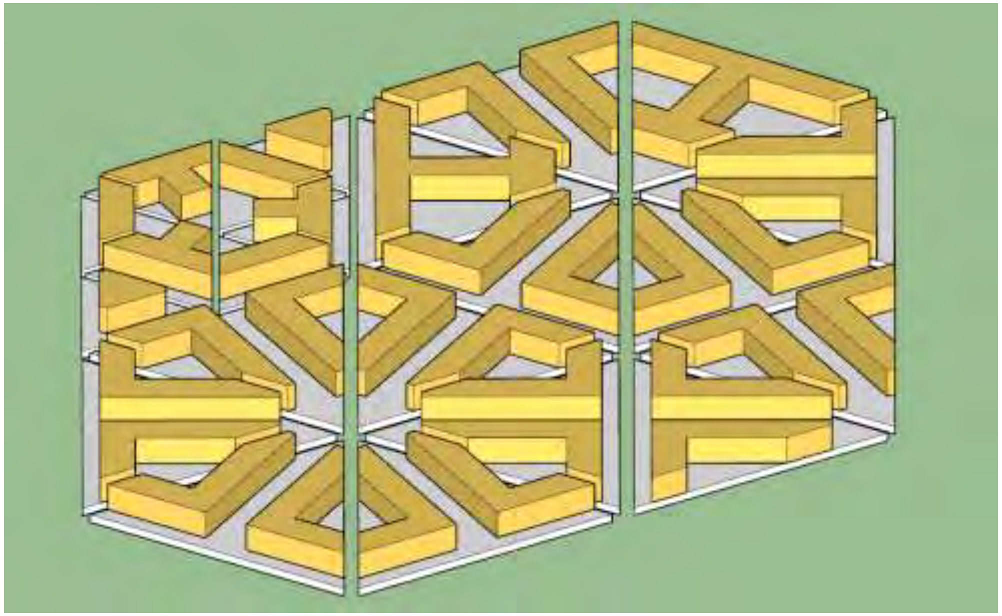
STUDIES

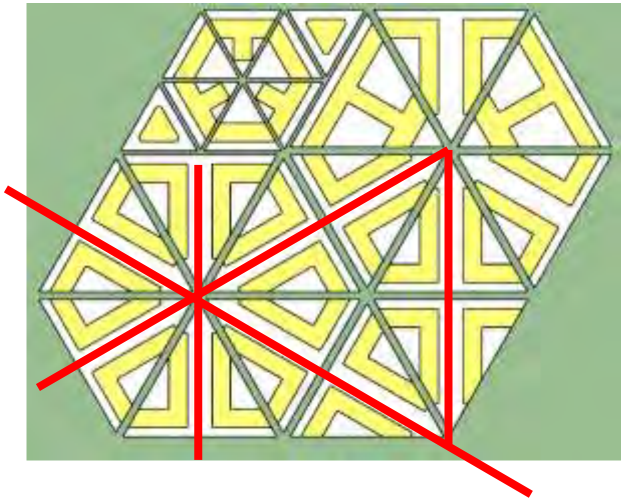




Function	Foot print	platform typology	Percentage	Built-%	Road-%	Green-%	blue or cut on platform-%	No of layers	Number of platforms	Total Platform
Living Residential	**29535**	Type -1	40	42,1				3	6	
		Type -2	60	29,9				6	8	**14**

STUDIES



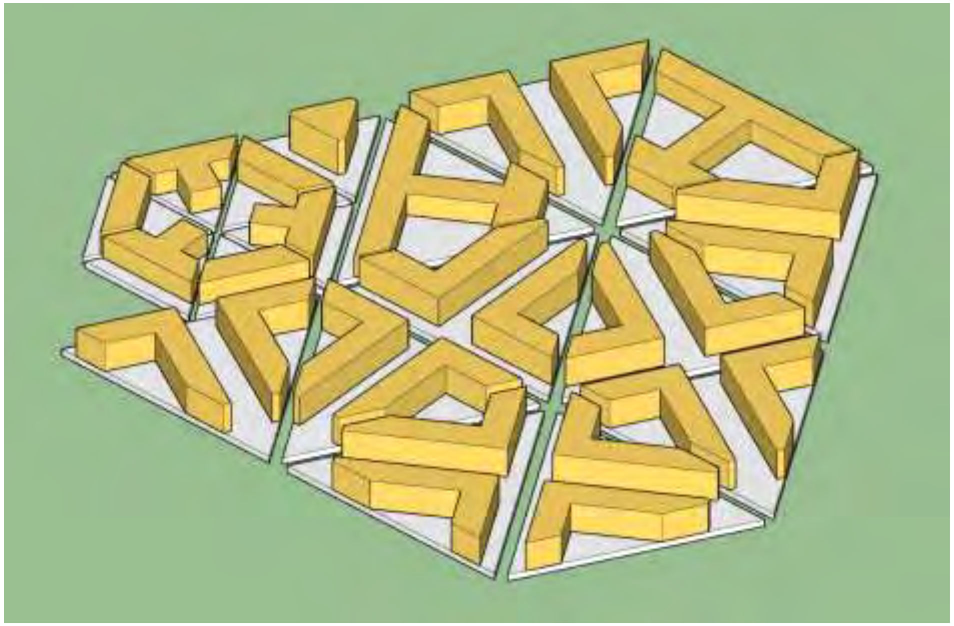


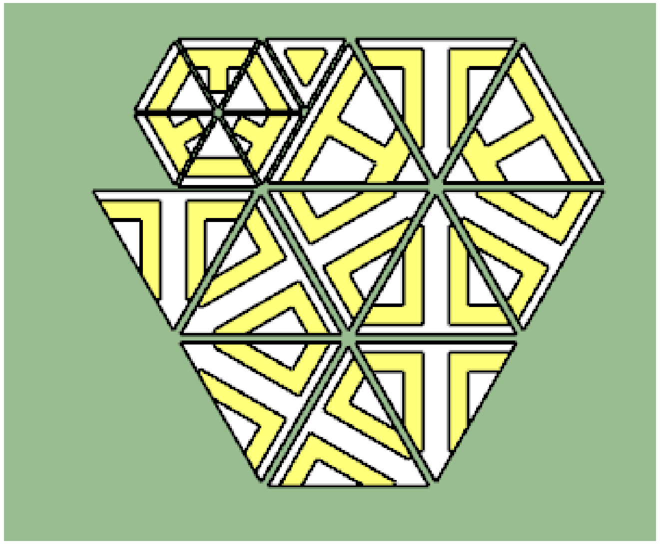
Function	Foot print	platform typology	Percentage	Built-%	Road-%	Green-%	blue or cut on platform-%	No of layers	Number of platforms	Total Platform
Living Residential	**29535**	Type -1	74	43,7				3	12	
		Type -2	13	44,4				3	2	
		Type -3	2,4	33				3	2	
		Type -4	6,2	56,6				3	3	
		Type -5	4,4	40				3	3	**22**

- In this the transportation is integrated.

SPACE@SEA

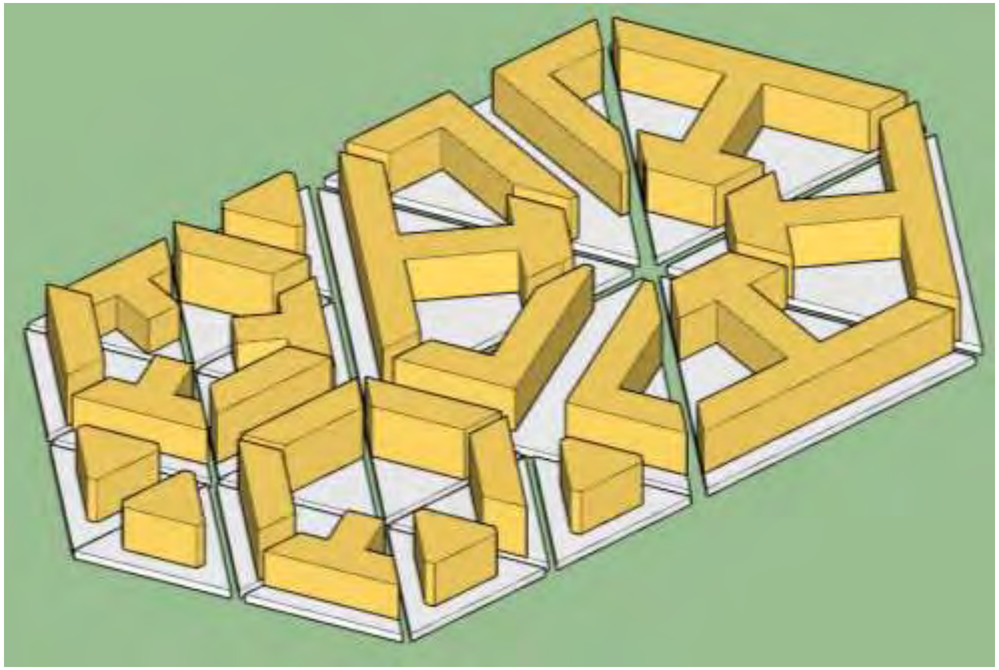
STUDIES

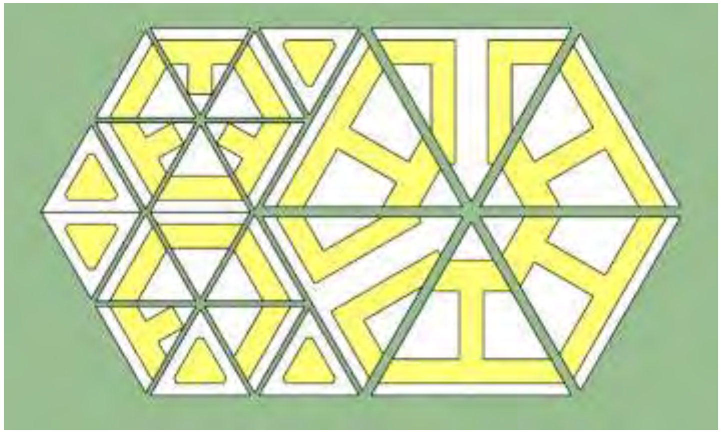




Function	Foot print	platform typology	Percentage	Built-%	Road-%	Green-%	blue or cut on platform-%	No of layers	Number of platforms	Total Platform
Living Residential	**29535**	Type -1	74	43,7				4	9	
		Type -2	13	44,4				3	2	
		Type -3	2,4	33				5	1	
		Type -4	6,2	56,6				3	3	
		Type -5	4,4	40				3	3	**18**

STUDIES





- With variables in percentage and the number of layers based on the type, we can keep optimizing number of platforms and density required.

Function	Foot print	platform typology	Percentage	Built-%	Road-%	Green-%	blue or cut on platform-%	No of layers	Number of platforms	Total Platform
Living Residential	**29535**	Type -1	20	43,7				5	2	
		Type -2	40	44,4				5	4	
		Type -3	10	33				5	5	
		Type -4	10	56,6				4	4	
		Type -5	20	40				6	7	**22**

STUDIES

Now we will just try out with one single typology. Compare it with both the type of platform. The given function is constant in both conditions.

Conditions -
Given foot print – 40,000 m2.
Average initial layers – 2
Total gross area – 80,000 m2.
Per unit size – 90m2

Scenario -1

Platform	– 100 m.
Area	– 4330 m2
Built	– 57,8 %
No. of Layers	– 2
No. of Platforms	– 16
Actual built ground cover	– 39808 m2
Gross area per platform	– 4976 m2
Density (No of units per platform)	– 55,2

Scenario -2

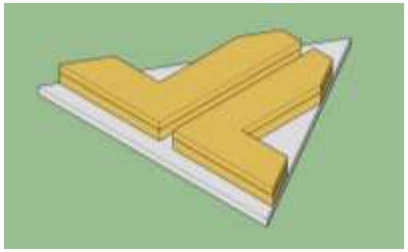
Platform	– 100 m.
Area	– 4330 m2
Built	– 57,8 %
No. of Layers	– 4
No. of Platforms	– 8
Actual built ground cover	– 19904 m2
Gross area per platform	– 9952 m2
Density (No of units per platform)	– 110,5

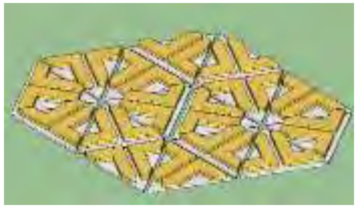
Scenario -3

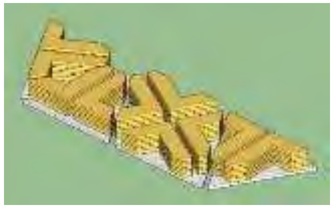
Platform	– 100 m.
Area	– 4330 m2
Built	– 57,8 %
No. of Layers	– 6
No. of Platforms	– 5
Actual built ground cover	– 12440 m2
Gross area per platform	– 14928 m2
Density (No of units per platform)	– 166

Selected type.

Size	- 100 m
Built	- 2488 m2
Built %	- 57,8 %
Road % (walkways)	- 26,7 %
Green %	- 15,5%
Water transportation.	







- We can optimize the number of platform but the distance between the block is too narrow, so the built % sholud be reduced to find a better spacing between the blocks.

STUDIES

Conditions -
Given foot print – 40,000 m2.
Average initial layers – 2
Total gross area – 80,000 m2.
Per unit size – 90m2

Selected type.

Size	- 100 m
Built	- 2119 m2
Built %	- 48,9 %
Road % (walkways)	- 26,7 %
Green %	- 24,4 %
Water transportation.	

Scenario -1

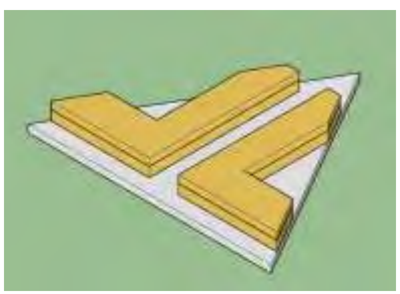
Platform	– 100 m.
Area	– 4330 m2
Built	– 48,9 %
No. of Layers	– 2
No. of Platforms	– 19
Actual built ground cover	– 40261 m2
Gross area per platform	– 4238 m2
Density (No of units per platform)	– 47

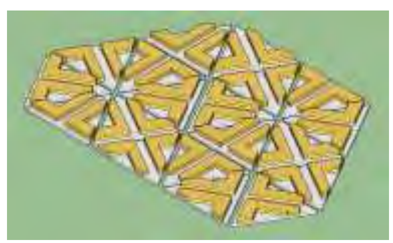
Scenario -2

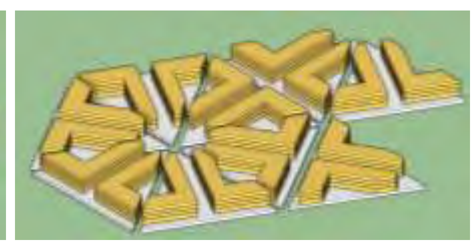
Platform	– 100 m.
Area	– 4330 m2
Built	– 48,9 %
No. of Layers	– 4
No. of Platforms	– 9
Actual built ground cover	– 19071 m2
Gross area per platform	– 8476 m2
Density (No of units per platform)	– 94

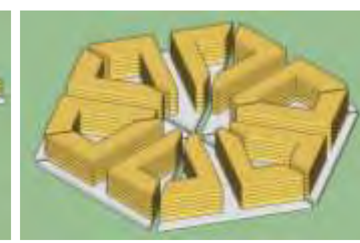
Scenario -3

Platform	– 100 m.
Area	– 4330 m2
Built	– 48,9 %
No. of Layers	– 6
No. of Platforms	– 6
Actual built ground cover	– 12714 m2
Gross area per platform	– 12714 m2
Density (No of units per platform)	– 141









- Space between the block is increased to have better conditions. – day light etc.

STUDIES

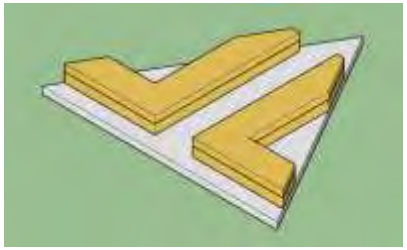
Conditions -
Given foot print – 40,000 m2.
Average initial layers – 2
Total gross area – 80,000 m2.
Per unit size – 90m2

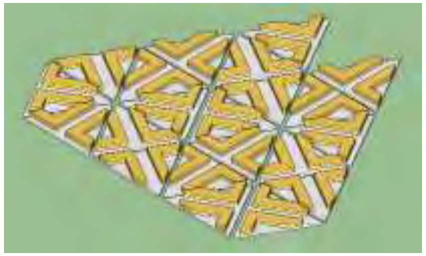
Selected type.

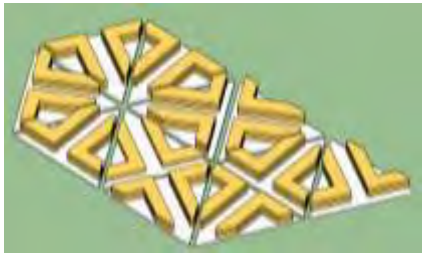
Size	- 100 m
Built	- 1891 m2
Built %	- 43,6 %
Road %	- 41,1 %
Green %	- 15,3 %

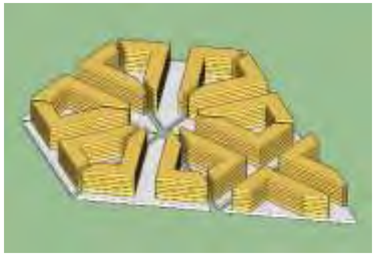
With roads transportation.

	Scenario -1	Scenario -2	Scenario -3
Platform	– 100 m.	– 100 m.	– 100 m.
Area	– 4330 m2	– 4330 m2	– 4330 m2
Built	– 43,6 %	– 43,6 %	– 43,6 %
No. of Layers	– 2	– 4	– 6
No. of Platforms	– 21	– 11	– 7
Actual built ground cover	– 39711 m2	– 20801 m2	– 13237 m2
Gross area per platform	– 3782 m2	– 7564 m2	– 11346 m2
Density (No of units per platform)	– 42	– 84	– 126









- In this we have incorporated the road way transport system, the road width is 16m. We obtain a primary road network.

- We can check the optimization, there is not enough space for road network. So the built % has to be reduced.

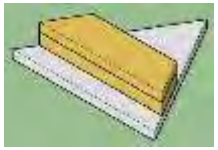
STUDIES

Conditions -
Given foot print – 10,000 m2.
Average initial layers – 2
Total gross area – 20,000 m2.
Per unit size – 90m2 – for density calculation
Gap between platform – 5 m
With pedestrian

Platform -1

Built % - 51,4 %
Road % (walkway) - 26 %
Green % - 22,6 %

Platform -2

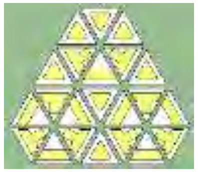


Built % - 40 %
Road % (walkway) - 26 %
Green % - 34%

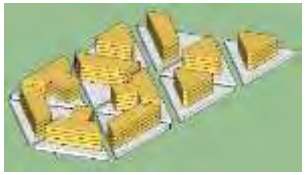
Platform -3

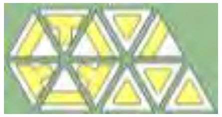
Built % - 33 %
Road % (walkway) - 67 %
Green % - 0

Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	1083	41,2	557	51,4	2	8	1114	12
2	1083	32,2	434	40	2	7	868	9,6
3	1083	26,5	358	33	2	7	716	8

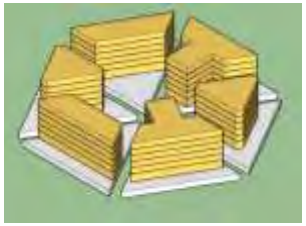


Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	1083	41,2	557	51,4	4	3	2228	25
2	1083	32,2	434	40	4	4	1736	19
3	1083	26,5	358	33	4	4	1432	16





Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	1083	41,2	557	51,4	6	2	3342	37
2	1083	32,2	434	40	6	2	2604	29
3	1083	26,5	358	33	6	2	2148	24

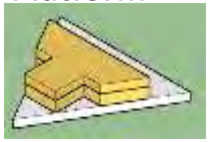


STUDIES

Conditions -

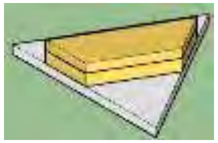
Given foot print	– 10,000 m2.
Average initial layers	– 2
Total gross area	– 20,000 m2.
Per unit size	– 90m2 – for density calculation
Gap between platform	– 5 m
With road transportation.	

Platform -



Built % - 47 %
Road % - 40,8 %
Green % - 12,2 %

Platform -

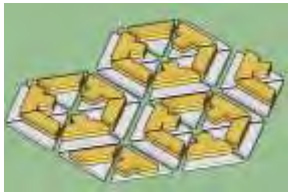


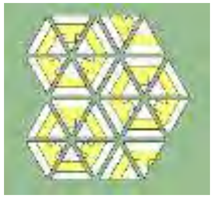
Built % - 34,9%
Road % - 40,8 %
Green % - 24,3 %

Platform -

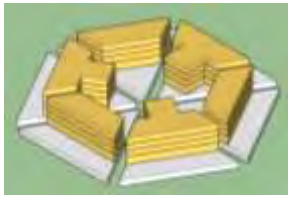
Built % - 0
Road % - 91 %
Green % - 9 %

Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	1083	57,3	509	47	2	11	1018	11,3
2	1083	42,7	378	34,9	2	11	756	8,4
3	1083	0	0	0	2	0	0	0

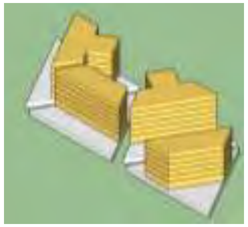


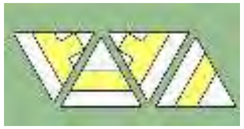


Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	1083	57,3	509	47	4	6	2036	22,6
2	1083	42,7	378	34,9	4	6	1512	16,8
3	1083	0	0	0	4	0	0	0



Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	1083	57,3	509	47	6	4	3054	34
2	1083	42,7	378	34,9	6	4	2268	25,2
3	1083	0	0	0	6	0	0	0





STUDIES

Comparison study on density –

Assuming we have same amount of built % for both 50 m and 100 m platforms. Having same amount of distribution.

Given foot print – 50,000 m2.
Average initial layers – 2
Total gross area – 100,000 m2.
Per unit size – 90m2 – for density calculation
Gap between platform – 5 m

Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	1083	41,2	557	51,4	2	37	1114	12,3
2	1083	32,2	434	40	2	37	868	9,6
3	1083	26,5	358	33	2	37	716	8

Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	4330	41,2	2226	51,4	2	9	4452	49,4
2	4330	32,2	1732	40	2	9	3464	38,4
3	4330	26,5	1429	33	2	9	2858	31,7

STUDIES

Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	1083	41,2	557	51,4	4	19	2228	24,7
2	1083	32,2	434	40	4	19	1736	19,2
3	1083	26,5	358	33	4	19	1432	16

Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	4330	41,2	2226	51,4	4	5	8904	99
2	4330	32,2	1732	40	4	5	6928	77
3	4330	26,5	1429	33	4	5	5716	63,5

Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	1083	41,2	557	51,4	6	12	3342	37
2	1083	32,2	434	40	6	12	2604	29
3	1083	26,5	358	33	6	12	2148	23,8

Platform	Area (m2)	Percentage distribution	Built (m2)	Built %	No. Of Layers	No of Platforms	Gross area per platform (m2)	Density
1	4330	41,2	2226	51,4	6	3	13356	148,4
2	4330	32,2	1732	40	6	3	10392	115,4
3	4330	26,5	1429	33	6	3	8574	95,2

STUDIES

Output from the studies –

- Platforms with just pedestrian network has got higher density comparing to the one with road transport network.
- 100 m platform has got 4 times the values compered with one 50 m platform.
- In proportion 100 m platform workes fine with better outputs – we can compare one 100 m platform with 2 layers – to a 50 m platform with 8 layers – we get a same amount of density.

STUDIES

Now we are reflecting the study on the density and the transport system on Tollebeek to test results.

Function	Foot print (m2)
Living Residential	55.248
Business Commercial	13.596
Business Light Industrial	14.074
Business Agriculture	561.210
Business Catering Industry	3.520
Public Park and open space	571.705
Public Building	4.821
Public Sports	20.284
Public educational Institute	1.375
Water	74.225

With this data – we will study it in 4 condition –

- **50 m platform with pedestrian walkways and water transport.**
- **50 m platform with road transport.**
- **100 m platform with pedestrian walkways and water transport.**
- **100 m platform with road transport.**

Same types of platforms area going to be used as in previous studies.
We are comparing it, all with 2 layers.

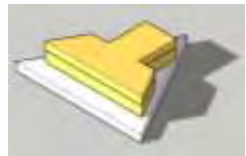
STUDIES

Same boundary profile as Tollebeek.

Condition – 1

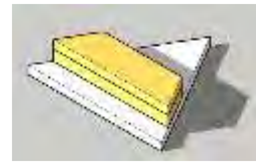
Platform	- **50 m**
Slope on Platform edge	- 0
Platform area	- 1083 m2
Platform depth	- 3 m
Gap between platform	- **5 m**

Platform -1



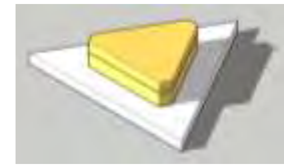
Built % - 51,4 %
Road % (walkway) - 26 %
Green % - 22,6 %

Platform -2



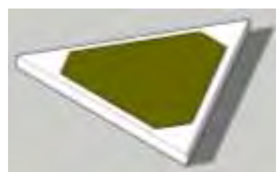
Built % - 40 %
Road % (walkway) - 26 %
Green % - 34%

Platform -3



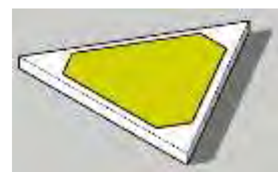
Built % - 33 %
Road % (walkway) - 67 %
Green % - 0

Platform -4

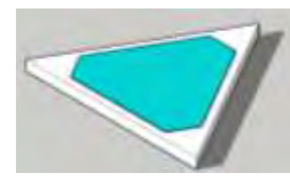


Park and open space

Built % - 0
Road % (walkway) - 33 %
Green % - 67 %



Agriculture



Water

Park –
571705 – 46588 =
525117

STUDIES

Same boundary profile as Tollebeek.

Function	Foot Print (m2)	Type	Percentage Distribution	No of Layers	No of Platforms	Total Platforms
Living Residential	55248	1	41,3	2	41	**123**
		2	32,2	2	41	
		3	26,5	2	41	
Business Commercial	13596	1	41,3	2	10	**30**
		2	32,2	2	10	
		3	26,5	2	10	
Business Light Industrial	14074	1	41,3	2	10	**30**
		2	32,2	2	10	
		3	26,5	2	10	
Business Agriculture	561210	4	100	1	773	**773**
Business Catering Industry	3520	1	41,3	2	3	**9**
		2	32,2	2	3	
		3	26,5	2	3	
Public Park and open space	525117	4	100	1	724	**724**
Public Building	4821	1	41,3	2	4	**12**
		2	32,2	2	4	
		3	26,5	2	4	
Public Sports	20284	1	20	2	7	**22**
		4	80	1	15	
Public educational Institute	1375	1	41,3	2	1	**3**
		2	32,2	2	1	
		3	26,5	2	1	
Water	74225	4	100	1	102	**102**

Total – 1828

SPACE@SEA

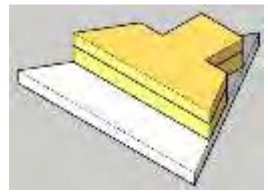
STUDIES

Same boundary profile as Tollebeek.

Condition – 2

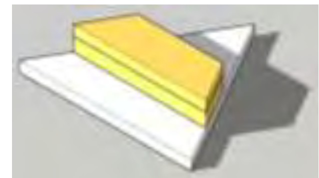
Platform	- **50 m**
Slope on Platform edge	- 0
Platform area	- 1083 m2
Platform depth	- 3 m
Gap between platform	- **5 m**

Platform -1



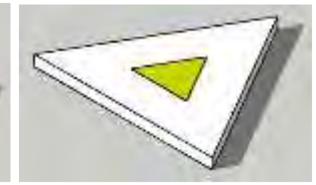
Built % - 47 %
Road % - 40,8 %
Green % - 12,2 %

Platform -2



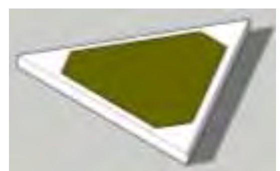
Built % - 34,9%
Road % - 40,8 %
Green % - 24,3 %

Platform -3

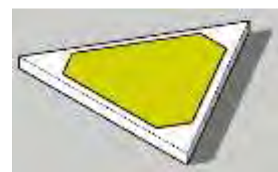


Built % - 0
Road % - 91 %
Green % - 9 %

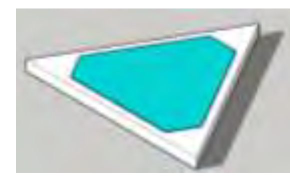
Platform -4



Park and open space



Agriculture



Water

Built % - 0
Road % (walkway) - 33 %
Green % - 67 %

Park –
571705 – 41080 =
530625

STUDIES

Same boundary profile as Tollebeek.

Function	Foot Print (m2)	Type	Percentage Distribution	No of Layers	No of Platforms	Total Platforms
Living Residential	55248	1	57,3	2	62	**124**
		2	42,7	2	62	
Business Commercial	13596	1	57,3	2	15	**30**
		2	42,7	2	15	
Business Light Industrial	14074	1	57,3	2	16	**32**
		2	42,7	2	16	
Business Agriculture	561210	4	100	1	773	**773**
Business Catering Industry	3520	1	57,3	2	4	**8**
		2	42,7	2	4	
Public Park and open space	530625	4	100	1	731	**731**
Public Building	4821	1	57,3	2	5	**10**
		2	42,7	2	5	
Public Sports	20284	1	20	2	8	**23**
		4	80	1	15	
Public educational Institute	1375	1	57,3	2	2	**4**
		2	42,7	2	2	
Water	74225	4	100	1	102	**102**

Total – 1837

STUDIES

Same boundary profile as Tollebeek.

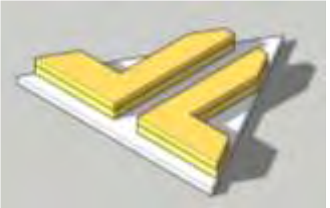
Condition – 3

Platform - **100 m**
Slope on Platform edge - 0
Platform area - 4330 m2
Platform depth - 3 m
Gap between platform - **5 m**

Function	Foot Print (m2)	Type	Percentage Distribution	No of Layers	No of Platforms	Total Platforms
Living Residential	55248	1	100	2	26	**26**
Business Commercial	13596	1	100	2	6	**6**
Business Light Industrial	14074	1	100	2	7	**7**
Business Agriculture	561210	2	100	1	206	**206**
Business Catering Industry	3520	1	100	2	2	**2**
Public Park and open space	518879	2	100	1	179	**179**
Public Building	4821	1	100	2	2	**2**
Public Sports	20284	1	20	2	2	**6**
		2	80	1	4	
Public educational Institute	1375	1	100	2	1	**1**
Water	74225	2	100	1	27	**27**

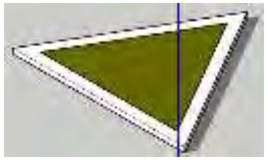
Total – 462

Platform -1

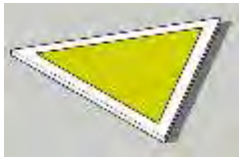


Built % - 48,9 %
Road % - 26,7 %
Green % - 24,4 %

Platform -2



Park and open space



Agriculture

Built % - 0
Road % (walkway)
Green % - 63 %

Water

Park –
571705 – 52826 = 518879

STUDIES

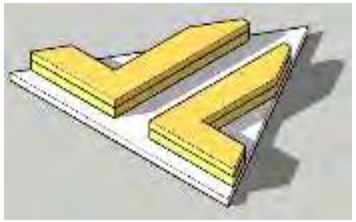
Output from the studies –

- We get high numbers in agriculture and green and open spaces from the previous demarked boundary.
- To have an effective study we re-map boundary and check the output results.

Condition – 4

Platform - **100 m**
Slope on Platform edge - 0
Platform area - 4330 m2
Platform depth - 3 m
Gap between platform - **5 m**

Platform -1

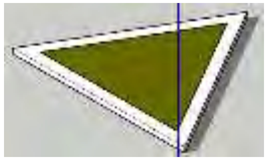


Built % - 43,6 %
Road % - 41,1 %
Green % - 15,3 %

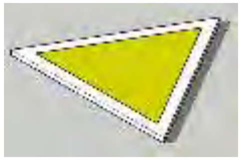
Function	Foot Print (m2)	Type	Percentage Distribution	No of Layers	No of Platforms	Total Platforms
Living Residential	55248	1	100	2	29	**29**
Business Commercial	13596	1	100	2	7	**7**
Business Light Industrial	14074	1	100	2	7	**7**
Business Agriculture	561210	2	100	1	206	**206**
Business Catering Industry	3520	1	100	2	2	**2**
Public Park and open space	538581	2	100	1	197	**197**
Public Building	4821	1	100	2	3	**3**
Public Sports	20284	1	20	2	2	**6**
		2	80	1	4	
Public educational Institute	1375	1	100	2	1	**1**
Water	74225	2	100	1	27	**27**

Total – 485

Platform -2



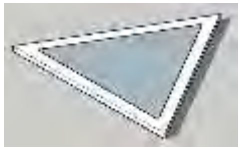
Park and open space



Agriculture

Built % - 0
Road % (walkway)
Green % - 63 %

Park –
571705 – 33124 =
538581



Water

Same boundary profile as Tollebeek.

Just for comparison no –built form type is prepared in the same area.

STUDIES

Condition – 3a

Platform - 100 m
Slope on Platform edge - 0
Platform area - 4330 m2
Platform depth - 3 m
Gap between platform - 5 m

Platform -1

Built % - 51,4 %
Road % (walkway) - 26 %
Green % - 22,6 %

Platform -2

Built % - 40 %
Road % (walkway) - 26 %
Green % - 34%

Platform -3

Built % - 33 %
Road % (walkway) - 67 %
Green % - 0

Platform -4

Park and open space — Agriculture — Water

Built % - 0
Road % (walkway) - 33 %
Green % - 67 %

Park –
571705 – 46588 = 525117

Total – 461

Function	Foot Print (m2)	Type	Percentage Distribution	No of Layers	No of Platforms	Total Platforms
Living Residential	55248	1	41,3	2	10	**30**
		2	32,2	2	10	
		3	26,5	2	10	
Business Commercial	13596	1	41,3	2	3	**9**
		2	32,2	2	3	
		3	26,5	2	3	
Business Light Industrial	14074	1	41,3	2	3	**9**
		2	32,2	2	3	
		3	26,5	2	3	
Business Agriculture	561210	4	100	1	193	**193**
Business Catering Industry	3520	1	41,3	2	1	**3**
		2	32,2	2	1	
		3	26,5	2	1	
Public Park and open space	525117	4	100	1	181	**181**
Public Building	4821	1	41,3	2	1	**3**
		2	32,2	2	1	
		3	26,5	2	1	
Public Sports	20284	1	20	2	2	**6**
		4	80	1	4	
Public educational Institute	1375	1	41,3	2	0	**1**
		2	32,2	2	1	
		3	26,5	2	0	
Water	74225	4	100	1	26	**26**

Just for comparison no –built form type is prepared in the same area.

STUDIES

Condition – 4a

Platform - 100 m
Slope on Platform edge - 0
Platform area - 4330 m2
Platform depth - 3 m
Gap between platform - 5 m

Platform -1

Built % - 47 %
Road % - 40,8 %
Green % - 12,2 %

Platform -2

Built % - 34,9%
Road % - 40,8 %
Green % - 24,3 %

Platform -3

Built % - 0
Road % - 91 %
Green % - 9 %

Platform -4

Park and open space Agriculture Water
Built % - 0
Road % (walkway)- 33 %
Green % - 67 %

Park –
571705 – 47400 = 524305

Total – 459

Function	Foot Print (m2)	Type	Percentage Distribution	No of Layers	No of Platforms	Total Platforms
Living Residential	55248	1	57,3	2	16	
		2	42,7	2	16	
						32
Business Commercial	13596	1	57,3	2	4	
		2	42,7	2	4	
						8
Business Light Industrial	14074	1	57,3	2	4	
		2	42,7	2	4	
						8
Business Agriculture	561210	4	100	1	773	**193**
Business Catering Industry	3520	1	57,3	2	1	
		2	42,7	2	1	
						2
Public Park and open space	524305	4	100	1	181	**181**
Public Building	4821	1	57,3	2	1	
		2	42,7	2	1	
						2
Public Sports	20284	1	20	2	2	**6**
		4	80	1	4	
Public educational Institute	1375	1	57,3	2	1	
		2	42,7	2	0	
						1
Water	74225	4	100	1	26	**26**

STUDIES

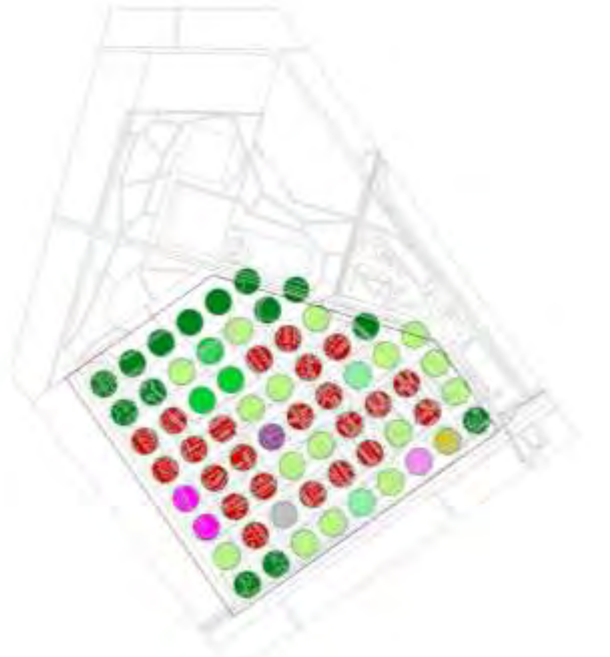
Function	Area (m2)
Living Residential	225.423
Business Commercial	19.602
Business Light Industrial	9.801
Business Catering Industry	9.801
Public Building	9.801
Public Sports	29.403
Public educational Institute	9.801
Public forest	137.214
Public grass land	147.015
Total area	**597.861 m2**

Total boundary area – 641.974 m2

- Re-mapping the functions and the boundary

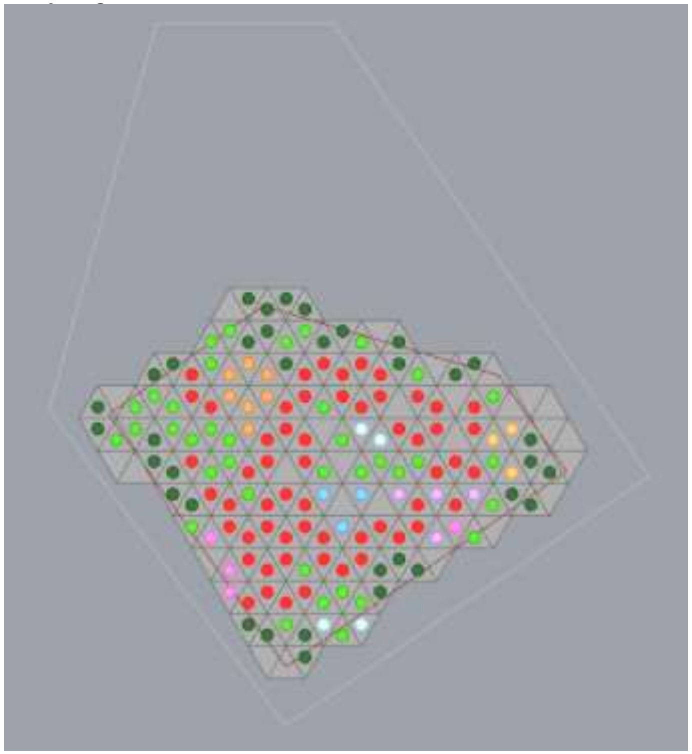
STUDIES

Function	Foot print (m2)
Living Residential	53.936
Business Commercial	7.706
Business Light Industrial	3.059
Business Catering Industry	580
Public Building	4.821
Public Sports	20.284
Public educational Institute	1.375
Public forest	113.347
Public grass land	114.372
Total area	**319.480 m2**

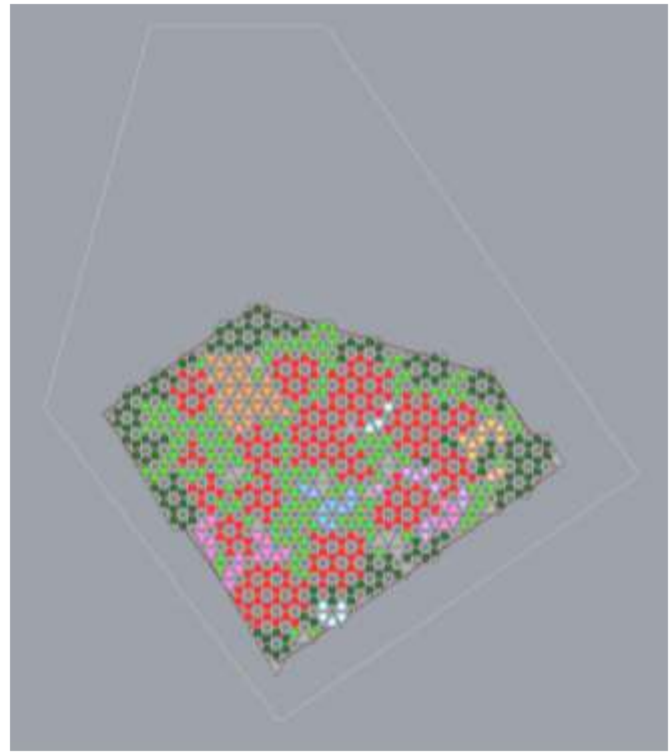


STUDIES

The distribution of the functions on triangle



100 meter platform.



50 meter platform.

- Distribution of functions based on the total area. So to see how functions are placed.

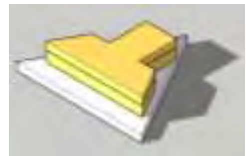
STUDIES

Same boundary profile as Tollebeek.

Condition – 1

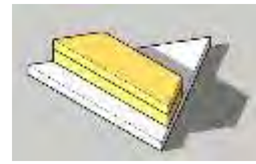
Platform	- **50 m**
Slope on Platform edge	- 0
Platform area	- 1083 m2
Platform depth	- 3 m
Gap between platform	- **5 m**

Platform -1



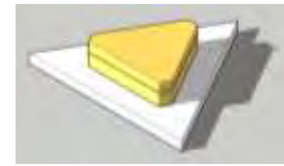
Built % - 51,4 %
Road % (walkway) - 26 %
Green % - 22,6 %

Platform -2



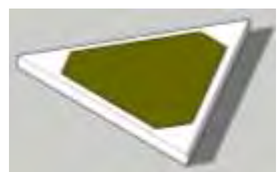
Built % - 40 %
Road % (walkway) - 26 %
Green % - 34%

Platform -3

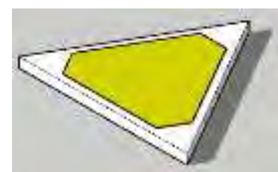


Built % - 33 %
Road % (walkway) - 67 %
Green % - 0

Platform -4



Forest



Grass Land

Built % - 0
Road % (walkway) - 33 %
Green % - 67 %

Grass Land –
114372 – 33715 =
80657

STUDIES

Same boundary profile as Tollebeek.

Function	Foot Print (m2)	Type	Percentage Distribution	No of Layers	No of Platforms	Total Platforms
Living Residential	53936	1	41,3	2	40	**120**
		2	32,2	2	40	
		3	26,5	2	40	
Business Commercial	7706	1	41,3	2	6	**18**
		2	32,2	2	6	
		3	26,5	2	6	
Business Light Industrial	3059	1	41,3	2	2	**6**
		2	32,2	2	2	
		3	26,5	2	2	
Business Catering Industry	580	1	41,3	2	1	**1**
		2	32,2	2	0	
		3	26,5	2	0	
Public Building	4821	1	41,3	2	4	**12**
		2	32,2	2	4	
		3	26,5	2	4	
Public Sports	20284	1	20	2	7	**22**
		4	80	1	15	
Public educational Institute	1375	1	41,3	2	1	**3**
		2	32,2	2	1	
		3	26,5	2	1	
Public forest	113347	4	100	1	156	**156**
Public Grass land	80657	4	100	1	111	**111**

Total – 449

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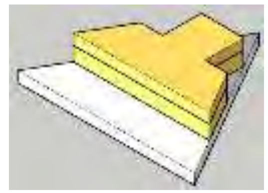
STUDIES

Same boundary profile as Tollebeek.

Condition – 2

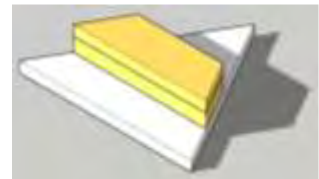
Platform	- **50 m**
Slope on Platform edge	- 0
Platform area	- 1083 m2
Platform depth	- 3 m
Gap between platform	- **5 m**

Platform -1



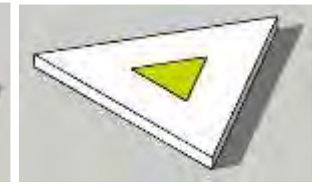
Built %	- 47 %
Road %	- 40,8 %
Green %	- 12,2 %

Platform -2



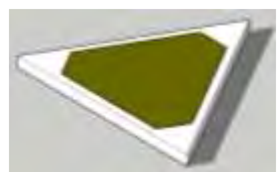
Built %	- 34,9%
Road %	- 40,8 %
Green %	- 24,3 %

Platform -3

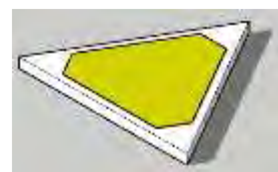


Built %	- 0
Road %	- 91 %
Green %	- 9 %

Platform -4



Forest



Grass land

Built %	- 0
Road % (walkway)	- 33 %
Green %	- 67 %

Grass Land –
114372 – 33180 =
81192

STUDIES

Same boundary profile as Tollebeek.

Function	Foot Print (m2)	Type	Percentage Distribution	No of Layers	No of Platforms	Total Platforms
Living Residential	53936	1	57,3	2	61	**122**
		2	42,7	2	61	
Business Commercial	7706	1	57,3	2	9	**18**
		2	42,7	2	9	
Business Light Industrial	3059	1	57,3	2	3	**6**
		2	42,7	2	3	
Business Catering Industry	580	1	57,3	2	1	**2**
		2	42,7	2	1	
Public Building	4821	1	57,3	2	5	**10**
		2	42,7	2	5	
Public Sports	20284	1	20	2	8	**23**
		4	80	1	15	
Public educational Institute	1375	1	57,3	2	2	**4**
		2	42,7	2	2	
Public forest	113347	4	100	1	156	**156**
Public Grass land	81192	4	100	1	112	**112**

Total – 453

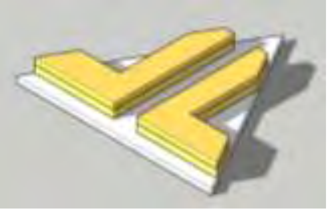
STUDIES

Condition – 3

Platform - **100 m**
Slope on Platform edge - 0
Platform area - 4330 m2
Platform depth - 3 m
Gap between platform - **5 m**

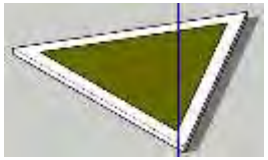
Same boundary profile as Tollebeek.

Platform -1

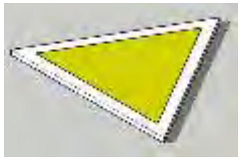


Built % - 48,9 %
Road % - 26,7 %
Green % - 24,4 %

Platform -2



Forest



Grass Land

Built % - 0
Road % (walkway) - 37 %
Green % - 63 %

Grass land – 114372 – 35881 = 78491

Function	Foot Print (m2)	Type	Percentage Distribution	No of Layers	No of Platforms	Total Platforms
Living Residential	53936	1	100	2	25	25
Business Commercial	7706	1	100	2	4	4
Business Light Industrial	3059	1	100	2	1	1
Business Catering Industry	580	1	100	2	1	1
Public Building	4821	1	100	2	2	2
Public Sports	20284	1	20	2	2	6
		2	80	1	4	
Public educational Institute	1375	1	100	2	1	1
Public Forest	113347	2	100	1	42	42
Public Grass Land	78491	2	100	1	29	29

Total – 111

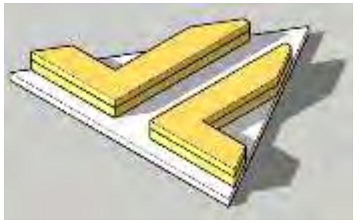
STUDIES

Condition – 4

Platform - **100 m**
Slope on Platform edge - 0
Platform area - 4330 m2
Platform depth - 3 m
Gap between platform - **5 m**

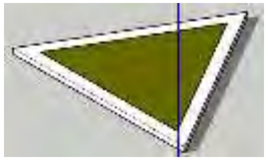
Same boundary profile as Tollebeek.

Platform -1

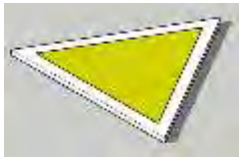


Built % - 43,6 %
Road % - 41,1 %
Green % - 15,3 %

Platform -2



Forest



Grass land

Built % - 0
Road % (walkway) - 37 %
Green % - 63 %

Grass land – 114372 – 27824 = 78491

Function	Foot Print (m2)	Type	Percentage Distribution	No of Layers	No of Platforms	Total Platforms
Living Residential	53936	1	100	2	29	**29**
Business Commercial	7706	1	100	2	4	**4**
Business Light Industrial	3059	1	100	2	2	**2**
Business Catering Industry	580	1	100	2	1	**1**
Public Building	4821	1	100	2	3	**3**
Public Sports	20284	1	20	2	2	**6**
		2	80	1	4	
Public educational Institute	1375	1	100	2	1	**1**
Public Forest	113347	2	100	1	42	**42**
Public Grass Land	86548	2	100	1	32	**32**

Total – 122

- As we keep changing the parameters- the outputs are constantly changing.
- Through this we can compare and opt a better results.

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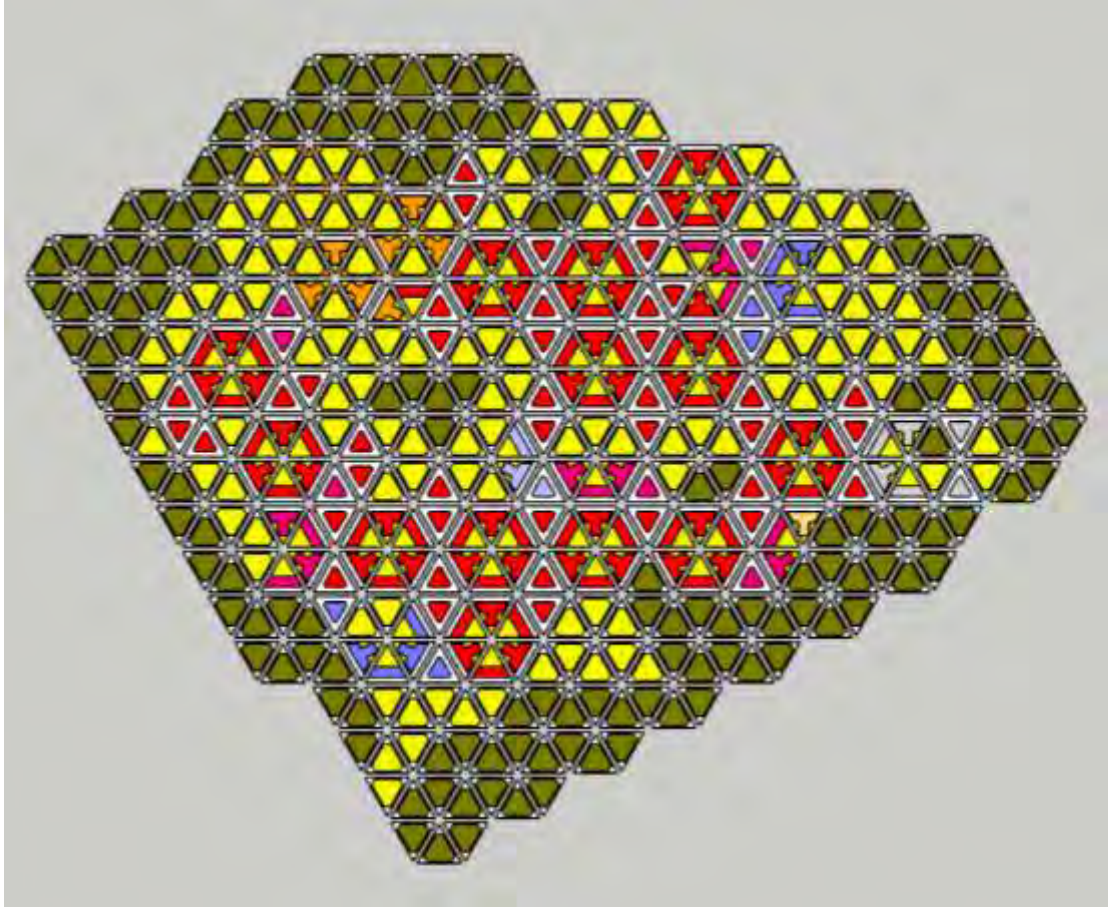
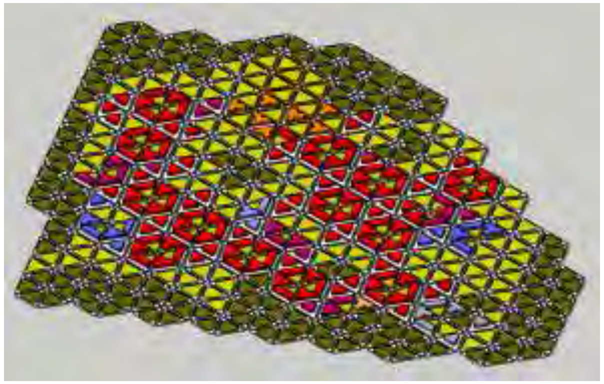
STUDIES

Condition – 1

Output –



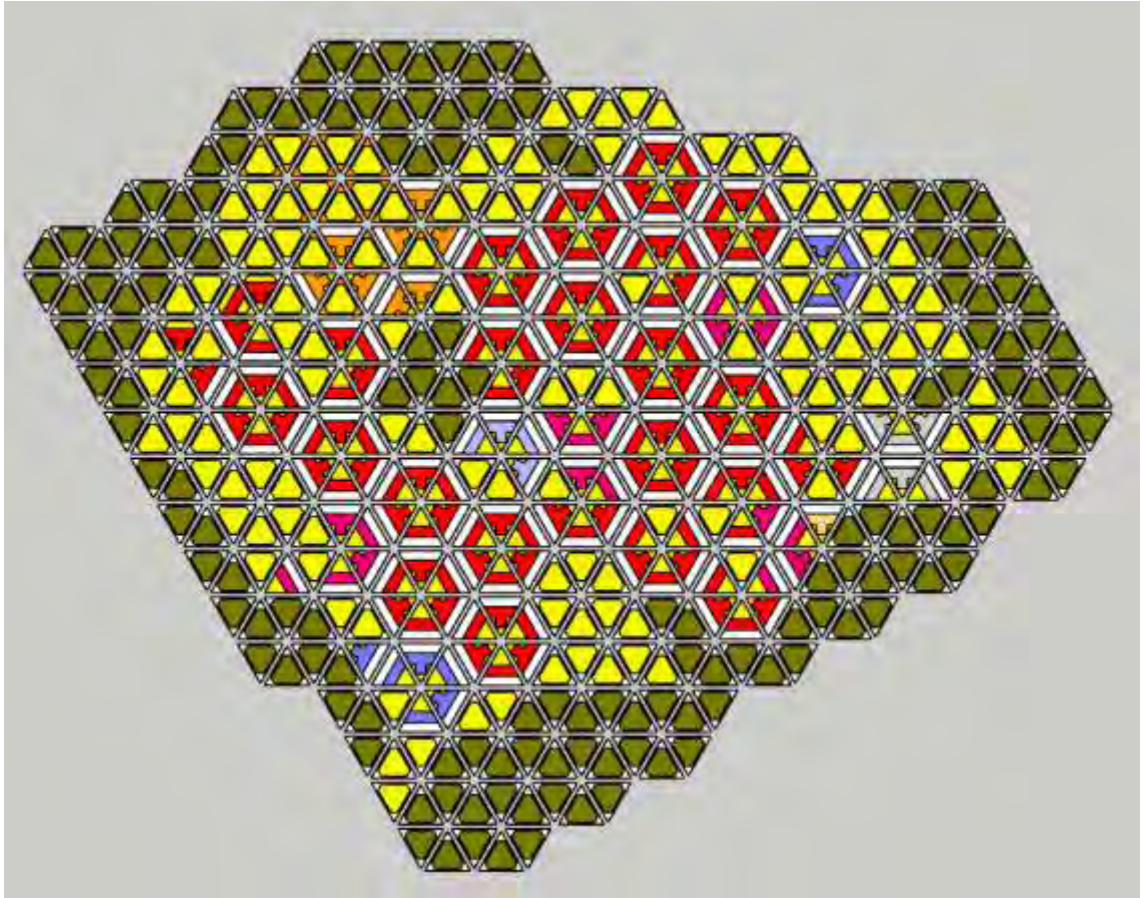


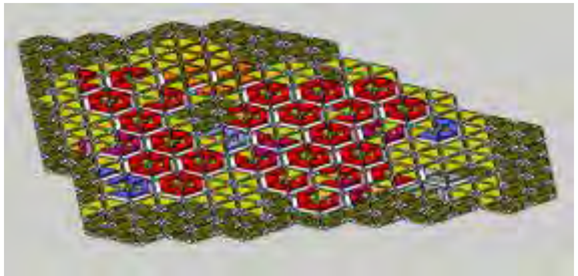
- This output is based on the exact placement of functions as in Tollebeek study and the number of platforms as we got in the previous output.

STUDIES

Condition – 2

Output –

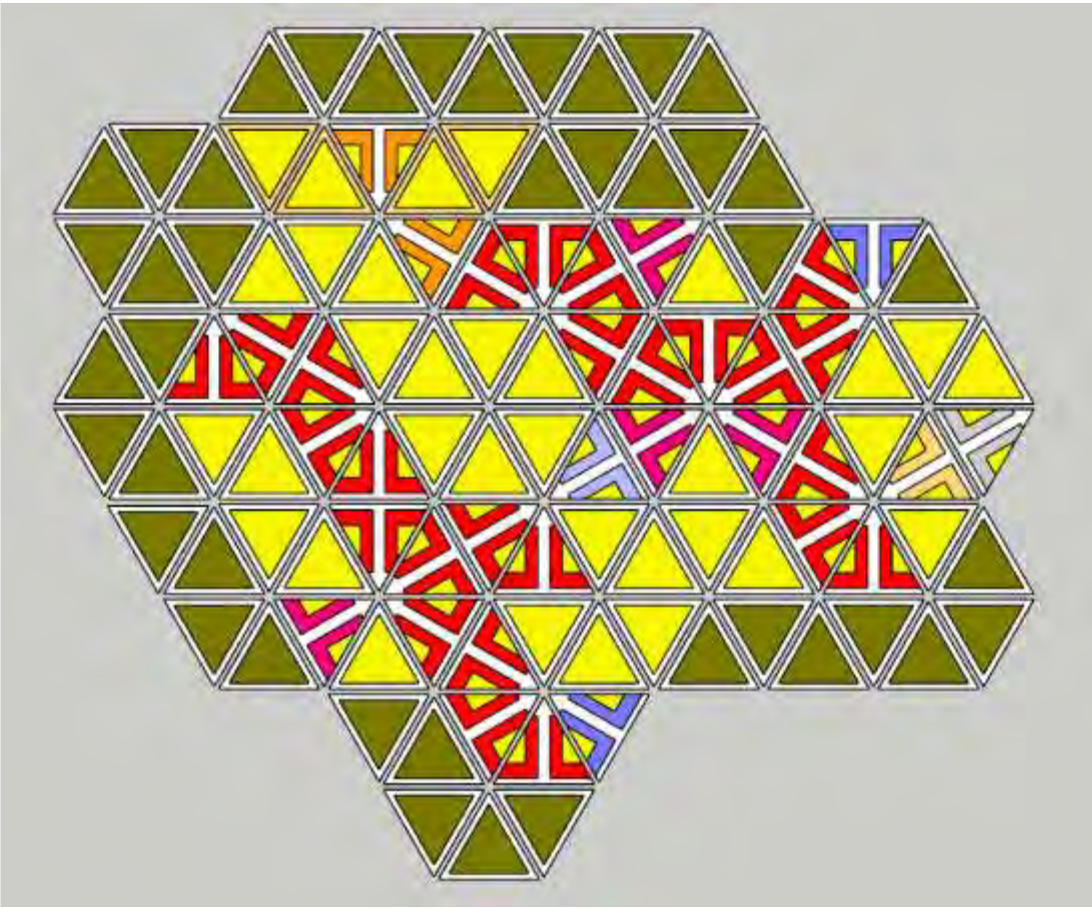


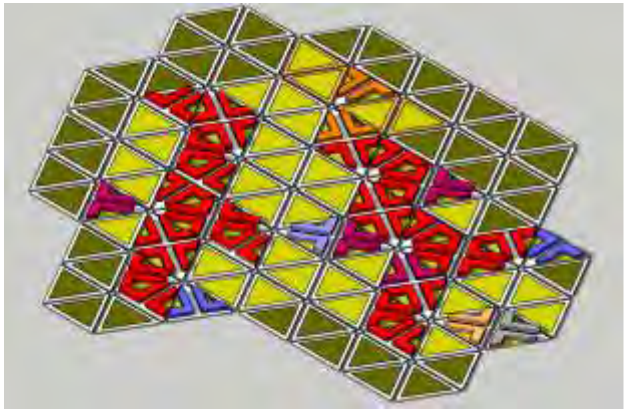


STUDIES

Condition – 3

Output –

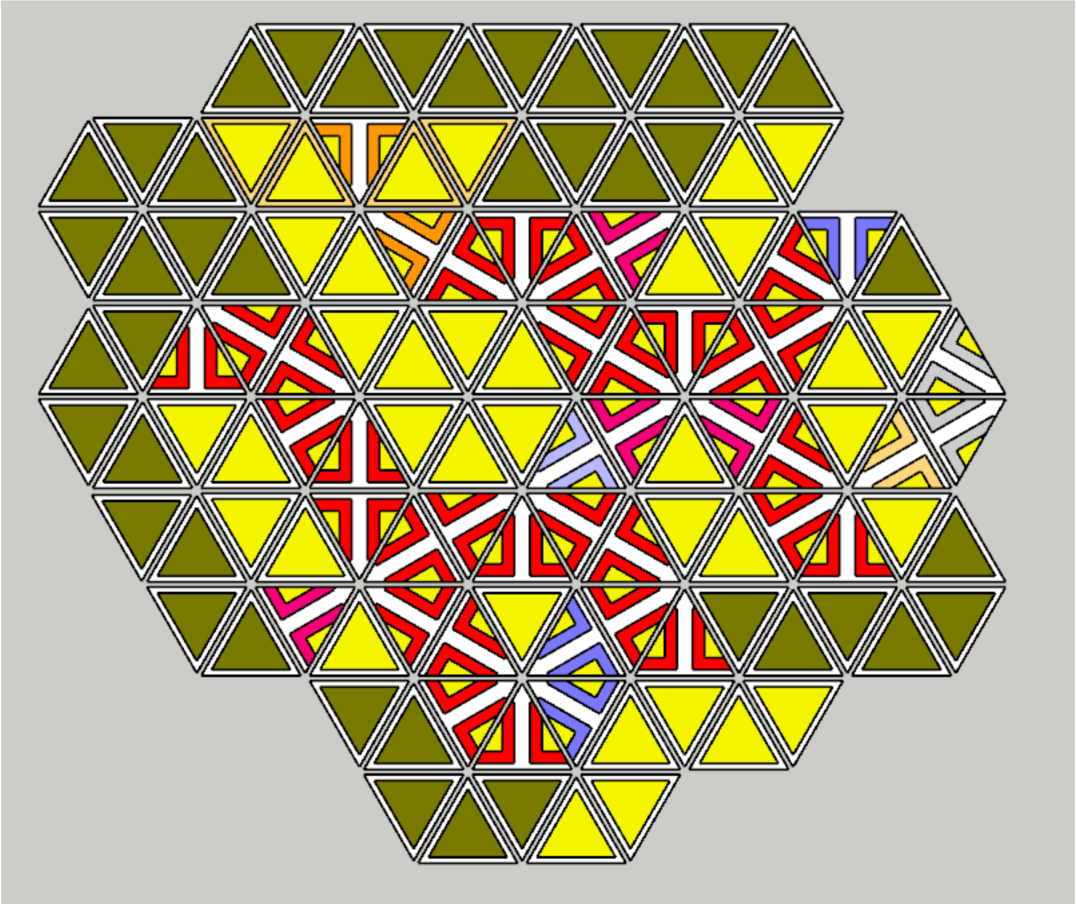


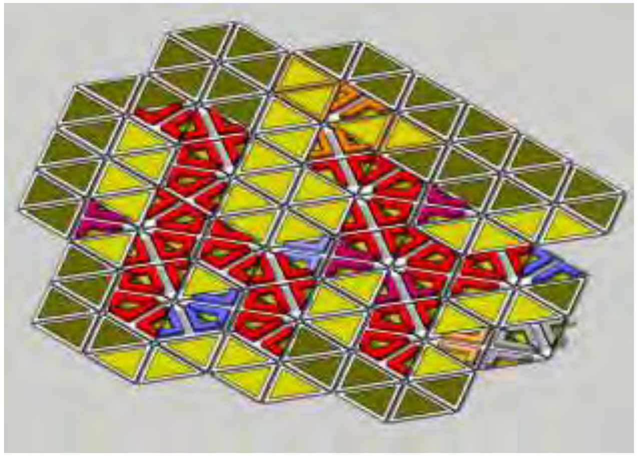


STUDIES

Condition – 4

Output –

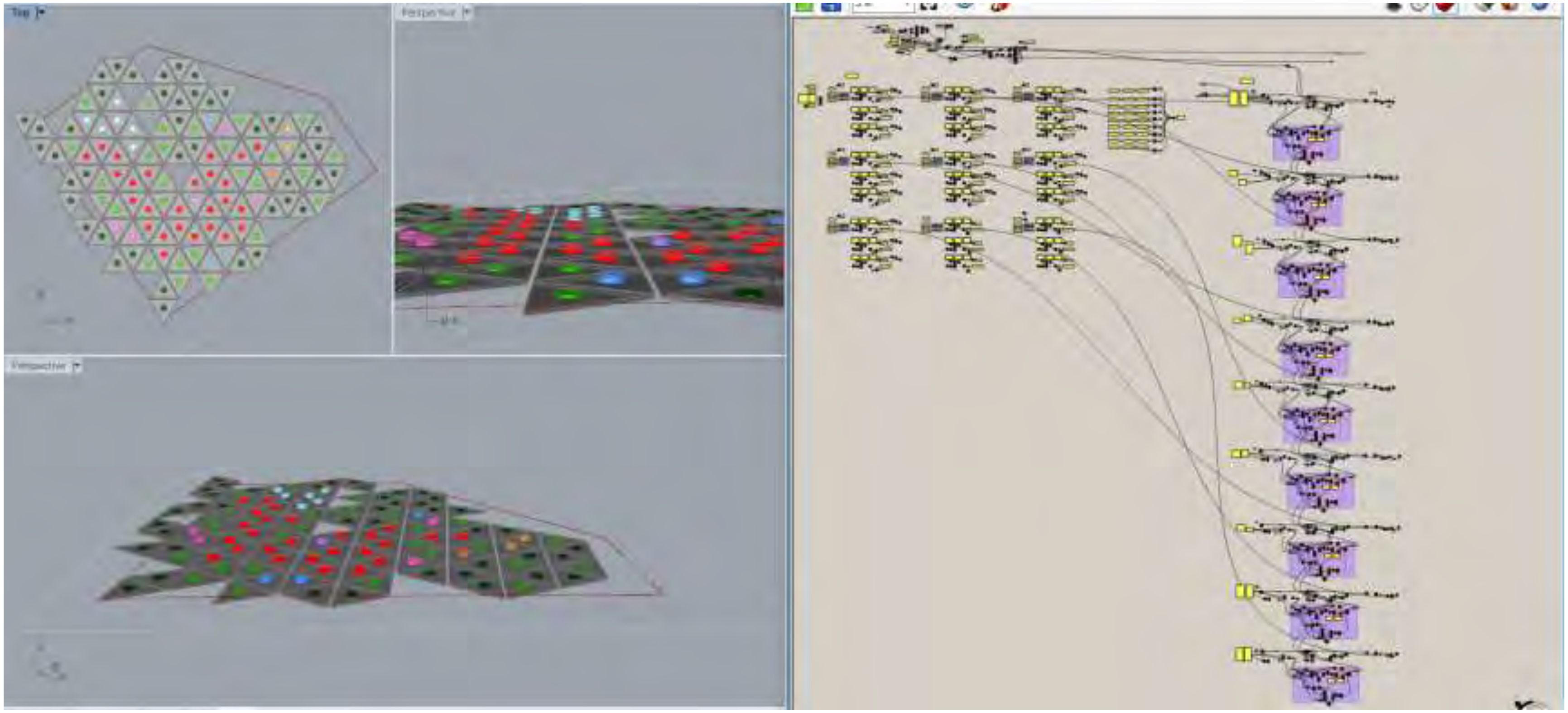




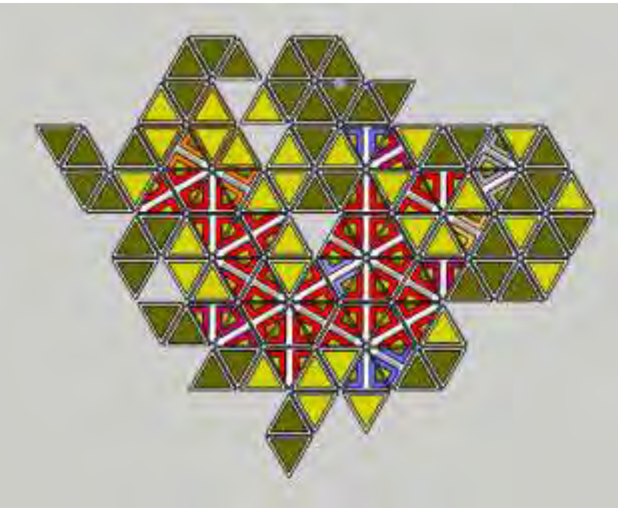
- Now with this we can further rearrange the platforms to match with entry points to the city by road networks.

