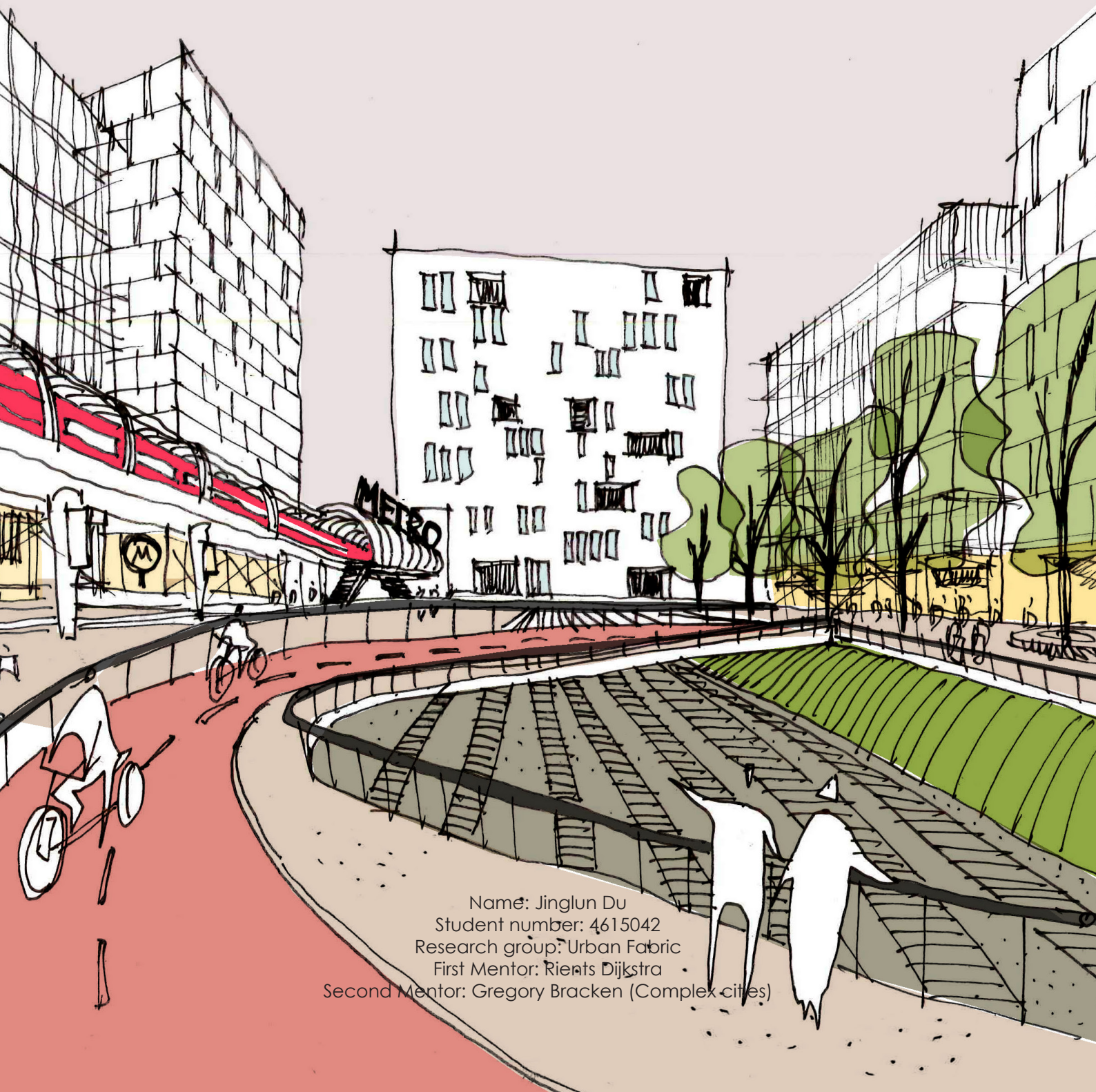
From isolated to integrated

The research on improvement of connectivity in Railway Station Area (RSA) in Chinese high-density city centers by applying Dutch experience to Shanghai Station area



