

Positioning our air hub

Management summary of the 2019 IPA results

Institute for Transport Planning and Systems
Institute for Spatial and Landscape Development
Institute of Construction & Infrastructure

Master Spatial Development and Infrastructure Systems





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Our trip to Singapore

In each autumn term at ETH Zurich, Master in Spatial Development and Infrastructure Systems students work on an interdisciplinary group assignment, called Interdisziplinäre Projektarbeit (IPA). In this class, students work within a defined project area – with a time horizon and with several (political) constraints - on the spatial and transport planning as well as infrastructure management issues interdisciplinarily for a particular area. Usually, the course focuses on an area within Switzerland's lower density suburbia, providing students a Swiss problem awareness, but surely not a global problem awareness. Therefore, to confront students with the challenges of a metropolis and conflicts unseen in Switzerland, the 2019 IPA focused for the first time on a city abroad: Singapore.

Among the most prominent urban planning projects underway in Singapore is the expansion of Changi Airport in the east of the island, providing many opportunities for interdisciplinary project work in spatial and transport planning as well as infrastructure management. The task was given to the students to develop a strategy to strengthen the position of Changi air hub that on the one hand makes Changi a livable area, but on the other hand supports Singapore's development towards a sustainable global city.

The strategy should also point out business opportunities, while addressing the challenges of resource scarcity (e.g., food, energy, water) and negative externalities (e.g., congestion, environment). In the following six chapters, each of the six groups summarizes their strategy and proposed measures to “position Changi air hub”.

For more than ten years, a strong collaboration between ETH Zurich and Singapore exists, most notably anchored in the Singapore-ETH-Centre (SEC). For the 2019 IPA, we have built upon this relationship, not only by working inside the CREATE tower, but also by relying on the established links to local agencies such as Land-Transport-Authority (LTA), Urban Redevelopment Authority (URA) and nParks. During our stay in Singapore, the students attended keynotes of each of the authorities involved and the students were given the opportunity to discuss ideas and questions with local experts.

The rector of ETH, Prof. S. Springman, supported the IPA by approving its funding through the Degen Stiftung. We are grateful to her and our partners in Singapore for this great event.

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Excursion program

The main part of the 2019 IPA was the two-week excursion to Singapore in September 2019. The students did not only receive a lot of professional input by various stakeholders in the Changi region as shown in Table 1 below, but also had plenty of time to discover and explore Singapore – its infrastructure and culture – by themselves to identify their core areas.

Day	Event	Location
09.09.2019	Welcoming presentation	Future Cities Laboratory
09.09.2019	Visit to the Urban Redevelopment Authority (URA)	The URA Centre
10.09.2019	Visit to the Housing and Development Board (HDB)	HDB Hub
10.09.2019	Visit to the Land and Transport Authority (LTA)	LTA HQ
11.09.2019	Natural Capital Singapore keynote by Justine Saunders	Future Cities Laboratory
13.09.2019	Presentation "First ideas"	Future Cities Laboratory
16.09.2019	Visit to NParks	Singapore Botanical Gardens
19.09.2019	Discussion with Anna Gasco and Pablo Acebillo Alonso	Future Cities Laboratory
19.09.2019	Cooling Singapore Keynote by Heinz Conrad Philipp	Future Cities Laboratory
20.09.2019	Presentation "First ideas revisited"	Future Cities Laboratory

Projects

SmartChangi

D. Lustenberger, J. Hess, M. Nehmiz, Y. M. R  th and X. Sun

Singapore, a city-state in Southeast Asia is facing constant competition to keep its position as a global city. As the biggest threats, we identified the lack of resources (food, water, and energy are among the most important ones), an unfavorable demographic development (aging population leading to a decrease of the nation's economic output), and a need to maintain a more flexible and resilient economic structure.

The opening of Terminal 5 of Changi Airport will bring new opportunities to the Changi Area, as well as to Singapore. We recognize the potential of the unused land south of the future Terminal 5 (see Figure 2). This area, named SmartChangi subsequently, will be able to serve as a model city to locate possible future developments and to support the future Terminal 5.

SmartChangi is planned as follows. Firstly, the airsea link is to be further strengthened, as a unique opportunity for the area. We transformed the current Tanah-Merah Ferry Terminal to a new sea hub with a higher capacity, which can host both ferries and up to two cruise ships. We see the cruise tourism market as a branch of tourism for Singapore with lots of potential for future development.

Secondly, the new district surrounding this new airsea link will provide space for both international business and tourism. These two functions are chosen for "SmartChangi, as business passengers and tourists are the main passenger groups for Changi Airport, and Singapore is seen as a worldleading destination for both business and sightseeing activities. A detailed land-use plan for SmartChangi can be seen in Figure 1. In SmartChangi, hotels, office spaces, and attractions such as convention centers, innovative museums, and shopping malls are provided.

Thirdly, to support the land-use development of SmartChangi, innovative transport measures are proposed. Beside the extension of the MRT network towards the new Terminal 5, SmartChangi will be a car-lite district with great emphasis on walking and cycling. For longer trips within the district, autonomous vehicles will circulate, which are pooled and operate on demand.

Last, on the eastern side, resource facilities will be located for vertical farming as well as district cooling. Additionally, solar panels will be installed on all the roofs throughout the district. With the expected technological advancements, the site will be able to almost fully cover its energy demand, by producing about 180 GWh during a year (at an expected consumption of 200 GWh). To ensure a sustainable water consumption, gray water will be reused in the buildings to minimize the demand for new fresh water. The freshwater can be collected through underground reservoirs, which are fed through rain gardens, which are dispersed throughout SmartChangi.

We argue that SmartChangi is able to tackle the three challenges described above and ensure the ongoing success of Singapore being a global city. Singapore's economy will be supported by SmartChangi, by enhancing the air-sea link and providing more space for business and tourism activities. With a big quantity of office space provision around the Changi Airport, more international companies will be attracted, bringing along more highly educated foreign workforce to Singapore. It is able to help Singapore to mitigate its demographic challenge. The transport system in SmartChangi connects the points of interest inside the area and also the area to the rest of the nation efficiently. The main functions of SmartChangi are thus ensured. Concluding the whole SmartChangi development can be seen as a "model city" of how to deal with the risks Singapore is facing on a

Figure 1: Smart Changi Overview Map



Buildings (Possible Examples):

- Public Buildings
- Hotel / Business
- Cooling / Food Production

Transport:

- Road
- Park Connector
- MRT Entry / Exit
- Cruise / Ferry Anchoring Point

Open Space & Greenery:

- Greenary
- Trees
- Shading Facilities
- Water Body
- Waterfront Open Space

Others:

- SmartChangi Border (until 2040)



local scale. Exemplary are the innovative transport measures such as electrical autonomous vehicles, the district cooling or the internal food production with urban farming. Those resource management solutions will help to tackle the challenges from food, water and energy within the area and give SmartChangi a unique branding. Together with the mix of uses and the proximity to the airport, the district has the necessary prerequisites to become a thriving model city, and provide salutary experience to the rest of the country.



Figure 2: Smart Changi Birdview

Projects

CHANGE - A transformation strategy

A. Farner, D. Fierz, C. Glanzmann, M. Hangartner and V. Zuber

Global air travel has experienced substantial growth during the past decades and it is expected to increase further, especially in Asia. This development not only has a strong influence on the globalized economy but also shapes the built environment on a large scale. Airport hubs, combining the flows of people, goods and capital therefore play an important role in the modern process of urbanization. In the case of the city-state Singapore, Changi Airport serves as a gate to the world and the global markets. Within the context of the planned airport expansion, this report examines its impact on the local level consisting of the surrounding urban areas of the Changi region for the given task Positioning Our Air Hub. The complex developments on the regional scale following the extension of Changi Airport call for coordination. In this context, this report frames a strategy and a vision for the Changi region for the next 20 years.

The work investigates topics in the realm of spatial planning, transportation and infrastructures on three levels of interdisciplinary scale: global, national and regional. Thus, based on the situation assessment, requirements and conditions targeted towards the Changi region are formulated, considering the perspectives of both the airport and Singapore as a city. These findings lead to the formulation of a strategy for the period until 2040 for the Changi region, including the most important aspects of spatial planning, transportation and infrastructures. The presented strategy towards the fulfillment of the requirements is implemented in a vision with an abstract understanding of Smart City. Thereby, the most important measures are located spatially within the region, defining the starting points for a transformation of the area. A Zoom-in specifies elements of the vision in more detail in the Loyang region. Finally, the discussion screens the presented results critically.