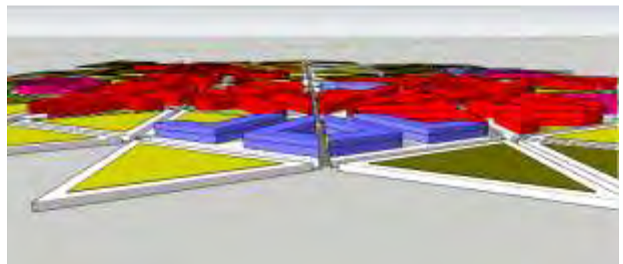
STUDIES

The integrated script till the previous studies.
In up coming slides - shown the outputs of **condition -3, when we tune the parameters.**



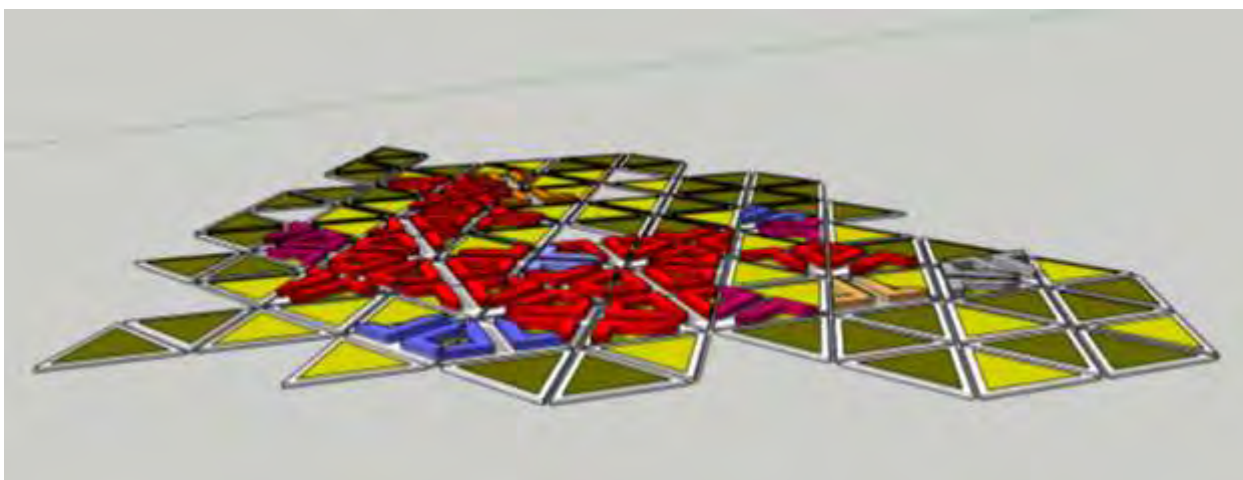
STUDIES

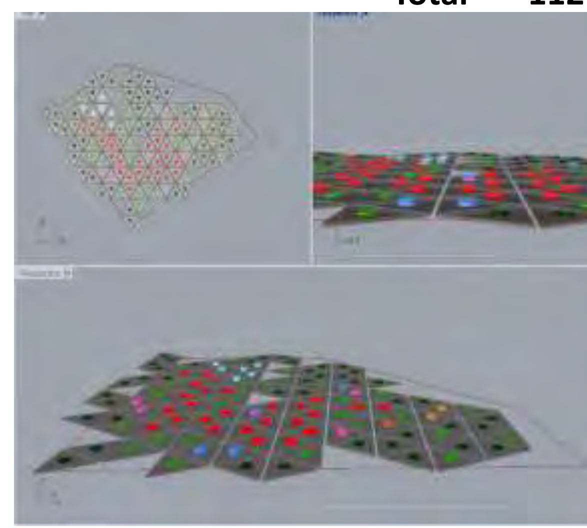




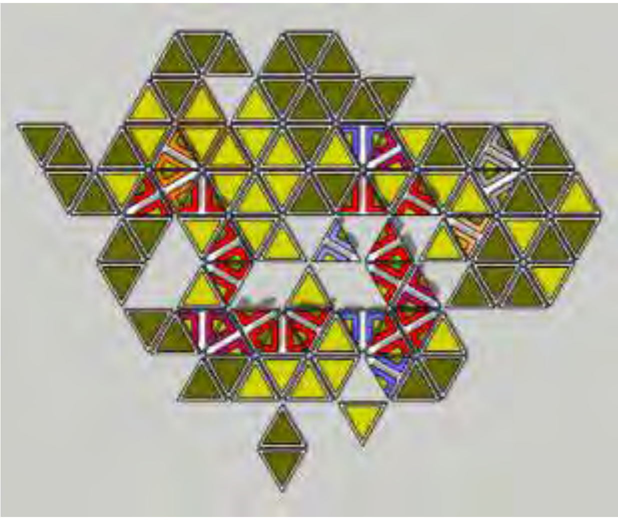
Function	Type	No of Layers	Total Platforms
Living Residential	1	2	**26**
Business Commercial	1	2	**4**
Business Light Industrial	1	2	**2**
Business Catering Industry	1	2	**1**
Public Building	1	2	**3**
Public Sports	1	2	**6**
	2	1	
Public educational Institute	1	2	**1**
Public Forest	2	1	**42**
Public Grass Land	2	1	**27**

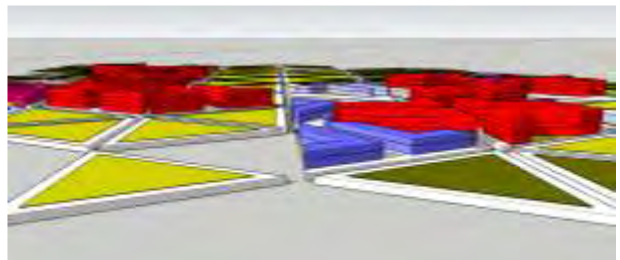
Total – 112





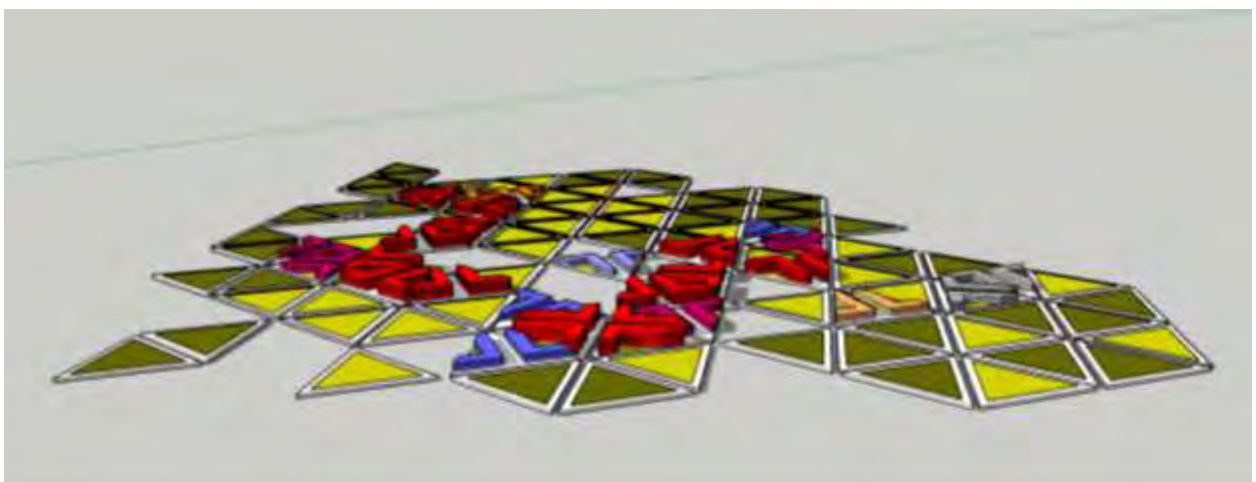
STUDIES

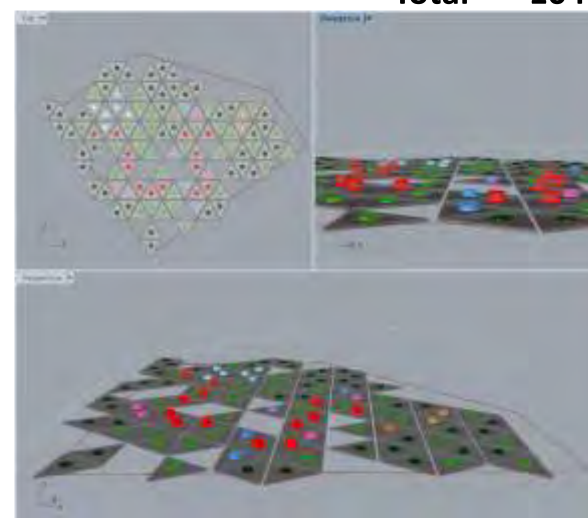




Function	Type	No of Layers	Total Platforms
Living Residential	1	4	**13**
Business Commercial	1	2	**4**
Business Light Industrial	1	2	**2**
Business Catering Industry	1	2	**1**
Public Building	1	2	**3**
Public Sports	1	2	**6**
	2	1	
Public educational Institute	1	2	**1**
Public Forest	2	1	**42**
Public Grass Land	2	1	**32**

Total – 104

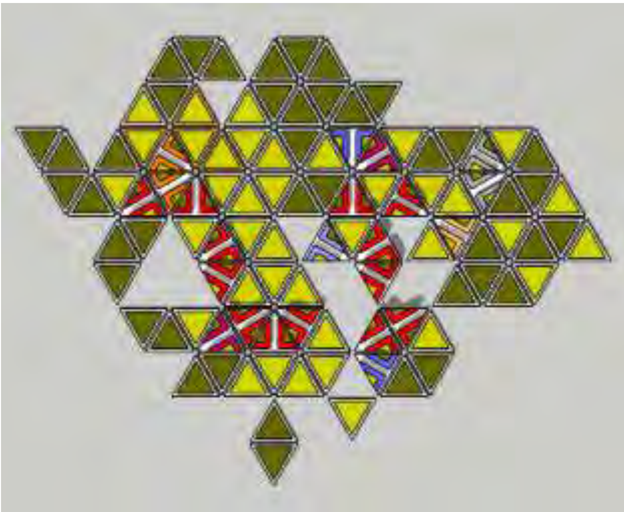


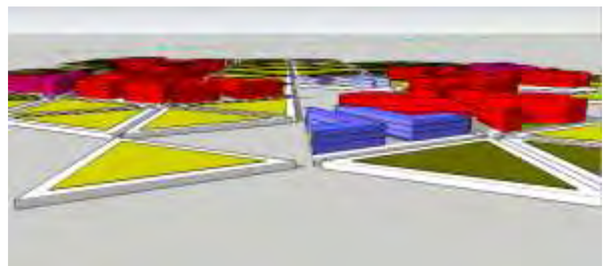


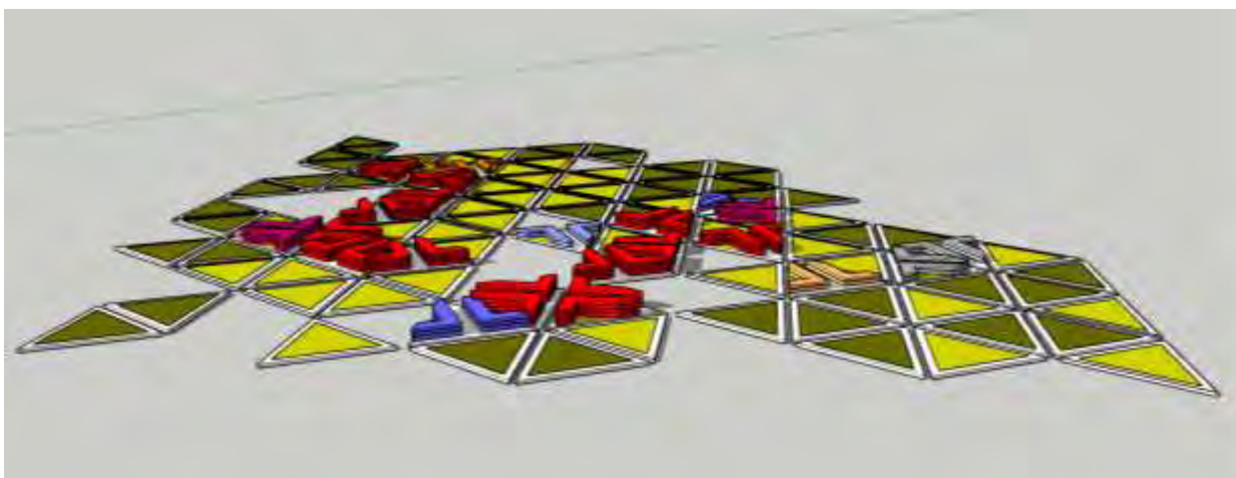
STUDIES

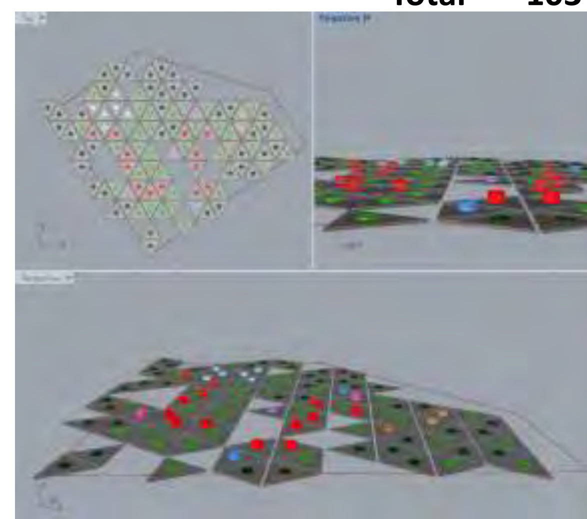
Function	Type	No of Layers	Total Platforms
Living Residential	1	4	**13**
Business Commercial	1	4	**2**
Business Light Industrial	1	2	**2**
Business Catering Industry	1	2	**1**
Public Building	1	3	**2**
Public Sports	1	2	**6**
	2	1	
Public educational Institute	1	2	**1**
Public Forest	2	1	**42**
Public Grass Land	2	1	**34**

Total – 103

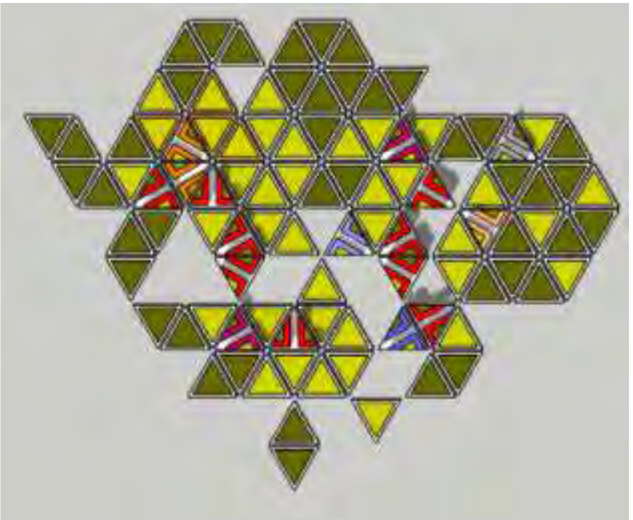


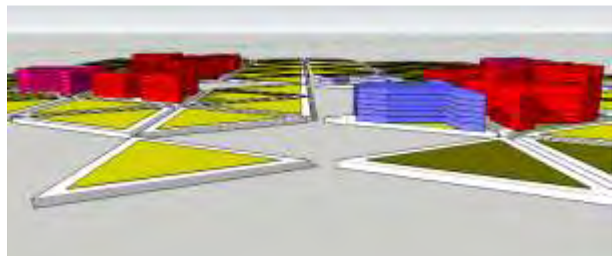






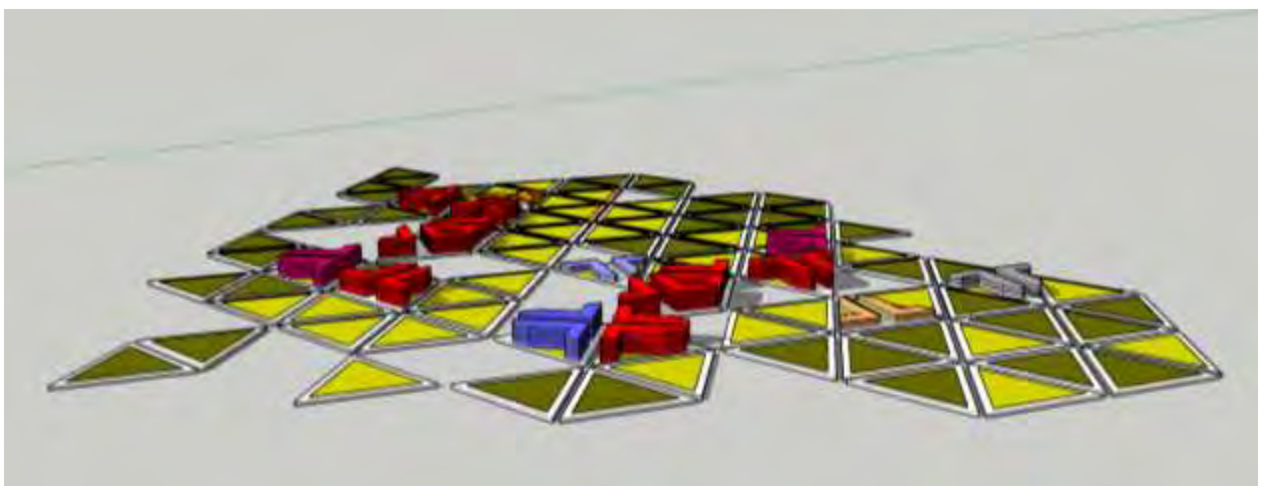
STUDIES

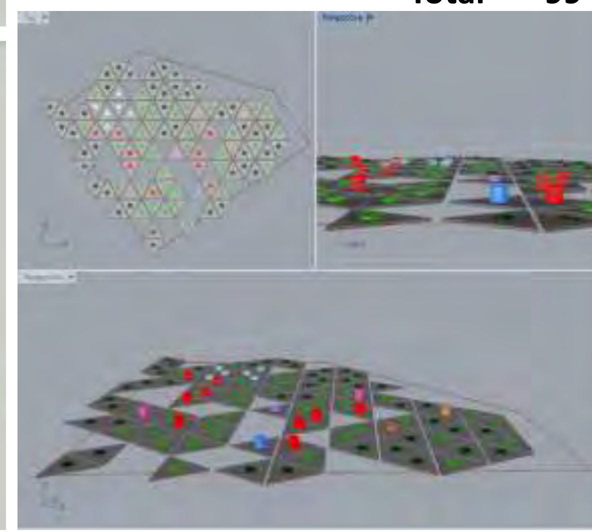




Function	Type	No of Layers	Total Platforms
Living Residential	1	6	**9**
Business Commercial	1	6	**2**
Business Light Industrial	1	4	**1**
Business Catering Industry	1	2	**1**
Public Building	1	6	**1**
Public Sports	1	2	**6**
	2	1	
Public educational Institute	1	2	**1**
Public Forest	2	1	**42**
Public Grass Land	2	1	**36**

Total – 99





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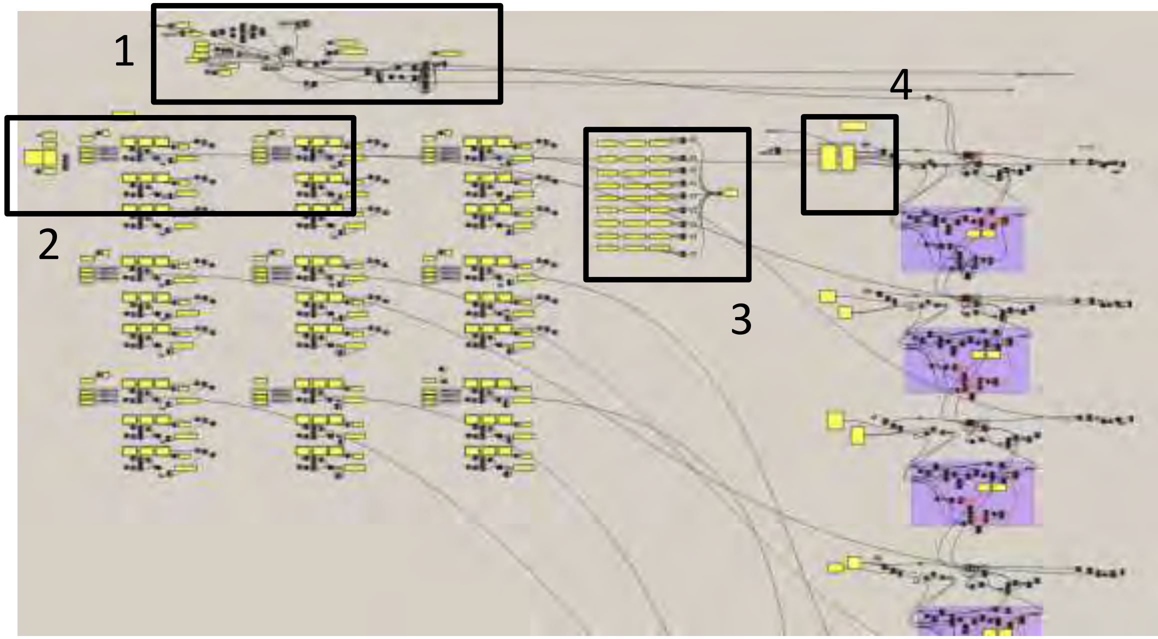
STUDIES

Pictures showing the works flow of the script -

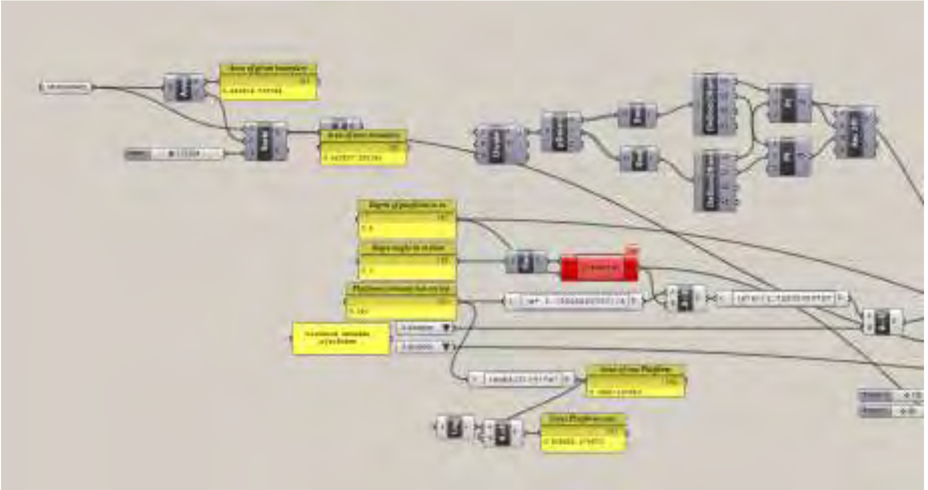


PARAMETERS

Size of the Platforms	Depth of the Platforms	Distance between platforms
Number of typologies	Distribution of typologies	No. Of layers per typology
No. Of Blocks	Proportion of each Block	Slope on edge of Platforms

STUDIES

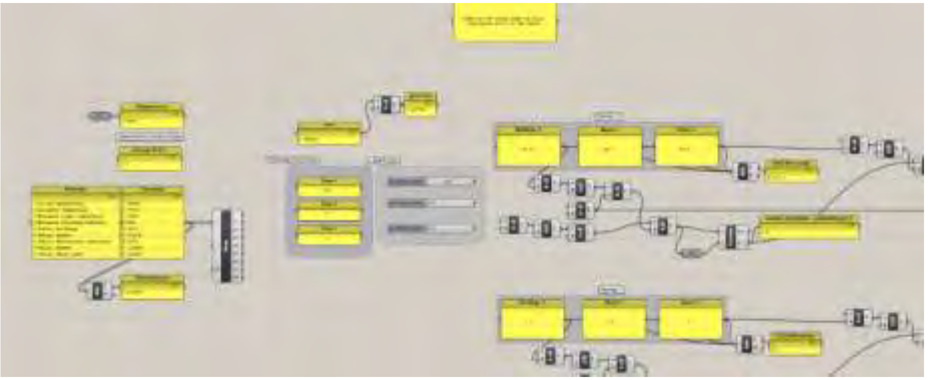
1- Assign the boundary and set the conditions for the platform.

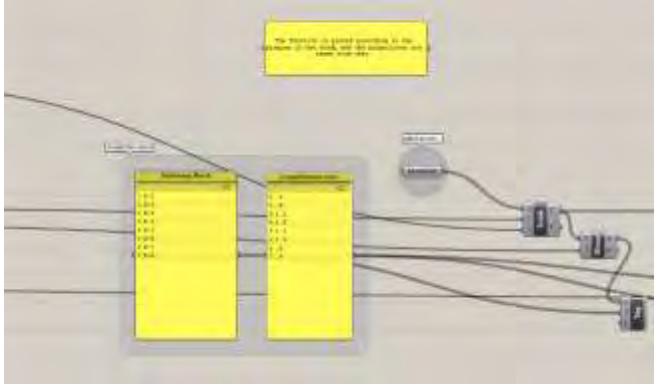


2 – From the study pick the typology and fill in the data and combinations.

3- Once we assign the combinations – we get number of platforms. Then based on this we decide number of blocks we need per function, then define them.

4- Place/define the function locations – we get a output on how the function is place and the density diagram.





STUDIES

Observations –

- We can optimize the number of platforms, based on the density and the typology we use.
- We can define number of typologies and can see their combinations also.
- After arriving at a better results and combination, we can reorganize the platforms- to bring a compact organization.
- The road network is defined in the typologies. For main network if a separate typology needed, can be integrate with script or we can add extra platforms for this purpose.
- Water network doesn't effect much, we just have to widen the space between the platforms along the route.

STUDIES

Observations –

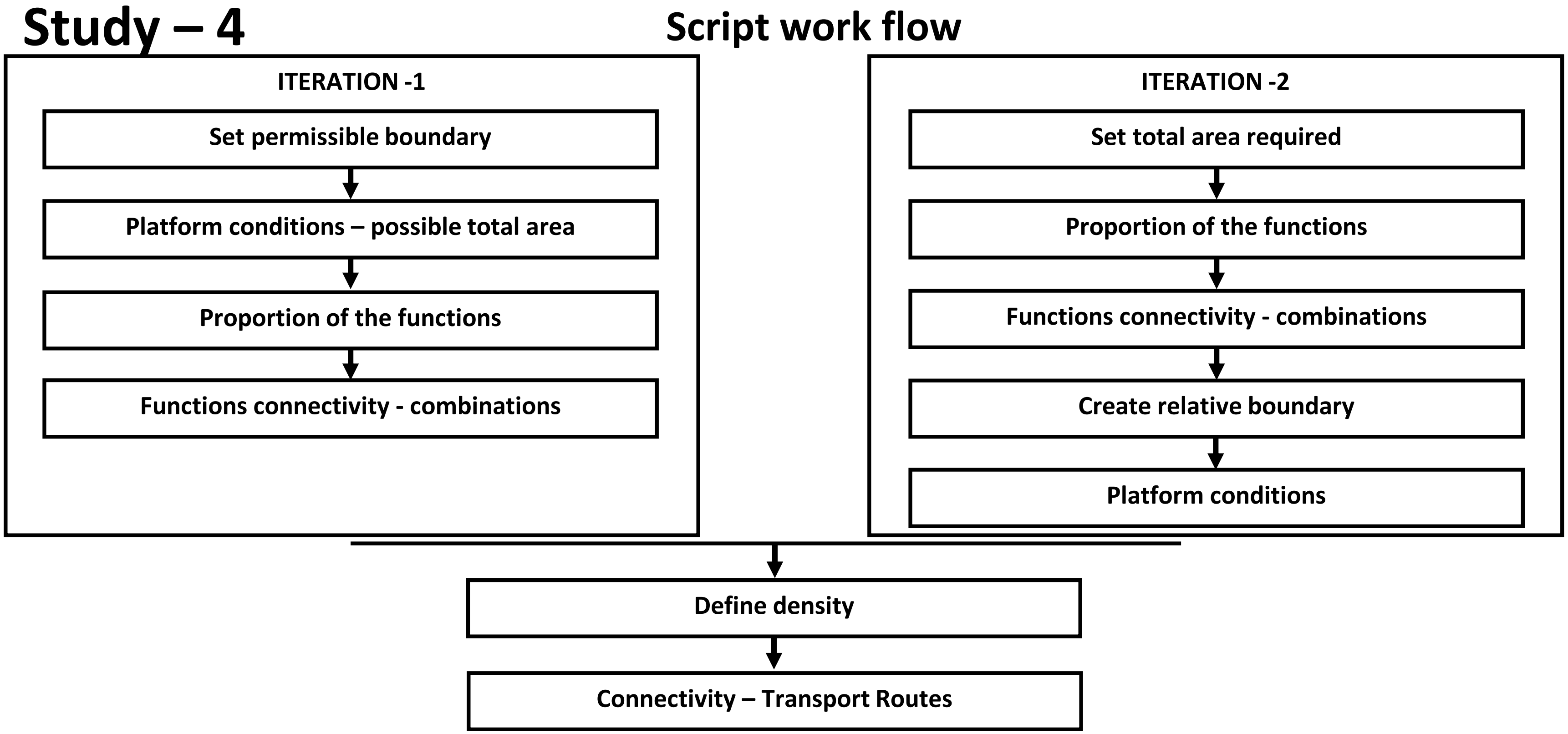
- Till now we have placed the function in position with the existing one on Tollebeek, also the boundary – due to which we get blank space in between because the functions are not moving relatively when the density increases.
- Next step is to attempt on this issue.

In our study -4

- We attempt to understand how functions can organize themselves based on the connectivity which we define. Also it can create its own boundary based on the organizations.

STUDIES

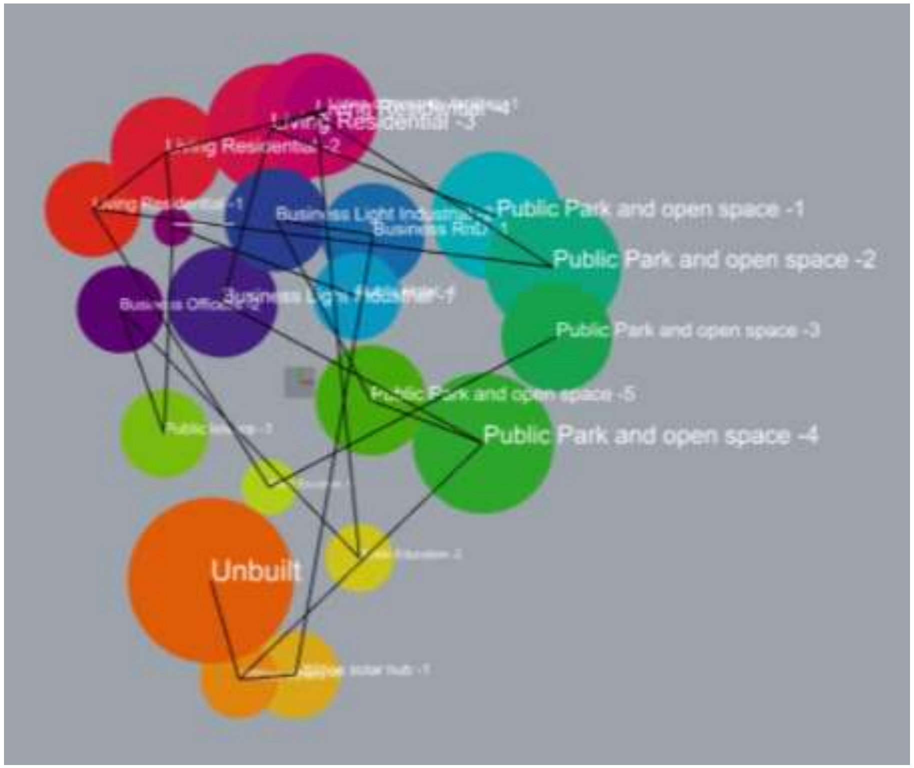
Study – 4

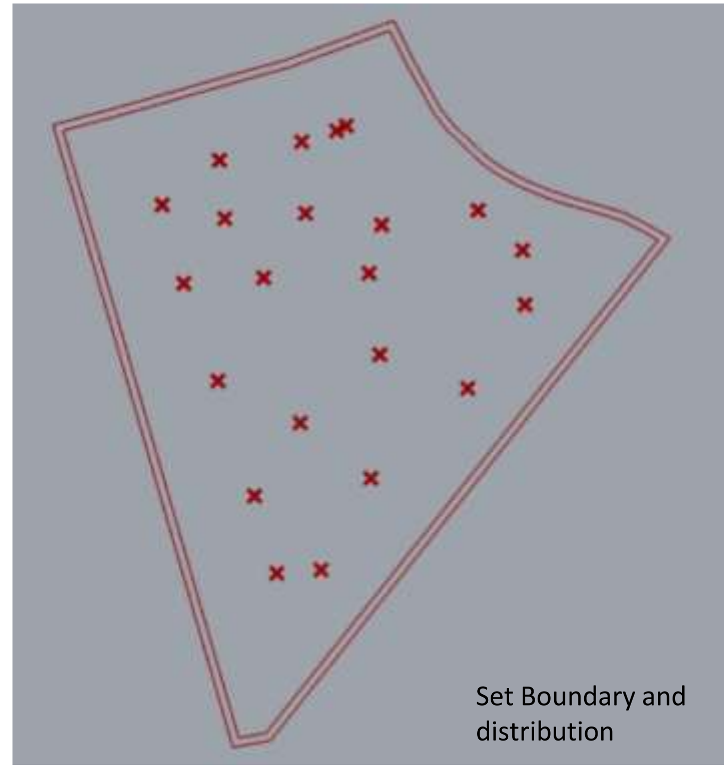


- This is the study – 4, where we test how to arrange the function in a defined boundary or create its own boundry.
- There is two possible approach. This is tested with Masdar City data.
- This script was attempted paralley. Now we try to merge both the scripts.

STUDIES

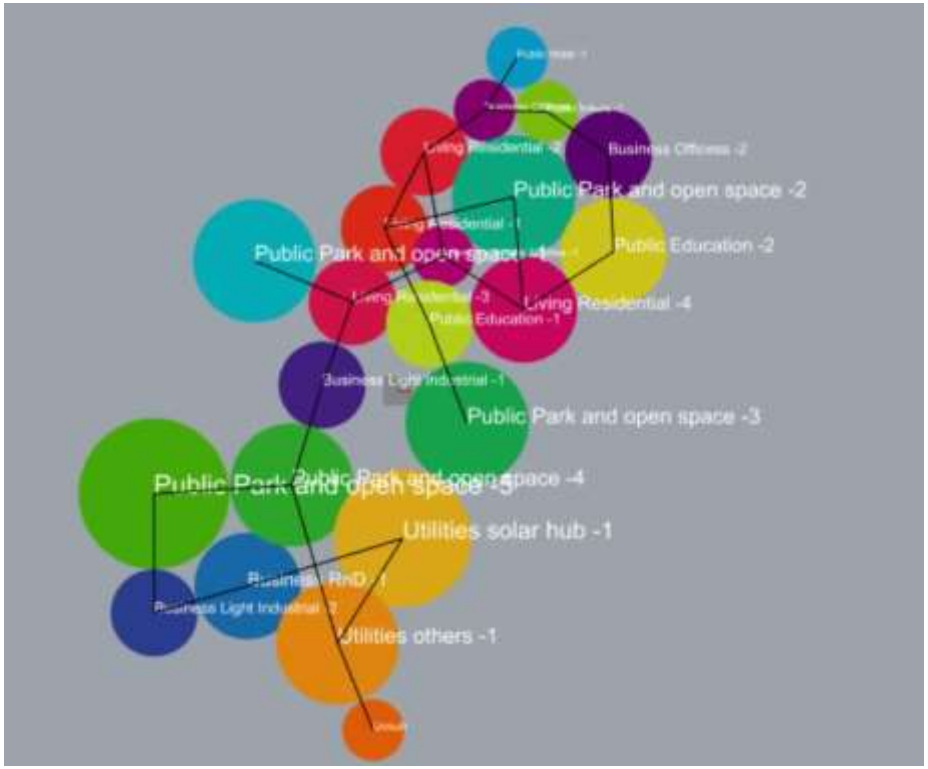
Trial -1

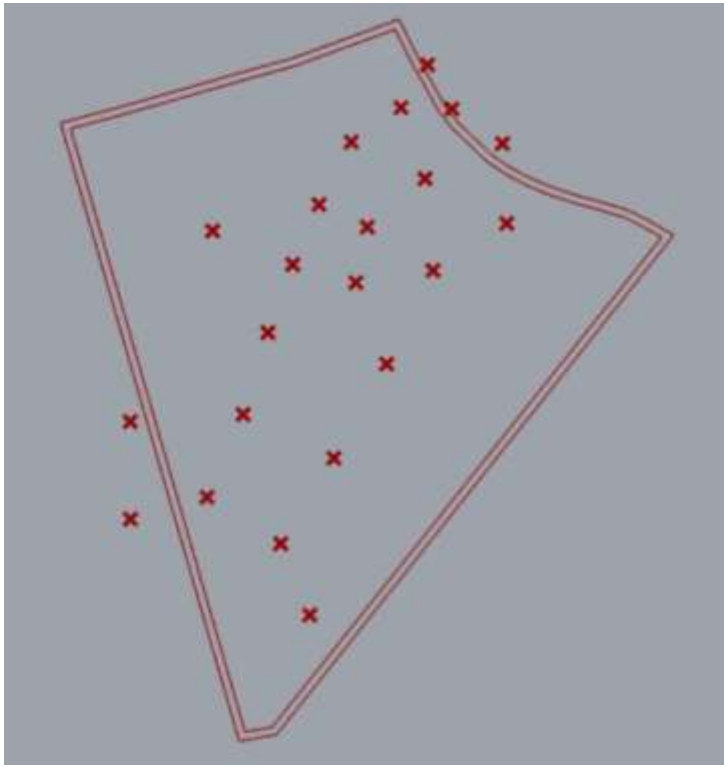




Understanding the program connectivity within the set boundary.

STUDIES



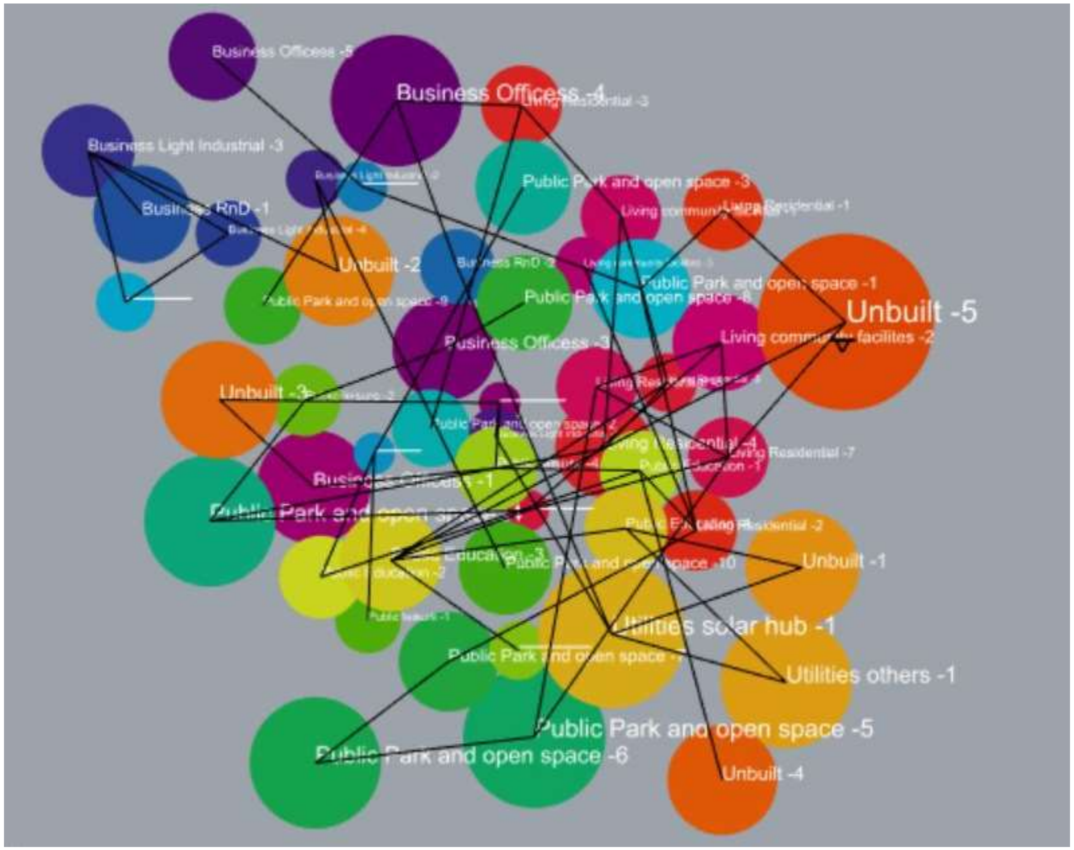


The buildable area is far lesser compared to the boundary area – based on the platform conditions.

The program combinations were limited – because of the boundary. Re-configuring with in same boundary was limited.

STUDIES

Trial -2



The possibilities of function combination is more.
We can change the function connectivity to re-configure.

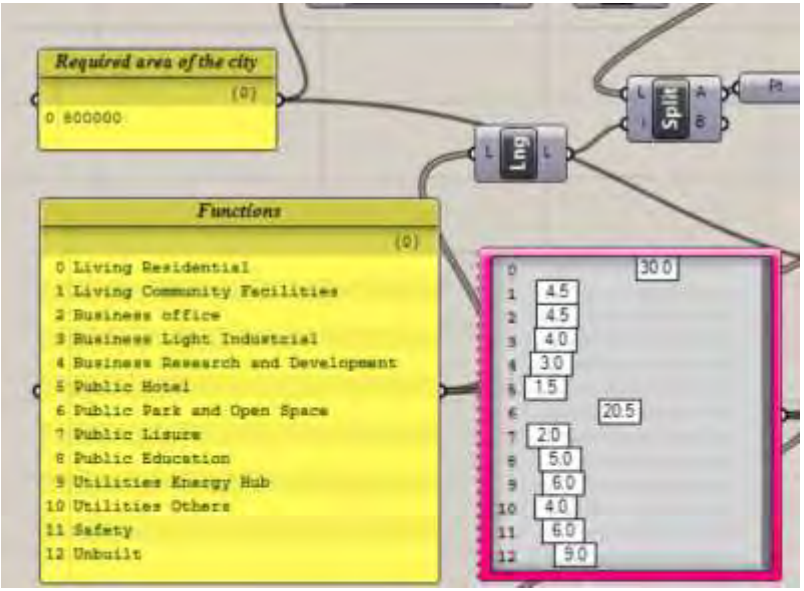
The boundary is set based on the distribution.

The number of functions and proportions has to be redefined to get a better defined layout.

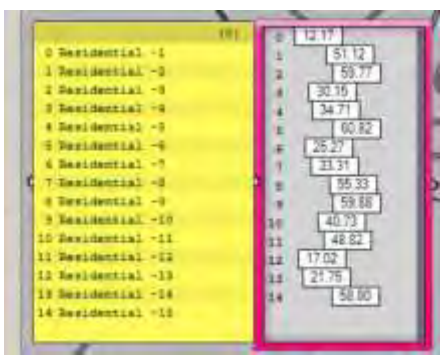
Redefining the script to accommodate the function and its distribution.

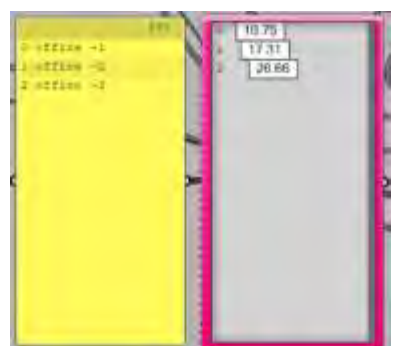
STUDIES

Script Definition -



The functions are listed based on the case study-
The area proportions.
It s 10% of Masdar city area.

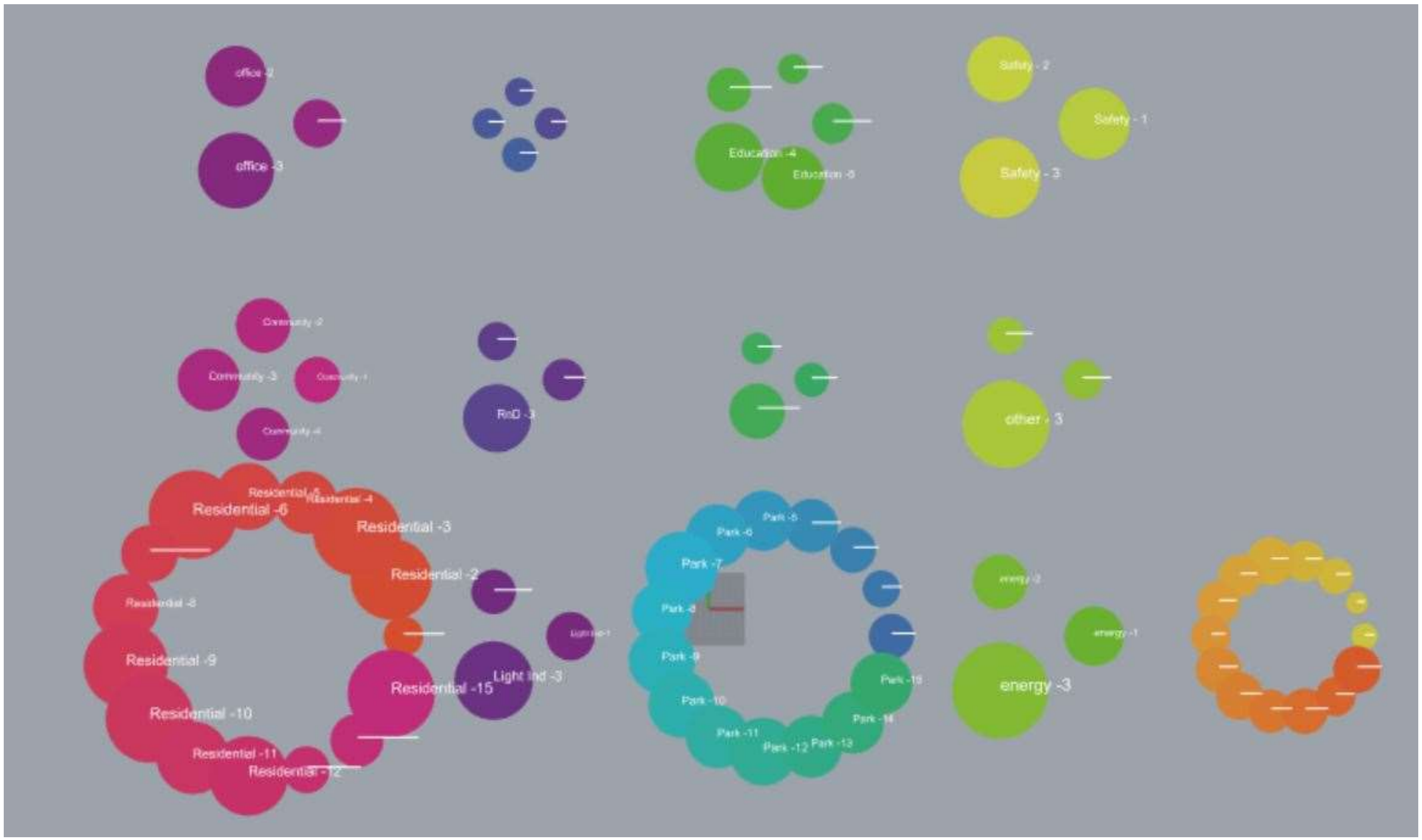




Further splitting the functions - to URBAN BLOCKS, get a grip on defining the connectivity.

STUDIES

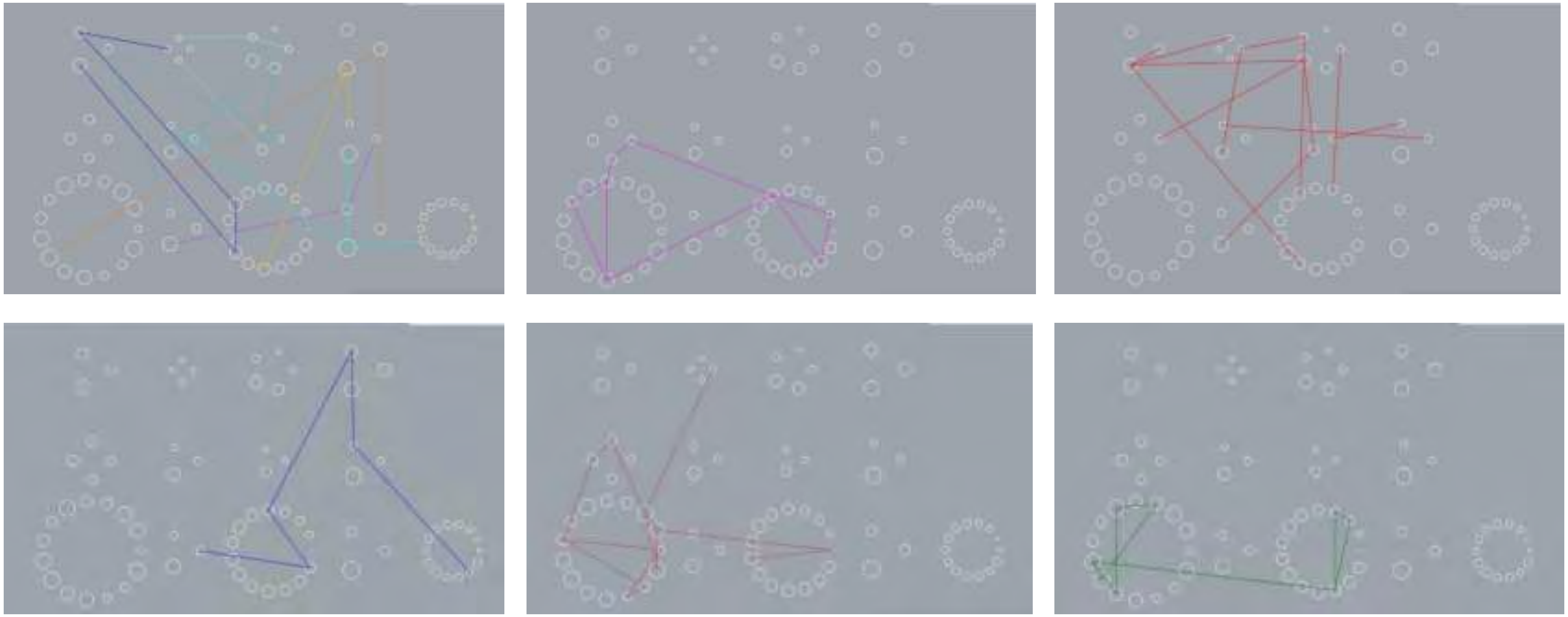
List of functions defined and the proportionate area – URBAN BLOCKS



SPACE@SEA

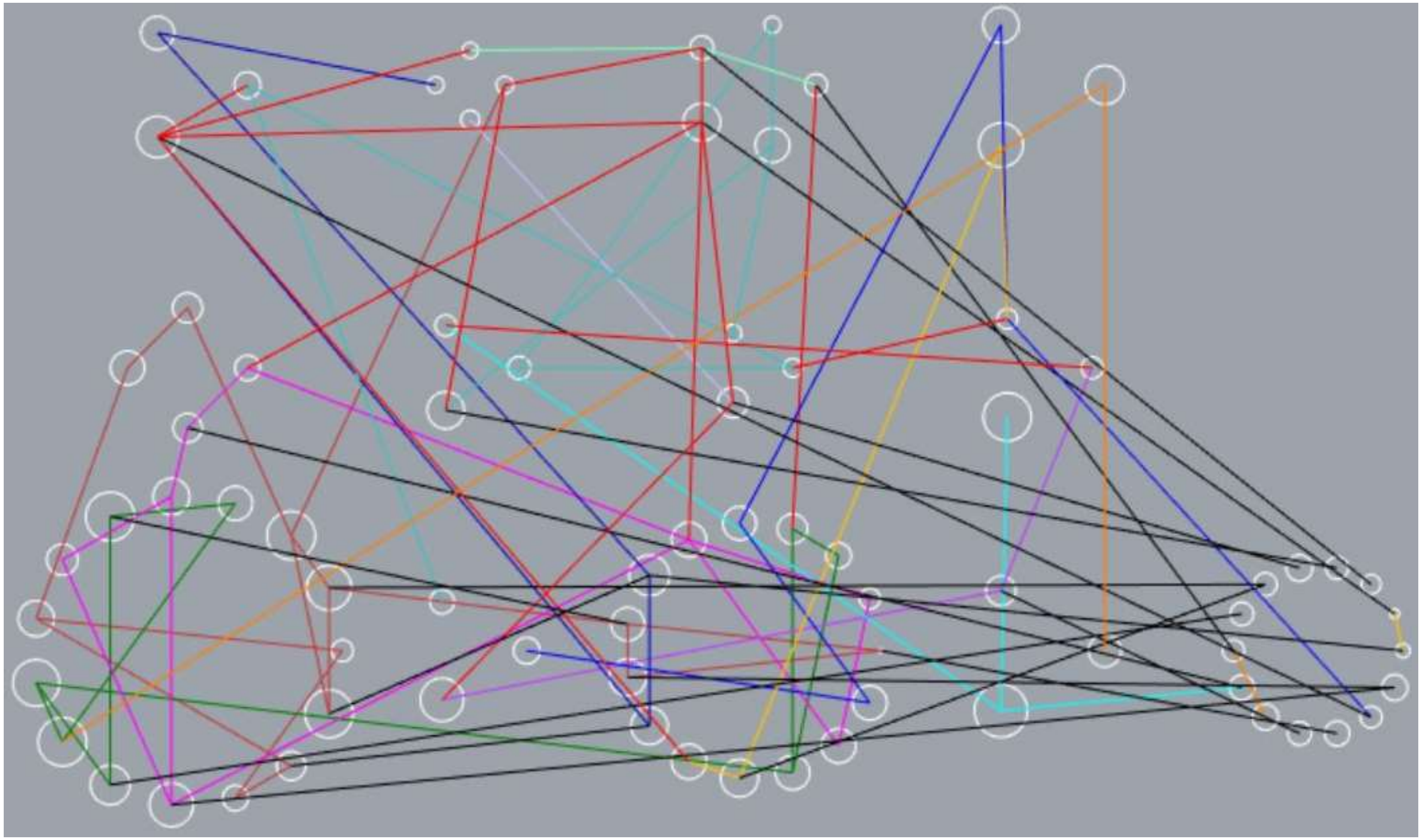
STUDIES

Defining connectivity between functions -



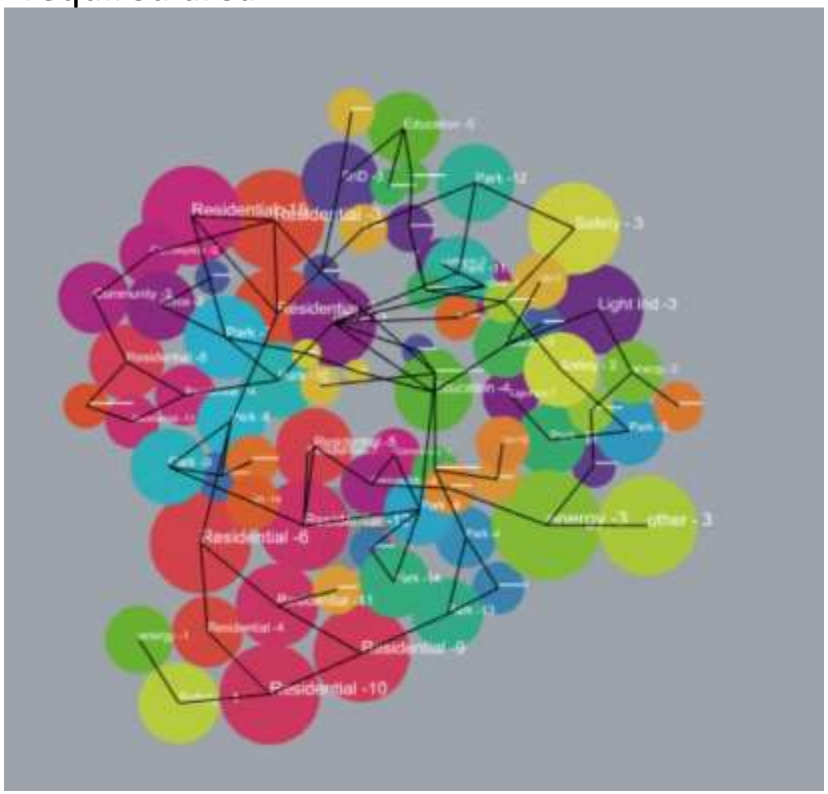
STUDIES

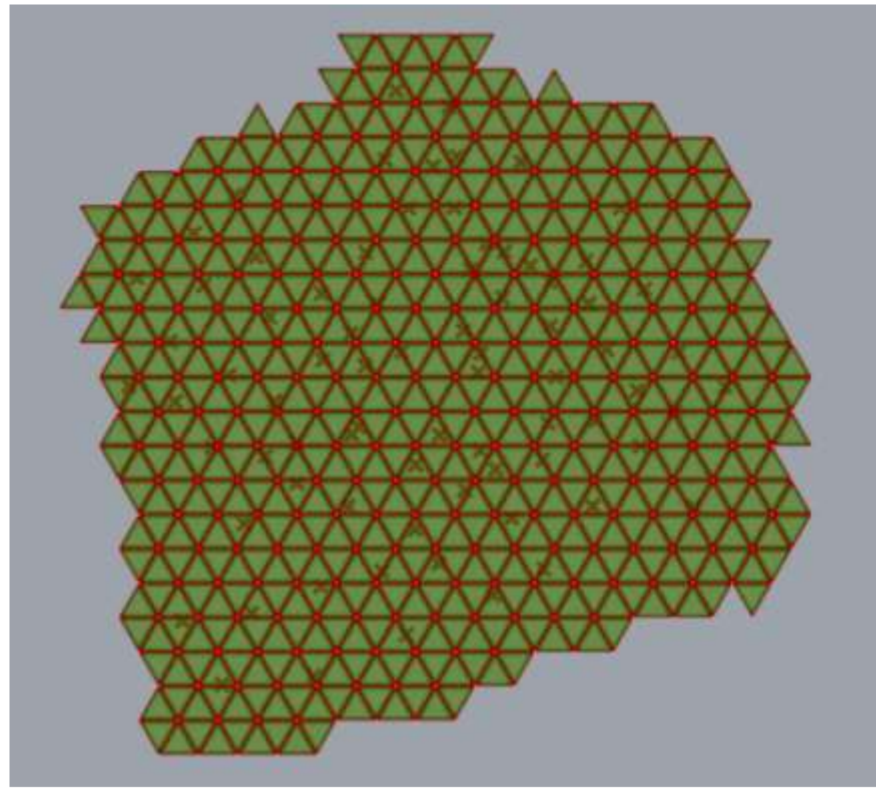
All connectivity -



STUDIES

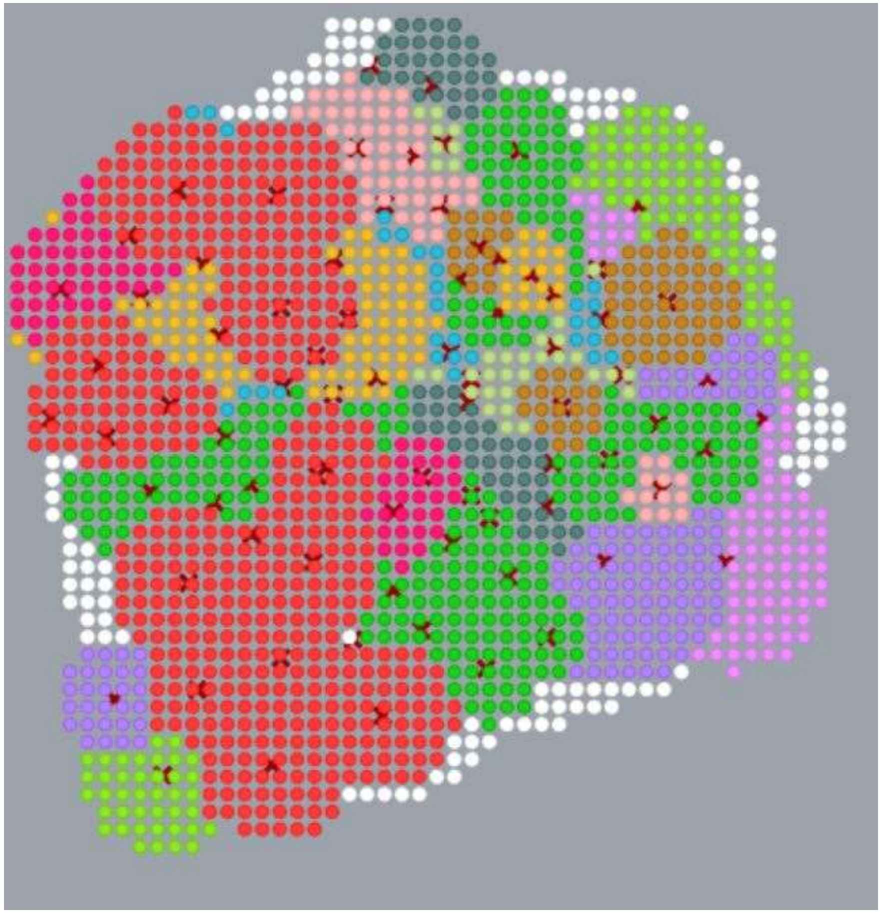
Configuration based on the connectivity of functions and the platforms formed based on the required area -





STUDIES

Representation of program distribution -

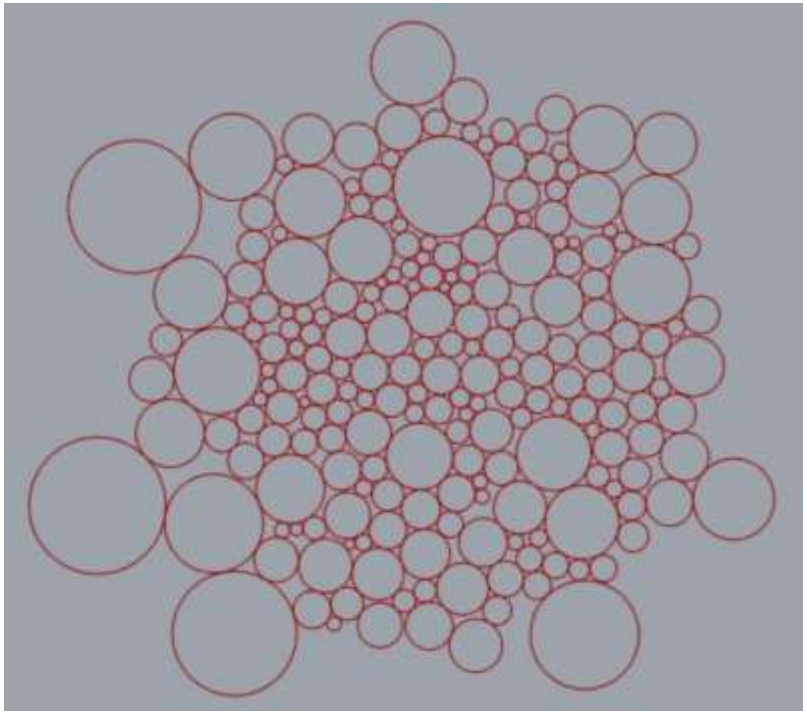


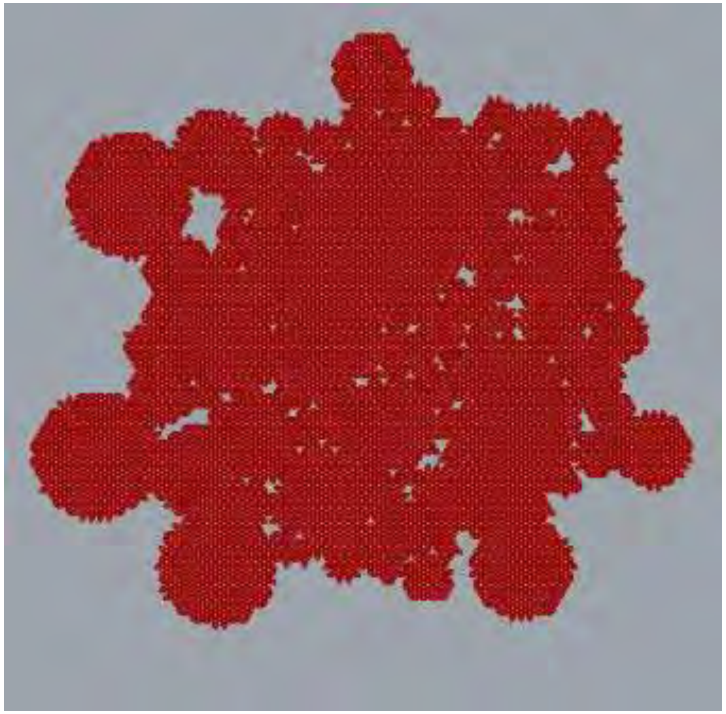
- So we get equal number of platforms which is almost equal to the previous study data.
- We can still break down the functions and address it to the level of city blocks, so we get a grip on the connectivity between each blocks or the functions.

STUDIES

Trial – 3

No boundary rule – the function proportion remains same.





The functions are placed without overlapping and the scaling factor is proportional to the gaps between the platform.

We get a better solution.

STUDIES

- With the study -4 now, we integrate it with existing script, so to attempt and see the program organize based on the connectivity between each of them.

- In this, we don't initially set the boundary. So we define the function and the foot print. Pick the typology and fill in the distributions. We will get the total number of platform.

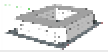
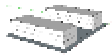
- Now we define the blocks based on the outputs, by using Space Syntax tool – we organize the blocks based on the connectivity. We get various outputs based on the input iterations. Which will give out the platforms and the function organization, with density details. Then the new shape- its not constrained inside a defined boundary.

STUDIES

- An attempt is done parallel to check the outputs when we change a step in the path.
- We try it with changing the triangle platform with a square one.
- We get almost the same analysis when we tried to define certain typologies.
- So now we update the script and check the results with the analysis report.

PLATFORM DESIGN

Concept – 50 m

	Platform			Open space		Building(s)							Spacematrix			Land use %									
	Polygon sides #	Side m	Area m²	Road m²	Green m²	Block length m	Floors #	Building depth m	Courtyard side m	Built-up area m²	Gross floor area (GFA) m²	Net floor area (NFA) m²	Floor area Ratio FAR or FSI	Gross Space Index GSI	Spaciou sness OSR	Buildings %	Road %	Green %	Total %	Apartm ents #	Reside nts #	Density ap./ha	Built volume m³	Façade surface m²	S/V
ers 	4	50	2500	651	529	43	3	10	23	1320	3960	2772	1.58	0.53	0.30	52.8%	26.0%	21.2%	100%	44.00	88.0	176.0	13,200	2640	0.40
corners 	4	50	2500	701	529	43	3	10	23	1270	3810	2667	1.52	0.51	0.32	50.8%	28.0%	21.2%	100%	42.3	84.7	169.3	12,700	2523	0.40
cks 	4	50	2500	651	817	43	3	12	19	1032	3096	2167	1.24	0.41	0.47	41.3%	26.0%	32.7%	100%	34.4	68.8	137.6	10,320	2200	0.41
	3	50	1082.5	461	45	38	3	8	10	576	1729	1211	1.60	0.53	0.29	53.3%	42.6%	4.1%	100%	19.2	38.4	177.5	5,765	1441	0.45

STUDIES

Condition – 1 – Pedestrian and Water transport

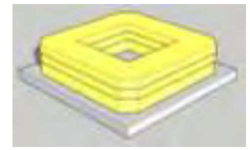
Platform - **50 m - Square**
Slope on Platform edge - 0
Platform area - 2500 m2
Platform depth - 3 m
Gap between platform - **5 m**

Function	Foot Print (m2)	Type	Percentage Distribution	No of Layers	No of Platforms	Total Platforms
Living Residential	53936	1	50,8	2	43	**43**
Business Commercial	7706	2	41,3	2	8	**8**
Business Light Industrial	3059	2	41,3	2	3	**3**
Business Catering Industry	580	2	41,3	2	1	**1**
Public Building	4821	2	41,3	2	5	**5**
Public Sports	20284	2	20	2	4	**11**
		3	80	1	7	
Public educational Institute	1375	1	50,8	2	2	**2**
Public forest	113347	3	100	1	62	**62**
Public Grass land	73354	3	100	1	40	**40**

Total – 175

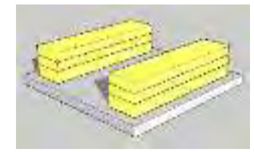
Same boundary profile as Tollebeek.

Platform -1



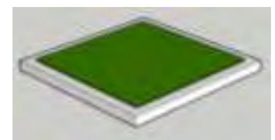
Built % - 50,8 %
Road % (walkway) - 28 %
Green % - 21,2 %

Platform -2

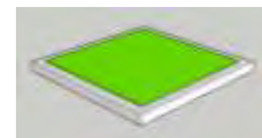


Built % - 41,3 %
Road % (walkway) - 26 %
Green % - 32,7%

Platform -3



Forest

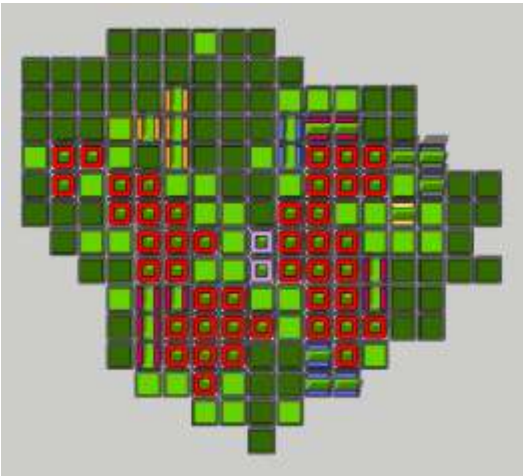


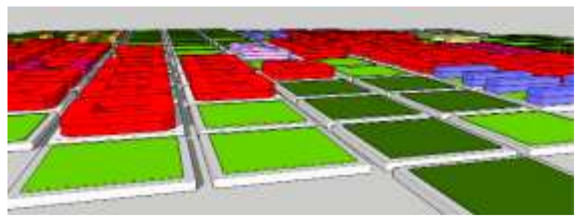
Grass Land

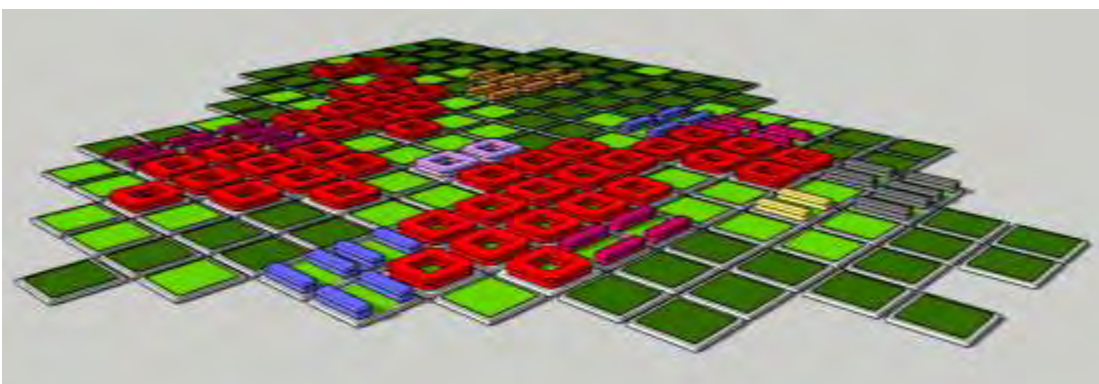
Built % - 0
Road % (walkway) - 26 %
Green % - 74 %

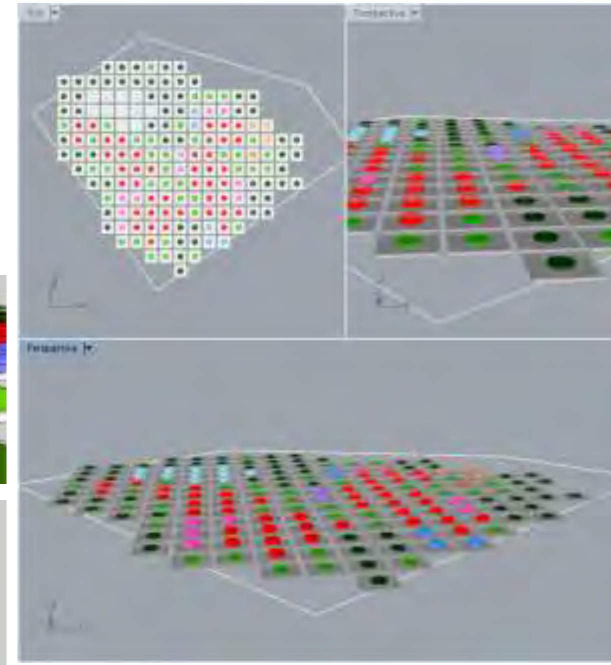
- When we compare it with the triangle platforms, its almost half the number of platforms .
- Now we can compare this situation with cost per platform between triangle and square and the density.

STUDIES









- We can continue to study various built typologies with 50m and 100m platform.
- Analyse the outputs and keep tuning until we get an optimal number of platforms.

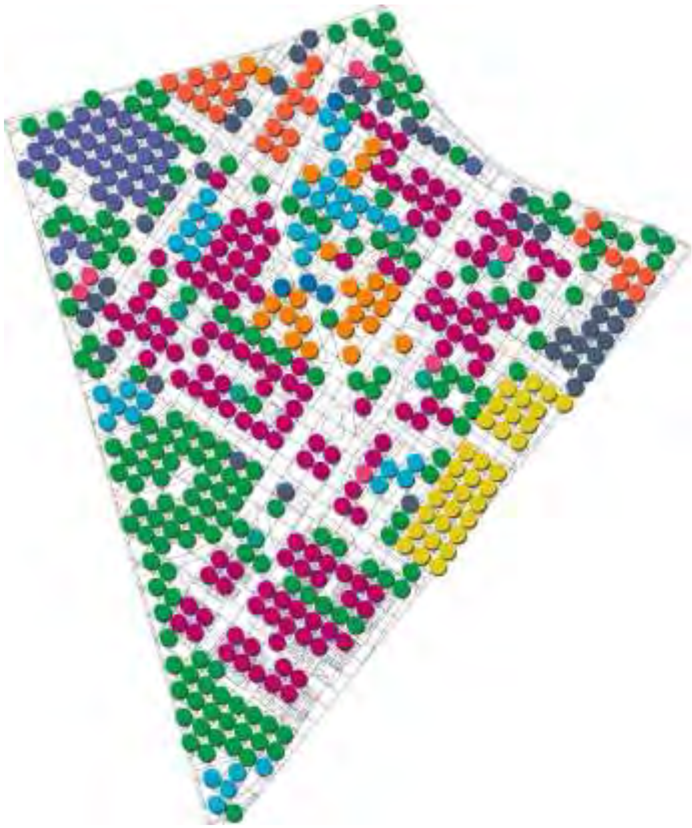
STUDIES

We continue to extend our studies on this, and adding new modules to the script – so it becomes easy to obtain a master plan based on the rules and parameters.

STUDIES

Masdar City Abu Dhabi

Function	Area (m2)	Percentage on boundary area
Living Residential	1.565.620	20
Living Community facilities	78.195	1
Business Offices	225.161	3
Business Light Industrial	340.128	4
Business Research and Development	258.718	3
Public Hotel	41.185	0.5
Public Park and open space	1.913.031	24
Public leisure	731.136	9
Public Education Institutional	444.079	6
Utilities Solar hub	360.622	4.5
Utilities Others	181.383	2



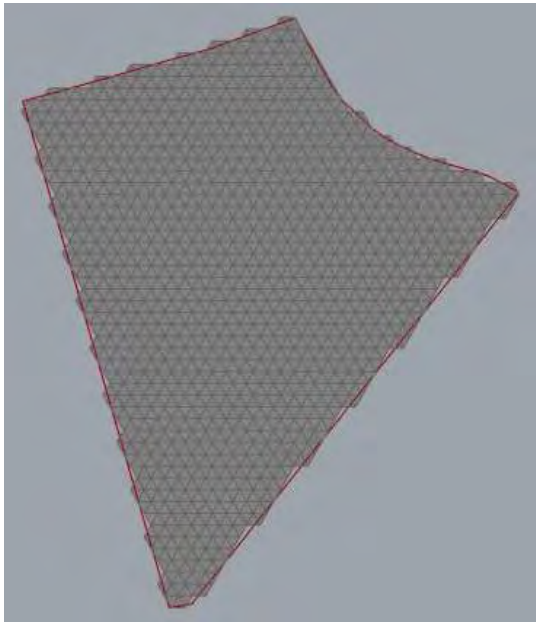
Total area **6.139.258 m2**

Total boundary area – 8.007.072 m2

This show the distribution of function.
23 % is unused or doesn't have any specific functional distribution.

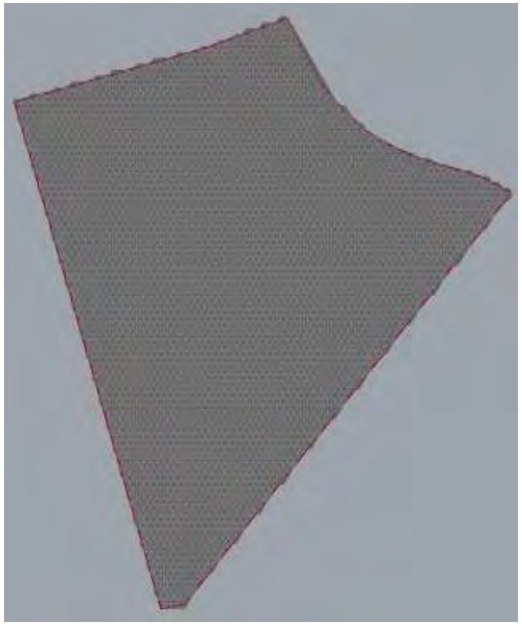
STUDIES

On land -
Total boundary area – 8.007.072 m2



On water - Without any gap between the platforms.

Platform size – 100 m
Total boundary area – 8.006.400 m2
Total platform area – 8.006.400 m2
Scaling factor – 1.0365
Total number of platforms - **1849** units

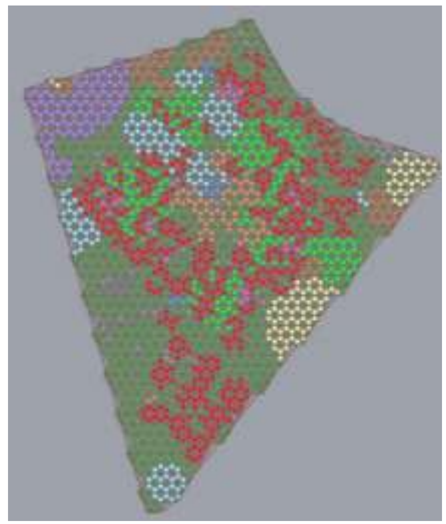


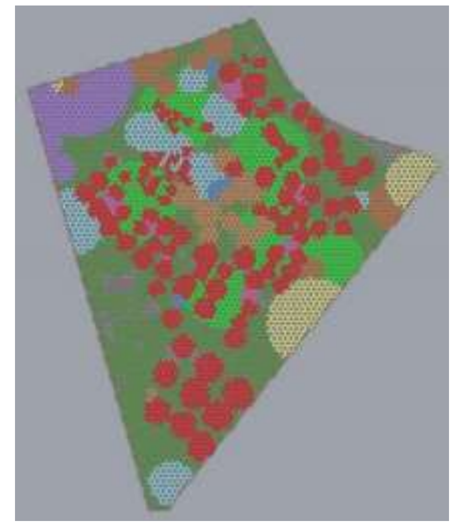
Platform size – 50 m
Total boundary area – 8.007.500 m2
Total platform area – 8.007.500 m2
Scaling factor – 1.0179
Total number of platforms - **7397** units

STUDIES

Platform with no gap between -

Function	**Number of units required if 100 m platform**	**Number of units required if 50 m platform**
Living Residential	480	1920
Living Community facilities	24	96
Business Offices	72	288
Business Light Industrial	97	384
Business Research and Development	72	288
Public Hotel	13	48
Public Park and open space	576	2307
Public leisure	216	864
Public Education Institutional	144	577
Utilities Solar hub	107	433
Utilities Others	48	192
Total	**1849**	**7397**





SPACE@SEA

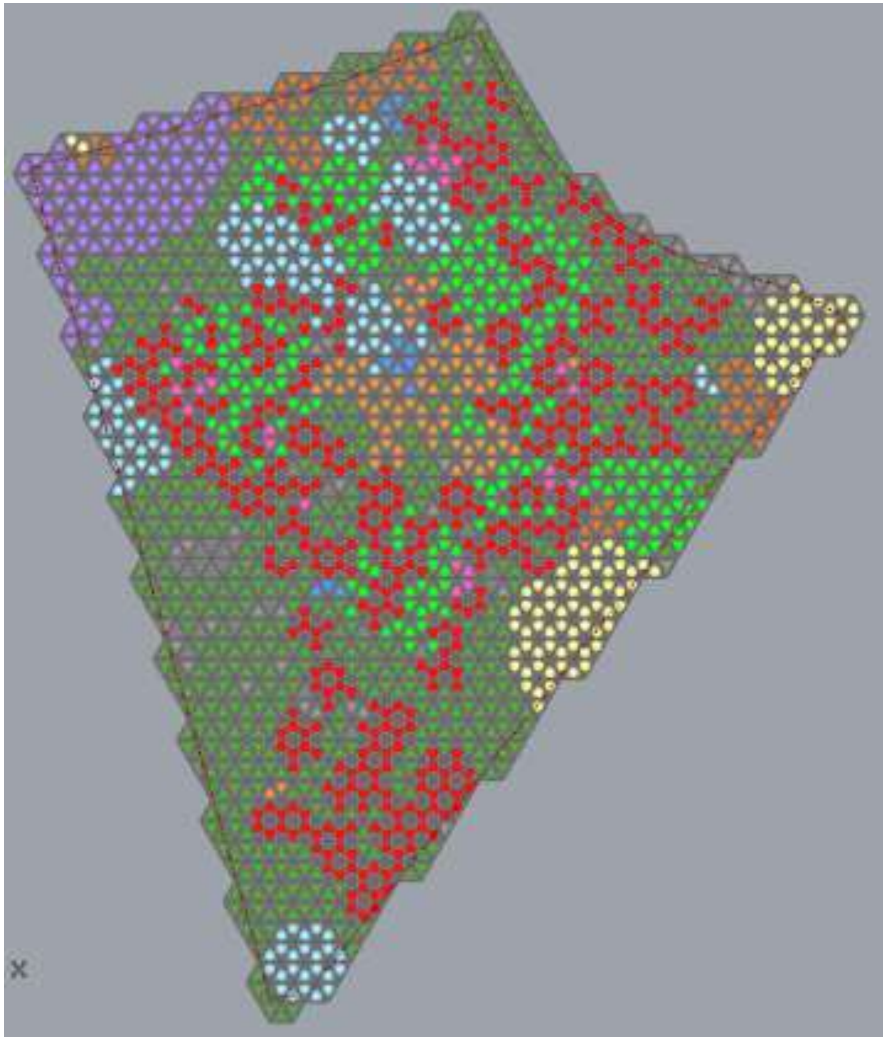
STUDIES

Rules –

Platform	– **100 m**
Platform depth	– 4 m
Slope of platform	– 0
Gap BTW.	– **2.5 m**

Area occupied on water – 8.714.800 m2
Total area of platforms – 8.006.400 m2

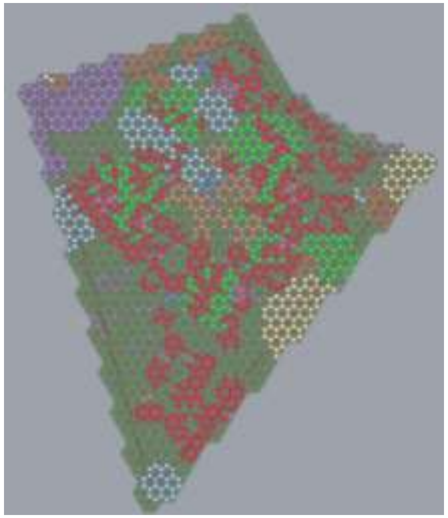
Scaling of boundary – 1.0812
Scaling of programs – 1.0433

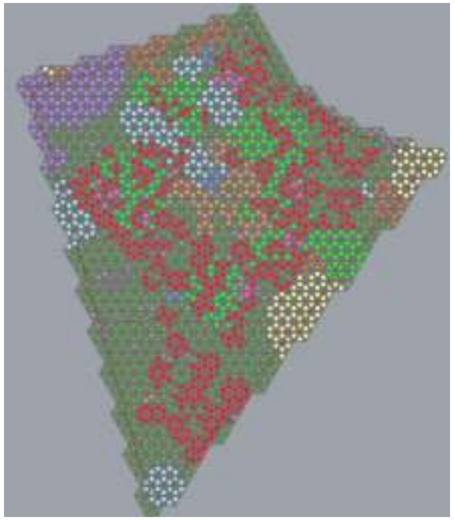


STUDIES

Rules –

Platform	**100 m**	**100 m**
Platform depth	4 m	4 m
Slope of platform	0	0
Gap BTW.	**5 m**	**7.5 m**
Area occupied on water	9.453.200 m2	10.222.000 m2
Total area of platforms	8.006.400 m2	8.006.400 m2
Scaling of boundary	1.126	1.171
Scaling of programs	1.0866	1.1299





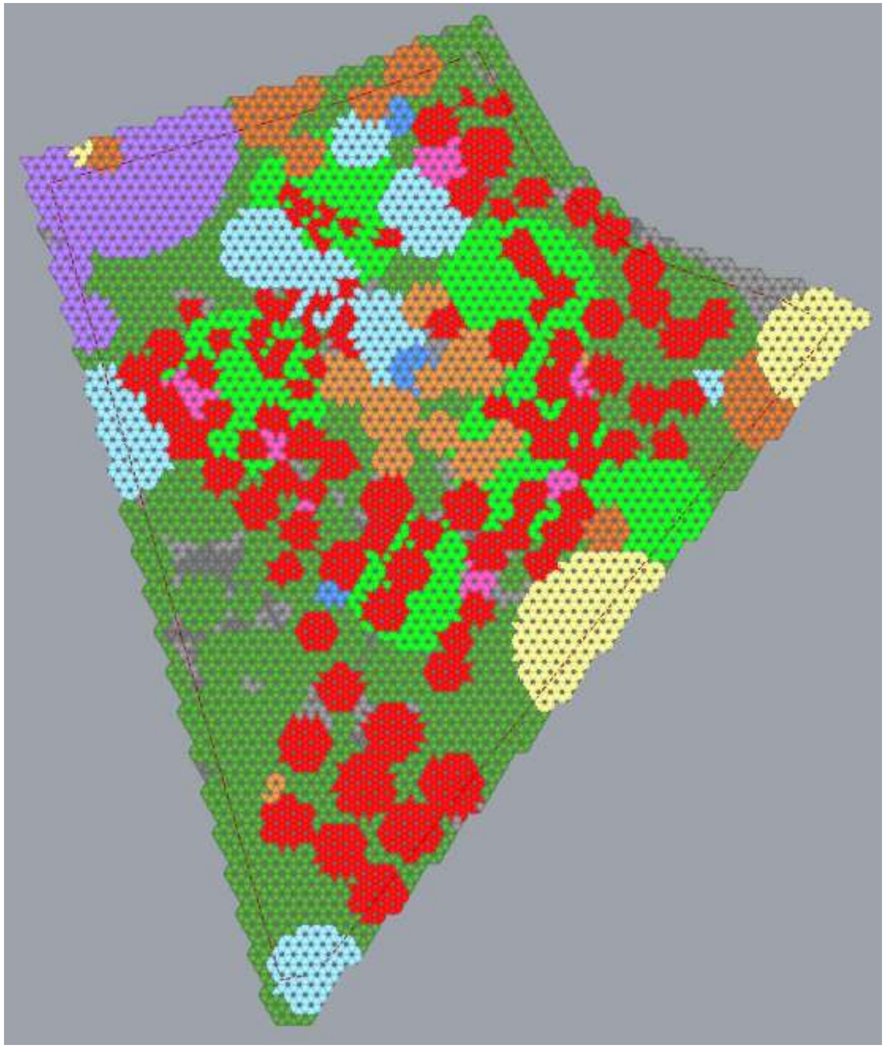
STUDIES

Rules –

Platform – **50 m**
Platform depth – 4 m
Slope of platform – 0
Gap BTW. – **2.5 m**

Area occupied on water – 9.454.400 m2
Total area of platforms – 8.007.500 m2

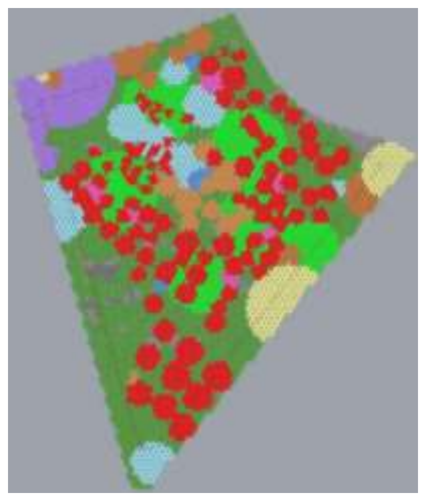
Scaling of boundary – 1.106
Scaling of programs – 1.0866

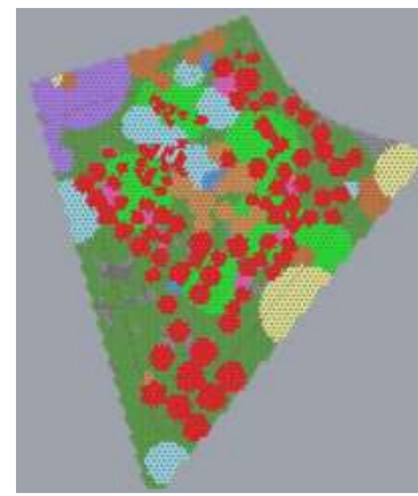


STUDIES

Rules –

Platform	**50 m**	**50 m**
Platform depth	4 m	4 m
Slope of platform	0	0
Gap BTW.	**5 m**	**7.5 m**
Area occupied on water	11.021.000 m2	12.709.000 m2
Total area of platforms	8.007.500 m2	8.007.500 m2
Scaling of boundary	1.1944	1.2825
Scaling of programs	1.1732	1.2598





STUDIES

Function	Area (m2)	Percentage on total area	Number of units required if 100 m platform	Number of units required if 50 m platform
Living Residential	1.565.620	25.5	362	1441
Living Community facilities	78.195	1	15	56
Business Offices	225.161	4	55	228
Business Light Industrial	340.128	5.5	77	312
Business Research and Development	258.718	4	59	227
Public Hotel	41.185	1	14	57
Public Park and open space	1.913.031	31	438	1756
Public leisure	731.136	12	171	680
Public Education Institutional	444.079	7	100	398
Utilities Solar hub	360.622	6	85	341
Utilities Others	181.383	3	42	168
		100	**1418**	**5664**

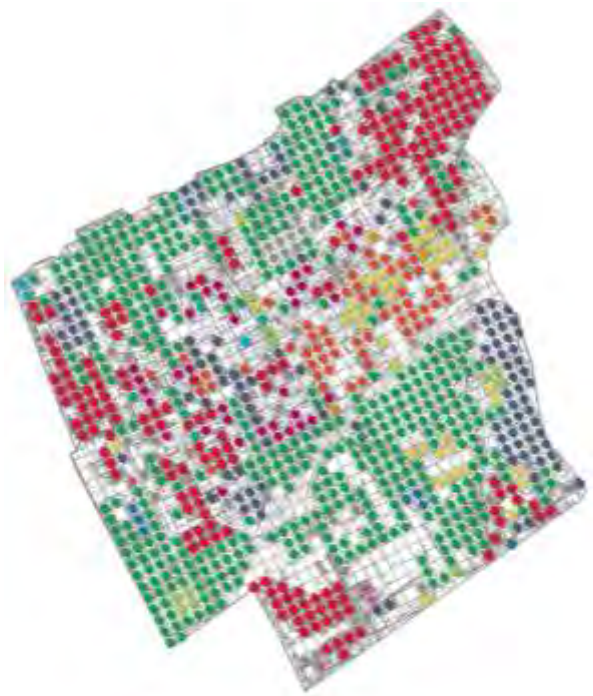
Total area **6.139.258 m2**

In this iteration – 23% unused space is majorly for transport network.

