RETHINKING URBAN PRACTICES

Designing for Jurong Vision 2050

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INTRODUCTION

RETHINKING URBAN PRACTICES

This book rethinks urban practices, both its processes and its products, within the context of JTC Corporation's 2050 vision for the Jurong Industrial Estate (JIE). This vision entails the transformation of JIE from an almost mono-functional, segregated and fragmented, polluted industrial area into a major catchment area for future population growth that integrates clean(ed) industrial plants with green lungs, attractive housing and vibrant urbanity for one million people.

The book presents selected student projects at varying scales that propose innovative ideas on how JIE can be re-imagined for a future Singapore. A first set of student projects is selected from the Final Design Project studio of the Master of Architecture specialisation in Design Technology and Sustainability at NUS. These projects present innovative, prototypical designs addressing collocation and mixed developments, with a focus on the Jurong Hill area and Pulau Samulun within JIE.

A second set of student projects is selected from the Master of Arts/Architecture (Urban Design) and Master of Urban Planning studios at NUS. These projects serve as demonstration for an urban planning and design workflow that leverage new computational tools and techniques in order to enable planning and design options to be systematically developed, evaluated, and analysed. The workflow addresses complex challenges that require new thinking about our city and its planning and design. It supports the exploration and development of alternative visions of the future city, and enables the evaluation and analysis of different urban planning and design options.

All selected projects have their genesis in the International Forum on Urbanism (IFoU) Winter School, held at the Department of Architecture, NUS, in January 2015, in collaboration with JTC Corporation.

ELEVATE

FUTURE TRANSPORT SYSTEMS FOR THE CITY

KOH TECK WEI

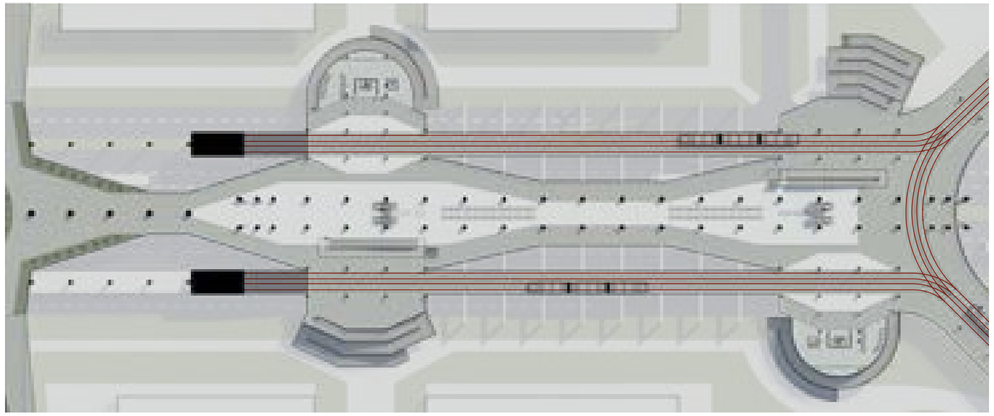
FINAL DESIGN PROJECT 2014-15

TUTOR :
PROF. RUDI STOUFFS

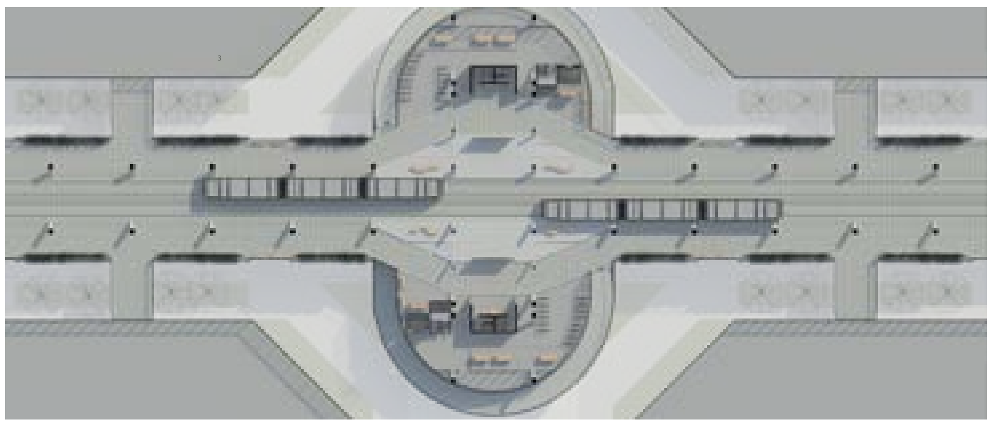
ABSTRACT

The “EleVate” project proposes an elevated tramway system as connectivity infrastructure for the transformation of Jurong Industrial Estate from its current focus on industry into a major catchment area for future population growth. As such, it can be developed in advance of or alongside the transformational developments integrating clean(ed) industrial plants with green lungs, attractive housing and vibrant urbanity for up to one million people.

Tram station at bridge level

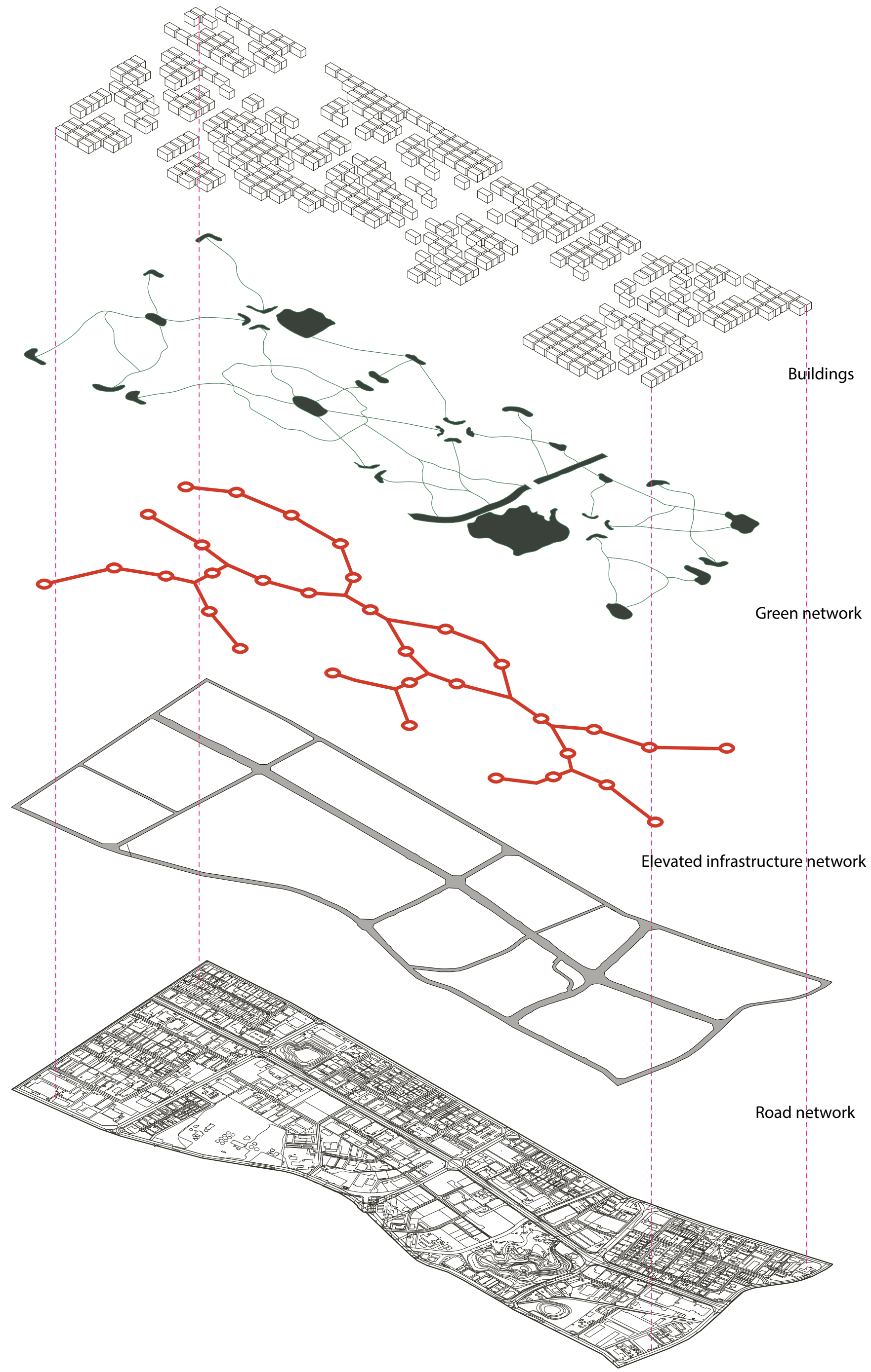


Tram and MRT interchange plan at bridge level
1:350



Tram station plan at bridge level
1:100

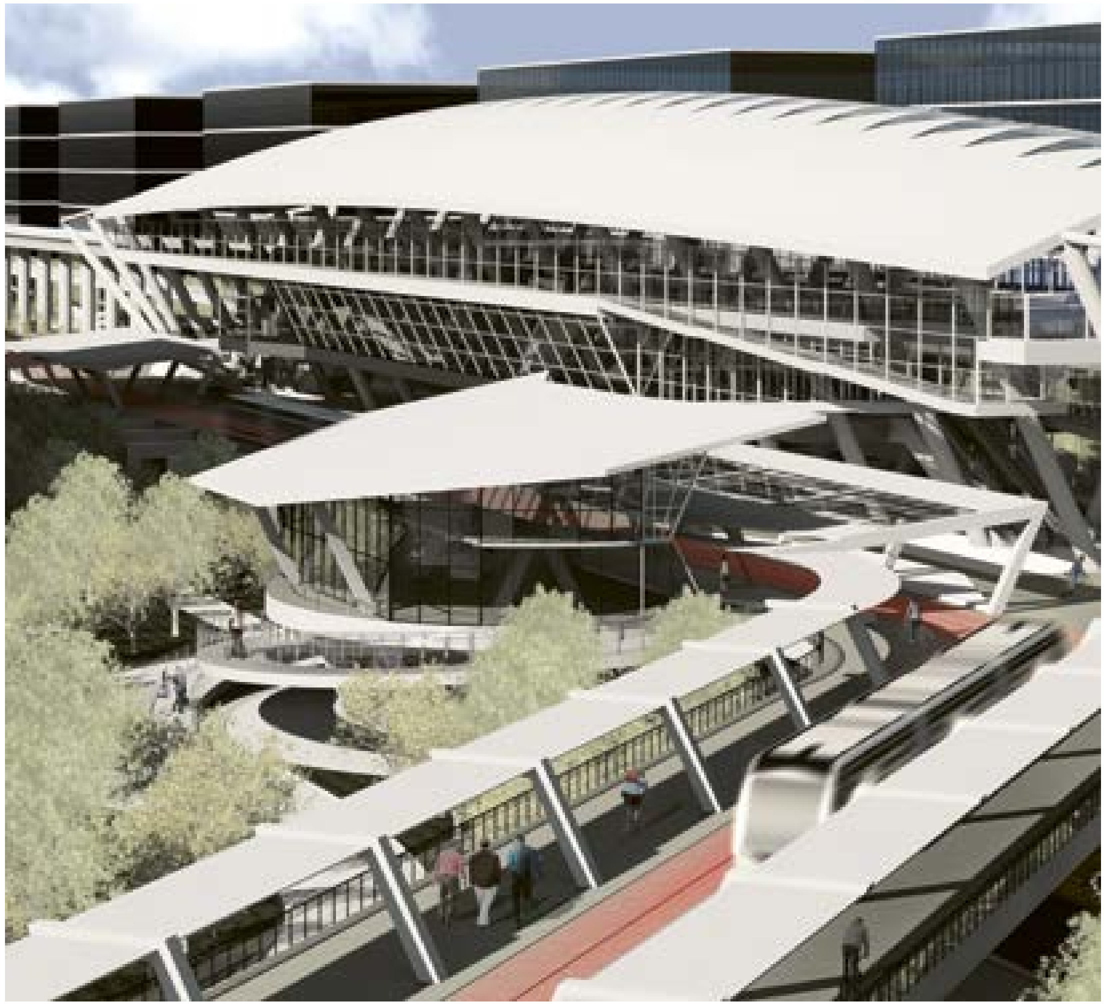
The tram seamlessly integrates with other modes of transportation, especially, means of active connectivity, such as pedestrian movement, bicycles, and other current or future, personal, green transportation. Trams, pedestrians, bicycles, etc., all share the same physical space. The elevated deck also enables developments along the infrastructure to reinforce the deck's public connectivity function by linking directly to it. The deck becomes the new ground level for pedestrians and bicyclists.