Situation analysis

The region west of Changi Airport (Changi Region) is characterized by various land uses: Residential areas

(Condominiums and Landed Properties), industrial and commercial sites, service centers, training centers, the Singapore Expo, national security infrastructures (police and military sites, prisons) as well as leisure and recreation areas. However, there was not a strategy to place the different land uses, but they are rather historically grown such as the military area and the prisons. Others are airport-oriented and need to be close to the airport or are noise insensitive. The area as a whole has a heterogeneous use but individual uses are isolated from one another and can therefore be seen as independent land use islands. In the west, Changi Region is bordered by the new towns Bedok, Tampines and Pasir Ris. They were built between the mid 70s and early 80s and have a homogenous structure. Expressways between the Changi Region and the new towns reinforce the separation between the homogenous structure of the new towns and the heterogeneous structure of Changi Region. New infrastructure constructions like north-south-corridor expressway cause the separation of Changi Region and the airport on the eastern side. Additionally, there is a lack of green spaces and accessibility of community centers within the Changi Region. Therefore, Changi Region can be identified as the Buffer Zone Changi, a spatial, identity-related and use-related negative selection.

Strategy

The expansion of Changi Airport through the Terminal 5 project leads to additional airport related jobs and an increased need for airport-oriented uses and infrastructures. To meet this additional demand, the URA identified suitable areas adjacent to the Terminal 5 project: The Changi East Industrial Zone and the Changi East Urban District. This offers the opportunity to restructure the buffer zone Changi into a district with its own identity.

The analysis of the buffer zone Changi clarifies which areas are suitable for a transformation and which uses should or have to remain at the current location. Based on this analysis, the areas are assigned to the following categories:



Figure 3: Identification of transformation areas and current land uses.

- Suitable areas for transformation (Loyang Industrial Estate, Changi North Industrial Estate).
- Undeveloped areas, which are within the Loyang Industrial Estate or at the edge of the Changi Business Park.
- Areas to be transformed with high priority, as they will no longer be able to fulfil their current use in the near future. This mainly concerns uses on the western edge of the airport. Due to the planned road corridor along the western edge, uses such as Changi Air Base (West), the airport fire station or the maintenance hangars of sats will be cut off from the airport grounds.
- Areas that are blocked with the current use in the long term and are therefore not suitable for transformation. The reasons for this are found in the lack of alternative locations for the current use (Selarang Camp), recently made investments (Changi Prison Complex, Selarang Park Complex) or small-scale ownership (landed houses in Loyang East).

Based on the previously identified deficits, the requirements for the transformed buffer zone are defined: supporting mixed-use developments, blue and green infrastructures as well as accessibility (20 Minute Town Concept) have to be improved, and measures to reduce the airport's noise

impact have to be implemented. The transformation zone also contributes to Singapore's strategic goal of partial food autonomy. It also provides alternatives to accommodate residents of nearby HDB buildings that require a major renovation cycle in the near future.

Vision

The spatial implementation of the strategy starts in five core areas in the transformation zone. Based on the local conditions, specific land uses are assigned to each core area, e.g., the core area next to Loyang Avenue, named Loyang Town, serves as a community center and provides living space, while the core area in the immediate vicinity of Changi Airport, named Agripark, is the main location for vertical farms. Various spatially specific and generally applied measures throughout the transformation zone implement the strategy.

- **Transformation Tools:** The transformation takes place in an already built environment. Therefore, every area's element requires an analysis of its potential for redevelopment. This is done by extensions of existing buildings, new additional buildings in the surrounding, conversion of buildings or the replacement of buildings.

- **Blue and green infrastructure:** To reduce the airport's noise emissions, a green space (Airside Park) is proposed along the western runway. Pyramid-shaped hills shape the park's surface and scatter and distort the noise. The Airside Park and greened roof surfaces contribute to the reduction of the Urban Heat Island effect and serve as a water catchment area.
- **Improvement of accessibility** in the transformation zone is primarily achieved with the implementation of new community centers. The improvement of the connection to the entire island is already being planned or built (e.g., Cross Island Line). To improve access to the airport, a new MRT station on the line between Airport and Tanah Merah is proposed in the Agripark area.
- **Vertical Farms** are area-intensive and noise-insensitive and therefore are put in places where the noise level is still too high to live or work. Further, if designed as rooftop farms, they productively use previously unused roof areas.

Zoom-in

The measures to promote mixed-use are discussed in the core area of Loyang Town. This area is chosen as the new MRT station is expected to promote a development impulse. Loyang Town is divided into three sub-areas: Loyang Village, Upper Loyang and Central Loyang.

In the first stage of development, Loyang Village will be south of Loyang Town. Today, the area is partly covered by a bus depot, the remainder consists of fallow land. The construction of the Loyang MRT station and the Changi Northern Corridor will act as a driver for further restructuring in the south of Loyang Town. This offers the opportunity to develop a mixed-use zone in the future, where living, working, education, commercial and cultural uses are combined. The latter will be brought into the area by the construction of the Loyang Hub, directly connected to the MRT station and thus accessible for a larger catchment area. The redirection

of the road on the new viaduct will lead to a reduction in traffic and its noise emissions. This opens up the possibility to locate public-oriented services, such as shops or restaurants, on the ground floor of the adjacent buildings. This should revive the urban space and create a place to stay for residents. The desired mix of uses is vertically implemented within the buildings. The brownfield site, located north of the current Loyang Avenue bus depot, is particularly suitable as a location for a functional mix of living and working. As the area is still undeveloped, it offers space for new HDB construction projects.

The second development phase focuses on Upper Loyang that is still in an undeveloped state today. Here too, a mix of uses is to take place and an area of urban production is to be created. This concept describes the coexistence of industrial companies, housing, educational facilities and office space in the same district. In contrast to Loyang Village, however, the different uses are mixed horizontally.

Central Loyang is located between Loyang Village and Upper Loyang. In contrast to the other two areas, there is already an existing building stock, consisting mainly of industrial and commercial uses. In a third stage, mixed land-use is promoted, mainly with the transformation tools of conversion and upgrading, as these are particularly suitable for dealing with existing buildings. The aim is to retain the existing urban structure, but also to further develop and build inside the area.

Discussion

The proposed vision focuses on the regional context as, arguably, the Singaporean government has already set the strategic course on the international and national level. The vision for Changi Airside formulates a region less dependent on the airport, yet better connected to it and flexible for different future scenarios. Even in case of a decline in aviation, Changi Airside can still fulfill its function and

increase its synergetic qualities. The proposed vision acts as a non-conclusive process of how the Changi region could continuously transform up until 2040 and beyond, not only fulfilling the requirements of the airport but more importantly of Singapore and its inhabitants.

The vision suggests mixed-use developments and establishes a holistic view instead of picking out individual measures. Through the efficient use of existing infrastructures, space, money and energy are saved as well as LTA's goals and a livable city are achieved by bringing people and jobs closer to each other. The proposed transformation tools are

yet to be established in the Singapore planning context, for which Changi serves as a prime location for future implementation in the whole of Singapore. These tools respect investments made and provide smooth transitions instead of disruptive intrusions.

For an effective implementation, URA plays a key role in coordinating the efforts, keeping the strategic overview and developing a new framework and tools in close cooperation with HDB, JTC and LTA. All other relevant agencies are integrated in their respective field of expertise to maximize the synergetic qualities of the government operations.



Figure 4: Core areas of transformation, extent and phases of the Airside Park as well as park connectors and waterbody restorations.

Projects

Airport City Changi+ - Your Happiness, Our Passion

A. Csiba, P. Hirsiger, P. Nève, N. Stutzmann and C. Wiher

The starting point of this work is the expansion of Changi Airport and its associated effects on the local (Changi Airport), regional (Changi Region) and global level (Singapore and other global Cities) as well as Singapore's future global orientation. The site assessment identifies deficits mostly at the regional level. The Airport City Changi+ at the new Terminal 5 should improve the airport's profitability, overcome the region's deficits and strengthen Singapore's international competitiveness. To make Changi+ attractive for people, a user-centered design based on the architect and urban planner Jan Gehl is proposed to make Changi+ an economically productive and meaningful location. The outcome of this work is a master plan for Changi+ that includes elements of urban development, traffic and open space.

Singapore is an important player in the competition between global cities with situating Changi Airport, one of the world's leading airports. The Changi region around the airport still has substantial development potential and is functionally separated from the airport and Singapore. The key findings from the site assessment are: The airport does not benefit from the Changi region; the Changi region does not benefit from the airport and Singapore misses out on potential from synergies between the region and Changi airport. Thus, according to our theme, "Your Happiness, Our Passion", based on Singapore's slogan "Passion made possible", people should work in Changi+ and spend their free time there.

Strategy for success

Based on the analysis of the business models of today's airports, the most important recent development was that an airport should sell like a brand, so that a connection between global and regional players is established. The focus is on three dimensions. First, aviation, where the focus is on operations and the key to success is operational excellence and innovation in security and terminal operations. Second, consumers, where the focus is on people and the key to success is good customer interaction and familiarity. Passengers are

seen as consumers and a visit to the airport should be a lasting experience (e.g., Jewel, airport cinema). Following our site assessment, we conclude that for these two dimensions Changi Airport is already among the world leaders. In the third dimension, airport city, Changi airport still has a lot of potential. The airport city is a business platform whose keys to success are partnership management, innovation and identity. The airport city serves as a multimodal hub (into the country/region), has excellent accessibility and offers a location for retail and other uses/services. (Brilha, 2019)

From an analysis of four potential locations, we identified Changi East Urban District as the most suitable one for an airport city. The decisive factors are its immediate proximity to the new Terminal 5 and sufficient free space to cover the uses from the newly generated demand.