Name: Jinglun Du
Student number: 4615042
Research group: Urban Fabric
First Mentor: Rients Dijkstra
Second Mentor: Gregory Bracken (Complex cities)

From isolated to integrated

The research on improvement of connectivity in Railway Station Area (RSA)
in Chinese high-density city centers by applying Dutch experience to Shanghai Station area

COLOPHON

P5 REPORT
From isolated to integrated
The research on improvement of connectivity in Railway Station Area (RSA) in Chinese high-density city centers by applying Dutch experience to Shanghai Station area

Jinglun Du
Student Number: 4615042

RESEARCH GROUP: Urban Fabric
Department of Urbanism
Faculty of Architecture
Delft University of Technology

MENTOR TEAM:
Rients Dijkstra
Gregory Bracken

July, 2018

Preface

This report is the final result of the graduation thesis led by Urban Fabrics research group, which is part of the department of Urbanism at the faculty of Architecture in TU Delft. My research topic focuses on the barrier effect caused by the existence of railway station areas and the possibility of applying the Dutch approaches to China, in terms of improving the connectivity in this specific area. The city of Rotterdam and Shanghai will be used as the study cases.

Thanks to an internship experience in the Netherlands, I was luckily involved in the redevelopment proposal of Leiden central station. A large amount of case study and design thinking inspired me to investigate the connectivity issue in railway station areas. I realize it is significant and eager to know how the railway station areas exactly cause the barrier effect. What are the current solutions and approaches can be summarized? Does the Dutch experience also suitable for China? These questions motivated me to choose this topic for studying in my graduation year.

Jinglun Du
July 2018

Acknowledgements

Here, I would like to thank my two mentors, Rients Dijkstra and Gregory Bracken, for all the time they spent on my project. I appreciate their knowledge, support, and critical inspirations which pushed me and also encouraged to pursue a higher level. I am so lucky to have the combination of these two great mentors and have enjoyed working with them.

In terms of Rients, He is a passionate designer for sure. Once you start discussing design with him, he will accelerate to the full speed in 2 seconds like a Maserati. He encouraged me that a designer's career may be mature at his age of 50. So there is still a long way to go. Never stop thinking and designing. He definitely sets a role model for my professional life.

As for Greg, I admire him as my spiritual mentor, he affirmed my thinking many times in my self-doubt, and gave me the greatest freedom, encouraging me to believe in my professional judgment. This kind of help plays the same important role as a specific advice, because as an urban designer, whether you can confidently express and sell your ideas is an extremely valuable skill.

Furthermore, I would like to thank my boss, Ronald Knapper from VVKH, who offered me the internship job inspired this research. My lovely fellow students, my roommate, Matias Iversson Piazza, and my family for all the support during the last years.

Jinglun Du
July 2018

From isloted to integrated- the research on connectivity of railway station area

Contents

Fig.1 Taking a Dutch city, Leiden, as an example, the railway station area breaks in the middle part between the old city center and new developed area, causing several social problems: Traffic congestion, uncomfortable Pedestrian experience, and discontinuous urbanscape. These problems further restrict the development of this area.

Thesis abstract

The relationship between the city and railway development is fascinating. In Europe, railway stations were originally placed at urban periphery. Step by step, as the urban dense core area expands outwards, the railway station areas were pulled in and now absorbed by the urban fabric. Because of large-scale and special facility form, Railway surrounding Area (RSA) always acts as a boundary breaking urban in pieces. The physical fragment and even social segregation lead to compromises in both urban operations and quality of urban environment. (Fig.1)

At the same time, ongoing trends of train station area redevelopment and ambition of tripling the current network (White Paper of Transport, EU) further exacerbate the seriousness of this problem. It is time to rethink our city's relationship with the Railway Surrounding Area (RSA). Can we solve those existing problems? Can we attach new meanings to a station and its facilities? Can we improve the pedestrian-friendly and livability around RSA for meeting the request for redevelopment? **The Netherlands** offers a valuable model- Since 1998, 6 major railway stations have started to be redeveloped. These projects which not only the stations are transformed, but also their connecting surroundings. A railway station and its surrounding were seen as one entirety to be designed.