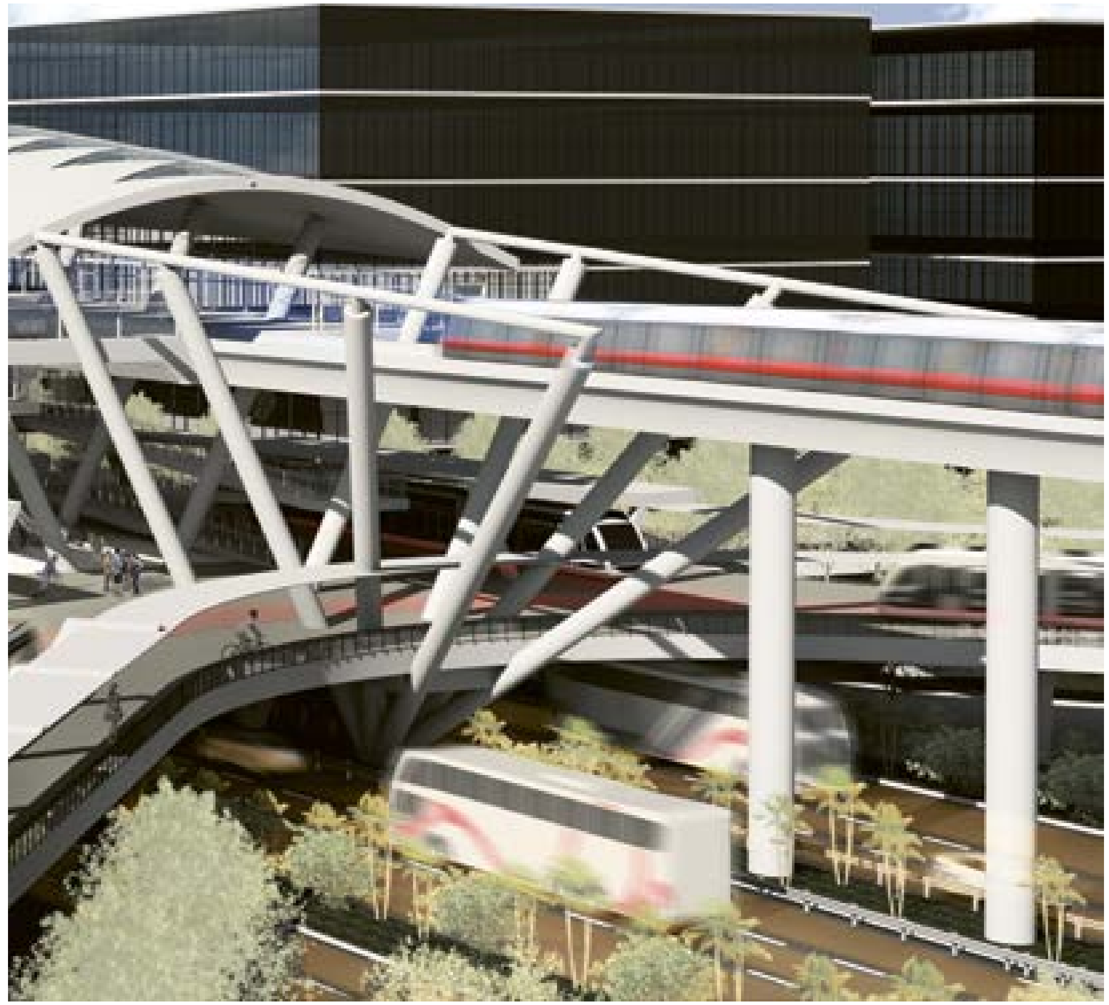


Layers of the proposal

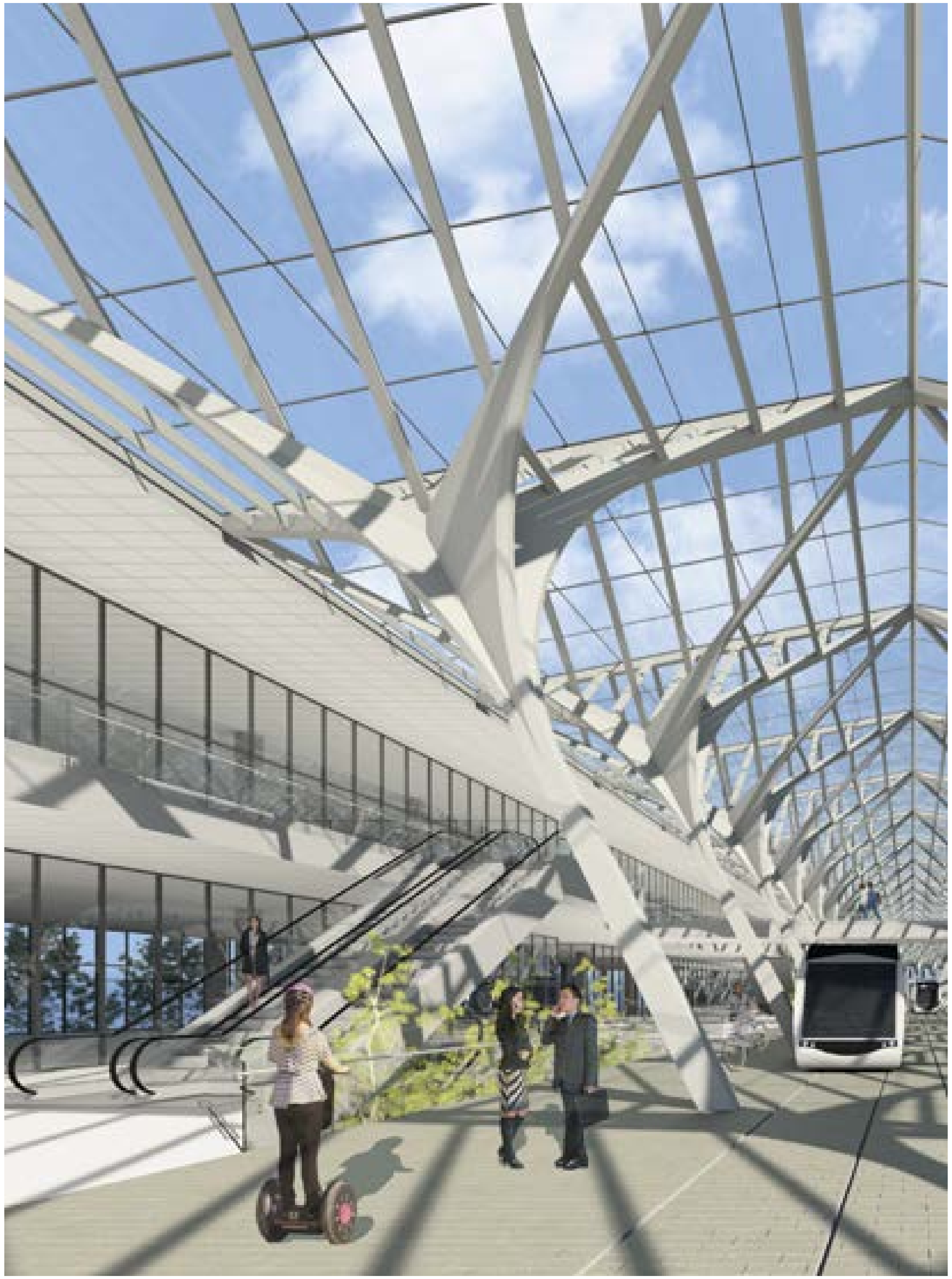
Elevation of tram station crossing a park connector

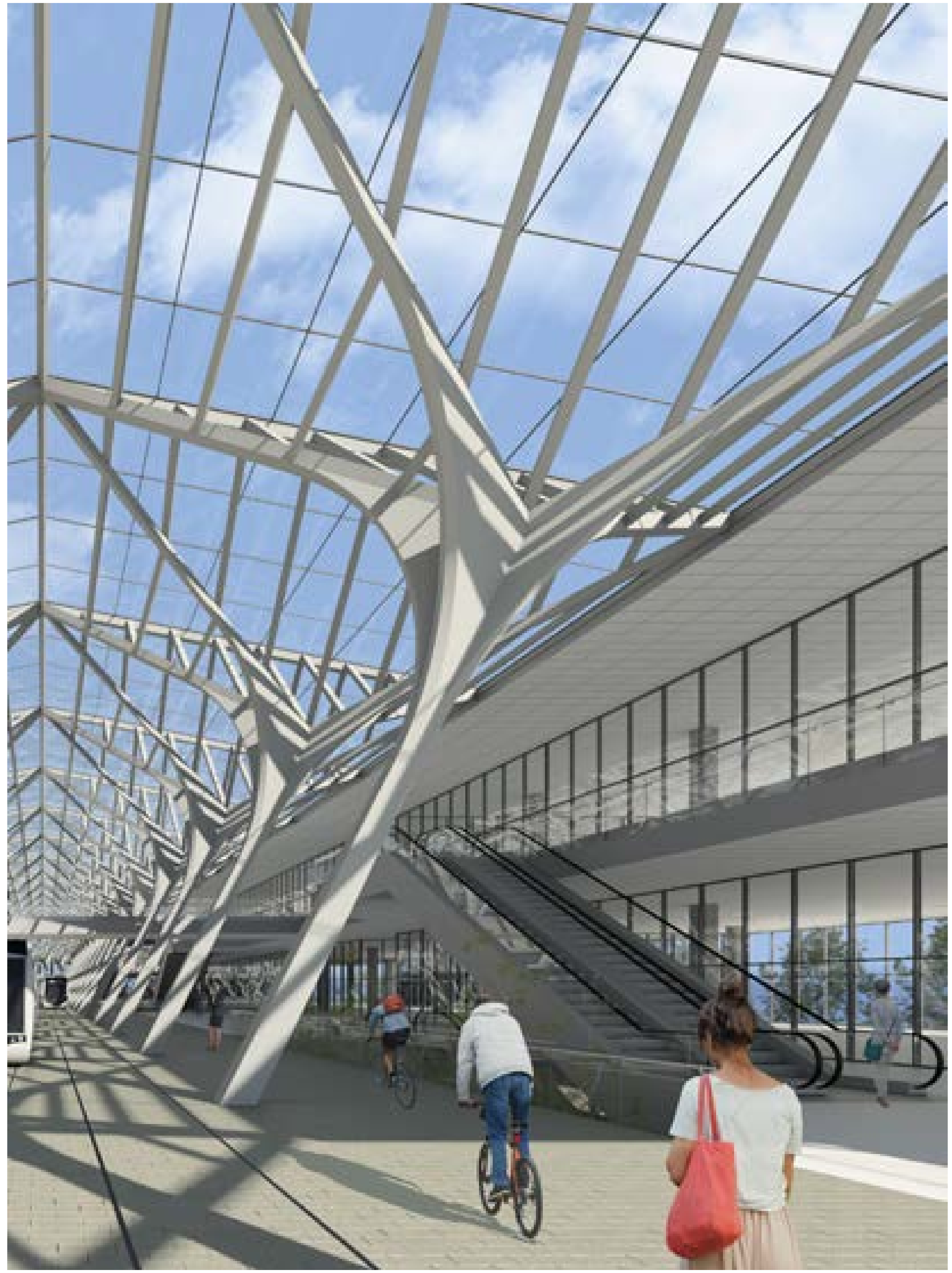
Tram and MRT interchange at bridge level





Tram and MRT exchange above Ayer Rajah expressway





Tramway integrated with mall development

PERFORMATIVE IMAGINATION

DESIGNING FOR THE JURONG HILL AREA

A first selection of student projects is taken from the results of an M.Arch. Design Technology and Sustainability thesis studio led by Rudi Stouffs, addressing JTC's Jurong Vision 2050 with an emphasis on the Jurong Hill area and delivering innovative, prototypical designs targeting collocation and mixed developments and construction over air-space.

Due to a shortage of space, Singapore is experimenting with providing developers air rights, e.g., allowing them to build over a road or highway. However, building over a highway is not just a legal issue, nor a structural issue of spanning the width of the road. There are many other performative issues that may play a role, such as noise pollution, air pollution, accessibility, connectivity, safety, etc. Some of these issues might be avoided by burying the road under the development. Other issues might be solved adequately during the design materialisation and detailing stages, considering material choices, technological innovations, structural dimensions, etc. However, considering selected issues as design drivers in the conceptual design stage might yield much more imaginative and effective solutions, merging form, function and materialisation in innovative and synergistic ways.

In this guided M.Arch. thesis studio, students considered one or more performative qualities as design drivers in the exploratory design of a multi-functional building or building cluster serving as an activity hub for a mixed-use industrial area. The selection of design drivers is argued from a design idea and supported by an investigation into (analytical and other) means for assessing the respective performative qualities. These investigations formed the research component at the start of the studio, where each student investigated a performative quality and shared the results of these investigations among the studio participants.The site proposed by the studio is the surroundings of the Jurong Hill Flyover on the Ayer Rajah Expressway (AYE).

The site is part of Jurong West, which is currently under consideration by JTC Corporation to be transformed from an almost mono-functional, fragmented and polluted industrial area into an attractive and healthy mixed-use area for clean-tech industry and housing for one million people, amongst greenery and water. The attractiveness of the site for the studio lies in the proximity of Jurong Hill and Jurong Bird Park, the complex interaction of the elevated AYE with its parallel road, Jalan Ahmad Ibrahim, and a traversing industrial main road, Jurong Pier Road, and the projected development of an MRT station on Jurong Pier Road.

In order to attract living in the Jurong West area, new centralities would need to be developed that transform existing transportation nodes into vibrant urban centres integrating living, commerce, and culture in a high-density development. The Jurong Hill area is a prime target for such developments, creating a new centrality that builds upon its current qualities and further enhances the surrounding area to attract living and other mixed uses. Land use planning and major improvements in this area should create a network of vibrant, mixed-use, higher-density pedestrian and transit-oriented corridors that link to major, existing community centres such as the Jurong lake district.

The studio's design research was funded by JTC. All students also participated in the International Forum on Urbanism (IFoU) Winter School, held at the Department of Architecture, NUS, in collaboration with JTC, in January 2015, and the projects have their genesis in this winter school. Students interpreted the site context from the results of the winter school, with the proposed building accentuating a future transition towards a more mixed-use development.

Four students successfully participated in the studio. The first two here described have their design included in the book.

Koh Teck Wei designed an elevated tramway system as connectivity infrastructure for the transformation of Jurong Industrial Estate from its current focus on industry into a major catchment area for future population growth. It is elevated above the ground so as not to hinder, nor to be hindered, by the existing road network. The structural system is designed as a V-shape that can be adapted and reused in different forms to support different versions of the elevated deck (see EleVate).

Chiang Wei Han proposed a reclamation of the ground under the Jurong Hill Flyover to pedestrians. His design explores how re-routing vehicular roads underground could create a green oasis for a densely populated neighbourhood, even in the presence of a major expressway. The space is developed as a conduit to bring people to Jurong Hill (see The Ascent).

Hao Yi Chun designed a mixed-use building with both residential (including SOHO (small office/home office)) and office clusters within a same organisational structure and offering full adaptability over time.

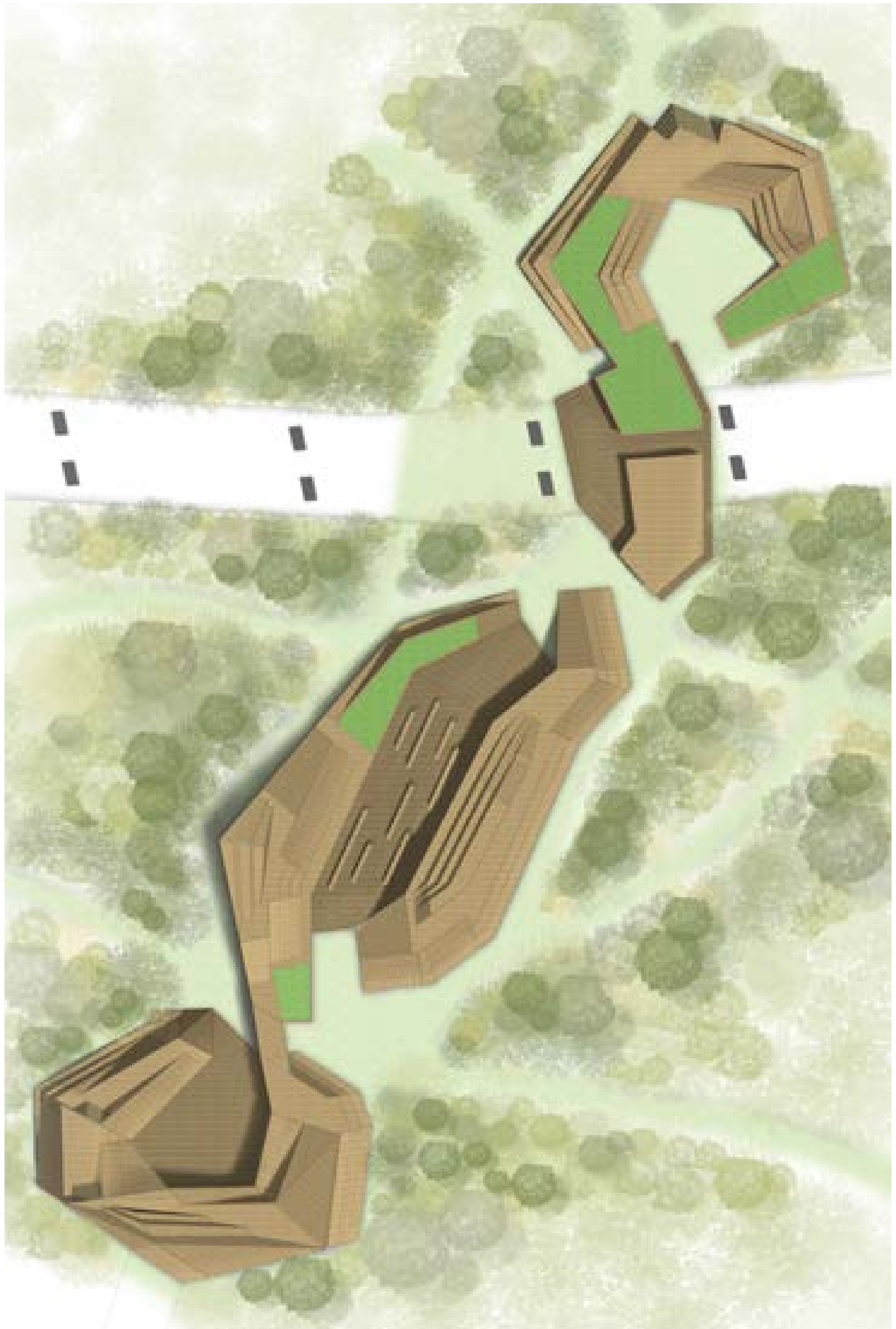
Jasmin Mok designed a stacked industrial building that acts as a sound barrier and billboard to shelter the Jurong Hill from the noise generated on the expressway.