An Airport City for the people

The Airport City Changi+ is planned following Jan Gehl's, a Danish architect and urban planner, principle «Life, Space, Buildings» as shown in Figure 5. He considers people as the starting point of a project. First, the type and extent of possible future human use of the project perimeter has to be determined, using interests, transportation, behavioral patterns and engagement with the environment of the people in space as a basis for changes in space. Measurements are made in that space to include the aspect «life» in the best possible way. (Gehl People, 2019) Thereafter, space utilization is determined based on desired walking and cycling connections, providing an optimal space for the development of buildings so that the city life, the urban spaces and the buildings create a common entity.

The future land-uses of the airport city and the user requirements are determined in a "pseudo-participative process" using users or personas that will enliven the airport city, whose profiles are derived from forecasts, statistics and literature. Here, ten personas are created, representing important user classes with special requirements for the region.

Life



Space



Buildings



Figure 5: Three core elements of the method by Jan Gehl which was used to plan Changi+ with a user centered design (Gehl People [2019]).

The personas include description of their relationship with Changi+, demonstrating the persona's requirements on the region and clearly emphasizing the difference to other personas. (Aquino and Filgueiras, 2005)

An efficient road network, strategic positioning of uses and a sustainable network of open spaces, traffic areas and buildings will turn Changi+ into a dynamic airport city with its own identity. The public transport services and high walkability form the backbone of Changi+. The attractive Park Connectors are pleasant, safe and direct connections within the Changi+ network, which provide a harmonious offer for pedestrians and bike paths.

Changi+ takes on the function of the urban center of the Changi region. According to Christaller (1933), a city requires a centralized arrangement to be understood and to meet its needs. Christaller (1933) calls places «central places of higher importance» if their central function is defined by an area, which also provides space for smaller central locations. The smaller central places are called «places of lower order» (Christaller, 1933). At the same time, central places are assigned a significance that is greater the larger the place is.

The distribution of green spaces in Changi+ follows the idea of the unlimited metropolis by Otto Wagner (1911). Based on a grid system, each parcel of land connects to green space (usually in the form of a park) at least via one corner. The Park Connectors in Changi+ are used as connecting axes and public recreation rooms and can be used by everyone. Changi+ will be a showpiece of Singapore's car-lite strategy with sustainable mobility, having a high proportion of walking and cycling and public transport trips (Land Transport Authority, 2019). This strategy, implementing Jan Gehl's approach, begins with connecting spaces with the determination of the «desirable walking and cycling path

connections», where the desired trajectories form the basis for the road network.

Masterplan

Changi+ is an Airport City for people, offering good connectivity and walkability for slow transport modes. Changi+ is intended for office, gastronomy, retail, hotel and car park use. In total, 81,000 new jobs will be created at Changi+ and around 19,000 visitors will visit Airport City every day. The masterplan layout of Changi+ is shown in Figure 6, which is based on 90x90 m grid to promote walking.

In the planning for the building typology in Changi+, tall buildings are placed on the northwestern and southeastern sides to counteract airplane noise. Along the central avenue, building heights are lower to counteract constricting feelings. To improve cooling, building types at the north and south entrances are aligned with the predominant wind directions. This arrangement ensures that the public or private spaces are located between buildings and at road intersections. Frequently visited uses such as retail are located primarily along the central avenue and around the plus-shaped building in the city center. Further sub-centers within the office uses, located on both sides of the avenue, are created by allowing additional retail uses.

Based on the grid system, each plot is connected to green space via at least one corner. This design together with the arrangement of the buildings leads to numerous green spaces, creating pocket parks. Throughout Changi+, there are integrated connections via Park Connectors. All these green elements create passageways for walking or cycling as well as provide a high quality of stay. Altogether, this offer of green and open spaces contributes further to Singapore's image of the garden city.

Due to the isolated location of the Airport City, a high level of commuting from across the island is expected on

Figure 6: Master plan combining all spatial elements analyzed in this work.



weekdays. By restricting car traffic with various means to an ambitiously low 25% of all trips to the Changi+ and Terminal 5, the road system can handle traffic volumes even at peak times without congestion. Changi+ and Terminal 5 will be accessible by individual motorized transport (MIV) from the new underground Tanah Merah Coast Road via the partly underground four-lane one-way ring road. Entrances to Changi+ from this ring road are located in the east and west. The low share of 25% is due to the car-lite strategy in Changi+. 10% of journeys to Changi+ are done with the bicycle via park connectors. Approximately 65% of journeys to the airport region will use the MRT (extensions). Changi+ is optimally connected to Singapore with the new Thomson East Coast Line, the Cross Island Line, as well as via the connection to the East West Line and the Down Town Line and the MRT stations Changi+ and Terminal 5. The MRT thus ensures the main access by and capacity of public transport. A ring bus line further then ensures the local distribution of travelers within Changi+. A cable car will provide a direct connection between Terminal 5 and the ferry terminal. This will strengthen the innovation of the Airport City and create identity. Most importantly, it creates the unique selling point of the Airport City.

Outlook

The master plan Changi+ 2040 provides an experimental, «pseudo-participative» and idealistic approach to strengthen the position of Changi air hub. The Masterplan strengthens Singapore's position in the race between global cities, while at the same time Changi region benefits from an identity-creating center with a significant number of work and leisure functions.

Projects

Positioning our air hub

M. Baumgartner, P. Burchard, J. M. Castrezana Lopez and F. Fuchs

In 2018, Changi airport recorded more than 65 million passenger movements (Changi Airport Group, 2019). Changi Air Hub and its resulting airside connections to the world have been essential for Singapore to position itself in global economic networks (Teck et al., 2019). However, Changi Air Hub is more than an airport. Contextually understood, the Air Hub functions in three major roles:

- Changi as a **transfer site** operates global passenger and cargo flows, where goods and people are flown in, redistributed and leave the country again.
- Changi as a **gateway** imports resources (food, goods and human capital) from other countries that are then distributed on the island. Vice versa, the gateway works similarly for exports.
- Changi as a **center** is embedded in the national economic context. Additionally, Changi region provides an urban habitat for residents and a site for free time activities for Singaporeans and tourists. Nevertheless, it also forms

a natural habitat for plant and animal species, which in turn enrich the environment as recreational space for us human beings.

In all these roles, Changi Air Hub is a component in networks across different spatial and organizational scales. Its positioning for the future has to account for these three roles. This summary gives insights how possible conflicts can be solved, potentials are activated and demonstrates new ways and solutions how to position the Air Hub.

The growth of the transfer role due to the expansion of Terminal 5 acts as a driver of change for the entire Changi Air Hub. This will affect the other two roles, the gateway and the center. The overall strategy for positioning the air hub must be designed in such a way that the transfer role will not be restricted in its function in the future. Consequently, the transfer role has to remain physically expandable even after Terminal 5 is completed.

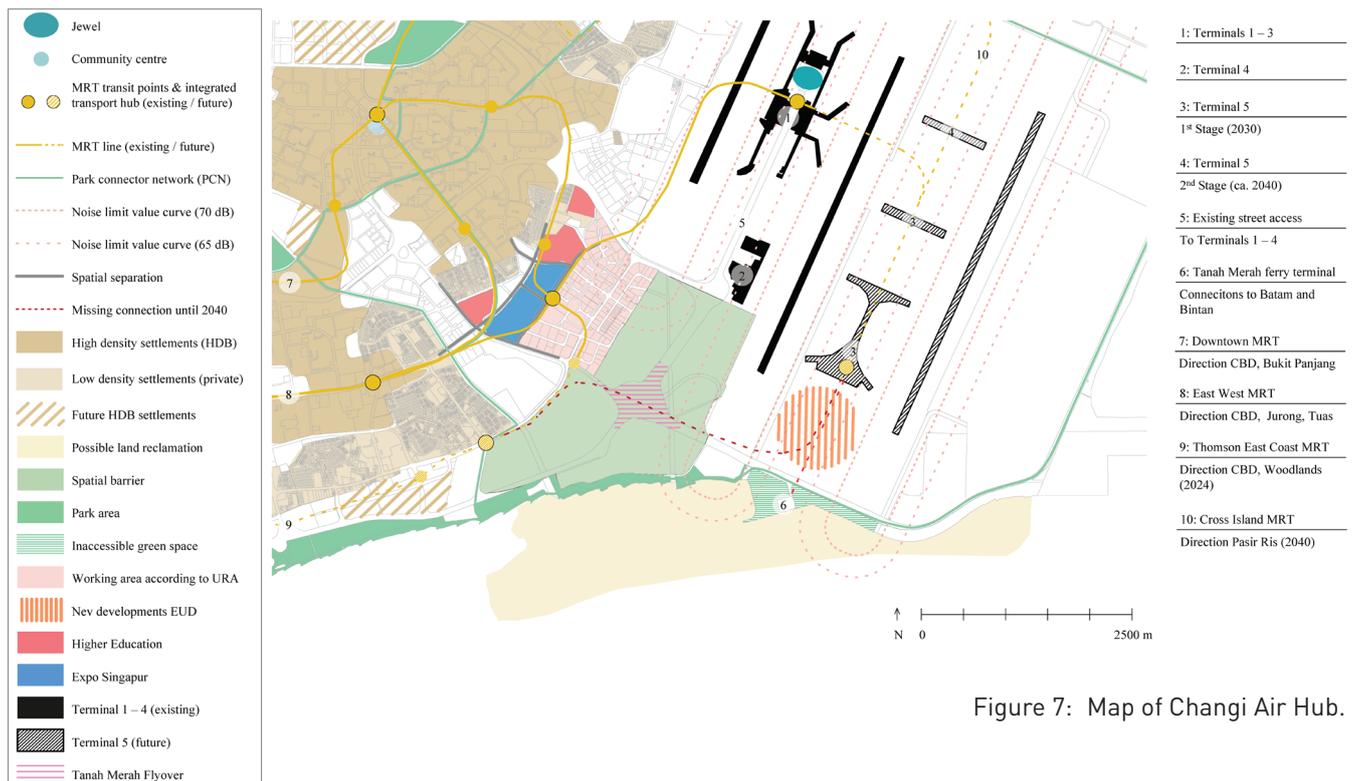


Figure 7: Map of Changi Air Hub.