STUDIES

Rijswijk

Function	Area (m2)	Percentage on boundary area
Living Community	40.000	2.7
Living <3 layers	2.050.000	14.3
Living >3 Layers	370.000	2.6
Business Commercial	620.000	4.3
Business office	30.000	0.2
Business Light Industrial	360.000	2.5
Business Agriculture	90.000	0.6
Business Catering Industry	30.000	0.2
Public Park and open space	4.430.000	30.9
Public Building	70.000	0.5
Public educational Institute	90.000	0.6
Public Daily Care	30.000	0.2
Utility	1.130.000	8
Water	560.000	4

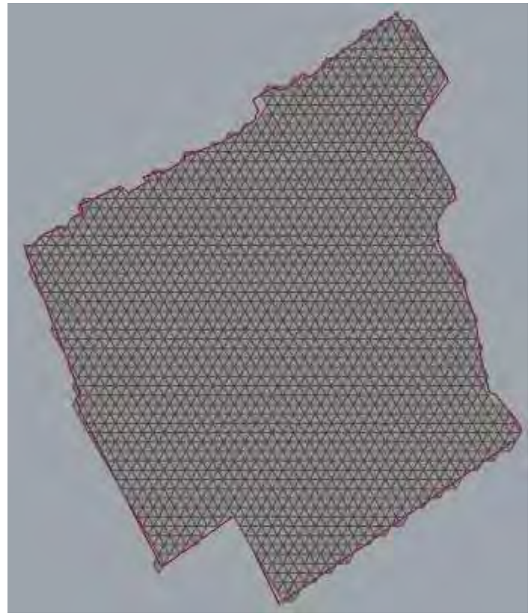


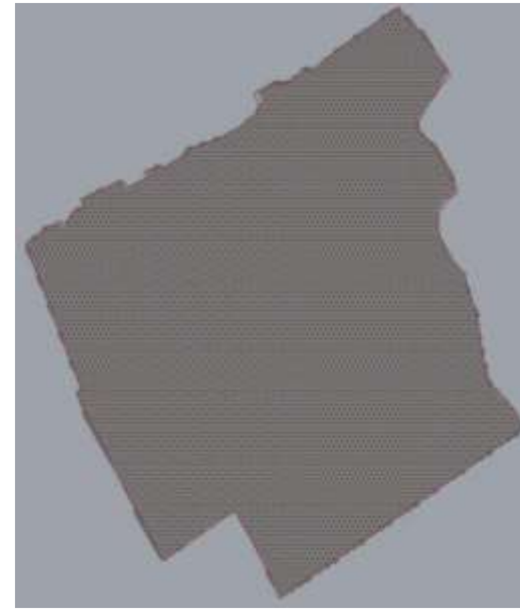
Total area	**9.900.000 m2**
Total boundary area	14.335.323 m2

This show the distribution of function. 28.4 % is unused or doesn’t have any specific functional distribution.

STUDIES

On land -
Total boundary area – 14.335.323 m2





On water - Without any gap between the platforms.

Platform size – 100 m

Total boundary area	14.333.000 m2
Total platform area	14.333.000 m2
Scaling factor	1.02820
Total number of platforms	**3310** units

Platform size – 50 m

Total boundary area	14.336.000 m2
Total platform area	14.336.000 m2
Scaling factor	1.01402
Total number of platforms	**13243** units

STUDIES

Platform with no gap between -

Function	Number of units required if 100 m platform	Number of units required if 50 m platform
Living Community	124	500
Living <3 layers	658	2644
Living >3 Layers	125	480
Business Commercial	199	797
Business office	9	36
Business Light Industrial	114	465
Business Agriculture	28	110
Business Catering Industry	9	36
Public Park and open space	1423	5725
Public Building	25	90
Public educational Institute	27	111
Public Daily Care	9	36
Utility	368	1479
Water	179	745
Total	**3297**	**7397**

STUDIES

Function	Foot print (m2)
Living Community	16.000
Living <3 layers	823.633
Living >3 Layers	244.303
Business Commercial	183.314
Business office	24.000
Business Light Industrial	190.000
Business Agriculture	40.000
Business Catering Industry	11.000
Public Park and open space	2.976.000
Public Building	15.827
Public educational Institute	30.519
Public Daily Care	25.399
Utility	205.887
Water	650.400
Total	**5.436.282**

PARAMETRIC MODELING

How and why –

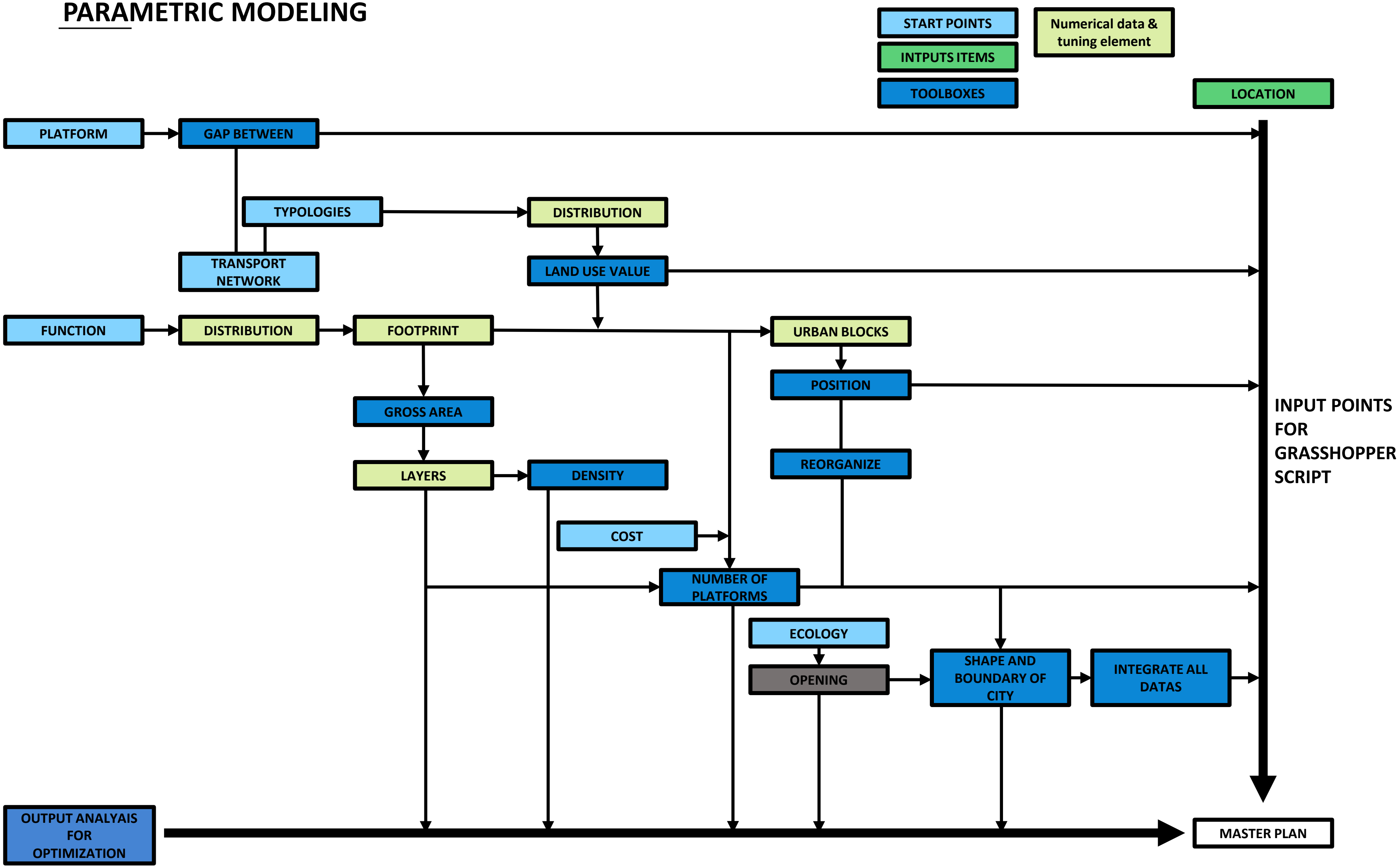
- We build our study from comparing a city form land to water.
- On land, a city is defined by its topography – which defines its boundary.

In water the boundary is defined by the platform shape, size, analytical data's of the waters, etc.

- Most of the cities are program driven – they address a particular function and rest all functions build around it.
- We cannot depict exact city planning strategies and layout for a floating city, it has to develop its own typologies and planning strategies. Due to various factors like cost, feasibility, natural constrains like depth of waters.
- The easy availability of land helps it to easily develop in future.

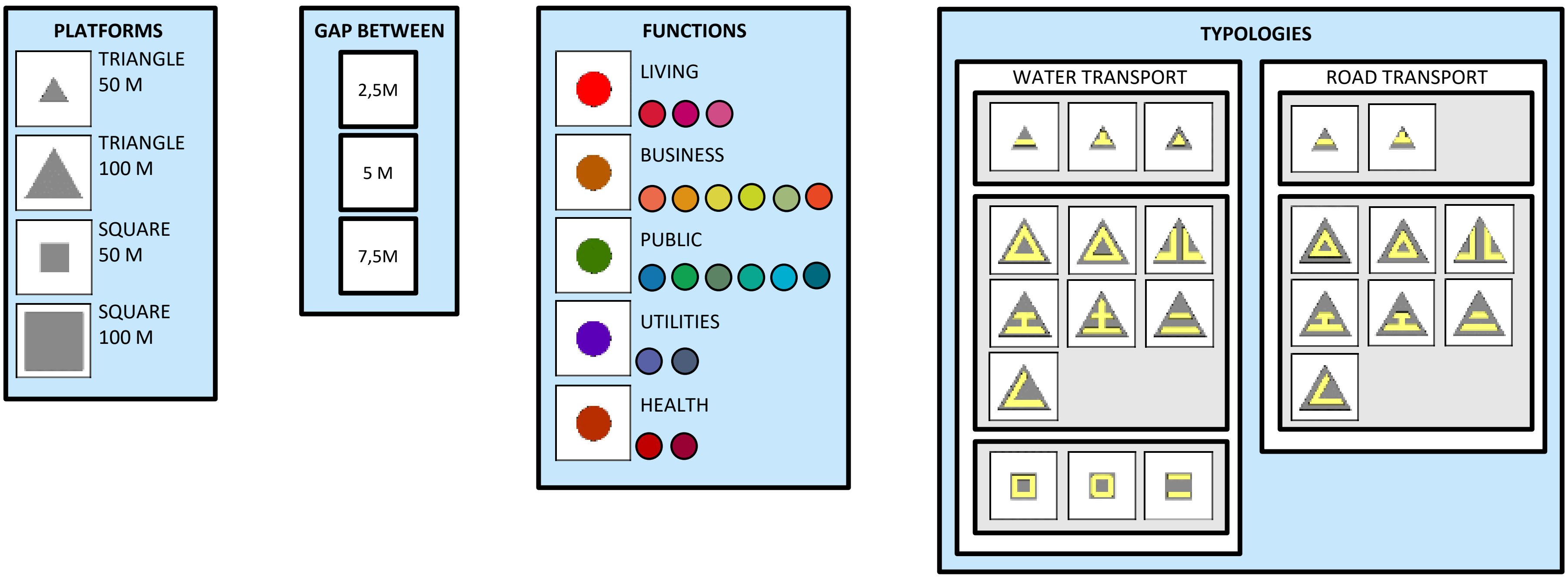
  For floating cities the expansion has to be strategically planned as we are building it artificially from the bottom line.

PARAMETRIC MODELING

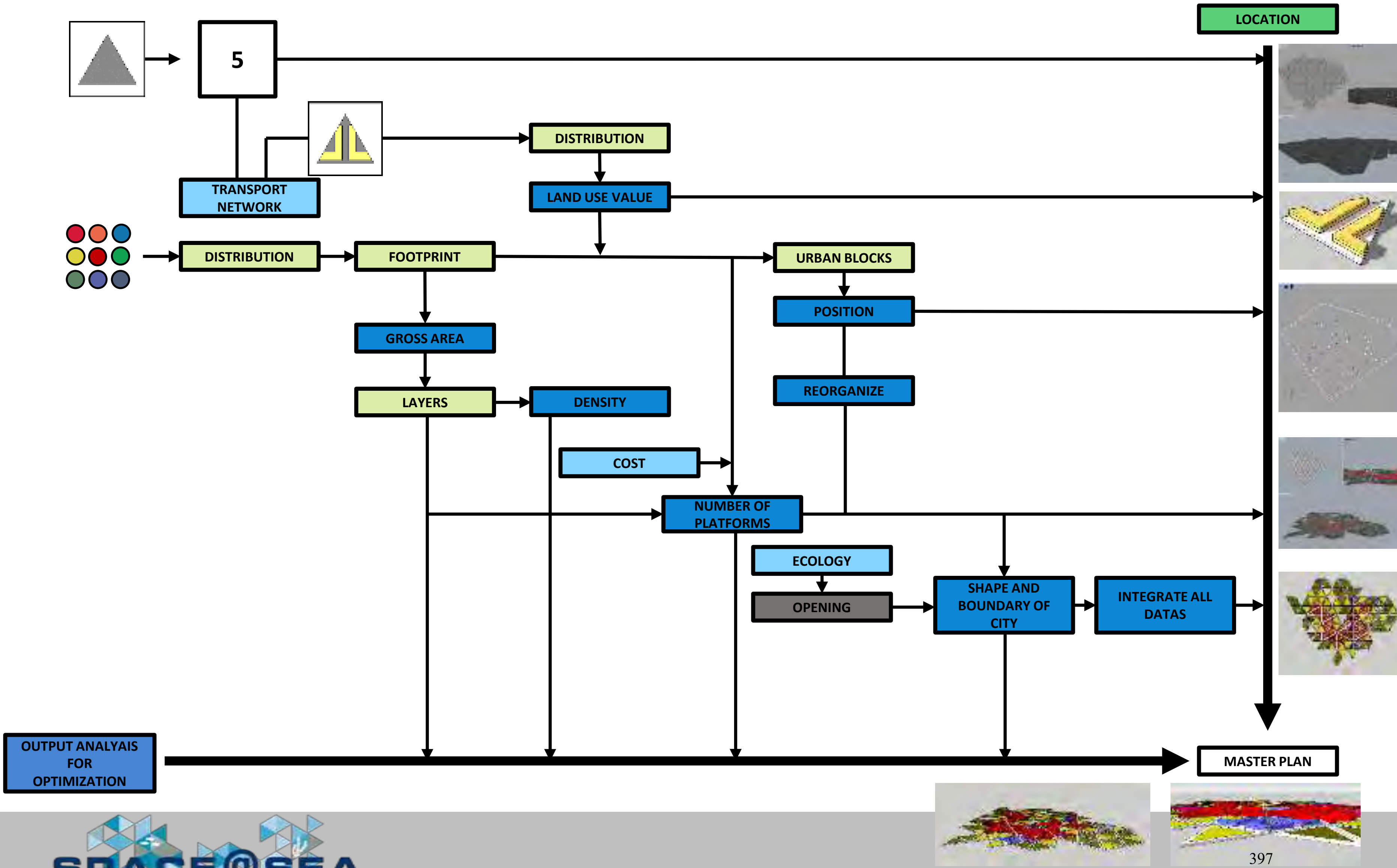


PARAMETRIC MODELING

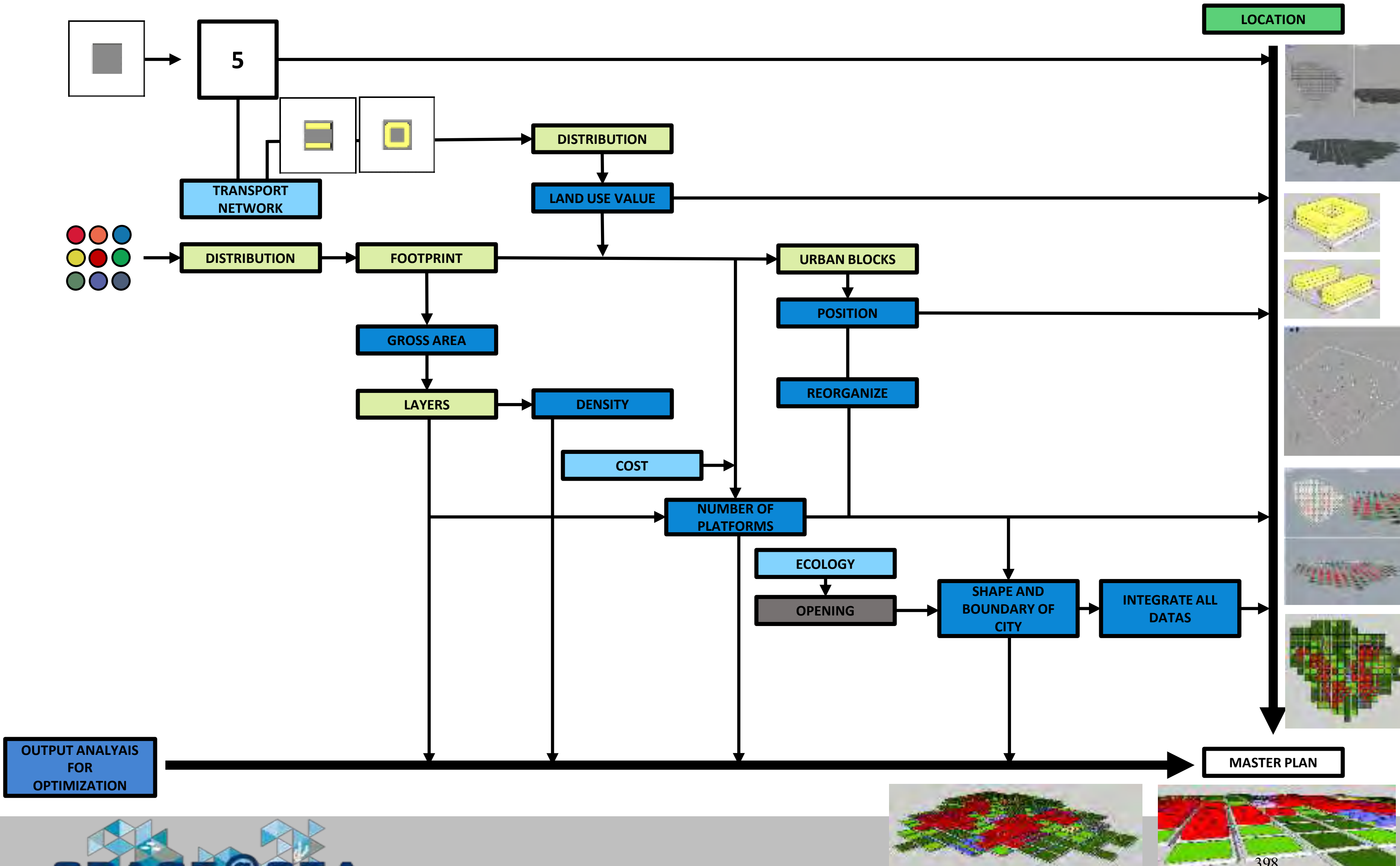
TOOLBOXES



PARAMETRIC MODELING



PARAMETRIC MODELING

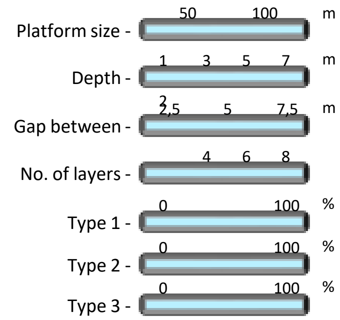


PARAMETRIC MODELING

ANALYSIS

Function	Foot print (m2)
Living Residential	53.936
Business Commercial	7.706
Business Light Industrial	3.059
Business Catering Industry	580
Public Building	4.821
Public Sports	20.284
Public educational Institute	1.375
Public forest	113.347
Public grass land	114.372
Total area	**319.480 m2**

Parameters



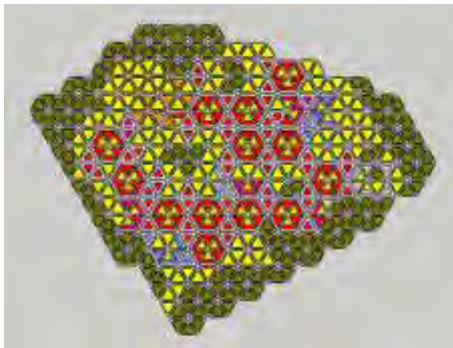
With this data – we will study it in 4 condition –

- **50 m platform with pedestrian walkways and water transport.**
- **50 m platform with road transport.**
- **100 m platform with pedestrian walkways and water transport.**
- **100 m platform with road transport.**

Same types of platforms area going to be used as in previous studies.
We are comparing it, all with 2 layers.

PARAMETRIC MODELING

ANALYSIS

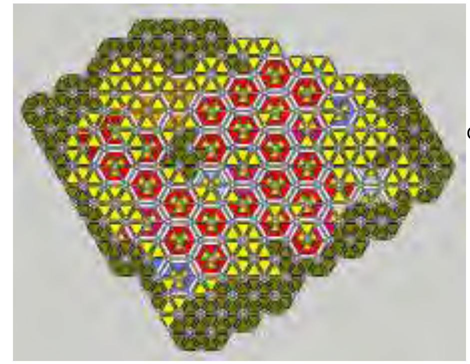


Given boundary – Fixed program position

Platform size - (50, 100 m)
Depth - (1, 3, 5, 7 m)
Gap between - (2,5, 5, 7,5 m)
No. of layers - (2, 4, 6, 8)
Type 1 - (0, 100 %)
Type 2 - (0, 100 %)
Type 3 - (0, 100 %)

Total no. of platform -
449

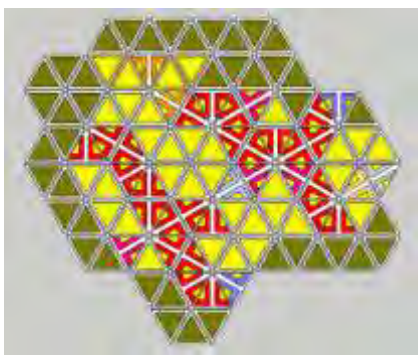
	Condition – 1	Condition – 2
Type -1 -		
Built %	- 51,4 %	47 %
Road %	- 26 %	40,8 %
Green %	- 22,6 %	12,2 %
Type -2 -		
Built %	- 40 %	34,9 %
Road %	- 26 %	40,8 %
Green %	- 34%	24,3 %
Type -3 -		
Built %	- 33 %	
Road %	- 67 %	
Green %	- 0	



Given boundary – Fixed program position

Platform size - (50, 100 m)
Depth - (1, 3, 5, 7 m)
Gap between - (2,5, 5, 7,5 m)
No. of layers - (2, 4, 6, 8)
Type 1 - (0, 100 %)
Type 2 - (0, 100 %)
Type 3 - (0, 100 %)

Total no. of platform -
453

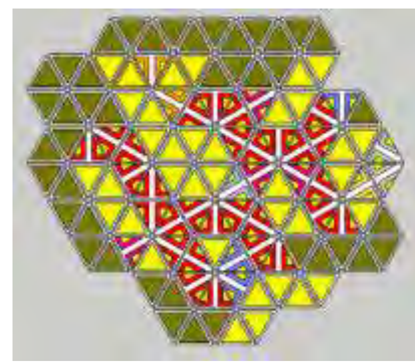


Given boundary – Fixed program position

Platform size - (50, 100 m)
Depth - (1, 3, 5, 7 m)
Gap between - (2,5, 5, 7,5 m)
No. of layers - (2, 4, 6, 8)
Type 1 - (0, 100 %)
Type 2 - (0, 100 %)
Type 3 - (0, 100 %)

Total no. of platform -
112

	Condition – 3	Condition – 4
Type -1 -		
Built %	- 48,9 %	43,6 %
Road %	- 26,7 %	41,1 %
Green %	- 24,4 %	15,3 %



Given boundary – Fixed program position

Platform size - (50, 100 m)
Depth - (1, 3, 5, 7 m)
Gap between - (2,5, 5, 7,5 m)
No. of layers - (2, 4, 6, 8)
Type 1 - (0, 100 %)
Type 2 - (0, 100 %)
Type 3 - (0, 100 %)

Total no. of platform -
122

PARAMETRIC MODELING

ANALYSIS

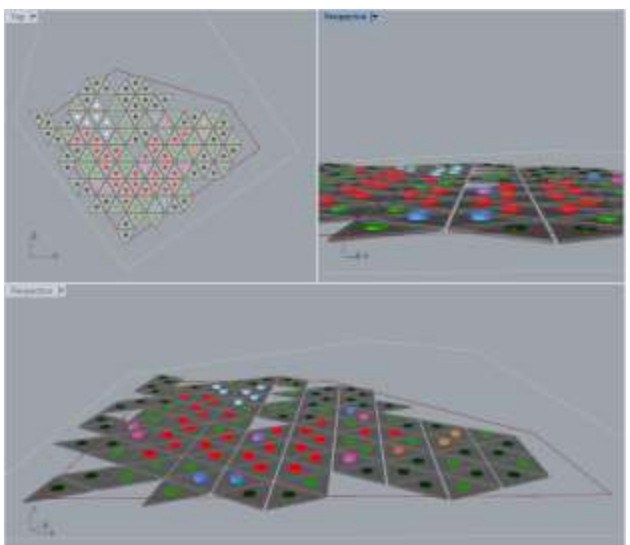
Condition - 3

Platform size - (50, 100) m
Depth - (1, 3, 5, 7) m
Gap between - (2,5, 5, 7,5) m
No. of layers - (2, 4, 6, 8)

Type 1 - (0, 100) %
Type 2 - (0, 100) %
Type 3 - (0, 100) %

Total no. of platform -
112

Given boundary – Fixed program position

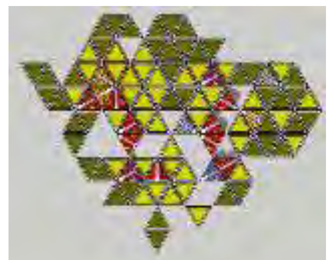


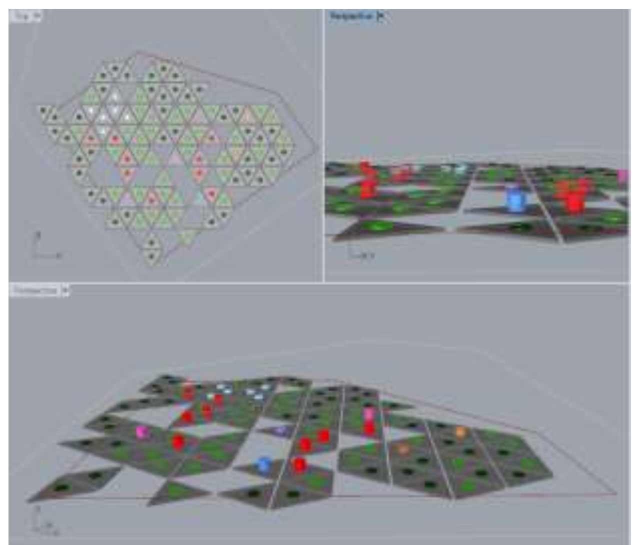
Platform size - (50, 100) m
Depth - (1, 3, 5, 7) m
Gap between - (2,5, 5, 7,5) m
No. of layers - (2, 4, 6, 8)

Type 1 - (0, 100) %
Type 2 - (0, 100) %
Type 3 - (0, 100) %

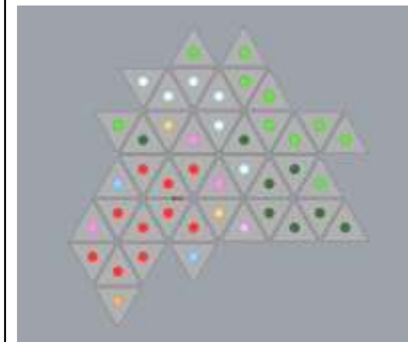
Total no. of platform -
99

Given boundary – Fixed program position

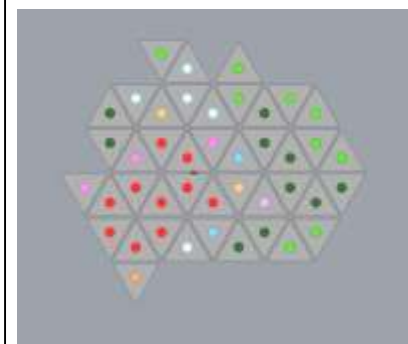




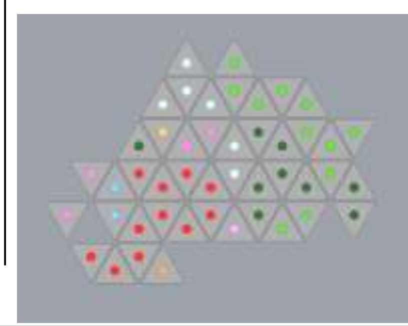
Reorganizing – on going analysis



Iteration - 25



Iteration - 50



Iteration - 75

PARAMETRIC MODELING

ANALYSIS

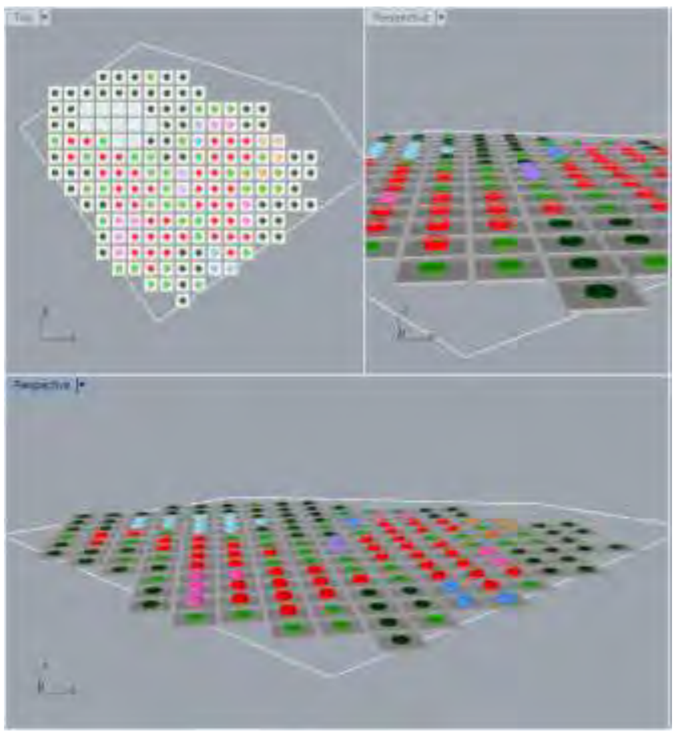
WITH SQUARE PLATFORM

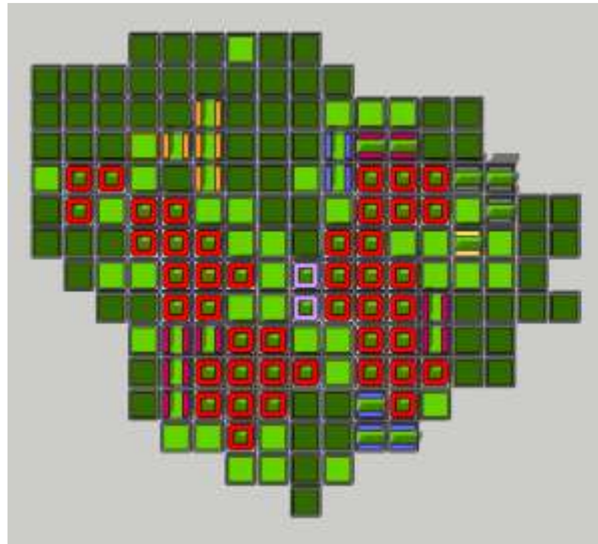
Platform size - (50 – 100 m)
Depth - (1 – 3 – 5 – 7 m)
Gap between - (2,5 – 5 – 7,5 m)
No. of layers - (2 – 4 – 6 – 8)

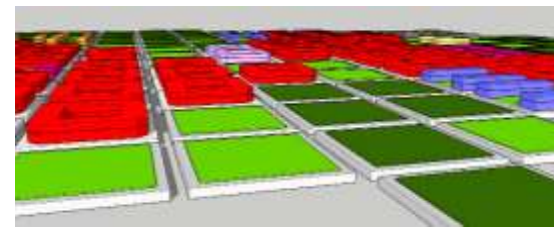
Type 1 - (0 – 100 %)
Type 2 - (0 – 100 %)
Type 3 - (0 – 100 %)

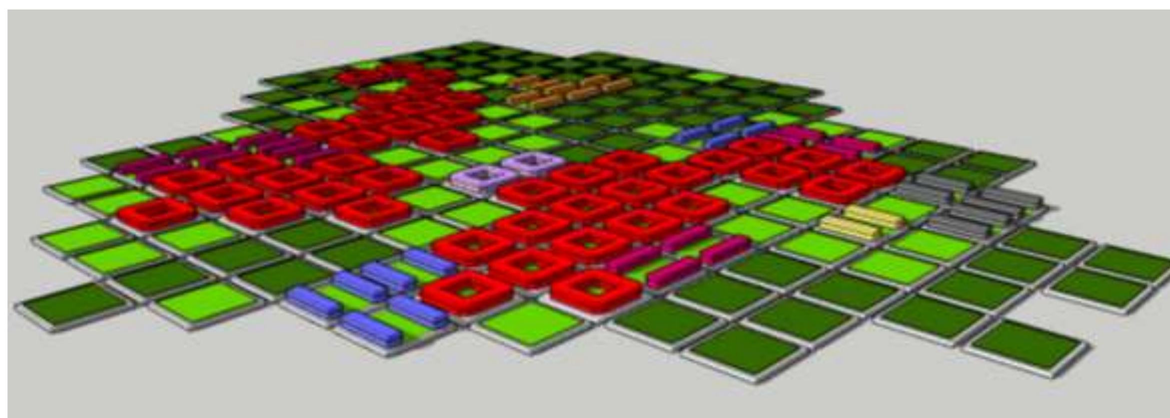
Total no. of platform - **175**

Given boundary – Fixed program position



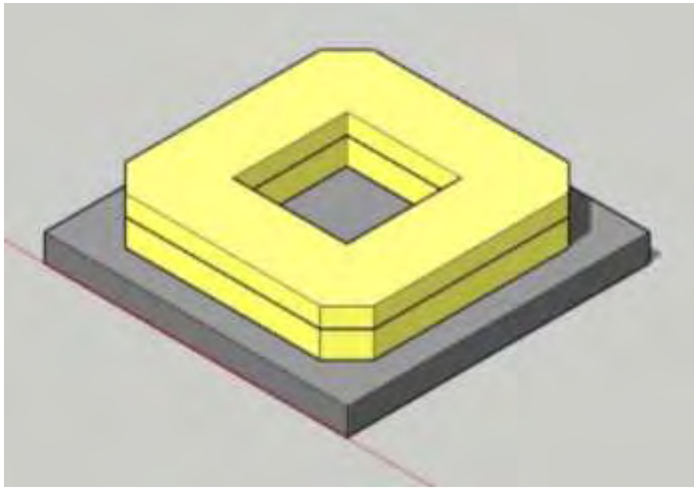






PLATFORM DESIGN

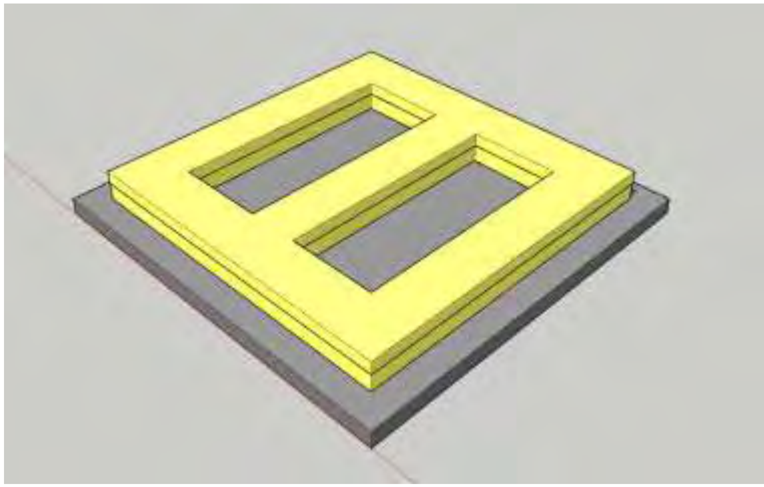
CONCEPT



Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courty ard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciou sness	Buildings	Road	Green	Total	Apartm ents	Reside nts	Density	Green	Green deficit/surp lus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
4	**45**	**2025**	**688**	**289**		**2**	**10**		**1048**																

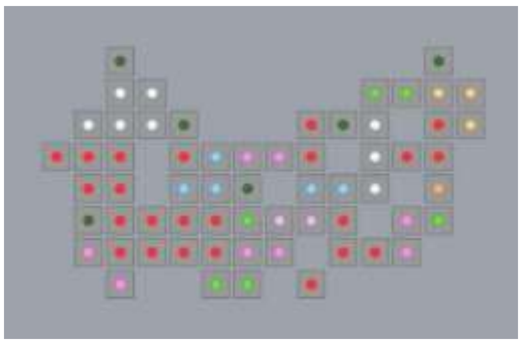
PLATFORM DESIGN

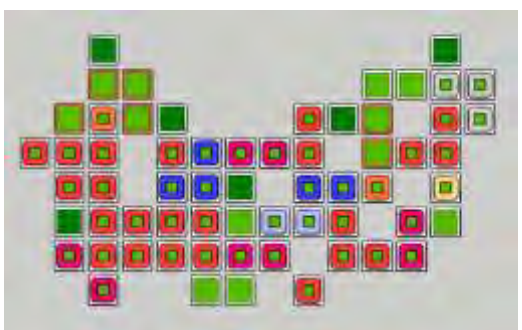
CONCEPT



Platform			Open space		Building(s)							Spacematrix			Land use %							Standards			
Polygon sides	Side	Area	Road	Green	Block length	Floors	Building depth	Courtyard side	Built-up area	Gross floor area (GFA)	Net floor area (NFA)	Floor area Ratio	Gross Space Index	Spaciousness	Buildings	Road	Green	Total	Apartments	Residents	Density	Green	Green deficit/surplus	Parking	Built volume
#	m	m²	m²	m²	m	#	m	m	m²	m²	m²	FAR or FSI	GSI	OSR	%	%	%	%	#	#	ap./ha	m²	m²	#	m³
4	90	8100	2016	2268		2	12		3816																

Function	Required footprint – m2	No. of platforms
Living Residential	23.334	23
Business Commercial	7.706	8
Business Light Industrial	3.059	3
Business Catering Industry	580	1
Public Building	4.821	5
Public Sports	10.000	8
Public educational Institute	1.375	2
Public forest	7.264	6
Public grass land	7.264	6
		62

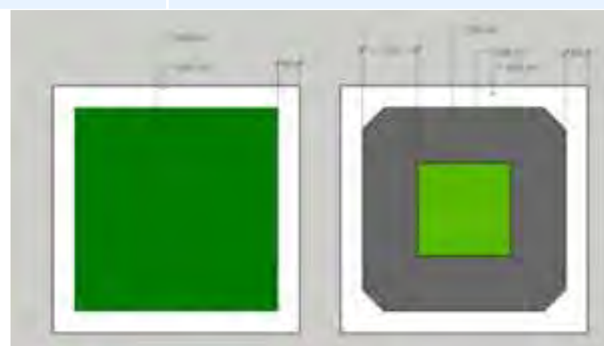




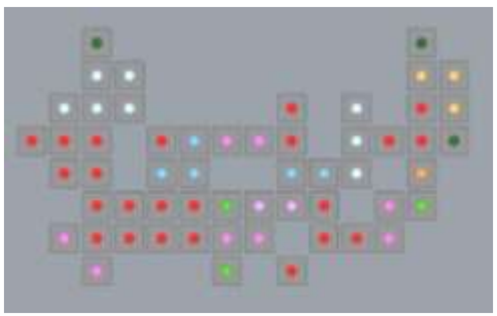
Shape	Square	
Size	45 meters	
Gap between	7,5 meters	
Depth of platform	4 meters	
Inhabitants	2,000	
Built typologies	Type – 1	
	Built %	51,75
	Green %	14,27
	Transport %	33,98
	Levels	2
Green - in total	23.21 %	13% + 14,27% (each platform)
Per unit Size	70 m2	3 inhab per unit avg.
Total Platforms	62	
Boundary Condition		
Cost		
Ecology		

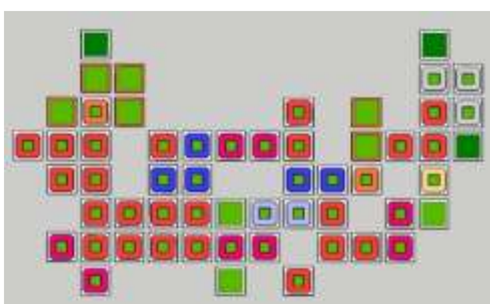
13% * 55875 = 7264 + 7264

Gross required – 2000 / 3 = 666,66 . * 70 = 46666,66



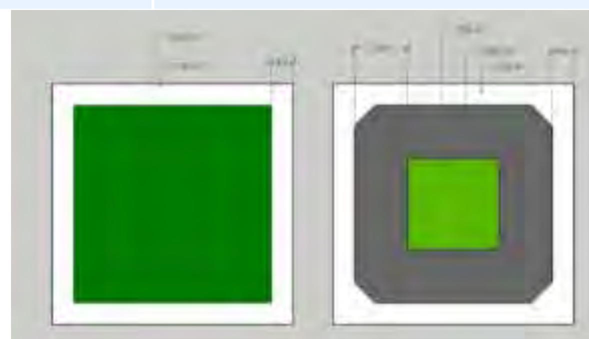
Function	Required footprint – m2	No. of platforms
Living Residential	23.334	23
Business Commercial	7.706	8
Business Light Industrial	3.059	3
Business Catering Industry	580	1
Public Building	4.821	5
Public Sports	10.000	8
Public educational Institute	1.375	2
Public forest	3.632	3
Public grass land	3.632	3
		56



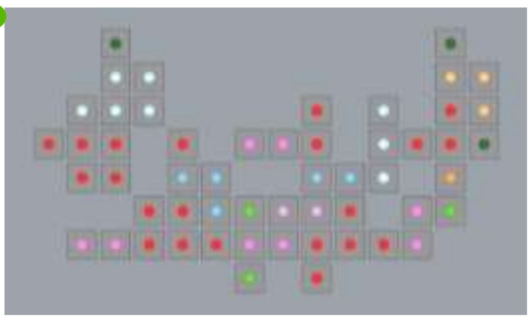


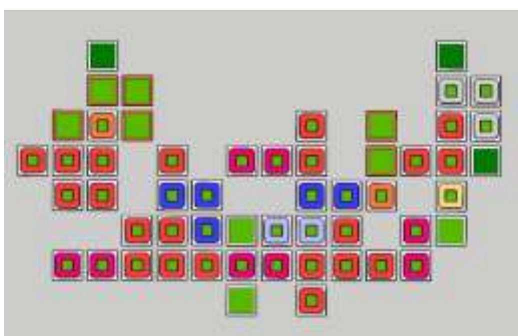
Shape	Square	
Size	45 meters	
Gap between	7,5 meters	
Depth of platform	4 meters	
Inhabitants	2,000	
Built typologies	Type – 1	
	Built %	51,75
	Green %	14,27
	Transport %	33,98
	Levels	2
Green - in total	**18.45 %**	13% + 14,27% (each platform)
Per unit Size	70 m2	3 inhab per unit avg.
Total Platforms	56	
Boundary Condition		
Cost		
Ecology		

13% * 55875 = 7264
Gross required – 2000 / 3 = 666,66 . * 70 = 46666,66



Function	Required footprint – m2	No. of platforms
Living Residential	21.667	21
Business Commercial	7.706	8
Business Light Industrial	3.059	3
Business Catering Industry	580	1
Public Building	4.821	5
Public Sports	10.000	8
Public educational Institute	1.375	2
Public forest	3.199	3
Public grass land	3.199	3
		54

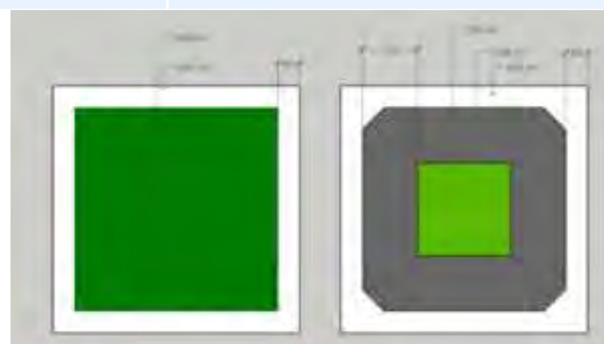




Shape	Square	
Size	45 meters	
Gap between	7,5 meters	
Depth of platform	4 meters	
Inhabitants	2,000	
Built typologies	Type – 1	
	Built %	51,75
	Green %	14,27
	Transport %	33,98
	Levels	2
Green - in total	18,61 %	13% + 14,27% (each platform)
Per unit Size	**65 m2**	3 inhab per unit avg.
Total Platforms	54	
Boundary Condition		
Cost		
Ecology		

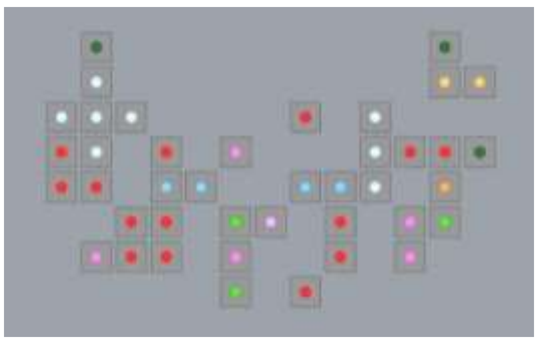
13% * 49208 = 6397

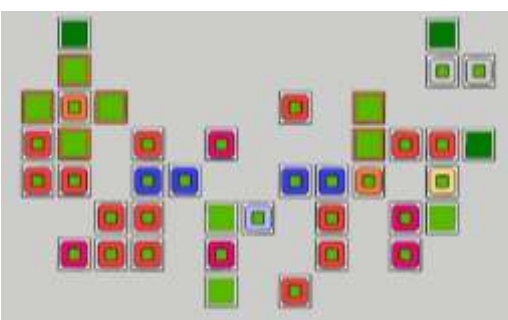
Gross required – 2000 / 3 = 666,66 . * 65 = 43333



SPACE@SEA

Function	Required footprint – m2	No. of platforms
Living Residential	21.667	14
Business Commercial	7.706	5
Business Light Industrial	3.059	2
Business Catering Industry	580	1
Public Building	4.821	4
Public Sports	10.000	8
Public educational Institute	1.375	1
Public forest	3.199	3
Public grass land	3.199	3
		41

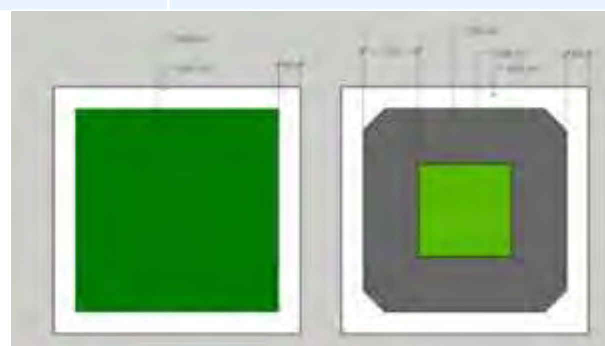




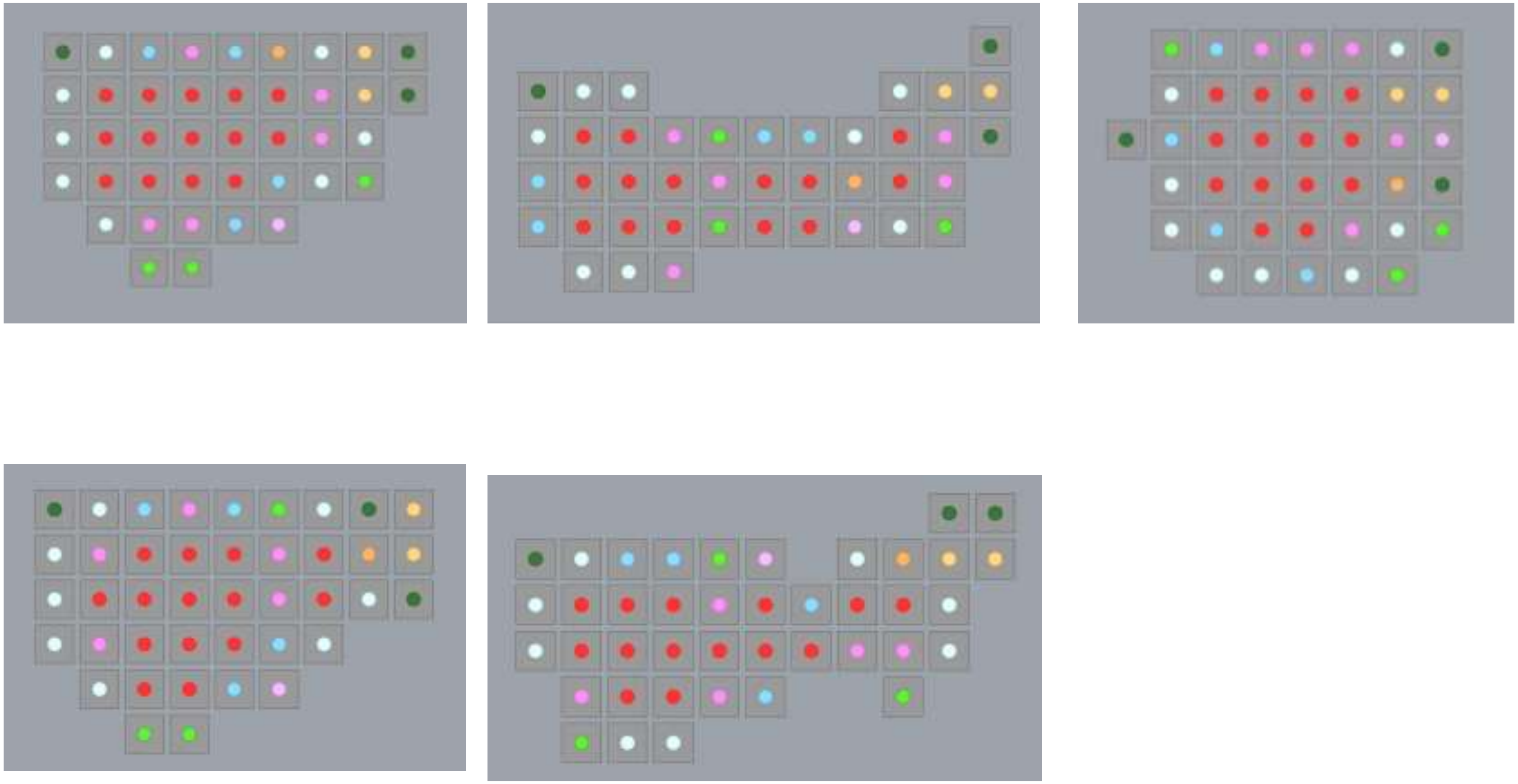
Shape	Square	
Size	45 meters	
Gap between	7,5 meters	
Depth of platform	4 meters	
Inhabitants	2,000	
Built typologies	Type – 1	
	Built %	51,75
	Green %	14,27
	Transport %	33,98
	Levels	3
Green - in total	19.98 %	13% + 14,27% (each platform)
Per unit Size	65 m2	3 inhab per unit avg.
Total Platforms	41	
Boundary Condition		
Cost		
Ecology		

13% * 49208 = 6397

Gross required – 2000 / 3 = 666,66 . * 65 = 43333

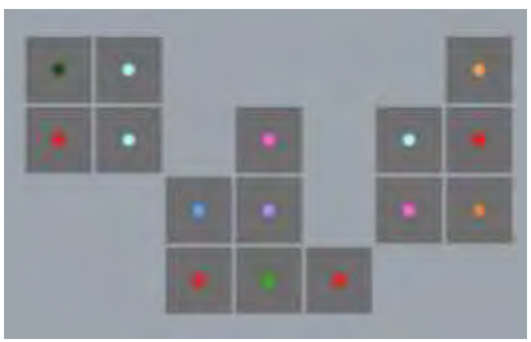


Boundary Conditions options –



Now the configurations have the built in the
middle and the green area outside.
Need your inputs to choose one condition.

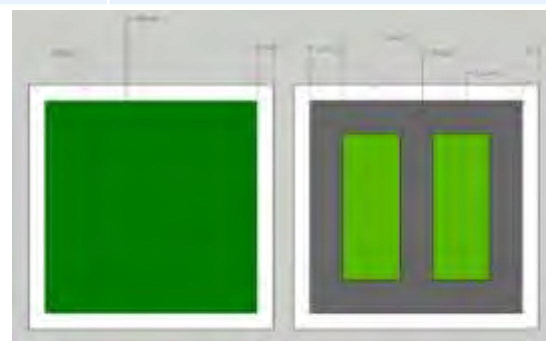
Function	Required footprint – m2	No. of platforms
Living Residential	21.667	4
Business Commercial	7.706	2
Business Light Industrial	3.059 580	1 1
Business Catering Industry	4.821 10.000	1 3
Public Building	1.375	1
Public Sports	3.199	1
Public educational Institute	3.199	1 **15**
Public forest		
Public grass land		



Shape	Square	
Size	90 meters	
Gap between	7,5 meters	
Depth of platform	4 meters	
Inhabitants	2,000	
Built typologies	Type – 1	
	Built %	47,1
	Green %	28
	Transport %	24,9
	Levels	3
Green - in total	30,53 %	13% + 28% (each platform)
Per unit Size	65 m2	3 inhab per unit avg.
Total Platforms	15	
Boundary Condition		
Cost		
Ecology		

13% * 49208 = 6397

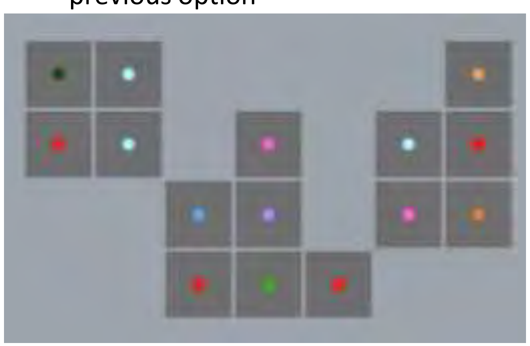
Gross required – 2000 / 3 = 666,66 . * 65 = 43333



SPACE@SEA

Function	Required footprint – m2	No. of platforms
Living Residential	21.667	4
Business Commercial	7.706	2
Business Light	3.059	1
Industrial	580	1
Business Catering	4.821	1
Industry	10.000	3
Public Building	1.375	1
Public Sports	3.199	1
Public educational	3.199	1
Institute		**15**
Public forest		
Public grass land		

Gross area is more compared to previous option

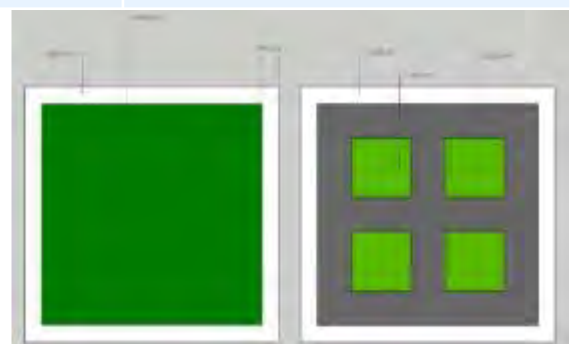


Shape	Square	
Size	90 meters	
Gap between	7,5 meters	
Depth of platform	4 meters	
Inhabitants	2,000	
Built typologies	Type – 1	
	Built %	53,33
	Green %	21,77
	Transport %	24,9
	Levels	3
Green - in total	25,97 %	13% + 21,77% (each platform)
Per unit Size	65 m2	3 inhab per unit avg.
Total Platforms	15	
Boundary Condition		
Cost		
Ecology		

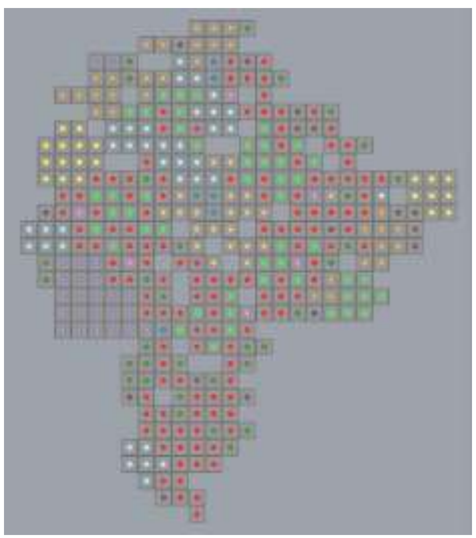
13% * 49208 = 6397

Gross required – 2000 / 3 = 666,66 .

* 65 = 43333

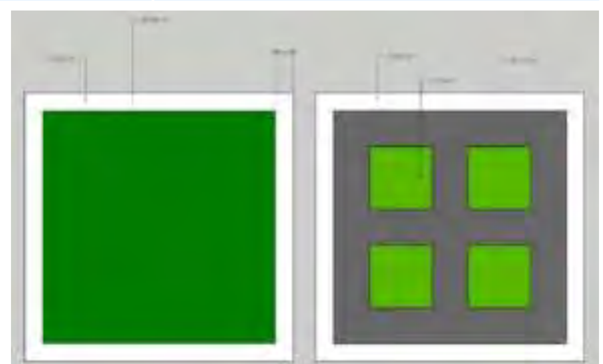


Function	Required footprint – m2	No. of platforms
Living Residential	541667	126
Living Community facilities	21667	6
Business Offices	86668	21
Business Light Industrial	86668	21
Business Research and	130002	31
Development	21667	6
Public Hotel	190082	32
Public Park and open space	260004	49
Public leisure	151669	36
Public Education Institutional	130002	24
Utilities Solar hub	65001	16
Utilities Others		
		368

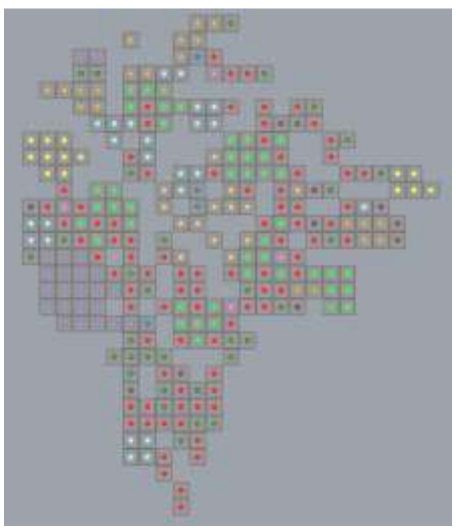


Shape	Square	
Size	90 meters	
Gap between	7,5 meters	
Depth of platform	4 meters	
Inhabitants	50,000	
Built typologies	Type – 1	
	Built %	53,33
	Green %	21,77
	Transport %	24,9
	Levels	**2**
Green - in total	24,29	
Per unit Size	65 m2	3 inhab per unit avg.
Total Platforms	368	
Boundary Condition		
Cost		
Ecology		

Gross required – 50000 / 3 = 16,666 . * 65 = 1,083,333

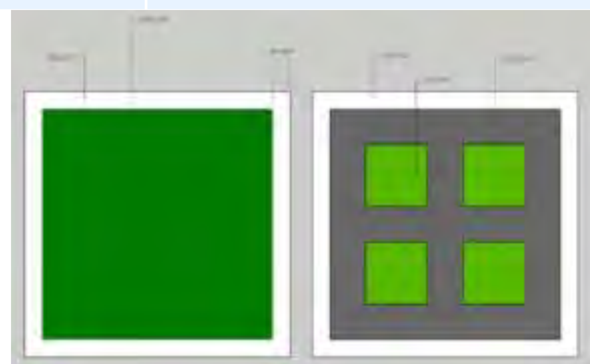


Function	Required footprint – m2	No. of platforms
Living Residential	541667	84
Living Community facilities	21667	4
Business Offices	86668	14
Business Light Industrial	86668	14
Business Research and	130002	21
Development	21667	4
Public Hotel	190082	32
Public Park and open space	260004	44
Public leisure	151669	24
Public Education Institutional	130002	23
Utilities Solar hub	65001	11
Utilities Others		
		275



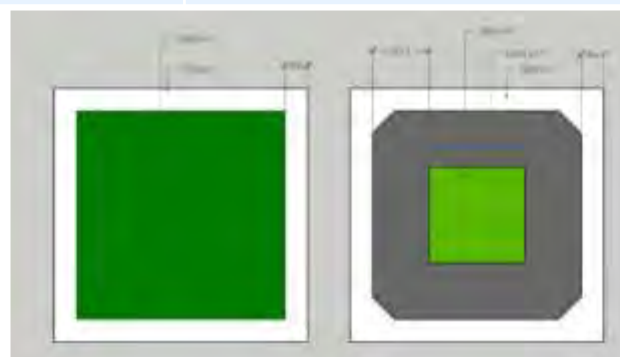
Shape	Square	
Size	90 meters	
Gap between	7,5 meters	
Depth of platform	4 meters	
Inhabitants	50,000	
Built typologies	Type – 1	
	Built %	53,33
	Green %	21,77
	Transport %	24,9
	Levels	**3**
Green - in total	24,87	
Per unit Size	65 m2	3 inhab per unit avg.
Total Platforms	275	
Boundary Condition		
Cost		
Ecology		

Gross required – 50000 / 3 = 16,666 . * 65 = 1,083,333

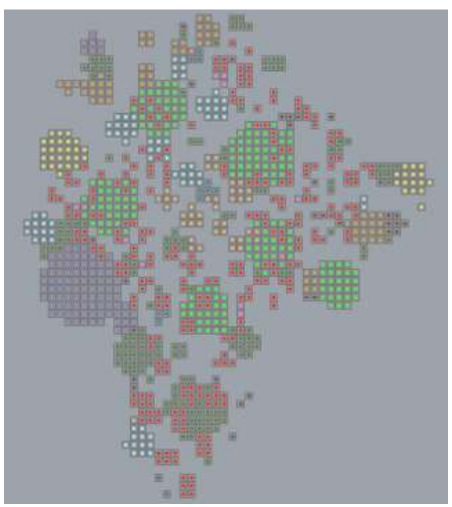


Function	Required footprint – m2	No. of platforms
Living Residential	541667	345
Living Community facilities	21667	14
Business Offices	86668	56
Business Light Industrial	86668	56
Business Research and	130002	83
Development	21667	14
Public Hotel	190082	143
Public Park and open space	260004	188
Public leisure	151669	97
Public Education	130002	97
Institutional	65001	42
Utilities Solar hub		
Utilities Others		**1135**

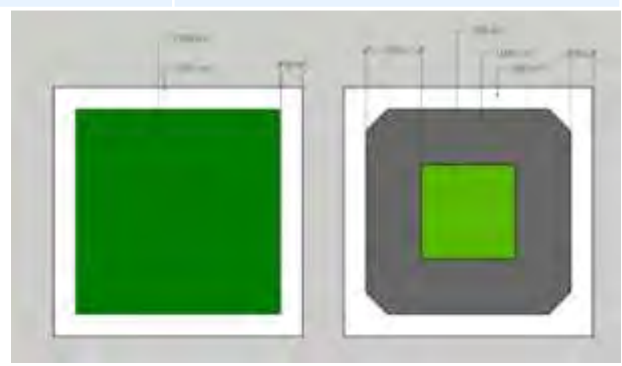
Shape	Square	
Size	45 meters	
Gap between	7,5 meters	
Depth of platform	4 meters	
Inhabitants	50,000	
Built typologies	Type – 1	
	Built %	51,75
	Green %	14,27
	Transport %	33,98
	Levels	**3**
Green - in total	18,54 %	
Per unit Size	65 m2	3 inhab per unit avg.
Total Platforms	1135	
Boundary Condition		
Cost		
Ecology		



Function	Required footprint – m2	No. of platforms
Living Residential	541667	259
Living Community facilities	21667	11
Business Offices	86668	42
Business Light Industrial	86668	42
Business Research and	130002	63
Development	21667	11
Public Hotel	190082	143
Public Park and open space	260004	178
Public leisure	151669	73
Public Education Institutional	130002	95
Utilities Solar hub	65001	32
Utilities Others		
		949



Shape	Square	
Size	45 meters	
Gap between	7,5 meters	
Depth of platform	4 meters	
Inhabitants	50,000	
Built typologies	Type – 1	
	Built %	51,75
	Green %	14,27
	Transport %	33,98
	Levels	4
Green - in total	19,24 %	
Per unit Size	65 m2	3 inhab per unit avg.
Total Platforms	949	
Boundary Condition		
Cost		
Ecology		



Discussions –

The optimized outputs for Living @ sea –

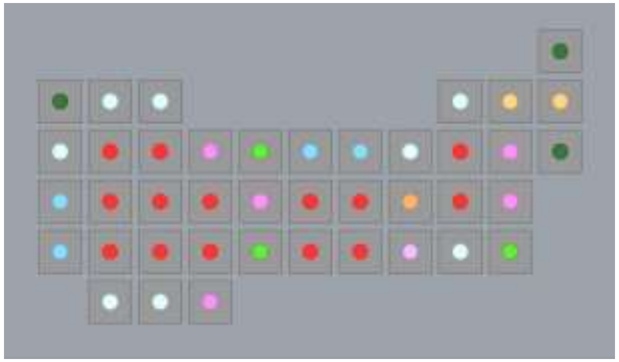
For 2,000 inhabitants –

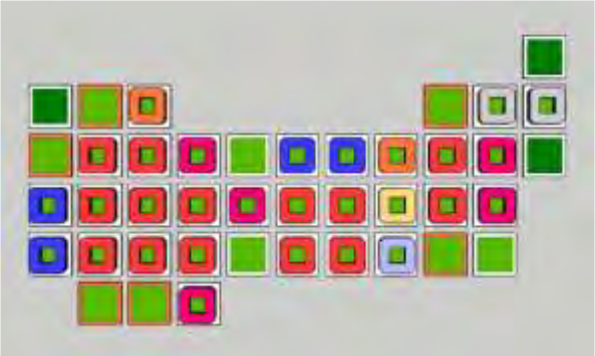
Square	45 m platform	42	7.5m
gap	3 levels		
Square	90 m platform	15	7.5m
gap	3 levels		

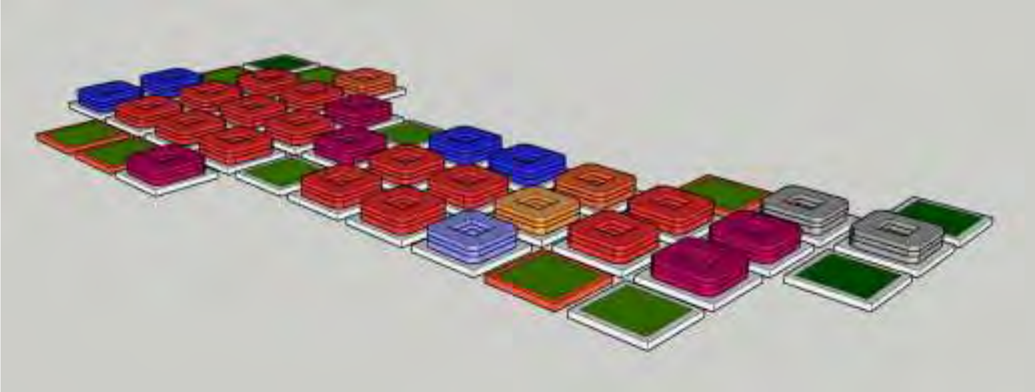
For 50,000 inhabitants –

Square	45 m platform	949	7.5m
gap	4 levels		
Square	90 m platform	275	7.5m
gap	3 levels		

We have taken outputs for different configurations for the first case.
We want inputs on how the configurations to be assigned based on your studies.