THE ASCENT
JURONG HILL 2050

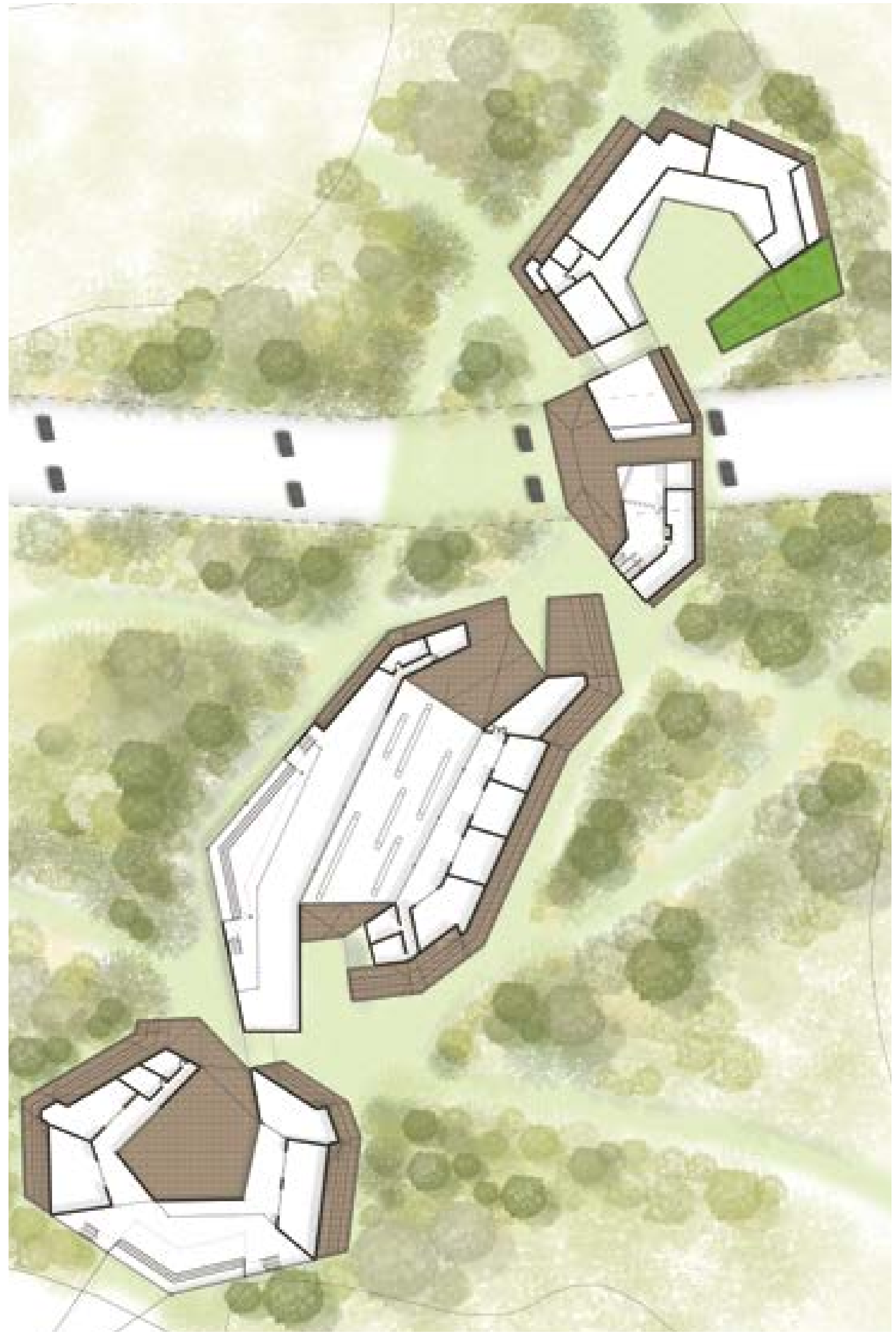
CHIANG WEI HAN
FINAL DESIGN PROJECT 2014-15

TUTOR :
PROF. RUDI STOUFFS

ABSTRACT
With a projected population of 6.9 million people residing in Singapore by the year 2030, we can expect that much of the land-use will need to be reconsidered. In particular, the intense industrial zoning of Jurong Industrial Estate will likely need to make way for the large influx of residents, but still retain its identity as the industrial heart of Singapore. This project explores what a possible scenario in the future urban landscape of Singapore could be, based on estimations and postulations made according to statistics of the current situation in this country.

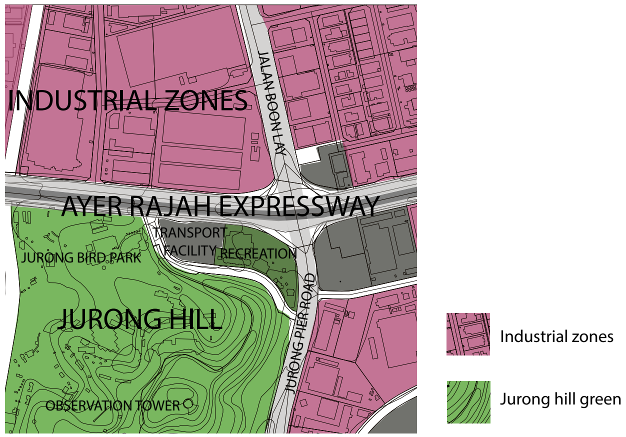


Site plan

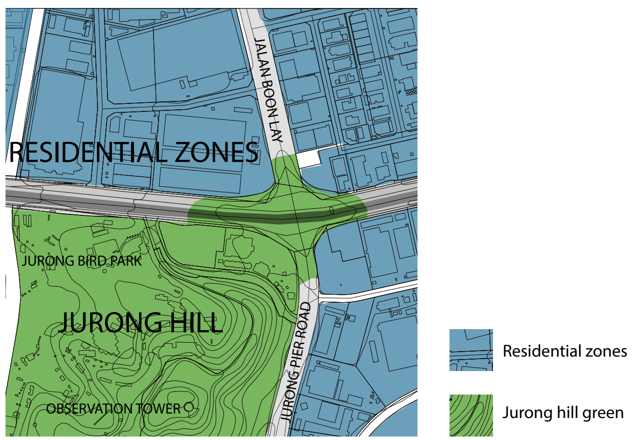


First floor plan

The project aims to develop a prototype solution for the site of Jurong Hill Flyover along the Ayer Rajah Expressway. Serving as an intersection of major lateral and longitudinal axes, the site is presently utilised by vehicular traffic. This commits a large surface area on the ground to hard, asphalt roads while turning away pedestrians. Proposing a reclamation of the ground for pedestrians, the project explores how re-routing vehicular roads underground could create a green oasis for a densely populated neighbourhood.



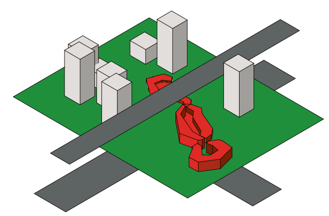
Current site plan based on 2014 Urban Redevelopment Authority (URA) Singapore masterplan



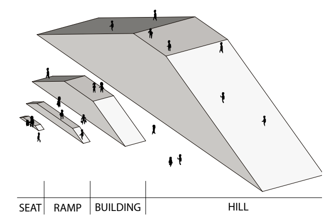
Proposed site plan for transformation of the area by 2050

In particular, the currently under-utilised Jurong Hill can be exploited as a natural resource to enhance the quality of the living environment when the area is fully built up. Since it is anticipated that Jurong Industrial Estate will house one million people by 2050, the hill as a natural green space will become invaluable in the future. Specifically, the space reclaimed by re-routing the roads on the surface underground is developed as a conduit to bring people to the hill.

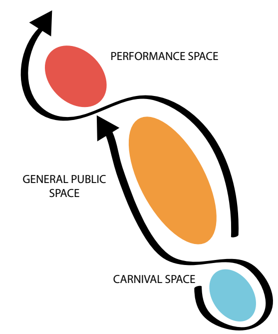
Current land-use in Jurong Industrial Estate



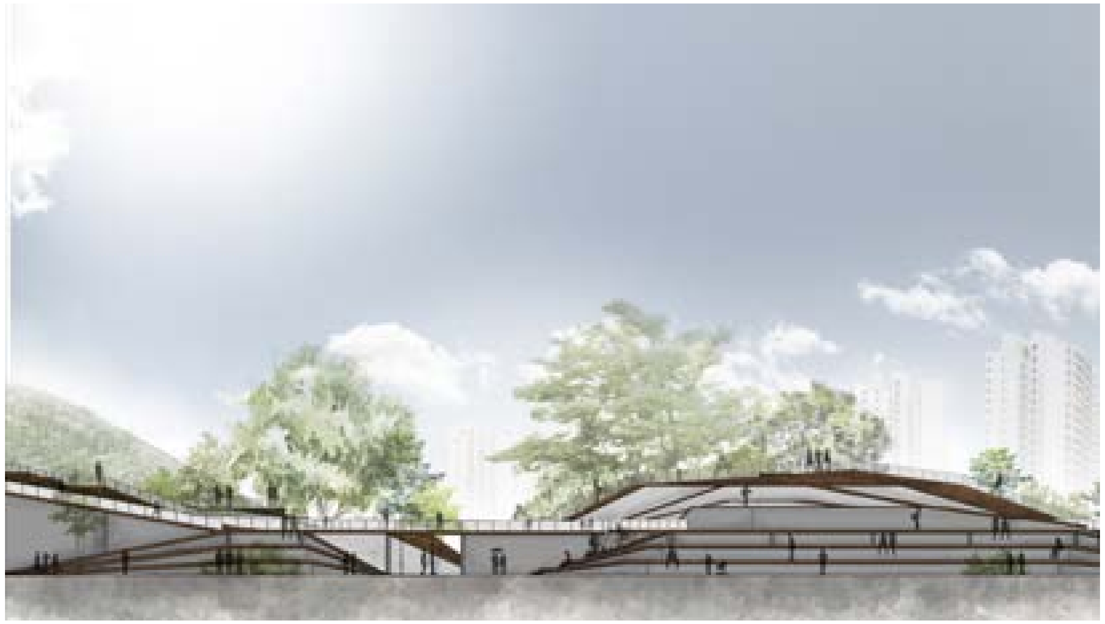
Proposal to reclaim the ground plane for pedestrians



Scale of elements used in project



Layout of programs



Long elevation

Section through carnival space

Section through public square space

Public square space

Carnival space for community events and festivals

IFOU

JURONG VISION 2050

The International Forum on Urbanism (IFoU) organised a Winter School in January 2015 at the School of Design and Environment, NUS, in collaboration with JTC Corporation. The Winter School had the title 'Jurong Vision 2050' and the aim to generate a long-term vision for the re-development of the Jurong area in the west of Singapore, more specifically, the Jurong Industrial Estate (JIE), a 5000 ha industrial area. The brief was to develop proposals for the transformation of JIE from an almost mono-functional, segregated and fragmented, polluted industrial area into a major catchment area for future population growth that integrates clean(ed) industrial plants with green lungs, attractive housing and vibrant urbanity for one million people.

More than 170 students and 30 design tutors, including the authors, participated from 18 different universities of the IFoU network, from all over the world. The Winter School lasted for 12 days. Students were divided into teams of 8 to 10 students, each focusing on one of ten topics: industrialisation, connectivity, energy, food, liveability, transit networks, city in the garden, waterfront development, and living together. The students within each team then worked intensively together to develop visions and proposals. The grouping of the students was organised in such a way so as to ensure that each group included a mix of students from different institutions and regions in the world. While this rich mix of students created great opportunities for cross-cultural interaction and design, it also presented some significant challenges.

One of these challenges was the dynamic and at times even chaotic nature of the design process. The design process that emerged from within these groups of students was highly non-linear, and combined sketching and drawing with digital methods and tools. Typically, groups would meet intermittently to discuss overall strategies and goals, and would then break into smaller sub-clusters to work in parallel on specific topics. Often, these sub-clusters would then start exploring completely new ideas, which would later have to be reconciled within the larger group. In many cases, conflicts emerged which then had to be resolved through heated discussion. In general, this reflects the fact that urban planning and design is fundamentally an unstructured or 'wicked' process characterised by (1) multiple actors with differing, legitimate values and opinions; (2) high uncertainty; (3) aspects of irreversibility; (4) no clear solutions; (5) being fraught with contradictions; (6) being persistent and unsolvable (Rutledge et al., 2008).

At the start of the winter school, students were provided with a USB stick that contained extensive data on the existing conditions of the JIE. The students were then encouraged to use this data as a starting point for their design process, and to use digital methods and tools to develop proposals. However, while almost all students brought laptops, the software tools that they tended to use were very diverse. For this kind of context, suggesting the idea of using a single integrated computational environment would have been too inflexible. Instead, students had to be able to use the tools they were familiar with and to exchange data in a variety of formats. Although some students had experience in using GIS software, most were only able to use simpler, modelling types of tools such as AutoCAD and SketchUp. These issues may seem to be secondary, but in reality they have a significant impact on the types of proposals that were developed and on the arguments made to support those proposals.

Prior to the start of the winter school, a semi-automated data synthesis method was developed to generate building models based on a set of simple rules. As the main purpose of these building models was to quantify the overall massing and floor areas that can be achieved, these models only needed to consist of simple massing with floor plates and did not need to be highly detailed in their visual appearance. In order to support fast iterative generation of large-scale urban models, a parametric modelling method was conceived that generates building models based on parameter fields encoded as images (see Generative). These building models include floor plates for each floor, which makes it straightforward to calculate floor areas, such as the total floor area for each function.

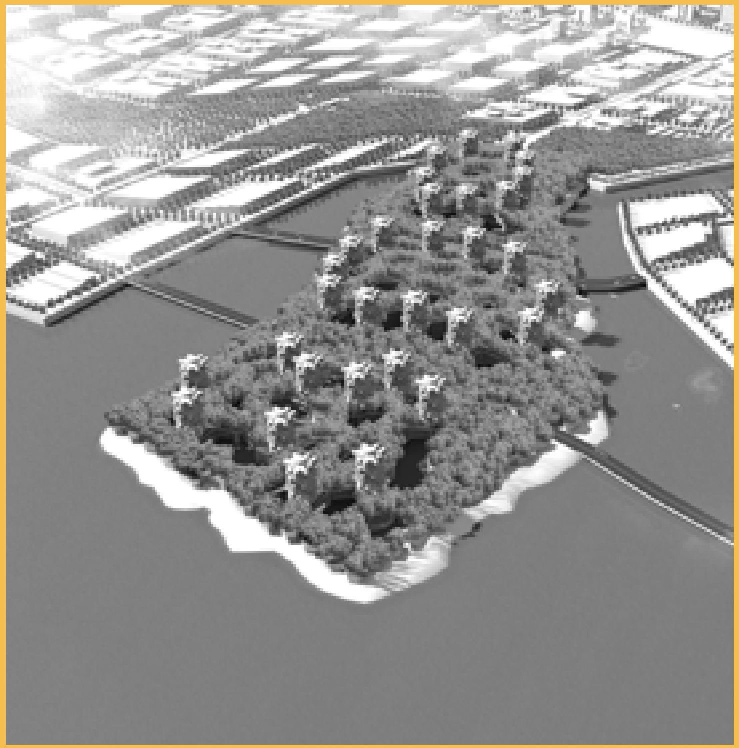
However, having developed these workflows, it quickly became apparent during the winter school that there was not enough time for groups to apply these types of workflows. This was mainly due to the fact that the students had limited knowledge of both GIS and parametric modelling, and learning these methods in such a short time-frame was not feasible.

Some of the results of the IFoU Winter School were further developed within an M.A. Urban Design studio and a Master of Urban Planning studio, both at the Department of Architecture, NUS. The workflow was adapted and used to further develop a number of proposals from these studios to demonstrate the applicability of the method in the context of a design studio. Two such proposals are included in the book, both as designs resulting from the studio and as cityscapes resulting from the application of the workflow (see Envisioning Ecotopia and Urban Metabolism).

D. T. Rutledge, M. Cameron, S. Elliott, T. Fenton, B. Huser, G. McBride, G. McDonald, M. O'Connor, D. Phyn, J. Poot, R. Price, F. Scrimgeour, B. Small, A. Tait, H. Van Delden, M. E. Wedderburn, R. A. Woods (2008). Choosing Regional Futures: Challenges and choices in building integrated models to support long-term regional planning in New Zealand, Regional Science Policy & Practice 1(1), 85-108.

EDEN OF JURONG

INTEGRATING URBAN ECOLOGY WITH HIGH DENSITY LIVING



LIN XIONG

FINAL DESIGN PROJECT 2014-15

TUTOR :
PROF. PATRICK JANSSEN

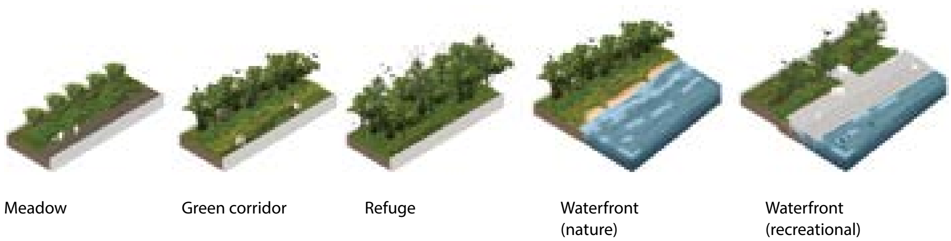
ABSTRACT

"Eden of Jurong" focuses on the design of a high-density development for a population of 25,000 on Pulau Samulun, targeting the issue of liveability for high-density mixed-use design that combines housing and residential amenities with other commercial and industrial programmes. It investigates the use of performance-based and parametric modelling in design, focusing on the development of a new self-sufficient and environmentally stable urban model. The main focus of the project revolves around the loss of biodiversity within the urban context. It explores the issues that contribute to the phenomena and proposes a possible design implementation to reintroduce biodiversity into the urban context, striving for a balance between nature and man.