With the opening of Terminal 5 and the development of Changi east industrial zone, the flows of the gateway change. Thus, efficient transport systems are required to distribute goods and passengers on the island. Projects regarding Changi east industrial zone and the logistics area in the north of the airport seem well-developed (with the three-level-corridor as a major feature). However, the need for actions arises with respect to future passenger flows in the southwest of Changi. The Mass Rapid Transit (MRT) accessing Terminal 5 and the East Urban District (EUD) will start operation around 2040. For a period of ten years, consequently, there will be a gap in the public transport network. This time gap is in clear conflict with Singapore's car-lite strategy and the ambitions to position itself as a forward-looking and sustainable country. Furthermore, there seems to be no strategy for connecting the thriving Tanah Merah ferry terminal to Terminal 5 and the rest of the island.

The Changi/Tampines regional center, designed by the Urban Redevelopment Agency (URA), consists of a network of central locations and facilities, one of which being the air hub with its main facilities the Jewel and the area around the Expo. The Jewel stands out for its architecture and consumer facilities, while it already experiences capacity limitations. The Expo area offers a wide variety of central functions: cultural activities, working, education and consumption. Furthermore, the area forms an interface between the air hub and the rest of the Tampines/Changi region and its residential areas. However, the different institutions and uses are separated by inaccessible or unused areas and separating infrastructures.

With the development of the EUD, from 2030 onwards, a further central node will be created. However, it is unclear what should be developed and what benefit the EUD will bring to the stakeholders. In addition, with respect to the car-lite strategy, the connection with the existing central locations in Changi/Tampines and across the island is not ensured.

To position the air hub, which spatial strategy can improve the functioning of the air hub according to the stakeholders' requirements and thus the three roles as transfer, gateway and center? In the following, measures for the focus areas EUD, East Coast and Expo are proposed to foster a sustainable and resilient development of the air hub in all its three roles.

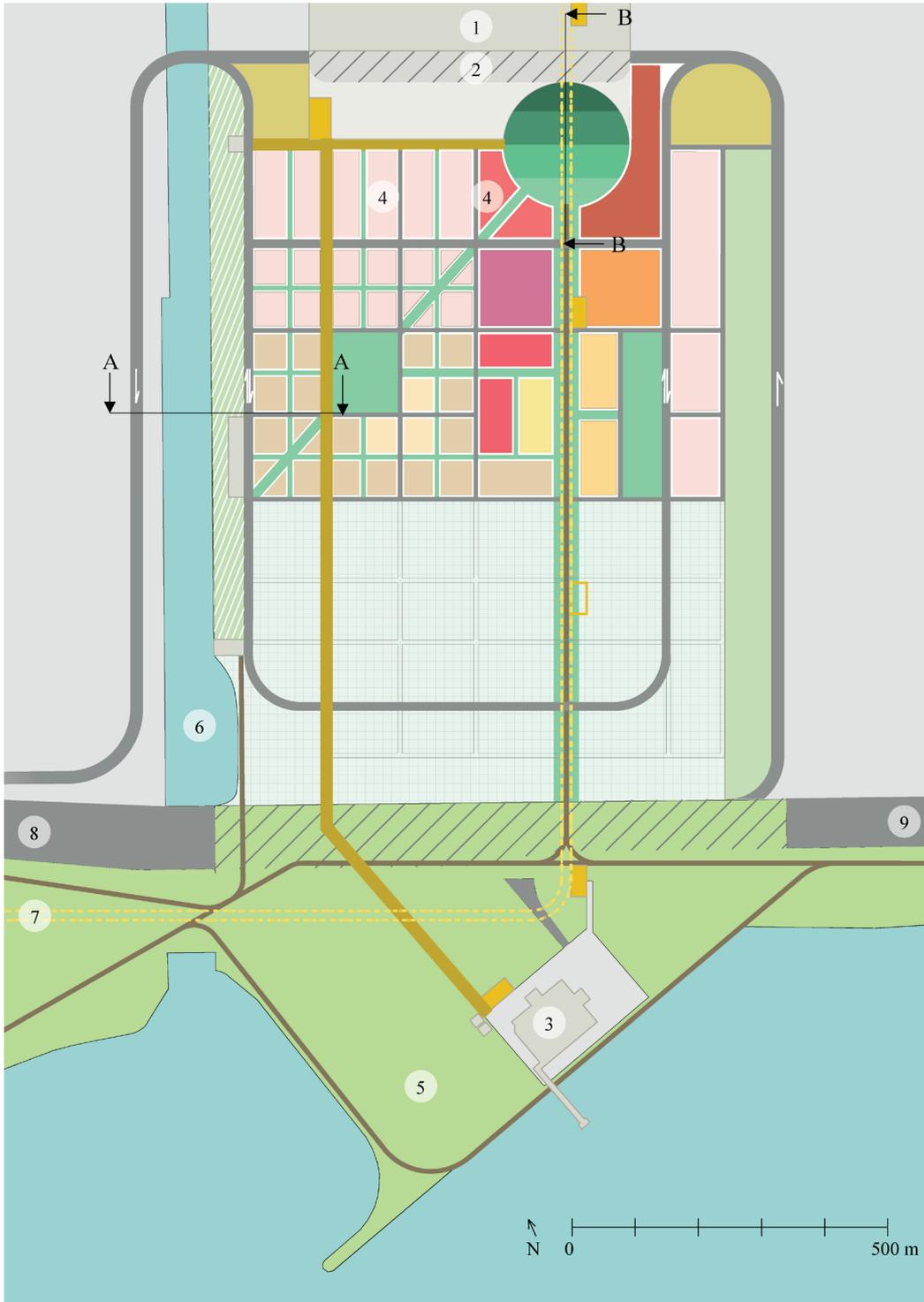
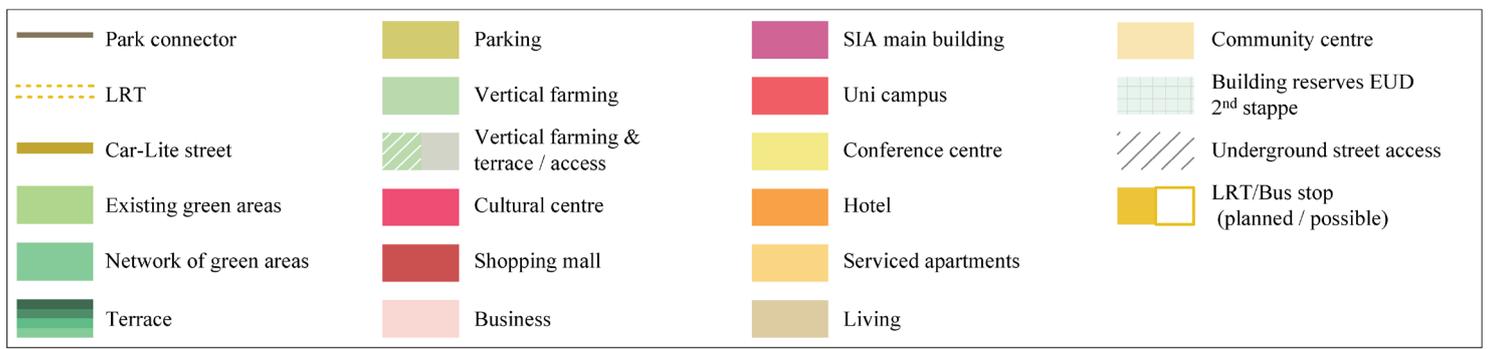
EUD

Terminal 5 and the existing Tanah Merah ferry terminal come together in the area of the planned EUD. The three roles of the air hub overlap here, giving it a strategically high significance for future development. However, currently, no founded concept for the development of EUD seems to be present. Thus, the strategy for this area is to develop the EUD as an outstanding, complementary and networked component of the center, while managing the passenger flows between Terminal 5, the ferry terminal and Singapore's national transport network and at the same time not to restrict the transfer role in its functioning.