Whereas in China, The rapid development of high-speed railway is not only facing the request of technological updates and urban development in the city center, also are acting as a driving force to promote the new town growth in the rural area. In last 30 years, more than 800 stations were built up, new or upgraded. Even though China is the biggest railway construction site right now. But due to this very early stage of HSR and urban development in China, the impact is still blurred.

The methods I adopted in this research is that by clarifying the multiple barrier elements and collecting the current design patterns, I can build up an interpret that how Dutch projects perceive and design connectivity issue in RSA. Then, based on the different context, the application of Dutch experience to China could be explored.

The results obtained in this research include Barrier Elements Clarifying, Dutch experience summary and Application Design in Shanghai Station area. Hopefully, this research could contribute to solving the current physical fragment and social segregation problems around railway surrounding area, and also offer new thinkings for railway area redevelopment, both theoretically and practically.

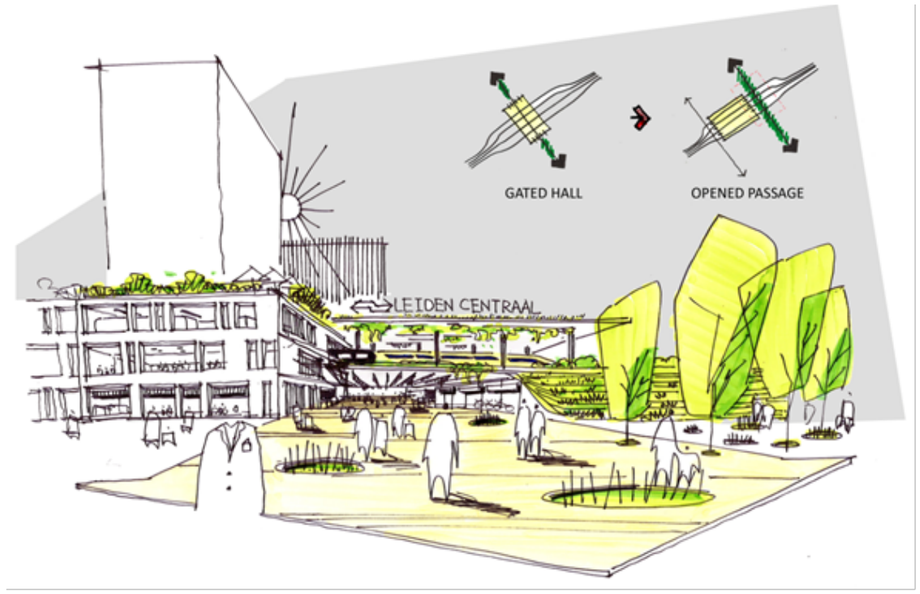
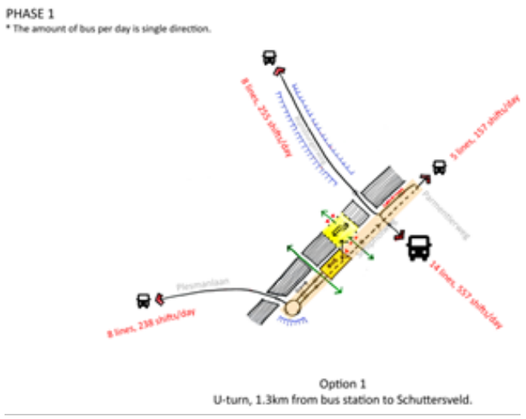
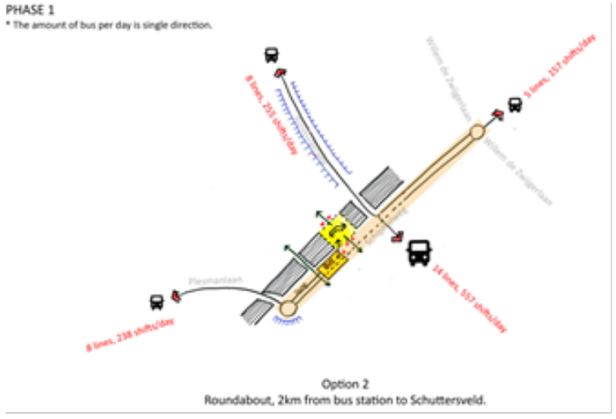


Fig.2 Station hall will become the most important corridor connecting the old and new Leiden.