Site plan for Pulau Samulun
1:1500

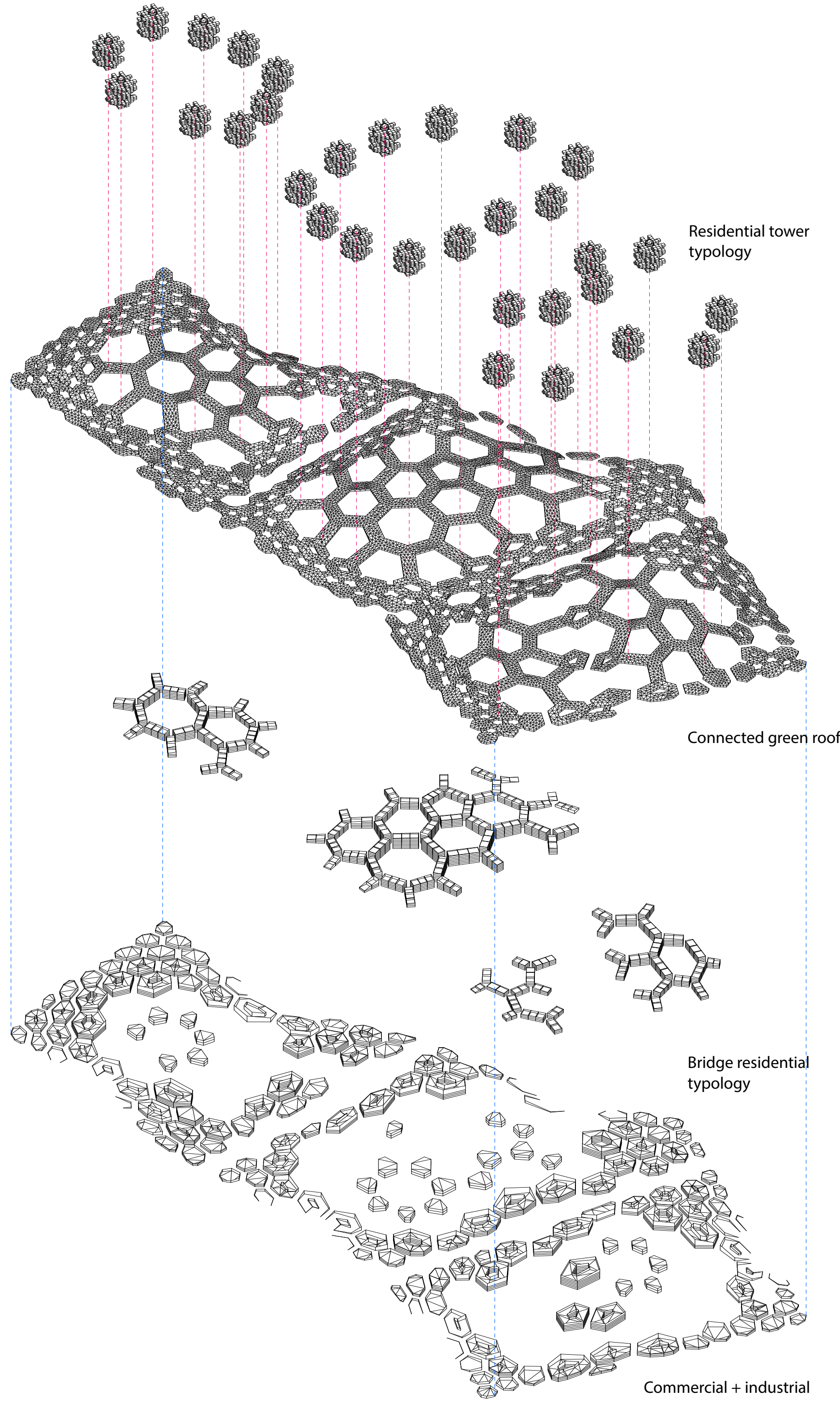
The island is divided into three smaller neighbourhood zones, with one mega block development per zone. Each zone supports different types of programmes: the north zone focuses on biodiversity, the middle zone focuses on commercial and industrial, and the south zone focuses on education and sport recreation.

Site green coverage



Roof habitants types

The patio mega block is used as the main building typology for the development. This typology has good potential for the creation of connected green roofs and also offers higher potential for site green coverage. The roofs are covered with a deep layer of soil supporting a diversity of flora and a rich bird habitat. At certain points, the green roof connects with the water's edge, thereby helping in attracting birds. Parts of these roofs also serve as recreational parks for the residents. Each mega block includes a set of residential towers that rise above the green roof. In order to avoid interrupting the green connectivity, the flats in these towers are lifted above the level of the planting.



Layers of development


Rear elevation


Sectional perspective across site

Courtyard view

Street view

Water's edge view

Aerial view

THE INDUSTRIAL CITY

PROPOSALS FOR 25,000 PEOPLE

A next selection of student projects is taken from the results of an M.Arch. Design Technology and Sustainability thesis studio led by Patrick Janssen. The studio participated in the IFoU Winter School, and the students then went on to develop their own individual projects. The overall vision was the transformation of Jurong Industrial Estate, with one of the fundamental ambitions being the creation of attractive neighbourhoods that combined residential programmes with clean-tech industries. However, even for industries that are relatively 'clean', the placing of residential and industrial programmes in close proximity raised numerous potential conflicts. Key issues were heavy goods transport, industrial noise and pollution, and health and safety risks. What was required was a new positive vision of an industrial city that overcomes these inherent conflicts.

The site for the studio was Pulau Samulun, a 30 ha island separated from the mainland by a narrow 50 metre waterway. Currently, the island has a range of low quality industrial building and sheds on it. As part of the larger planning proposal, the island was to be completely redeveloped as a high density mix of residential and industrial programmes.

The studio started with an investigation into the 1960's Metabolist movement. In particular, two competing ides were investigated: megastructures versus group form (Lin 2010). Megastructures were seen as gigantic long-lasting frameworks that provided an infrastructure within which the diverse functions of a city could grow and evolve. Fumihiko Maki (1964) described such megastructure as being like a "great hill on which Italian towns were built".

As one of the earliest examples, the studio studied the 1959 Boston Harbour project, developed by Kenzo Tange and four of his 5th year students at MIT. It consisted of a pair of huge curving A-frame structures planned for a population of 25,000 people, built as an artificial island in the middle of the harbour. The project was similar in size to the site for the Singapore studio, and as a challenge for highdensity development, the studio also adopted the target of 25,000.

Maki (1964) argued that the megastructure approach was too rigid, and as an alternative, he proposed a more bottom-up approach, where large-scale order would arise from the grouping of smaller elements. He referred to this as the 'group form' approach. "The ideal is a kind of master form which can move into ever new states of equilibrium and yet maintain visual consistency and a sense of containing order in the long run. This suggests that the megastructure which is composed of several independent systems that can expand and contract with the least disturbance to the others would be more preferable to the one of a rigid hierarchical structure."

The studio explored how these two ideas of megastructure and group form could be combined. In particular, strategies of vertical stacking were explore. This allowed both the required high densities to be achieved while at the same time circumventing some of the inherent conflicts in the bringing together of residential and industrial programmes. In general, the industrial programmes were place on the ground with access to the water for the transport of heavy goods. The residential programmes were elevated above, and integrated with nature and greenery. Three students took part in the studio. The first two projects are included in the book.

Lin Xiong divided the island into three smaller neighbourhood zones, with one mega block development per zone. Each zone supported different types of programmes: the north zone focuses on biodiversity, the middle zone focuses on commercial and industrial, and the south zone focuses on education and sport recreation. Each mega block included a set of residential towers that rose above the green roof. In order to avoid interrupting the green connectivity, the flats in these towers were lifted above the level of the planting (see Eden of Jurong).

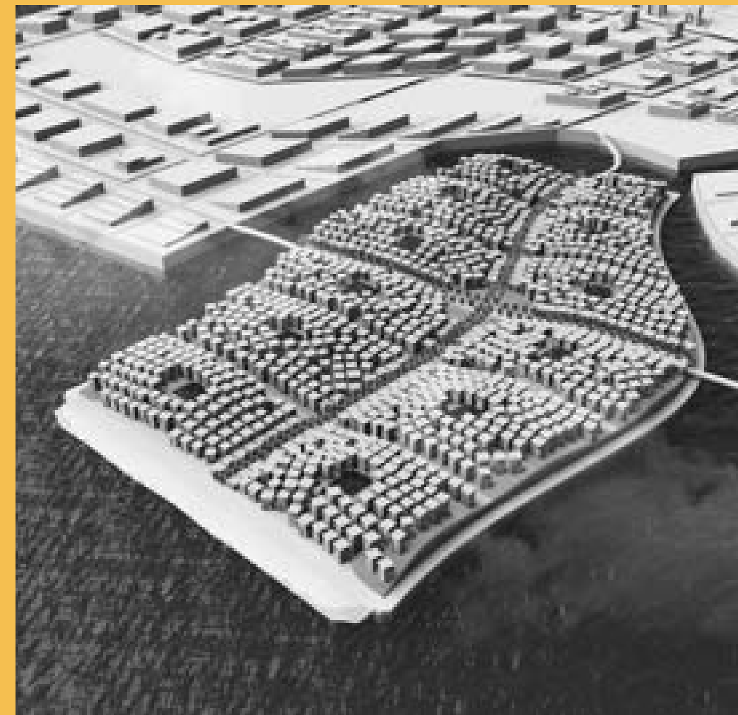
Elvira Tan proposed the creation of an artificial landscape consisting of a set of undulating hills. The landscape was constructed as a concrete space-frame truss, incorporating all services and supporting a layer of green planting. Industrial spaces were placed underneath the hills while residential buildings were constructed on top. The topography of the hill was low in the middle and high at the edges, thereby giving the industrial spaces direct access to the water. The residential buildings on top of the hills were designed as neighbourhoods of low-rise but tightly-packed blocks. An artificial beach was created along the southern edge of the island (see Small Hill Town).

Zhaoying Chew also proposed a hill with industrial programmes below and residential programmes above. However, in his case, the topography of the hill was high in the middle and low at the waterfront, thereby allowing the residential communities to have a more direct interaction with the water's edge. In order to allow heavy good to be delivered via the water, a harbour was created along the southern edge linked to the industrial space via a goods road that created a canyon through the hill.

Z. Lin (2010). Kenzo Tange and the Metabolist Movement: Urban Utopias of Modern Japan. London; New York: Routledge.
F. Maki (1964). Investigations in Collective Form. School of Architecture, Washington University.

SMALL HILL TOWN

LOW-RISE HOUSING FOR THE FUTURE OF SINGAPORE



ELVIRA TAN

FINAL DESIGN PROJECT 2014-15

TUTOR :
PROF. PATRICK JANSSEN

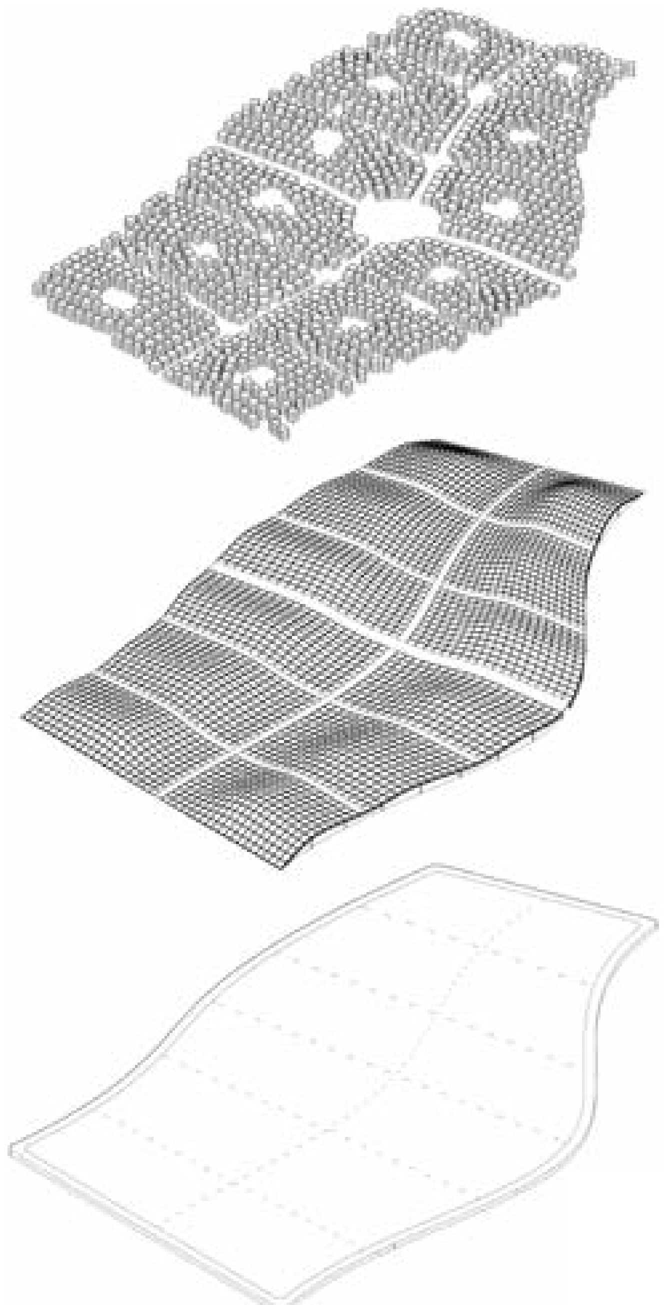
ABSTRACT

"Small Hill Town" envisions Pulau Samulun in 2050 as a low-rise, high density town for 25,000 people, integrating industrial and residential functions. One of the key requirements of the Jurong Industrial Estate master plan is to maintain a high level of clean-tech industry. This project explores how residential neighbourhoods can be placed on top of large factories and warehouse spaces for industry.

The main concept of this project is the creation of an artificial landscape consisting of a set of undulating hills. The landscape is constructed as a concrete space-frame truss, incorporating all services and supporting a layer of green planting. Industrial spaces are placed underneath the hills while residential buildings are constructed on top. The industrial spaces have access to a road along the perimeter of the island, while the residential buildings have access to two main streets that cross the island. Since the perimeter road is at the waterfront, the industrial spaces have the advantage of using water-based transport systems to transport heavy goods.

The residential buildings on top of the hills are designed as neighbourhoods of low-rise but tightly-packed blocks. For the design of these buildings, one of the main drivers was the desire to achieve the perception of a low-rise human-scale town from the two main streets that cross the island. The heights of the buildings were therefore limited to be between 3 to 6 floors high. Walking along the main streets, pedestrians will see no tall buildings protruding into the view of the sky. The residential buildings are grouped into small neighbourhoods with an open space at the centre. The ground slabs of these spaces are constructed using translucent building blocks, thereby allowing daylight to penetrate deep into the industrial spaces below.

Master plan - physical model

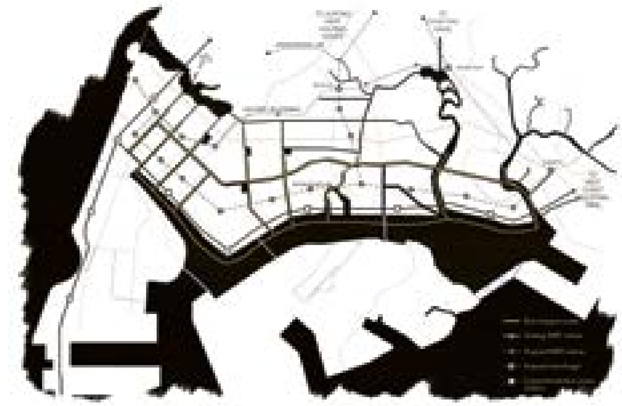


Residential

Artificial hill

Industry

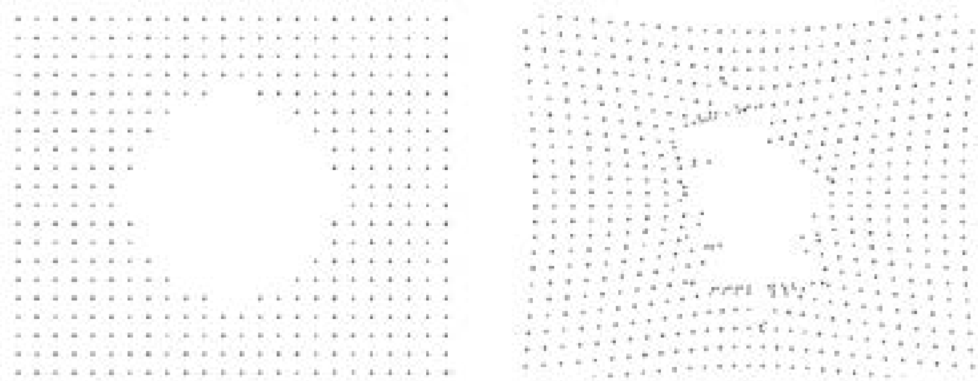
Layers of the island
The introduction of an artificial hill generates space for industry and residence.