A hierarchical separation of the transport systems allows an efficient connection of Terminal 5 with the higher road network and projected Tanah Merah flyover. Arterial roads are placed on the boundaries of the EUD, so that the area does not become fragmented and noise emissions are reduced. Two elements separate the EUD from the roads and runways to further reduce the noise. Inside the EUD, a superordinate ring road and a subordinate road network will provide access. Singapore's car lite strategy is considered: Some streets are kept car-free and the focus of the EUD is on public transport and urban traffic. Consequently, the design of the EUD follows the principle of best possible walkability. The workplace area envisaged by the URA offers space for innovative companies and start-ups. In addition, complementary uses are established. For example, long infrastructures on the border of EUD could contain vertical farming facilities and could be partially made accessible for visitors. The vertical farms could act as an incubator for related industries and companies, synergies with educational facilities (e.g., NTU that already researches these technologies) can be achieved. These measures would establish the EUD its own identity of a green, future-oriented and attractive district. Furthermore, a new headquarter of the Singapore Airlines along the central avenue, right in front of Terminal 5 provides opportunities for another landmark building. Through a diverse mix of uses with commercial facilities, education, culture and housing, EUD can be enlivened at different times of the day with people engaged in different activities.

The forest area south of the Coast Road provides already today a habitat for plants and animals and thus provides an opportunity for development: a green axis through EUD creates a direct connection to the existing forest area and parks, also serving as a public transport axis between Terminal 5 and the ferry terminal. An overview of the measures is shown in Figure 8.

Figure 8: Measures EUD.



- 1: Terminal 5

- 1st stage (2030)
- 2: Covered Kiss&Ride zone

- 3: Tanah Merah ferry terminal
Connections to Batam and Bintan

- 4: Reduced building height
Limitation to 5 levels (cultural centre and 1st row of business buildings) to protect view

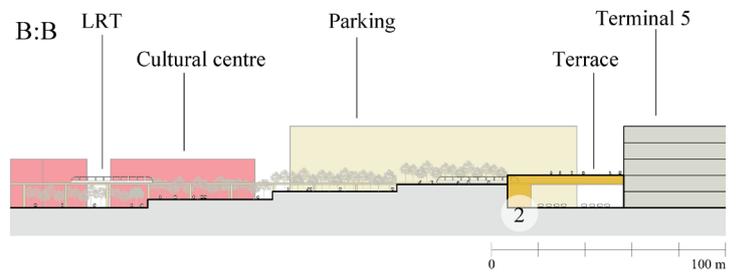
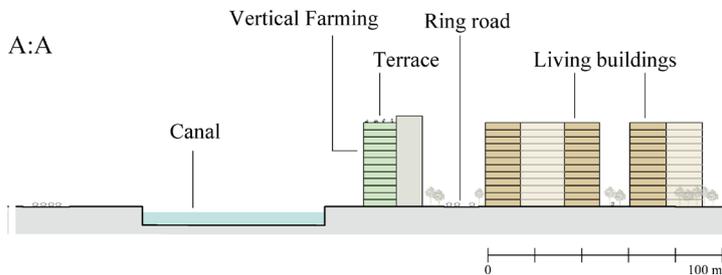
- 5: Forest areas
Made accessible

- 6: Canal
Volume to store water caught on the airport area

- 7: LRT extension
Direction Sungei Bedok

- 8: Tanah Merah Coast Road
Direction Expo / CBD

- 9: Tanah Merah Coast Road
Direction Changi East Industrial Zone, Changi Freight Center, Airport Logistics



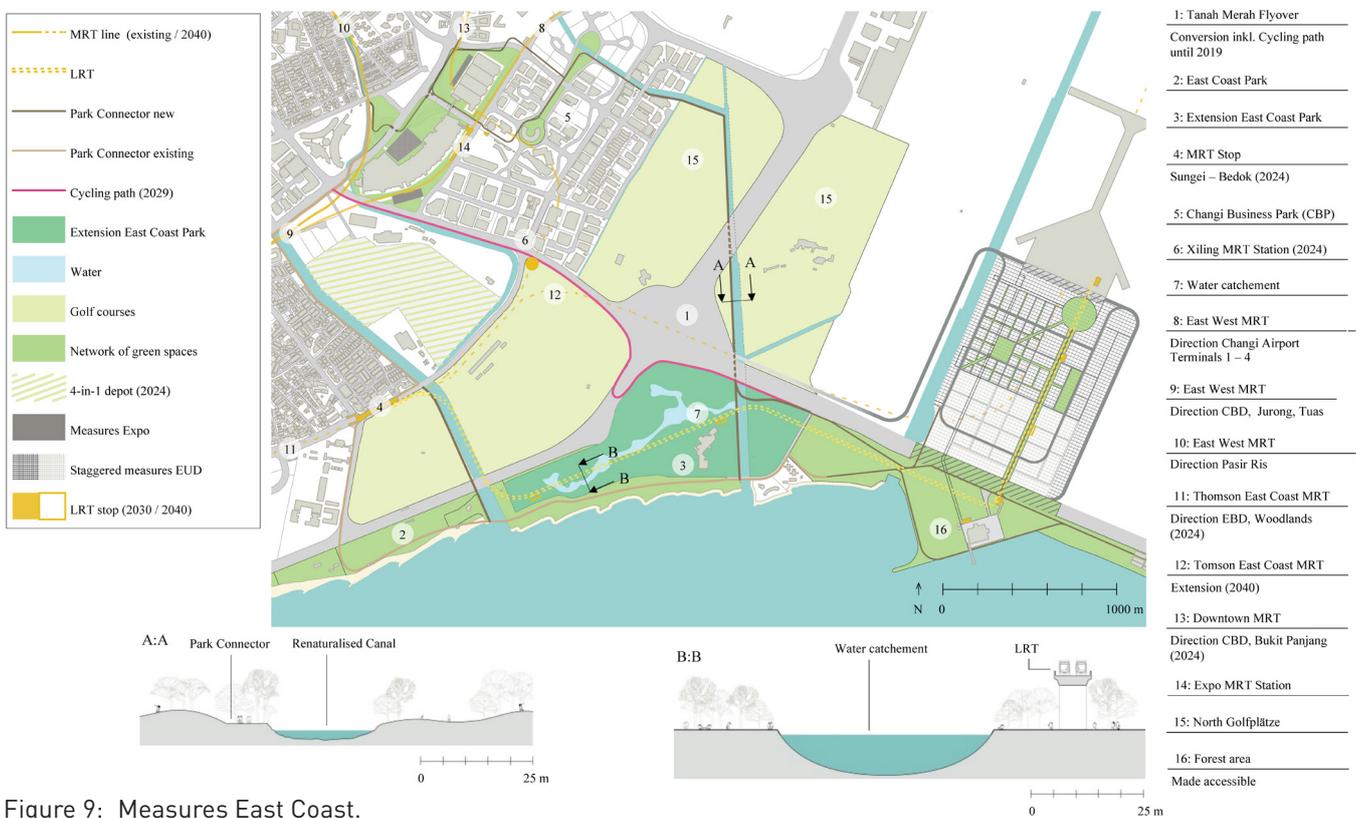


Figure 9: Measures East Coast.

East Coast

Today, the East Coast area is characterized by four golf courses and road infrastructure, both representing a separation for light modes as seen in Figure 9. Especially regarding the future development of Terminal 5, the EUD and regarding a good connection to the whole Changi area and the East Coast Park, this is a clear deficit. However, the golf courses are also a potential reserve area for an expansion of the airport. The strategy for the East Coast focuses on providing a connection between the EUD, as a new component of the air hub, and the various existing networks, by optimizing the transport networks. Existing green spaces are connected to form a coherent EUD network and their potential is exploited, as it has significance for residents and nature.

The East Coast Park (ECP) is extended to the green areas in front of the EUD by transforming some of golf areas. With this measure, an attractive connection between the existing popular ECP and EUD developments is established. With a conversion of existing canals, they can be used as Park Connectors. As a synergy of these two measures, canals, the remaining golf courses and the park with its new lake create a water catchment area, delivering water to the nearby Changi NEWater station.

As mentioned, Terminal 5 will not be accessible by MRT from 2030 to 2040, which is in clear conflict with Singapore's car lite strategy and threatens the functioning of the gateway role. As a solution, the gap between the Terminal 5 and the MRT network is closed by a new light rail transit (LRT) connecting Terminal 5 with the existing MRT station Sungei Bedok with only few stops to provide a fast connection. Potentially, this LRT can be connected to the airport's LRT

system. After the opening of the MRT Thomson East-Coast line in 2040, the LRT will lose its purpose, but it can then serve to access the extended ECP. This transformation contains the addition of two new stops in the ECP, making it even more accessible for Singaporeans.