Fig.3 Leiden central station project, reorganizing the network and flows.





1.1 Motivation for the study

This study mainly inspired by my internship project, Leiden Central station redevelopment (Fig.2&3). In that design process, the main aim was to strengthen the connection between two sides, the historic city center in its south and Leiden Bio-Science district in its north. For achieving this, I studied the bus lines, taxi parking lot area, pedestrian behaviors and bicycle routes passing through station area, hoping by reorganizing the traffic flows to improve the walkability and accessibility in that area. Station building topology and environmental quality are both under design consideration. All the efforts I did make me realize how much the station and its facilities, mainly the rail track, will influence the urban operation and environmental quality. Based on this first thinking, I built up my potential topic-How to cross this barrier, or even remove the barrier to create a 'barrierless' railway surrounding area.

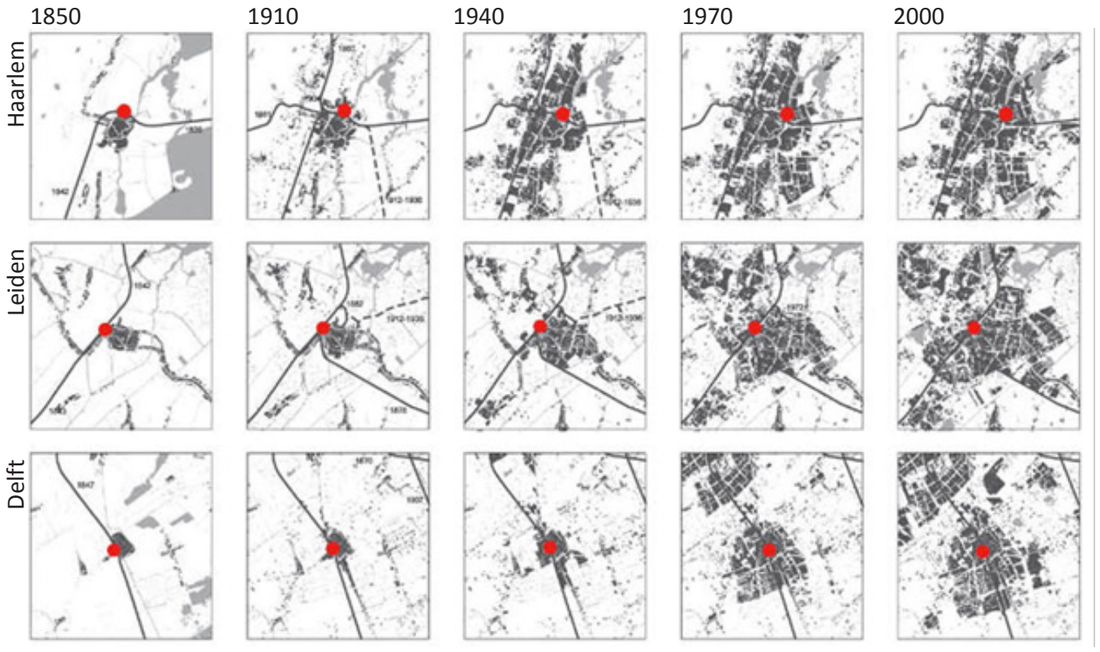


Fig.4 Three Dutch cases show how were railway stations and tracks absorbed into city center.

1.2 Context analysis

The context analysis first tries to explain that in the past, how did the train station and its facility turn into a barrier for a city. This will be achieved by a series of mapping. As the city's dense core area expands outwards, the train stations which originally intended for urban periphery were absorbed in. The outsiders became insiders. The image above shows three Dutch cases which could support this statement. (Fig.4)

The dilemma of railway stations exists through their history. With their appearance in the urban environment since the nineteenth century, trains brought both the stations and the tracks. Prosperous shops showed up in front of the stations, while rail yards, industry, and cheap housing found space on the back side of the tracks. These two types developed separately, the former is in the front and the later is behind the tracks. For decades, and even until nowadays, stations are still struggling in the middle of this divided environment. So how to cross this barrier is the core focus both in the academic field and practical project.