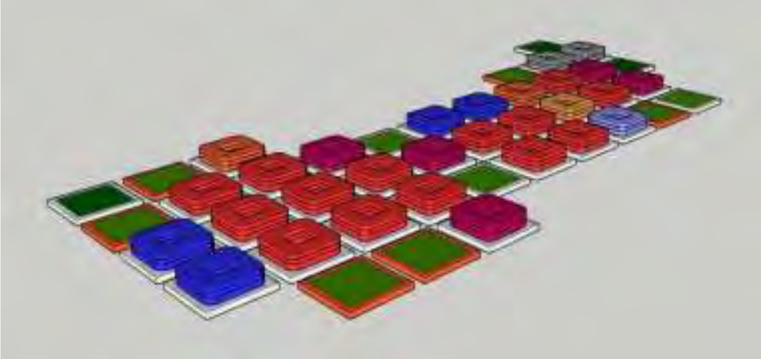






Estimated load for 3 layers –(G+2) building
205 pound / sq.ft – 275 pound / sq.ft
Built area in a platform – 1048 m2
Gross area = 3114 m2
On average – 240 pound / sq.ft = 1172 kg / sq.m

Load = 3,684,768 kg



Reference link – for load values

- http://old.seattletimes.com/html/asktheexpert/2002122968_homehay19.html

Amended table –

For 2,000 Inhabitants			45m Platform	
Gross Floor Area / Apartment			75m2	
Residents			3/ apartment	
Green			20%	
Built			51.75%	
Transport			33.98%	
Total Platforms			41	
Road width for pedestrian access			4m	
Function List	**Percentage distribution of total (%)**	**Plot Area (m)**	**Gross Area (m2)**	**No. Platforms**
Living Residential	34	28,229	44016	-
Business Commercial	12	9,963	15720	-
Business Light Industrial	5	4,151	6288	-
Public Catering Industry	2.5	2,075	3144	-
Public Building	10	8,302	12576	-
Public Sports	10	8214	8214	-
Public Educational Institute	2.5	2,075	3144	-
Public Forest	7	5,811	5811	-
Public Grass Land	7	5,811	5811	-
Solar/ Waste Water Treatment	10	8,000	8,000	-
TOTAL	100	82631	112724	

Optimum Platform numbers -

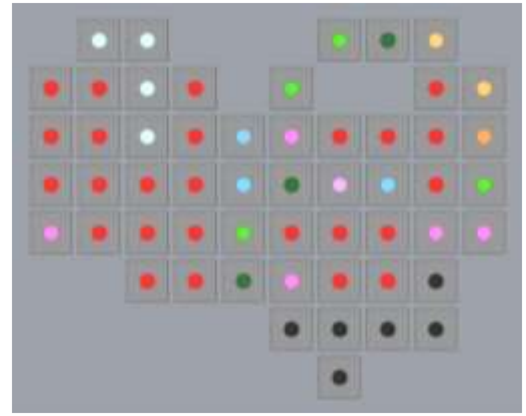
Assumption and discussion – for Logistics @ Sea			
LOCATION	North sea		
PROGRAMS		Distribution percentages %	
	Living Residential		41
	Business Commercial		8
	Business Light Industry		3
	Business Catering Industry		2
	Public Buildings		5
	Public Sports		9
	Public Educational Institute		2
	Public Forest		7
	Public Grassland		10
	Solar / Waste-Water Treatment		13
		Total	100
TRANSPORT SYSTEM	Within City – Pedestrian, cycling and waterways	Primary channel width	12 m
		Secondary channel width	7.5 m
	Axis to city from mainland – waterways		

Number of platforms –

Option 1.a -

Shape	Square	No. Of inhabitant per apartment	2
Size	45 meters	Per apartment unit size	75 m2
Gap between	7,5 meters	No. Of levels	3 - (G+2)
Depth of platform	4 meters	Green percentage	20,39
Inhabitants	2,000		

Programs	Percentage distribution	FootPrint area – m2	Gross Area – m2	No. Of . Platform
Living Residential	41	25.399	76.196	25
Business Commercial	8	5.240	15.719	5
Business Light Industrial	3	2.096	6.288	2
Business Catering Industry	2	1.048	3.144	1
Public Building	5	3.144	9.431	3
Public Sports	9	5.476	5.476	4
Public educational Institute	2	1.048	3.144	1
Public forest	7	4.562	4.562	3
Public grass land	10	6.083	6.083	4
Solar / w.w.t	13	8.213	8.213	6
Total	**100**	**62.309**	**138.256**	**54**



	Built Typologies		No. Of platform
Typology -1	Built %	51,75	32
	Green %	14,27	
	Transport %	33,98	
Typology -2	Built %	43,85	5
	Green %	23,75	
	Transport %	32,4	
Typology -3	Built %	0	17
	Green %	67,6	
	Transport %	32,4	
		Total	54

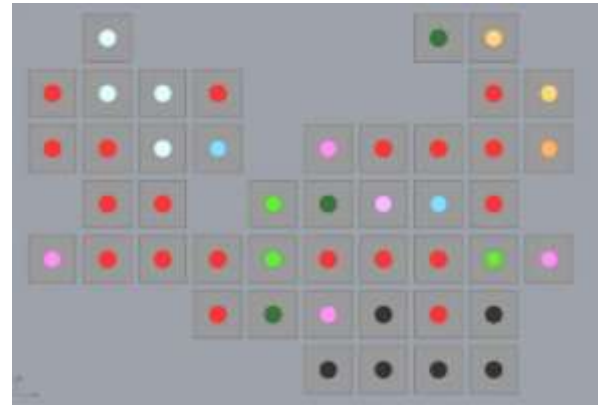

Typology -1


Typology -2


Typology -3

Option 1.b -

Shape	Square	No. Of inhabitant per apartment	2
Size	45 meters	Per apartment unit size	75 m2
Gap between	7,5 meters	No. Of levels	4 - (G+3)
Depth of platform	4 meters	Green percentage	20,05
Inhabitants	2,000		

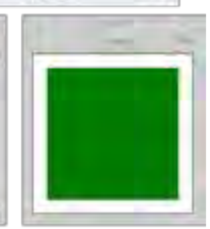


Programs	Percentage distribution	FootPrint area – m2	Gross Area – m2	No. Of . Platform
Living Residential	37	19.271	77.084	19
Business Commercial	8	4192	16.767	4
Business Light Industrial	4	2096	8.384	2
Business Catering Industry	2	1048	4.192	1
Public Building	4	2096	8.384	2
Public Sports	10	5476	5.476	4
Public educational Institute	2	1048	4.192	1
Public forest	9	4562	4.562	3
Public grass land	9	4562	4.562	3
Solar / w.w.t	15	8213	8.213	6
Total	**100**	**52.564**	**141.816**	**45**

	Built Typologies		No. Of platform
Typology -1	Built %	51,75	25
	Green %	14,27	
	Transport %	33,98	
Typology -2	Built %	43,85	4
	Green %	23,75	
	Transport %	32,4	
Typology -3	Built %	0	16
	Green %	67,6	
	Transport %	32,4	
		Total	45

Typology -1

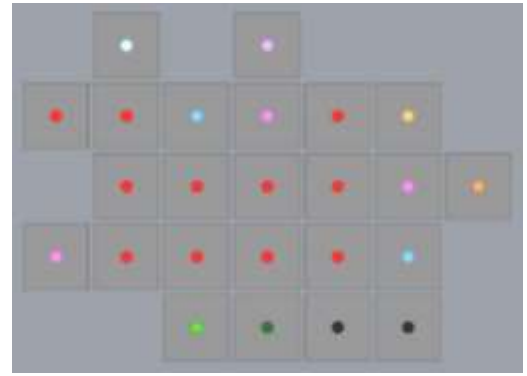
Typology -2



Typology -3

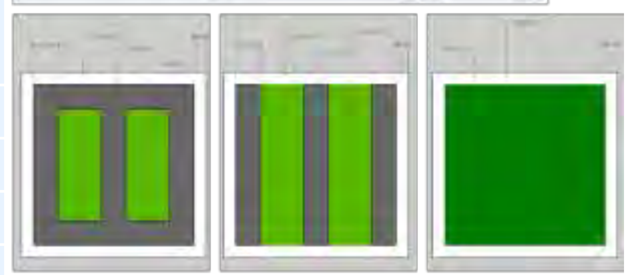
Option 2.a -

Shape	Square	No. Of inhabitant per apartment	2
Size	90 meters	Per apartment unit size	75 m2
Gap between	7,5 meters	No. Of levels	2 – (G+1)
Depth of platform	4 meters	Green percentage	30
Inhabitants	2,000		



Programs	Percentage distribution	FootPrint area – m2	Gross Area – m2	No. Of . Platform
Living Residential	39	38.929	77.857	11
Business Commercial	11	11.445	22.891	3
Business Light Industrial	4	3.815	7.630	1
Business Catering Industry	4	3.815	7.630	1
Public Building	8	7.630	15.260	2
Public Sports	6	6.083	6.083	1
Public educational Institute	4	3.815	7.630	1
Public forest	6	6.083	6.083	1
Public grass land	6	6.083	6.083	1
Solar / w.w.t	12	12.166	12.166	2
Total	**100**	**93.781**	**169.263**	**24**

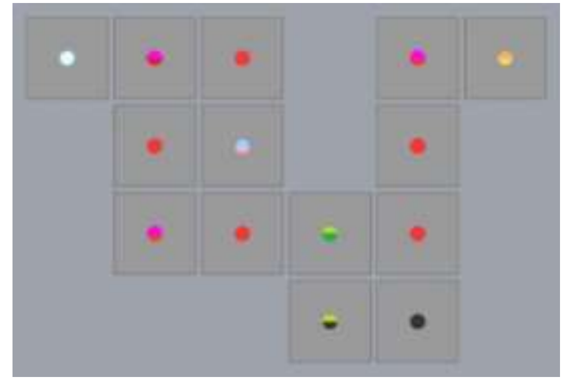
	Built Typologies		No. Of platform
Typology -1	Built %	47,1	16
	Green %	28	
	Transport %	24,9	
Typology -2	Built %	34,6	3
	Green %	40,5	
	Transport %	24,9	
Typology -3	Built %	0	5
	Green %	75,1	
	Transport %	24,9	
		Total	24



Typology -1 Typology -2 Typology -3

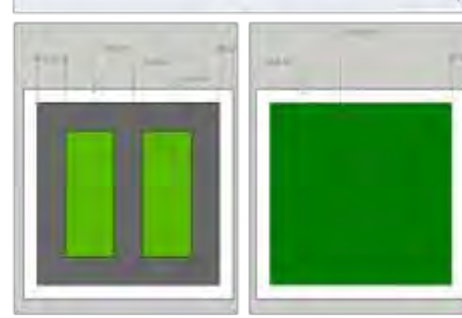
Option 2.b -

Shape	Square	No. Of inhabitant per apartment	2
Size	90 meters	Per apartment unit size	75 m2
Gap between	7,5 meters	No. Of levels	3 – (G+2)
Depth of platform	4 meters	Green percentage	20
Inhabitants	2,000		



Programs	**Percentage distribution**	**FootPrint area – m2**	**Gross Area – m2**	**No. Of . Platform**
Living Residential	49	30.520	75.000	8
Business Commercial			22.891	
Business Light Industrial	6	3.815	11.445	1
Business Catering Industry				
Public Building	10	3.815	11.445	1
Public educational Institute				
Public Sports	6	6.083	6.083	1
Public forest	29	5.000	5.000	3
Public grass land		5.000	5.000	
Solar / w.w.t		8.249	8.249	
Total	**100**	**62.482**	**145.113**	**14**

	Built Typologies			**No. Of platform**
Typology -1	Built %	47,1		10
	Green %	28		
	Transport %	24,9		
Typology -2	Built %	0		4
	Green %	75,1		
	Transport %	24,9		
			Total	**14**



Typology -1 Typology -2

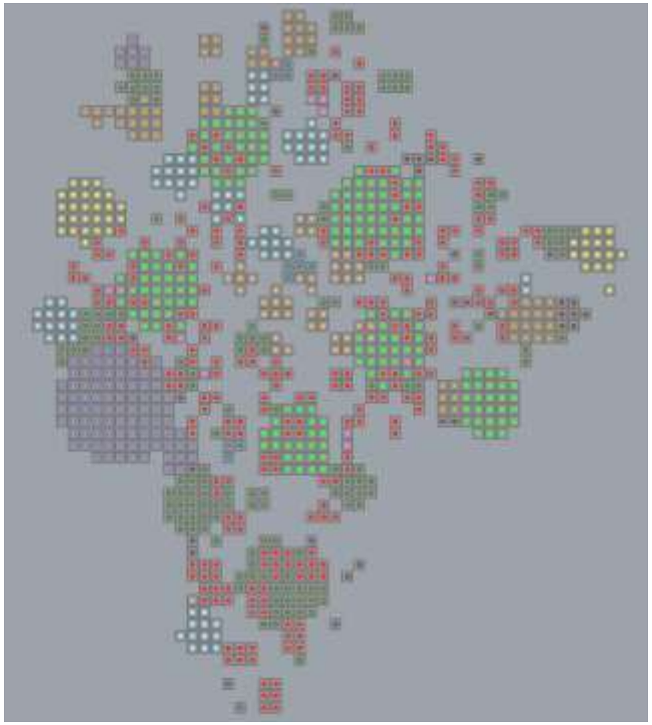
Assumption and discussion – for Living @ Sea

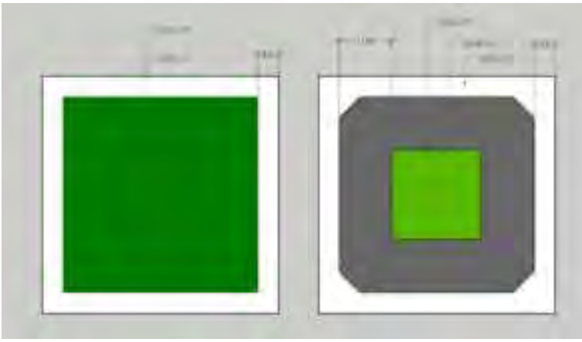
LOCATION	Rostock Den Haag Malmö Copenhagen Stockholm Dublin Tallinn		
PROGRAMS		Distribution percentages %	
	Living Residential		32
	Living Community facilities		1.5
	Business Offices		5
	Business Light Industrial		5
	Business Research and Development		8
	Public Hotel		1.5
	Public Park and open space		11
	Public leisure		15
	Public Education Institutional		9
	Utilities Solar hub		8
	Utilities Others		4
		Total	100
TRANSPORT SYSTEM	Within City – Pedestrian, cycling and waterways Axis to city from mainland – waterways	Primary channel width Secondary channel width	12 m 7.5 m

Number of platforms –
Option 1.a -

Shape	Square	No. Of inhabitant per apartment	3
Size	45 meters	Per apartment unit size	65 m2
Gap between	7,5 meters	No. Of levels	4 - (G+3)
Depth of platform	4 meters	Green percentage	19.24
Inhabitants	50,000		

Programs	Percentage distribution	FootPrint area – m2	Gross Area – m2	No. Of . Platform
Living Residential	32	541.667		256
Living Community facilities	1.5	21.667		11
Business offices	5	86.668		42
Business Light Industrial	5	86.668		42
Business Research and Development	8	130.002		63
Public Hotel	1.5	21.667		11
Public Park and open space	11	190.082		143
Public Leisure	15	260.004		178
Public educational Institute	9	151.669		73
Utility Solar	8	130.002		95
Utility Others	4	65.001		32
Total	**100**	**1.685.097**		**949**



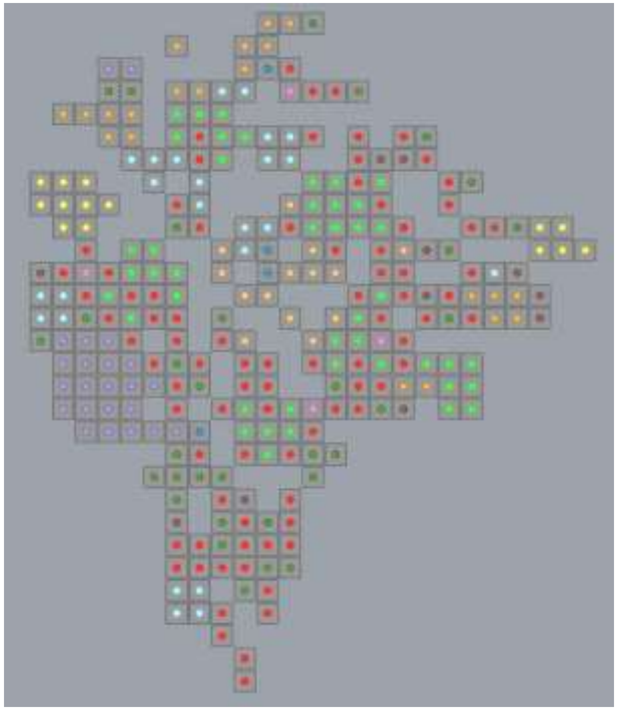


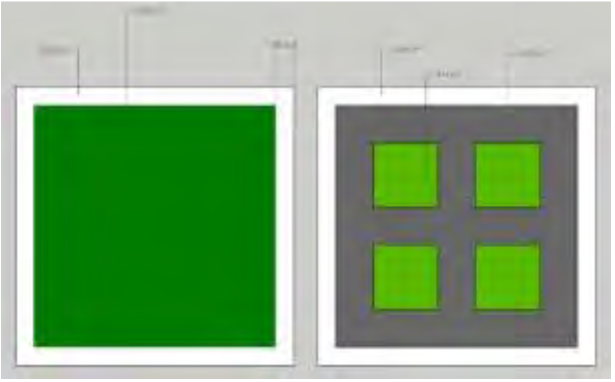
Number of platforms –

Option 2.a -

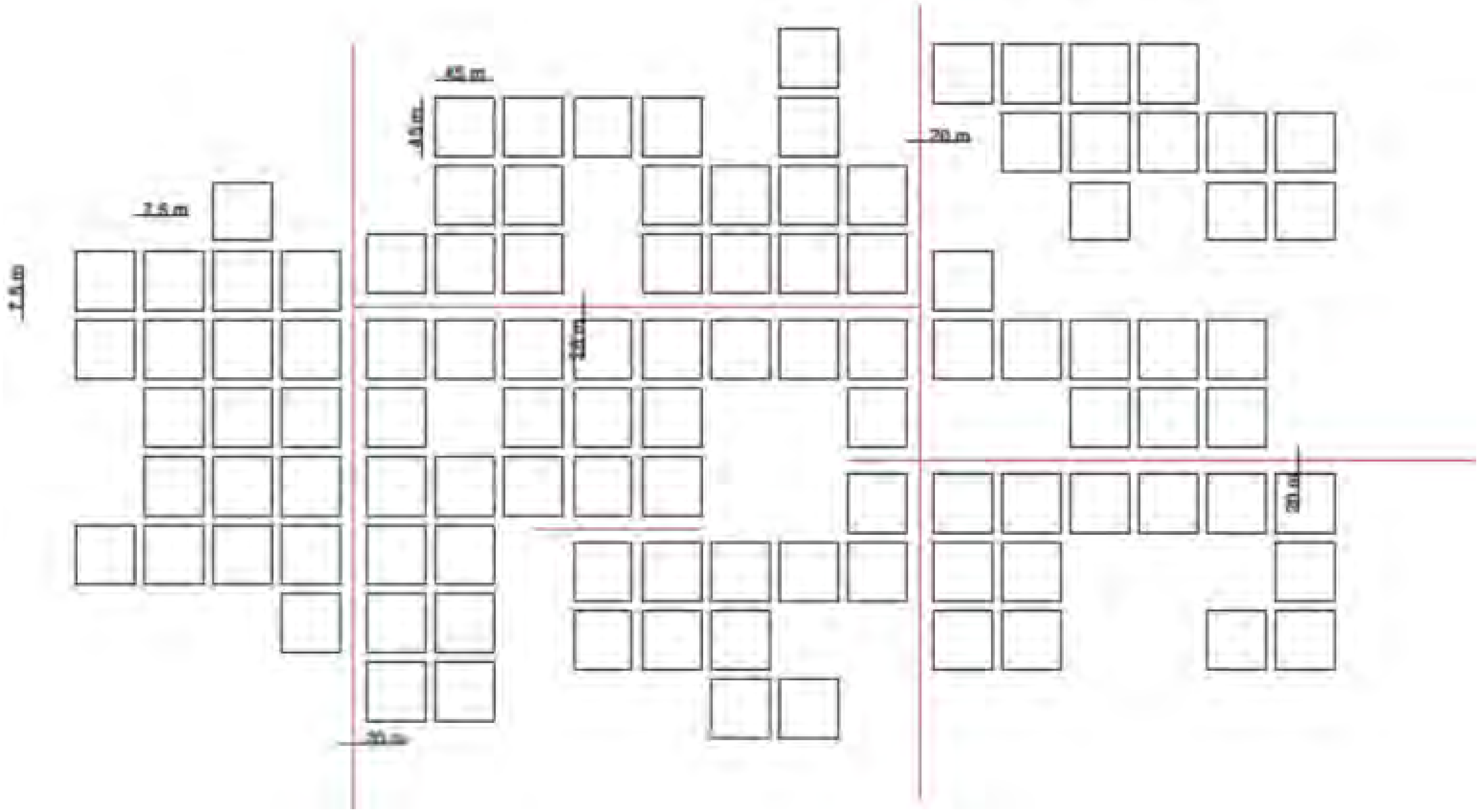
Shape	Square	No. Of inhabitant per apartment	3
Size	90 meters	Per apartment unit size	65 m2
Gap between	7,5 meters	No. Of levels	3 - (G+2)
Depth of platform	4 meters	Green percentage	24.87
Inhabitants	50,000		

Programs	**Percentage distribution**	**FootPrint area – m2**	**Gross Area – m2**	**No. Of . Platform**
Living Residential	32	541.667		84
Living Community facilities	1.5	21.667		4
Business offices	5	86.668		14
Business Light Industrial	5	86.668		14
Business Research and Development	8	130.002		21
Public Hotel	1.5	21.667		4
Public Park and open space	11	190.082		32
Public Leisure	15	260.004		44
Public educational Institute	9	151.669		24
Utility Solar	8	130.002		23
Utility Others	4	65.001		11
Total	**100**	**1.685.097**		**275**





Input for simulation –



- 100 platforms was ideal situations to test various edge conditions.
- Water ways is considered as the primary transport system.

Primary waterways transport network

Total – 108 platforms

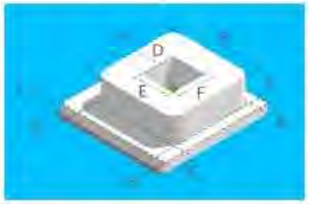
Configuration Concepts -

Overview –

- This document is an overview of potential configurations explored for the application of logistics at sea.
- These configurations were designed with consideration of the following criteria;
- Residential Proximity e.g to Green Space, Amenities, Public Functions and Parking Facilities.
- % Green Space
- Floor Space Index
- Protection from motions (edge)
- Water Accessibility
- Platform Accessibility
- Spatial Integration (Functional relationships e.g Having a School next to a library & Public Sports area).
- Zoning (Area character e.g Public Zone, Industrial Zone, Academic Zone).
- Public Space Distribution e.g central core vs distributed
- Boat Mooring Facilities
- Wind Protection (Tunnelling)

Typologies –

Category	Residential	Function	Low Density
Shape	Courtyard Block	No of Storeys	3
A width (m)	33.75	B width (m)	33.75
C width (m)	10.90	D width (m)	10
E width (m)	13.75	F width (m)	13.75
G width (m)	7.5	H width (m)	3.25
I width (m)	4	GFA per block (m²)	2850
Interior Void (m²)		Independent Platform	✓

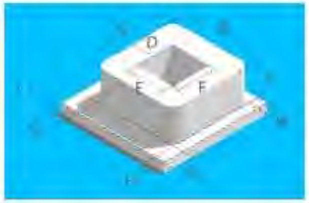


Distribution	(m²)	(%)
Total Plot	2025	100
Built	950	46
Green	189	10
Accessibility	886	44

Category	Residential	Function	High Density
Shape	L Block	No of Storeys	5
A width (m)	75	B width (m)	75
C width (m)	17.20	D width (m)	10
E width (m)	13.75	F width (m)	55
G width (m)	7.5	H width (m)	5
I width (m)	4	GFA per block (m²)	8375
Interior void (m²)		Independent Platform	×

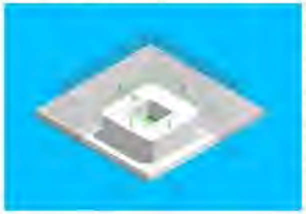
Distribution	(m²)	(%)
Total Plot	5160	100
Built	1675	32
Green	1323	27
Accessibility	2162.5	42

Category	Residential	Function	Medium Density
Shape	Courtyard Block	No of Storeys	4
A width (m)	33.75	B width (m)	33.75
C width (m)	14.10	D width (m)	9
E width (m)	15.75	F width (m)	15.75
G width (m)	7.5	H width (m)	3.25
I width (m)	4	GFA per block (m²)	3564
Interior Void (m²)		Independent Platform	✓



Distribution	(m²)	(%)
Total Plot	2025	100
Built	891	44
Green	248	12
Accessibility	886	44

Category	Residential	Function	High Density
Shape	Courtyard Block	No of Storeys	5
A width (m)	41.25	B width (m)	41.25
C width (m)	17.20	D width (m)	12
E width (m)	17.25	F width (m)	17.25
G width (m)	5	H width (m)	7.5
I width (m)	4	GFA per block (m²)	7020
Interior void (m²)		Independent Platform	×



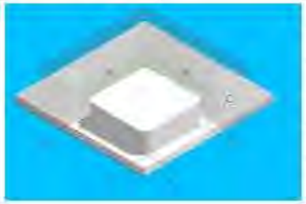
Distribution	(m²)	(%)
Total Plot	2940	100
Built	1404	48
Green	298	10
Accessibility	1238	42

Typologies –

Category	Business Catering Industry	Function	Hotel
Shape	Courtyard Block	No of Storeys	3
A width (m)	41.25	B width (m)	41.25
C width (m)	10.90	D width (m)	12
E width (m)	17.25	F width (m)	17.25
G width (m)	5	H width (m)	7.5
I width (m)	4	GFA per block (m²)	4212
Interior void (m²)		Independent Platform	×

Distribution	(m²)	(%)
Total Plot	2940	100
Built	1404	48
Green	298	10
Accessibility	1238	42

Category	Public Educational Institute	Function	Library & Learning Centre
Shape	Square	No of Storeys	4
A width (m)	41.25	B width (m)	41.25
C width (m)	14.10	D width (m)	5
E width (m)	7.25	F width (m)	4
Interior void (m²)	108	GFA per block (m²)	6700
Independent Platform	×		



Distribution	(m²)	(%)
Total Plot	2940	100
Built	1702	58
Green	0	0
Accessibility	1238	42

Category	Public Education Institute	Function	Library & Learning Centre
Shape	Square	No of Storeys	4
A width (m)	33.75	B width (m)	33.75
C width (m)	14.10	D width (m)	7.5
E width (m)	3.25	F width (m)	4
Interior Void (m²) *	108	GFA per block (m²)	4452
Independent Platform	✓		

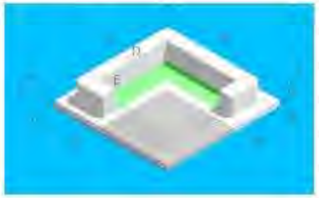
Distribution	(m²)	(%)
Total Plot	2025	100
Built	1140	56
Green	0	0
Accessibility	885	44

Category	Public Education Institute	Function	High School
Shape	Square	No of Storeys	2 - 4
A width (m)	33.75	B width (m)	33.75
C width (m)	10	D width (m)	23.75
E width (m)	14.10	F width (m)	10.90
Interior Void (m²) *	248	GFA per block (m²)	4146
Independent Platform	✓		

Distribution	(m²)	(%)
Total Plot	2025	100
Built	1093	54
Green	0	0
Accessibility	932	46

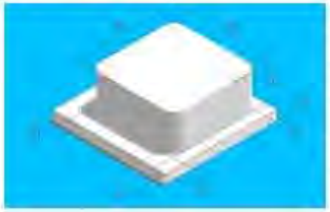
Typologies –

Category	Business Commercial	Function	Offices L Block
Shape	L- Block	No of Storeys	4
A width (m)	75	B width (m)	75
C width (m)	14.10	D width (m)	10
E width (m)	13.75	F width (m)	55
G width (m)	7.5	H width (m)	5
I width (m)	4	GFA per block (m²)	6700
Interior Void		Independent Platform	×



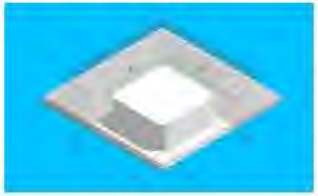
Distribution	(m²)	(%)
Total Plot	5160	100
Built	1675	32
Green	1323	27
Accessibility	2126.5	42

Category	Public Community	Function	Cultural Centre
Shape	Square	No of Storeys	4
A width (m)	33.75	B width (m)	33.75
C width (m)	14.10	D width (m)	7.5
E width (m)	3.25	F width (m)	4
Interior Void (m²) *	36	GFA per block (m²)	4524
Independent Platform	✓		



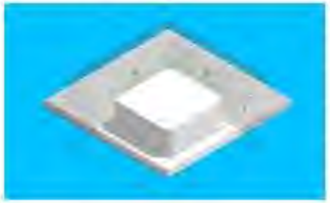
Distribution	(m²)	(%)
Total Plot	2025	100
Built	1140	56
Green	0	0
Accessibility	885	44

Category	Public Community	Function	Cultural Centre
Shape	Square	No of Storeys	4
A width (m)	41.25	B width (m)	41.25
C width (m)	14.10	D width (m)	5
E width (m)	7.25	F width (m)	4
Internal Void (m²) *	36	GFA per block (m²)	6772
Independent Platform	×		



Distribution	(m²)	(%)
Total Plot	2940	100
Built	1702	32
Green	0	0
Accessibility	1238	42

Category	Public Community	Function	Theatre
Shape	Square	No of Storeys	4
A width (m)	41.25	B width (m)	41.25
C width (m)	14.10	D width (m)	5
E width (m)	7.25	F width (m)	4
Interior Void (m²) *	1200	GFA per block (m²)	5608
Independent Platform	×		



Distribution	(m²)	(%)
Total Plot	2940	100
Built	1702	32
Green	0	0
Accessibility	1238	42

Typologies –

Category	Public Community	Function	Theatre
Shape	Square	No of Storeys	4
A width (m)	33.75	B width (m)	33.75
C width (m)	14.10	D width (m)	7.5
E width (m)	3.25	F width (m)	4
Interior Void (m²) *	1200	GFA per block (m²)	3360
Independent Platform	✓		

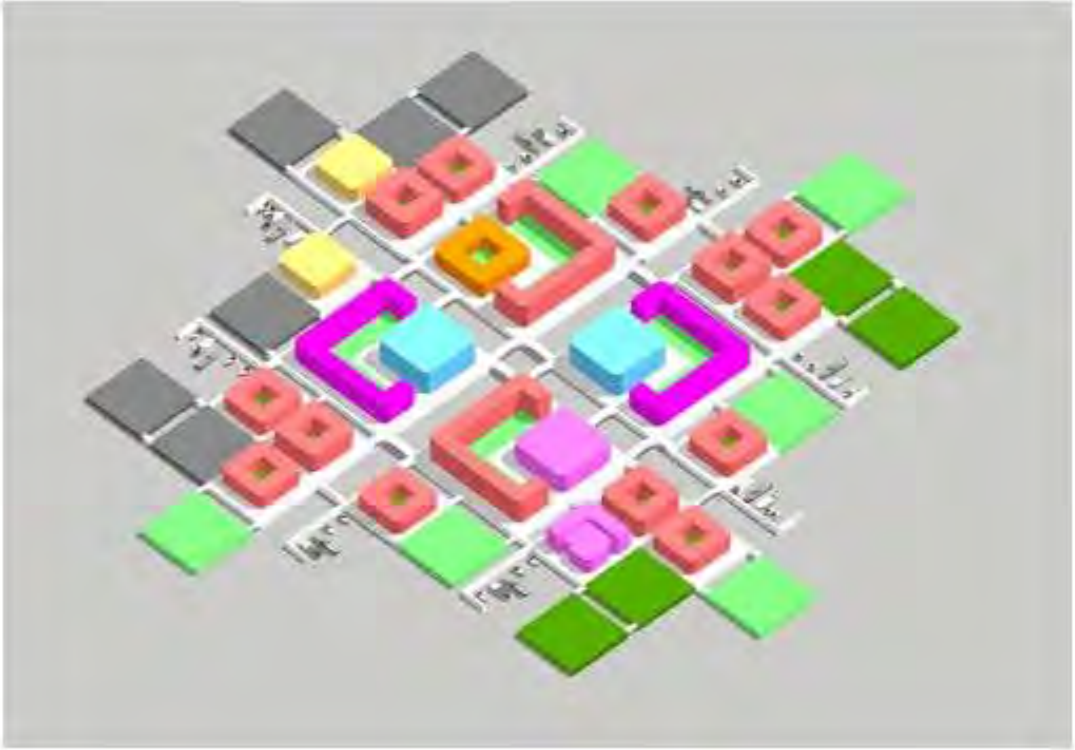
Distribution	(m²)	(%)
Total Plot	2025	100
Built	1140	56
Green	0	0
Accessibility	885	44

Category	Business Light Industry	Function	Warehouse
Shape	Square	No of Storeys	3
A width (m)	33.75	B width (m)	33.75
C width (m)	10.90	D width (m)	7.5
E width (m)	3.25	F width (m)	4
Interior Void (m²) *	-	GFA per block (m²)	3420
Independent Platform	✓		

Distribution	(m²)	(%)
Total Plot	2025	100
Built	1140	56
Green	0	0
Accessibility	885	44

Concept -1

Function	Plot Area (m²)
Green	28,533
Built	28,697
Accessibility	27,820
Utilities	12,150
Total Floor Area:	97,200
Gross Floor Area (m²)	104,344
Floor Space Index	1.0734
Green Space (%)	29.35
Accessibility Space (%)	28.62
Built Space (%)	29.52
Utilities Space (%)	12.5



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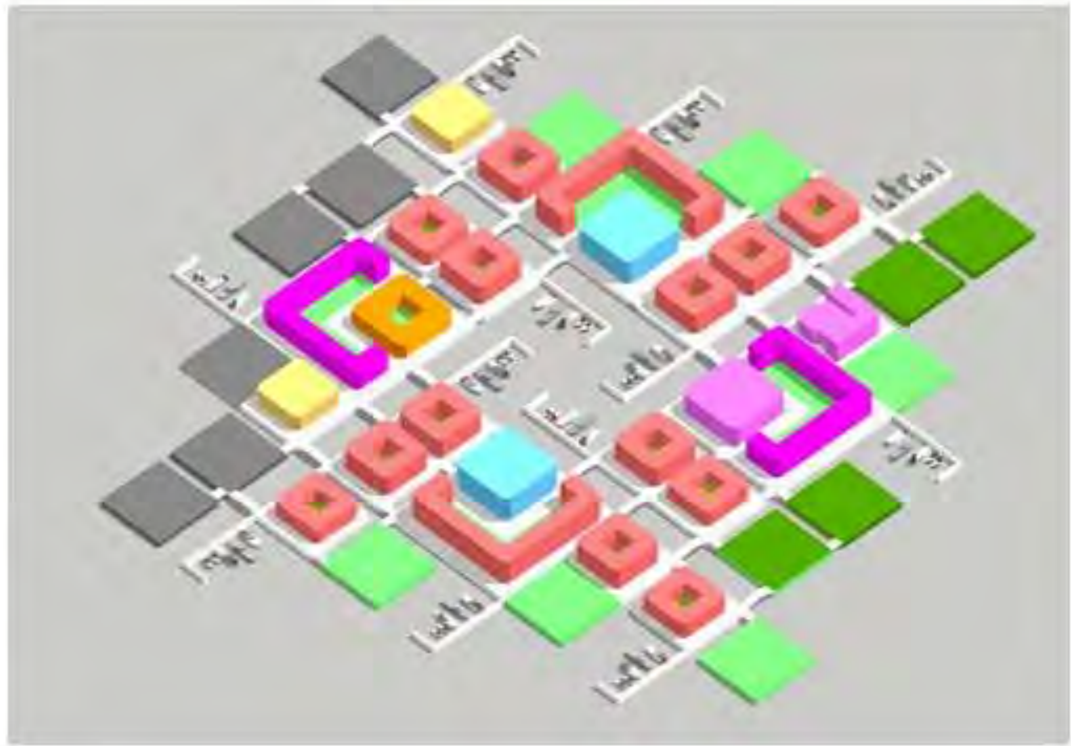
Function Distribution Concept -1

Function	Type	Percentage Distribution of GFA (%)	Total Plot Area excluding accessibility (m²)	Total Building Plot Area (m²)	Gross Floor Area (m²)	No. of Platforms	No. of Levels
Residential	Low Density	18.76	10,251	8,550	25,650	9	3
	Med Density	10.43	4,536	3,564	14,256	4	4
	High Density (L)	12.25	5,995	3,350	16,750	6	5
Business Commercial	Offices L-Block	9.80	5,995	3,350	13,400	6	4
Business Light Industry	Warehouse	5.00	2,280	2,280	6,840	2	3
Business Catering Industry	Hotel	3.08	1,404	1,404	4,212	1	3
Public Community Facilities	Cultural Centre	4.95	1,702	1,702	6,772	1	4
	Theatre	4.10	1,702	1,702	5,608	1	4
Public Educational Institute	Library and Learning Centre	4.90	1,702	1,702	6,700	1	4
	School	3.03	1,093	1,093	4,146	1	4
Public Sports		5.92	8,100	-	-	4	-
Public Green Space		8.89	12,150	-	-	6	-
Utilities		8.89	12,150	-	-	6	-
TOTAL		100	69,080	28,697	104,344	48	-

Concept -2

Function	Plot Area (m²)
Green	28,533
Built	28,697
Accessibility	27,820
Utilities	12,150
Total Floor Area:	97,200
Gross Floor Area (m²)	104,344
Floor Space Index	1.0734
Green Space (%)	29.35
Accessibility Space (%)	28.62
Built Space (%)	29.52
Utilities Space (%)	12.5

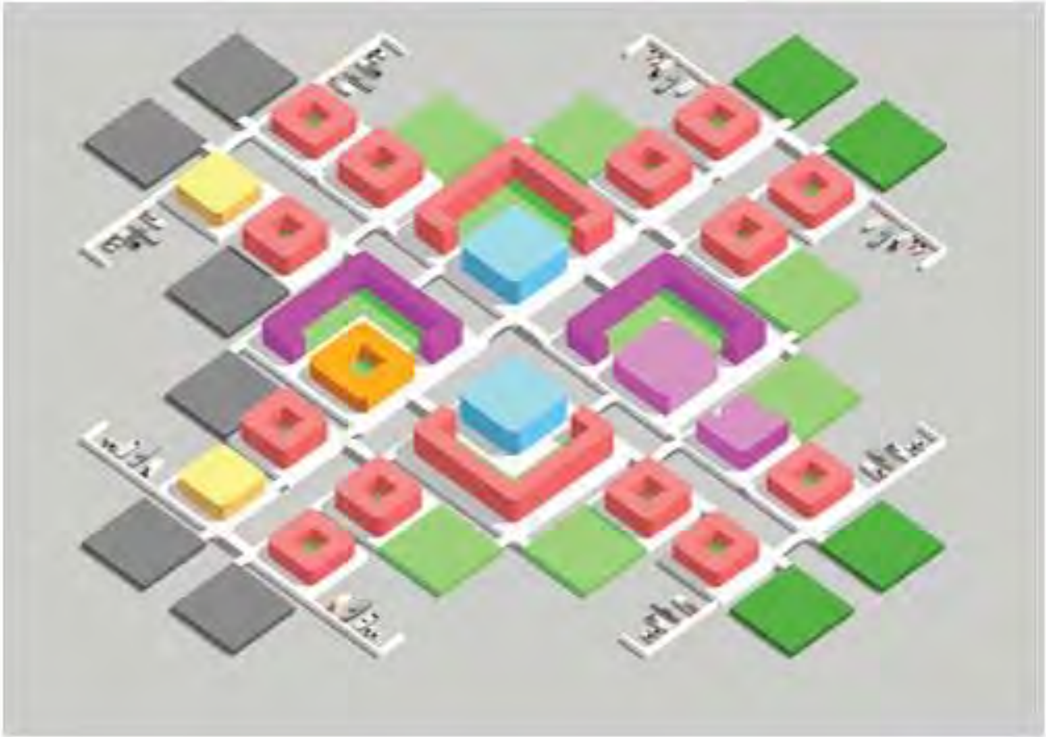


Function Distribution Concept -2

Function	Type	Percentage Distribution of GFA (%)	Total Plot Area excluding accessibility (m²)	Total Building Plot Area (m²)	Gross Floor Area (m²)	No. of Platforms	No. of Levels
Residential	Low Density	18.76	10,251	8,550	25,650	9	3
	Med Density	10.43	4,536	3,564	14,256	4	4
	High Density	12.25	5,995	3,350	16,750	6	5
Business Commercial	Offices	9.80	5,995	3,350	13,400	6	4
Business Light Industry	Warehouse	5.00	2,280	2,280	6,840	2	3
Business Catering Industry	Hotel	3.08	1,404	1,404	4,212	1	3
Public Community Facilities	Cultural Centre	4.95	1,702	1,702	6,772	1	4
	Theatre	4.10	1,702	1,702	5,608	1	4
Public Educational Institute	Library and Learning Centre	4.90	1,702	1,702	6,700	1	4
	School	3.03	1,093	1,093	4,146	1	4
Public Sports		5.92	8,100	-	-	4	-
Public Green Space		8.89	12,150	-	-	6	-
Utilities		8.89	12,150	-	-	6	-
TOTAL		100	69,080	28,697	104,344	48	-

Concept -3

Function	Plot Area (m²)
Green	28,710
Built	28,556
Accessibility	27,784
Utilities	12,150
Total Floor Area:	97,200
Gross Floor Area (m²)	106,467
Floor Space Index	1.095
Green Space (%)	29.54
Accessibility Space (%)	28.58
Built Space (%)	29.37
Utilities Space (%)	12.5



Function Distribution Concept -3

Function	Type	Percentage Distribution of GFA (%)	Total Plot Area excluding accessibility (m²)	Total Building Plot Area (m²)	Gross Floor Area (m²)	No. of Platforms	No. of Levels
Residential	Low Density	12.31	6,834	5,700	17,100	6	3
	Med Density	17.97	7,973	6,273	24,948	7	4
	High Density	12.06	5,995	3,350	16,750	6	5
Business Commercial	Offices	9.65	5,995	3,350	13,400	6	4
Business Light Industry	Warehouse	4.92	2,280	2,280	6,840	2	3
Business Catering Industry	Hotel	3.03	1,404	1,404	4,212	1	3
Public Community Facilities	Cultural Centre	4.88	1,702	1,702	6,772	1	4
	Theatre	4.04	1,702	1,702	5,608	1	4
Public Educational Institute	Library and Learning Centre	4.82	1,702	1,702	6,700	1	4
	School	2.99	1,093	1,093	4,146	1	4
Public Sports		5.83	8,100	-	-	4	-
Public Green Space		8.75	12,150	-	-	6	-
Utilities		8.75	12,150	-	-	6	-
TOTAL		100	69,080	28,556	106,476	48	-

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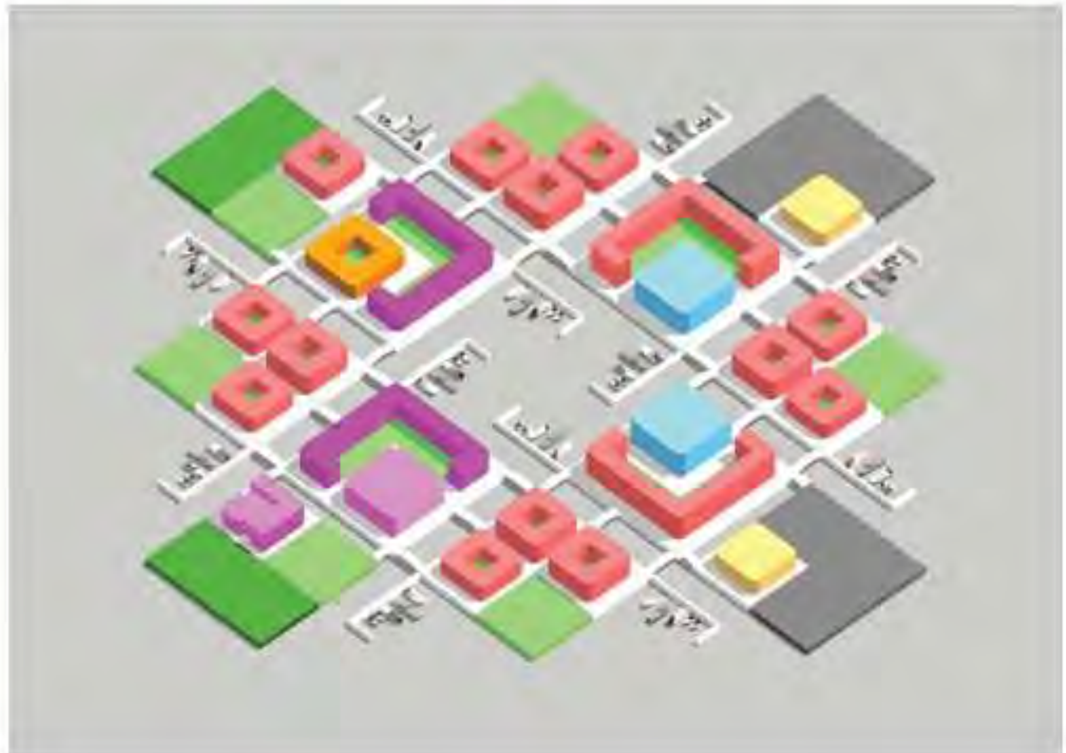
Concept -4

Function	Plot Area (m²)
Green	28,233
Built	28,697
Accessibility	28120
Utilities	12,150
Total Floor Area:	97,200
Gross Floor Area (m²)	104,344
Floor Space Index	1.074
Green Space (%)	29.04
Accessibility Space (%)	29.52
Built Space (%)	28.93
Utilities Space (%)	12.5

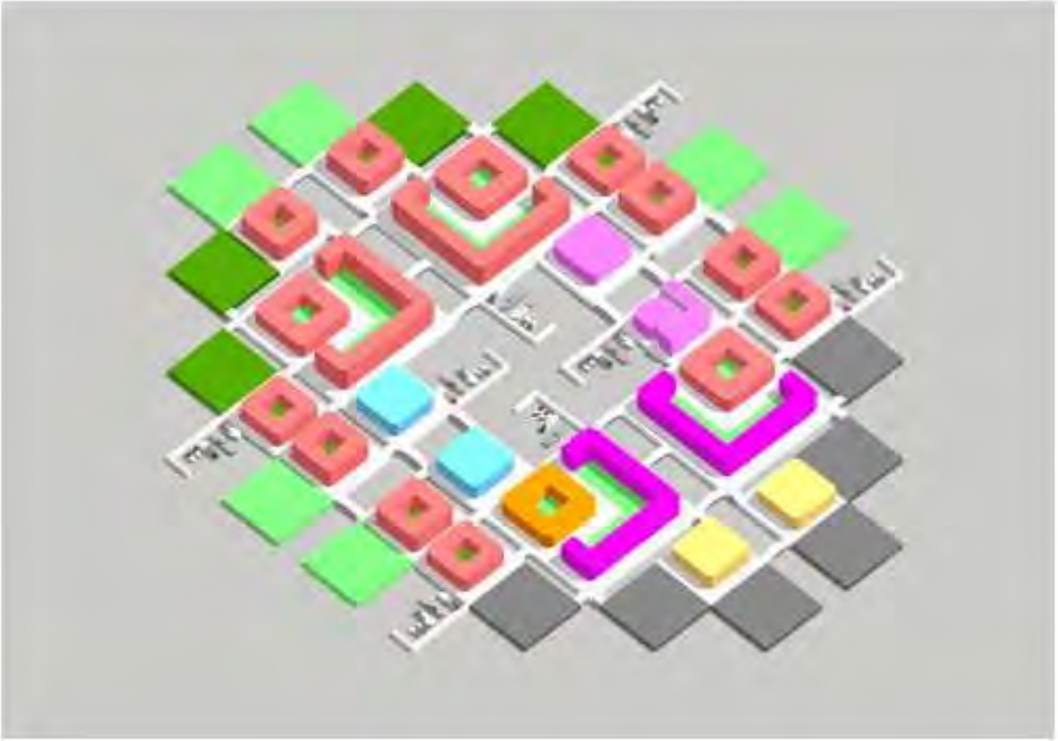


Function Distribution Concept -4

Function	Percentage Distribution of GFA (%)	Function	Total Plot Area excluding accessibility (m²)	Total Building Plot Area (m²)	Gross Floor Area (m²)	No. of Platforms (45x45m)	No. of Levels
Residential	41.44	Low Density Housing	10,251	8,550	25,650	9	3
		Med Density Housing	4,536	3,564	14,256	4	4
		High Density Housing (L)	5,995	3,350	16,750	6	5
Business Commercial	9.80	Offices	5,995	3,350	13,400	6	4
Business Light Industry	5.00	Warehouse	2,280	2,280	6,840	2	3
Business Catering Industry	3.08	Hotel	1,404	1,404	4,212	1	3
Public Community Facilities	9.05	Cultural Centre	1,702	1,702	6,772	1	4
		Theatre	1,702	1,702	5,608	1	4
Public Educational Institute	7.93	Library	1,702	1,702	6,700	1	4
		School	1,093	1,093	4,146	1	4
Public Sports	5.92		8,100	-	-	4	-
Public Green Space	8.89		12,150	-	-	6	-
Utilities	8.89		12,150	-	-	6	-
TOTAL	100		69,080	28,697	104,334	48	-

Concept -5

Function	Plot Area (m²)
Green	28,978
Built	28,255
Accessibility	27,817
Utilities	12,150
Total Floor Area:	97,200
Gross Floor Area (m²)	101,132
Floor Space Index	1.04
Green Space (%)	29.82
Accessibility Space (%)	28.62
Built Space (%)	29.01
Utilities Space (%)	12.5



Function Distribution Concept -5

Function	Type	Percentage Distribution of GFA (%)	Total Plot Area excluding accessibility (m²)	Total Building Plot Area (m²)	Gross Floor Area (m²)	No. of Platforms	No. of Levels
Residential	Low Density	8.55	4,556	3,800	11,400	4	3
	Med Density	11.38	6,834	5,346	15,200	6	4
	High Density (L)	12.54	5,995	3,350	16,750	6	5
	High Density (C)	12.62	5,106	4,212	16,848	3	5
Business Commercial	Offices	10.03	5,995	3,350	13,400	6	4
Business Light Industry	Warehouse	5.12	2,280	2,280	6,840	2	3
Business Catering Industry	Hotel	3.15	1,404	1,404	4,212	1	3
Public Community Facilities	Cultural Centre	3.39	1,140	1,140	4,524	1	4
	Theatre	2.52	1,140	1,140	3,360	1	4
Public Educational Institute	Library and Learning Centre	3.33	1,140	1,140	4,452	1	4
	School	3.10	1,093	1,093	4,146	1	4
Public Sports		6.07	8,100	-	-	4	-
Public Green Space		9.10	12,150	-	-	6	-
Utilities		9.10	12,150	-	-	6	-
TOTAL		100	69,083	28,255	101,132	48	-

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THE FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION

HORIZON 2020

Appendix – 5 City Design – Square shape platform

Table of Contents

1 - 45m Platform
1.1 - Typologies
1.2 - Function Distribution
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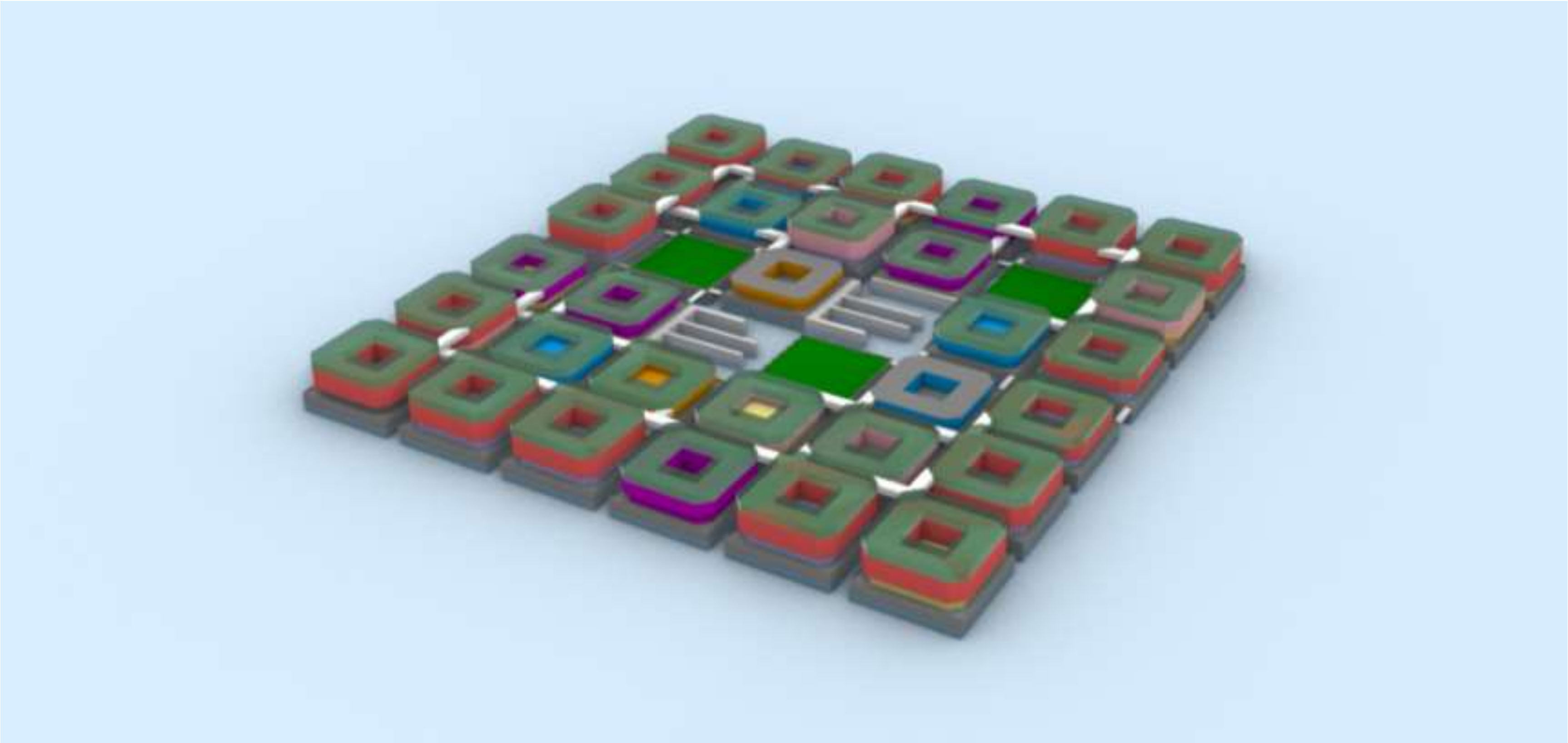
1.5 - Mockup model
1.6 - Options for planning layout of blocks
1.7 - Planning layout of blocks
Typologies
Function Distribution
Residential Block
Other Blocks

2 - 90 m platform
2.1 - Function Distribution
2.2 - Organisation of the city(land use maps)

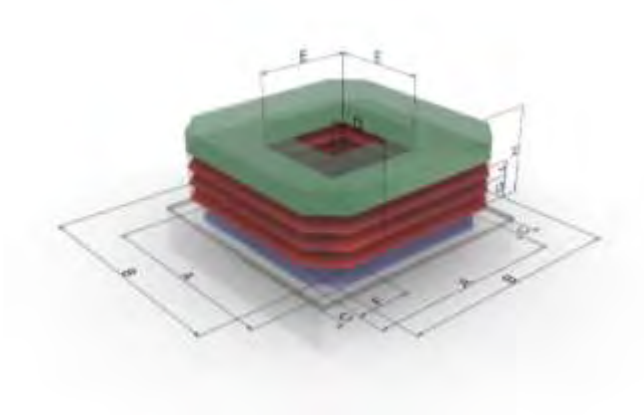
1 - 45m PLATFORM



1.1 - Typologies –

Type -1

Category	Residential	**Function**	Residence and amenities
Shape	Courtyard Block	**No of Storeys**	5
A width (m)	38.50	**B width (m)**	42.50
C width (m)	3.25	**D width (m)**	12
E width (m)	18.50	**F width (m)**	10
G width (m)	4.50	**H width (m)**	17.50
I width (m)	3	**GFA per block (m²) without terrace**	5364
Terrace green (m²)	1414	**Independent Platform**	✓

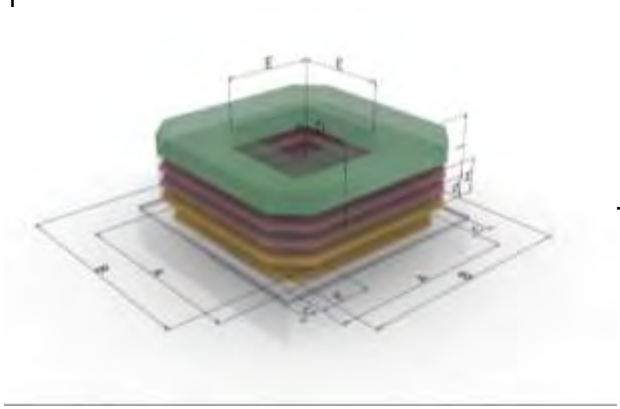


Distribution	**(m²)**	**(%)**
Total Plot	2025	100
Built	1123	55.50
Green	342	16
Accessibility	560	28.50

1.1 - Typologies –

Type -2

Category	Mixed Use	**Function**	Business, Community and Educational
Shape	Courtyard Block	**No of Storeys**	4
A width (m)	38.50	**B width (m)**	42.50
C width (m)	3.25	**D width (m)**	12
E width (m)	18.50	**F width (m)**	10
G width (m)	4.50	**H width (m)**	17.50
I width (m)	3	**GFA per block (m²) without terrace**	5364
Terrace green (m²)	1414	**Independent Platform**	✓

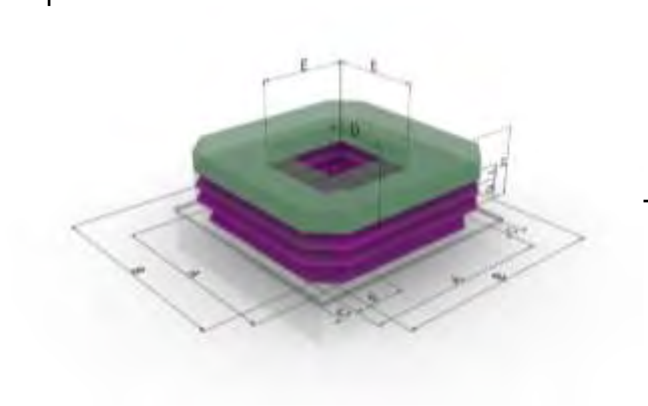


Distribution	**(m²)**	**(%)**
Total Plot	2025	100
Built	1123	55.50
Green	342	16
Accessibility	560	28.50

1.1 - Typologies –

Type -3

Category	Mixed Use	**Function**	Business, Community and Educational
Shape	Courtyard Block	**No of Storeys**	4
A width (m)	38.50	**B width (m)**	42.50
C width (m)	3.25	**D width (m)**	12
E width (m)	18.50	**F width (m)**	10
G width (m)	4.50	**H width (m)**	14.50
I width (m)	3	**GFA per block (m²) without terrace**	3950
Terrace green (m²)	1414	**Independent Platform**	✓

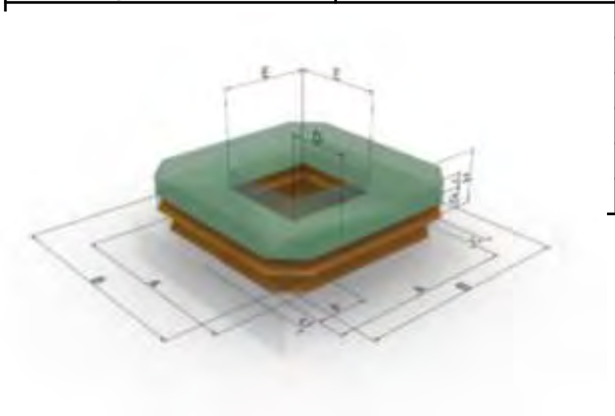


Distribution	**(m²)**	**(%)**
Total Plot	2025	100
Built	1123	55.50
Green	342	16
Accessibility	560	28.50

1.1 - Typologies –

Type -4

Category	Mixed Use	**Function**	Business, Community and Educational
Shape	Courtyard Block	**No of Storeys**	3
A width (m)	38.50	**B width (m)**	42.50
C width (m)	3.25	**D width (m)**	12
E width (m)	18.50	**F width (m)**	10
G width (m)	4.50	**H width (m)**	11.50
I width (m)	3	**GFA per block (m²) without terrace**	2536
Terrace green (m²)	1414	**Independent Platform**	✓

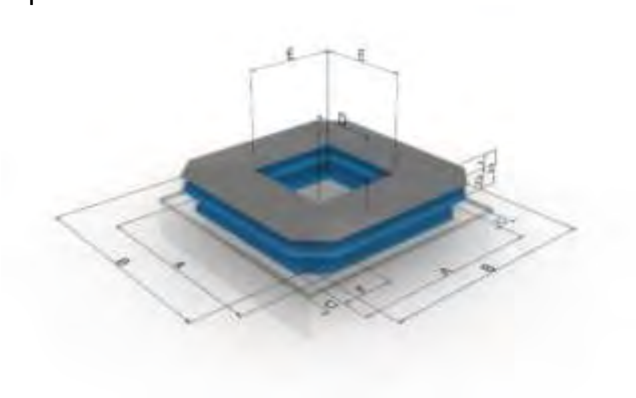


Distribution	**(m²)**	**(%)**
Total Plot	2025	100
Built	1123	55.50
Green	342	16
Accessibility	560	28.50

1.1 - Typologies –

Type -5

Category	Mixed Use	**Function**	Business, Community and Educational
Shape	Courtyard Block	**No of Storeys**	2
A width (m)	38.50	**B width (m)**	42.50
C width (m)	3.25	**D width (m)**	12
E width (m)	18.50	**F width (m)**	10
G width (m)	4.50	**H width (m)**	7.50
I width (m)	3	**GFA per block (m²) without terrace**	2536
Terrace green (m²)	-	**Independent Platform**	✓



Distribution	**(m²)**	**(%)**
Total Plot	2025	100
Built	1123	55.50
Green	342	16
Accessibility	560	28.50

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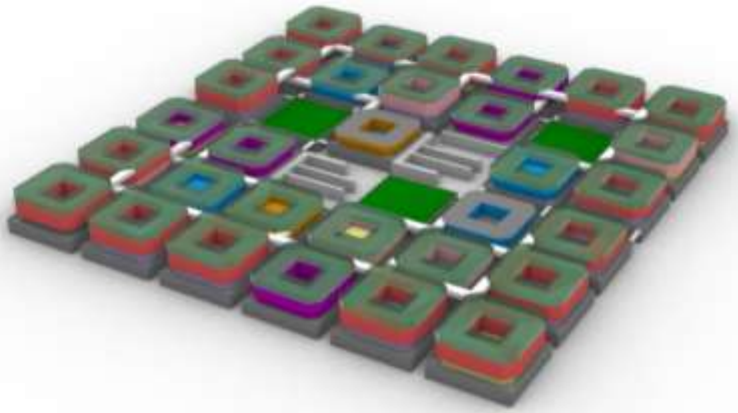
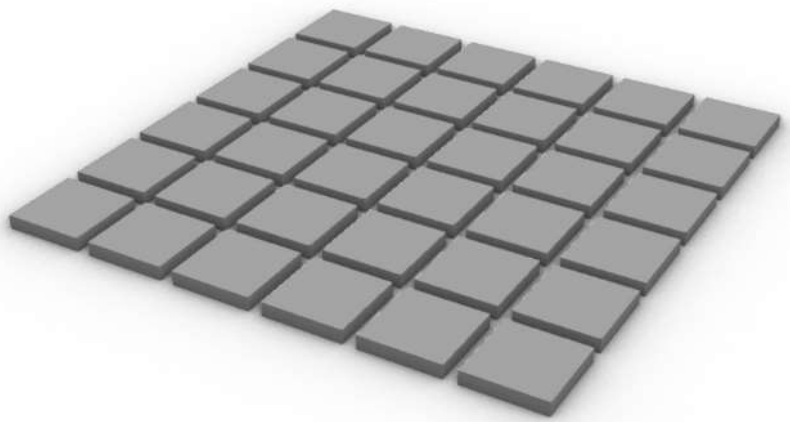
1.2 - Functional Distribution –

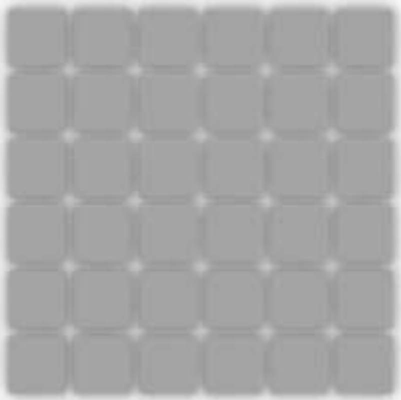
Function		Type	Percentage Distribution of GFA (%)	Gross Floor Area (m²)	
	Residential	Med Density	44	65,290	
	Business Commercial	Offices	9	13,317	
	Business Light Industry	Warehouse	4,5	6,718	
	Business Catering Industry	Hotel	3,5	5,417	
	Public Community Facilities	Cultural Centre	5	6,831	
		Theatre	3,5	5,417	
	Public Educational Institute	Library and Learning Centre	5	7,070	
		School	3,5	5,364	
	Public Sports		5	7,335	
	Public Green Space		4	6,075	
	Public Terrace Green		-	-	41,006
	Public Amenities		6	8,802	
	Utilities		7	10,210	
	TOTAL		100	147,846	



1.3 - Organization of the city (land-use map) –

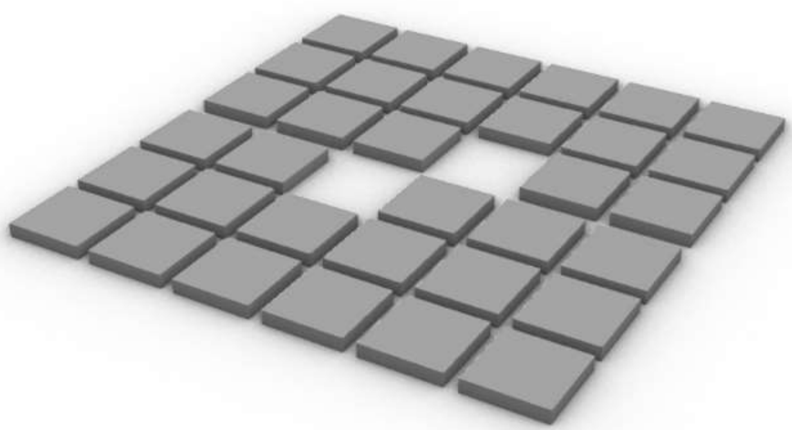
Assigning the grid pattern

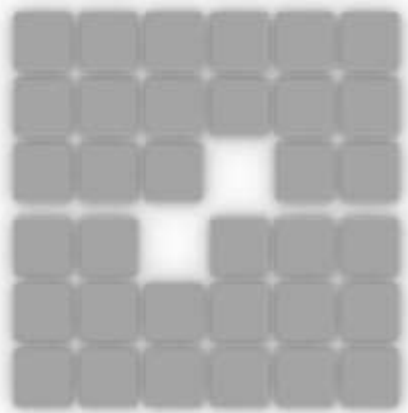




1.3 - Organization of the city (land-use map) –

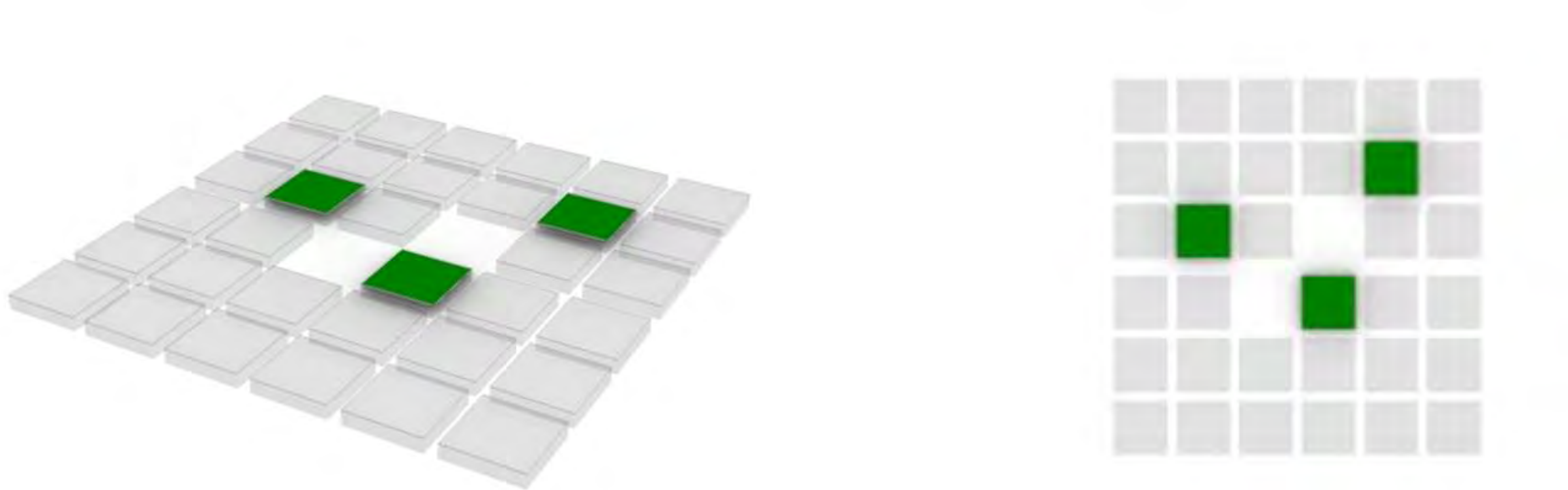
Water transport network





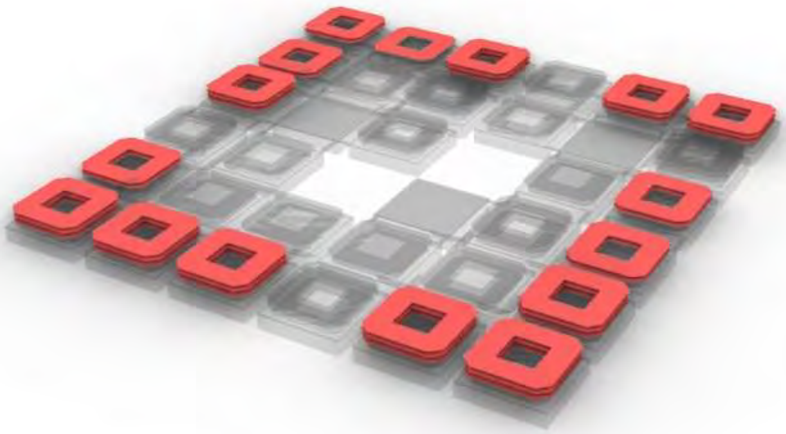
1.3 - Organization of the city **(land-use map) –**

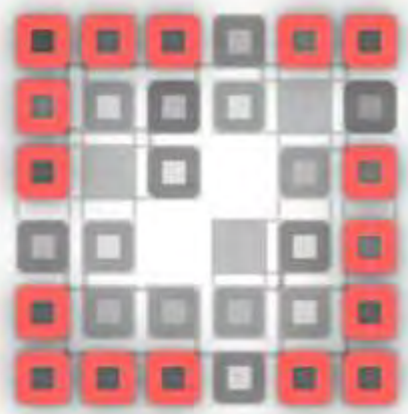
Green Spaces



1.3 - Organization of the city (land-use map) –

Residential



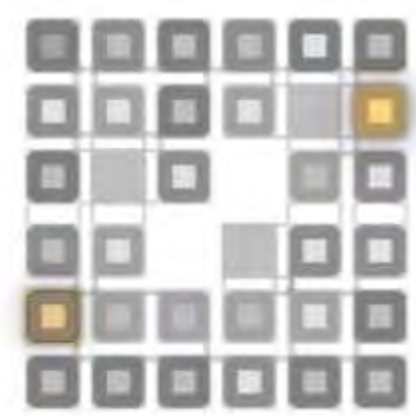


1.3 - Organization of the city (land-use map) –

Business Commercial

1.3 - Organization of the city (land-use map) –

Business Light Industry



1.3 - Organization of the city (land-use map) –

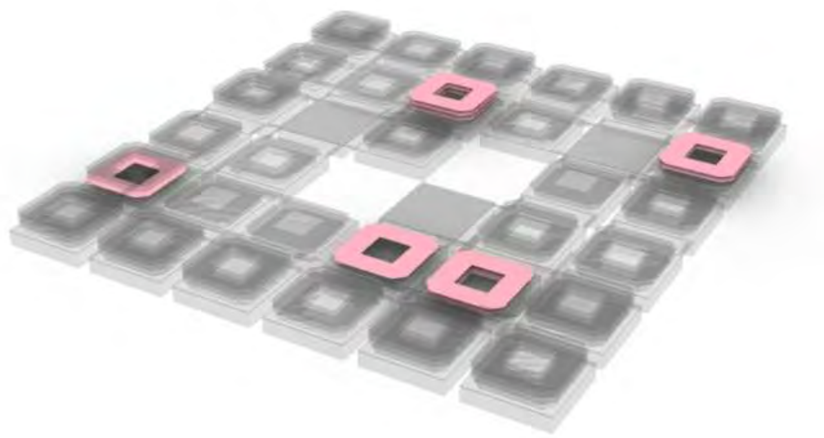
Business Catering Industry

1.3 - Organization of the city (land-use map) –

Public Community Facilities

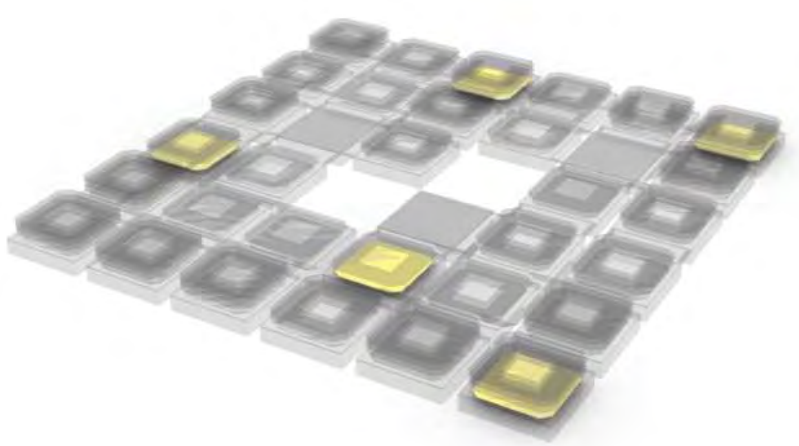
1.3 - Organization of the city (land-use map) –

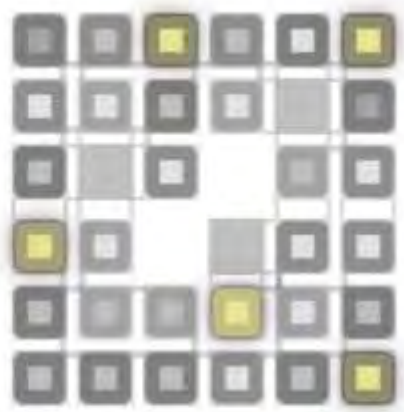
Public Educational Institute



1.3 - Organization of the city (land-use map) –

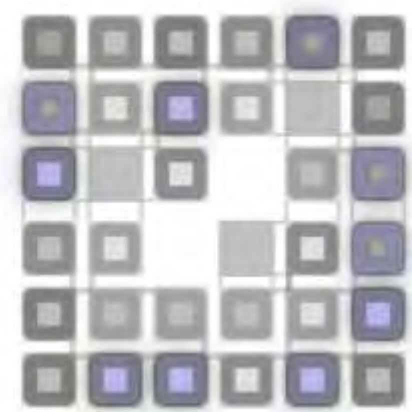
Public Sports – Indoor Spaces





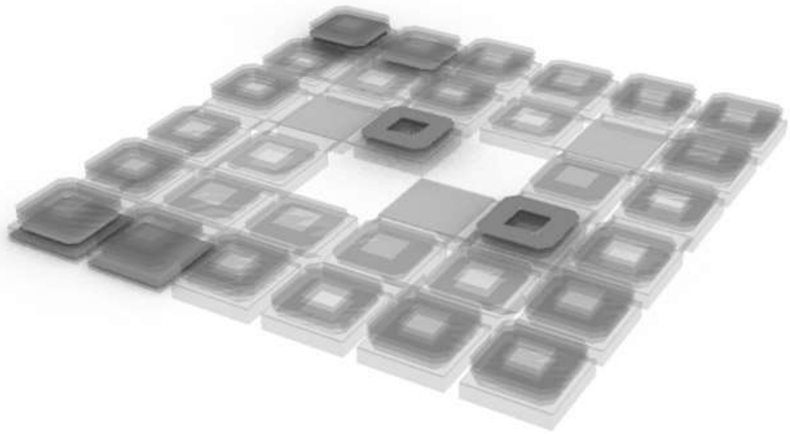
1.3 - Organization of the city (land-use map) –

Public Amenities



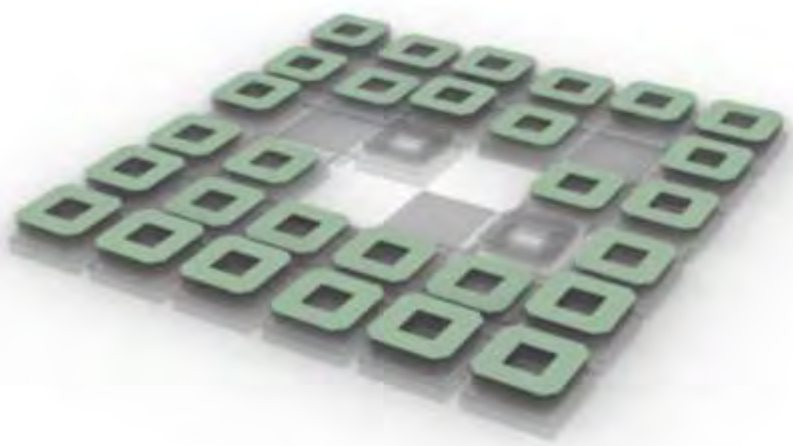
1.3 - Organization of the city (land-use map) –

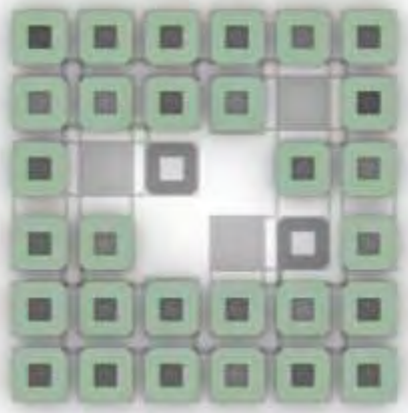
Utilities



1.3 - Organization of the city (land-use map) –

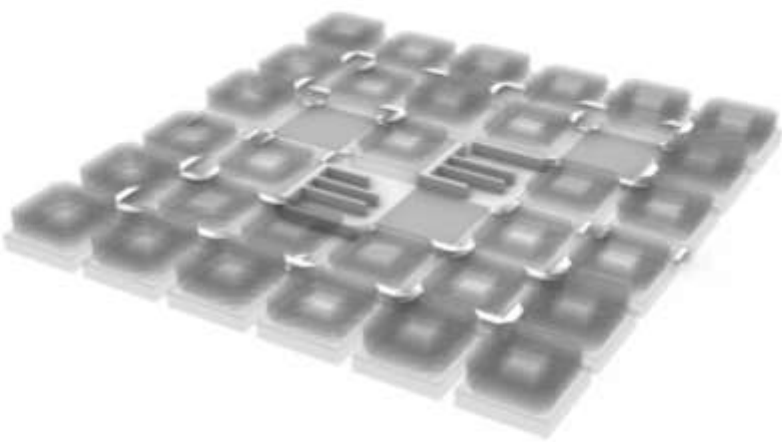
Public Terrace Green





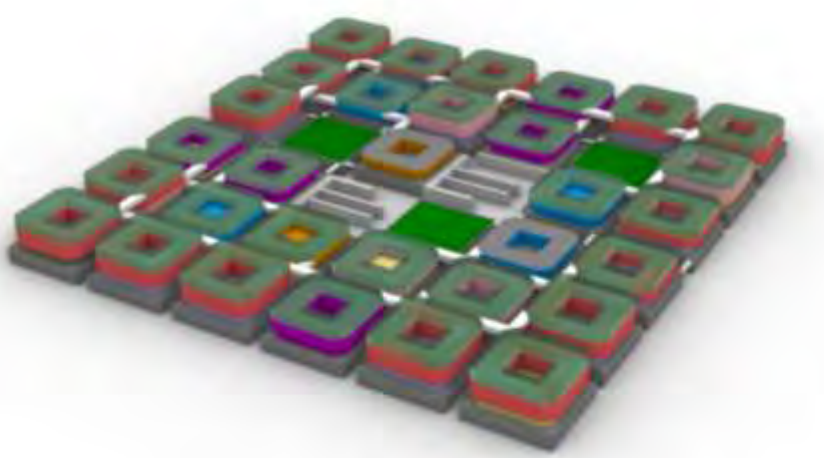
1.3 - Organization of the city (land-use map) –

Bridges connecting blocks at higher level.