Expo

The strategy for the area around the expo (see Figure 7) focuses on the optimization of the air hub in the center role. Already today, many important facilities are concentrated here, but due to roads, which are hard to cross for pedestrians, the area appears monofunctional with the Changi Business Park, the Singapore University of Technology and Design or the Expo itself. Thus, inhibiting interactions and exchange between humans across functions, but synergies between functions can be use when brought closer together. Useless and inaccessible areas can be activated such as the open spaces surrounded by the Expo, the SUTD, the residential areas and the ITE College. Cars in front of the Expo can be parked underground or elsewhere outside this center. A coherent network of public and green spaces connects as part of the park connector network to the Changi Business Park. Road crossings in the center area are rebuilt above or underground to make them more attractive for walking and cycling. The measures enable encounters and exchanges and make the Expo area a coherent center. Together with the measures at the East Coast, they will also improve the connection of the air hub to Tampines/Changi region, creating benefits for the regional community from the development. In closing, the proposed measures strengthen the air hub in all its three roles: transfer, gateway and center for the region of Changi/Tampines and entire Singapore.

Projects

Changi: A hub for exchange

S. Mettan, S. Nussbaumer, T. Wettstein, D. Zani and R. Zängerle

Singapore's government plans to build a fifth terminal at Changi Airport to deal with the increasing number of passengers. This expansion shall support the development of a sustainable global city while transforming the region into a space with high living, working, and recreational quality. To successfully "Position Our Air Hub" at Changi, the flows of people, knowledge, money, and goods must be brought together in a concentrated area where their seamless exchange is enabled. This definition of a hub involving various exchanges applies to different geographical levels. Such an understanding is important for creating a strategy that not only positions Changi Airport spatially but also reinforces its position across all levels: globally, nationally, regionally, and at the airport level to enable synergies between contexts. Instead of proposing changes to the already completed planning work, proposed developments will evolve and synergize with these existing projects. It would be counterproductive to suggest measures that contradict Singapore's decisions

thus far. In addition, food, energy, and water create a collection of national needs that seem to be at the forefront of Singaporean national security planning, and which will therefore be considered in this project. Synergies between the national needs and proposed measures will be sought out wherever possible.

Strategy: Three cores

This project leverages opportunities at the local level, the direct periphery of the airport, where Terminal 5 is a major disruption: with its southern orientation, it will spill new flows of people into the Southern Changi region. Flexibility provided by open land and attractive natural capital in the South invite strategic development. This project's strategy therefore focuses on development of the southern portion of the Changi region. Here, three core areas are strengthened (see Figure 10), and the exchanges of people, knowledge, money, and goods are made possible. These core areas were identified through a spatial analysis of opportunities in the

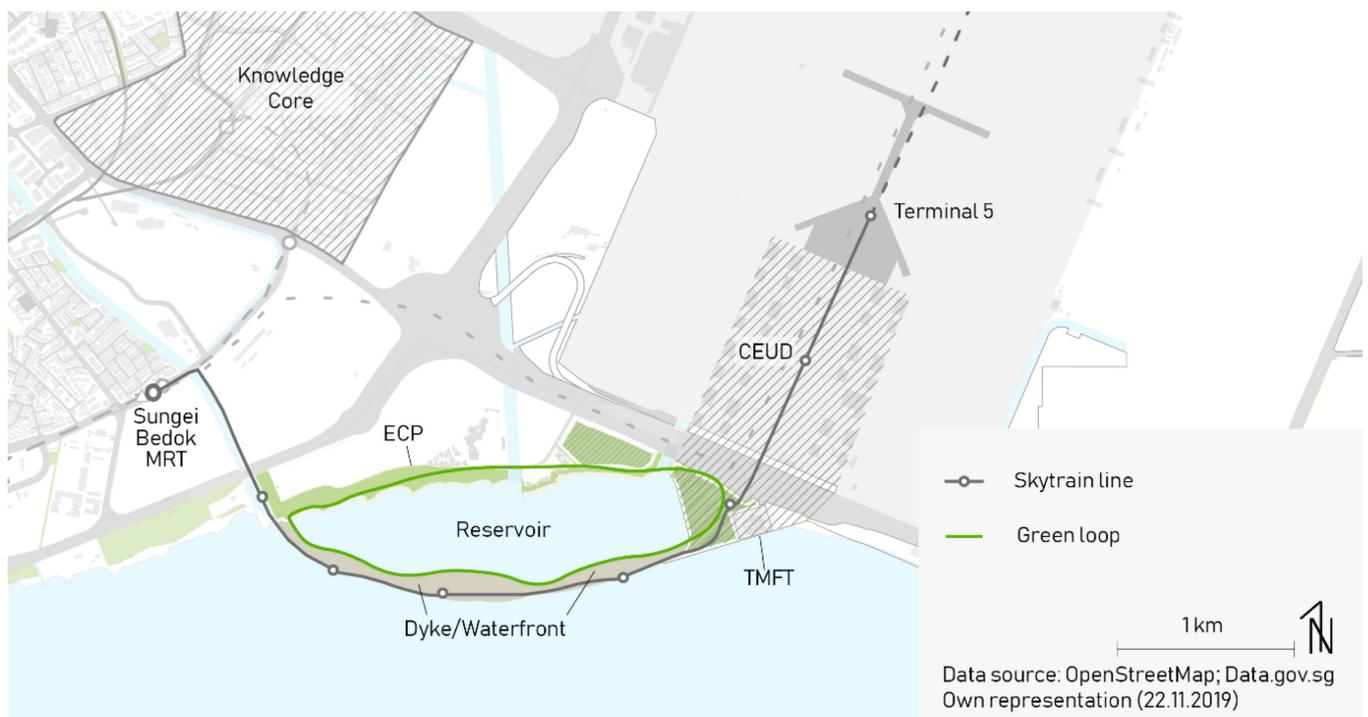


Figure 10: Location of the three core areas: Knowledge Core, Waterfront, and CEUD.

Changi region - places which stand out as hitherto positive, placemaking, or otherwise beneficial to the attractiveness of Changi. The challenge is to reinforce cohesion and exchange between different functional spaces to transform them into an interconnected whole. The strategy will attempt to overcome functional divisors to join the region into a place worthy of a global air hub. Although each of the three cores - Waterfront, Knowledge Core, and Changi East Urban District (CEUD) - is itself an origin for future development, exchanging different flows and producing economical value on its own, together they form the gestalt that is the Changi Hub.

The space between the core areas is to remain golf courses until required for a different use, making this strategy flexible. Preserving this underdeveloped space (referred to as the Flex Space) lends to flexibility for future developments and guarantees the hub's long-term success.

Waterfront Core

The keystone of the strategy in the Changi region is the Waterfront core: it is the most direct answer to Terminal 5' disruptions. Here, a strip of reclaimed land along the East Coast Park (ECP) with a unique selling point (USP) will attract both visitors and Singaporeans, while preserving the ecosystem services the park provides. On the original coastal side, ecological measures enhance biodiversity; the Waterfront itself will be dense and urbanized. This "loop" of land encircles a freshwater reservoir with floating solar panels, which satisfies Singaporeans' needs for water, energy, and recreation in nature. The reservoir will be able to fulfill the water demand of the Waterfront and surrounding housing: at full capacity, the reservoir has a volume of almost four times the yearly water demand of the Waterfront, making up 5 % of Singapore's reservoir water supply. Solar panels provide electricity for up to 42,000 four-room HDB flats.

The Waterfront bridges the disconnect between airport and Singapore, allowing their flows to be united and offering attractive spaces where tourists and Singaporeans can meet and exchange. Tying this area to the airport will be an extension of the existing Skytrain, an Automated People Mover currently operating in Changi Airport. The Skytrain will offer attractive and efficient movement, allowing arriving visitors at the airport to ride directly to the Waterfront without transfer. Through its proximity to the airport, the Waterfront will capture the significant transit tourist market - a visitor arriving at Terminal 5 reaches the Waterfront's USP within six minutes. Travelers should experience their stopover at the Waterfront as a seamless offer: free transportation to the Waterfront via Skytrain and hotel booking integrated into an inclusive visitor package. The Skytrain will be connected

to the MRT at Sungei Bedok station, which will be connected to the Thomson-East Coast Line and the Downtown Line Extension in the future. Thus, the Waterfront is optimally accessible from entire Singapore.

On the reclaimed land, the USP and other recreational activities (hotels, space for retail, living, and recreation) attract Singaporeans and tourists much like the Jewel, but with the advantage that people are outside and not trapped inside the airport. The USP reinforces the identity of Singapore, drawing people from all over the island and abroad. A promising possibility the USP is the cooperation with a globally recognized arts institution (e.g., The Louvre or Guggenheim), as Singapore has been underlining its willingness of asserting itself as a global arts city.

Conscious of Singapore's climate and effects it has on outdoor leisure attractions, the urban design of the Waterfront will contribute to comfortable outdoor spaces. This is achieved through pedestrian-friendly movement axes and careful arrangement of buildings. Movement to and from the Waterfront will not only be made possible through the Skytrain connection, but also through attractive cycling and pedestrian infrastructure. More than enabling connectivity, the whole Waterfront will be a car-free zone. Small open spaces in the form of parks and squares are disseminated all along the Waterfront. These parks together with the park connector network on the Waterfront and the ECP form a loop of greenery.