2.1 Why does the connectivity of railway surrounding area in city center need to be improved?

-Existing problems along the railway

As huge interventions into the urban environment, the railway stations and their relating facilities greatly changed the scape of surrounding neighborhoods. This research focuses on those negative influences, namely poor livability, less prosperity, traffic congestion, the security issue, environmental pollutions, different urbanization and social segregation, etc.

-High expectation about a city center

Currently, we have more and more expectation for railway surrounding area, especially the ones located in the city center, since a larger number of passengers will reach cities by high-speed trains. This will bring spending power into the station areas. (Bertolini, 1996; 1998; Bertolini & Spit, 1998; Serlie, 1998; Zweedijk & Serlie, 1998)
Thus, railway stations are becoming the city centers that further integrate our transportation with our social lives. People are increasingly perceiving stations as centers for leisure and business, not only as places to departure or arrival. In order to generate urban quality around the station area, the stations need to be integrated into the urban gird physically - especially the local-scale networks. Since the regional accessibility of the stations is not capable to support commercial prosperity in their surrounding, only if a station is well integrated into its local urban configuration, the livability will appear by itself and also guarantee its commercial sustainability. (Railway station, centers and markets-Change and Stability in Patterns of Urban Centrality)

-Better Mobility Request

Thanks to modern transport and telecommunication technologies, the interaction of human activities can be free from limitation of physical distance step by step. But public transportation nodes and their vicinity are one of the very few places in nowadays' cities where the participants still need physically meet (Bertolini, 1996) since social and economic activities require physical proximity in these specific areas.
The city is an increasingly open system, and high physical mobility is one of the structural features. People live in a certain place, and work in a second and spends their leisure time in the third. All these new movements of urban consumption need better mobility to support.

-Densification Request

About 25% to 30% people express their willingness to live in a metropolitan region, where closely link to transportation facilities, or even right locate central place (Spaans et al., 2004). This preference enhances the competitiveness of station area as a living environment. (Govers et al., 1999; Bontje, 2003; Van den Burg & Dieleman, 2004). And local connectivity is one of the most important criteria for assessing living quality.

1.2.1 How to interpret that railway surrounding area acts as a barrier?

Physical fragmentation+Social segregation

Renaissance of city center area

-By reviews of existing perspectives the conclusion, railway area is intended to guarantee the connectivity of regional scale, at the expense of integration with the urban grid, could be clearly drawn.

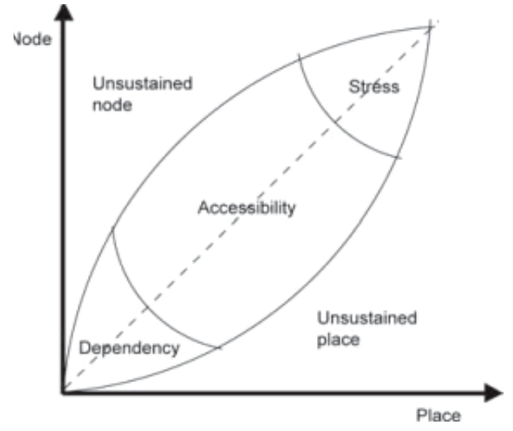
-Large-scale railway facility may destroy the livability and prosperity based on small block pattern

--Changes in network density cause traffic congestion, and mixed-use by pedestrian and vehicle.

-Unregulated Brownfield land raises the security issues

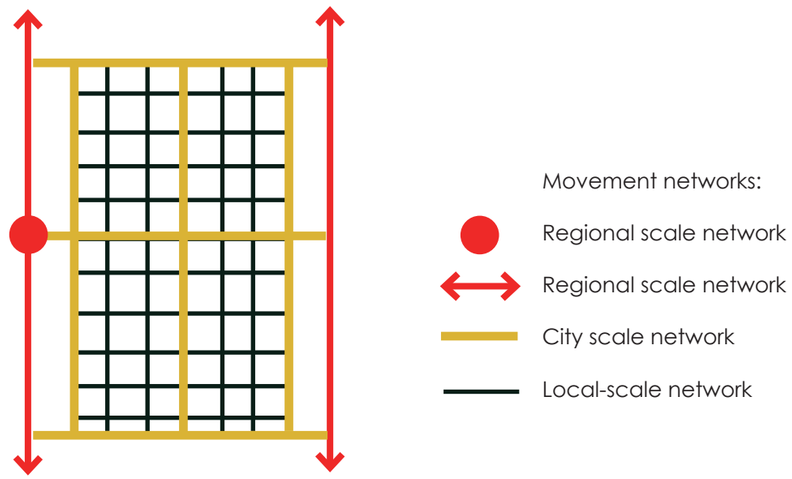
-Noise/Particles/Vibration/Visual pollution influences environmental quality