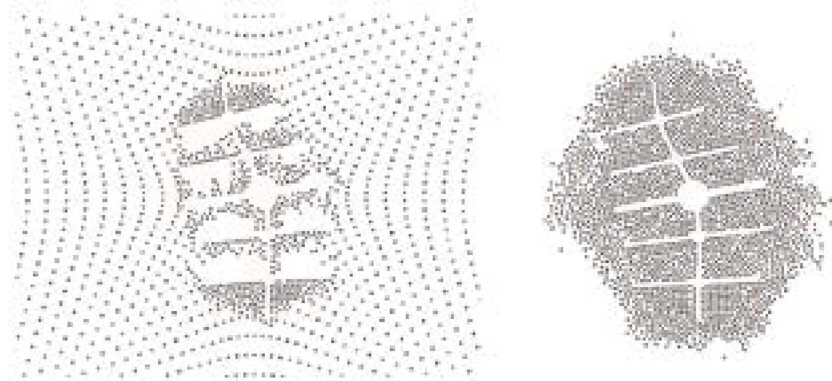


Transport system

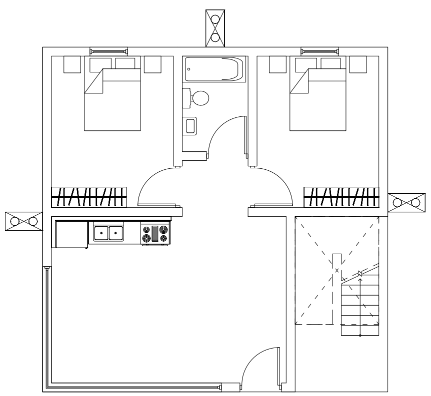
Land zoning

Tram line

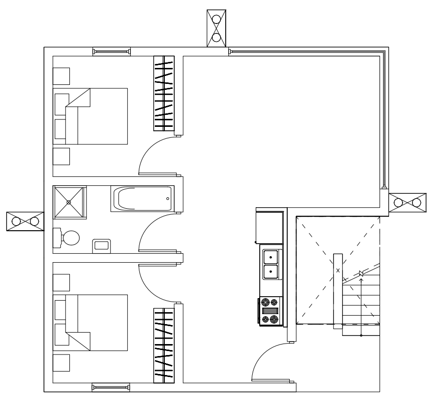




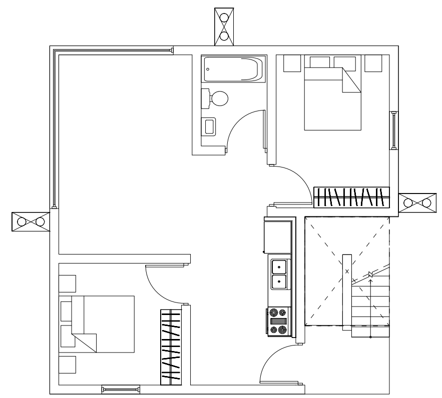
Parametric arrangement of housing blocks drawn to attractors along main and cross streets



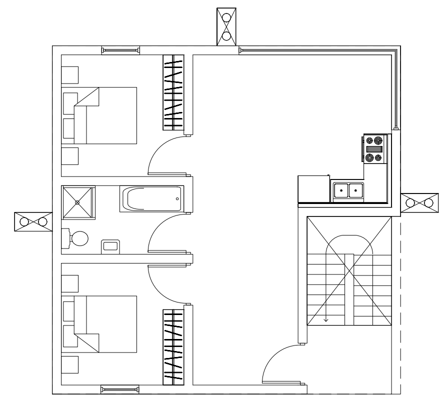
Ground floor



Middle floor 1

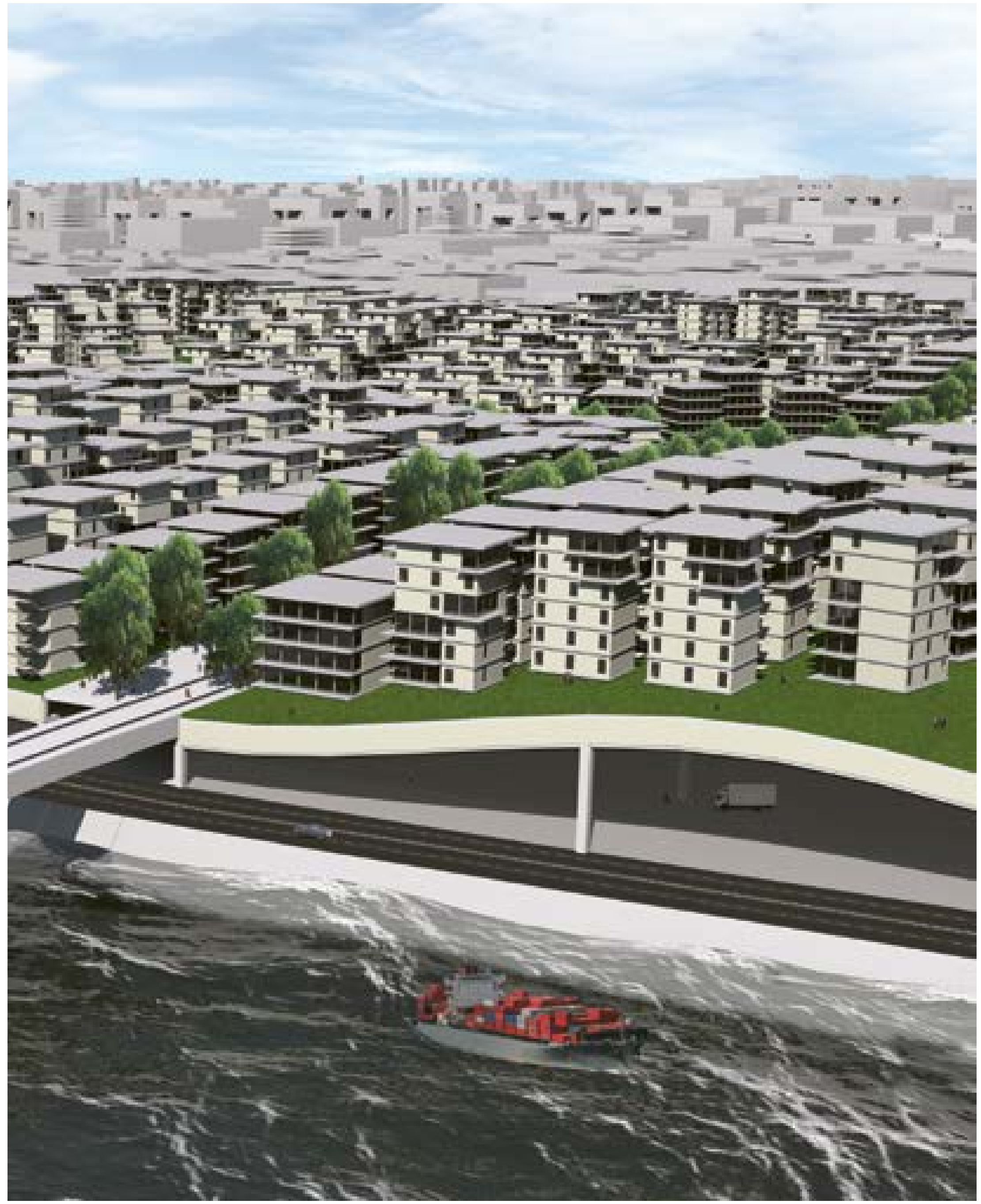


Middle floor 2



Top floor

Examples of housing plans
1:200



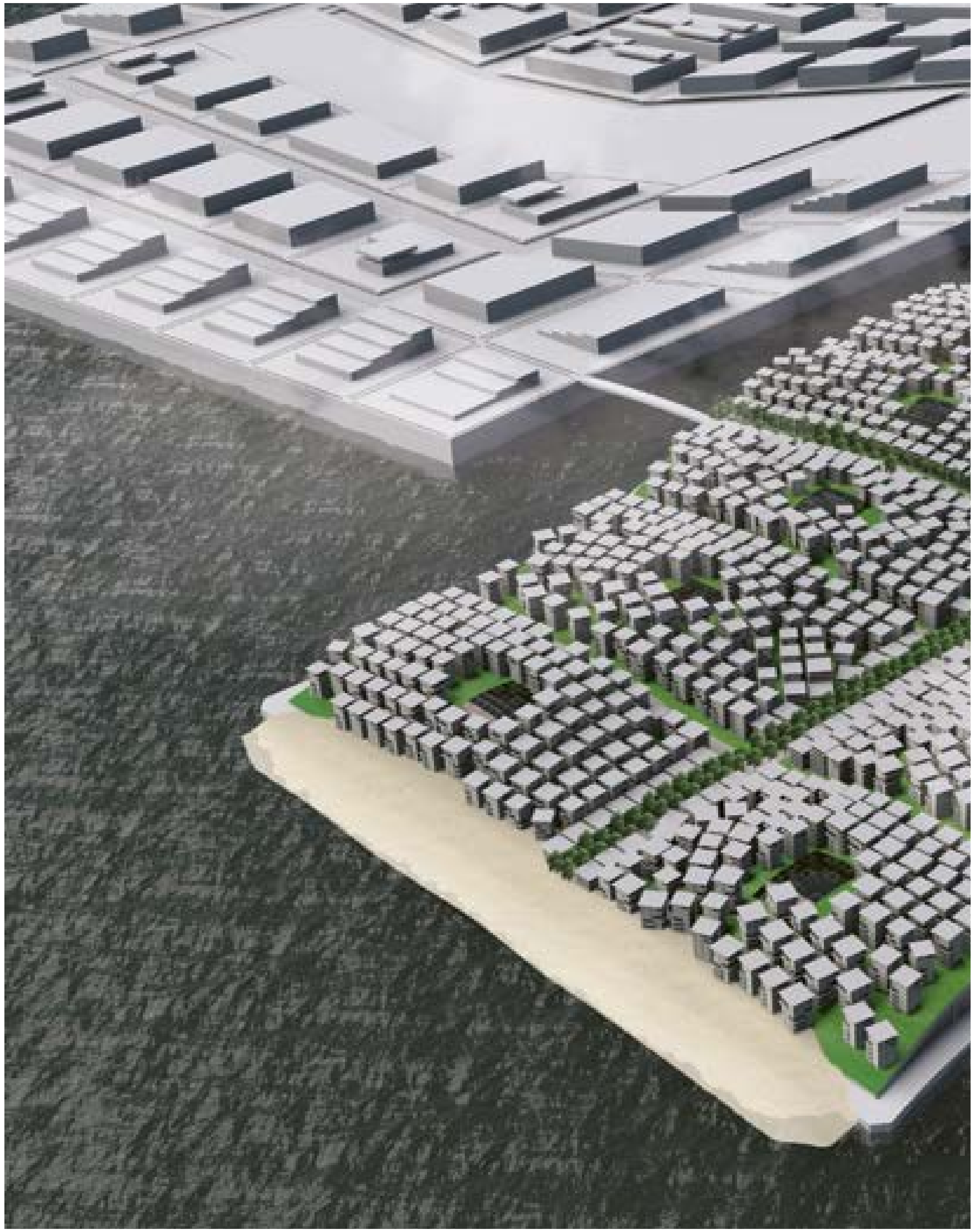
Industry facing the waterfront


Main north-south commercial street


View of central plaza


Residential plaza


Artificial beach along southern shore



Aerial view

GENERATIVE WORKFLOWS FOR SYNTHESISING DATA

Prior to the start of the IFoU Winter School, a semi-automated data synthesis method was developed to generate building models based on a set of simple rules. As the main purpose of these building models was to quantify the overall massing and floor areas that can be achieved, these models only needed to consist of simple massing with floor plates and did not need to be highly detailed in their visual appearance. In order to support fast iterative generation of large-scale urban models, a parametric modelling method was conceived that generated building models based on parameter fields encoded as images.

This method consisted of three main stages (Stouffs and Janssen, 2016). First, the proposed urban typologies were encoded as parametric models with a small number of general parameters, such as maximum building height, site coverage, plot ratio, and ratio of functions (e.g., residential, commercial, and industrial). Second, for each parameter, a grey scale image was overlaid over the site and used to create a parameter field. These images could either be created by hand in an image-editing tool, or in a GIS system based on certain proximity rules. Third, large parcels on the site were subdivided into smaller plots according to various subdivision rules, and the parametric models were then used to generate varying building models for each plot, reducing the need to manually detail the road network and plot distribution. These building models included floor plates for each floor, which made it straightforward to calculate floor areas, such as the total floor area for each function.

SideFX Houdini was used to implement the data synthesis method. The parametric models that serve to generate the building models were actually encoded as procedural rules taking as input the respective values from the different parameter fields. Additionally, a number of workflows were developed to support both generating and evaluating urban models. Exporting the Houdini model to Unity Technologies' game engine allowed for advanced visualisation. In order to be able to import the data back into a GIS system the 3D model of each plot was converted back to the base polygon for that plot, with attribute data attached.

After the winter school was completed, the workflow was adapted and used to further develop a number of proposals from an M.A. Urban Design studio and a Master of Urban Planning studio to demonstrate the applicability of the method in the context of a design studio (see Envisioning Ecotopia and Urban Metabolism). Specifically, rather than relying on parameter field images, the rules were adapted to consider proximity to roads of different categories, MRT lines, parks, waterfront and, possibly, other boundaries, all elements that would have been previously identified in the 2D model. Additionally, the workflows were further relaxed to allow the import of the 2D model as a drawing (e.g., from AutoCAD).

More recently, a parametric GIS workflow was developed combining QGIS and Möbius, a newly developed parametric modeller that provides a novel approach for visual programming, uses a rich topological data structure that supports objects consisting of multiple geometric entities, and is entirely web-based (Janssen et al., 2016). In the proposed parametric GIS workflow, QGIS is linked to Möbius in order to support fast iterative generation and evaluation of large-scale urban models. The workflow uses parameter fields and relies heavily on the ability to attach attribute data to geometric entities in the model in both QGIS and Möbius. The workflow consists of five main stages that alternate between QGIS and Möbius, with data exchange using the GeoJSON file format.

In stage 1, QGIS is used to create a map of the area, including existing buildings and infrastructure. Geographic data is collected and manually integrated into a single geospatial dataset. A series of large parcels are defined in QGIS, indicating the areas of the site where future development is proposed. The parcels are exported from QGIS and imported into Möbius.

In stage 2, Möbius is used to recursively subdivide each parcel into similar size plots, with tertiary roads also inserted between the plots. The subdivision is performed by a parametric procedure that attempts to create plots that are as evenly sized as possible. The parameters allow the designer to specify the target size of the plot. The plots and tertiary roads are exported as a GeoJSON file and imported back into QGIS.

In stage 3, QGIS is used to create parameter fields through a combination of proximity functions and custom formulas. A series of additional attributes are defined in the attribute table for the plots for this purpose. For example, first, proximity attributes can be created that calculate proximity to roads, parks, and the waterfront. Second, parameter attributes can be created that calculate the building height and plot coverage based on the proximity attributes. This results in each plot being assigned multiple building heights and plot coverages. Third, a final pair of attributes can be created that calculates the final value for both parameters using formulas that give priority to certain rules or conditions. The plots with the attributes are exported from QGIS and imported into Möbius.

In stage 4, Möbius is used to generate urban models using a library of parametric urban typologies. The parameters for each plot are extracted from the attributes attached to the plot polygon, e.g., the building height and the plot coverage. The urban model is then generated by selecting and instantiating a parametric urban typology on each plot. All polygons in the model will have a 'type' attribute assigned that defines the types of building elements that they represent, such as 'plot', 'footprint', 'floor', 'wall', 'roof', and 'window'. Floors can be further categorised as 'residential', 'commercial', and 'industrial'. Möbius can then be used to calculate the floor areas for each of the different functions, and these values can be added as attributes to the footprint polygons. Finally, in order to be able to export the model back to QGIS, the model is flattened back to 2D. The critical information that is transferred is the building footprints together with the floor area attributes. These attributes are important as they will be used for the QGIS analysis in the final stage. Möbius exports the building footprints as a 2D model which can then be imported back into QGIS.