The Waterfront will embrace the "work-live-play» slogan of Singapore in an elegant form, creating a unique global attraction which strengthens both Changi and Singapore in the regional and global competitive networks: the tourism sector (contributing 4 % to GDP) is promoted; an estimated 11,200 jobs will be created; and Singaporeans' needs are satisfied. All this is achieved while preserving the overall ecological situation in the Changi region.

Knowledge Core

The Knowledge Core will form a collection of institutions: the Singapore University of Technology and Design (SUTD), the Singapore Expo, and Changi Business Park (CBP) (focused on creation, exchange, and valorization of knowledge, respectively). This core will be based around the CBP, facilitated by expansion of the existing SUTD master plan, where some parts have already been realized. Implementing these ideas will synergize with business development in the rest of the core. They will become the framework for shaping the Knowledge Core into part of the Changi Hub by supporting establishment of industries, overcoming functional barriers,



Figure 11: Existing and proposed new public spaces and mobility infrastructure in the Knowledge Core.

creating shared facilities, and improving access to public transit (see Figure 11).

An SUTD expansion will attract academic professionals and students, creating new knowledge and expertise that can benefit from the joint expansion of research and business activities in CBP. By adhering to the principles laid out in the university's master plan, improvements can be made to outdoor spaces, pedestrian mobility, and access to public transportation throughout the Knowledge Core. The Singapore EXPO will grow in importance for knowledge exchange through MICE (meetings, incentives, conferences, and exhibitions). Proximity to Changi Airport and the Waterfront attraction allows for easy exchange with potential customers from around the world. At the CBP, focusing on specific industries enables an efficient, coordinated policy approach to provide the infrastructure needed and create a marketing strategy. The Aerospace, Urban Solutions and Smart City, and Satellites industries are well-positioned for cluster development as they can benefit from the locational advantages. As in other parts of Singapore, a LaunchPad Space in the Knowledge Core will provide spaces explicitly designed for start-ups, incubators, and labs. These spaces commercialize technologies developed at nearby universities, effectively valorizing the created knowledge. Future development of the Knowledge Core will occur along

development axes, steering the growth of knowledge-related activities.

Developing CBP supports economic growth by creating jobs. There will be around 8,000 new jobs in CBP alone, and the doubling of SUTD's campus will add a further 500 jobs and up to 7,000 students. Creating workplaces outside of the CBD promotes the government's goal of a polycentric network. As SUTD is the only university in the eastern part of the nation, fewer students in nearby Tampines, Bedok, and Pasir Ris have to commute across the island.

By focusing on supporting the three key functions of the Knowledge Core, its tasks as part of the Changi Hub can be fulfilled. The urban quality created by applying SUTD's master plan to the entire core creates more accessible and attractive spaces. These, are in concert with opportunities for exchange and collaboration created by the LaunchPad Space.

Changi East Urban District

Singapore's Urban Redevelopment Authority has outlined CEUD's functions: a business and tourism focused air-sea-land mode interchange. This third core area is characterized by the movement of people between Terminal 5, Tanah Merah Ferry Terminal, and Singapore. The CEUD therefore needs to enable inviting and seamless links between these

locations, the Waterfront core, and the rest of Singapore to fulfill its role in forming the Changi Hub.

Flex Space

This strategy does not aim to explicitly change the Flex Space. Instead, it shall continue to fulfill its current functions. By remaining largely undeveloped, the space allows for optimal interventions at ideal times, enabling the Changi Hub to grow evolutionarily. Rather to predict future uses, this project accepts that there is uncertainty in a 20-year timeline and offers scenarios that could repurpose the Flex Space: agricultural production, solar energy production, autonomous vehicle infrastructures, housing, airport expansion, or naturalization to a park.

Conclusion

On the global level, the Waterfront together with CEUD advertises Singapore and Changi Airport as an attractive destination. The distinctive Waterfront with its USP positions Singapore in the global competition for air traffic against other destinations.

At the national level, jobs and additional income sources are created. Collection of drinking water and electricity production contribute to the abatement of national needs. By building new attractions and space for recreational purposes, creating workplaces, and improving accessibility, Changi region concentrates uses and becomes part of the polycentric network of Singapore.

At the regional level, airport-oriented uses are strengthened. The CEUD and Waterfront will have conference rooms and hotels that benefit from their proximity to the airport. Visitors and people working and living in the region benefit from upgraded and newly created open spaces, shared facilities, and leisure infrastructure both in the Knowledge Core and the Waterfront. The region's space fragmentation is addressed by several measures: improvement of pedestrian, bicycle, and PCN networks contribute to better

accessibility to public transportation stops, which increases their attractiveness; and the Waterfront with its Skytrain becomes a destination in the Flex Space and therefore a bridge between Singapore and Changi Airport.

At the airport level, the operations can continue unhindered by this project's proposed measures. Possible room for future growth of Changi Airport is set aside in the Flex Space, and the extension of the Skytrain to the Waterfront integrates Terminal 5 into the regional context.

This strategy can react flexibly to future uncertainties. The Flex Space offers room and opportunities to respond to future developments. Ideally, the cores and Changi Airport develop successfully and have room to expand in the long-term. If this is not the case by 2040, the Flex Space can be made available to fulfill any demands Singapore may have. Through the proposed strategy, new value creating flows will emerge, creating synergies and ultimately a hub.

In closing, a concrete recommendation is to find a partnering institution to situate the USP. This cornerstone of the Waterfront Core and of the entire strategy is responsible for attracting Singaporeans and visitors from around the world. A globally recognized arts institution must be found that is interested in cooperation. The elements of this strategy that interfere with existing planning must be addressed immediately. This includes the Skytrain-Sungei Bedok MRT interchange. Plans at this stop require adjustments so that the two transportation systems can be coordinated. The Skytrain extension into Terminal 5 requires similar organization with existing plans. As a first action for the Knowledge Core, JTC together with SUTD should conduct a cluster analysis to decide which industries and companies should be located there and how they can be supported in their development. The existing master plan of SUTD should be expanded throughout the whole Knowledge Core, so that a holistic and coordinated development is achieved.

Projects

Changi - a future business center of Singapore

J. Hug, M. Maurer, F. Meisser and M. Weber

Our group took it as a challenge to establish a new economic center for Singapore in the Changi region based on the economic gateways shown in the Master Plan. As mentioned there, the Eastern Gateway will host aviation related business and „it will also be supported by an innovative lifestyle business cluster comprising the Singapore University of Technology & Design, Changi Business Park and the future Changi “East Urban District“. To establish and strengthen this goal of an economic center, we termed a „Development Concept Changi 2040“. Further, to foster the Changi region economically, we set up a package of measures for Changi’s economy.

Development Concept Changi 2040

Our concept describes how the economic center of Changi is strategically constructed. It consists of different focus areas, each described in the following. Figure 12 shows the Changi region and presents its future development sites. It also numbers the jobs created and the size of each area.

The Brain The area in and around the Expo will become Changi’s new center with a brain-shaped building on the Expo’s surrounding empty sites. In this building, the Changi ThinkTank will be located that coordinates and supports the region’s economic development in active interactions between industry, research at the three regional universities (Singapore University of Technology and Design, ITE College East and Temasek Polytechnic) and Singapore’s government. The iconic Brain building will bring Changi a new identity representing knowledge and exchange. The building will also host interdisciplinary courses to encourage clustering and knowledge spillovers. With the proposed transport infrastructural improvements, The Brain will also become highly accessible by public transport.

TechCity We see a large potential in the tech industry given the vicinity to the three universities. Therefore, the area south of Bedok, an existing golf course, will be developed into

a tech cluster. With Amazon as an „anchor company“ and support by the Changi ThinkTank, the region will experience an economic boost for its development. The area will be built in two stages. With its own autonomous shuttle bus system and various amenities for daily life on site, it will act as an own city in which people will work.

Business Park The existing Changi Business Park still has empty land for further extension. It will be used to capture the potential given the Terminal 5 expansion as it offers companies space for development, which in turn could create a further boost in the local economy.

Golf Island A new island will be reclaimed south of the golf courses. The island itself will be used for different sports activities and recreation. As a replacement for the removed golf course at the site of the TechCity, a new golf course will be placed on the island.

Water reservoir East Coast Laguna Bordered by the mainland, the Golf Island and two dams at each end, sweet water can be captured in a reservoir. This will contribute to the demand of the east of Singapore, since, so far, there is no water catchment reservoir. Even further, its coasts will also be used for recreation and leisure activities combined with the ones on the Golf Island. Both together form an equivalent to Sentosa Island but with a different theme.

East Urban District At the southern end of Changi airport, a large area is dedicated for the new Terminal 5. It will not only be used for taxfree shopping by tourists, for international conferences and for business meetings. Further amenities will be shopping centers, casinos, cinemas, but also hotels, restaurants and bars. We expect a unique architecture there like „The Jewel“ close to the existing four terminals. This will give the East Urban District a magnet effect for visitors and residents. Further, the connection to the Tanah Merah Ferry Terminal will be improved to enable directly journeys to close Indonesian islands.