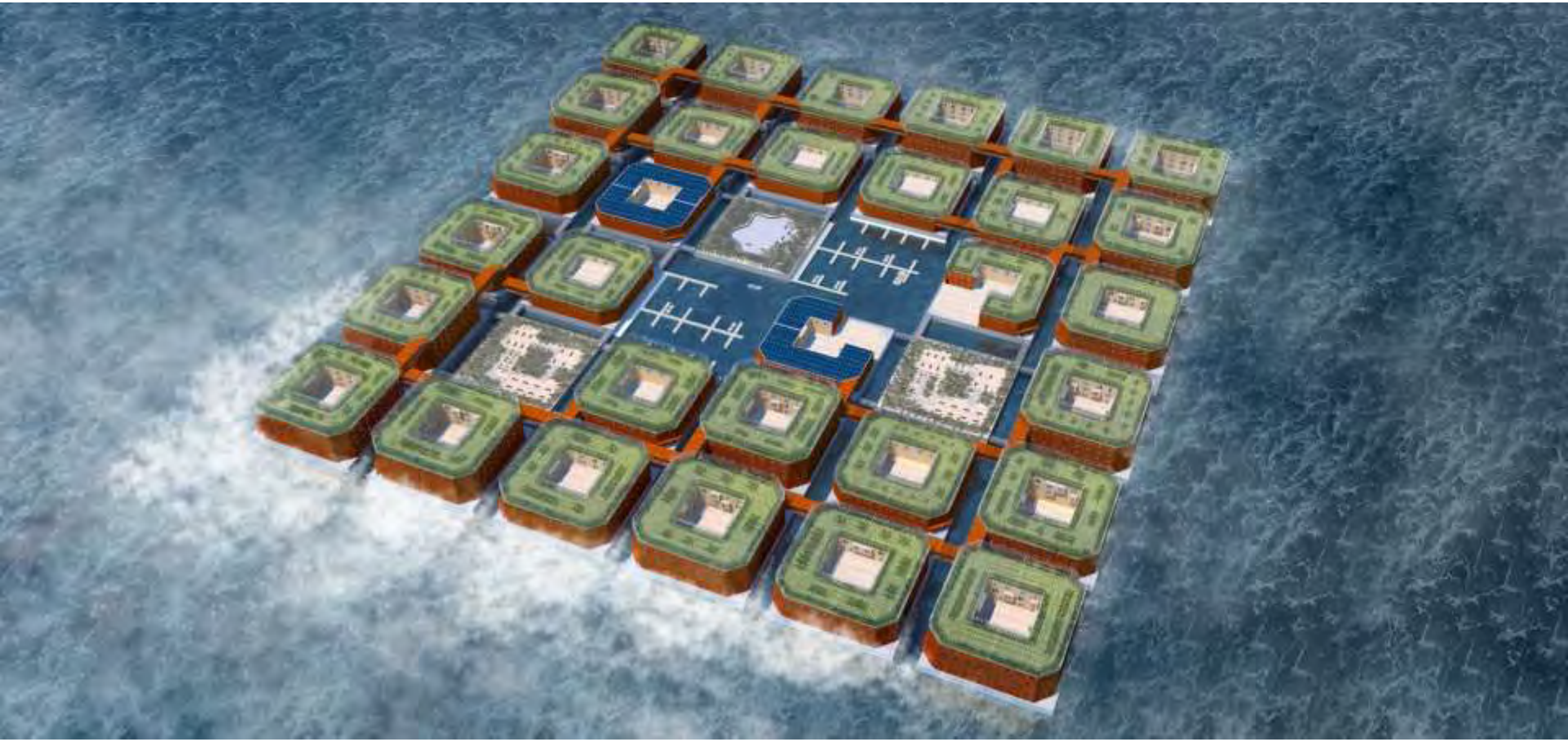
1.3 - Organization of the city (land-use map) –

City layout



1.4 - Visualizations –

Aerial view



1.4 - Visualizations –

Canal view

1.4 - Visualizations –

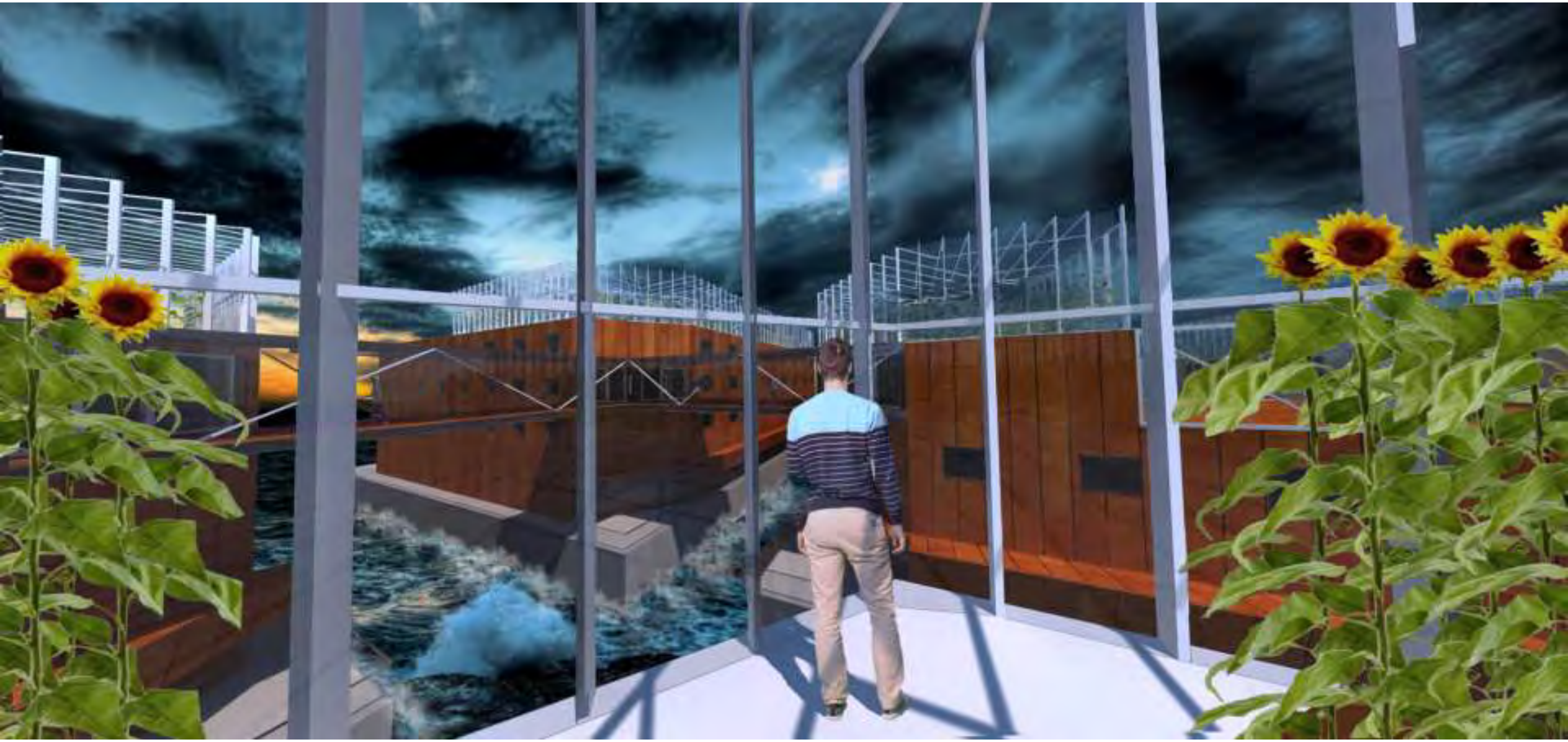
Center Courtyard

1.4 - Visualizations –

Roof terrace

1.4 - Visualizations –

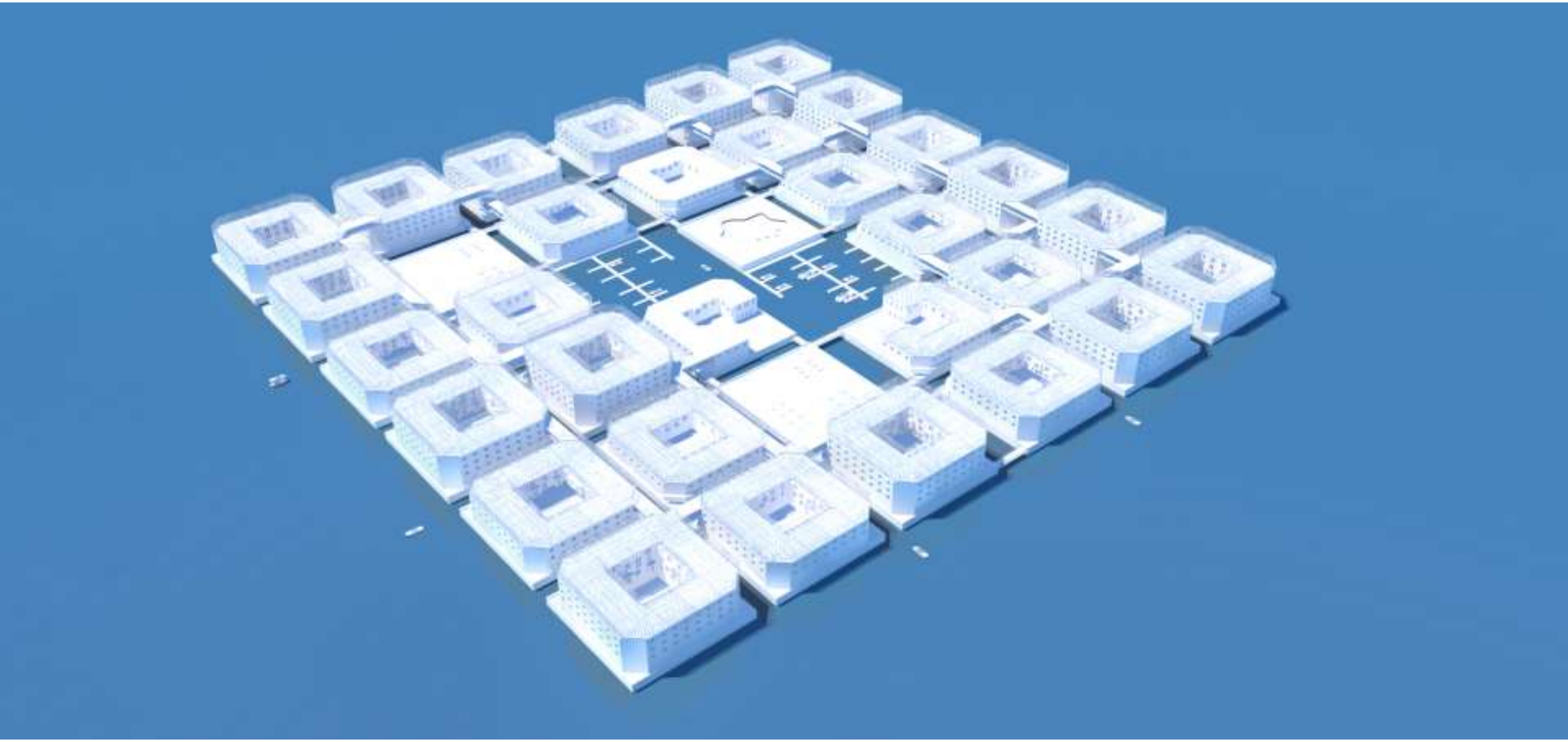
Roof terrace and bridge junction



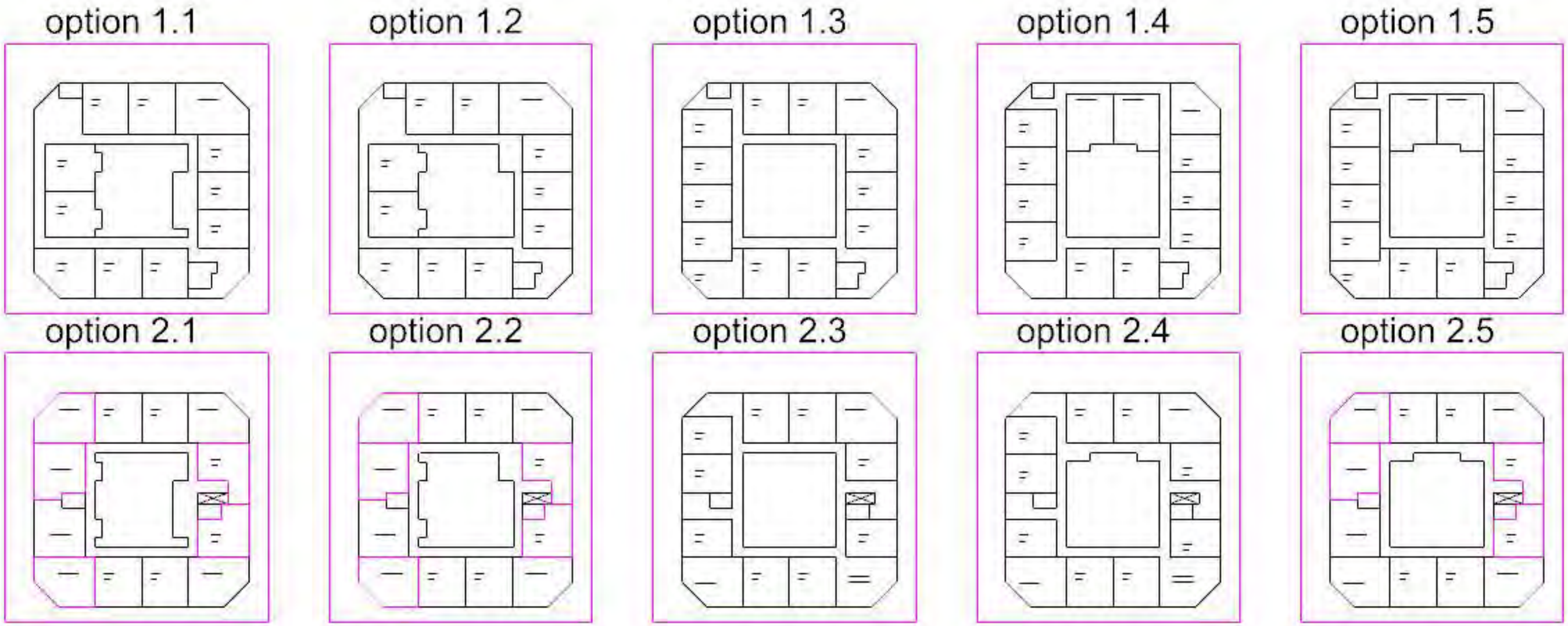
1.4 - Visualizations –

Dock and open space

1.5 - Mock-up model –



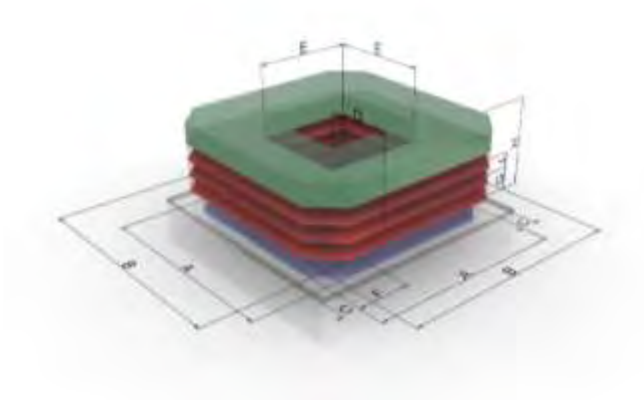
1.6 – Options for planning layout of blocks –



1.7 - Planning layout of blocks –

Typology -1

Category	Residential	**Function**	Residence and amenities
Shape	Courtyard Block	**No of Storeys**	5
A width (m)	38.50	**B width (m)**	42.50
C width (m)	3.25	**D width (m)**	13.25
E width (m)	16	**F width (m)**	11.25
G width (m)	4	**H width (m)**	18.10
I width (m)	3.20	**GFA per block (m²) without terrace**	5708
Terrace green (m²)	1500	**Independent Platform**	✓

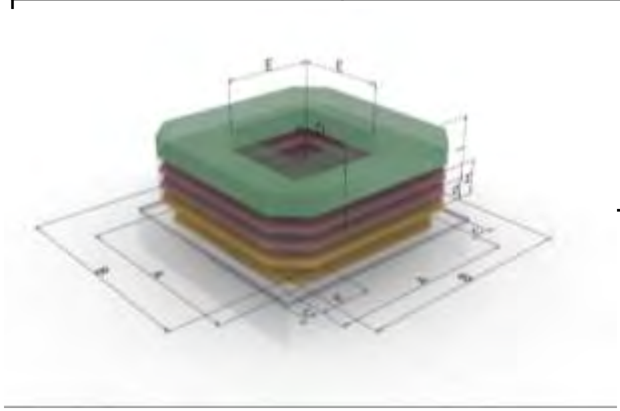


Distribution	**(m²)**	**(%)**
Total Plot	2025	100
Built	1208	59.65
Green	256	12.60
Accessibility	560	27.25

1.7 - Planning layout of blocks –

Typology -2

Category	Mixed Use	**Function**	Business, Community and Educational
Shape	Courtyard Block	**No of Storeys**	4
A width (m)	38.50	**B width (m)**	42.50
C width (m)	3.25	**D width (m)**	13.25
E width (m)	16	**F width (m)**	11.25
G width (m)	4	**H width (m)**	18.10
I width (m)	3.20	**GFA per block (m²) without terrace**	5708
Terrace green (m²)	1500	**Independent Platform**	✓

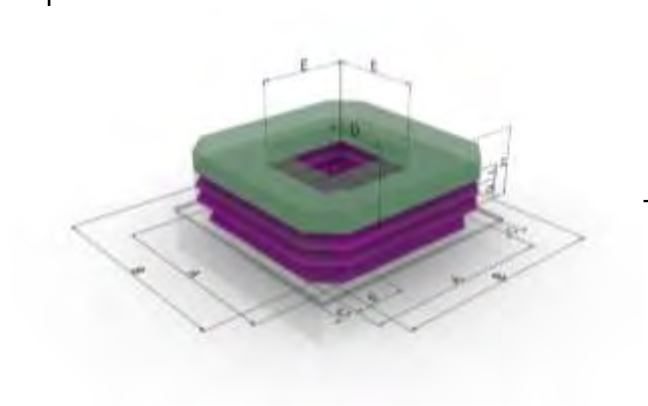


Distribution	**(m²)**	**(%)**
Total Plot	2025	100
Built	1208	59.65
Green	256	12.60
Accessibility	560	27.25

1.7 - Planning layout of blocks –

Typology -3

Category	Mixed Use	**Function**	Business, Community and Educational
Shape	Courtyard Block	**No of Storeys**	4
A width (m)	38.50	**B width (m)**	42.50
C width (m)	3.25	**D width (m)**	13.25
E width (m)	16	**F width (m)**	11.25
G width (m)	4	**H width (m)**	14.90
I width (m)	3.20	**GFA per block (m²) without terrace**	4208
Terrace green (m²)	1500	**Independent Platform**	✓

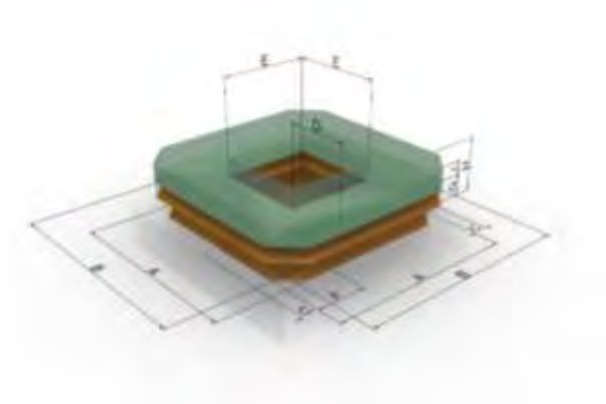


Distribution	**(m²)**	**(%)**
Total Plot	2025	100
Built	1208	59.65
Green	256	12.60
Accessibility	560	27.25

1.7 - Planning layout of blocks –

Typology -4

Category	Mixed Use	**Function**	Business, Community and Educational
Shape	Courtyard Block	**No of Storeys**	3
A width (m)	38.50	**B width (m)**	42.50
C width (m)	3.25	**D width (m)**	13.25
E width (m)	16	**F width (m)**	11.25
G width (m)	4	**H width (m)**	11.70
I width (m)	3.20	**GFA per block (m²) without terrace**	2708
Terrace green (m²)	1500	**Independent Platform**	✓

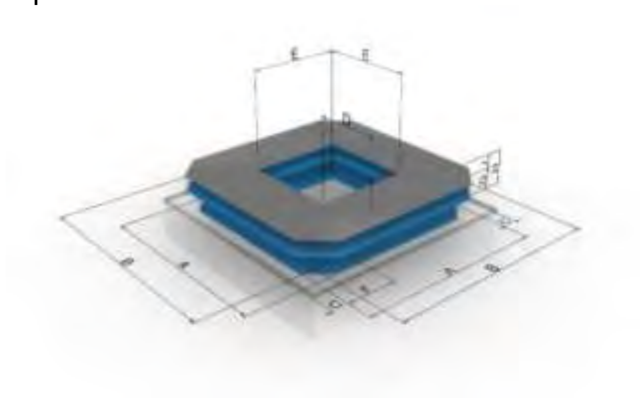


Distribution	**(m²)**	**(%)**
Total Plot	2025	100
Built	1208	59.65
Green	256	12.60
Accessibility	560	27.25

1.7 - Planning layout of blocks –

Typology -5

Category	Mixed Use	**Function**	Business, Community and Educational
Shape	Courtyard Block	**No of Storeys**	2
A width (m)	38.50	**B width (m)**	42.50
C width (m)	3.25	**D width (m)**	13.25
E width (m)	16	**F width (m)**	11.25
G width (m)	4	**H width (m)**	7.20
I width (m)	3.20	**GFA per block (m²) without terrace**	2708
Terrace green (m²)	-	**Independent Platform**	✓



Distribution	**(m²)**	**(%)**
Total Plot	2025	100
Built	1208	59.65
Green	256	12.60
Accessibility	560	27.25

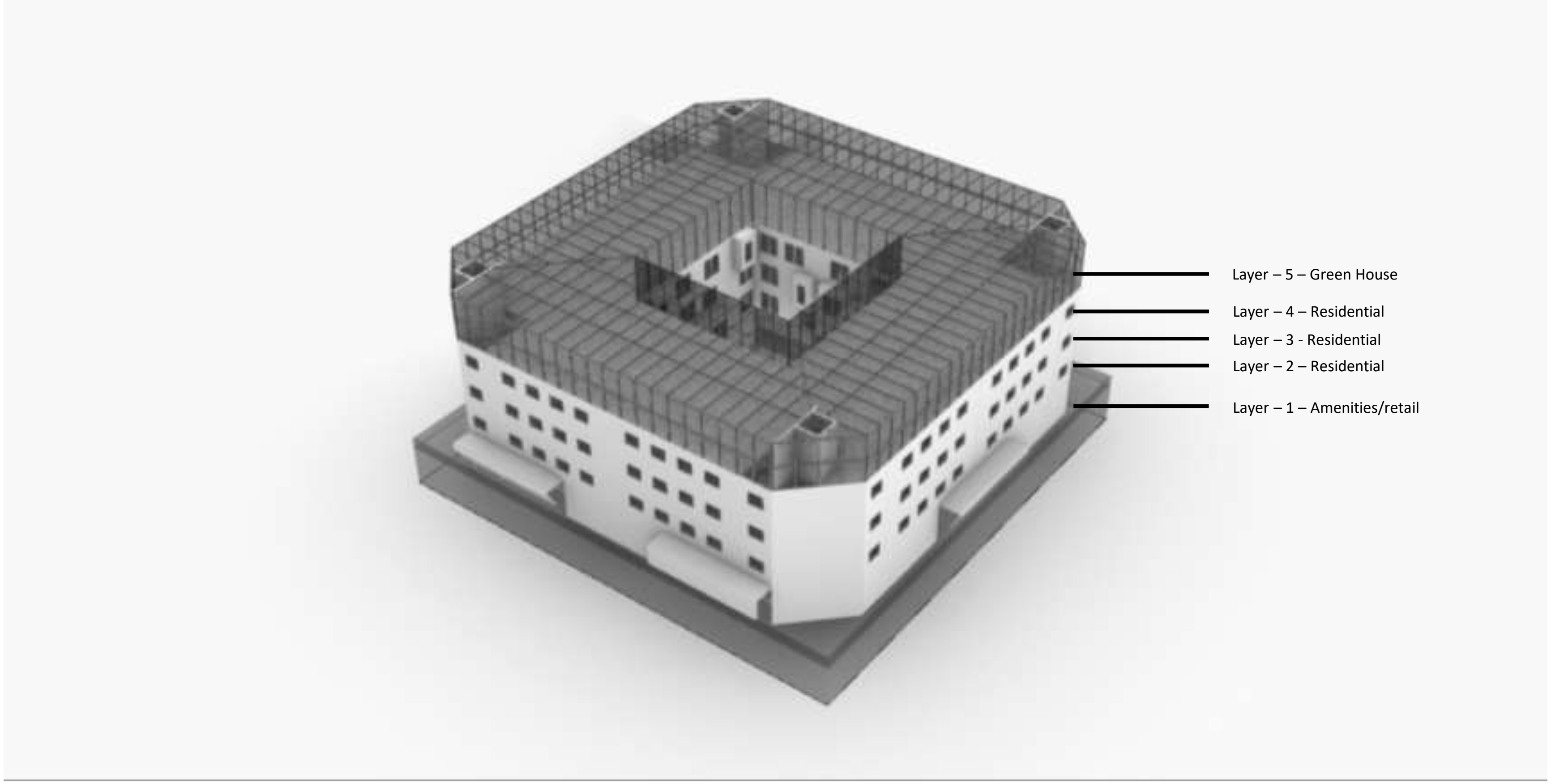
1.7 - Planning layout of blocks –

Funcional distribution -

Function	Type	Percentage Distribution of GFA (%)	Gross Floor Area (m²)		Floor Type – Area (m²)				
					1208	1500.25	1464.25	1756.25	2025
Residential	Med Density	44.5	69,342		4	43			
Business Commercial	Offices	9	13,833		4	6			
Business Light Industry	Warehouse	4.5	7,002				1	2	1
Business Catering Industry	Hotel	3.5	5,672		1	2	1		
Public Community Facilities	Cultural Centre	4.5	6,917		2	3			
	Theatre	3.5	5,928			2	2		
Public Educational Institute	Library and Learning Centre	5	7,208		1	4			
	School	4	6,001			4			
Public Sports		5	7,321				5		
Public Green Space		4	6,075						3
Public Terrace Green		-	-	43,507		29			
Public Amenities		4.5	6,809		2		3		
Utilities		8	13,199			2	3	1	2
TOTAL		100	155,307						

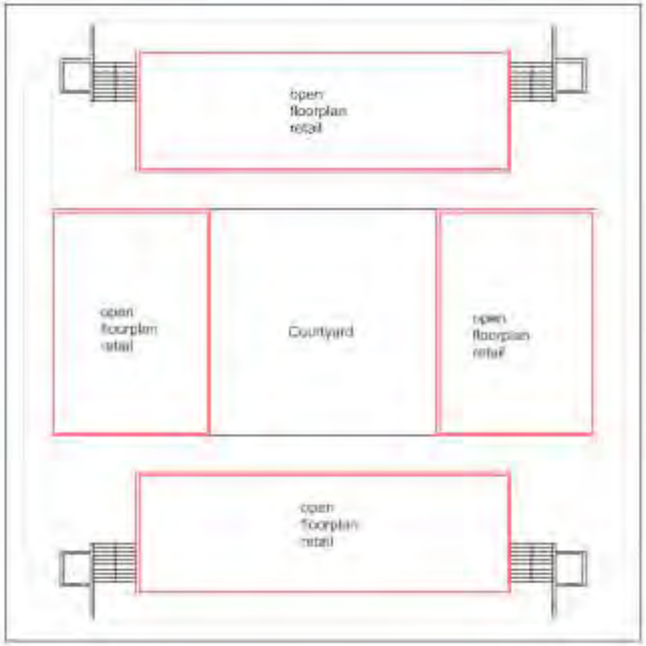
1.7 - Planning layout of blocks –

Residential Block -

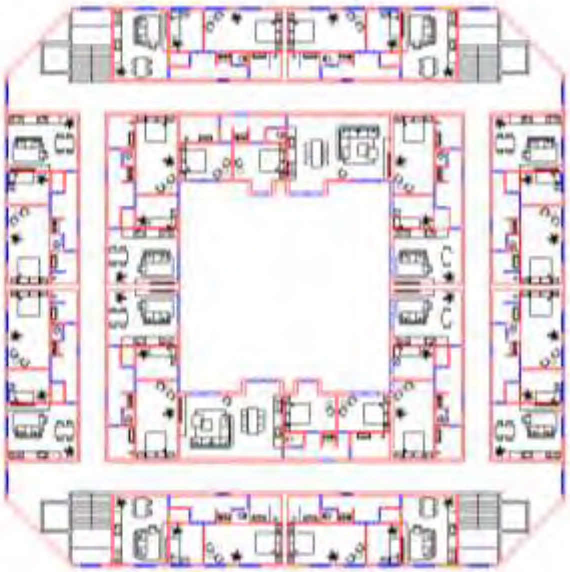


1.7 - Planning layout of blocks –

Residential Block -



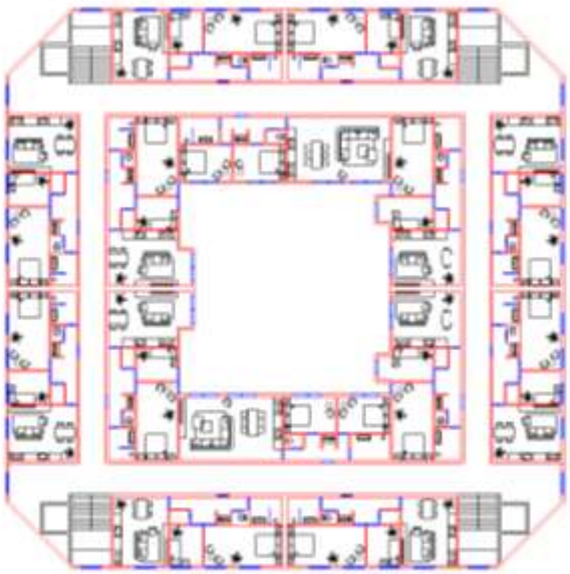
Layer - 1



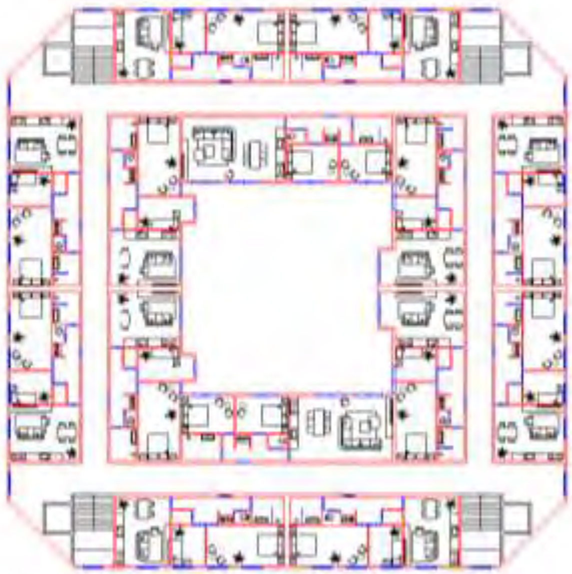
Layer - 2

1.7 - Planning layout of blocks –

Residential Block -



Layer - 3

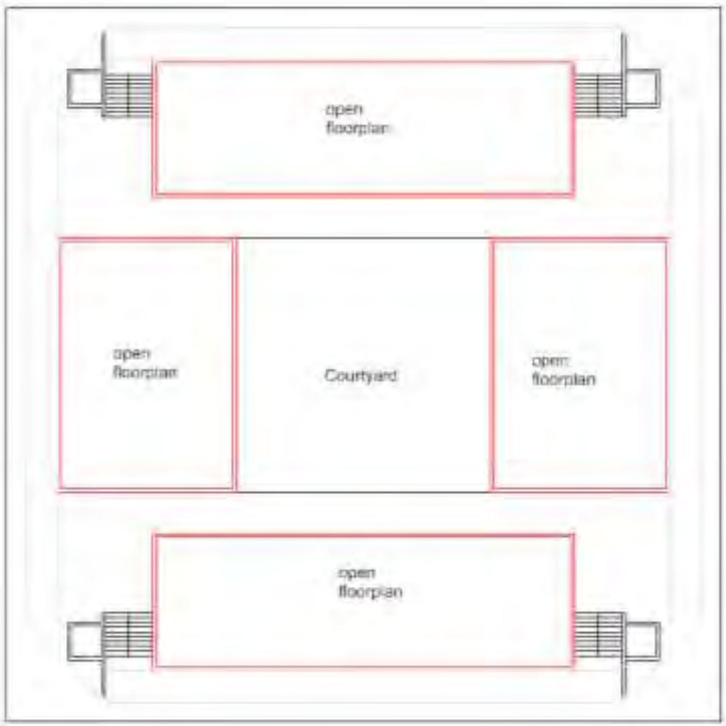


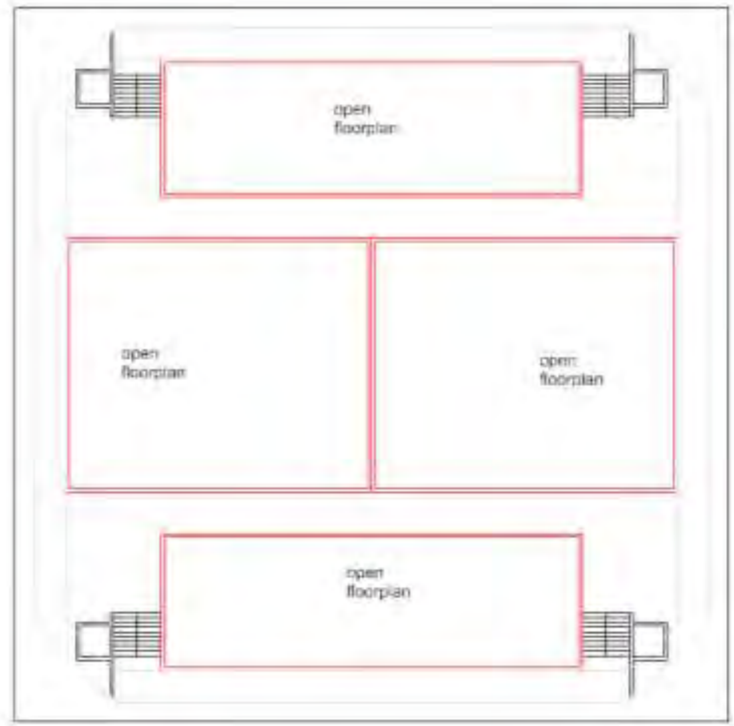
Layer - 4

Every floor layer has 14 units.
12 units - 74.50 m2 each
2 units   - 86 m2 each
The 3 layouts can be mixed in different combinations to get different projections in the courtyard space.

1.7 - Planning layout of blocks –

Other Blocks -

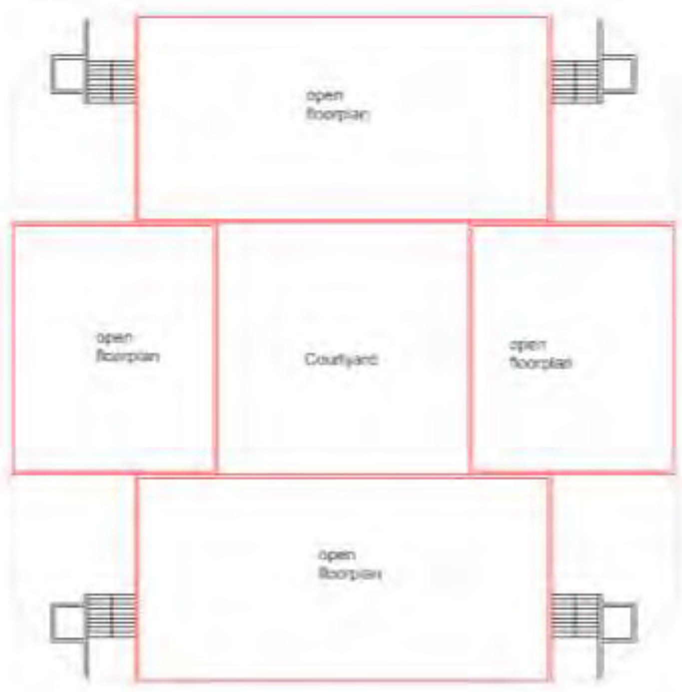


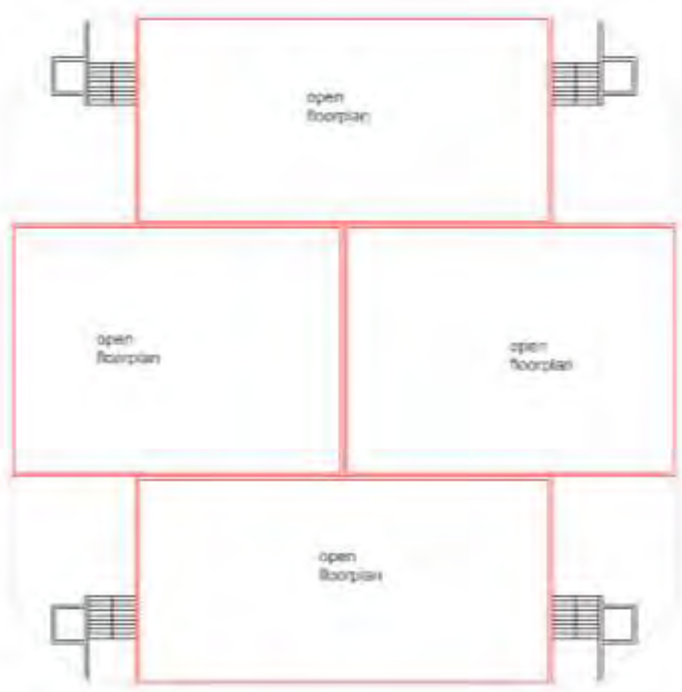


Options for layer -1 (different functions)

1.7 - Planning layout of blocks –

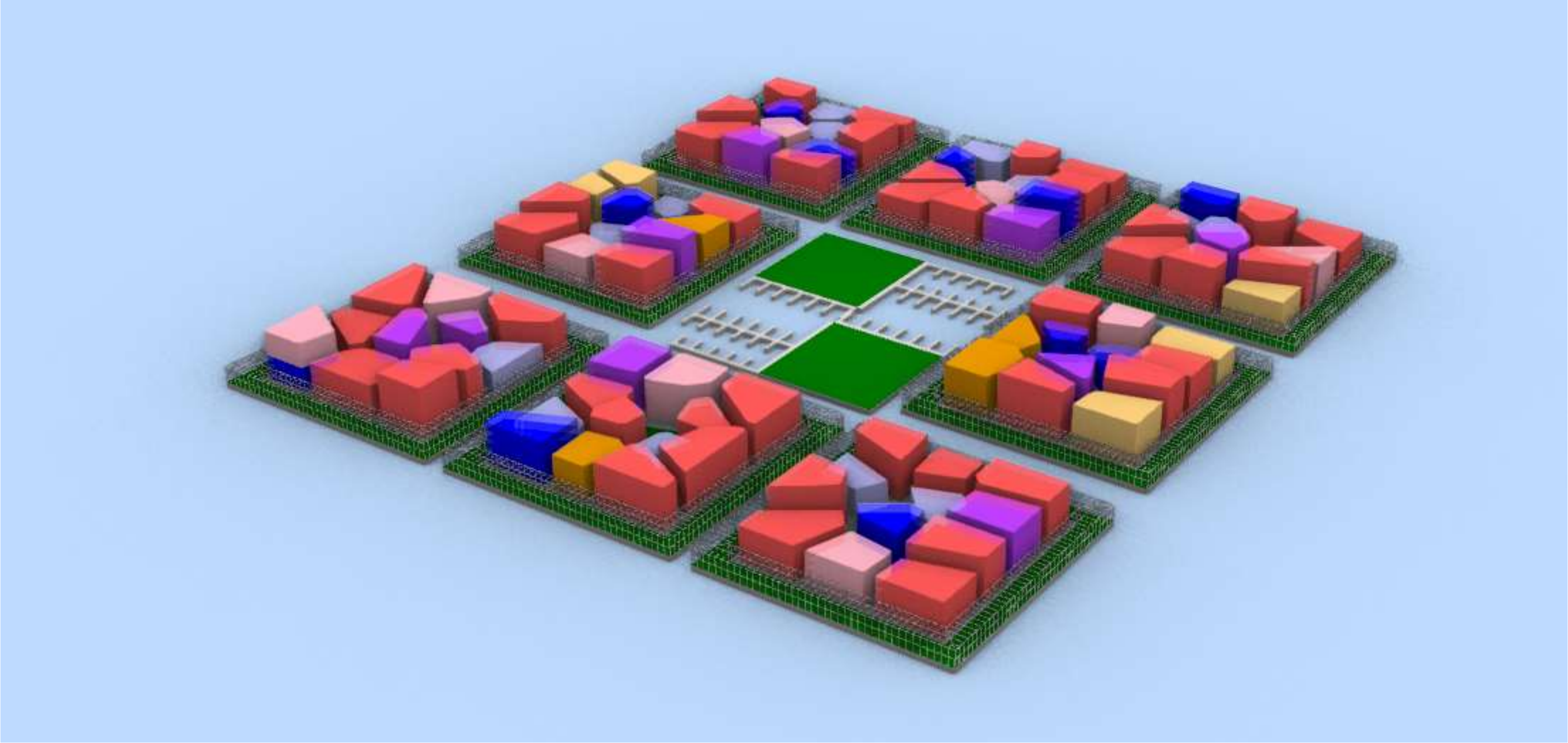
Other Blocks -





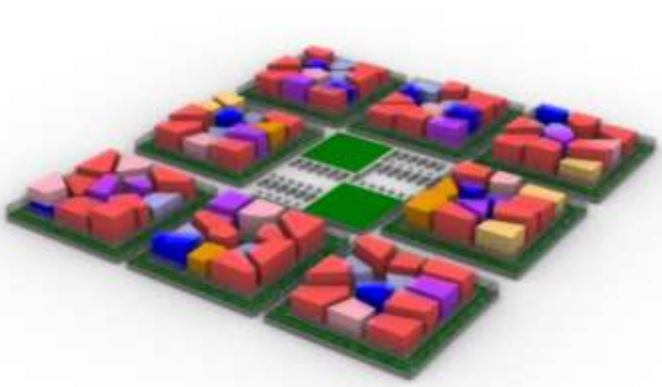
Options for other layers – (different functions)

2 - 90m PLATFORM



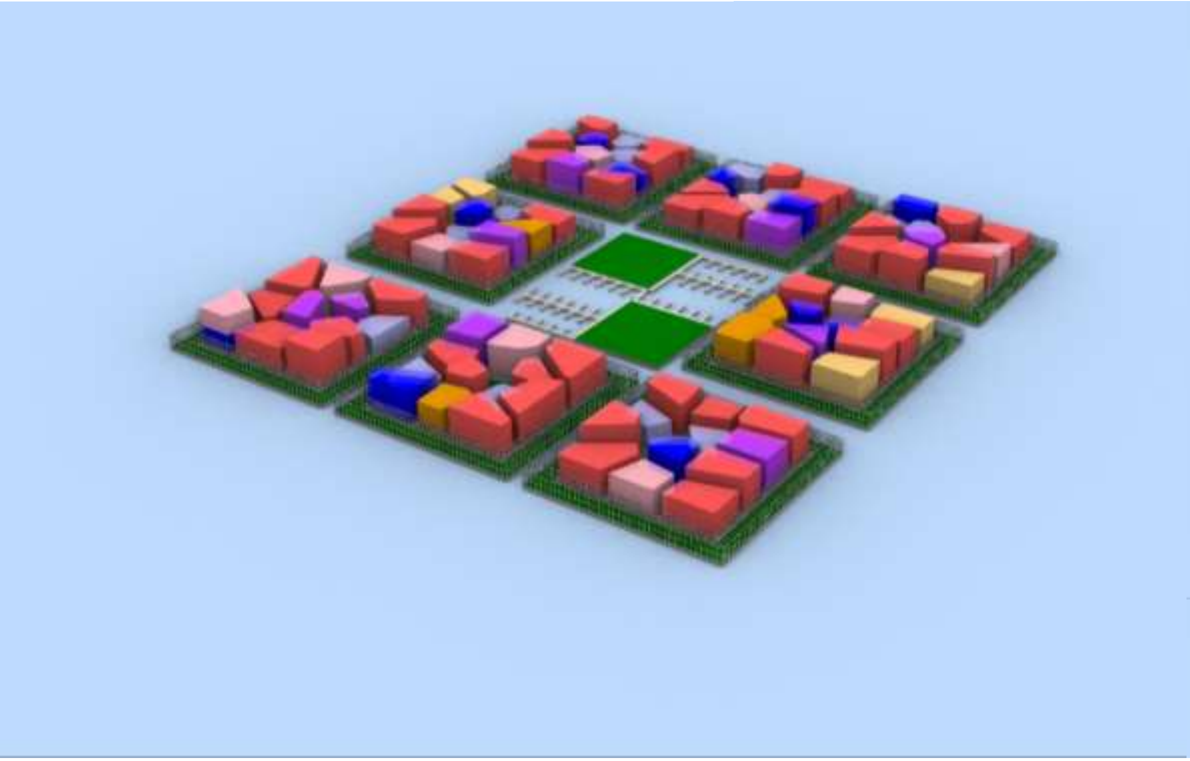
2.1 - Functional Distribution –

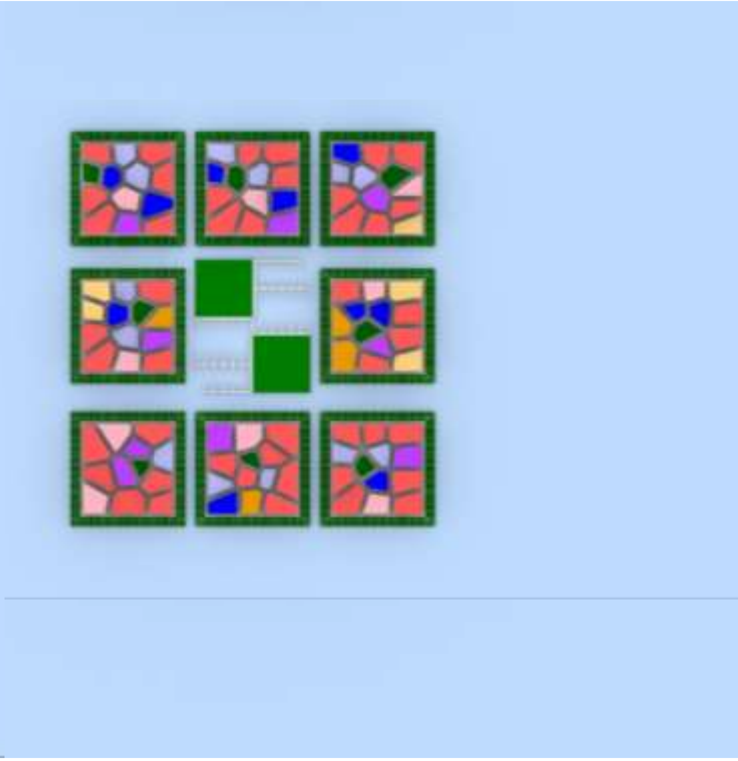
Function	Type	Percentage Distribution of GFA (%)	Gross Floor Area (m^2)	
Residential	Med Density	49	68,462	
Business Commercial	Offices	9	13,093	
Business Light Industry	Warehouse	5	6,450	
Business Catering Industry	Hotel	4	5,247	
Public Community Facilities	Cultural Centre Theatre	9	11,959	
Public Educational Institute	Library and Learning Centre	8	11,263	
	School			
Public Green Space		4	5,458	
Public Peripheral Green				21,000
Public Amenities		6	8,834	
Utilities		6	8,100	
TOTAL		100	138,866	



2.2 - Organisation of the city (land-use map) –

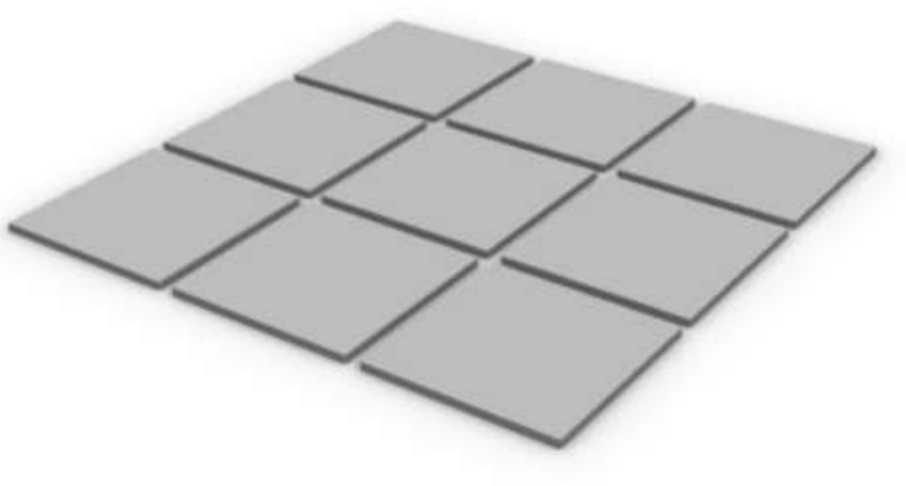
City layout





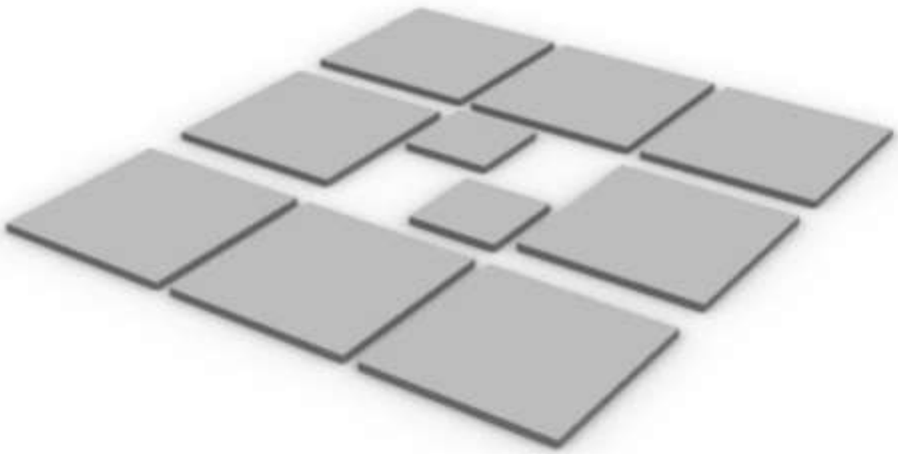
2.2 - Organisation of the city **(land-use map) –**

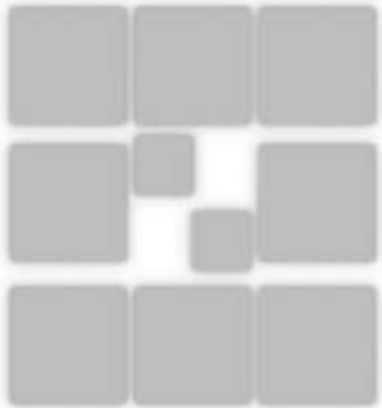
Assigning the grid pattern



2.2 - Organisation of the city (land-use map) –

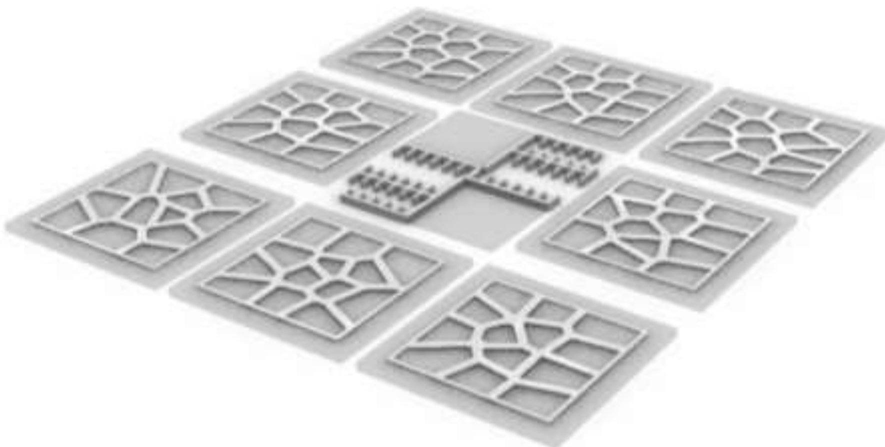
Water transport network

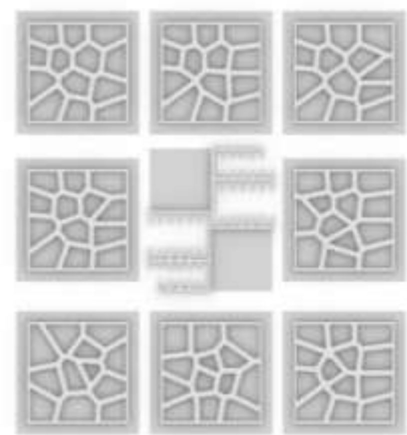




2.2 - Organisation of the city (land-use map) –

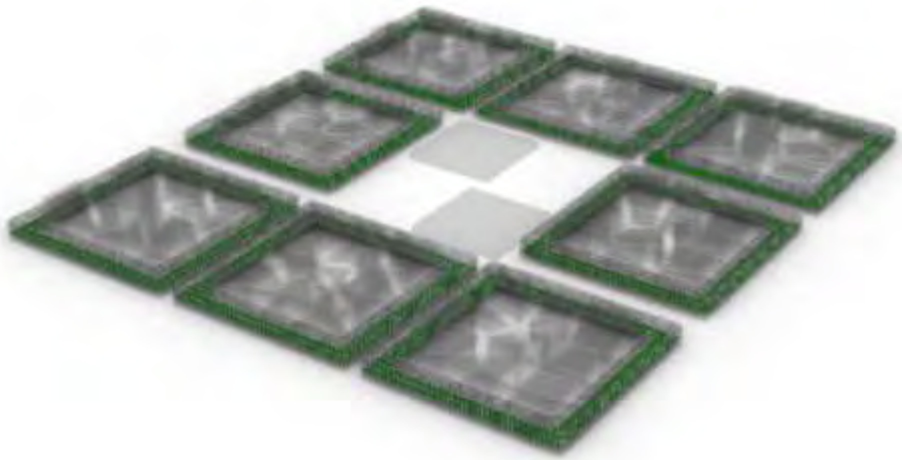
Accessibility and Dock

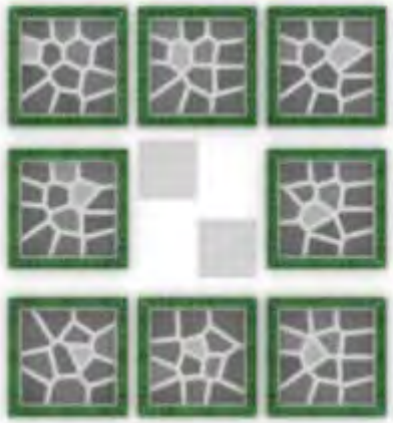




2.2 - Organisation of the city (land-use map) –

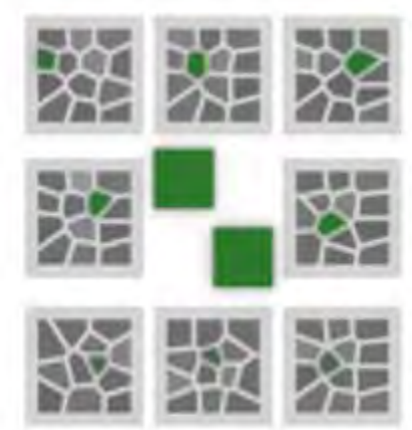
Public Peripheral Green





2.2 - Organisation of the city (land-use map) –

Public Green Space

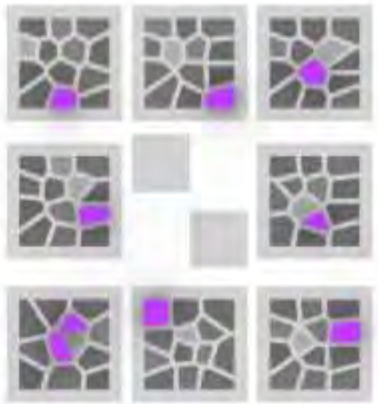


2.2 - Organisation of the city (land-use map) –

Residential

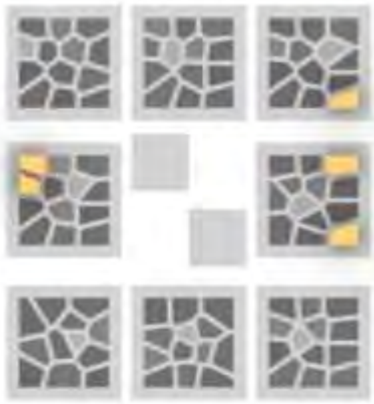
2.2 - Organisation of the city (land-use map) –

Business Commercial



2.2 - Organisation of the city (land-use map) –

Business Light Industry

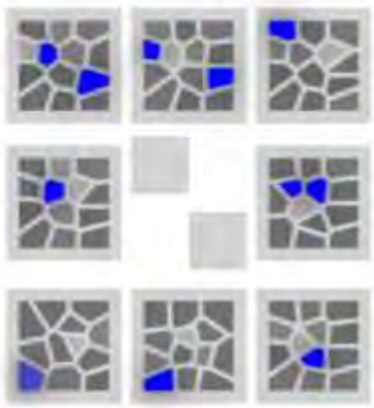


2.2 - Organisation of the city (land-use map) –

Business Catering Industry

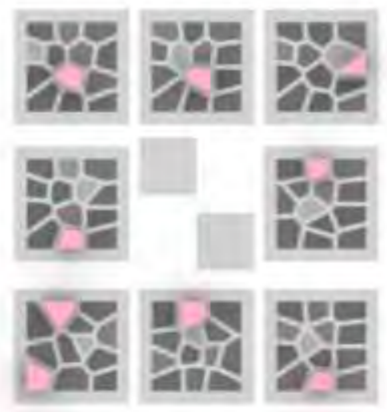
2.2 - Organisation of the city (land-use map) –

Public Community Facilities



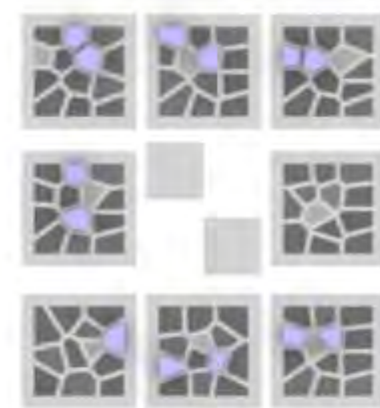
2.2 - Organisation of the city (land-use map) –

Public Educational Institute



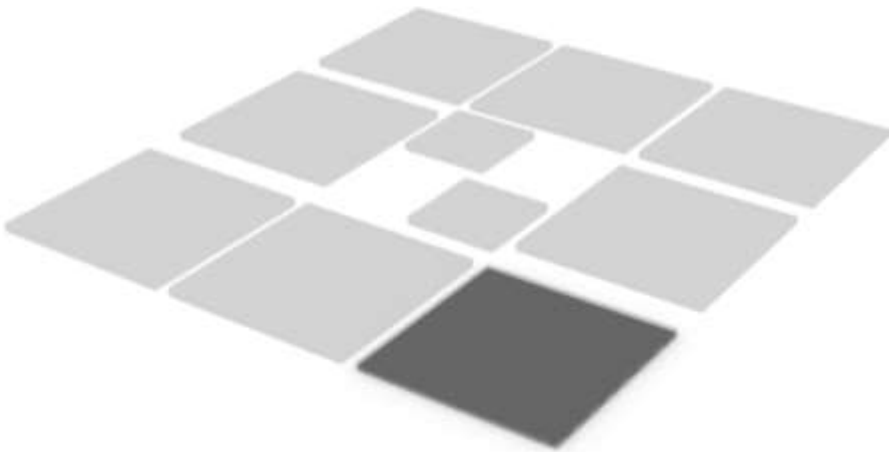
2.2 - Organisation of the city (land-use map) –

Public Amenities



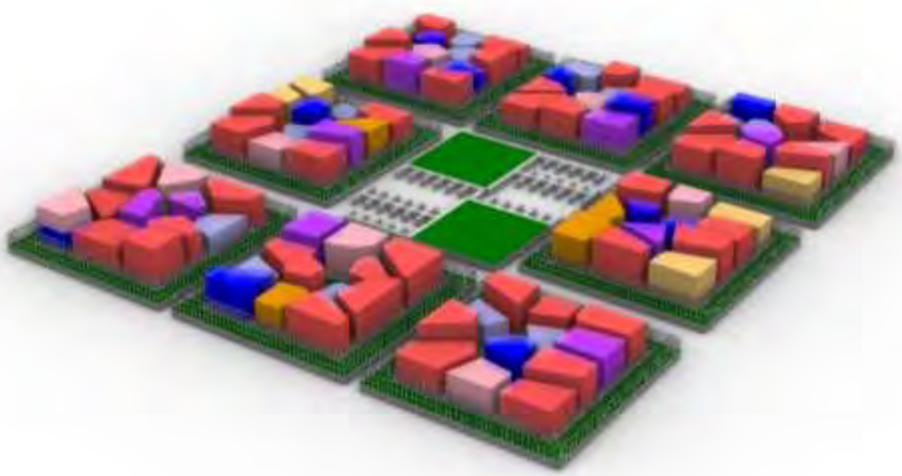
2.2 - Organisation of the city (land-use map) –

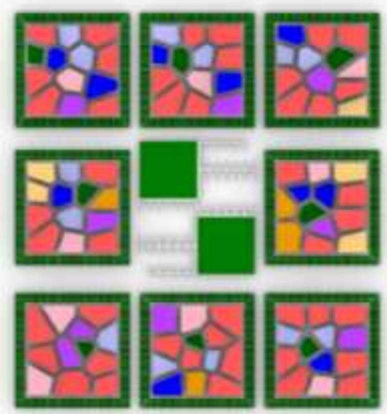
Utilities



2.2 - Organisation of the city (land-use map) –

City Layout





Appendix – 6 Energy hub@Sea

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Concept 1 : Triangular Based Offshore Platform
Concept 2: Triangular Based Floating Platform
Concept 3 : Square Based Offshore Platform
Concept 4: Square Based Floating Platform

1.1 Concept 1&3 :
Offshore Platform

Create a concept for a new Offshore Platform, based on the document (Space@Sea – WP6, List of requirements of the O&M hub), for two different scenarios:

- North Sea
- Mediterranean Sea

The requirements are compared with regulations of residential functions on land and with the preferences of offshore workers collected during interviews (D7.1 report).

Based on regulations and offshore worker's preferences, a new design brief is proposed.

1.1 Concept 1&3 :

Offshore Platform

Requirements are reviewed according to the information included in the following documents:

- "Space@Sea – WP6, List of requirements of the O&M hub".
- Bouwbesluit (Dutch Building Code)for the comparison with regulations of residential functions on land.
- D7.1 report, for understanding offshore worker's wishes.

1.2 Concept 2&4 :

Floating Platform

Create a concept for a new Floating Platform, based on the documents and interviews, for different scenarios.

Many of the interviewees (offshore workers) expressed the preference to increase the living space and also the possibility to receive family visits.

Therefore, the new requirements include a higher number of people and more living space per person. Flats of 35 m^2 circa are envisioned, which could accommodate 1 or 2 people. Additionally, more space for outdoor activities and for leisure facilities is included in the overview.

1.2 Concept 2&4 :

Floating Platform

Requirements are reviewed according to the information included in the following documents:

- “Space@Sea – WP6, List of requirements of the O&M hub”
- Bouwbesluit (Dutch Building Code)for the comparison with regulations of residential functions on land
- D7.1 report, for understanding offshore worker’s wishes

2. References:
O&M HUB Design

According to the document “List of requirements of the O&M hub”, the Bouwbesluit (Dutch Building Code) and the D7.1 report, for understanding offshore worker’s wishes the building consists of the following parts:

- Basic Module
- Storage hall and quay
- Accommodation building
- Columns

The platform shape is triangular, with equal sides. Each side is 50m.

On top of the platform, a building is constructed. Around the building, a 4m wide quay is present. The side of the building on top of the platform is circa 36m and it is footprint is approximately 566sqm.

2. References:

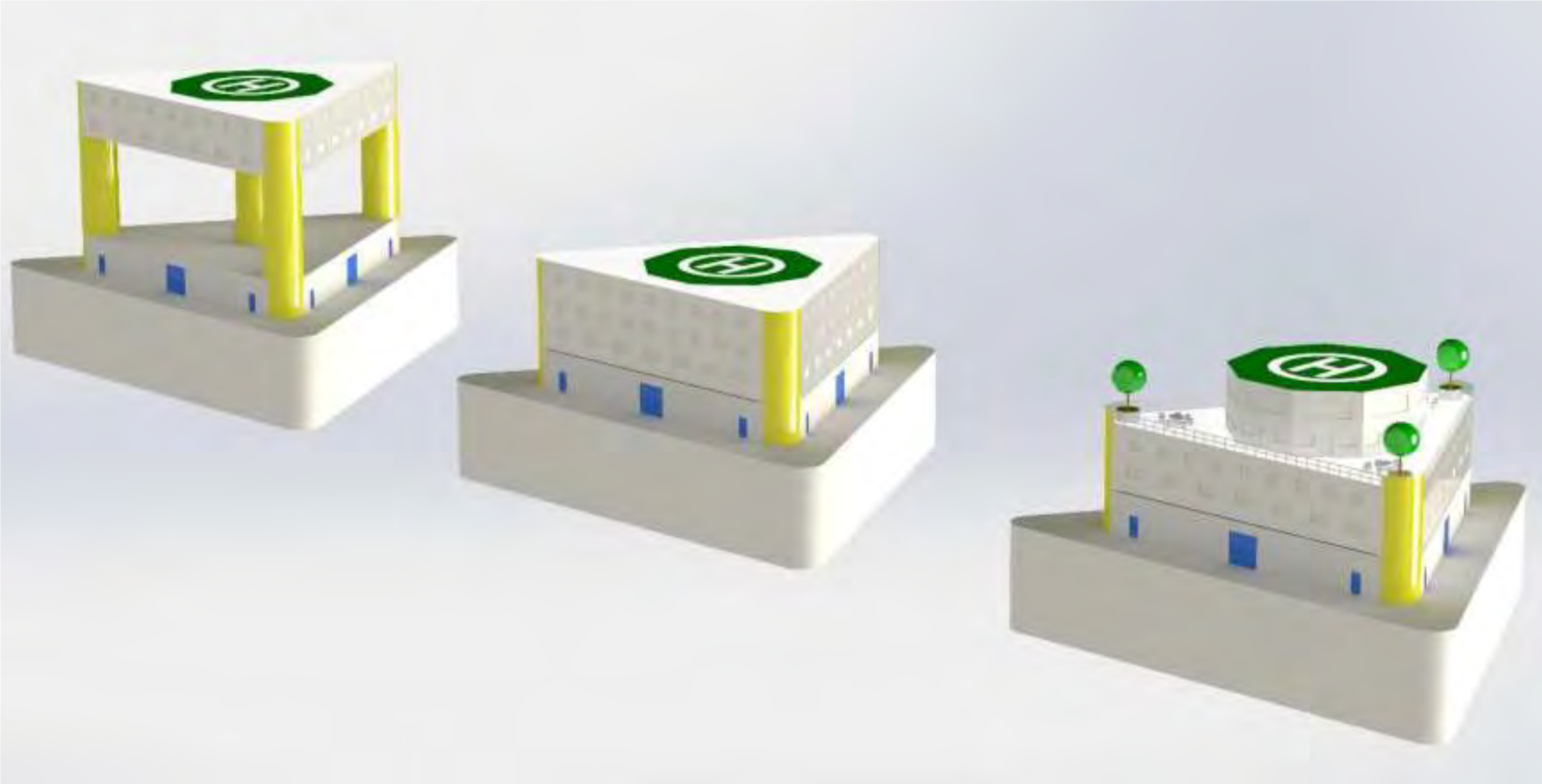
O&M HUB Design

Building Example

Basic module	The standardized floating structure
Storage hall and quay	For maintenance use, storage and logistic
Accommodation building	Accommodation, house technics, supply of crew, office
Columns	Stairways, lifts for material and persons, power and supply lines

2. References:
O&M HUB Design

Figure 1, from left to right: North Sea, Baltic Sea and Mediterranean Sea version



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2. References:
O&M HUB Design

Depending on the context where the platform will be built, different configurations are possible.

- Configuration #1 has 2 floors
- Configuration #2 and #3 have 3 and 4 floors
- The additional floor space created in configuration #2 and #3 allow more room for functions. The 3th design has an integration of green elements

3. Concept 1

Offshore Triangular Based Platform

- 3.1: Program of Demands
- 3.2: Initial compositional scheme
- 3.3: Concept 1.A Mediterranean Sea
- 3.4: Concept 1.B North Sea

3. Concept 1:
Offshore Platforms

Program of Demands

Functional requirements for accommodation building

- The document “List of requirements of the O&M hub”, is referred to a platform that provides enough space (rooms and services) for 32 workers

3. Concept 1:
Offshore Platforms

Program of demands

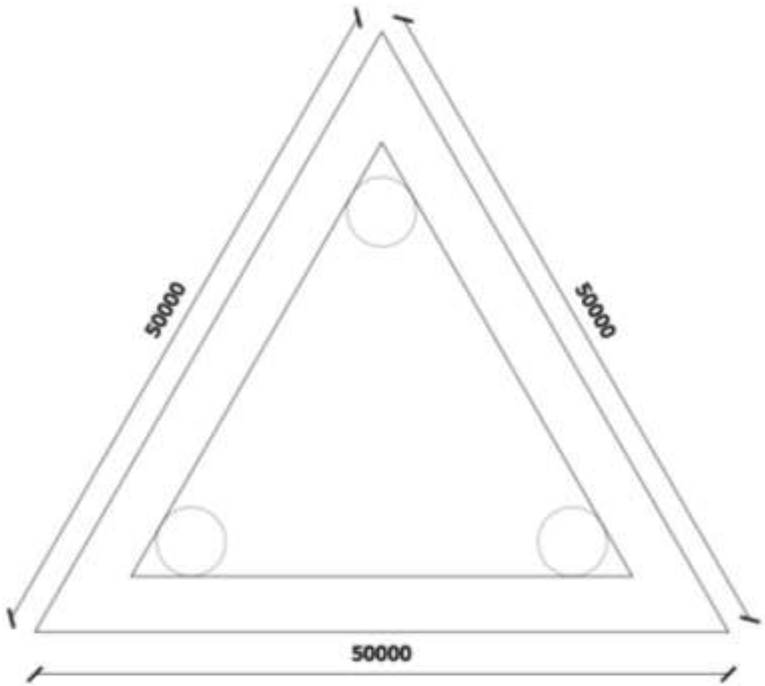
	m^2 (NFA)	Description
Single rooms	400	min. $12m^2$ each - windows to the outside - bath with toilet and shower - desk, chairs, wardrobe - heating, air condition, ventilation
Corridors	200	no daylight necessary - heating, air condition, ventilation
Kitchen + canteen	150	kitchen with stoves, ovens, air exhaust systems, refrigerators, freezers, boards, dishwashers - canteen for 32 persons with counters, heated wells, dishwashers, cupboards, windows to outside - sanitary rooms - heating, air condition, ventilation
Food storage	100	storage rooms for food with a capacity of 30 days - refrigeration chamber with a capacity of 30 days - house service room with storage of cleaning agents and other consumables, vacuum cleaner - laundry with washing machines, tumble dryers, linen cupboards, with ventilation
Offices	20	
Conference	25	
Health room	15	
Social rooms	30	gym etc.
Total, accommodation building	**940**	

3.2 Concept 1

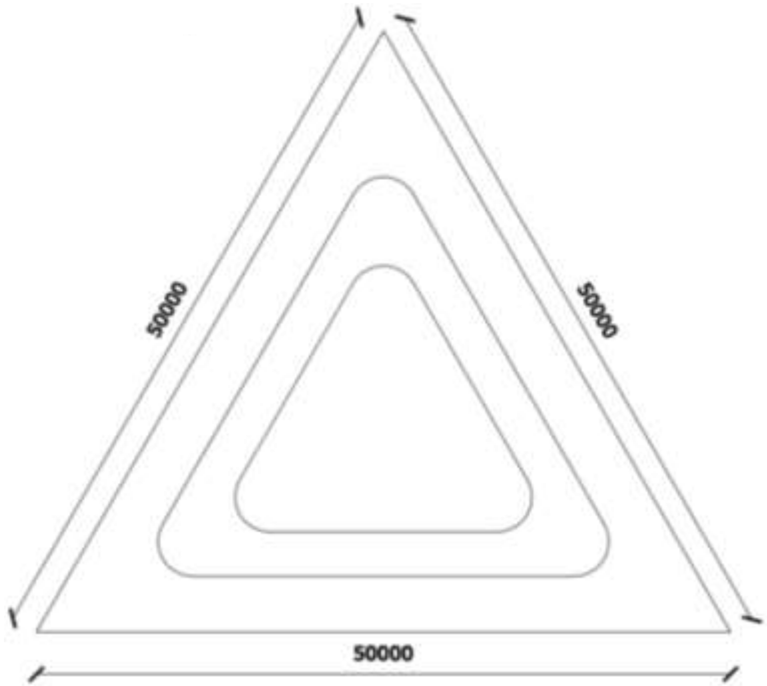
Initial compositional scheme

The concept of the floorplans started from the study of a triangular platform with sides of (50x50x50)m.

The plans have been studied to answer the requirements mentioned in the List of requirements of the O&M hub.