In stage 5, QGIS is used to analyse the flattened map of the urban model. Calculating the number of people in each building for each of the functions using a formula that divides the floor area for each function by average 'area-per-person' values, population densities can also be determined. Using a simple buffer analysis, the percentage of people within a certain walking distance of transport nodes can also be determined (see Evaluative).

P. Janssen, R. Stouffs, A. Mohanty, E. Tan, R. Li (2016). Parametric modelling with GIS, Complexity & Simplicity: Proceedings of the 34th International Conference on Education and research in Computer Aided Architectural Design in Europe, 22-26 August 2016, Oulu, Finland.

Stouffs, R., P. Janssen (2016). A rule-based generative analysis approach for urban planning. In: J.-H. Lee (ed.), Morphological Analysis of Cultural DNA, Springer.

ENVISIONING ECOTOPIA

A CARBON NEUTRAL CITY AMIDST MID-RISE LIVEABILITY

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ABSTRACT
ECOTOPIA is a vision of a new urban metabolism model. Bearing in mind future needs of resources according to a projected 2050 population of 7.4 million, ECOTOPIA strives to become the future sustainability model of self-sufficiency by considering five metabolism elements : water, energy, food, waste, and greenery.

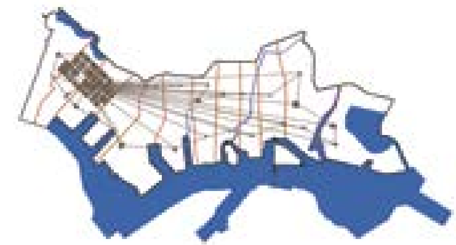
Land use Master plan
1:30000

ECOTOPIA has four goals:
- a new industrial model with an emphasis on R&D
- a hybrid urban metabolic system
- a mid-rise and sustainable city with increased energy efficiency
- a unique and enhanced liveability

Using the concept of Urban Metabolism as the basis for planning, Jurong Industrial Estate is divided into ECO-grid cells. Horizontally, the site is divided into three different mixed-use belts : residential, industrial, and commercial. Three different mixed-use cells make up a self-sustainable ECO-strip. Using projected numbers of future demands on resources, a 'per person area requirement' is calculated, which is taken into consideration in calculating the maximum possible population.

ECOTOPIA also proposes a new model of industrial clustering according to the metabolism elements of waste, energy, food, and water. To ensure self-sufficiency, each different industry is represented in each cell to then join together in a closed loop within each ECO-strip. The new industries in Jurong Industrial Estate will be steered towards high-end manufacturing, clean energy, and R&D. The metabolism clusters are allocated based on the existing context such as the presence of Pandan Reservoir and clean-tech Park near NTU.

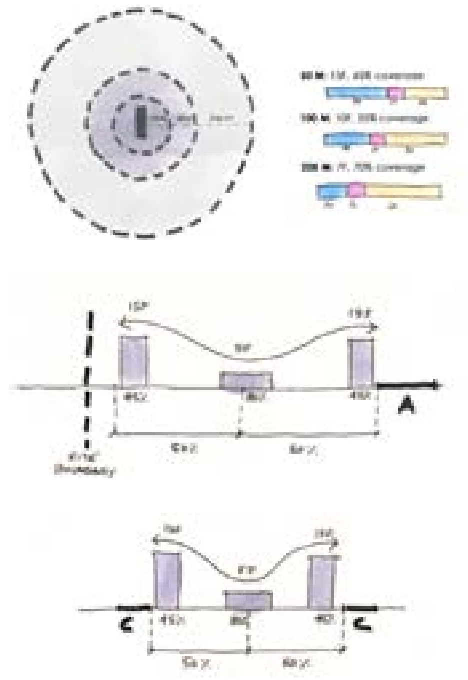
New industrial metabolism model



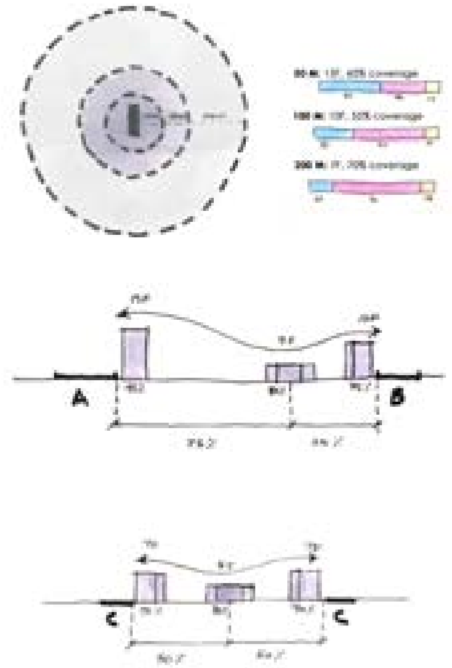
Waste flow (centralised biomass energy plant)

Energy flow (centralised clean energy plants)

Food flow (new age industrial farming)



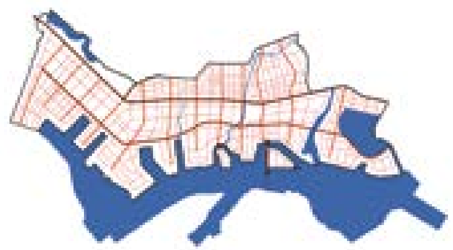
Parameters for roads and MRT in residential belt



Parameters for roads and MRT in industrial belt

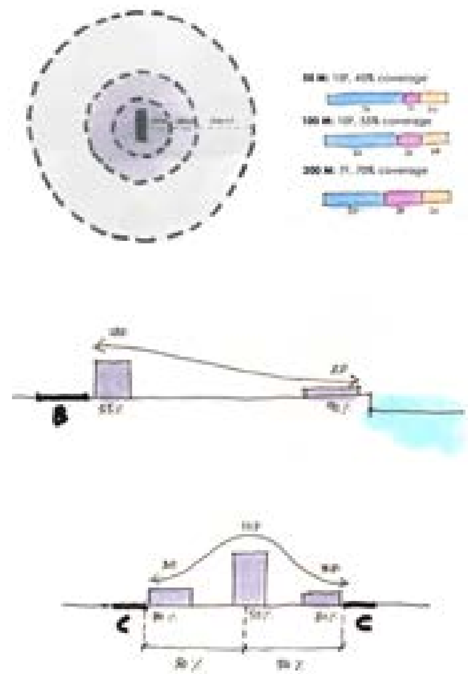
East west line
Cross island line
Jurong regional line
PRT networks (on ground)
Tracks above ground
Tracks underground

Proposed public transportation network

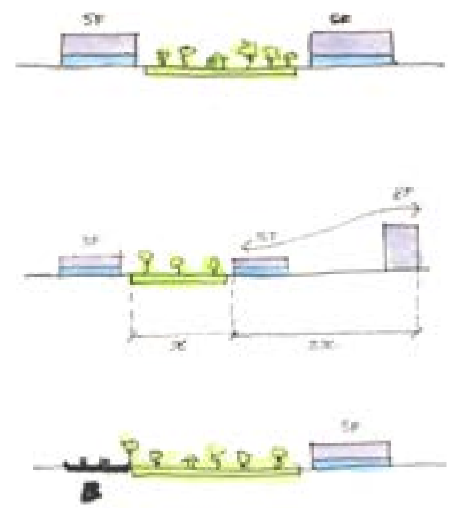


Category A
Category B
Category C
Category D

Proposed road network



Parameters for roads and MRT in commercial belt

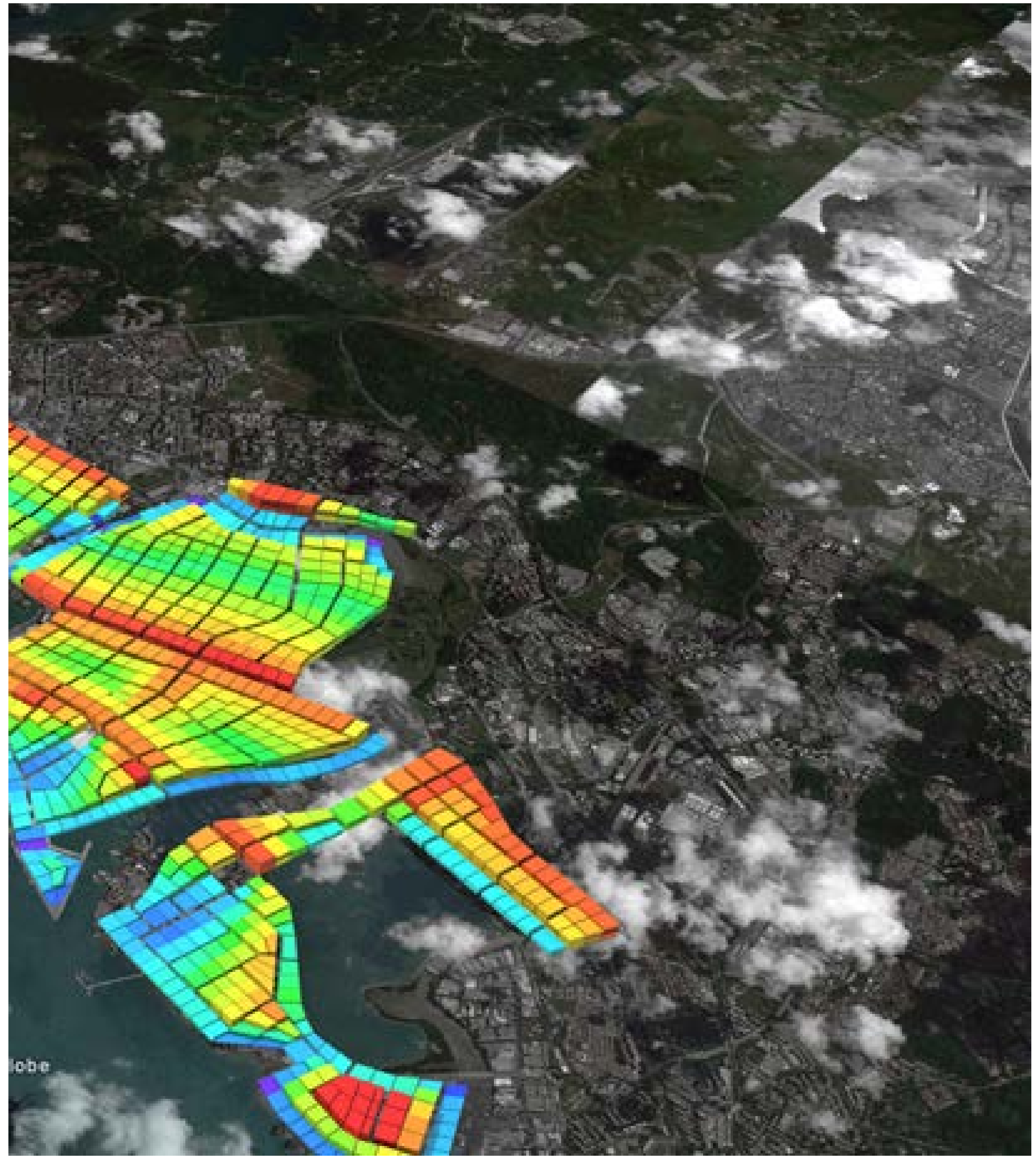


Parameters for parks category 2 and 3

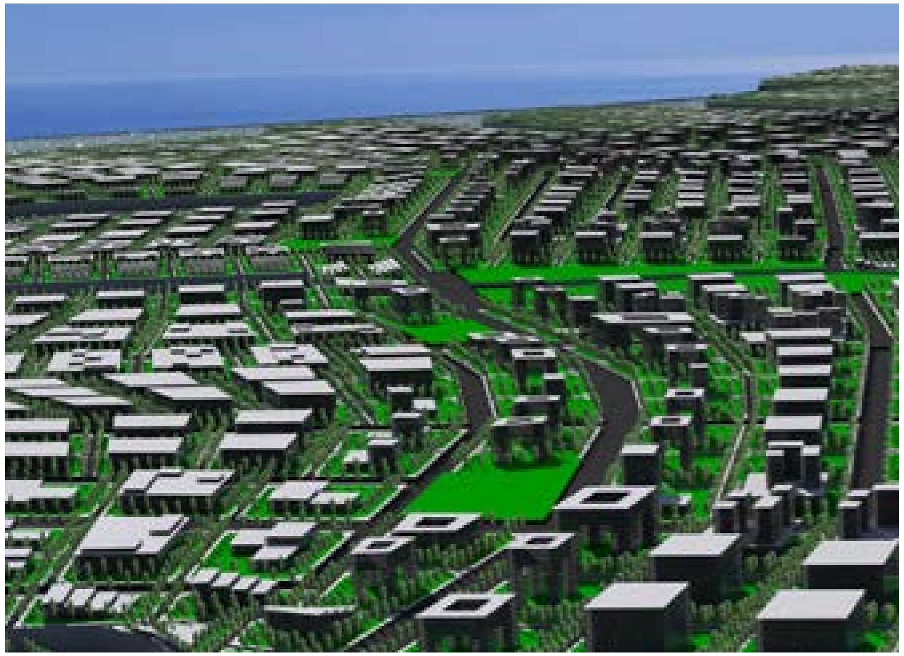
Water flow (new reservoir supply)

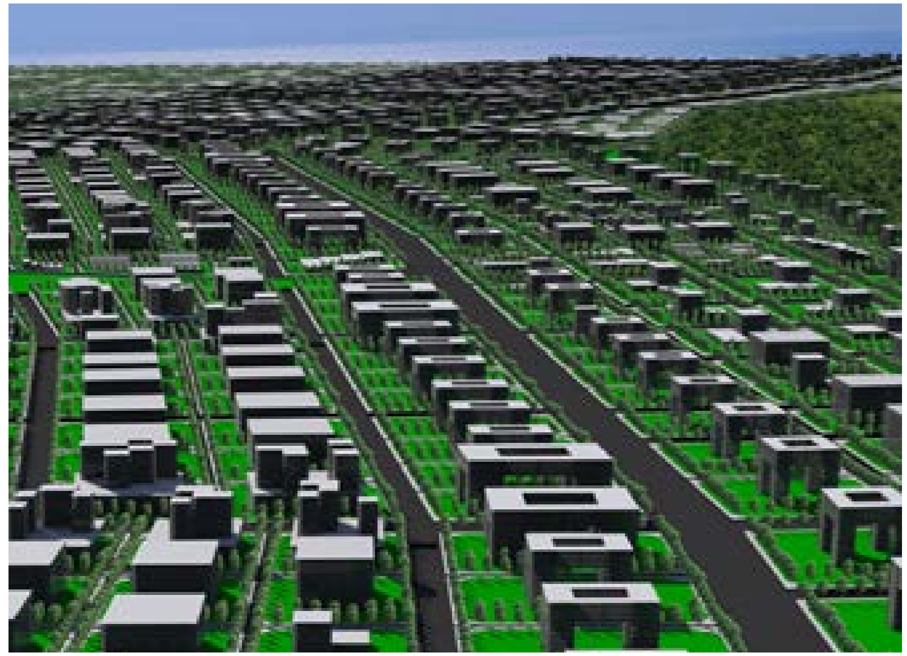
Heritage railway corridor
Leisure parks
Universities
Clean energy research
Convention centre
Incineration plant