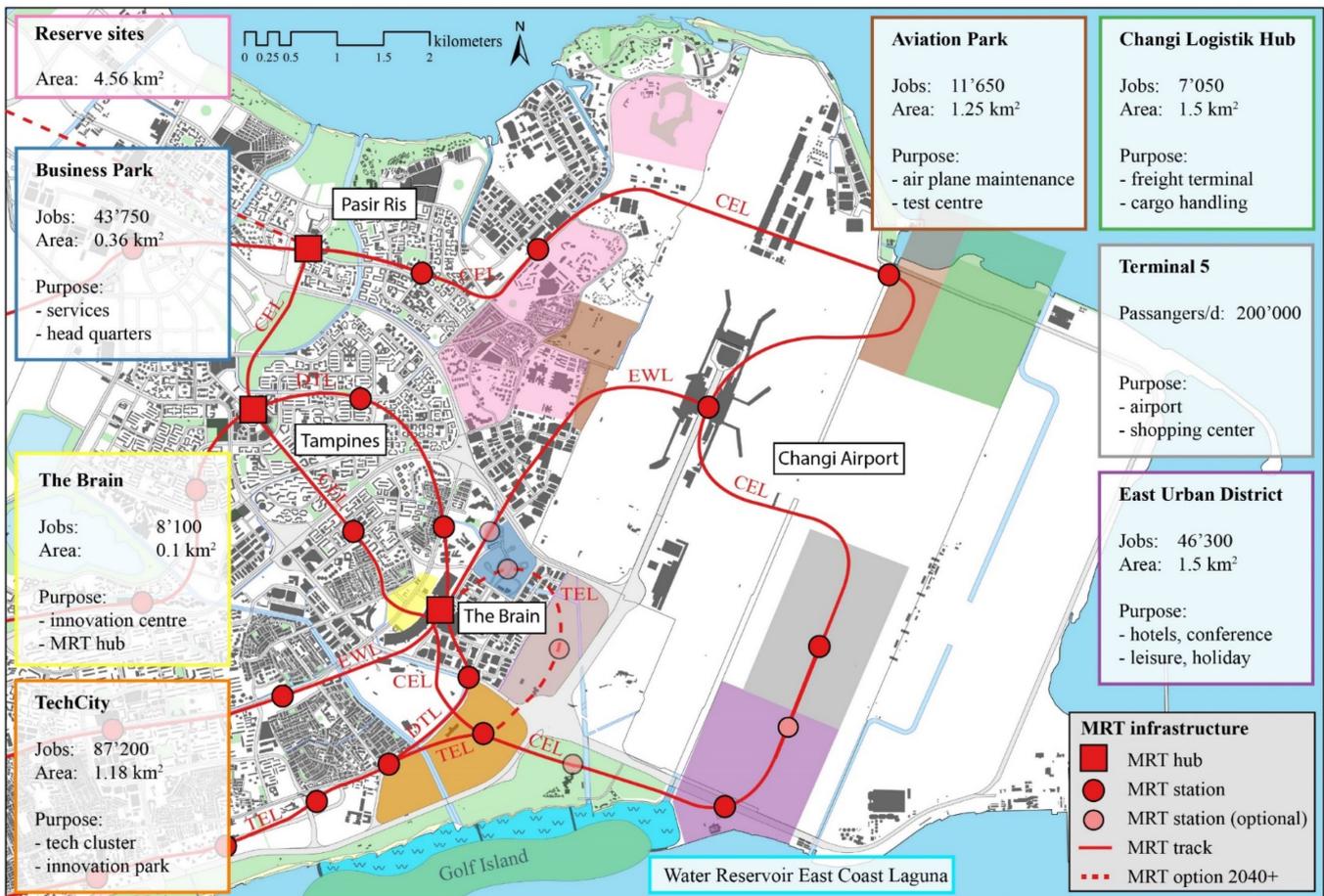


Figure 12: Situation overview in Changi.

Changi Logistics Hub Along with the new terminal, new facilities for air cargo have to be built to deal with increasing volumes. Therefore, the land north of Terminal 5 will be partially used for logistics. Many goods flown into Singapore can be stored temporarily before transported into Singapore or shipped to other countries. For further increased demand after 2040, more land can be reclaimed in the North.

Aviation Park The remaining land north of Terminal 5 is designated to aviation maintenance, training and testing. Another area of the Aviation Park will be located west of Terminals 1-4 to handle increased demand there. If needed, more land can be reclaimed in the North as well.

Changi Express Line To support and foster transportation and exchange within the Changi Region, a new MRT ring line will be built connecting all three areas above as shown in Figure 13. Its name is Changi Express Line (CEL) and it will be built in several phases until 2040. The ring line supports the creation of a center in the Changi region by shortening travel times within the region and reducing the frequency

of transfers for the passengers. The line will reduce travel times between Changi region's new employment centers and residential areas by 40% - 80%. The line layout is mainly according to LTA's planned development of the MRT Line extensions, so costs are expected not to substantially increase.

Reserve sites for further expansion of the airport-related businesses beyond 2040, we designated areas around the airport area that can be transformed when required.

Package of measures for Changi's economy

To support the economic development, a package of seven measures has been identified: foundation of a central contact organization, promotion of company foundations, recruiting of workers, fostering innovation, location marketing, promoting clustering and its monitoring. To show how the measure may take place in the Changi region, an introduction to the first measure is given.

Central contact organ „Changi ThinkTank

“To coordinate economic development as described in the Development Concept Changi 2040, we propose to a central

contact organization called „Changi ThinkTank“, located in „The Brain“. This will be created as an institution under the „Economic Development Board“ (EDB). Its organization chart is shown in Figure 14 and discussed below:

Portfolio servicing, settlement and foundation of businesses: This division is in a steady contact with local firms in Changi and knows about their future development plans. Further, it helps to allocate and found new companies in Changi.

Coordination between firms, state and research: The main task is to connect industry, research and government. Apart from the coordination and communication between these actors, this division also maintains an associated online

platform. There, companies can publish their ideas or problems that researchers, students or companies can work on.

Marketing: This division has to make the Changi region nationally and internationally known. For example, by marketing or branding as well as connecting with potential companies for Changi. The latter will be done by hosting events and receptions for exchange between interested companies and already established companies and the research institutions.

Administration: The administration division takes care of the finances of the Changi ThinkTank. It will also help in possible legal questions and offer legal assistance (especially for small and one-man companies and start-ups).

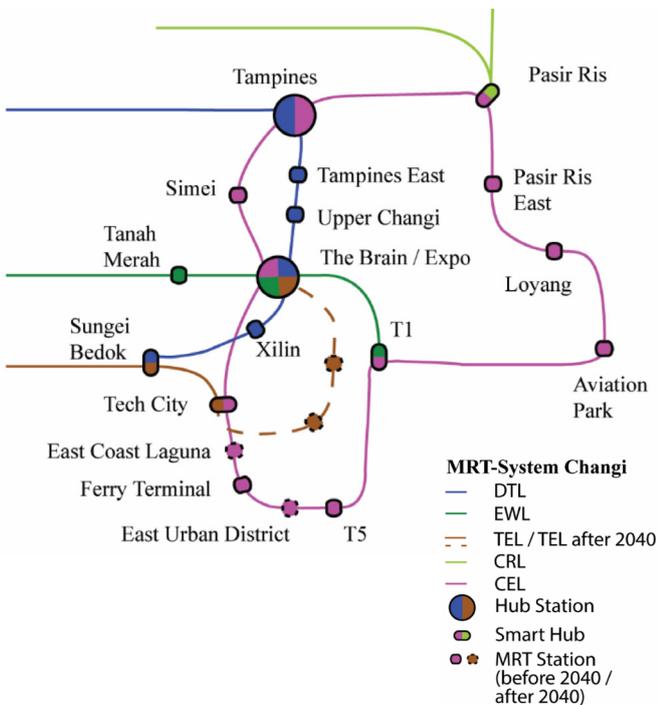


Figure 13: New MRT system for the Changi region.

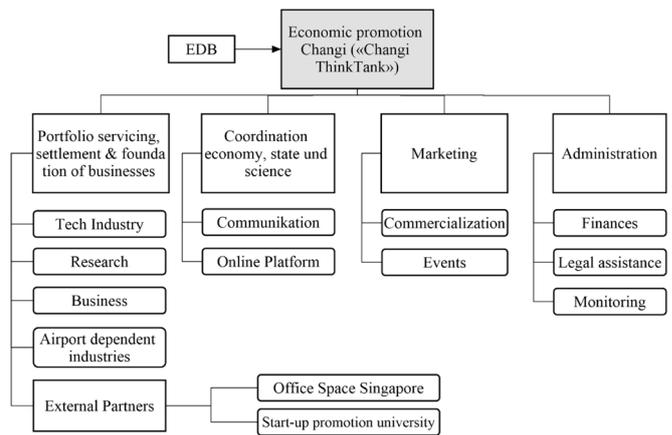


Figure 14: Organization chart of Changi ThinkTank

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