Phase 1

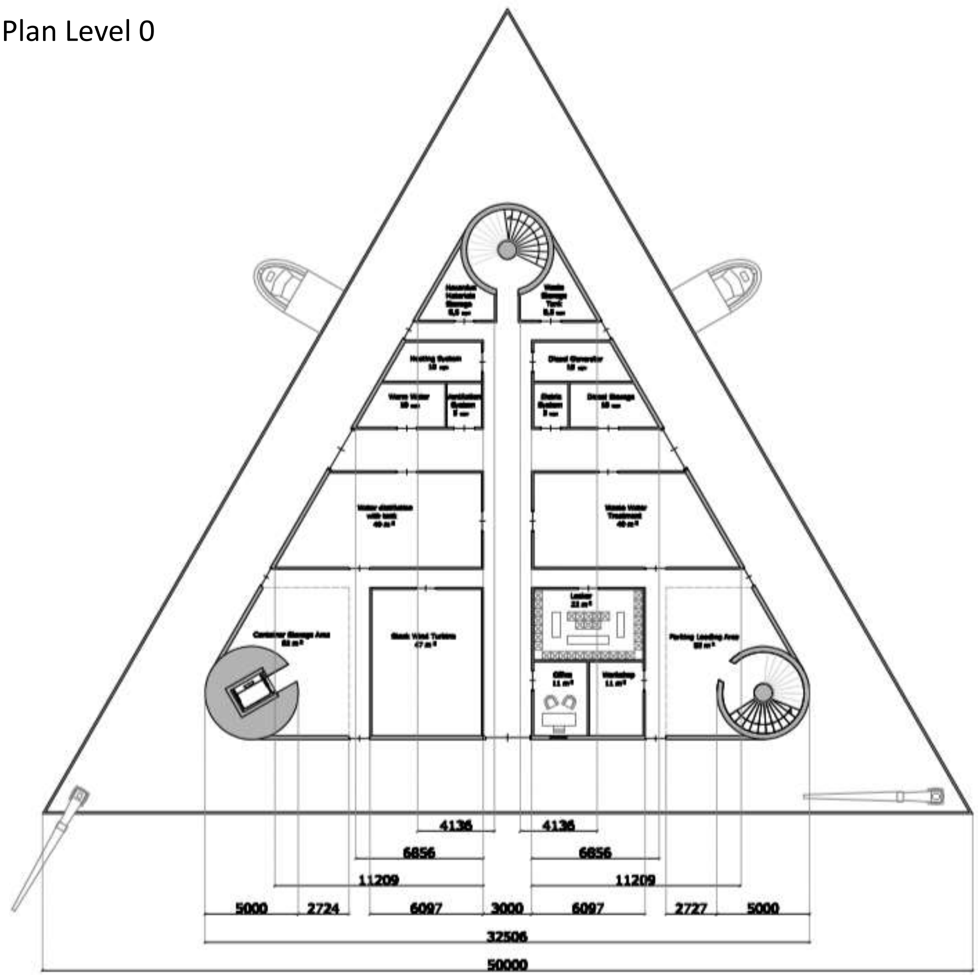


Phase 2

3.3 Concept 1.A:

Mediterranean Sea

Plan Level 0



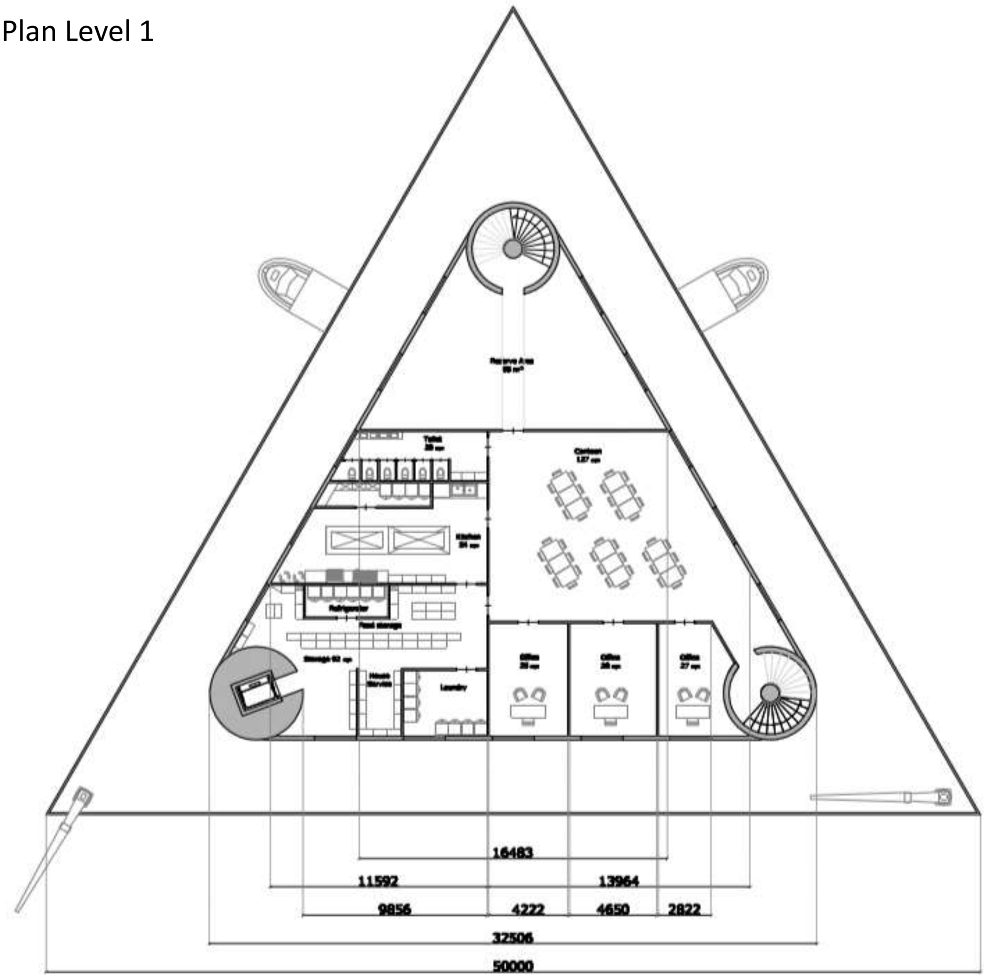
Storage, hall and quay

Area index	
2 doors and 3x3m hall door on each side	
Turbines stock area	47 sqm
Parking, loading area	82 sqm
Transport paths	141 sqm
Container storage area	33 sqm
Locker room	22 sqm
Office	11 sqm
Workshop	11 sqm
Hazardous materials storage	8,5 sqm
Waste storage tank	8,5 sqm
Water distillation reserve	49 sqm
Waste water treatment	49 sqm
Heating system	10 sqm
Warm water	10 sqm
Diesel Generator station	10 sqm
Ventilation System	5 sqm
Diesel storage	10 sqm
Electric system	5 sqm

3.3 Concept 1.A:

Mediterranean Sea

Plan Level 1



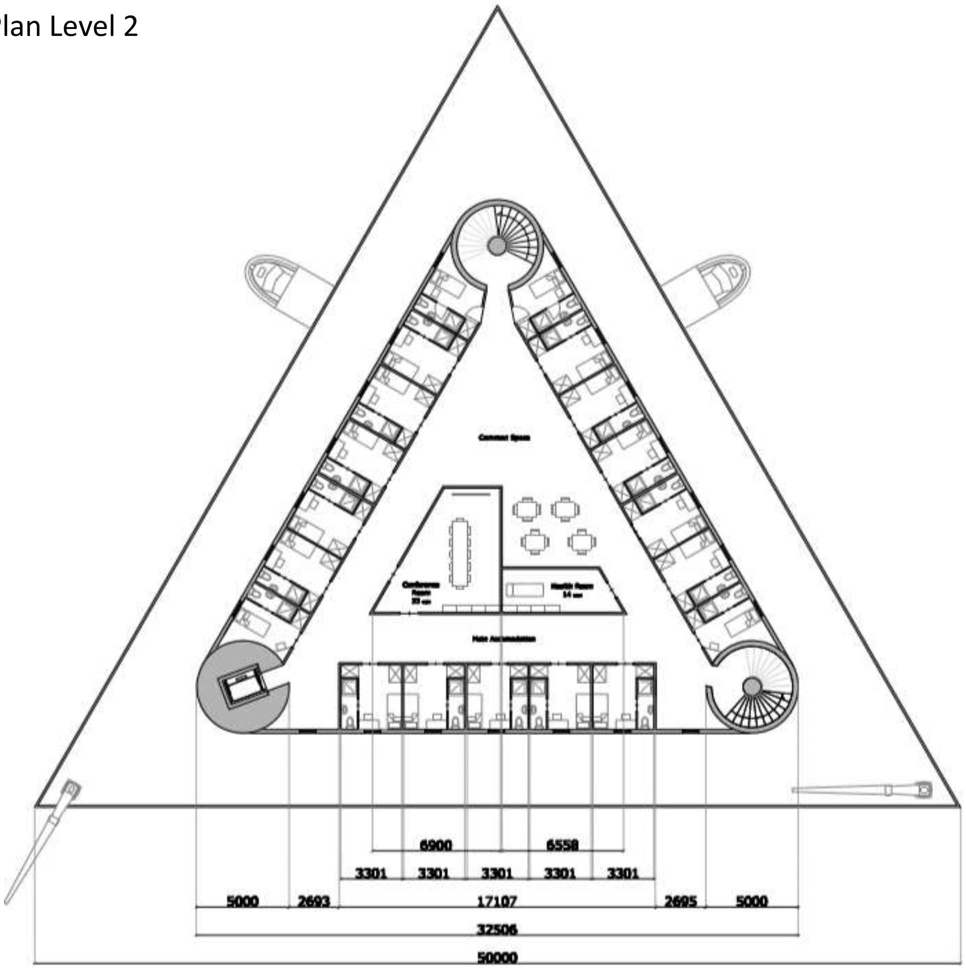
Storage, restaurant, offices

Area index	
Reserve area	95 sqm
Kitchen	52 sqm
Canteen	127 sqm
Food storage and house service	92 sqm
Office 1	25 sqm
Office 2	28 sqm
Office 3	27 sqm

3.3 Concept 1.A:

Mediterranean Sea

Plan Level 2



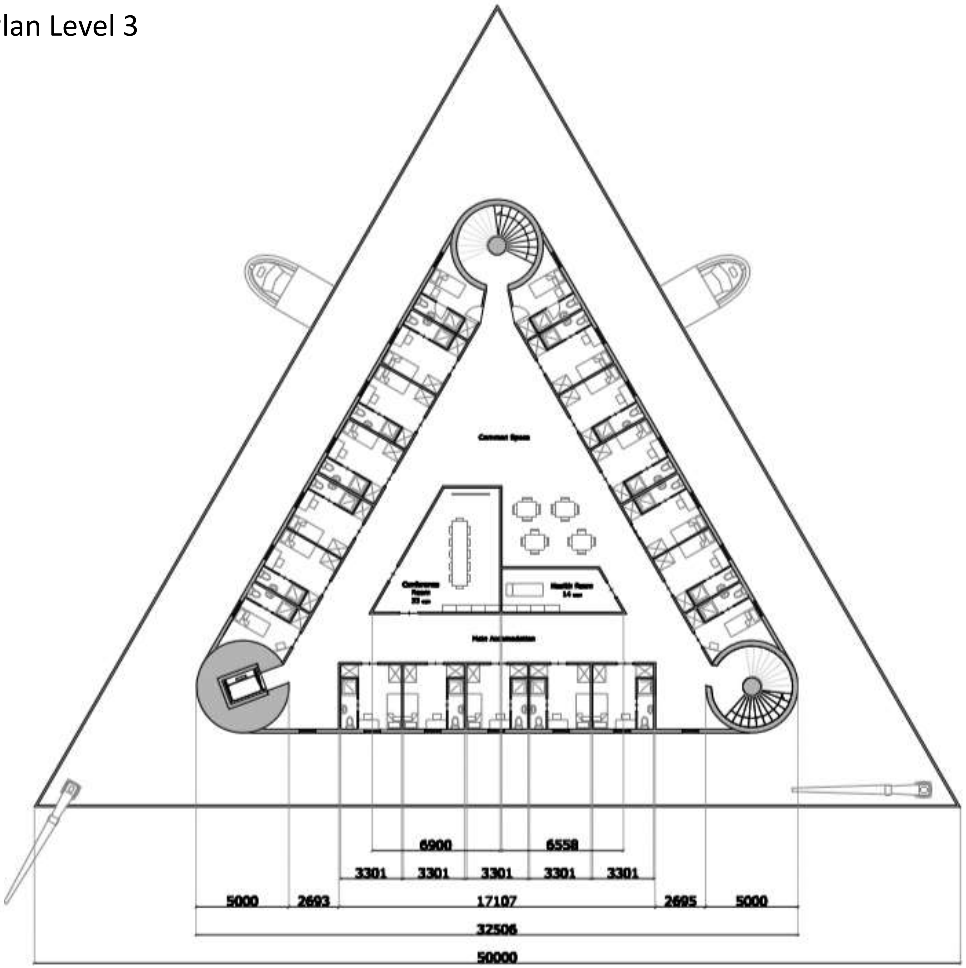
Bedrooms,conference,health room

Area index	Accommodation for 19 people
Bedrooms x 19 (12 sqm each)	228 sqm
Conference Room	33 sqm
Health Room	15 sqm

3.3 Concept 1.A:

Mediterranean Sea

Plan Level 3



Bedrooms, common areas

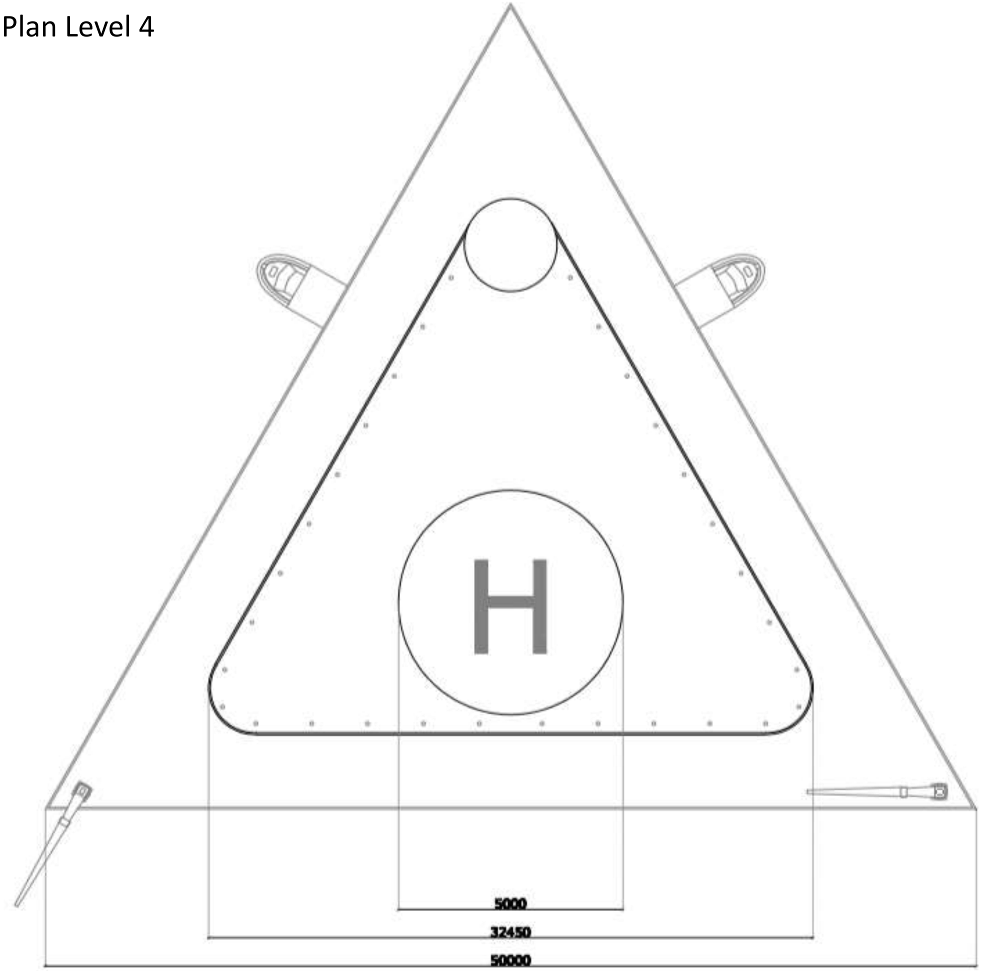
Area index	Accommodation for 14 people
Bedrooms x 19 (12 sqm each)	168 sqm
Gym	60 sqm
Common space	245 sqm

3.3 Concept 1.A:

Mediterranean Sea

Plan Level 4

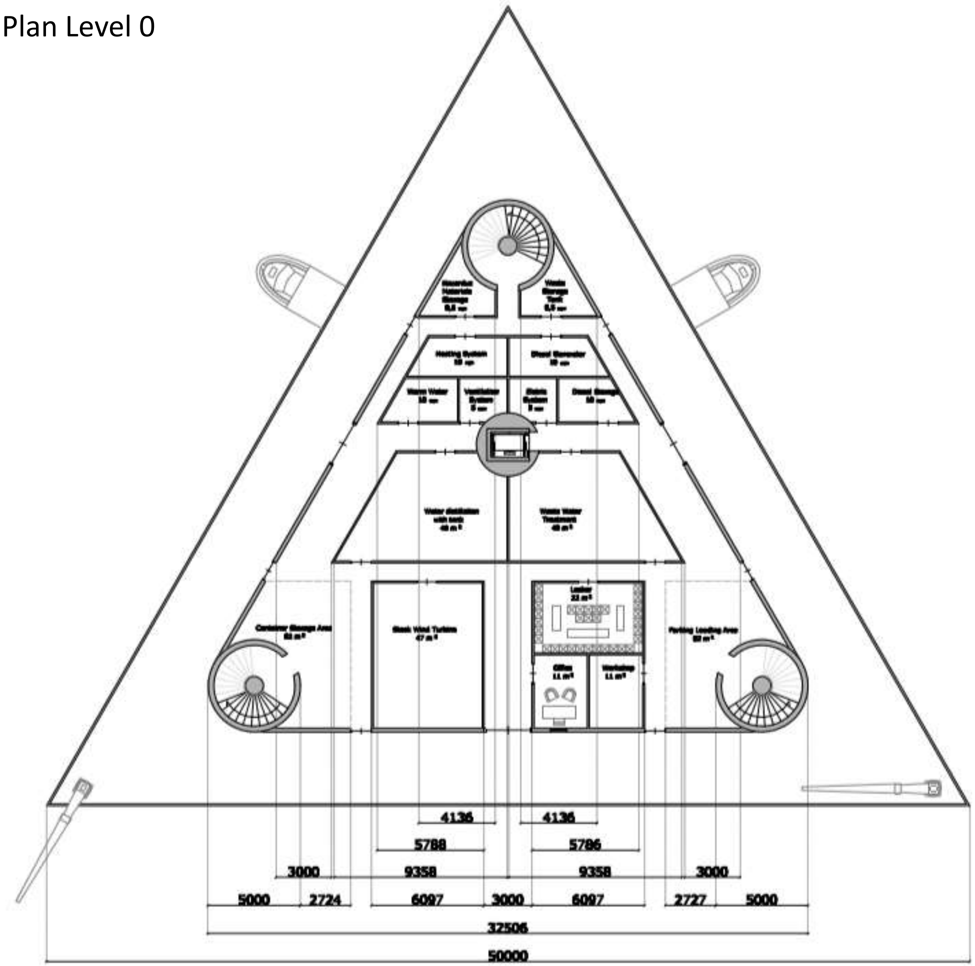
Rooftop



3.4 Concept 1.B:

North Sea

Plan Level 0



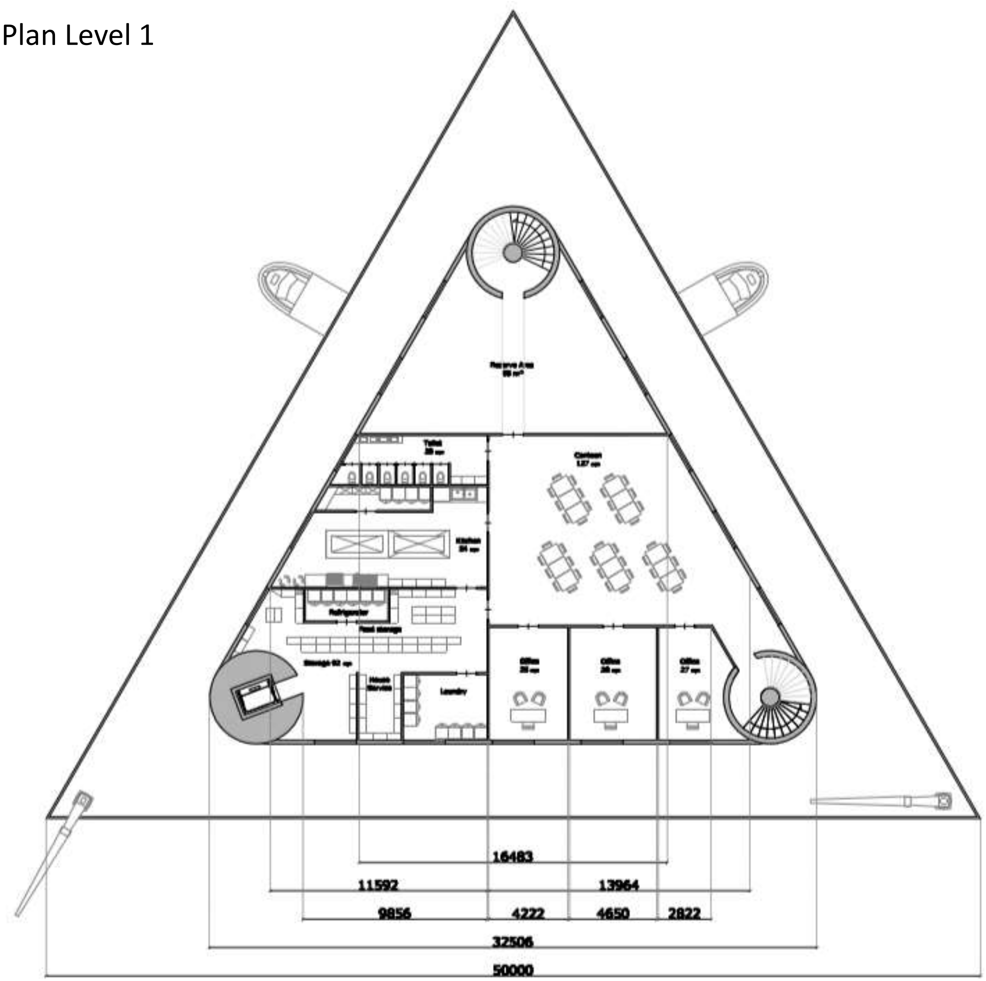
Storage, hall and quay

Area index	
2 doors and 3x3m hall door on each side	
Turbines stock area	47 sqm
Parking, loading area	82 sqm
Transport paths	141 sqm
Container storage area	33 sqm
Locker room	22 sqm
Office	11 sqm
Workshop	11 sqm
Hazardous materials storage	8,5 sqm
Waste storage tank	8,5 sqm
Water distillation reserve	44 sqm
Waste water treatment	44 sqm
Heating system	10 sqm
Warm water	10 sqm
Diesel Generator station	10 sqm
Ventilation System	5 sqm
Diesel storage	10 sqm
Electric system	5 sqm

3.4 Concept 1.B:

North Sea

Plan Level 1



Storage, restaurant, offices

Area index	
Reserve area	95 sqm
Kitchen	52 sqm
Canteen	127 sqm
Food storage and house service	92 sqm
Office 1	25 sqm
Office 2	28 sqm
Office 3	27 sqm

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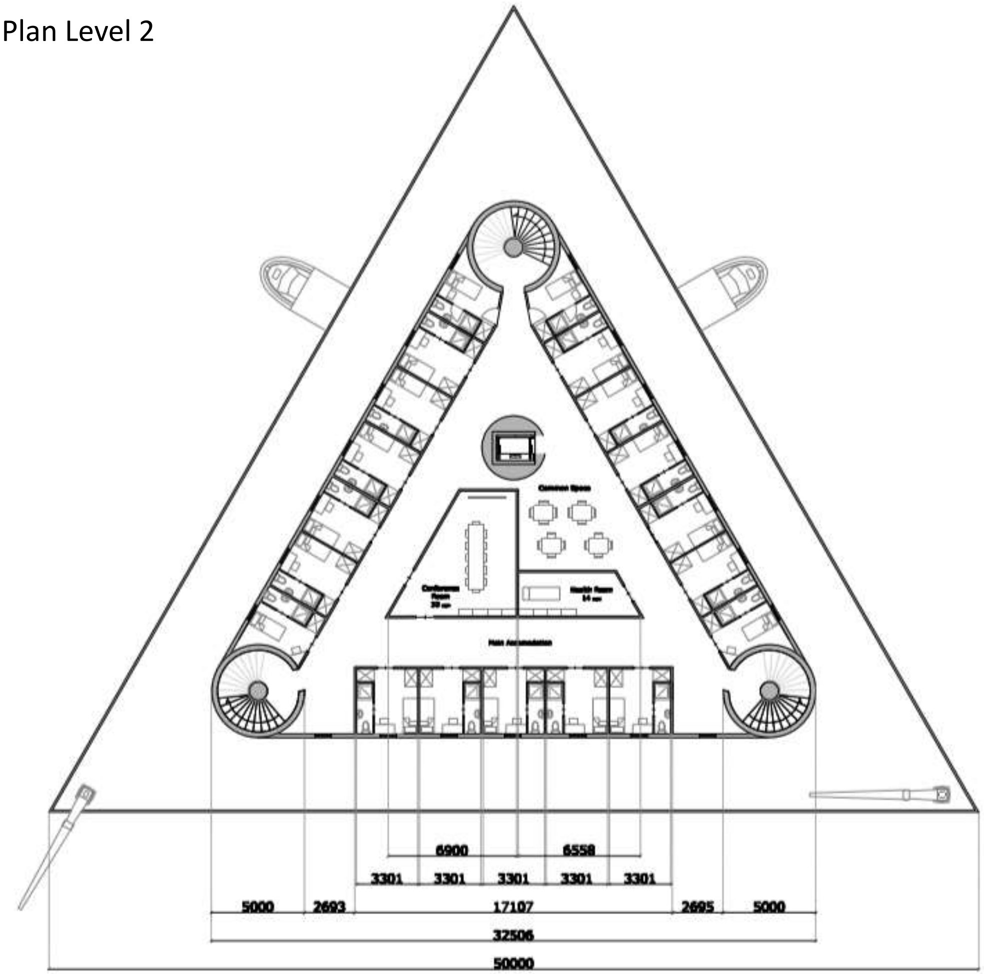
3.4 Concept 1.B:

North Sea

Plan Level 2



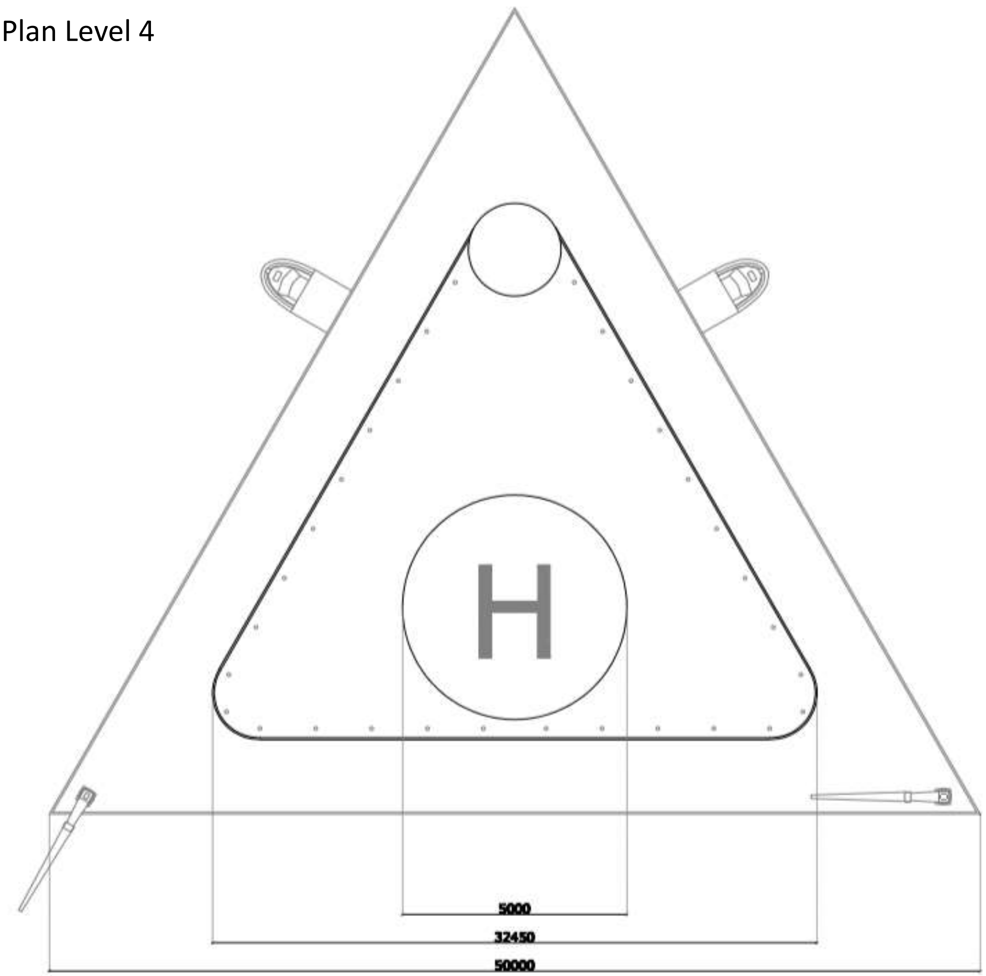
Bedrooms,conference,health room

Area index	Accommodation for 19 people
Bedrooms (19 of 12 sqm each)	228 sqm
Conference Room	33 sqm
Health Room	14 sqm

3.4 Concept 1.B:

North Sea

Plan Level 4



Rooftop

4. Concept 2

Triangular Based Floating Platform

- 4.1: Program of Demands
- 4.2: Initial compositional scheme
- 4.3: Concept 2.A Triangular Based Floating Tower
- 4.4: Concept 2.B Triangular Based Floating City

4.1 Concept 2:
Program of Demands

Program of demands

Functional requirements for accommodation building based on:

- The interview (D7.1 report) at offshore workers, that expressed the preference to increase the living space and also the possibility to receive family visits
- Necessity of 32 apartments at list
- The Bouwbesluit (Dutch Building Code).

4.1 Concept 2:
Program of Demands

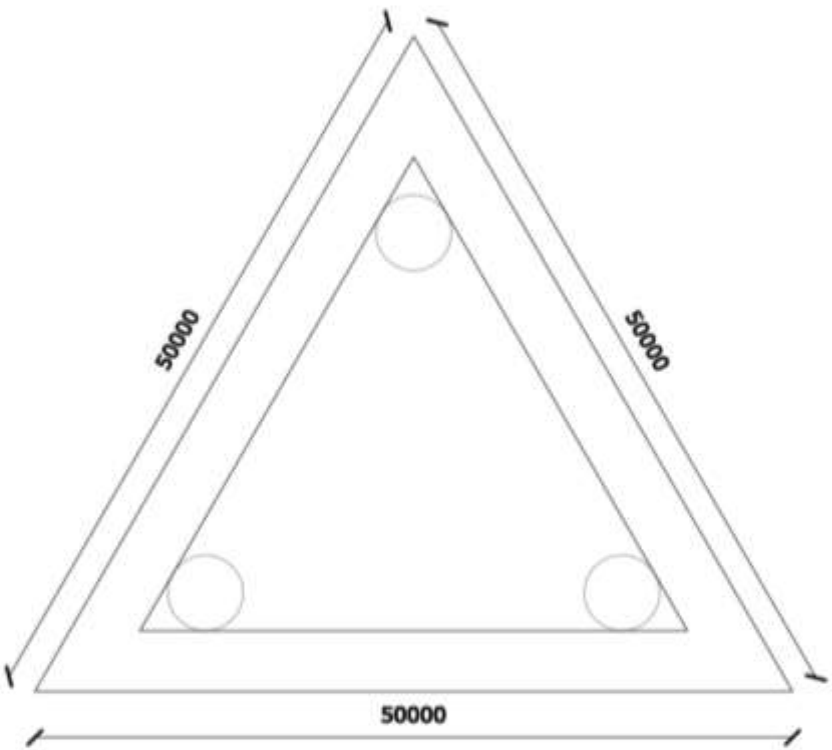
	m^2 (NFA)	Description
Mini Flats	1120	35 m^2 each - windows to the outside - bathroom with toilet and shower - separation between living and sleeping area - kitchen - heating, air condition, ventilation
Corridors/Stairs	480	no daylight necessary - heating, air condition, ventilation
Kitchen + canteen	240	kitchen with stoves, ovens, air exhaust systems, refrigerators, freezers, boards, dishwashers – canteen for 30 persons with counters, heated wells, dishwashers, cupboards, windows to outside - sanitary rooms - heating, air condition, ventilation
Food storage (Small Supermarket)	130	storage rooms for food with a capacity of 30 days - house service room - laundry with washing machines
Social Room	176	fitness, sauna/ showers, game room (pool, table, lounge)
Offices	64	
Conference	40	
Health room	15	
Outdoor space	250-500 (depending on the platform)	Green (180-360 m^2, based on 9m^2 p.p.) with plants and bushes, should be accessible most of the time and should be safe, accessible without addition safety measures.
Total, accommodation building	**940**	

4.2 Concept 2

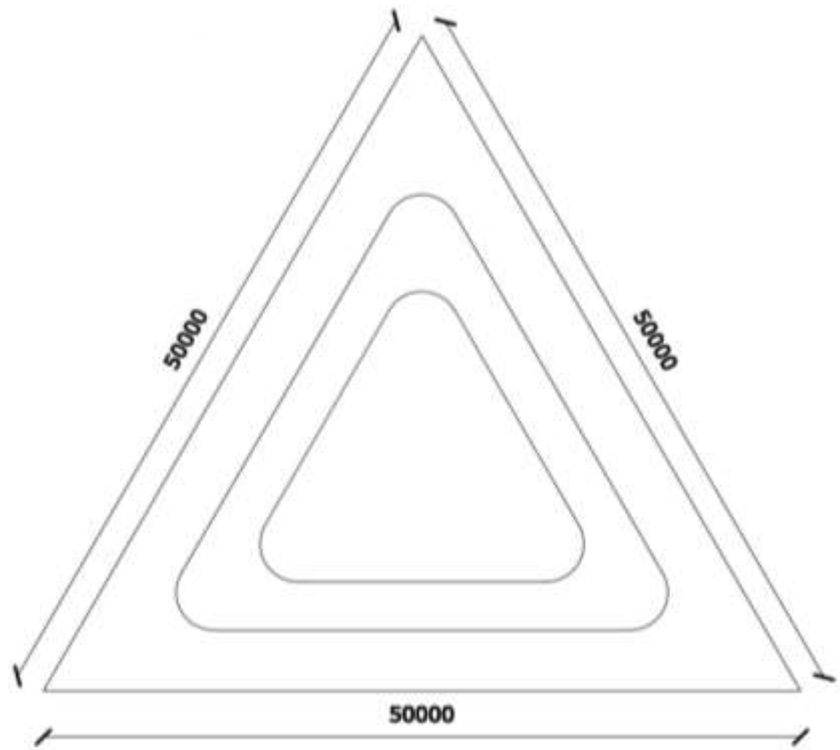
Initial compositional scheme

As for the (50x50x50)m triangular offshore building schemes, the same studies been made for the floating platform systems.

The projects are designed to satisfy a program of demands based on the interview at offshore workers, that expressed the preference to increase the living space and also the possibility to receive family visits.



Phase 1



Phase 2

4.3 Concept 2.A:

Triangular Based Floating Tower

This floating tower is designed to accommodate a minimum of 32 families to a maximum of 36 families. The first two levels are for common activities and facilities, above these levels there are 6 other levels, which are equipped with 6 apartments of 37sqm each.

4.3 Concept 2.A:

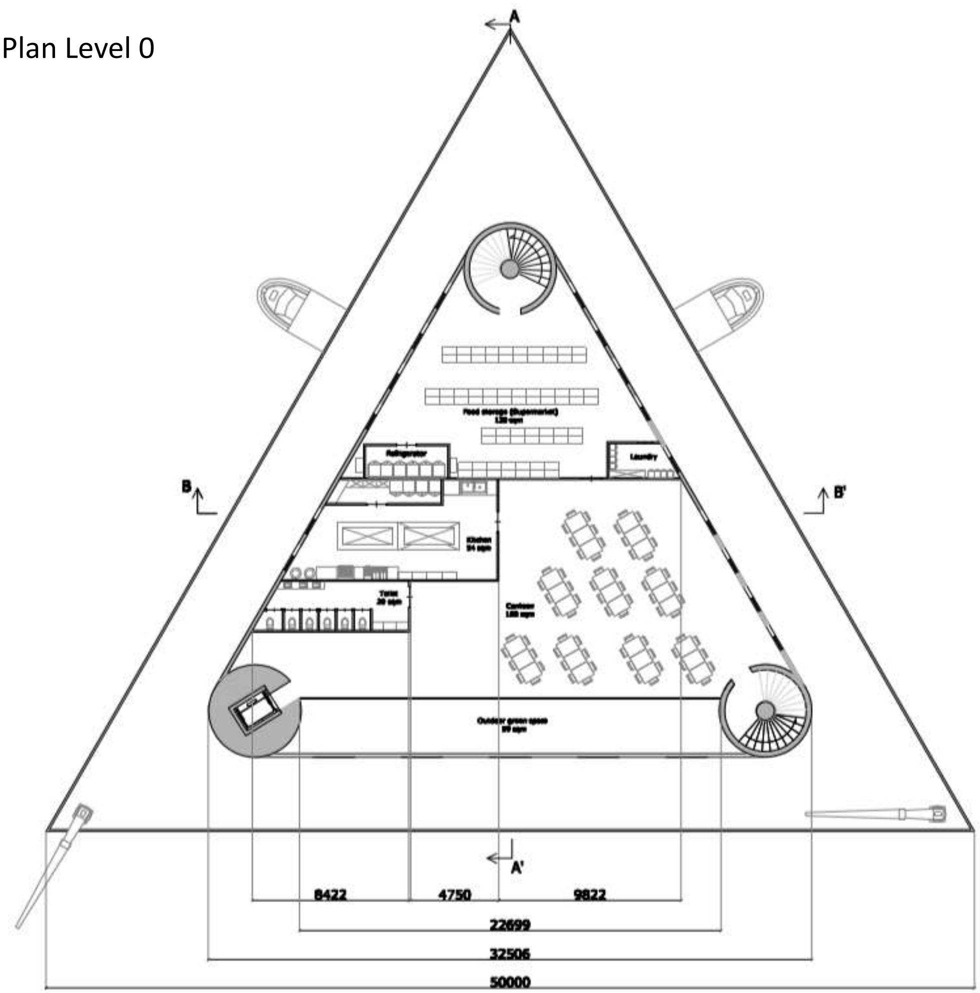
Triangular Based Floating Tower

This floating tower is designed to accommodate a minimum of 32 families to a maximum of 36 families. The first two levels are for common activities and facilities, above these levels there are 6 other levels, which are equipped with 6 apartments of 37sqm each.

4.3 Concept 2.A:

Floating Tower

Plan Level 0



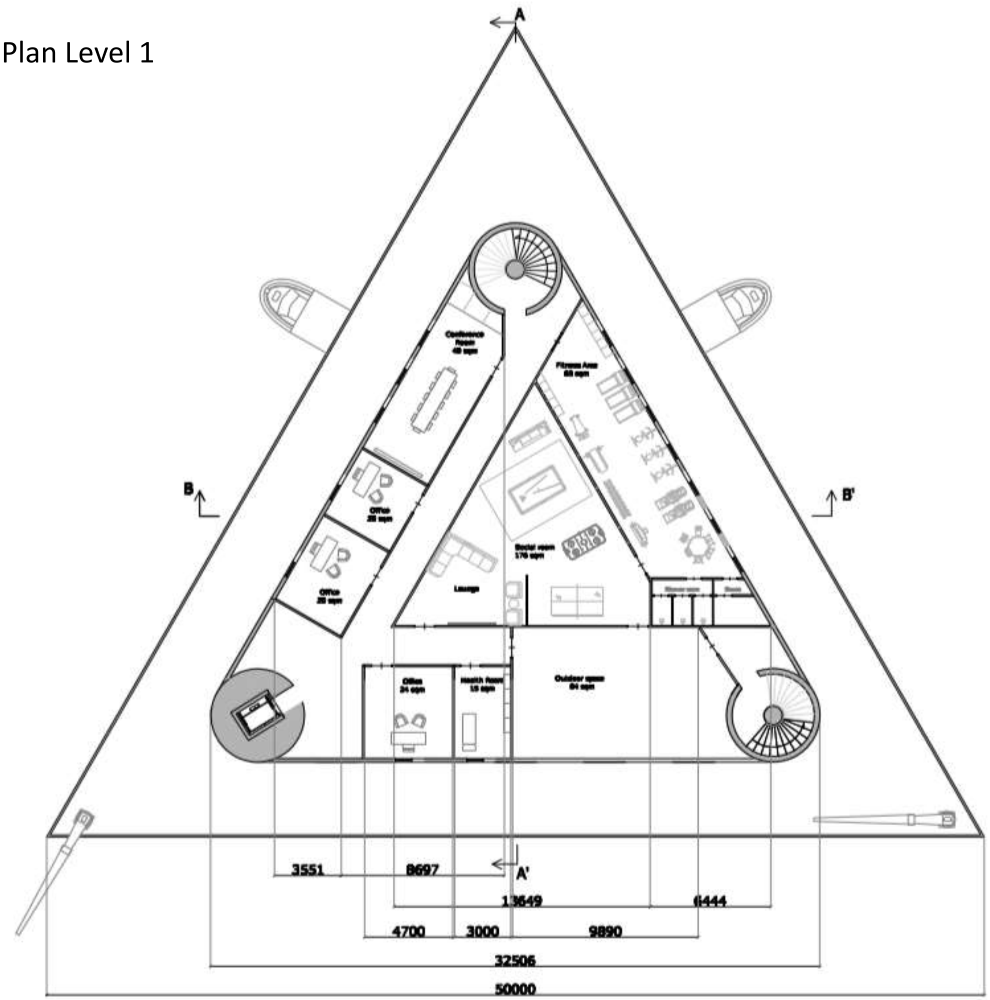
Storage, Restaurant, Outdoor Green

Area index	
Outdoor Common Green	59 sqm
Kitchen	54 sqm
Canteen	168 sqm
Food storage and Supermarket	130 sqm
Toilet	20 sqm
Laundry	7 sqm
Refrigerator	8 sqm

4.3 Concept 2.A:

Floating Tower

Plan Level 1



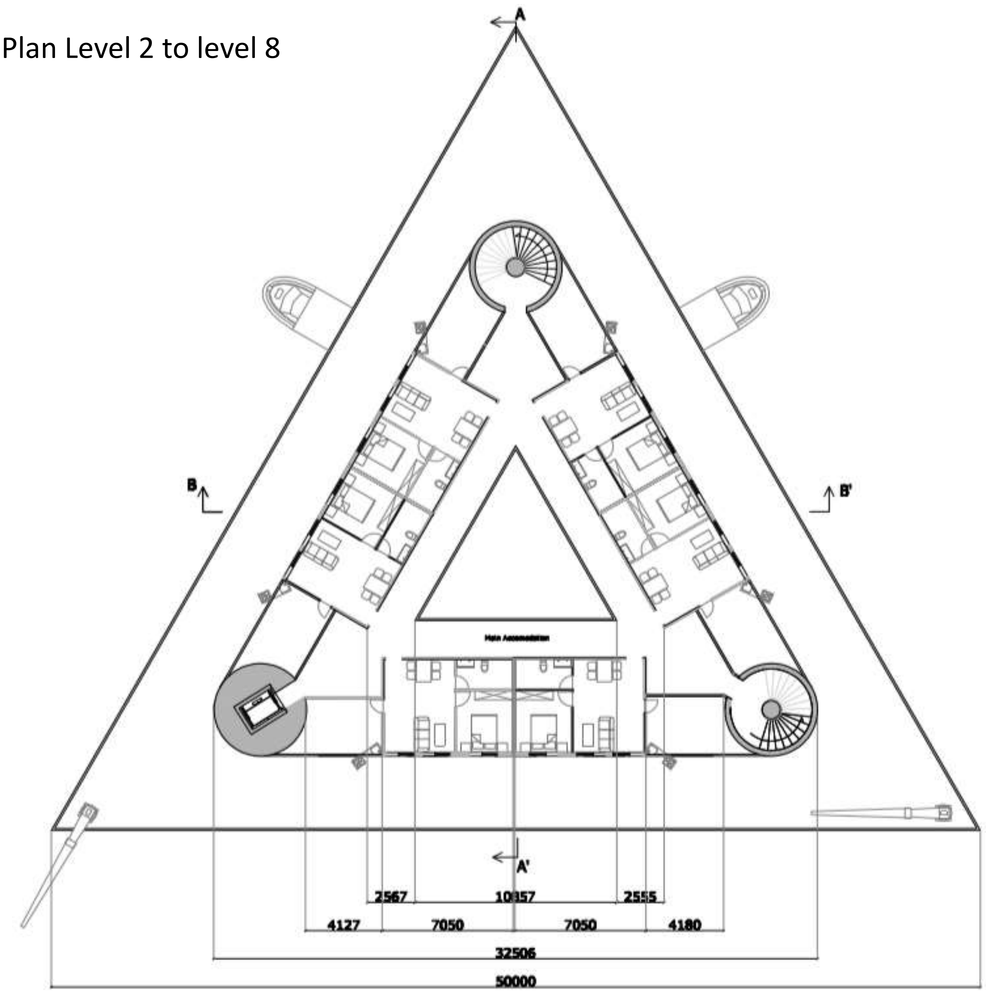
Offices, social, outdoor space

Area index	
Outdoor Space	84 sqm
Social (game + lounge)	76 sqm
Fitness	63 sqm
Conference	40 sqm
Heath Room	15 sqm
Office 1	20 sqm
Office 2	20 sqm
Office 3	24 sqm

4.3 Concept 2.A:

Floating Tower

Plan Level 2 to level 8



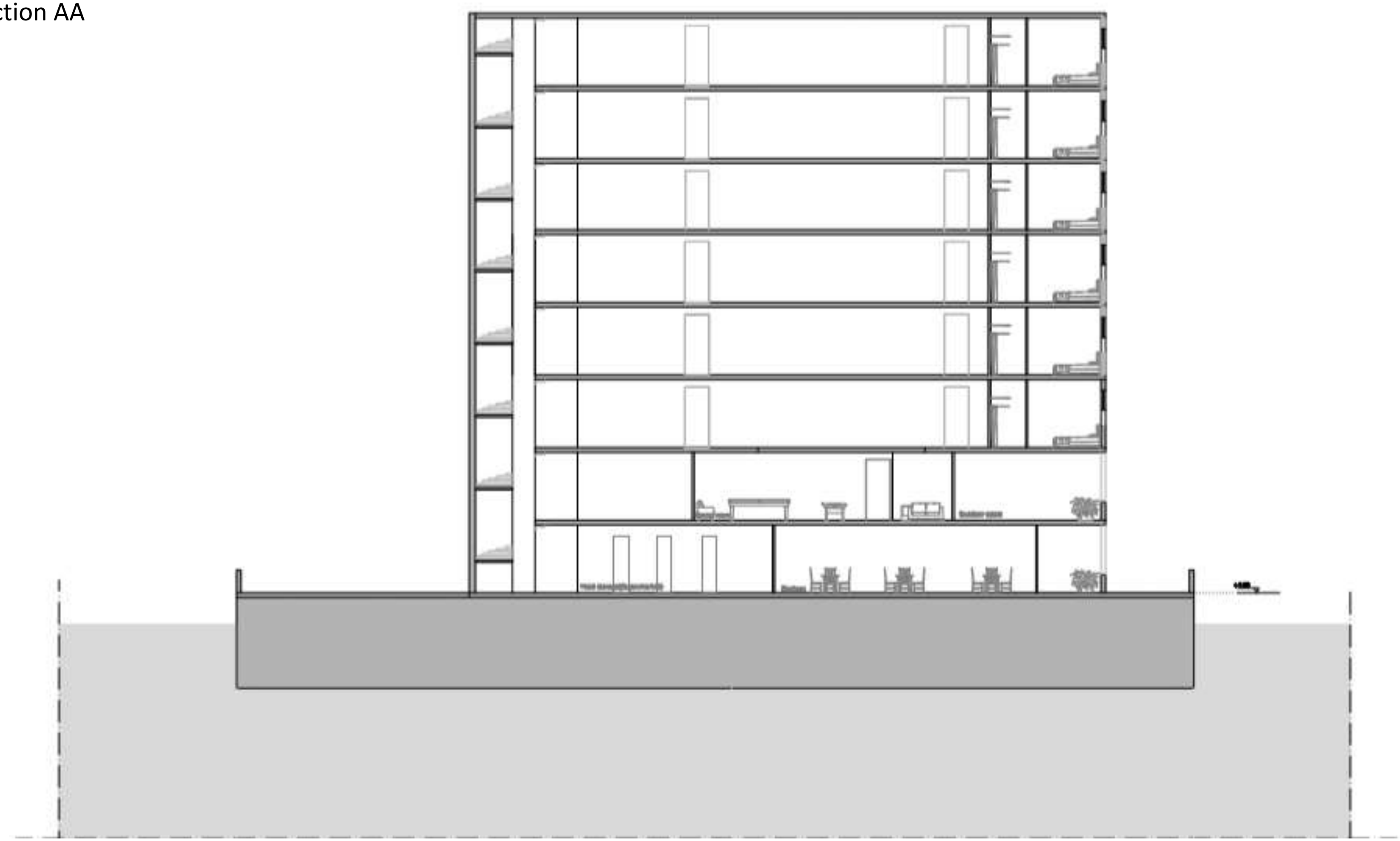
Apartments

Area index	
Apartments (6/floor 37 sqm each) Private Garden (1/ap. 15 sqm each)	222 sqm 90 sqm

4.3 Concept 2.A:

Floating Tower

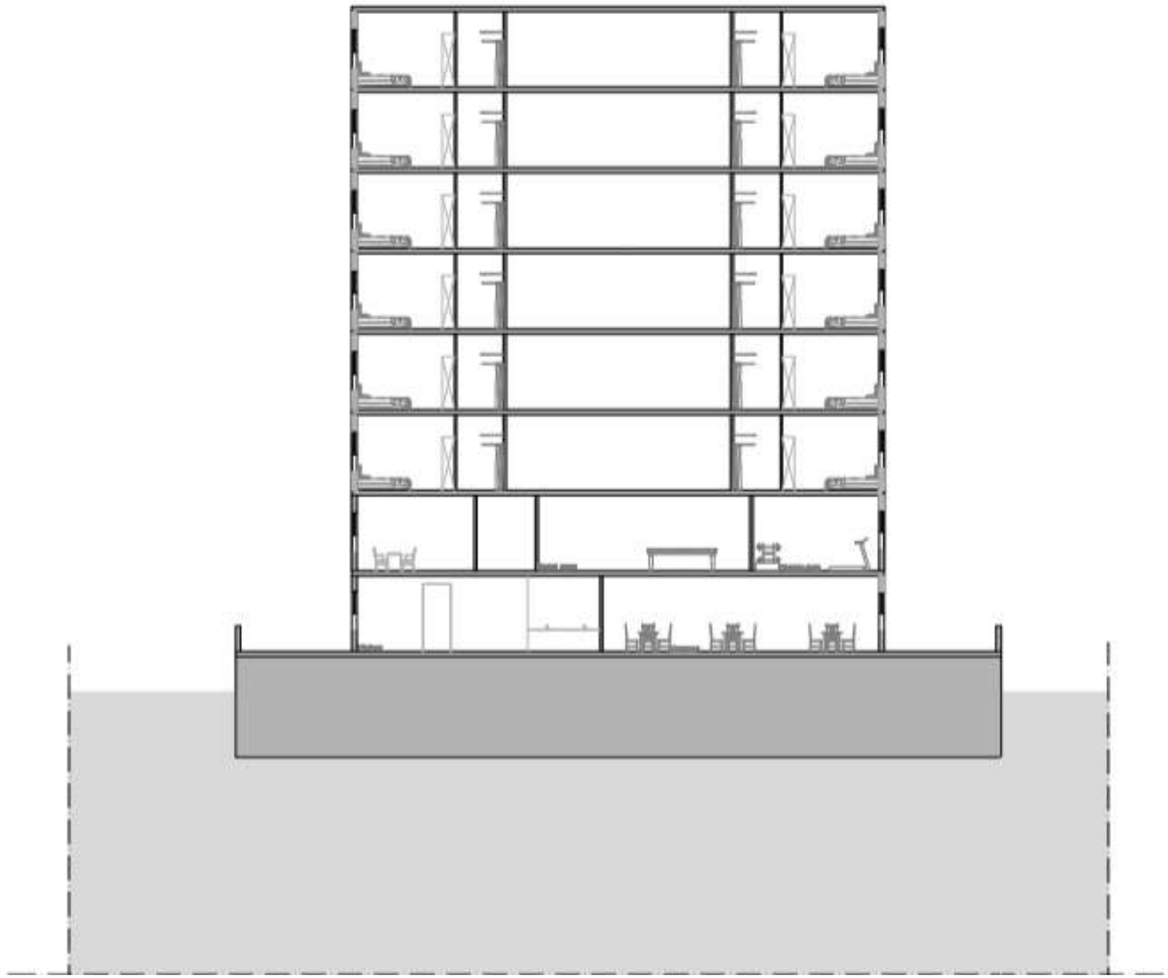
Section AA



4.3 Concept 2.A:

Floating Tower

Section BB



4.4 Concept 2.B:

Triangular Based Floating city

PLANAR SOLUTION

Study started at the triangular module platform of (50X50X50)m

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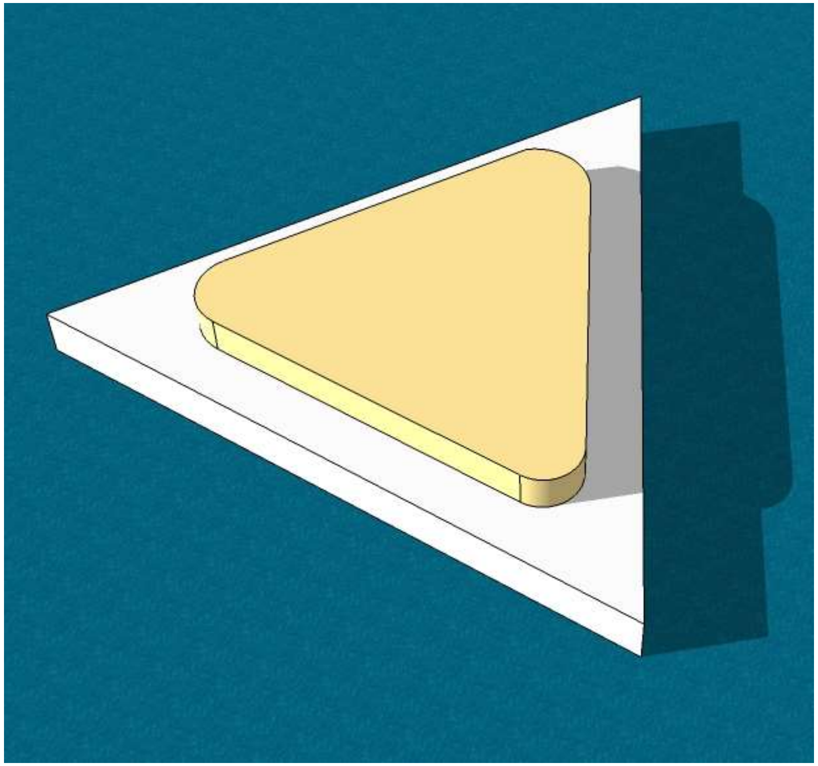
4.4 Concept 2.B:

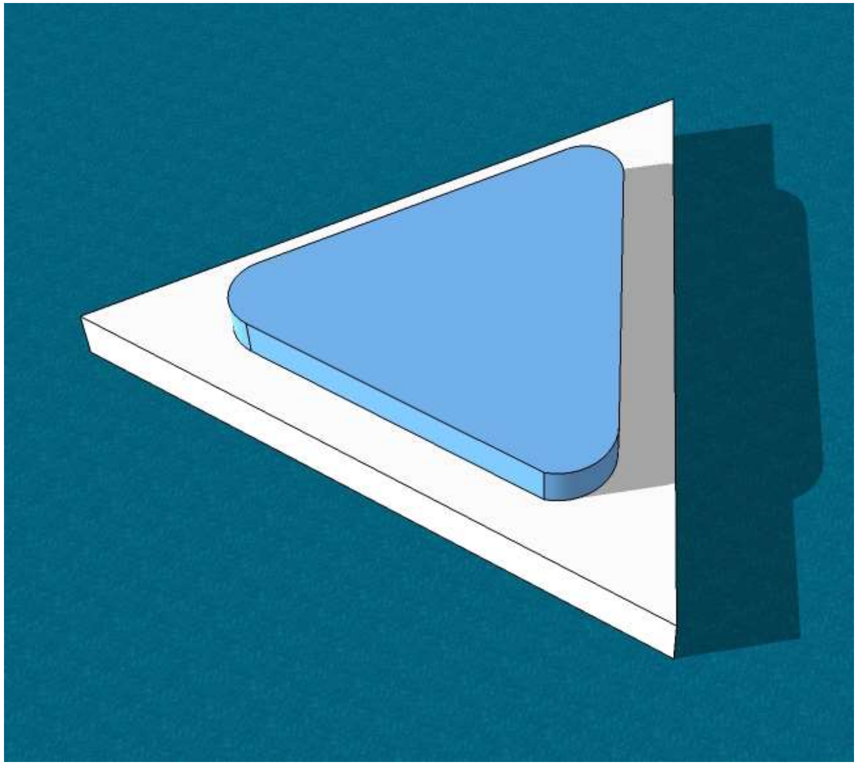
Compositive Schemes

BASIC MODULES

The solutions are made by two main functions: accommodation and facilities. The two modules can combined into different configurations



Accommodation



Facilities

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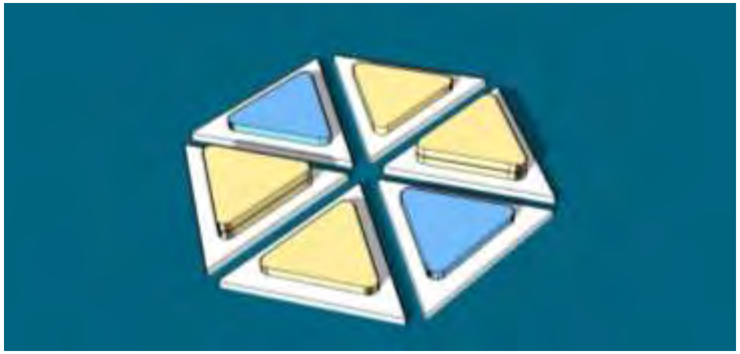
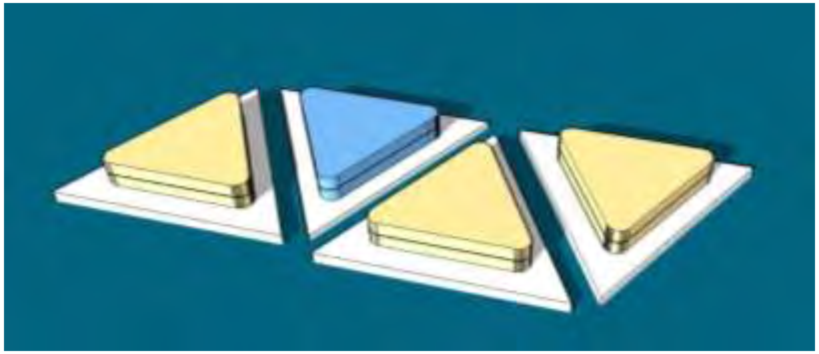
4.4 Concept 2.B:

INITIAL CONFIGURATION

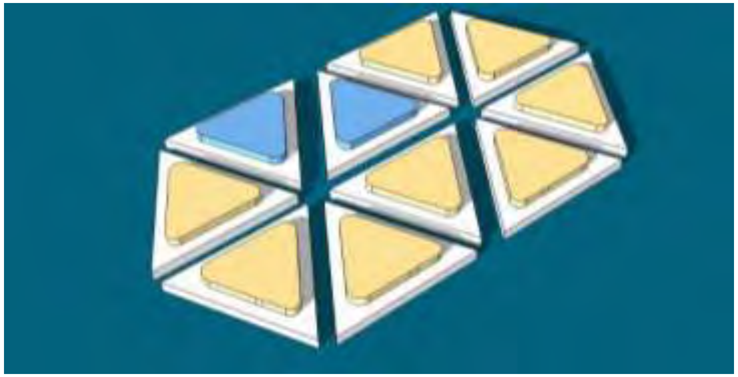
Each solution is made to answer the requirements of 32 families.



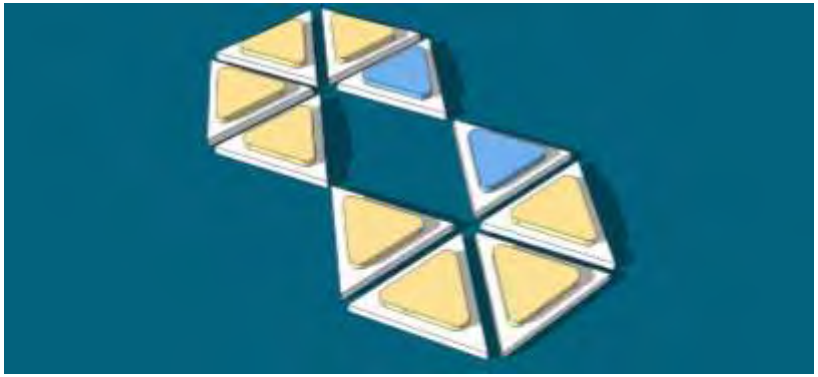
Layout 1



Layout 2



Layout 3



Layout 4

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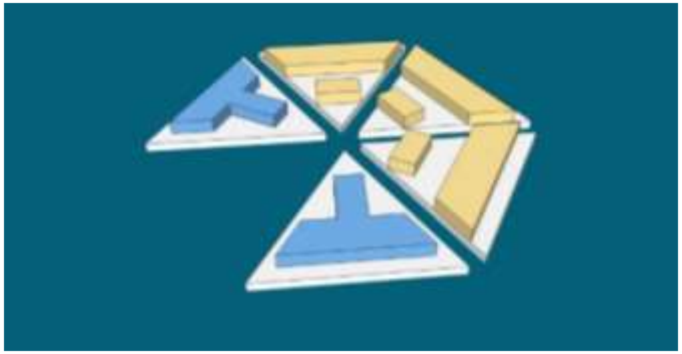
4.4 Concept 2.B1:

32 Apartments Floating City

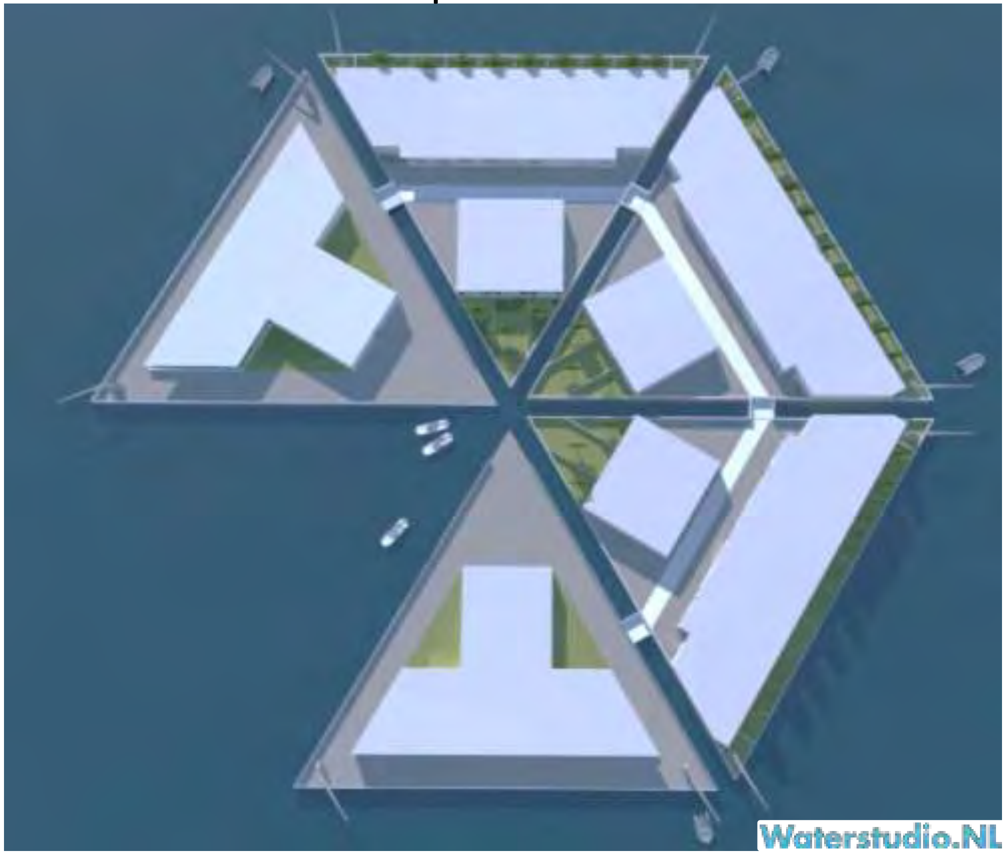
SCHEME 1: 3 accommodation blocks (11 apartments/platform) + 2 facility blocks

Basic Scheme



Side View

Top View

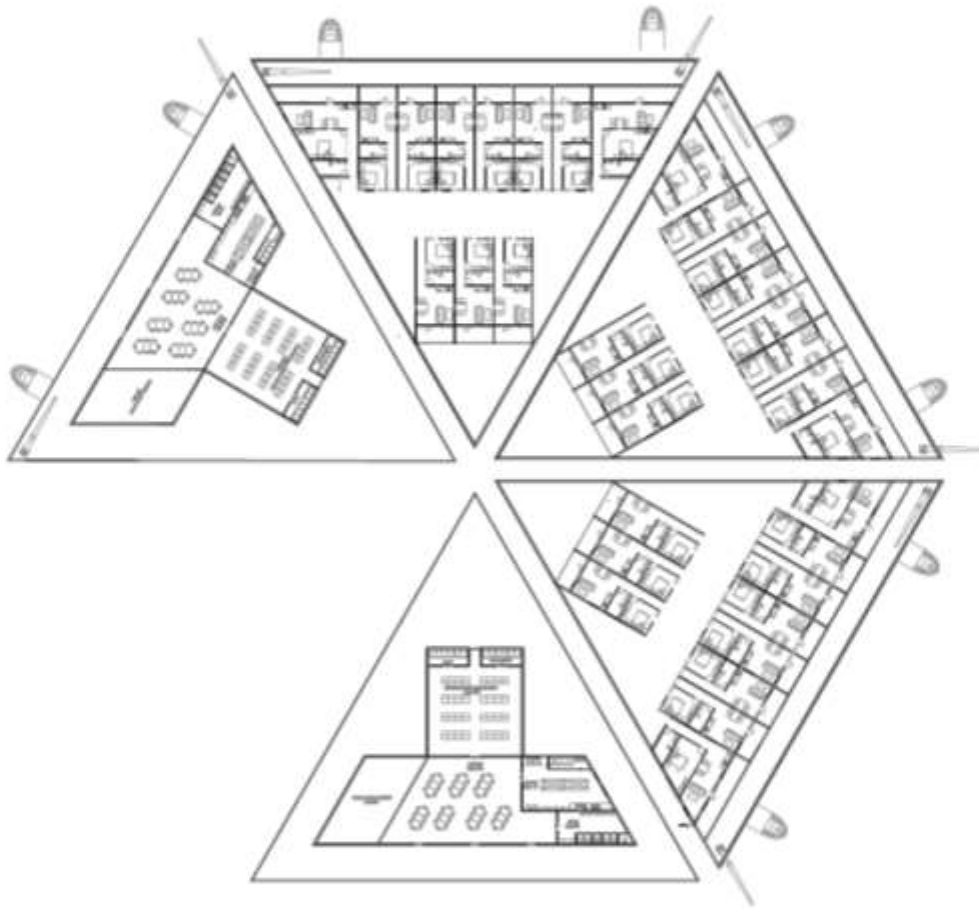


4.4 Concept 2.B1:

32 Apartments Floating City

SCHEME 1: 3 accommodation blocks (11 apartments/platform) + 2 facility blocks

Master plan



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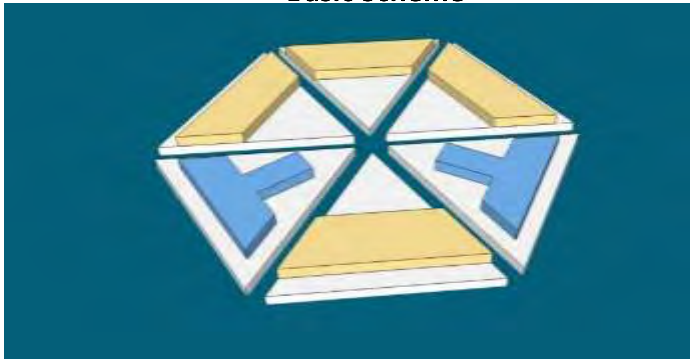
4.4 Concept 2.B2:

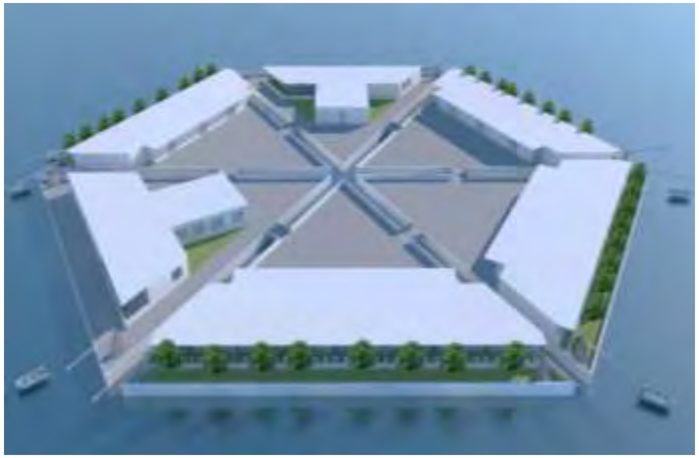
32 Apartments Floating City

SCHEME 2: 4 accommodation blocks (8 apartments/platform) + 2 facility blocks

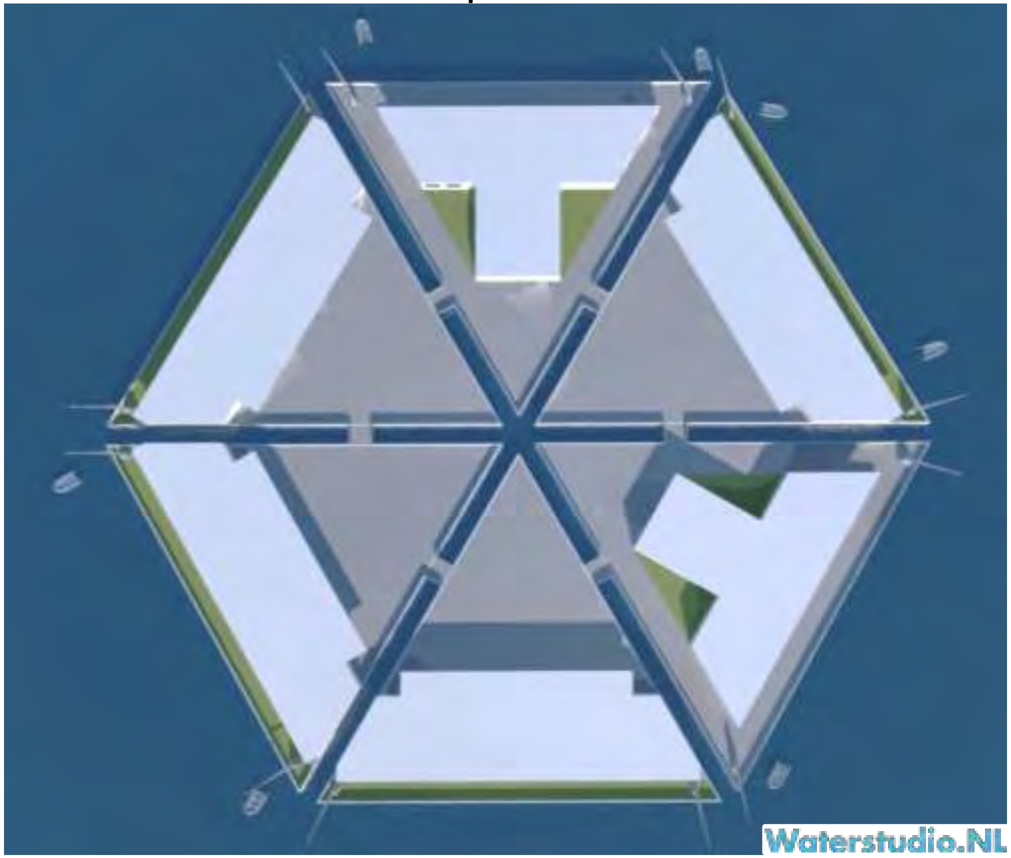
Basic Scheme



Side View



Top View

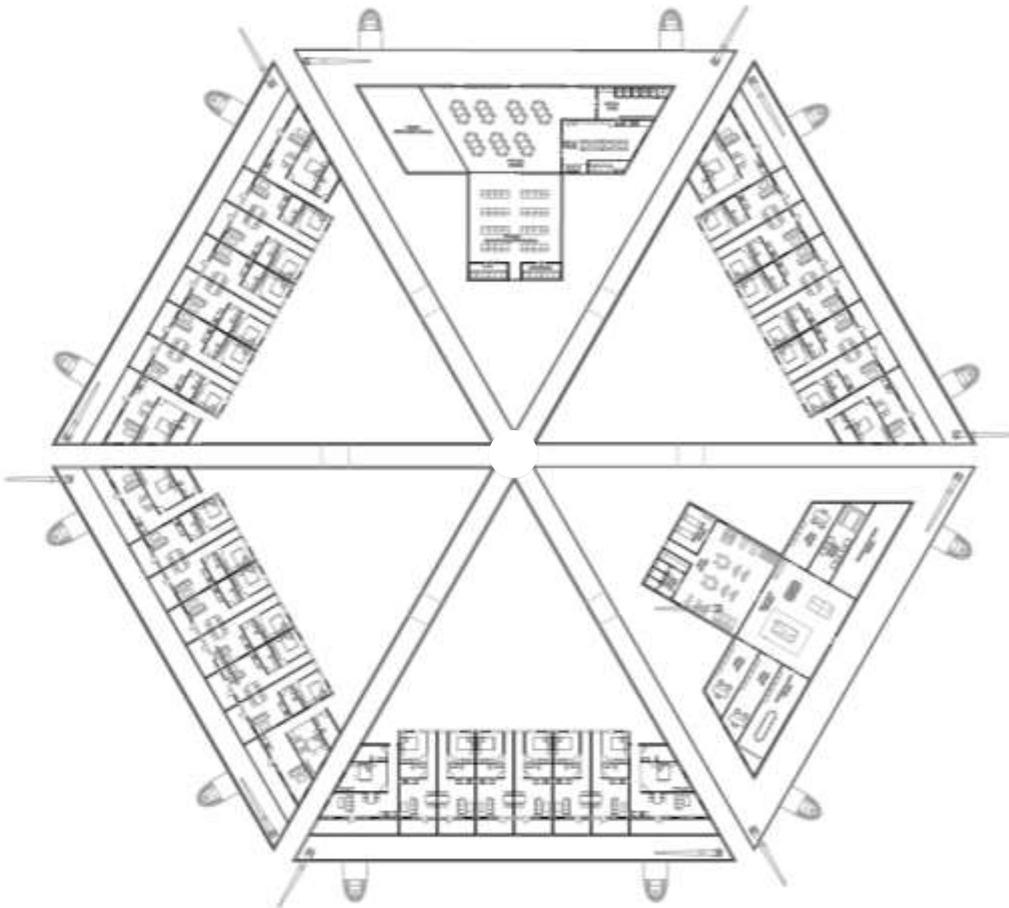


4.4 Concept 2.B2:

32 Apartments Floating City

SCHEME 2: 4 accommodation blocks (8 apartments/platform) + 2 facility blocks

Master plan



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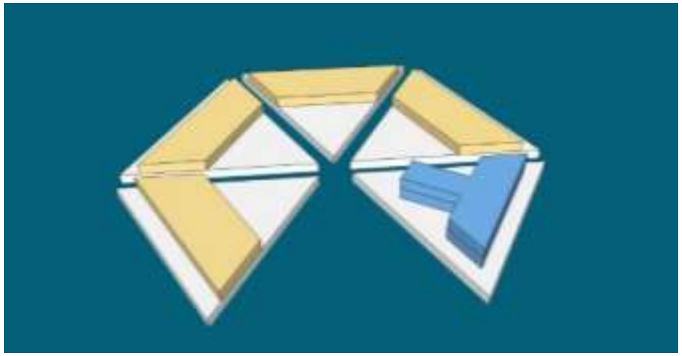
4.4 Concept 2.B3:

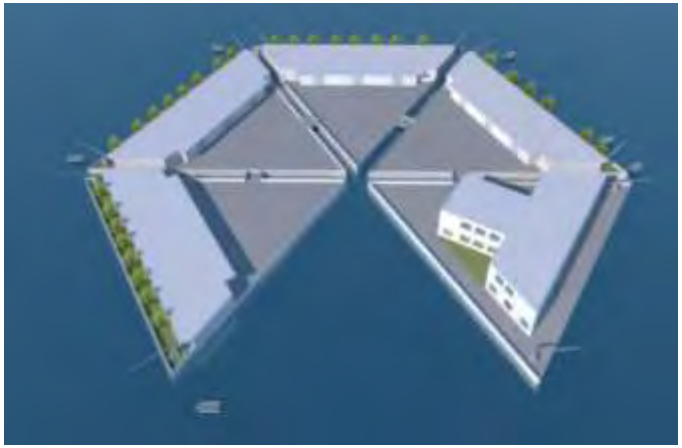
32 Apartments Floating City

SCHEME 3: 4 accommodation blocks (8 apartments/platform) + 1 facility block

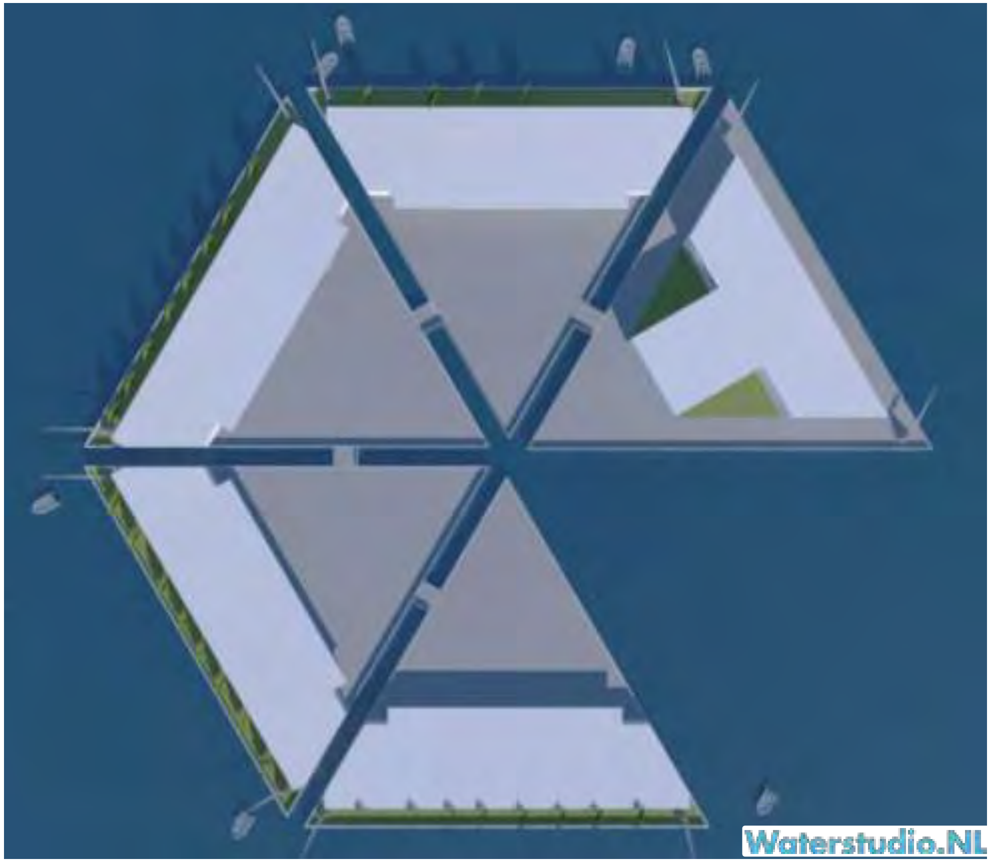
Basic Scheme



Side View



Top View

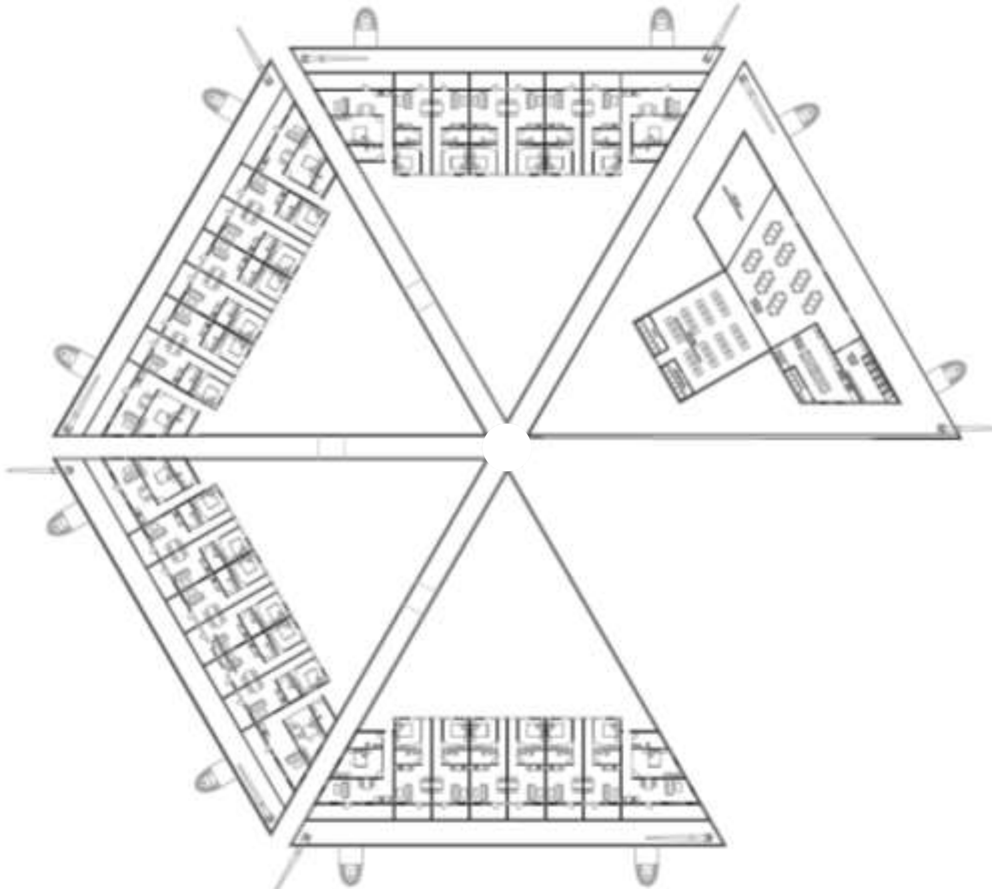


4.4 Concept 2.B3:

32 Apartments Floating City

SCHEME 3: 4 accommodation blocks (8 apartments/platform) + 1 facility block

Master plan



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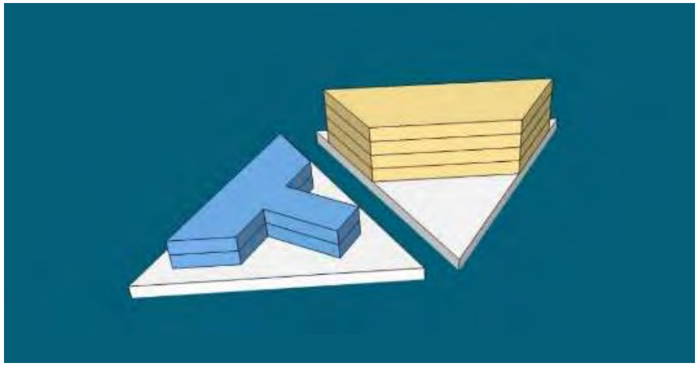
4.4 Concept 2.B4:

32 Apartments Floating City

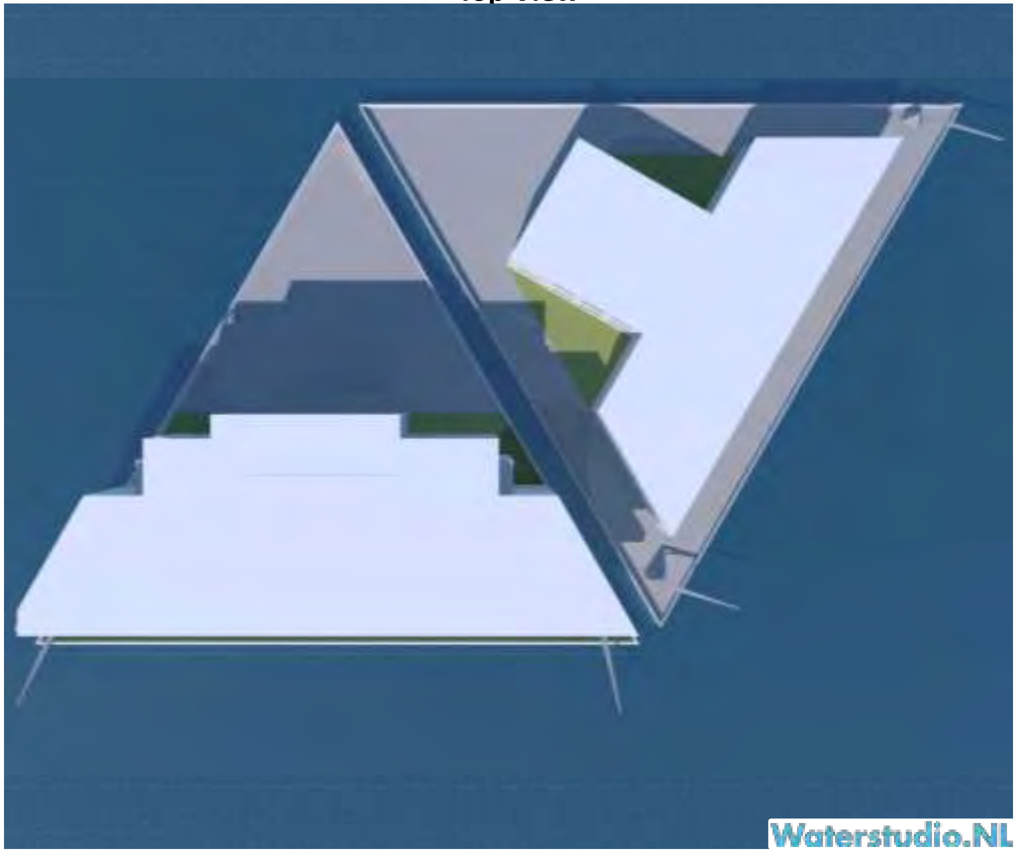
SCHEME 4: 1 accommodation blocks (32 apartments/platform) + 1 facility block

Basic Scheme



Side View

Top View

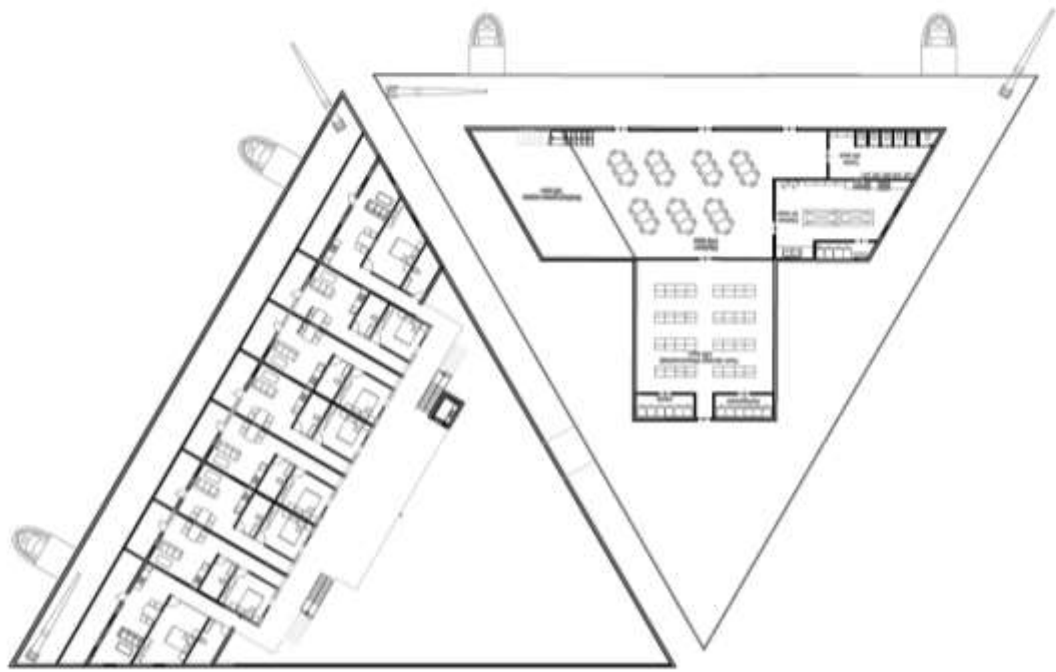


4.4 Concept 2.B4:

32 Apartments Floating City

SCHEME 4: 1 accommodation blocks (32 apartments/platform) + 1 facility block

Master plan



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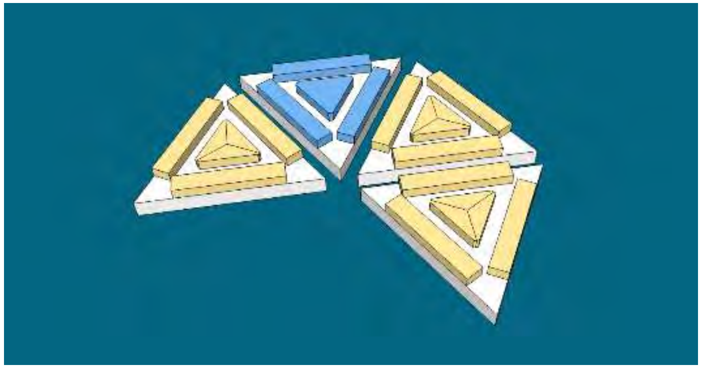
4.4 Concept 2.B5:

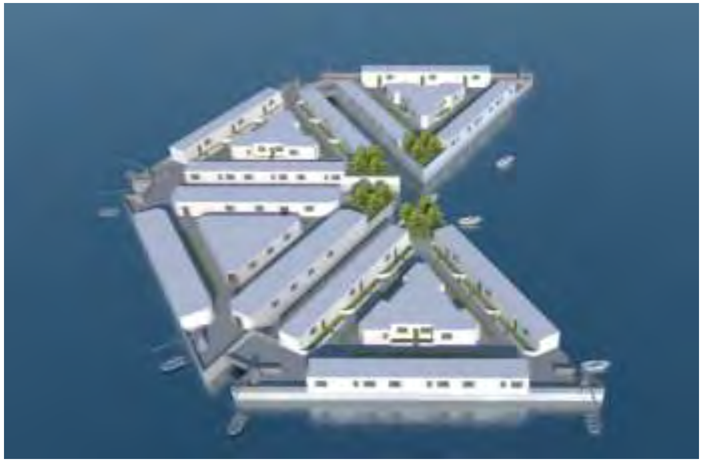
32 Apartments Floating City

SCHEME 5: 3 accommodation blocks (12 apartments/platform) + 1 facility block

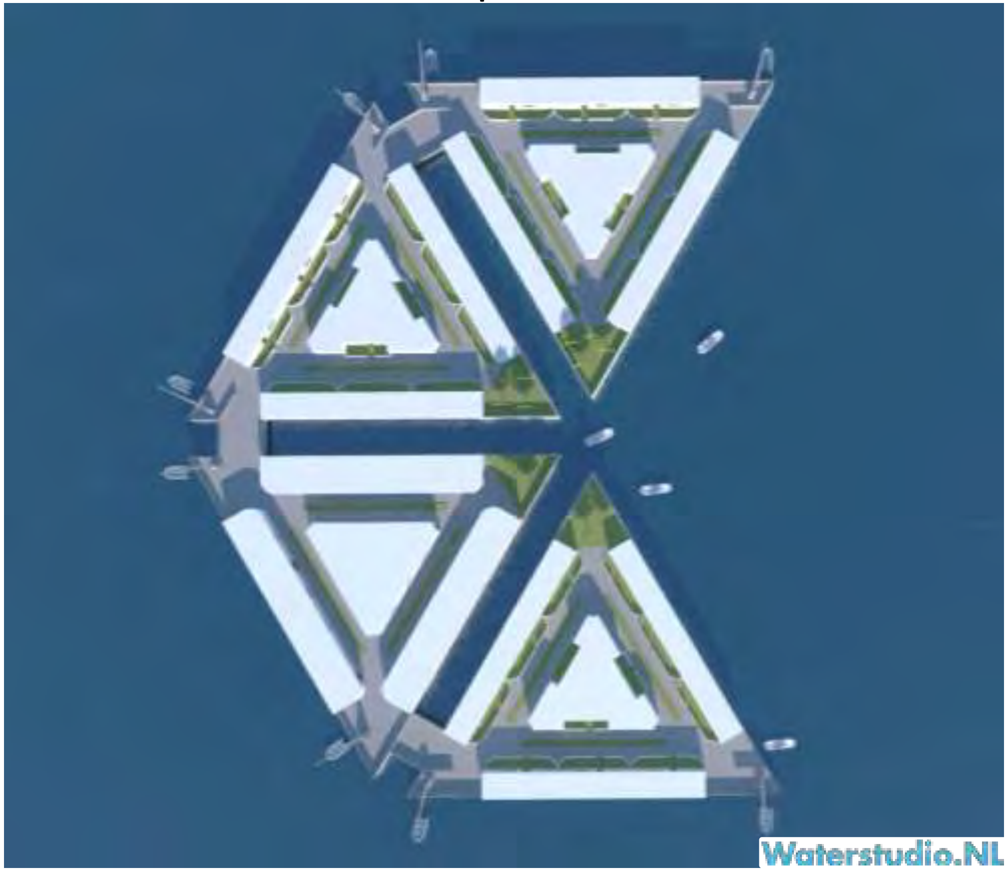
Basic Scheme



Side View



Top View

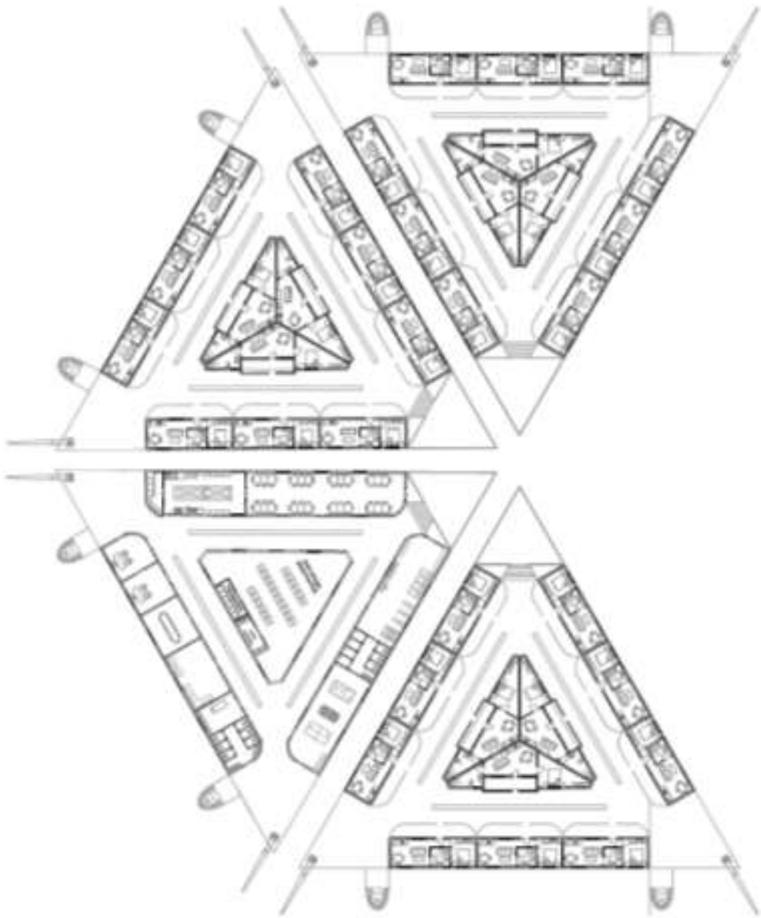


4.4 Concept 2.B5:

32 Apartments Floating City

SCHEME 5: 3 accommodation blocks (12 apartments/platform) + 1 facility block

Master plan



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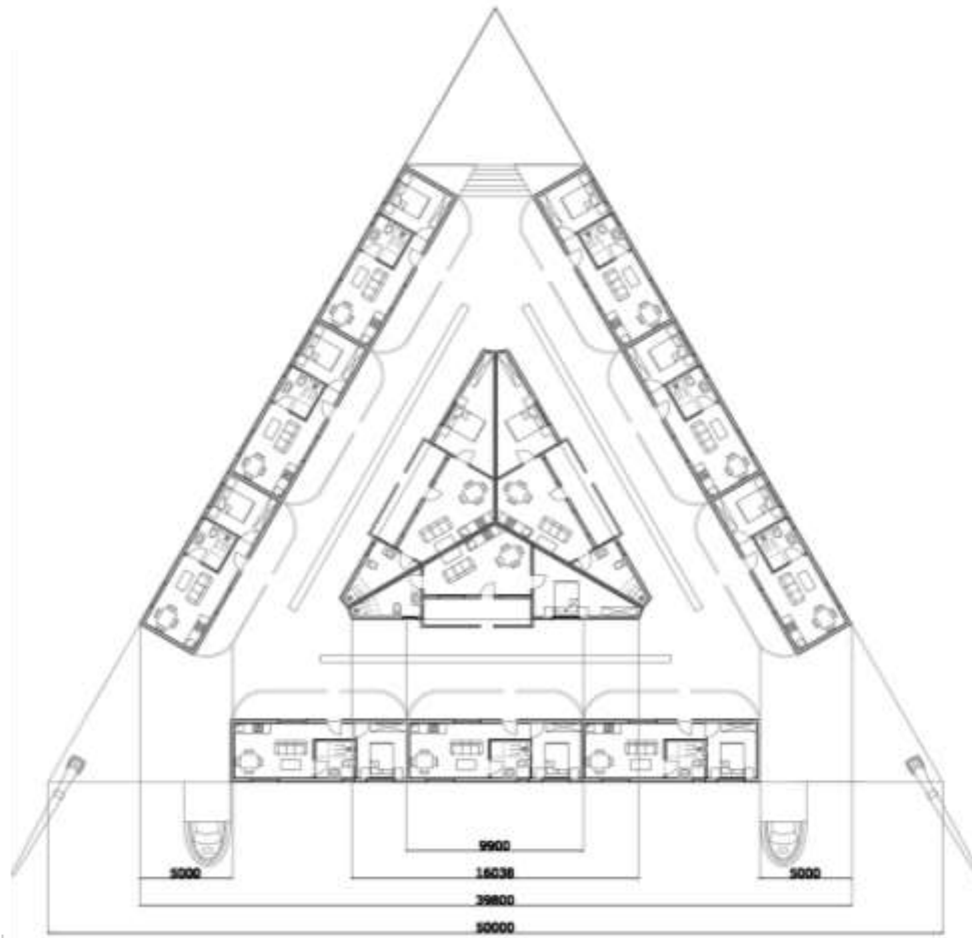
4.4 Concept 2.B5:

32 Apartments Floating City

Plan accommodations



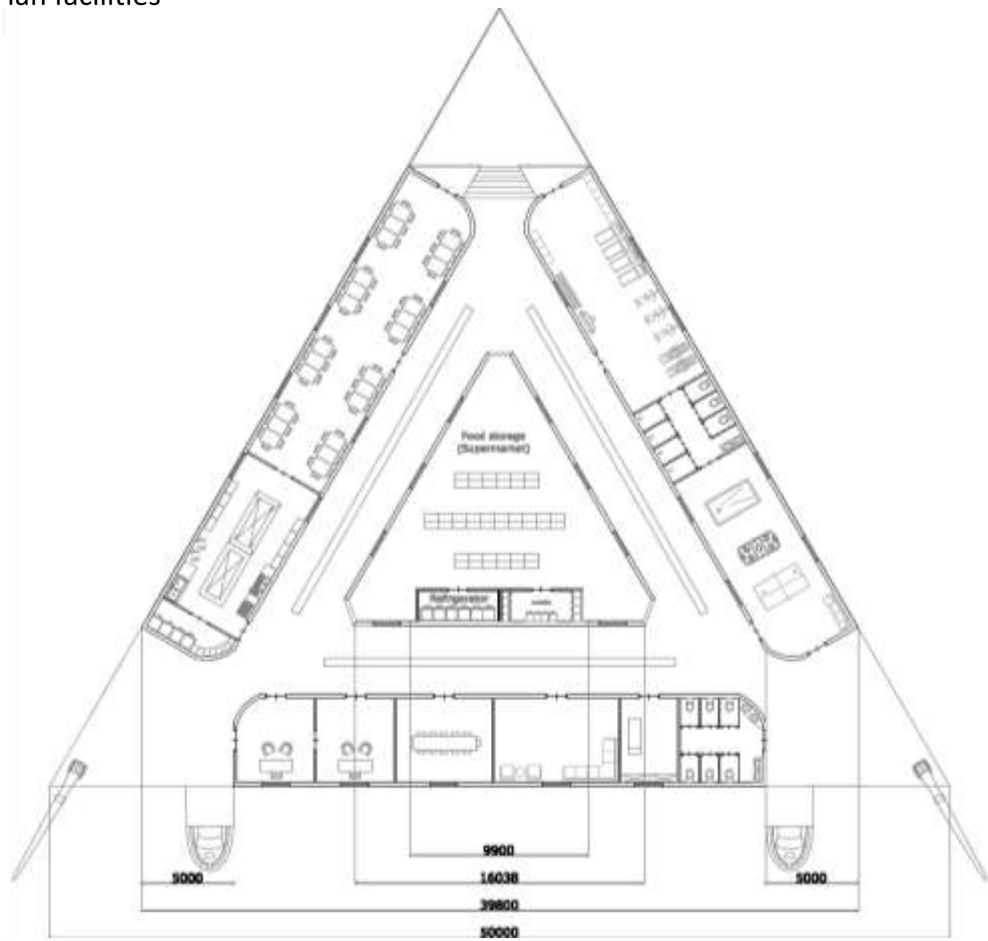
Apartments

Area index	
Apartments (9/block of 35 sqm)	315 sqm
Apartments (3/block of 50 sqm)	150 sqm

4.4 Concept 2.B5:

32 Apartments Floating City

Plan facilities



Offices, social, outdoor space

Area index	
Outdoor Space	84 sqm
Social (game + lounge)	76 sqm
Fitness	63 sqm
Conference	40 sqm
Heath Room	15 sqm
Office 1	20 sqm
Office 2	20 sqm
Office 3	24 sqm

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4.4 Concept 2.B5:

32 Apartments Floating City

Side view

4.4 Concept 2.B5:

32 Apartments Floating City

IMPRESSION

View From the green area

5. Concept 3 :

Offshore Square Based Platform

- 5.1: Program of Demands
- 5.2: Initial compositional scheme
- 5.3: Concept 1.A Mediterranean Sea Option
- 5.4: Concept 1.B North Sea Option

5. Concept 1:
Offshore Platforms

Program of demands

Functional requirements for accommodation building

- In the document “List of requirements of the O&M hub”, a list of requirements that includes space for 32 people is proposed.

5.1 Concept 1:

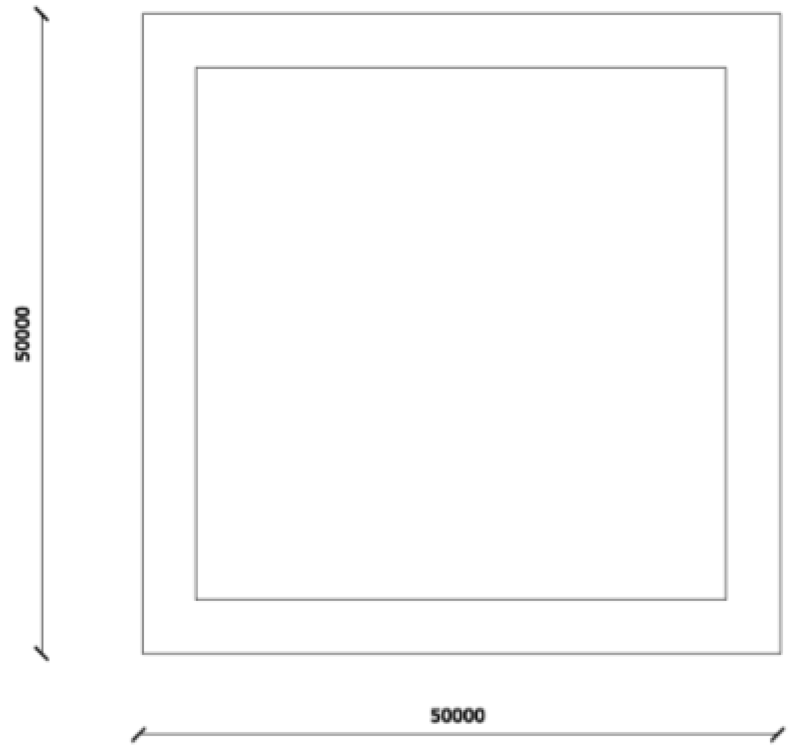
Program of demands

Program of demands	m^2 (NFA)	Description
Single rooms	400	min. $12m^2$ each - windows to the outside - bath with toilet and shower - desk, chairs, wardrobe - heating, air condition, ventilation
Corridors	200	no daylight necessary - heating, air condition, ventilation
Kitchen + canteen	150	kitchen with stoves, ovens, air exhaust systems, refrigerators, freezers, boards, dishwashers - canteen for 32 persons with counters, heated wells, dishwashers, cupboards, windows to outside - sanitary rooms - heating, air condition, ventilation
Food storage	100	storage rooms for food with a capacity of 30 days - refrigeration chamber with a capacity of 30 days - house service room with storage of cleaning agents and other consumables, vacuum cleaner - laundry with washing machines, tumble dryers, linen cupboards, with ventilation
Offices	20	
Conference	25	
Health room	15	
Social rooms	30	gym etc.
Total, accommodation building	**940**	

5.2 Concept 3:

Initial compositional scheme

This concept is based on a square shaped floating platform, L: 50.
The plans have been studied to answer to the requirements mentioned in the program of demands.

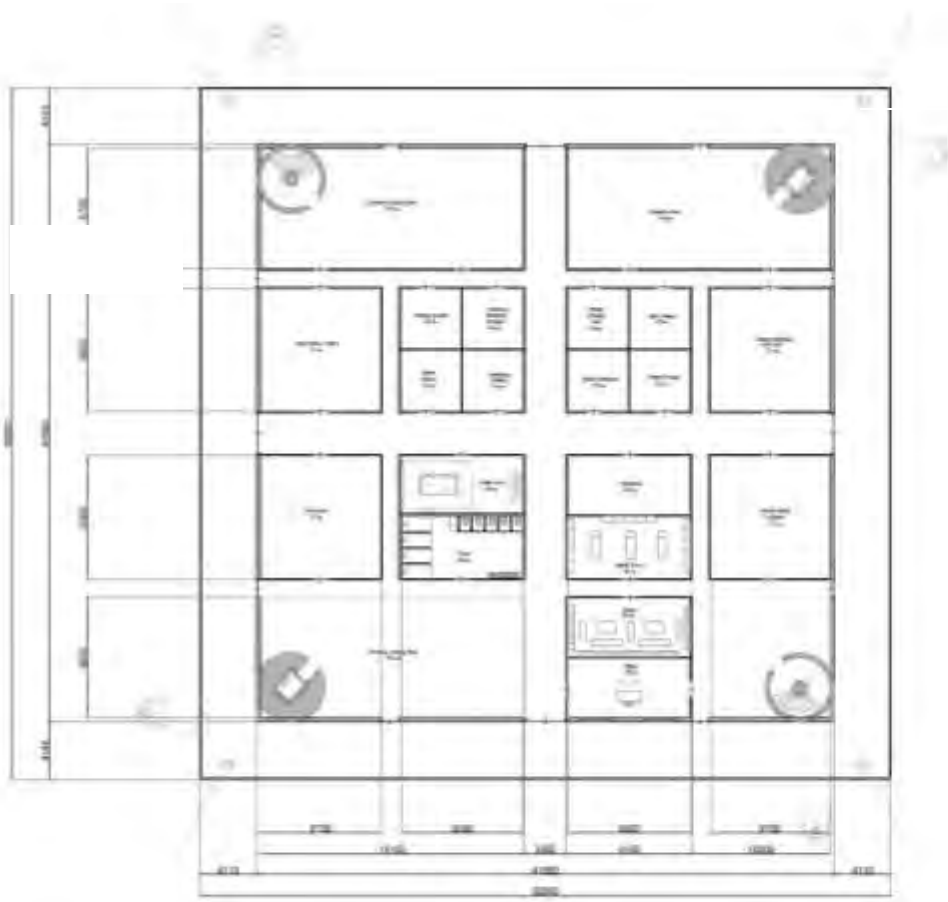


Phase 1

5.3 Concept 3.A:

Mediterranean Sea

Plan Level 0



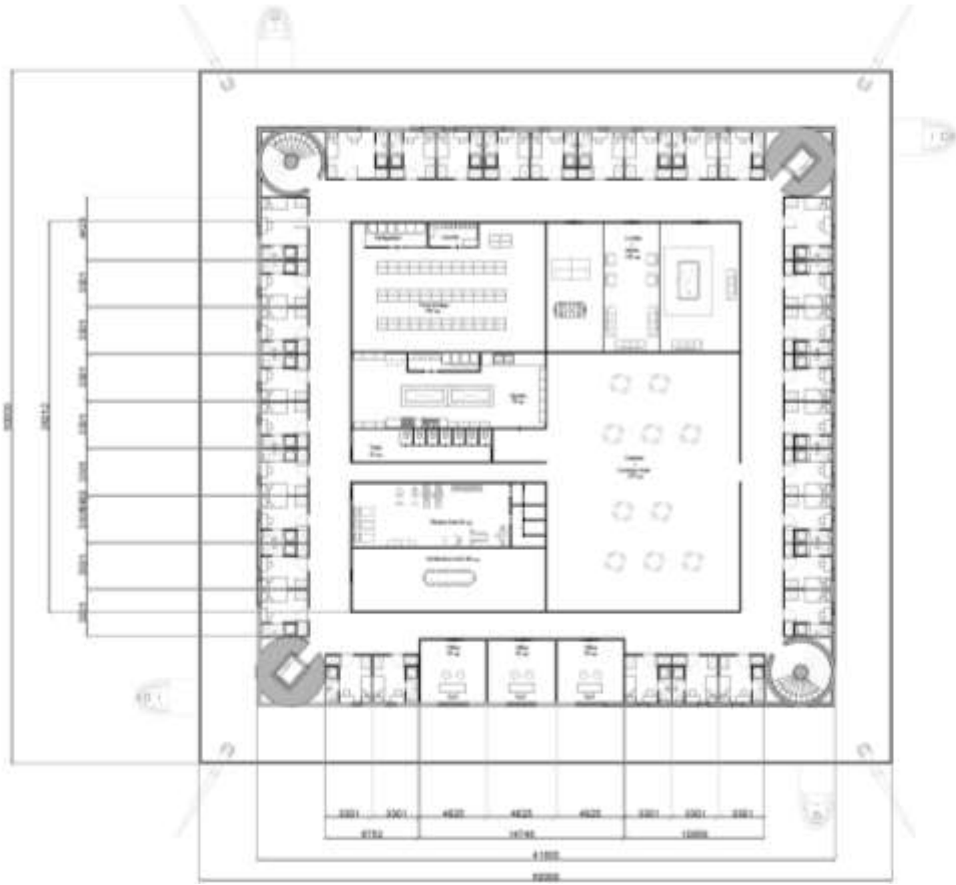
Storage, hall and quay

Area index	
2 doors and 3x3m hall door on each side	
Turbines stock area	47 sqm
Parking, loading area	82 sqm
Container storage area	33 sqm
Locker room	38 sqm
Office	38 sqm
Toilet	38 sqm
Reserve Area	140 sqm
Workshop	38 sqm
Hazardous materials storage	20 sqm
Waste storage tank	20 sqm
Water distillation reserve	77 sqm
Waste water treatment	77 sqm
Heating system	20 sqm
Warm water	20 sqm
Diesel Generator station	20 sqm
Ventilation System	20 sqm
Diesel storage	20 sqm

5.3 Concept 3.A:

Mediterranean Sea

Plan Level 1



Storage, restaurant, offices accommodation

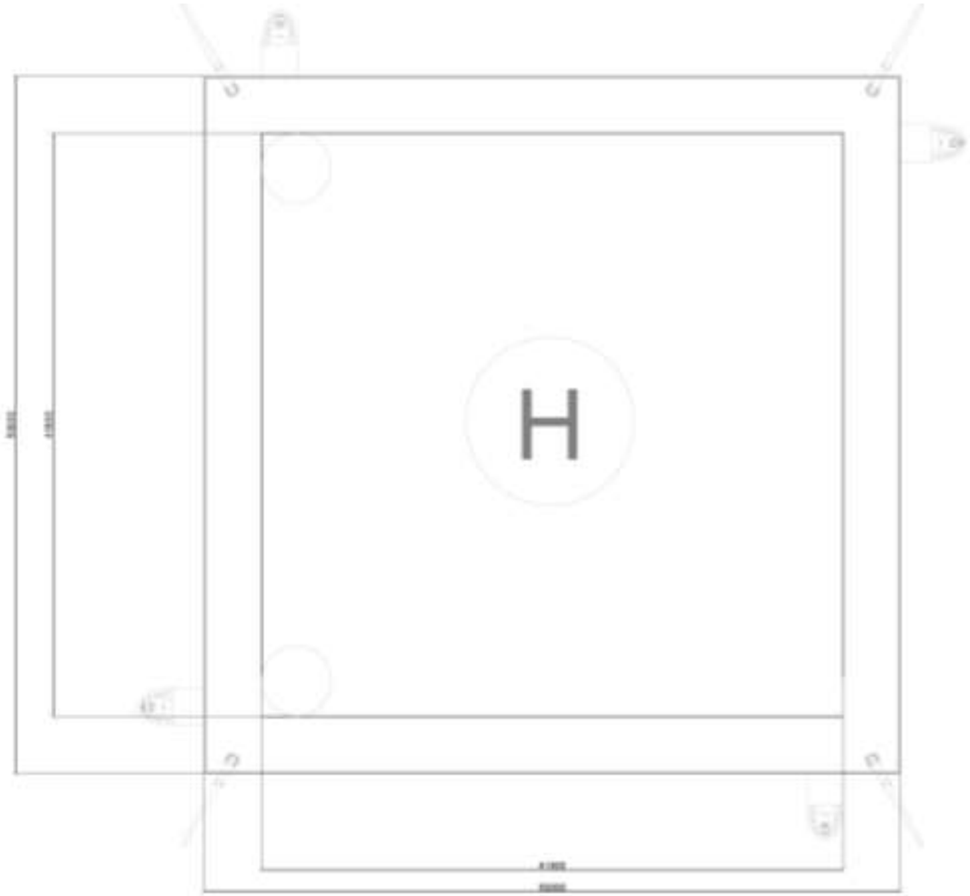
Area index		
Rooms 12 sqm x n.32	384	sqm
Kitchen	75	sqm
Canteen + Common Area	270	sqm
Food storage and house service	130	sqm
Office 22 sqm x n.3	66	sqm
Toilet	23	sqm
Relax area	130	sqm
Fitness	60	sqm
Conference	60	sqm

5.3 Concept 3.A:

Mediterranean Sea

Plan Level 2

Rooftop



5.4 Concept 3.B:

North Sea

Plan Level 1

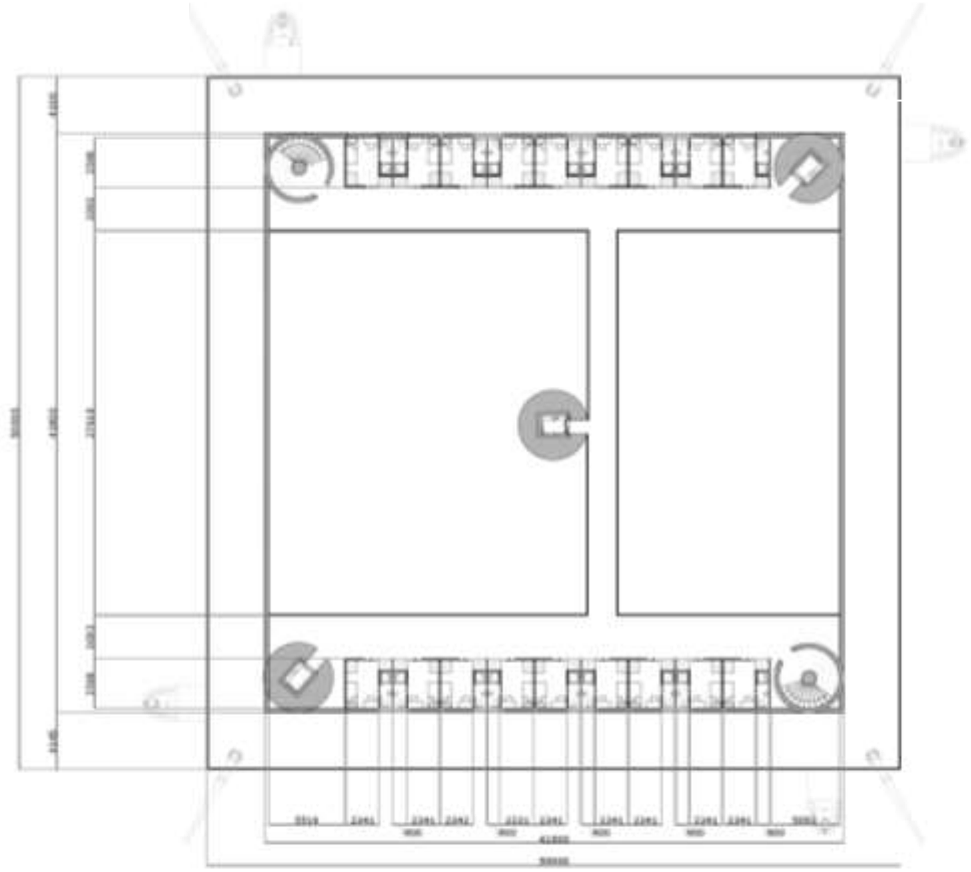
Storage, hall and quay, facilities

Area index		
2 doors and 3x3m hall door on each side		
Turbines stock area	38	sqm
Parking, loading area	150	sqm
Container storage area	88	sqm
Locker room	37	sqm
Office	10	sqm
Workshop	10	sqm
Hazardous materials storage	11	sqm
Waste storage tank	11	sqm
Water distillation reserve	38	sqm
Waste water treatment	38	sqm
Heating system	10	sqm
Warm water	10	sqm
Diesel Generator station	10	sqm
Ventilation System	5	sqm
Diesel storage	10	sqm
Electric system	5	sqm

5.4 Concept 3.B:

North Sea

Plan Level 1



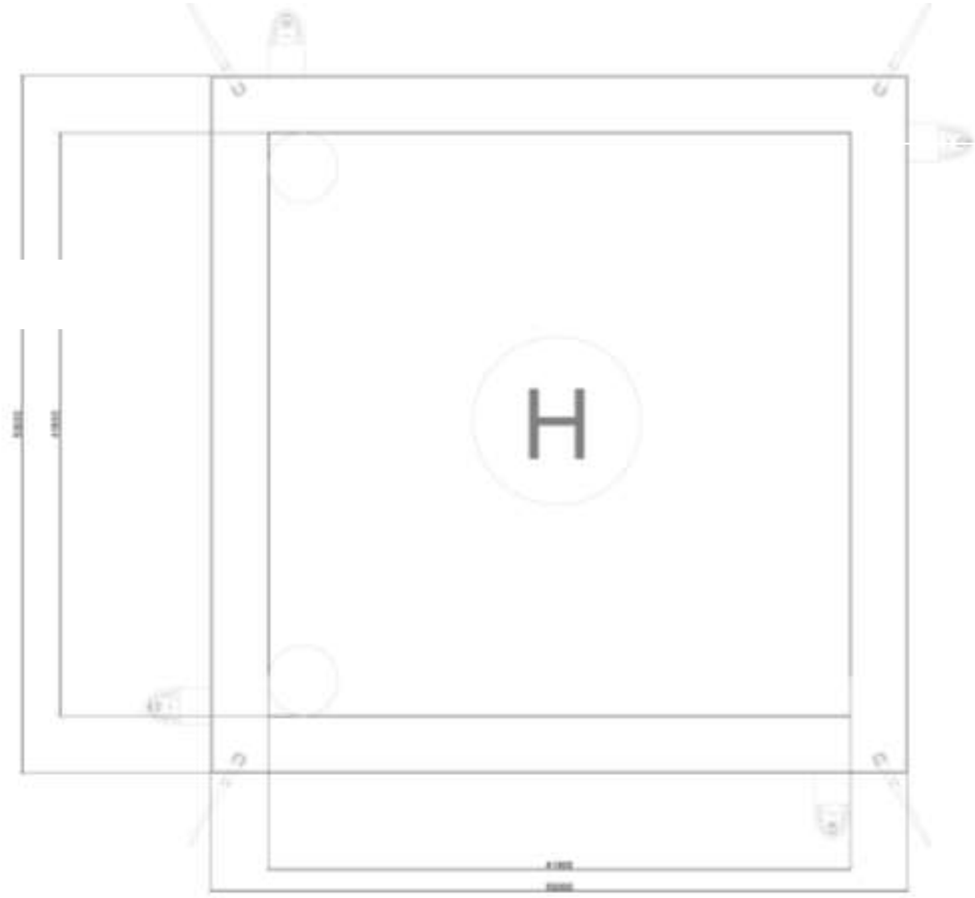
Rooms

Area index	
Rooms 18 (19sqm/ap)	342 sqm

5.4 Concept 3.B:

North Sea

Plan Level 2



Rooftop

6. Concept 4:

Square Based Floating Platform

- 6.1: Program of Demands
- 6.2: Initial compositional scheme
- 6.3: Concept 4.A Square Based Floating Tower
- 6.4: Concept 4.B Square Based Apartments Floating City

6.1 Concept 4:

Program of demands

Functional requirements for accommodation building based on:

- The interview (D7.1 report) at offshore workers, that expressed the preference to increase the living space and also the possibility to receive family visits
- Necessity of 32 apartments at list
- The Bouwbesluit (Dutch Building Code).

6.1 Concept 4:
Program of demands

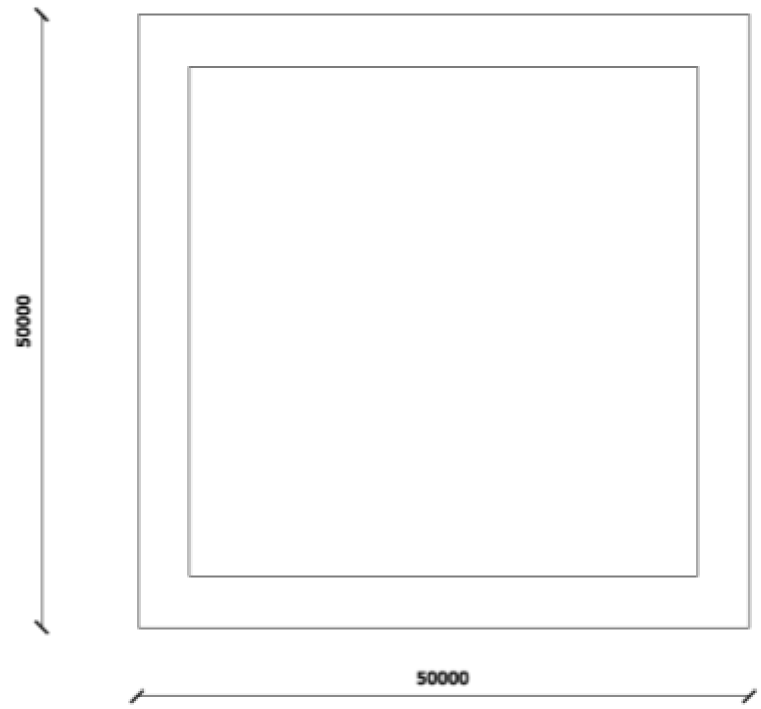
	m² (NFA)	Description
Mini Flats	1120	~ 35 m² each - windows to the outside - bathroom with toilet and shower - separation between living and sleeping area - kitchen - heating, air condition, ventilation
Corridors/Stairs	480	no daylight necessary - heating, air condition, ventilation
Kitchen + canteen	240	kitchen with stoves, ovens, air exhaust systems, refrigerators, freezers, boards, dishwashers – canteen for 30 persons with counters, heated wells, dishwashers, cupboards, windows to outside - sanitary rooms - heating, air condition, ventilation
Food storage (Small Supermarket)	130	storage rooms for food with a capacity of 30 days - house service room - laundry with washing machines
Social Room	176	fitness, sauna/ showers, game room (pool, table, lounge)
Offices	64	
Conference	40	
Health room	15	
Outdoor space	250-500 (depending on the platform)	Green (180-360 m², based on 9m² p.p.) with plants and bushes, should be accessible most of the time and should be safe, accessible without addition safety measures.
Total, accommodation building	**940**	

6.2 Concept 4:

Initial compositional scheme

This concept is based on a square shaped Floating platform, L: 50. Inside of it the plans are designed to satisfy a program of demand based on the interview at offshore workers, that expressed the preference to increase the living space and also the possibility to receive family visits.

Phase 1



6.3 Concept 4.A:

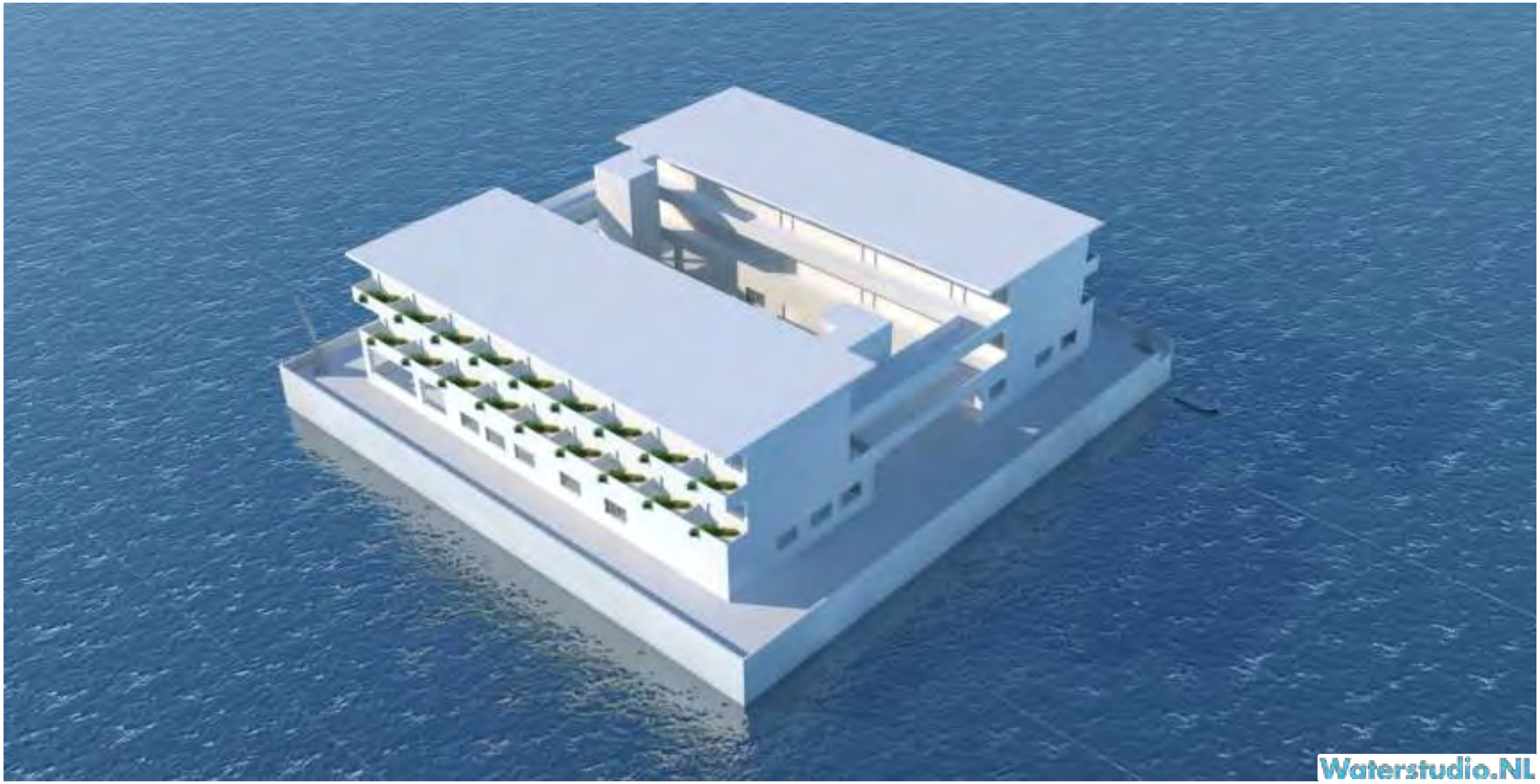
Square Based Floating Tower

This floating tower is designed to accommodate 36 families. The first level is for common activities and facilities, the other two levels, are each provided with 18 apartments of 40 sqm per apartment.

6.3 Concept 4.A:

Square Based Floating Tower

Each apartment is provided with its own green exterior area.



6.3 Concept 4.A:

Square Based Floating Tower

Plan Level 0

Storage, Restaurant, Outdoor Green

Area index	
Indoor Common Area	330 sqm
Outdoor Common Area	470 sqm
Kitchen	54 sqm
Canteen	168 sqm
Food storage and Supermarket	130 sqm
Toilet	20 sqm
Laundry	7 sqm
Refrigerator	8 sqm
Office room	64 sqm
Conference room	40 sqm
Health room	15 sqm
Social room	176 sqm
Fitness area	52 sqm

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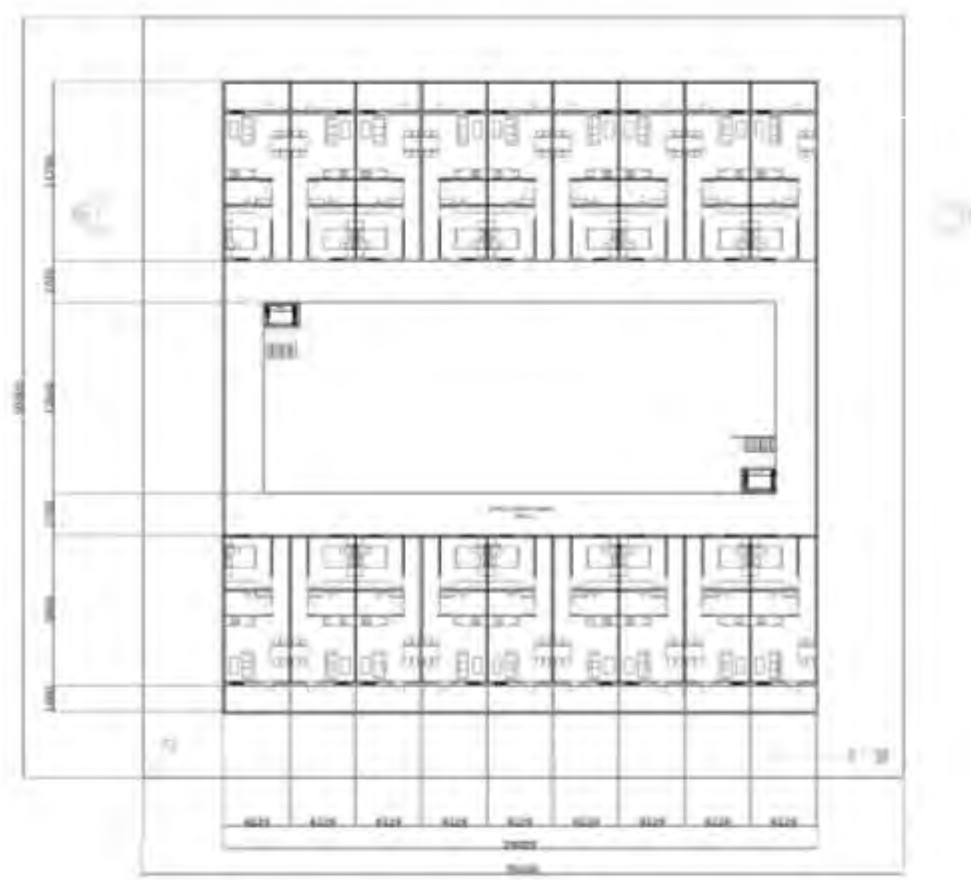
6.3 Concept 4.A:

Square Based Floating Tower

Plan Level 1 and 2



Apartments and outdoor space

Area index	
Outdoor Space Apartments (18 of 40sqm each)	280 sqm 720 sqm

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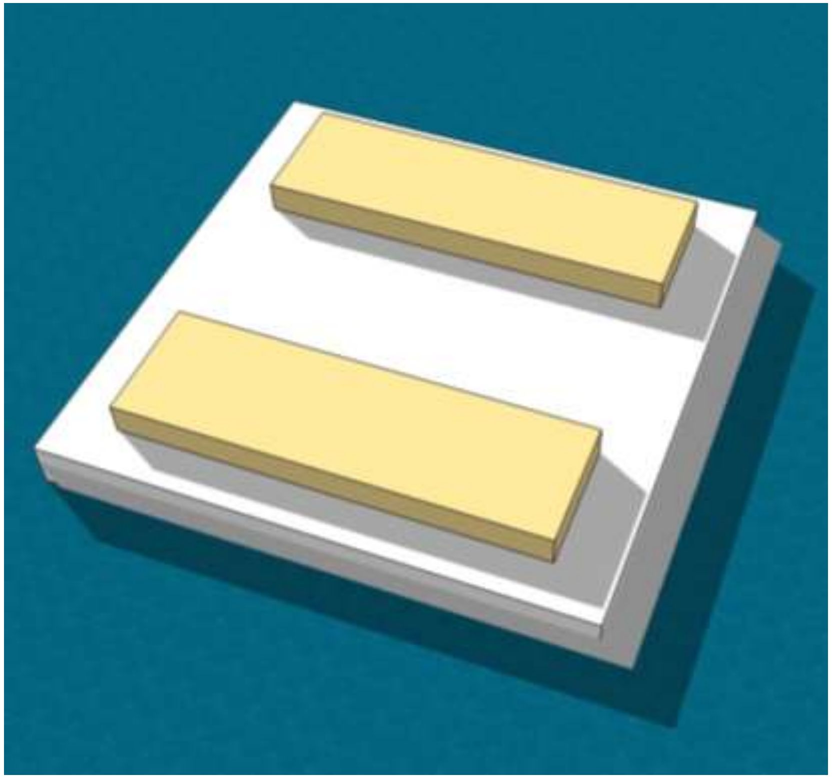
6.4 Concept 4.B:

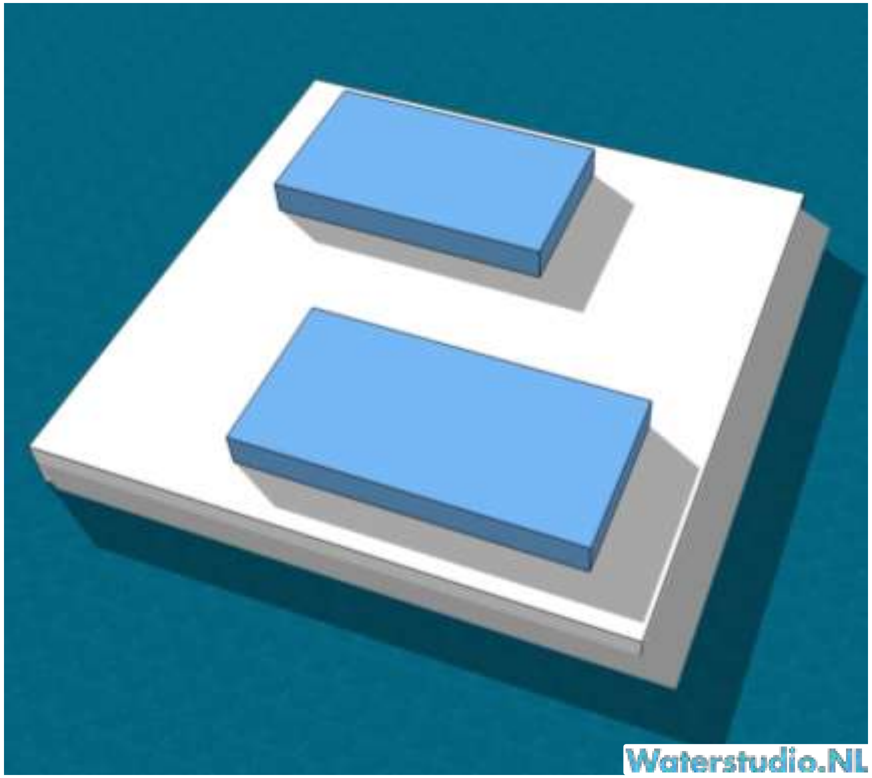
Compositive schemes

BASIC MODULES
The solutions are made by two main functions: accommodation and facilities. The two modules can be combined in different configurations.

Accommodation



Facilities

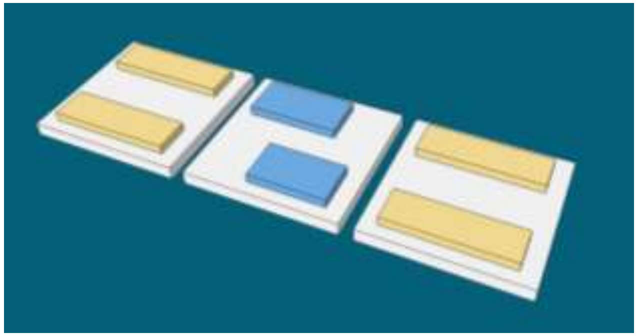


6.4 Concept 4.B1:

32 Apartments Floating City

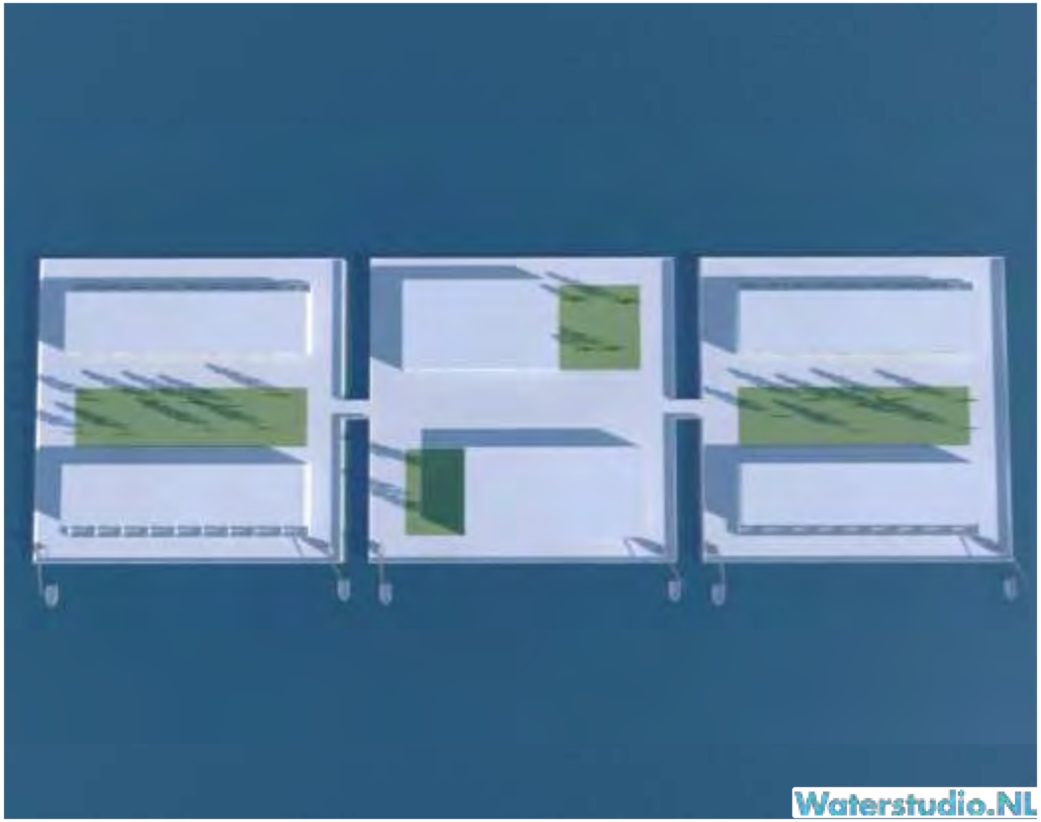
SCHEME 1: 2 accommodation blocks (18 apartments/platform) + 1 facility block

Basic Scheme



Side View

Top View



6.4 Concept 4.B1:

32 Apartments Floating City

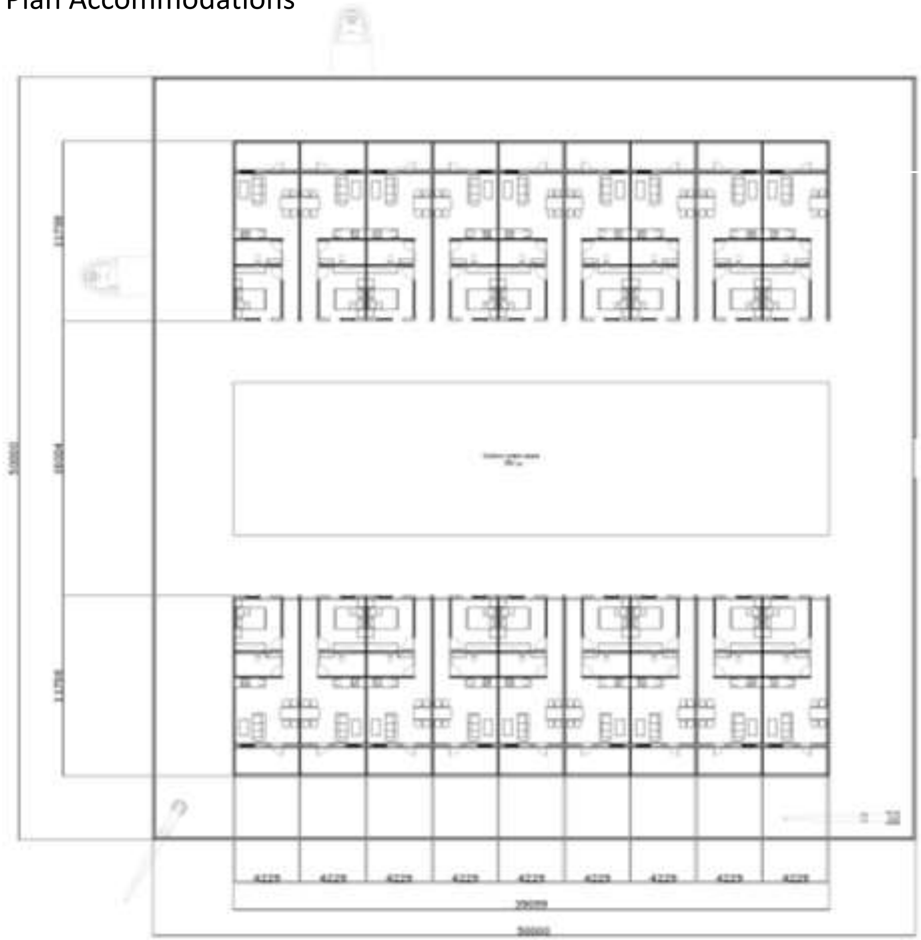
SCHEME 1: 2 accommodation blocks (18 apartments/platform) + 1 facility block

Master plan

6.4 Concept 4.B1:

32 Apartments Floating City

Plan Accommodations



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Apartments and outdoor space

Area index	
Outdoor Space	1557 sqm
Apartments (18 of 40sqm each)	720 sqm

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6.4 Concept 4.B1:

32 Apartments Floating City

Plan Facilities

Storage, Restaurant, Outdoor Green

Area index	
Outdoor Common Green	138 sqm
Kitchen	54 sqm
Canteen	168 sqm
Food storage and Supermarket	130 sqm
Toilet	20 sqm
Laundry	7 sqm
Refrigerator	8 sqm
Office room	64 sqm
Conference room	40 sqm
Health room	15 sqm
Social room	176 sqm
Fitness area	52 sqm

6.4 Concept 4.B1:

32 Apartments Floating City

IMPRESSION

Aerial View

6.4 Concept 4.B1:

32 Apartments Floating City

IMPRESSION

View From the green area

Appendix 7 - Performance Requirements

The following performance requirements was determined by findings of task 7.2: Research current and future inhabitants and other stakeholders. These requirements shall be met in the final design outcome of this work task.

Comfort

- Increase of the platform's stability.
- Minimisation of industrial noises and odours in housing spaces.
- Soundproof rest areas.
- Filter for odours or airlocks including lockers for working clothes.

Availability

- Provision of passenger traffic back to the mainland in a fast, frequent, safe, cost efficient and unproblematic way. If that can be achieved, the distance to the mainland becomes irrelevant.
- Mail and delivery services inside of the platform and from the outside world.

Working Conditions

- Same working hours as on the mainland.
- Work-life balance

Design of residential space

- Assurance of privacy.
- Sizes of flats should equal flats' sizes onshore. Size of flat is depending on the size of the household. In relation to the household size, number and size of rooms can be determined.
- Private and spacious bathroom including a shower and/or a bathtub as well as an own kitchen with a full range of kitchen equipment.
- Different options concerning the design of the living space (e.g. flooring material) and individual furniture.
- Large windows in living quarters.
- Elaborate and appealing design / self-influence on the design
- Enhancing the feeling of being at home.

Communication

- Provision of high-powered, safe and cost-efficient internet access for the inhabitants' use.

Design of Outdoor Areas

- Adequate amount of space for outdoor activity.
- Extensive green area (a park or a small forest) including animals.

  Barbecue area.

Social life

- Adequate amount of people to increase the probability to make friends, but also to be able to avoid each other. Minimal size of a group: approximately 20 families.
- Recruitment not only in relation to occupational competence, but also with regard to social and intercultural abilities.
- Fostering private contacts.
- Possibility of bringing the family to the island.

- Permission for taking pets to the island.
- Visits from the mainland.
- Work opportunities for the significant other (dual career concept).
- Childcare.

Leisure Facilities

- Many and appealing leisure facilities for people of all ages.
- Sport: fitness rooms with equipment adequate in amount and quality, sports fields and/or sports halls for all sorts of ball games, in- and outdoors swimming pool.
- Wellness- and sauna area.
- Restaurants, pubs, bars, clubs.
- Cultural offers: cinemas, theatres, concerts.
- Possibilities for further education and a variety of courses (language classes, music lessons, dance classes etc.).

Shopping Facilities

- Food shopping (same kind of shopping like onshore, large and many offers, fresh products).
- Shopping (clothes, everyday needs).
- Online shopping: assurance of delivery services.

Safety

- Assurance of health care.
- Examination of the adherence to security rules.
- Examination of safety drills' quality.

Waste and Electricity Generation

- Ecologically friendly waste disposal.
- Environmentally friendly power generation: wind power, water turbines or solar power.
- Environmentally friendly water treatment and wastewater treatment.
- Decent thermal insulation.
- Minimisation of private electric power consumption.

Appendix 8 - Technical, comfort & safety requirements

The following requirements were determined from the findings of Task 7.3: technical comfort and safety requirements. These requirements shall be met in the final design outcome of this work task.

General

- Utilisation of space (building area, parking area, public area, green area, etc.)
- Topography (size, shape and levels, etc.)
- Accessibility and boundaries (space and width for roads, walls, fences, etc.)
- Resource demands (water, energy, food)
- Adaptability (Incorporation of elements to assist with future expansion
- Practicability (Dimensions of rooms, ceiling heights, accessibility etc.)

External Environment and Acts of Nature

- Protection against external environment: (outdoor areas, vehicular access, waste, hazardous substances, etc.)
- Protection against acts of nature, in particular extreme weather (strong wind, torrential downpour, flooding, storm surge, etc.)

Safety

- Structural stability (Foundations, structure, interior finishes, live and dead loads etc.)
- Structural safety (personal, material, material falls, falls from structures, collision with structures, lightning, etc.)
- Fire safety (load bearing capacity and stability in case of fire and explosion, extinguishing, escape, rescue, etc.)
- Layouts and routes (entrance, communication routes, rooms, storage, building components, dock, etc.)
- Construction & maintenance safety. (On site hazard control, access for machinery tools, materials, etc.)

Environment, Health & Comfort

- Air quality (ventilation, etc.)
- Indoor thermal climate (conduction, radiation, etc.)
- Sound and vibrations (soundproofing, room acoustics, noise from technical installations, etc.)
- Natural lighting and views (lighting levels, visual amenity, etc.)
- Weather resistance (Moisture ingress and vapour diffusion).
- Wet space (moisture in the buildings, rooms with water installation, surface water, precipitation, etc.)

Utility Space

- Energy supply and efficiency
- Heating and/or cooling installation
- Indoor water and drainage installation
- Outdoor water supply and sewerage installation
- Lifting equipment
- Service maintenance and accessibility (hoisting equipment, window cleaning access).

Appendix 9 - Intact Stability Calculation - GHS Report

WEIGHT and DISPLACEMENT STATUS
Baseline draft: 7.279 @ Origin
Trim: Aft 0.81 deg., Heel: Stbd 1.10 deg.

Part	Weight(MT)	LCG	TCG	VCG
Outdoor (Ground floor)	1.97	22.500f	0.000	11.900
Level 4 Interior Outfitti	25.52	22.500f	0.000	27.545
Level 1, 2 & 3 Apartment	36.37	22.500f	0.000	18.697
Technical Equipment & Out	1,917.35	22.500f	0.000	2.100
Hull (Connectors)	4,924.80	22.500f	0.000	7.517
Hull (Technical)	2,748.00	22.500f	0.000	1.040
Bulkwark	35.05	22.500f	0.000	10.497
Stairs & Lifts	201.87	22.500f	0.150s	18.485
(Level0) Walls	204.35	22.552f	0.000	11.900
Level 1 (Floor)	635.87	22.490f	0.000	14.030
(Level1) Walls	252.99	22.501f	0.000	15.500
Level 1 (Windows)	141.85	22.533f	0.000	15.500
Level 2 (Floor)	674.02	21.538f	1.314s	17.230
(Level2) Walls	252.63	22.681f	0.000	18.701
Level 2 (Windows)	165.06	16.776f	7.754s	18.966
Level 3 (Floor)	674.02	21.196f	0.953s	20.430
(Level3) Walls	251.90	22.545f	0.046p	21.901
Level 3 (Windows)	170.21	14.886f	5.603s	22.160
Level 4 (Floor)	635.70	22.510f	0.000	23.630
Level 4 (Walls)	7.94	22.500f	0.000	27.331
Level 4 (Windows)	474.54	22.500f	0.000	27.545
PAX	19.80	22.500f	0.000	18.500
Total Weight-------->	14,451.81	22.244f	0.262s	9.555

	SpGr	Displ(MT)	LCB	TCB	VCB	RefHt
HULL	1.025	14,451.82	22.159f	0.464s	3.488	-7.277

Righting Arms:	0.000	0.087s
External Arms:	0.000	0.087s
Residual Righting Arms:	0.000	0.000s

Distances in METERS.