Existing and proposed landmarks

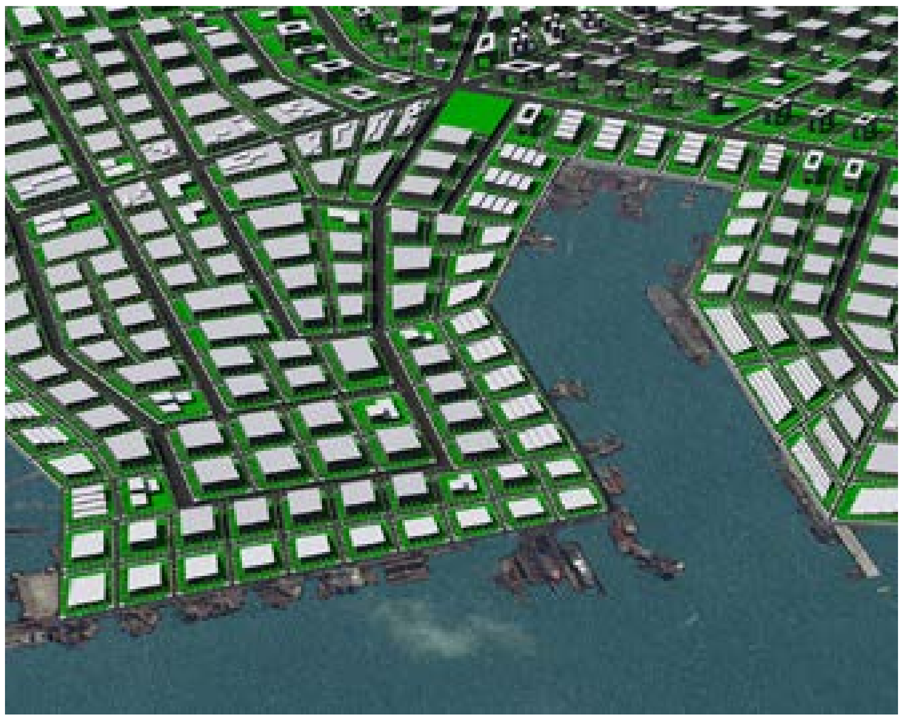


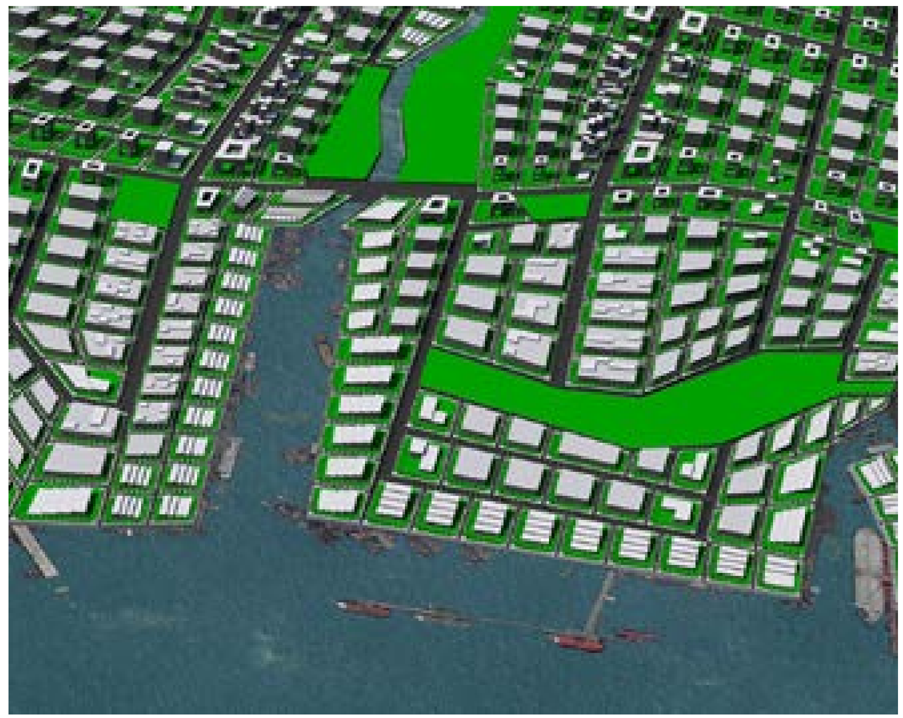
Building height analysis overlaid on aerial view





Street view





Harbour view

Aerial view

EVALUATIVE
DATA ANALYSIS
WORKFLOWS

One key challenge all groups in the IFoU Winter School faced, was the difficulty in backing-up claims about their proposals with quantitative data. The overall target for the winter school was to create housing and other amenities for one million people, while still maintaining a significant portion of industrial clean-tech industry. The target resulted in some quite well defined requirements of floor areas for different functions. However, most of the urban models were purely visual and could not be used to quantify the total floor area that would result. With all groups, it was difficult to understand whether the proposed typologies and urban massing were appropriate for one million people or not. In some cases, the floor areas may have fallen far short. This type of quantification is important since proposals that work well at lower densities may be fundamentally flawed at these higher densities.

These types of issues can be tackled using semi-automated data synthesis methods that generate building models based on a set of rules, as described previously. These building models only need to consist of simple massings with floor plates and do not need to be highly detailed in their visual appearance, as their main purpose is to quantify the overall floor areas that can be achieved. Having identified floor areas, the number of people in each building for different functions such as residential, commercial, and industrial, can be calculated using a formula that divides the floor area for each function by average 'area-per-person' values. Subsequently, population densities can be determined. In addition, GIS systems such as ESRI ArcGIS and QGIS both have tools that could be used to quantify improvements in accessibility, such as proximity analysis and network analysis. For example, this would allow for the calculation of indicators such as the percentage of people who live within five minutes of a transport node. This would then allow for direct comparison of alternative options.

Data mining as a data analysis technique was not explored for use in the IFoU Winter School, though it was recognised to have the potential to further support the students' design processes. In particular, it was recognised that data mining could play a role in integrating performance simulation techniques and tools into the urban planning and design process. Two of the groups in the winter school specifically focused their investigations on sustainable energy production, consumption, and distribution within the built environment, elaborating the topic on two levels. While new approaches of energy exchange, circulation, and balancing were investigated at the urban level, at a precinct and block level design explorations aimed at reducing energy demand of buildings, improving natural ventilation and daylight access, and integrating photovoltaic, solar thermal energy, and other technologies into the building design. While the latter explorations can be supported with simulations, applying these simulations at the urban level or extrapolating the findings from a block level to the urban level is not always possible.

Exactly this issue of extrapolating findings was investigated after the winter school, based on the data made available to the students. Specifically, the object of investigation was the prediction of energy consumption of public residential (HDB) buildings at the urban scale. Performing building simulation requires extensive knowledge on the physical behaviour of the building and the local environment. Furthermore, simulations have to be repeated every time the building information is changed, such as its number of stories, footprint, orientation, etc. At the same time, simulation results may differ from actually measured results as a consequence of various aspects, including lifestyle of the occupants. On the other hand, data mining the actual electricity consumption of all HDB buildings can give insight into the specific relationship between, e.g., building site coverage and electricity consumption (Liu et al., 2015).

Preliminary research involved training a neural network to relate actual energy consumption to a number of building and environmental variables, including the green plot ratio (defined as the total leaf area divided by the site area), the floor area ratio (defined as gross floor area divided by the site area), a sky view factor, a 'compacity' factor reflecting on the compactness of the building, the total number of stories of the building, the building typology (shape of the footprint of the building), and the gross floor area. Additional climatic parameters were also considered. The research showed that the most important variable predicting energy consumption for HDB buildings is the number of stories, followed by the gross floor area and the building compacity. The green plot ratio, the floor area ratio, and the sky view factor, on the other hand, have little impact on the actual electricity consumption. Certainly, the research doesn't fully explain why this is the case, but it does show that these relationships hold with considerable accuracy. Furthermore, including a baseline simulation greatly improved the efficiency of the neural network learning process, without relinquishing accuracy. Though this reintroduces a simulation into the process, the baseline simulation is made for an existing HDB building for which data on actual electricity consumption is available that has no other relation to the planning site.

While it may not be possible as of yet for urban planners and designers to adopt such data mining methodology, the research does show that it would be possible to assess electricity consumption for public residential housing at the level of detail of the generated building data described above in real-time. The development of an application that makes this methodology accessible to urban planners and designers is envisioned

Y. Liu, Y. Huang, R. Stouffs (2008). Using a data-driven approach to support the design of energy-efficient buildings, Journal of Information Technology in Construction 20, 80-96.

URBAN METABOLISM

RE-THINKING URBAN FLOWS

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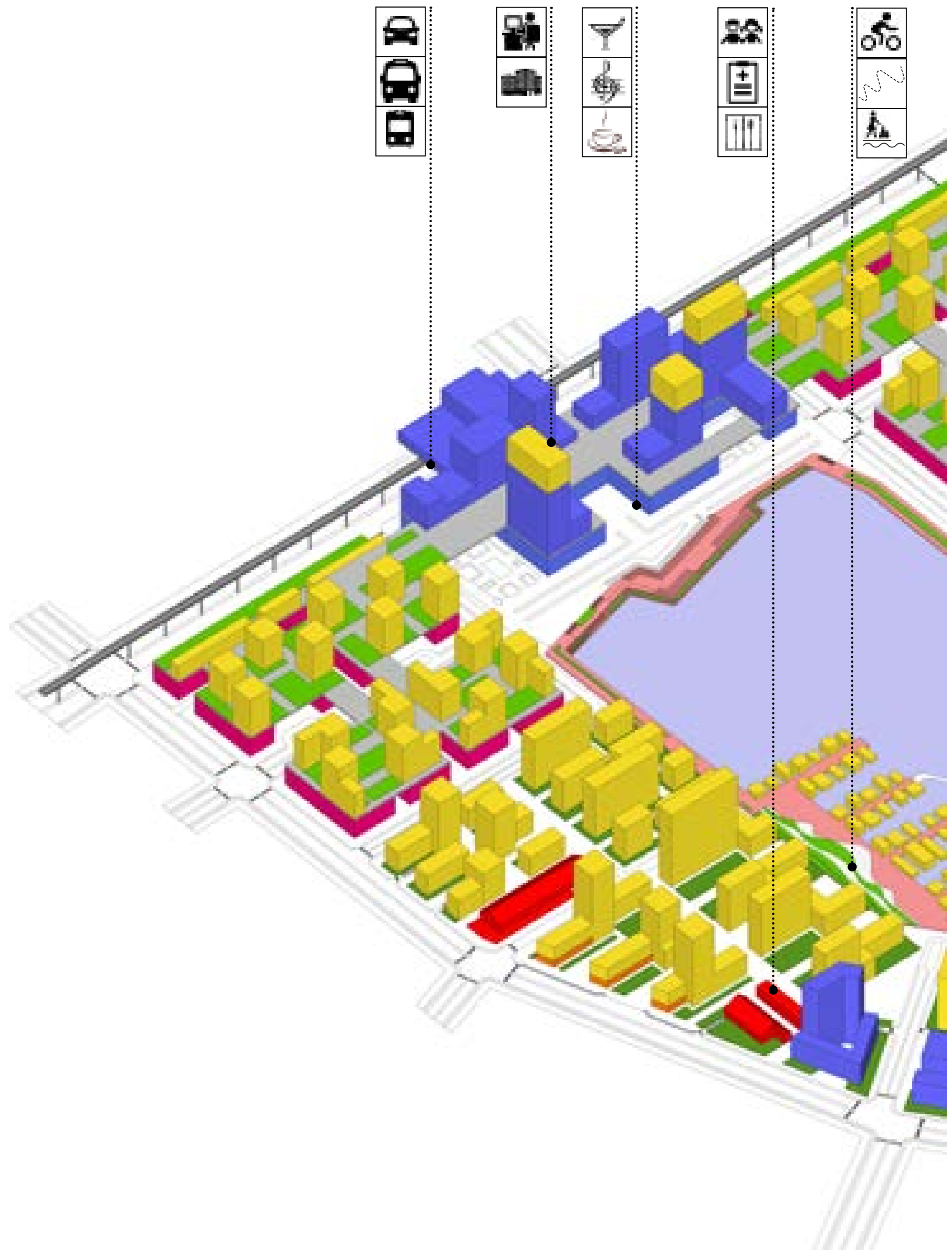
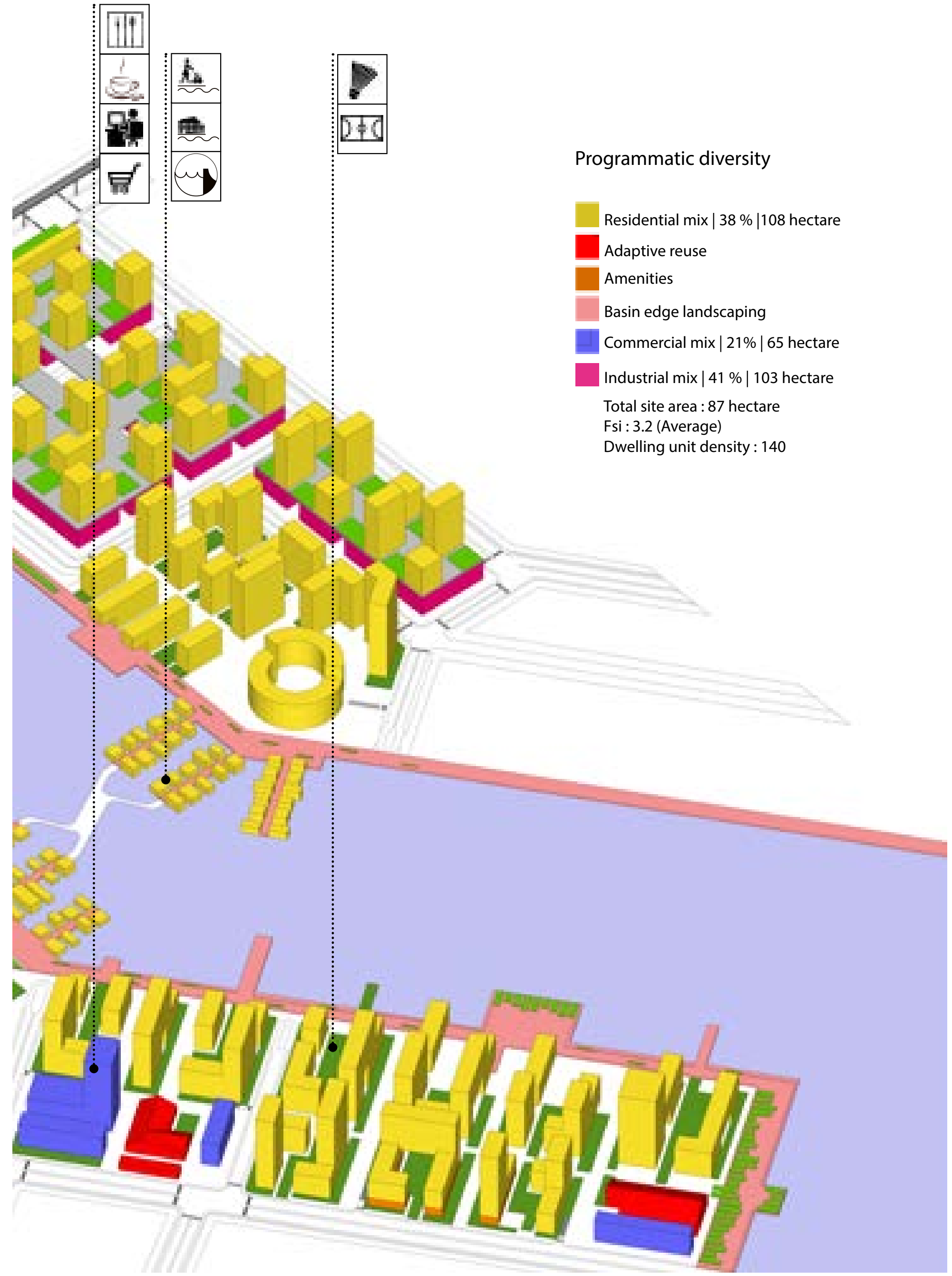
ABSTRACT
Urban Metabolism is an analogy describing the city as a living organism that requires resources to nourish its activities. The flow of goods, people, biota, energy, fresh water, and fresh air is critical in maintaining the Urban Metabolism. For Jurong Vision 2050, three important aspects were considered: Flow of Goods, Flow of People, and Flow of Water & Green.