A X I S 0

RESIDUAL RIGHTING ARMS vs HEEL ANGLE
LCG = 22.244f TCG = 0.262s VCG = 9.555

Origin Depth	Degrees of Trim	Degrees of Heel	Displacement Weight(MT)	Residual Arms in Trim	Residual Arms in Heel	Res. Area	Flood Pt Height
7.278	0.81a	0.82s	14,452	0.000	-0.087	0.0000	0.713(5)
7.277	0.81a	1.10s	14,452	0.000	0.000	-0.0002	0.633(5)
7.269	0.81a	2.89s	14,452	0.000	0.569	0.0087	-0.000(6)
7.255	0.80a	4.69s	14,452	0.000	1.146	0.0357	50% DeckImm
7.238	0.80a	6.10s	14,452	0.000	1.598	0.0693	9.593(2)
7.170	0.84a	11.10s	14,452	0.000	3.215	0.2791	7.583(2)
7.131	0.89a	16.10s	14,452	0.000	4.677	0.6246	5.435(2)
7.022	1.05a	21.10s	14,452	0.000	6.002	1.0916	3.275(2)
6.750	1.38a	26.10s	14,452	0.000	6.720	1.6511	1.221(2)
6.603	1.69a	29.01s	14,453	0.000	6.847	1.9971	-0.002(2)
6.552	1.81a	30.03s	14,452	0.000	6.855	2.1183	-0.430(2)
6.509	1.98a	31.10s	14,452	0.000	6.846	2.2464	-0.891(2)
6.389	3.00a	36.10s	14,452	0.000	6.615	2.8368	-3.113(2)
6.616	5.03a	41.10s	14,453	0.000	6.139	3.3951	-5.579(2)
7.966	10.14a	46.10s	14,452	0.000	5.380	3.8998	-8.767(2)
11.186	20.74a	51.10s	14,453	0.000	4.066	4.3160	-12.956(2)
13.684	30.14a	56.10s	14,452	0.000	2.679	4.6109	-16.209(2)
14.934	36.16a	61.10s	14,455	0.000	1.642	4.7968	-18.370(2)

```
15.496  40.04a  66.10s      14,453     0.000     0.880     4.9048 -19.941(2)
15.670  42.15a  70.00s      14,453     0.000     0.407     4.9481 -20.933(2)
Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.
                                  +
Note:  The Residual Righting Arms shown above are in excess of the
       wind heeling arms derived from these moments (in m.-MT):
                Stbd heeling moment = 1251.35 (constant)
                                  +
Note: Angle of MaxRA refers to the absolute Righting Arm curve.
                                  +
          Critical Points----------------------LCP-----TCP-----VCP
      (2) c2                        FLOOD   7.000f 21.250  19.100
      (5) c5                        TIGHT   0.000  16.827   8.235
      (6) c6                        TIGHT   5.673f 22.500   8.335
LIM-------------------STABILITY CRITERION-----------Min/Max--------Attained
(1) Abs Area from Equ0 (no moments) to MaxRA0      >   0.0800 m.-Rad 2.1624 P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.   >     0.00  deg    68.90 P
(3) Angle from Equilibrium to RAzero or Flood      >    20.00  deg    27.92 P
(4) Absolute Area from Equ0 (no moments) to Flood  >   0.0800 m.-Rad 2.0397 P
---------------------------------------------------------------------------
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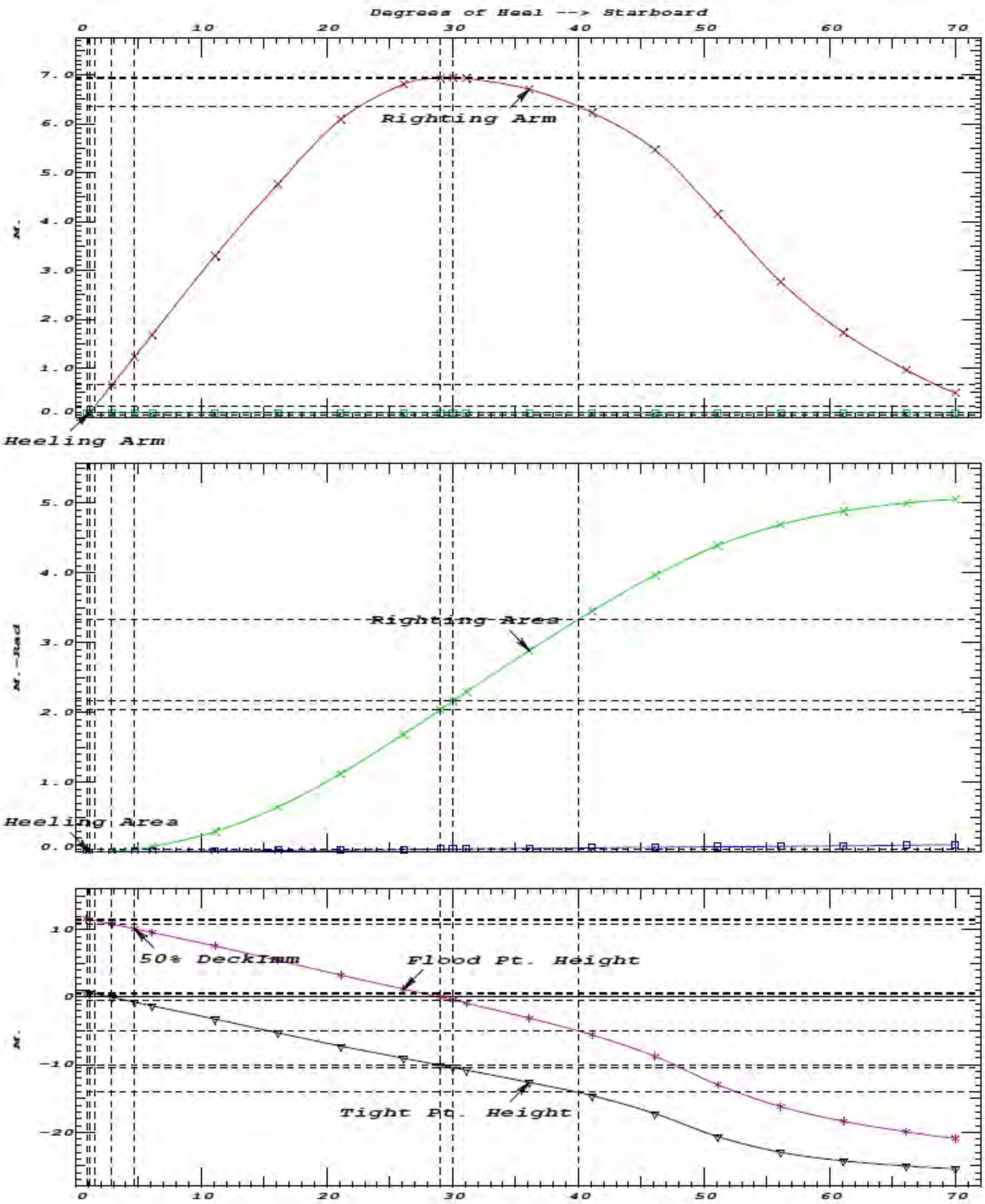


A X I S 15

RESIDUAL RIGHTING ARMS vs HEEL ANGLE

LCG = 22.244f TCG = 0.262s VCG = 9.555

Inclination axis rotated 15.00 degrees CW

Origin Depth	Degrees of Trim	Degrees of Heel	Displacement Weight(MT)	Residual Arms in Trim	Residual Arms in Heel	Res. Area	Flood Pt Height
7.278	0.57a	1.01s	14,452	0.000	-0.087	0.0000	0.713(5)
7.304	0.57a	1.27s	14,452	0.000	-0.003	-0.0002	0.612(5)
7.451	0.56a	2.79s	14,452	0.000	0.479	0.0061	-0.000(6)
7.566	0.56a	4.01s	14,452	0.000	0.869	0.0205	50% DeckImm
7.770	0.56a	6.27s	14,452	0.000	1.596	0.0691	9.292(2)
8.236	0.66a	11.27s	14,452	0.000	3.171	0.2773	6.979(2)
8.730	0.87a	16.27s	14,452	0.000	4.636	0.6187	4.547(2)
9.203	1.42a	21.27s	14,454	0.000	5.806	1.0765	2.107(2)
9.655	2.37a	25.55s	14,452	0.000	6.340	1.5333	0.003(2)
9.738	2.57a	26.27s	14,452	0.000	6.386	1.6128	-0.352(2)
10.121	3.57a	29.48s	14,452	0.000	6.470	1.9727	-1.954(2)
10.351	4.21a	31.27s	14,452	0.000	6.443	2.1746	-2.857(2)
11.051	6.32a	36.27s	14,452	0.000	6.155	2.7266	-5.399(2)
11.872	9.01a	41.27s	14,452	0.000	5.623	3.2423	-7.965(2)
12.810	12.29a	46.27s	14,452	0.000	4.909	3.7031	-10.511(2)
13.782	15.99a	51.27s	14,452	0.000	4.072	4.0959	-12.950(2)
14.638	19.67a	56.27s	14,452	0.000	3.186	4.4129	-15.181(2)
15.273	22.93a	61.27s	14,452	0.000	2.321	4.6531	-17.153(2)
15.655	25.62a	66.27s	14,452	0.000	1.512	4.8199	-18.870(2)
15.780	27.21a	70.00s	14,450	0.000	0.951	4.8999	-20.003(2)

Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.

+

Note: The Residual Righting Arms shown above are in excess of the wind heeling arms derived from these moments (in m.-MT):

Stbd heeling moment = 1251.35 (constant)

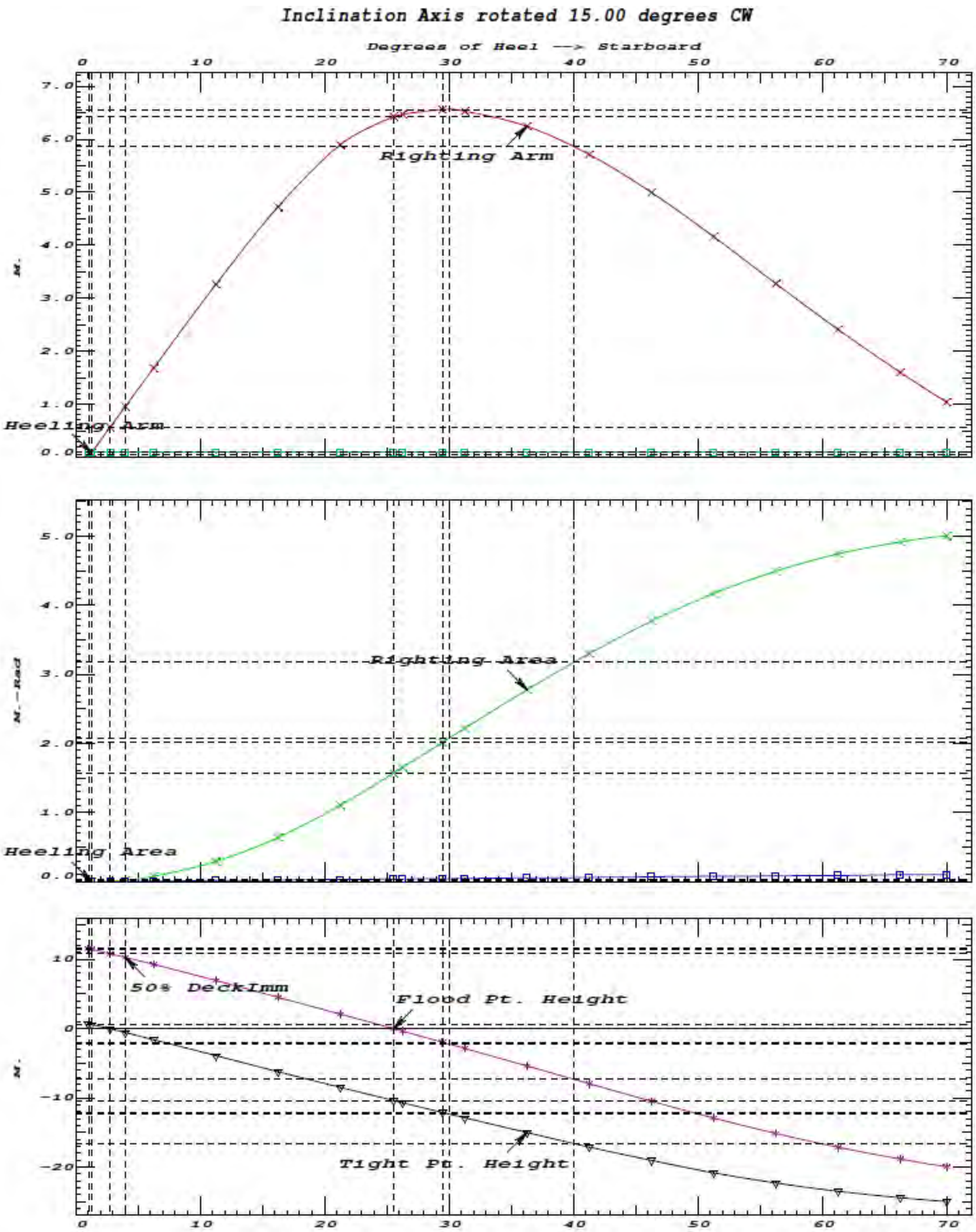
+

Note: Angle of MaxRA refers to the absolute Righting Arm curve.

+

Critical Points		LCP	TCP	VCP
(2) c2	FLOOD	7.000f	21.250	19.100
(5) c5	TIGHT	0.000	16.827	8.235
(6) c6	TIGHT	5.673f	22.500	8.335

LIM	STABILITY CRITERION		Min/Max		Attained	
(1)	Abs Area from Equ0 (no moments) to MaxRA0	>	0.0800	m.-Rad	2.0157	P
(2)	Angle from Equ. to abs 70 deg to 50% Dk Imm.	>	0.00	deg	68.73	P
(3)	Angle from Equilibrium to RAzero or Flood	>	20.00	deg	24.28	P
(4)	Absolute Area from Equ0 (no moments) to Flood	>	0.0800	m.-Rad	1.5704	P



A X I S   30

RESIDUAL RIGHTING ARMS vs HEEL ANGLE

LCG = 22.244f   TCG = 0.262s   VCG =   9.555

Inclination axis rotated 30.00 degrees CW

Origin Depth	Degrees of Trim	Heel	Displacement Weight(MT)	Residual Arms in Trim	in Heel	Res. Area	Flood Pt Height
7.278	0.29a	1.12s	14,452	0.000	-0.087	0.0000	0.713(5)
7.324	0.29a	1.35s	14,452	0.000	-0.012	-0.0002	0.607(5)
7.331	0.29a	1.39s	14,452	0.000	0.000	-0.0002	0.590(5)
7.581	0.29a	2.70s	14,452	0.000	0.415	0.0045	0.001(5)
7.772	0.29a	3.70s	14,452	0.000	0.736	0.0146	50% DeckImm
8.262	0.28a	6.35s	14,452	0.000	1.588	0.0684	9.154(2)
9.190	0.36a	11.35s	14,452	0.000	3.129	0.2746	6.706(2)
10.108	0.53a	16.35s	14,452	0.000	4.535	0.6100	4.177(2)
10.938	0.96a	21.35s	14,452	0.000	5.565	1.0534	1.703(2)

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  11.498   1.46a  24.83s      14,452     0.000    5.944    1.4042  -0.001(2)
  11.740   1.72a  26.35s      14,452     0.000    6.033    1.5632  -0.745(2)
  12.237   2.33a  29.54s      14,452     0.000    6.101    1.9007  -2.298(2)
  12.512   2.71a  31.35s      14,452     0.000    6.079    2.0934  -3.178(2)
  13.242   3.87a  36.35s      14,452     0.000    5.845    2.6155  -5.582(2)
  13.918   5.19a  41.35s      14,451     0.000    5.418    3.1083  -7.937(2)
  14.532   6.63a  46.35s      14,451     0.000    4.854    3.5575 -10.221(2)
  15.066   8.16a  51.35s      14,451     0.000    4.193    3.9530 -12.411(2)
  15.500   9.71a  56.35s      14,451     0.000    3.464    4.2875 -14.483(2)
  15.810  11.19a  61.35s      14,451     0.000    2.692    4.5564 -16.419(2)
  15.974  12.52a  66.35s      14,451     0.000    1.899    4.7569 -18.206(2)
  15.992  13.34a  70.00s      14,451     0.000    1.316    4.8592 -19.412(2)
  Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.
                                     +
  Note:  The Residual Righting Arms shown above are in excess of the
         wind heeling arms derived from these moments (in m.-MT):
                  Stbd heeling moment = 1251.35 (constant)
                                     +
  Note: Angle of MaxRA refers to the absolute Righting Arm curve.
                                     +
            Critical Points----------------------LCP-----TCP-----VCP
        (2) c2                        FLOOD   7.000f 21.250  19.100
        (5) c5                        TIGHT   0.000  16.827   8.235
LIM--------------------STABILITY CRITERION------------Min/Max--------Attained
(1) Abs Area from Equ0 (no moments) to MaxRA0      >   0.0800 m.-Rad 1.9437 P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.   >     0.00  deg    68.61 P
(3) Angle from Equilibrium to RAzero or Flood      >    20.00  deg    23.44 P
(4) Absolute Area from Equ0 (no moments) to Flood  >   0.0800 m.-Rad 1.4401 P
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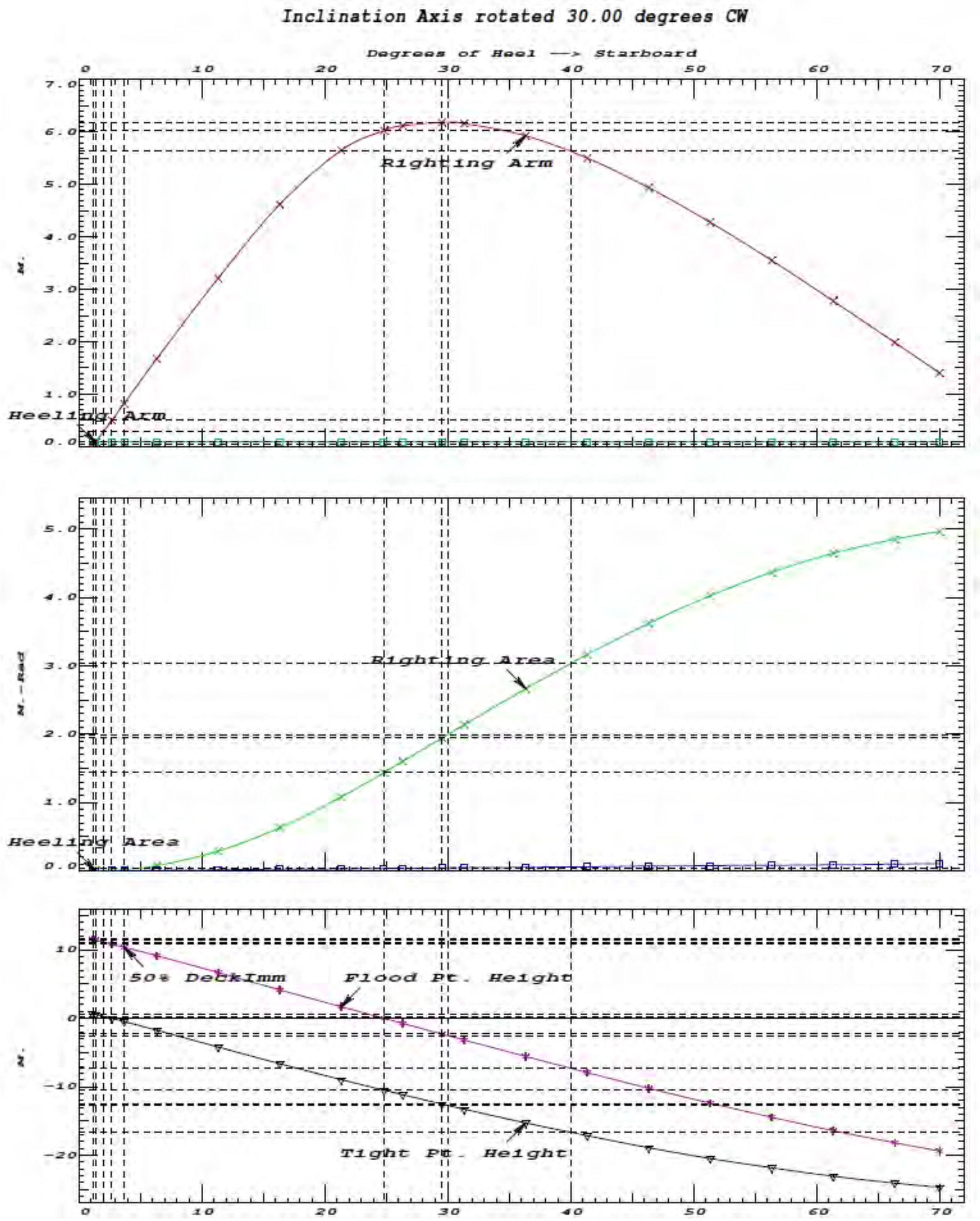

A X I S   45

RESIDUAL RIGHTING ARMS vs HEEL ANGLE

LCG = 22.244f   TCG = 0.262s   VCG = 9.555

Inclination axis rotated 45.00 degrees CW

Origin Depth	Degrees of Trim	Degrees of Heel	Displacement Weight(MT)	Residual Arms in Trim	Residual Arms in Heel	Res. Area	Flood Pt Height
7.278	0.01s	1.15a	14,452	0.000	-0.087	0.0000	0.713(5)
7.331	0.01s	1.35a	14,452	0.000	-0.025	-0.0002	0.619(5)
7.353	0.01s	1.43a	14,452	0.000	0.000	-0.0002	0.581(5)
7.680	0.01s	2.62a	14,452	0.000	0.380	0.0038	-0.000(5)
7.948	0.01s	3.62a	14,452	0.000	0.697	0.0131	50% DeckImm
8.675	0.01s	6.35a	14,452	0.000	1.574	0.0672	9.189(2)
9.983	0.01s	11.35a	14,452	0.000	3.103	0.2718	6.757(2)
11.232	0.01s	16.35a	14,452	0.000	4.484	0.6039	4.256(2)
12.296	0.01s	21.35a	14,452	0.000	5.466	1.0409	1.821(2)

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  13.008   0.01s  25.14a      14,452     0.000    5.843    1.4168  -0.002(2)
  13.221   0.01s  26.35a      14,452     0.000    5.907    1.5407  -0.581(2)
  13.769   0.01s  29.66a      14,452     0.000    5.975    1.8847  -2.164(2)
  14.028   0.01s  31.35a      14,452     0.000    5.957    2.0599  -2.963(2)
  14.721   0.01s  36.35a      14,452     0.000    5.749    2.5724  -5.314(2)
  15.297   0.02s  41.35a      14,452     0.000    5.363    3.0585  -7.620(2)
  15.753   0.02s  46.35a      14,452     0.000    4.849    3.5050  -9.865(2)
  16.087   0.02s  51.35a      14,452     0.000    4.238    3.9022 -12.032(2)
  16.297   0.02s  56.35a      14,452     0.000    3.555    4.2428 -14.107(2)
  16.382   0.02s  61.35a      14,452     0.000    2.815    4.5211 -16.072(2)
  16.341   0.02s  66.35a      14,452     0.000    2.032    4.7329 -17.915(2)
  16.232   0.02s  70.00a      14,452     0.000    1.441    4.8437 -19.175(2)
  Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.
                                    +
  Note:  The Residual Righting Arms shown above are in excess of the
         wind heeling arms derived from these moments (in m.-MT):
                   Aft heeling moment = 1251.35 (constant)
                                    +
  Note: Angle of MaxRA refers to the absolute Righting Arm curve.
                                    +
            Critical Points----------------------LCP-----TCP-----VCP
        (2) c2                       FLOOD   7.000f 21.250  19.100
        (5) c5                       TIGHT   0.000  16.827   8.235
LIM--------------------STABILITY CRITERION------------Min/Max--------Attained
(1) Abs Area from Equ0 (no moments) to MaxRA0      >   0.0800 m.-Rad 1.9278 P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.   >     0.00  deg    68.57 P
(3) Angle from Equilibrium to RAzero or Flood      >    20.00  deg    23.71 P
(4) Absolute Area from Equ0 (no moments) to Flood  >   0.0800 m.-Rad 1.4530 P
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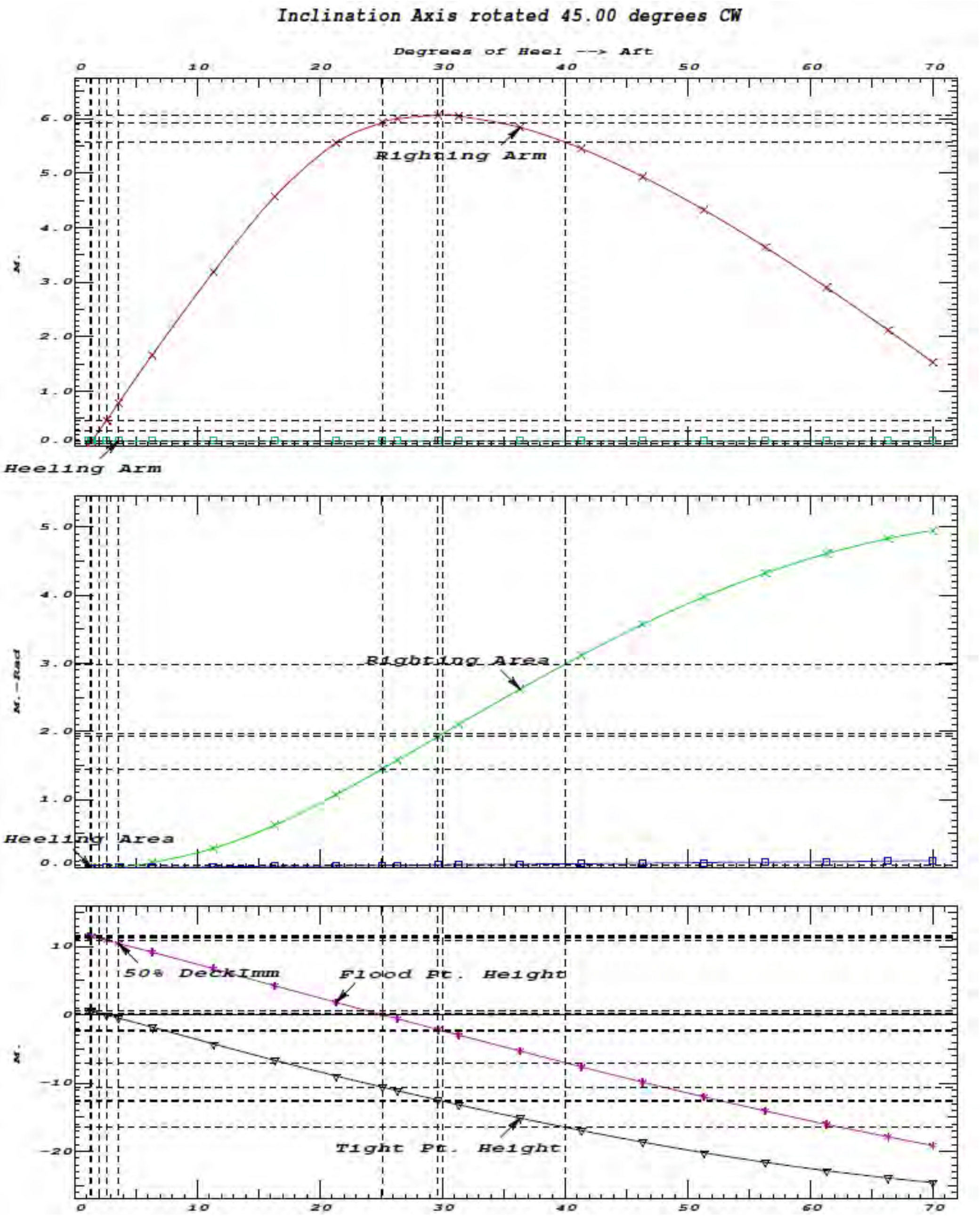


A X I S   60

RESIDUAL RIGHTING ARMS vs HEEL ANGLE

LCG = 22.244f   TCG = 0.262s   VCG = 9.555

Inclination axis rotated 60.00 degrees CW

Origin	Degrees of		Displacement	Residual Arms		Res.	Flood Pt
Depth	Trim	Heel	Weight(MT)	in Trim	in Heel	Area	Height
7.278	0.31s	1.11a	14,452	0.000	-0.087	0.0000	0.713(5)
7.324	0.31s	1.25a	14,452	0.000	-0.043	-0.0002	0.647(5)
7.370	0.31s	1.38a	14,452	0.000	0.000	-0.0002	0.580(5)
7.770	0.31s	2.57a	14,452	0.000	0.379	0.0037	-0.000(5)
8.145	0.31s	3.70a	14,452	0.000	0.737	0.0147	50% DeckImm
8.981	0.31s	6.25a	14,452	0.000	1.556	0.0656	9.204(1)
10.581	0.38s	11.25a	14,452	0.000	3.099	0.2691	6.758(1)
12.105	0.55s	16.25a	14,450	0.000	4.511	0.6021	4.231(1)
13.390	0.98s	21.25a	14,452	0.000	5.550	1.0438	1.754(1)

14.166	1.49s	24.83a	14,452	0.000	5.944	1.4048	-0.001(1)
14.446	1.73s	26.25a	14,452	0.000	6.029	1.5528	-0.694(1)
15.041	2.35s	29.54a	14,452	0.000	6.101	1.9016	-2.300(1)
15.319	2.71s	31.25a	14,452	0.000	6.081	2.0828	-3.127(1)
16.018	3.87s	36.25a	14,452	0.000	5.852	2.6054	-5.532(1)
16.540	5.19s	41.25a	14,450	0.000	5.429	3.0990	-7.887(1)
16.889	6.64s	46.25a	14,454	0.000	4.866	3.5492	-10.176(1)
17.058	8.17s	51.25a	14,451	0.000	4.206	3.9457	-12.366(1)
17.066	9.72s	56.25a	14,451	0.000	3.478	4.2815	-14.441(1)
16.929	11.20s	61.25a	14,451	0.000	2.708	4.5518	-16.380(1)
16.674	12.53s	66.25a	14,451	0.000	1.915	4.7536	-18.169(1)
16.421	13.38s	70.00a	14,452	0.000	1.315	4.8594	-19.412(1)

Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.

+

Note: The Residual Righting Arms shown above are in excess of the
wind heeling arms derived from these moments (in m.-MT):
Aft heeling moment = 1251.35 (constant)

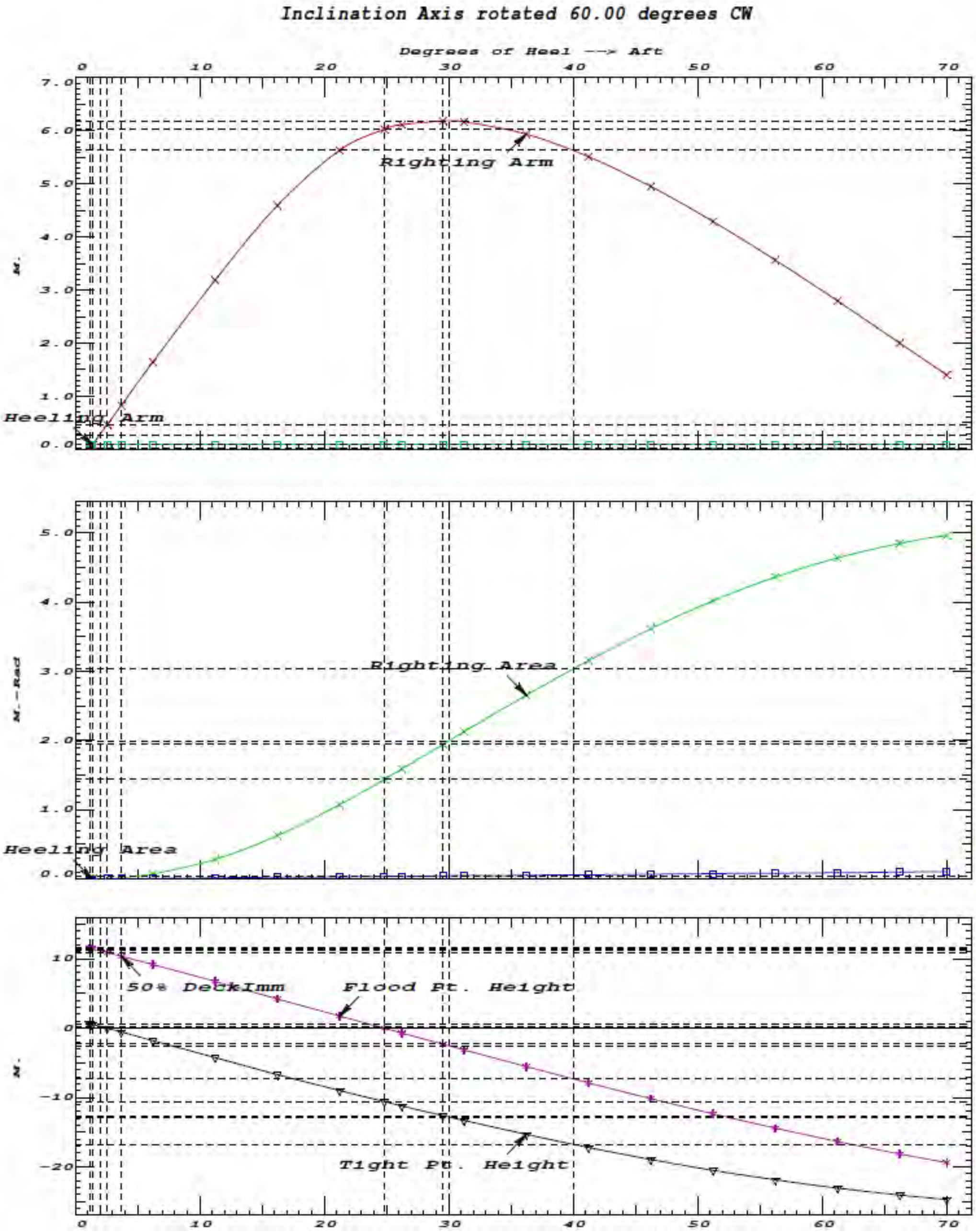
+

Note: Angle of MaxRA refers to the absolute Righting Arm curve.

+

Critical Points		LCP	TCP	VCP
(1) c1	FLOOD	1.250f	15.500	19.100
(5) c5	TIGHT	0.000	16.827	8.235

LIM---STABILITY CRITERION		Min/Max		Attained	
(1) Abs Area from Equ0 (no moments) to MaxRA0	>	0.0800	m.-Rad	1.9445	P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.	>	0.00	deg	68.62	P
(3) Angle from Equilibrium to RAzero or Flood	>	20.00	deg	23.45	P
(4) Absolute Area from Equ0 (no moments) to Flood	>	0.0800	m.-Rad	1.4406	P



A X I S   75

RESIDUAL RIGHTING ARMS vs HEEL ANGLE

LCG = 22.244f   TCG = 0.262s   VCG = 9.555

Inclination axis rotated 75.00 degrees CW

Origin Depth	Degrees of Trim	Degrees of Heel	Displacement Weight(MT)	Residual Arms in Trim	Residual Arms in Heel--->	Res. Area	Flood Pt Height
7.278	0.59s	0.99a	14,452	0.000	-0.087	0.0000	0.713(5)
7.305	0.59s	1.06a	14,452	0.000	-0.064	-0.0001	0.681(5)
7.381	0.59s	1.27a	14,452	0.000	0.000	-0.0002	0.589(5)
7.866	0.59s	2.56a	14,452	0.000	0.411	0.0044	-0.000(5)
8.402	0.59s	4.00a	14,452	0.000	0.871	0.0206	50% DeckImm
9.159	0.59s	6.06a	14,452	0.000	1.533	0.0638	9.380(1)
10.952	0.67s	11.06a	14,452	0.000	3.114	0.2667	7.074(1)
12.697	0.88s	16.06a	14,452	0.000	4.583	0.6033	4.644(1)
14.231	1.41s	21.06a	14,452	0.000	5.771	1.0571	2.205(1)

```
  15.368   2.39s  25.55a      14,452     0.000    6.342    1.5342   0.003(1)
  15.486   2.54s  26.06a      14,452     0.000    6.376    1.5914  -0.254(1)
  16.212   3.59s  29.45a      14,452     0.000    6.471    1.9725  -1.947(1)
  16.523   4.16s  31.06a      14,452     0.000    6.449    2.1543  -2.758(1)
  17.339   6.26s  36.06a      14,452     0.000    6.172    2.7050  -5.299(1)
  17.898   8.93s  41.06a      14,450     0.000    5.649    3.2225  -7.864(1)
  18.162  12.20s  46.06a      14,452     0.000    4.940    3.6859 -10.414(1)
  18.121  15.88s  51.06a      14,452     0.000    4.106    4.0815 -12.858(1)
  17.830  19.57s  56.06a      14,452     0.000    3.220    4.4015 -15.098(1)
  17.393  22.86s  61.06a      14,452     0.000    2.353    4.6445 -17.080(1)
  16.882  25.57s  66.06a      14,452     0.000    1.542    4.8140 -18.805(1)
  16.463  27.26s  70.00a      14,451     0.000    0.950    4.8994 -20.003(1)
  Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.
                                     +
  Note:  The Residual Righting Arms shown above are in excess of the
         wind heeling arms derived from these moments (in m.-MT):
                   Aft heeling moment = 1251.35 (constant)
                                     +
  Note: Angle of MaxRA refers to the absolute Righting Arm curve.
                                     +
            Critical Points----------------------LCP-----TCP-----VCP
        (1) c1                       FLOOD   1.250f 15.500  19.100
        (5) c5                       TIGHT   0.000  16.827   8.235
LIM--------------------STABILITY CRITERION------------Min/Max--------Attained
(1) Abs Area from Equ0 (no moments) to MaxRA0      >   0.0800 m.-Rad 2.0155 P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.   >     0.00  deg    68.73 P
(3) Angle from Equilibrium to RAzero or Flood      >    20.00  deg    24.28 P
(4) Absolute Area from Equ0 (no moments) to Flood  >   0.0800 m.-Rad 1.5713 P
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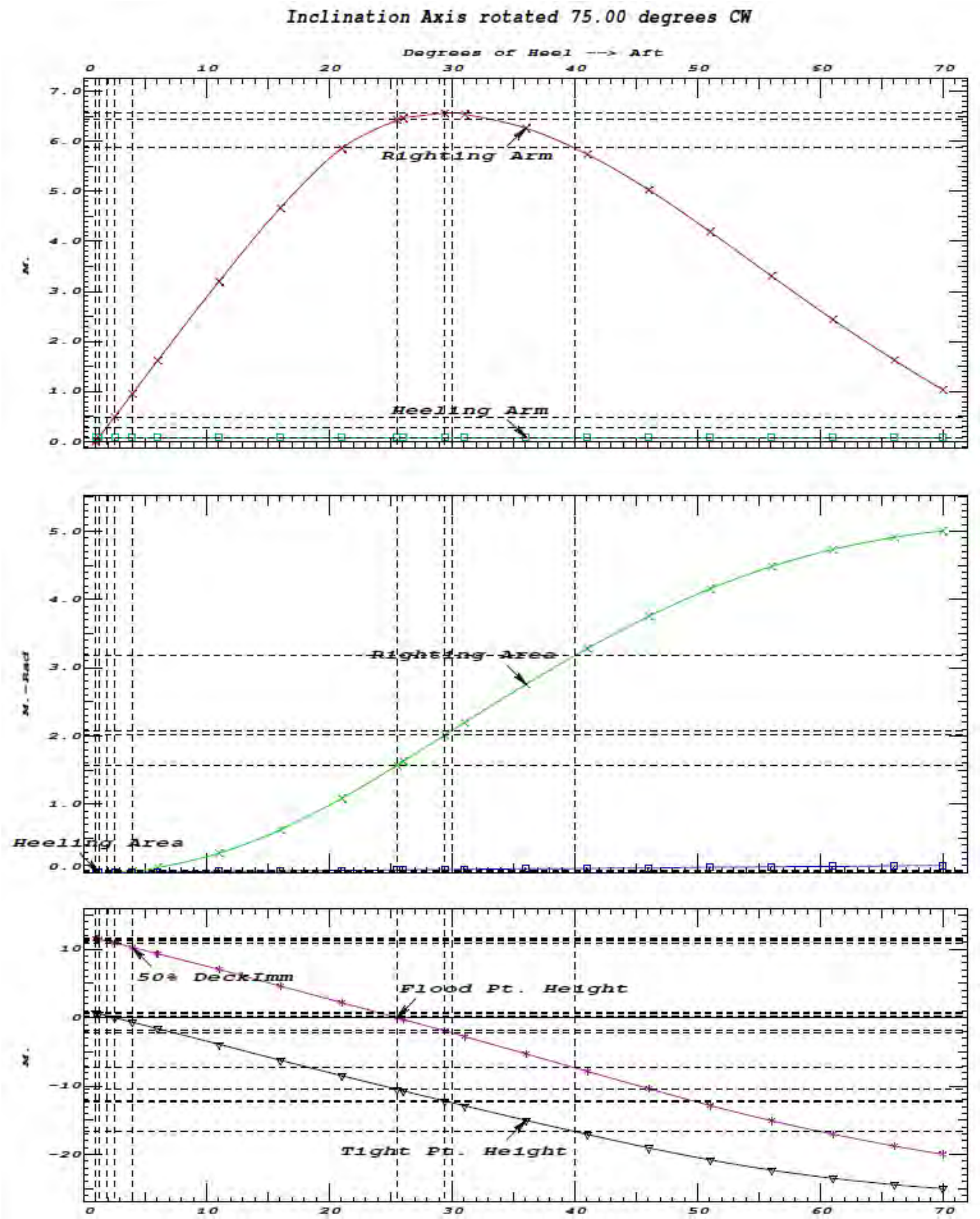

A X I S   90

RESIDUAL RIGHTING ARMS vs HEEL ANGLE

LCG = 22.244f   TCG = 0.262s   VCG = 9.555

Inclination axis rotated 90.00 degrees CW

Origin Depth	Degrees of Trim	Degrees of Heel	Displacement Weight(MT)	Residual Arms in Trim	Residual Arms in Heel	Res. Area	Flood Pt Height
7.278	0.82s	0.81a	14,452	0.000	-0.087	0.0000	0.713(5)
7.384	0.82s	1.08a	14,450	0.000	0.000	-0.0002	0.607(5)
7.984	0.82s	2.62a	14,452	0.000	0.490	0.0064	-0.001(5)
8.776	0.82s	4.68a	14,453	0.000	1.148	0.0358	50% DeckImm
9.203	0.82s	5.81a	14,453	0.000	1.509	0.0619	9.701(1)
11.063	0.85s	10.81a	14,453	0.000	3.132	0.2642	7.701(1)
12.914	0.91s	15.81a	14,452	0.000	4.596	0.6026	5.556(1)
14.619	1.06s	20.81a	14,454	0.000	5.944	1.0633	3.390(1)

```
  16.026   1.38s  25.81a      14,452     0.000    6.701    1.6193   1.336(1)
  16.842   1.71s  28.99a      14,454     0.000    6.850    1.9975   0.001(1)
  17.086   1.85s  30.01a      14,450     0.000    6.859    2.1185  -0.431(1)
  17.280   1.95s  30.81a      14,453     0.000    6.853    2.2143  -0.773(1)
  18.389   2.96s  35.81a      14,452     0.000    6.638    2.8061  -2.990(1)
  19.325   4.92s  40.81a      14,451     0.000    6.175    3.3670  -5.438(1)
  19.938   9.80s  45.81a      14,451     0.000    5.435    3.8756  -8.575(1)
  19.627  20.22s  50.81a      14,452     0.000    4.145    4.2976 -12.749(1)
  18.584  29.78s  55.81a      14,452     0.000    2.744    4.5991 -16.068(1)
  17.595  35.94s  60.81a      14,450     0.000    1.690    4.7900 -18.265(1)
  16.798  39.91s  65.81a      14,453     0.000    0.916    4.9017 -19.863(1)
  16.228  42.20s  70.00a      14,450     0.000    0.405    4.9493 -20.931(1)
  Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.
                                    +
  Note:  The Residual Righting Arms shown above are in excess of the
         wind heeling arms derived from these moments (in m.-MT):
                   Aft heeling moment = 1251.35 (constant)
                                    +
  Note: Angle of MaxRA refers to the absolute Righting Arm curve.
                                    +
            Critical Points----------------------LCP-----TCP-----VCP
        (1) c1                        FLOOD   1.250f 15.500  19.100
        (5) c5                        TIGHT   0.000  16.827   8.235
LIM--------------------STABILITY CRITERION------------Min/Max--------Attained
(1) Abs Area from Equ0 (no moments) to MaxRA0      >   0.0800 m.-Rad 2.1626 P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.   >     0.00  deg    68.92 P
(3) Angle from Equilibrium to RAzero or Flood      >    20.00  deg    27.92 P
(4) Absolute Area from Equ0 (no moments) to Flood  >   0.0800 m.-Rad 2.0401 P
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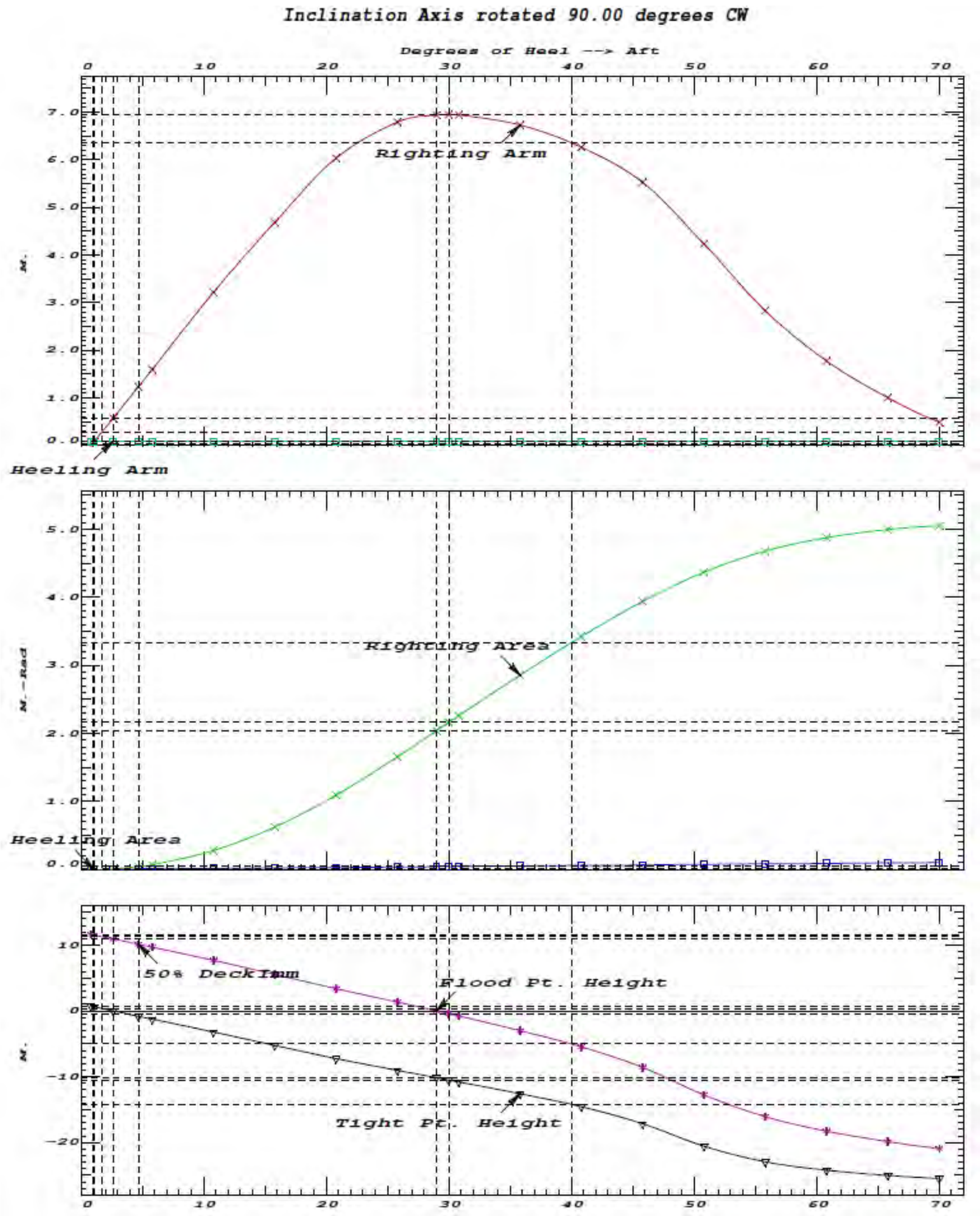

A X I S   105

RESIDUAL RIGHTING ARMS vs HEEL ANGLE
LCG = 22.244f TCG = 0.262s VCG = 9.555
Inclination axis rotated 105.00 degrees CW

Origin Depth	Degrees of Trim	Heel	Displacement Weight(MT)	Residual Arms in Trim	in Heel	Res. Area	Flood Pt Height
7.251	1.01s	0.49a	14,452	0.000	-0.109	0.0000	11.623(2)
7.278	1.01s	0.57a	14,452	0.000	-0.087	-0.0001	0.713(5)
7.381	1.01s	0.84a	14,452	0.000	0.000	-0.0003	0.630(5)
8.158	1.00s	2.91a	14,452	0.000	0.658	0.0116	0.001(5)
8.730	1.00s	4.45a	14,452	0.000	1.151	0.0359	50% DeckImm
9.112	1.00s	5.49a	14,452	0.000	1.485	0.0599	9.896(1)
10.908	0.97s	10.49a	14,452	0.000	3.098	0.2597	7.618(1)
12.683	0.87s	15.49a	14,452	0.000	4.566	0.5952	5.204(1)

```
  14.287   0.57s  20.49a      14,452     0.000    5.851    1.0510   2.774(1)
  15.608   0.14p  25.49a      14,454     0.000    6.573    1.5972   0.388(1)
  15.800   0.29p  26.30a      14,452     0.000    6.631    1.6904   0.002(1)
  16.592   1.01p  29.83a      14,452     0.000    6.732    2.1026  -1.689(1)
  16.733   1.17p  30.49a      14,452     0.000    6.728    2.1812  -2.012(1)
  17.682   2.50p  35.49a      14,451     0.000    6.522    2.7625  -4.441(1)
  18.424   4.32p  40.49a      14,452     0.000    6.074    3.3138  -6.909(1)
  18.895   6.91p  45.49a      14,450     0.000    5.442    3.8177  -9.429(1)
  19.032  10.41p  50.49a      14,452     0.000    4.650    4.2592 -11.972(1)
  18.808  14.54p  55.49a      14,450     0.000    3.743    4.6262 -14.413(1)
  18.339  18.58p  60.49a      14,452     0.000    2.802    4.9121 -16.609(1)
  17.765  21.95p  65.49a      14,452     0.000    1.904    5.1171 -18.501(1)
  17.236  24.28p  70.00a      14,452     0.000    1.154    5.2369 -19.973(1)
  Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.
                                     +
  Note:  The Residual Righting Arms shown above are in excess of the
         wind heeling arms derived from these moments (in m.-MT):
                   Aft heeling moment = 1251.35 (constant)
                                     +
  Note: Angle of MaxRA refers to the absolute Righting Arm curve.
                                     +
            Critical Points----------------------LCP-----TCP-----VCP
        (1) c1                        FLOOD   1.250f 15.500  19.100
        (2) c2                        FLOOD   7.000f 21.250  19.100
        (5) c5                        TIGHT   0.000  16.827   8.235
LIM-------------------STABILITY CRITERION------------Min/Max--------Attained
(1) Abs Area from Equ0 (no moments) to MaxRA0      >   0.0800 m.-Rad 2.1469 P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.   >     0.00  deg    69.16 P
(3) Angle from Equilibrium to RAzero or Flood      >    20.00  deg    25.46 P
(4) Absolute Area from Equ0 (no moments) to Flood  >   0.0800 m.-Rad 1.7294 P
-----------------------------------------------------------------------------
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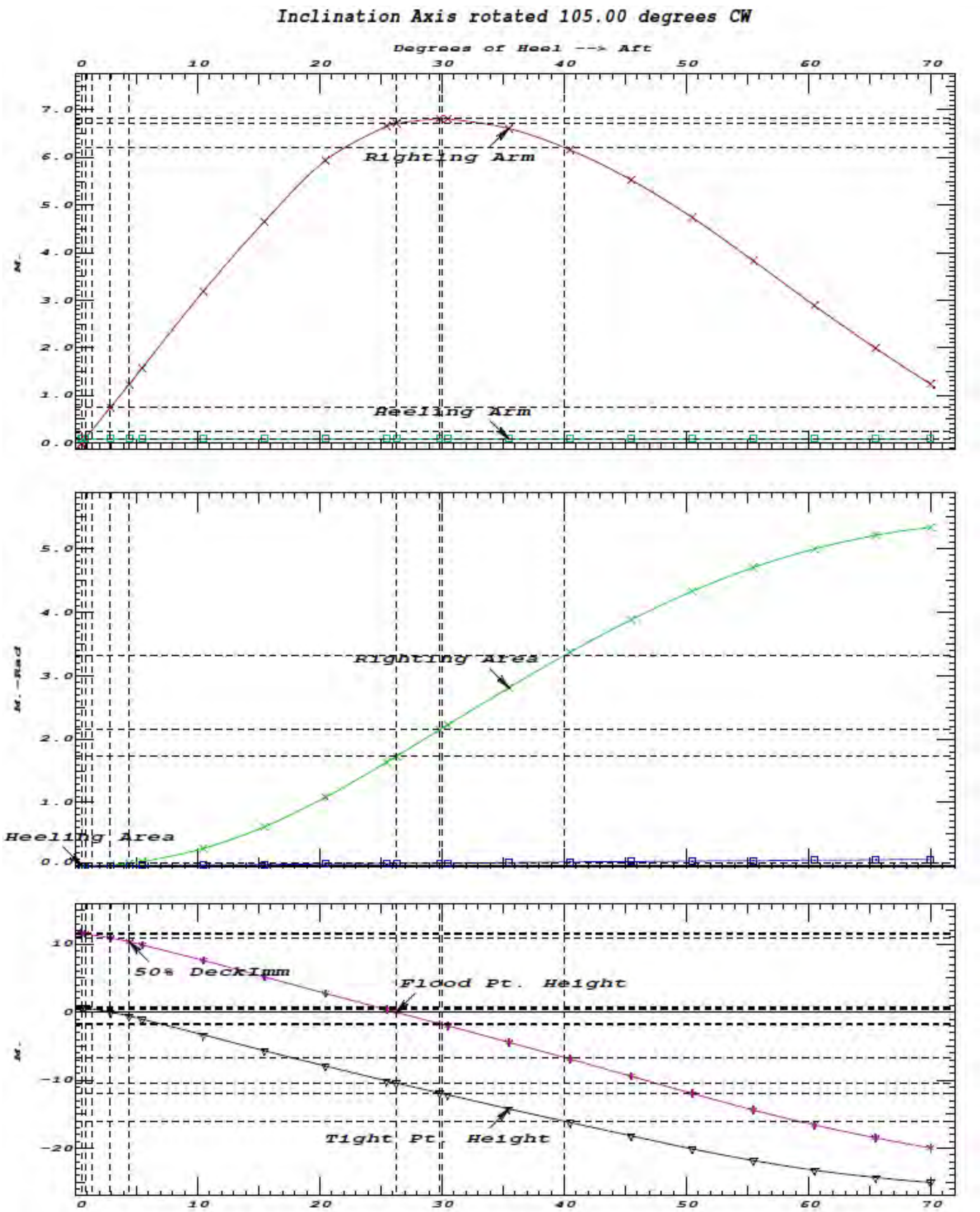

A X I S 120

RESIDUAL RIGHTING ARMS vs HEEL ANGLE

LCG = 22.244f TCG = 0.262s VCG = 9.555

Inclination axis rotated 120.00 degrees CW

Origin Depth	Degrees of Trim	Heel	Displacement Weight(MT)	Residual Arms in Trim	in Heel	Res. Area	Flood Pt Height
7.232	1.12s	0.15a	14,452	0.000	-0.130	0.0000	11.618(2)
7.278	1.12s	0.29a	14,452	0.000	-0.087	-0.0003	0.713(5)
7.370	1.12s	0.56a	14,452	0.000	0.000	-0.0005	0.660(5)
8.105	1.12s	2.74a	14,452	0.000	0.694	0.0128	-0.000(5)
8.486	1.12s	3.89a	14,452	0.000	1.059	0.0303	50% DeckImm
8.901	1.12s	5.15a	14,452	0.000	1.462	0.0580	9.794(1)
10.509	1.08s	10.15a	14,452	0.000	3.045	0.2547	7.378(1)
12.073	0.96s	15.15a	14,452	0.000	4.493	0.5846	4.854(1)

```
  13.435   0.66s  20.15a      14,452     0.000    5.657    1.0296   2.361(1)
  14.525   0.11s  24.98a      14,452     0.000    6.261    1.5355  -0.000(1)
  14.561   0.09s  25.15a      14,452     0.000    6.273    1.5541  -0.084(1)
  15.397   0.59p  29.52a      14,452     0.000    6.413    2.0398  -2.207(1)
  15.509   0.70p  30.15a      14,452     0.000    6.410    2.1108  -2.514(1)
  16.292   1.64p  35.15a      14,452     0.000    6.234    2.6652  -4.920(1)
  16.910   2.73p  40.15a      14,454     0.000    5.845    3.1938  -7.290(1)
  17.350   3.96p  45.15a      14,451     0.000    5.305    3.6813  -9.597(1)
  17.614   5.32p  50.15a      14,451     0.000    4.652    4.1166 -11.826(1)
  17.702   6.77p  55.15a      14,451     0.000    3.917    4.4911 -13.953(1)
  17.629   8.23p  60.15a      14,451     0.000    3.126    4.7989 -15.955(1)
  17.418   9.61p  65.15a      14,451     0.000    2.301    5.0359 -17.813(1)
  17.110  10.76p  70.00a      14,451     0.000    1.484    5.1963 -19.469(1)
  Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.
                                    +
  Note:  The Residual Righting Arms shown above are in excess of the
         wind heeling arms derived from these moments (in m.-MT):
                   Aft heeling moment = 1251.35 (constant)
                                    +
  Note: Angle of MaxRA refers to the absolute Righting Arm curve.
                                    +
            Critical Points----------------------LCP-----TCP-----VCP
        (1) c1                       FLOOD   1.250f 15.500  19.100
        (2) c2                       FLOOD   7.000f 21.250  19.100
        (5) c5                       TIGHT   0.000  16.827   8.235
LIM--------------------STABILITY CRITERION------------Min/Max--------Attained
(1) Abs Area from Equ0 (no moments) to MaxRA0      >   0.0800 m.-Rad 2.0843 P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.   >     0.00  deg    69.44 P
(3) Angle from Equilibrium to RAzero or Flood      >    20.00  deg    24.42 P
(4) Absolute Area from Equ0 (no moments) to Flood  >   0.0800 m.-Rad 1.5730 P
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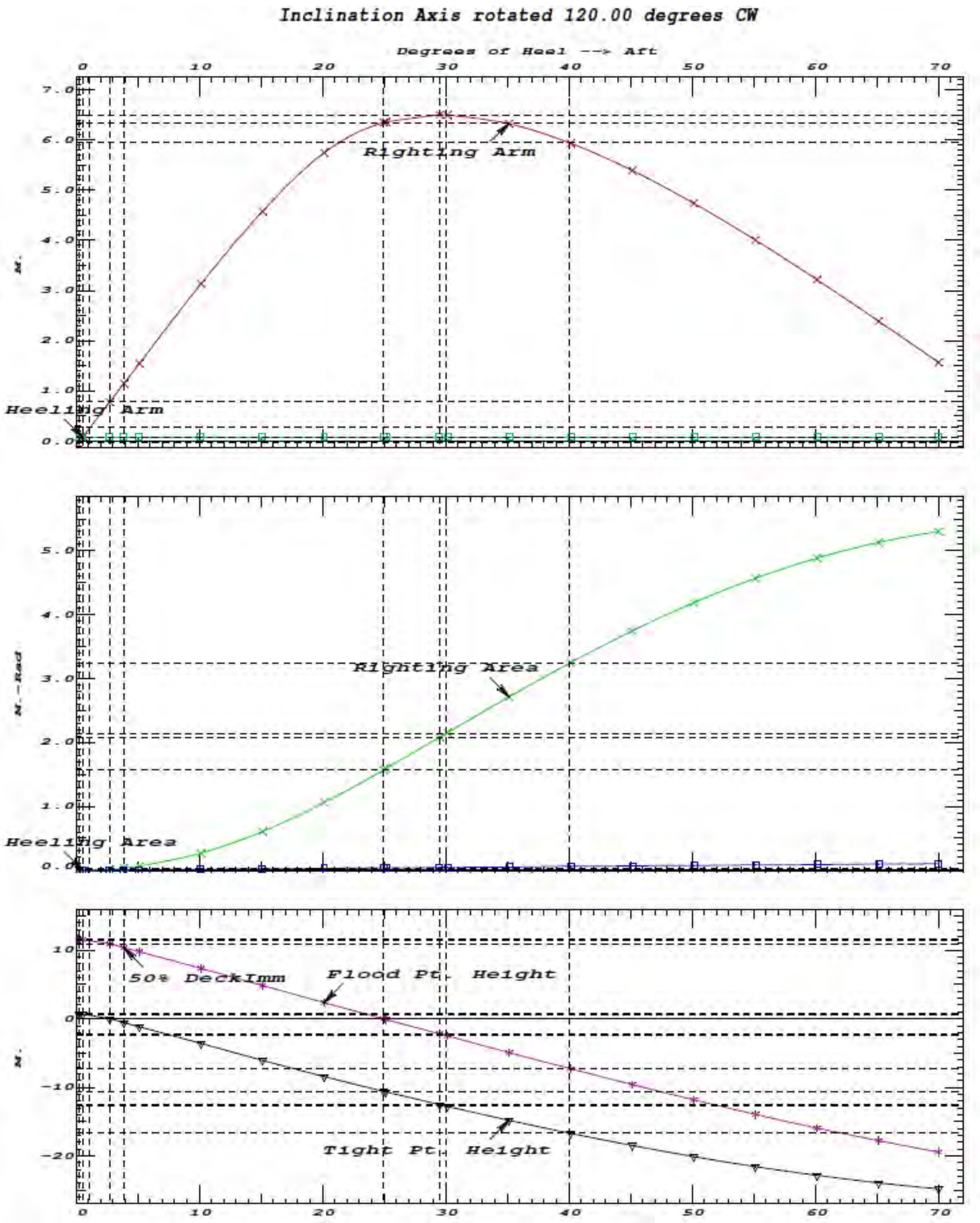

A X I S 135

RESIDUAL RIGHTING ARMS vs HEEL ANGLE

LCG = 22.244f TCG = 0.262s VCG = 9.555

Inclination axis rotated 135.00 degrees CW

Origin Depth	Degrees of Trim	Heel	Displacement Weight(MT)	Residual Arms in Trim	in Heel--->	Res. Area	Flood Pt Height
7.224	1.15s	0.21f	14,452	0.000	-0.148	0.0000	0.727(5)
7.278	1.15s	0.01f	14,452	0.000	-0.087	-0.0004	0.713(5)
7.354	1.15s	0.26a	14,452	0.000	0.000	-0.0006	0.694(5)
7.956	1.15s	2.45a	14,452	0.000	0.696	0.0127	-0.000(5)
8.271	1.15s	3.62a	14,452	0.000	1.066	0.0306	50% DeckImm
8.586	1.15s	4.79a	14,452	0.000	1.443	0.0564	9.839(1)
9.898	1.15s	9.79a	14,452	0.000	3.014	0.2510	7.444(1)
11.185	1.16s	14.79a	14,452	0.000	4.444	0.5774	4.946(1)

```
  12.315   1.19s  19.79a      14,452     0.000    5.567    1.0164   2.487(1)
  13.292   1.25s  24.79a      14,452     0.000    6.153    1.5317   0.076(1)
  13.322   1.25s  24.95a      14,452     0.000    6.164    1.5488  -0.000(1)
  14.079   1.32s  29.31a      14,452     0.000    6.293    2.0242  -2.085(1)
  14.159   1.33s  29.79a      14,452     0.000    6.292    2.0778  -2.318(1)
  14.917   1.44s  34.79a      14,452     0.000    6.135    2.6225  -4.687(1)
  15.563   1.57s  39.79a      14,452     0.000    5.778    3.1438  -7.016(1)
  16.093   1.71s  44.79a      14,452     0.000    5.277    3.6272  -9.289(1)
  16.503   1.85s  49.79a      14,452     0.000    4.670    4.0620 -11.489(1)
  16.788   1.99s  54.79a      14,452     0.000    3.982    4.4402 -13.601(1)
  16.945   2.12s  59.79a      14,452     0.000    3.231    4.7554 -15.607(1)
  16.973   2.23s  64.79a      14,451     0.000    2.433    5.0029 -17.493(1)
  16.874   2.35s  69.79a      14,452     0.000    1.599    5.1790 -19.246(1)
  16.869   2.36s  70.00a      14,452     0.000    1.564    5.1847 -19.315(1)
  Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.
                                       +
  Note:  The Residual Righting Arms shown above are in excess of the
         wind heeling arms derived from these moments (in m.-MT):
                   Aft heeling moment = 1251.35 (constant)
                                       +
  Note: Angle of MaxRA refers to the absolute Righting Arm curve.
                                       +
            Critical Points----------------------LCP-----TCP-----VCP
        (1) c1                        FLOOD   1.250f 15.500  19.100
        (5) c5                        TIGHT   0.000  16.827   8.235
LIM--------------------STABILITY CRITERION------------Min/Max--------Attained
(1) Abs Area from Equ0 (no moments) to MaxRA0      >   0.0800 m.-Rad 2.0689 P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.   >     0.00  deg    69.74 P
(3) Angle from Equilibrium to RAzero or Flood      >    20.00  deg    24.69 P
(4) Absolute Area from Equ0 (no moments) to Flood  >   0.0800 m.-Rad 1.5869 P
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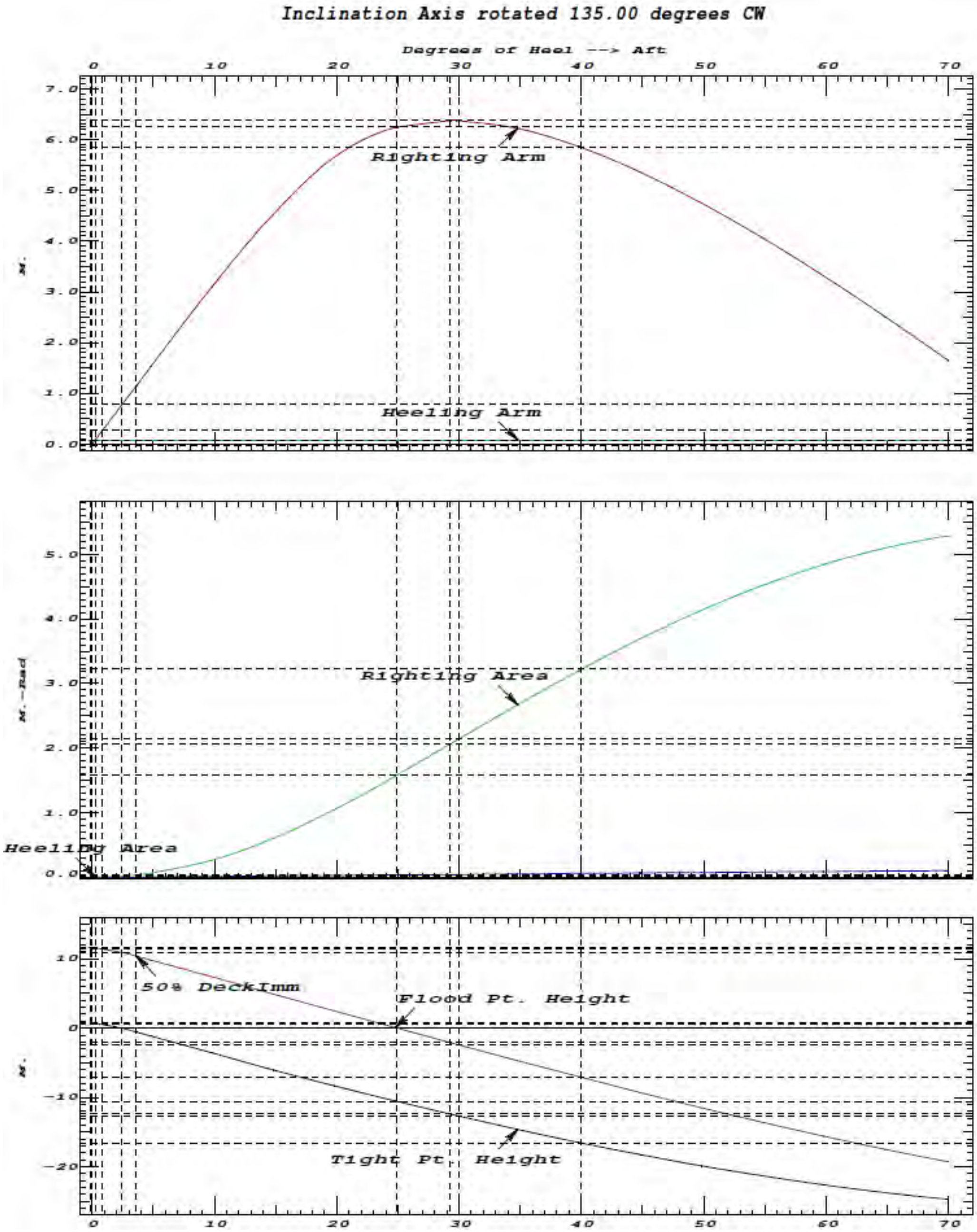

A X I S   150

RESIDUAL RIGHTING ARMS vs HEEL ANGLE

LCG = 22.244f TCG = 0.262s VCG = 9.555

Inclination axis rotated 150.00 degrees CW

Origin Depth	Degrees of Trim	Degrees of Heel	Displacement Weight(MT)	Residual Arms in Trim	Residual Arms in Heel	Res. Area	Flood Pt Height
7.231	1.11a	0.55s	14,452	0.000	-0.162	0.0000	0.700(5)
7.278	1.11a	0.31s	14,452	0.000	-0.087	-0.0005	0.713(5)
7.332	1.11a	0.04s	14,452	0.000	0.000	-0.0007	0.729(5)
7.793	1.11a	2.35p	14,452	0.000	0.756	0.0150	-0.000(5)
8.030	1.11a	3.59p	14,452	0.000	1.154	0.0358	50% DeckImm
8.191	1.11a	4.45p	14,452	0.000	1.428	0.0552	10.014(2)
9.111	1.14a	9.45p	14,452	0.000	3.009	0.2488	7.610(2)
10.053	1.29a	14.45p	14,452	0.000	4.457	0.5755	5.095(2)

```
  10.922   1.64a  19.45p      14,452     0.000    5.638    1.0179   2.597(2)
  11.749   2.34a  24.45p      14,452     0.000    6.282    1.5420   0.142(2)
  11.797   2.40a  24.74p      14,452     0.000    6.303    1.5740  -0.000(2)
  12.495   3.26a  29.02p      14,452     0.000    6.438    2.0515  -2.089(2)
  12.565   3.35a  29.45p      14,452     0.000    6.437    2.1003  -2.301(2)
  13.349   4.58a  34.45p      14,452     0.000    6.263    2.6572  -4.720(2)
  14.089   6.00a  39.45p      14,452     0.000    5.866    3.1880  -7.097(2)
  14.772   7.57a  44.45p      14,451     0.000    5.311    3.6768  -9.405(2)
  15.379   9.24a  49.45p      14,451     0.000    4.645    4.1121 -11.622(2)
  15.889  10.96a  54.45p      14,451     0.000    3.902    4.4855 -13.720(2)
  16.276  12.62a  59.45p      14,451     0.000    3.112    4.7919 -15.681(2)
  16.518  14.15a  64.45p      14,451     0.000    2.298    5.0281 -17.569(1)
  16.605  15.47a  69.45p      14,452     0.000    1.477    5.1928 -19.337(1)
  16.605  15.61a  70.00p      14,452     0.000    1.387    5.2065 -19.520(1)
  Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.
                                    +
  Note:  The Residual Righting Arms shown above are in excess of the
         wind heeling arms derived from these moments (in m.-MT):
                  Port heeling moment = 1251.35 (constant)
                                    +
  Note: Angle of MaxRA refers to the absolute Righting Arm curve.
                                    +
            Critical Points----------------------LCP-----TCP-----VCP
        (1) c1                       FLOOD   1.250f 15.500  19.100
        (2) c2                       FLOOD   7.000f 21.250  19.100
        (5) c5                       TIGHT   0.000  16.827   8.235
LIM--------------------STABILITY CRITERION------------Min/Max--------Attained
(1) Abs Area from Equ0 (no moments) to MaxRA0      >   0.0800 m.-Rad 2.0964 P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.   >     0.00  deg    70.04 P
(3) Angle from Equilibrium to RAzero or Flood      >    20.00  deg    24.78 P
(4) Absolute Area from Equ0 (no moments) to Flood  >   0.0800 m.-Rad 1.6124 P
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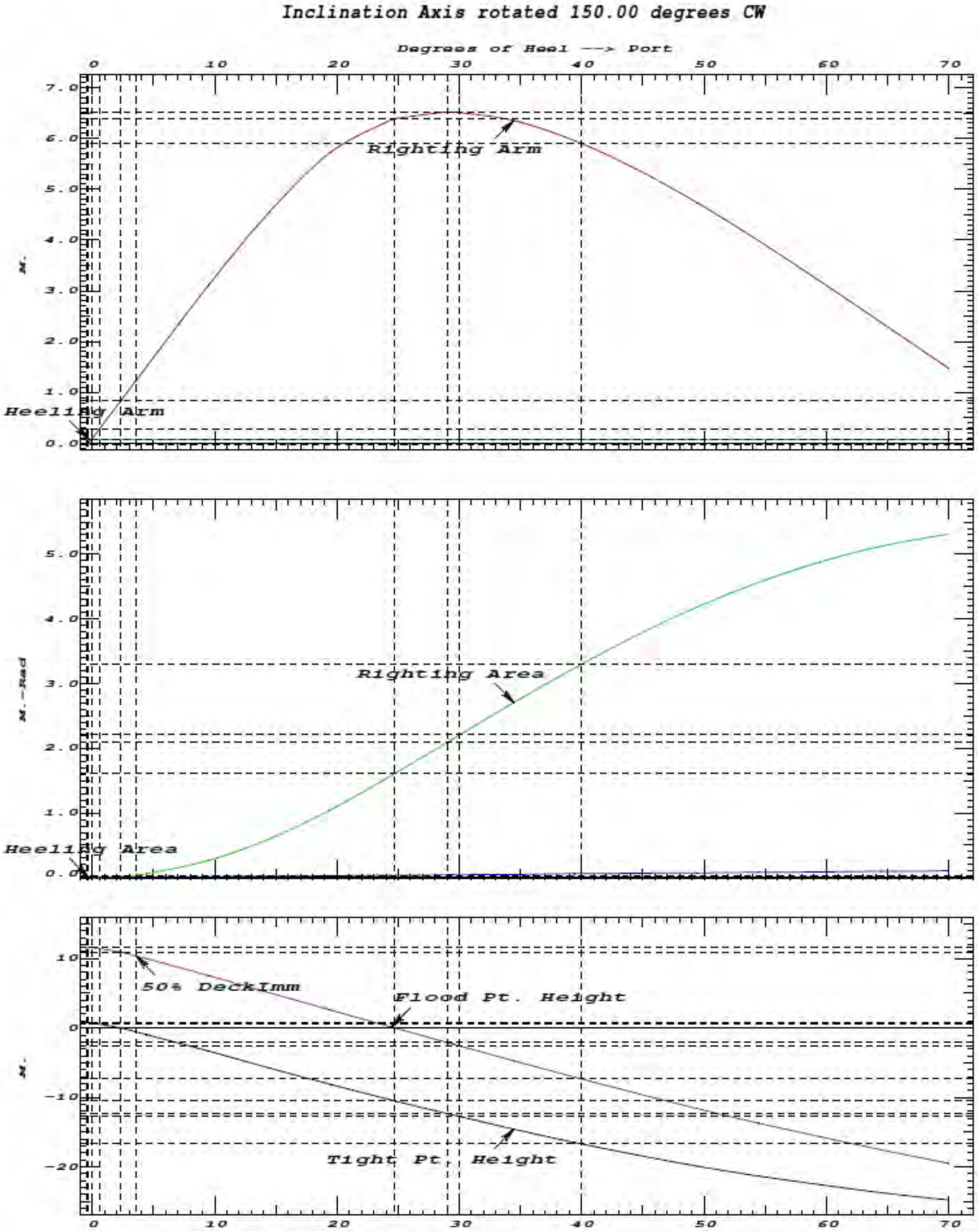

A X I S   165

RESIDUAL RIGHTING ARMS vs HEEL ANGLE
LCG = 22.244f TCG = 0.262s VCG = 9.555
Inclination axis rotated 165.00 degrees CW

Origin Depth	Degrees of Trim	Degrees of Heel	Displacement Weight(MT)	Residual Arms in Trim	Residual Arms in Heel	Res. Area	Flood Pt Height
7.251	0.99a	0.85s	14,452	0.000	-0.170	0.0000	0.665(5)
7.278	0.99a	0.59s	14,452	0.000	-0.087	-0.0006	0.713(5)
7.306	0.99a	0.32s	14,452	0.000	0.000	-0.0008	0.763(5)
7.587	0.99a	2.51p	14,452	0.000	0.898	0.0214	0.002(5)
7.716	0.99a	3.88p	14,452	0.000	1.334	0.0480	50% DeckImm
7.741	0.99a	4.15p	14,452	0.000	1.418	0.0544	10.165(2)
8.184	1.01a	9.15p	14,452	0.000	3.024	0.2481	7.911(2)
8.698	1.23a	14.15p	14,452	0.000	4.509	0.5777	5.508(2)

```
  9.191   1.63a  19.15p      14,452     0.000    5.826    1.0299   3.058(2)
  9.716   2.61a  24.15p      14,452     0.000    6.641    1.5775   0.605(2)
  9.863   2.95a  25.36p      14,452     0.000    6.741    1.7191  -0.000(2)
 10.361   4.23a  29.15p      14,452     0.000    6.856    2.1704  -1.912(2)
 11.102   6.37a  34.15p      14,450     0.000    6.653    2.7633  -4.474(2)
 11.975   9.12a  39.15p      14,452     0.000    6.156    3.3243  -7.073(2)
 12.972  12.51a  44.15p      14,452     0.000    5.443    3.8320  -9.662(2)
 14.013  16.36a  49.15p      14,452     0.000    4.578    4.2703 -12.155(2)
 14.946  20.23a  54.15p      14,452     0.000    3.648    4.6297 -14.442(2)
 15.665  23.76a  59.15p      14,452     0.000    2.731    4.9079 -16.465(2)
 16.137  26.75a  64.15p      14,452     0.000    1.876    5.1085 -18.220(2)
 16.374  29.17a  69.15p      14,450     0.000    1.095    5.2376 -19.847(1)
 16.393  29.52a  70.00p      14,451     0.000    0.969    5.2529 -20.115(1)
 Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.
                                   +
 Note:  The Residual Righting Arms shown above are in excess of the
        wind heeling arms derived from these moments (in m.-MT):
                 Port heeling moment = 1251.35 (constant)
                                   +
 Note: Angle of MaxRA refers to the absolute Righting Arm curve.
                                   +
           Critical Points----------------------LCP-----TCP-----VCP
       (1) c1                       FLOOD   1.250f 15.500  19.100
       (2) c2                       FLOOD   7.000f 21.250  19.100
       (5) c5                       TIGHT   0.000  16.827   8.235
LIM--------------------STABILITY CRITERION------------Min/Max--------Attained
(1) Abs Area from Equ0 (no moments) to MaxRA0      >   0.0800 m.-Rad 2.2159 P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.   >     0.00  deg    70.32 P
(3) Angle from Equilibrium to RAzero or Flood      >    20.00  deg    25.68 P
(4) Absolute Area from Equ0 (no moments) to Flood  >   0.0800 m.-Rad 1.7589 P
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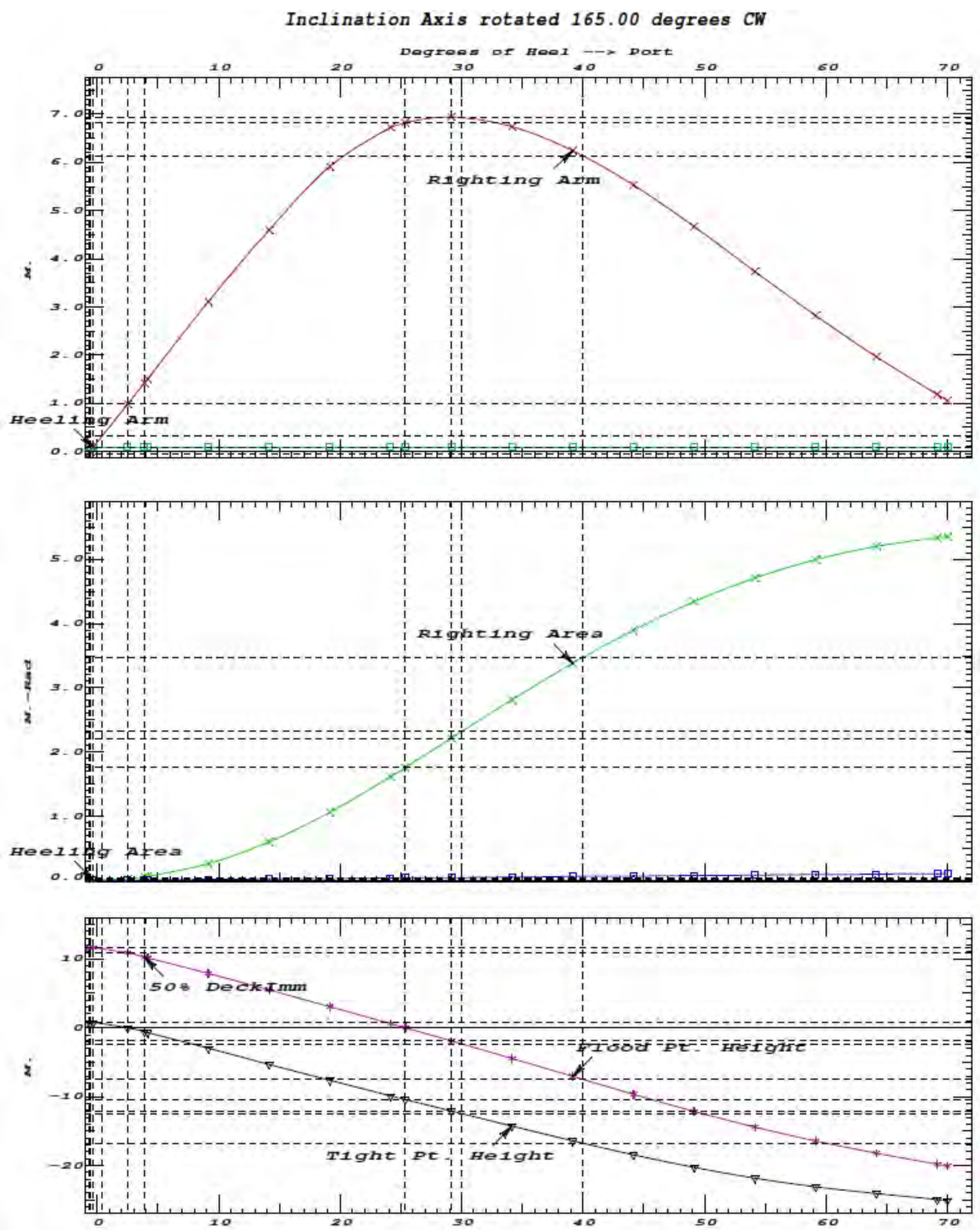


A X I S   180

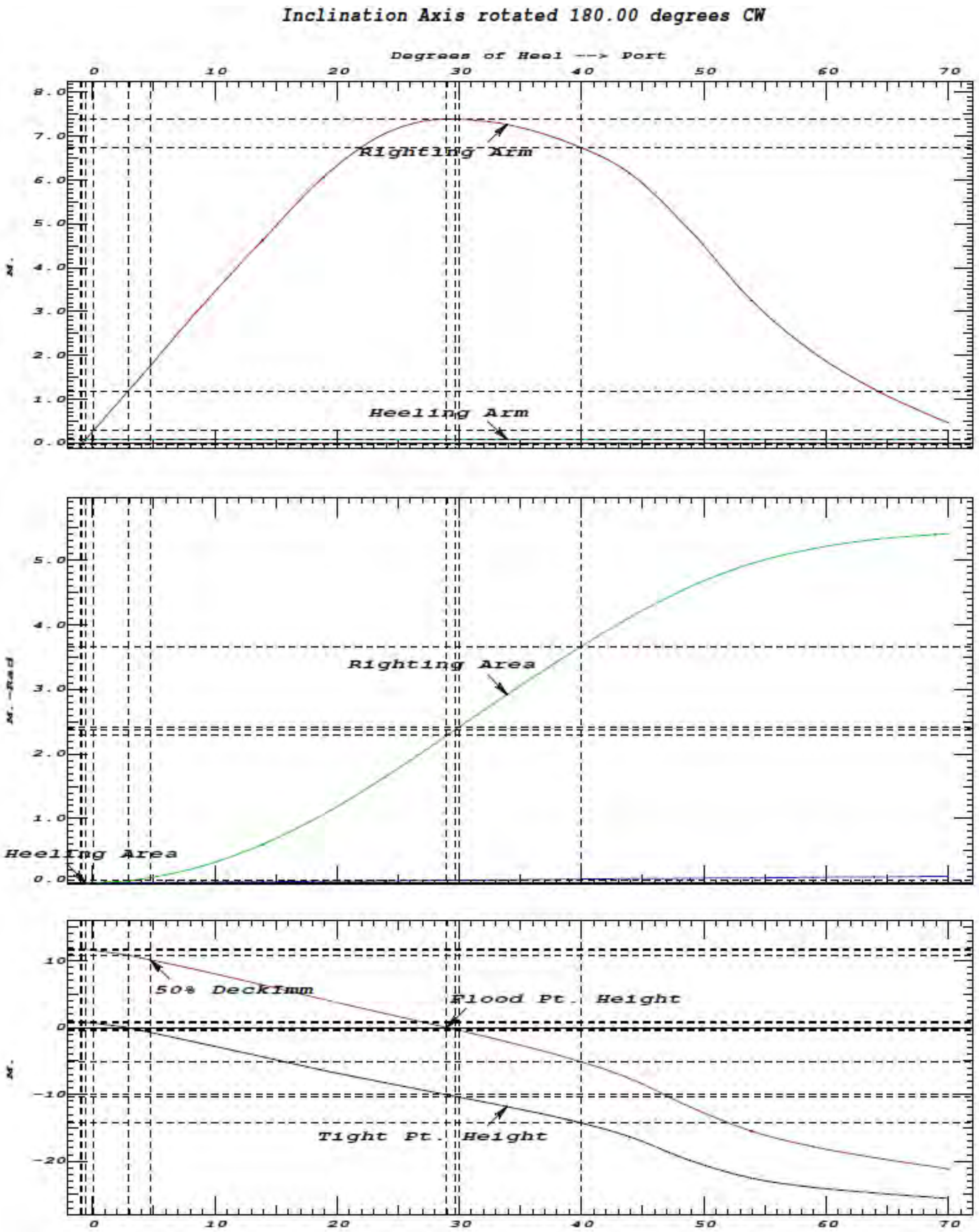
RESIDUAL RIGHTING ARMS vs HEEL ANGLE

LCG = 22.244f   TCG = 0.262s   VCG = 9.555

Inclination axis rotated 180.00 degrees CW

Origin Depth	Degrees of Trim	Heel	Displacement Weight(MT)	Residual Arms in Trim	in Heel	Res. Area	Flood Pt Height
7.277	0.81a	1.10s	14,452	0.000	-0.173	0.0000	0.633(5)
7.278	0.81a	0.82s	14,452	0.000	-0.087	-0.0006	0.713(5)
7.278	0.81a	0.55s	14,452	0.000	0.000	-0.0008	0.793(5)
7.270	0.81a	2.89p	14,452	0.000	1.091	0.0319	0.000(6)
7.263	0.81a	3.90p	14,452	0.000	1.414	0.0541	10.444(2)
7.255	0.81a	4.69p	14,452	0.000	1.666	0.0753	50% DeckImm
7.194	0.80a	8.90p	14,452	0.000	3.029	0.2477	8.484(2)
7.160	0.89a	13.90p	14,452	0.000	4.539	0.5784	6.382(2)

```
   7.098   0.96a  18.90p      14,452     0.000    5.984    1.0380   4.204(2)
   6.879   1.23a  23.90p      14,452     0.000    6.971    1.6066   2.121(2)
   6.625   1.72a  28.90p      14,452     0.000    7.302    2.2341   0.034(2)
   6.620   1.73a  28.98p      14,452     0.000    7.303    2.2442   0.001(2)
   6.588   1.83a  29.70p      14,452     0.000    7.307    2.3357  -0.305(2)
   6.468   2.60a  33.90p      14,452     0.000    7.181    2.8690  -2.154(2)
   6.587   4.31a  38.90p      14,452     0.000    6.771    3.4803  -4.546(2)
   7.659   8.63a  43.90p      14,452     0.000    6.076    4.0429  -7.571(2)
  10.932  19.26a  48.90p      14,452     0.000    4.753    4.5200 -11.887(2)
  13.853  29.90a  53.90p      14,452     0.000    3.168    4.8675 -15.493(2)
  15.287  36.61a  58.90p      14,452     0.000    1.991    5.0896 -17.799(2)
  15.963  40.99a  63.90p      14,452     0.000    1.145    5.2241 -19.434(2)
  16.263  44.09a  68.90p      14,452     0.000    0.501    5.2944 -20.842(1)
  16.297  44.65a  70.00p      14,452     0.000    0.378    5.3028 -21.133(1)
  Distances in METERS.----Specific Gravity = 1.025.-----------Area in m.-Rad.
                                     +
  Note:  The Residual Righting Arms shown above are in excess of the
         wind heeling arms derived from these moments (in m.-MT):
                  Port heeling moment = 1251.35 (constant)
                                     +
  Note: Angle of MaxRA refers to the absolute Righting Arm curve.
                                     +
            Critical Points----------------------LCP-----TCP-----VCP
        (1) c1                         FLOOD   1.250f 15.500  19.100
        (2) c2                         FLOOD   7.000f 21.250  19.100
        (5) c5                         TIGHT   0.000  16.827   8.235
        (6) c6                         TIGHT   5.673f 22.500   8.335
LIM--------------------STABILITY CRITERION------------Min/Max--------Attained
(1) Abs Area from Equ0 (no moments) to MaxRA0      >   0.0800 m.-Rad 2.3825 P
(2) Angle from Equ. to abs 70 deg to 50% Dk Imm.   >     0.00  deg    70.55 P
(3) Angle from Equilibrium to RAzero or Flood      >    20.00  deg    29.53 P
(4) Absolute Area from Equ0 (no moments) to Flood  >   0.0800 m.-Rad 2.2898 P
-----------------------------------------------------------------------------
```



Inclination Axis rotated 180.00 degrees CW
Degrees of Heel --> Port
Righting Arm
Heeling Arm
Righting Area
Heeling Area
50% DeckImm
Flood Pt. Height
Tight Pt. Height
M.
M.-Rad