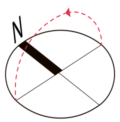




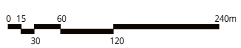
Programmatic diversity

- Residential mix | 38 % |108 hectare
- Adaptive reuse
- Amenities
- Basin edge landscaping
- Commercial mix | 21% | 65 hectare
- Industrial mix | 41 % | 103 hectare

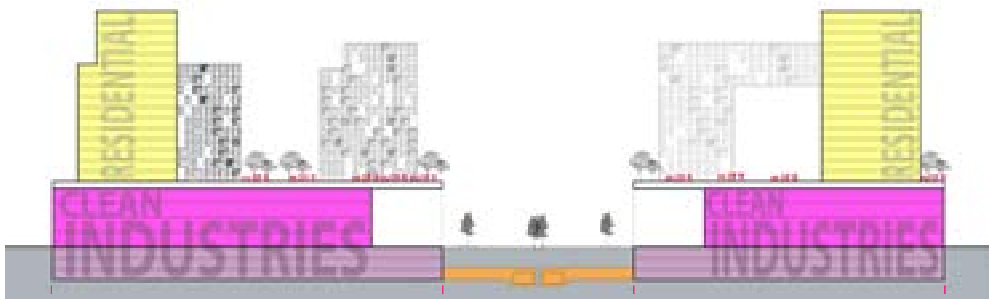
Total site area : 87 hectare
Fsi : 3.2 (Average)
Dwelling unit density : 140



Jurong basin development
1:3000



One of the main interventions of the proposal is to create a spine along Pioneer Road. The spine consists of an underground goods moving system, a road transport system, and an elevated MRT system. The second intervention is the priority placement of residential (mixed-use) land-use along the green and blue (water) infrastructure to provide a quality environment for residents. These residential areas are connected by PRT lines for the last kilometre coverage. The third intervention is to allocate industrial mixed-use along Pioneer Road. The central distribution system is located at the central spine, and connects via an underground conveyor belt system to the surrounding industries as a secondary mode of transportation of the goods. Major intersections or nodes on the central spine act as centralities with commercial mixed-use and residential mixed-use volumes on the roof of industrial buildings.



Industries and mid rise housing
Industrial basement connected to underground conveyor belt system
Community greens
Facilities and amenities

Underground conveyor belt for goods movement

Industries and mid rise housing
Industrial basement connected to underground conveyor belt system
Community greens
Facilities and amenities

Section through conveyor belt system

Basin edge

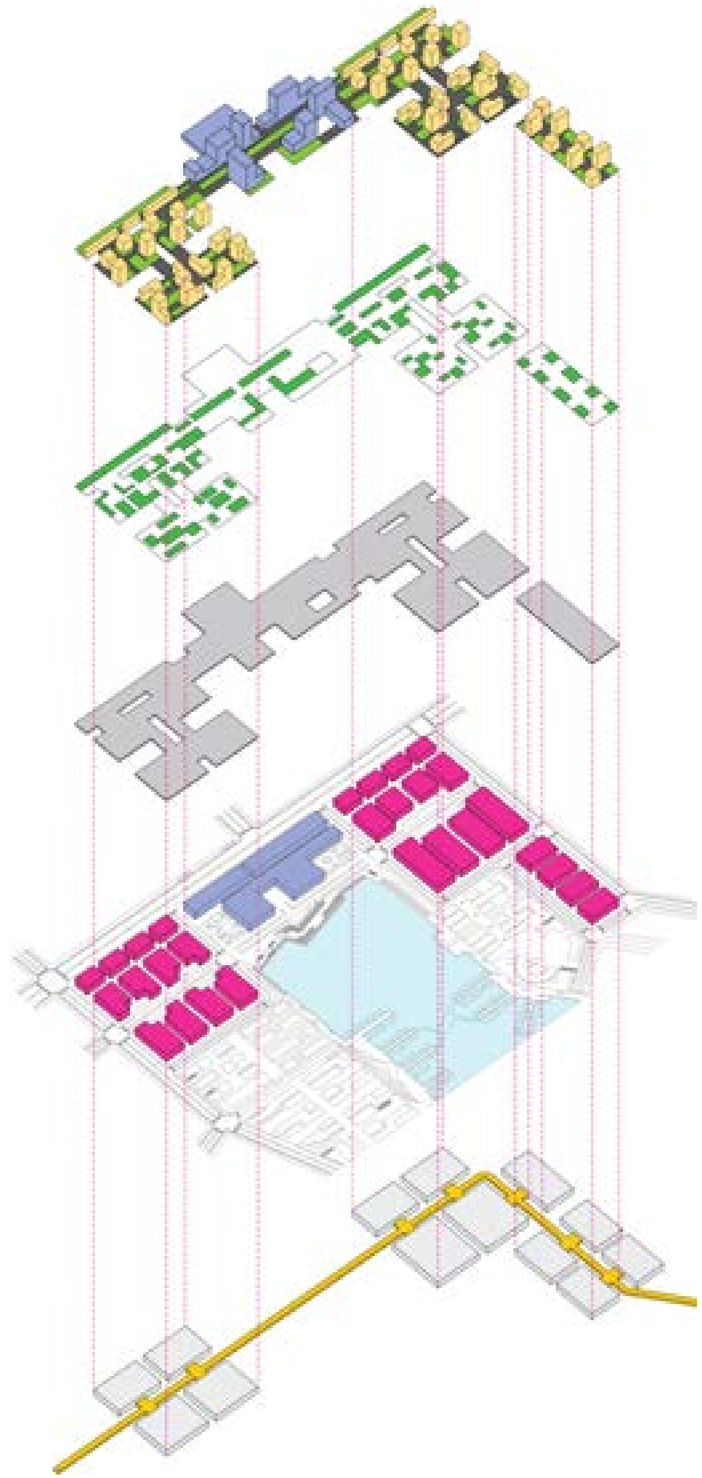
Steps
Informal sitting
Deck

Landscaped plaza
Open air restaurants

Shopping street
Flagship stores
Offices
Soho | moho

Pioneer road
Industrial spine

Section through MRT and immediate centrality



Creating intermediate centrality by placing commercial programmes connected to MRT and residential at top

Placing mid-rise housing on the rest of the deck with community green areas

Community green terraces

Second interaction level as a connected deck above industries

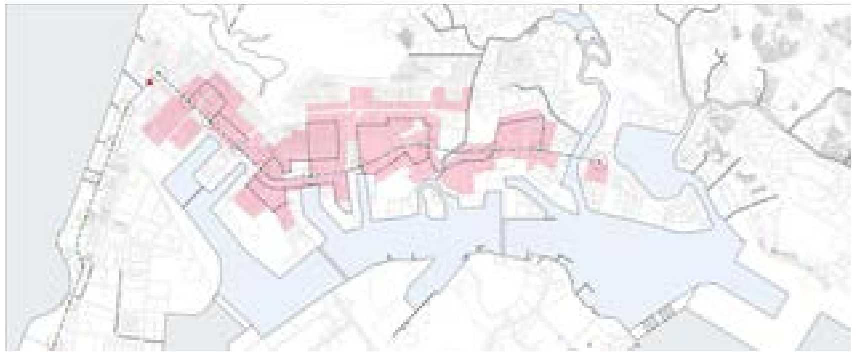
Ground level | first interaction level

Clean tech industries and retail and commercial programmes connected to overhead MRT station

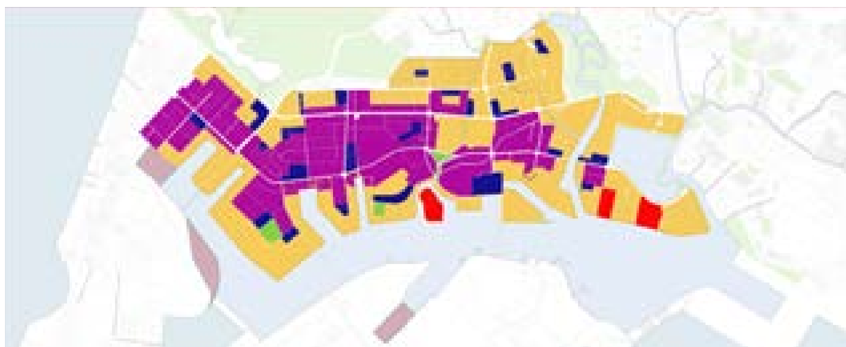
Underground conveyor belt connected to basement of surrounding industries

Industrial + commercial + residential

Creating an industrial spine

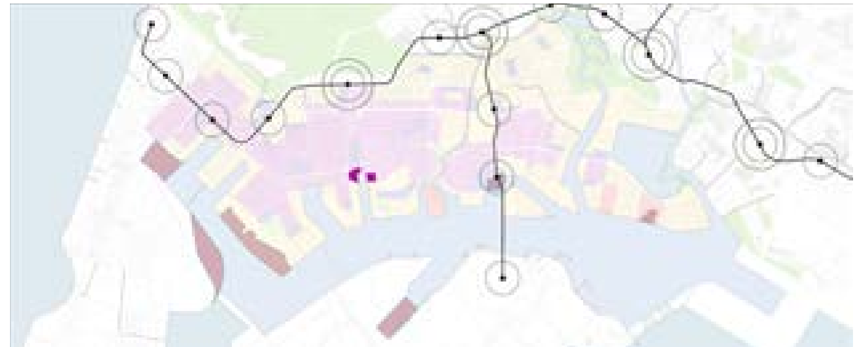


Industrial mix land-use along the spine



Residential mix land-use facing blue and green areas

- Commercial mix-use
- Industrial mix-use
- Residential mix-use
- Basin
- Adaptive reuse



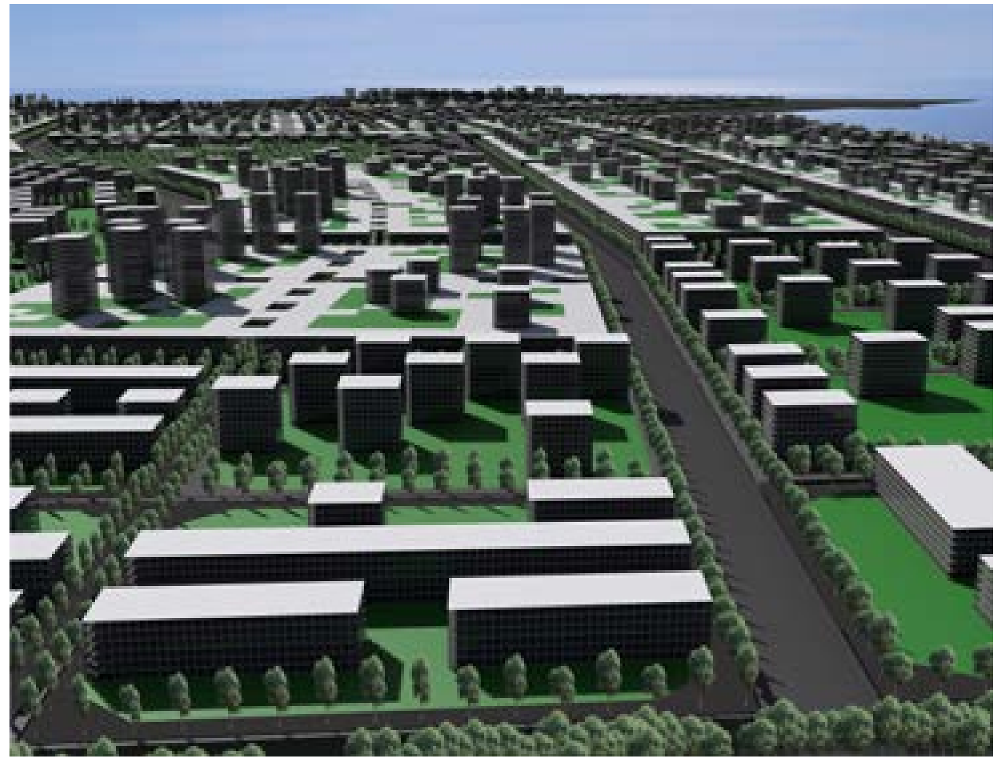
Existing and proposed extensions in 2030 for MRT lines : E-W line & Jurong regional line

Proposed extension of MRT lines for 2050

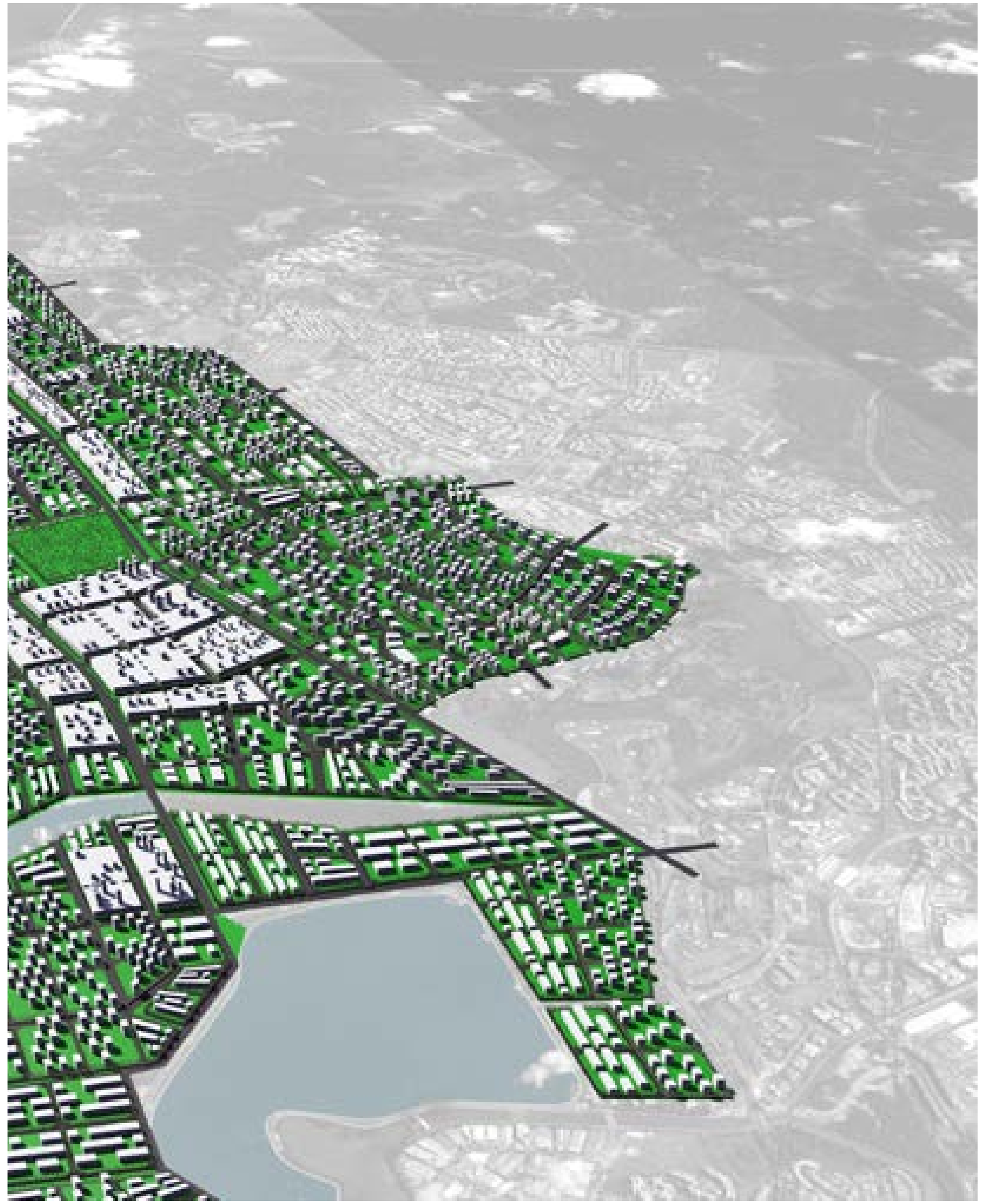
Last kilometre through PRT lines : 100% of the area covered by public transport in 2050

Aerial view

Bird’s eye view



Street view (industrial + commercial + residential)



Aerial view

CONCLUSION

This book rethinks urban practices, both its processes and its products, within the context of JTC Corporation's 2050 vision for the Jurong Industrial Estate (JIE). Selected student projects illustrated in this book are taken from different planning and design studios, and operate at varying scales, but they all propose innovative ideas on how JIE can be re-imagined for a future Singapore. In addition, all the planning and design studios featured in this book, including the IFoU Winter School, were supported financially by the NUS-JTC I^3 (Industrial Infrastructure Innovation) Centre.

The selected projects serve as demonstration for urban planning and design workflows that leverage new computational tools and techniques in order to enable planning and design options to be systematically developed, evaluated, and analysed. The workflows address complex challenges that require new thinking about our city and its planning and design. They support the exploration and development of alternative visions of the future city, and enable the evaluation and analysis of different urban planning and design options.

The urban planning and design workflows demonstrated in this book are not conclusive. They are the intermediate results of a continuing investigation into rethinking urban practices. The results in this book present a stepping-stone in this investigation.

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Final Design Project, Master of Architecture, 2014-15

The Ascent: Jurong Hill 2050
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Eden of Jurong: Integrating urban ecology with high density living
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Small Hill Town: Low–rise housing for the future of Singapore
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Envisioning Ecotopia: A carbon neutral city amidst mid-rise liveability
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