Urbanization(population density, Income per neighborhood and property value) on two sides develop at a different pace.



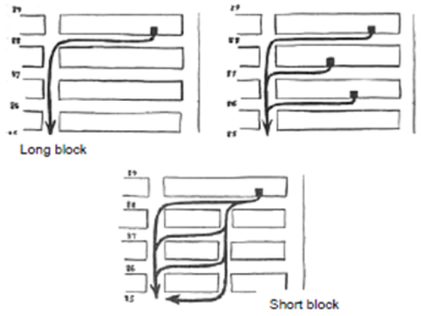
a. Node & Place, Luca Bertolini

Station areas are both 'nodes' and 'places': nodes of the network, and places in the city.
'Node and place' could be regarded as the most important theory in railway area research. After clarifying this dual-attribute nature of railway area, the barrier effect could be explained, as a node of mobility network, railway area paid more attention to transportation functions, at the expense of its 'place' identity. (Beritolini, 2007). (Fig.5)

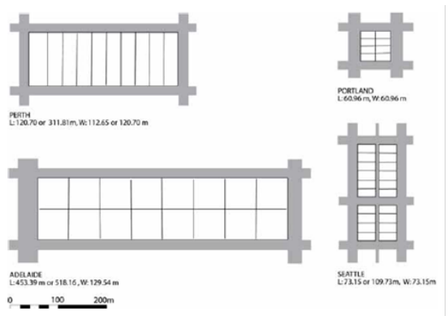


b. Scale & Layer, Spatial Configuration

Station areas clearly offer opportunities to reinforce urban dynamics within the urban fabric (Frank Bruinsma, 2007). Layer theory from spatial configuration field also offered the similar understanding. Railway area, as the connectivity for the regional layer, negatively influences the local layer (Fig.6)



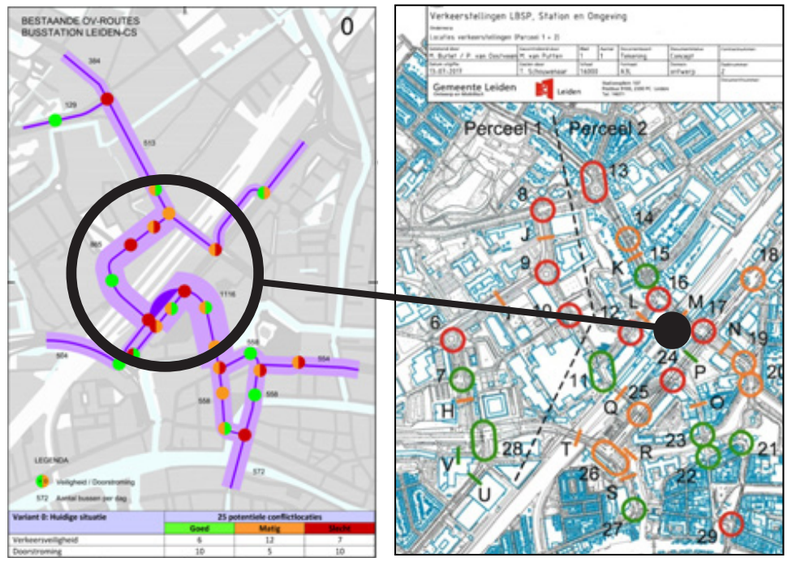
Sketch from Jacobs,1961
the long and short blocks



Sketch from Siksna,1998
Size of the original blocks

-Large-scale railway facility may destroy the livability and prosperity based on small block pattern.

Block scale was discussed by many scholars for explaining its relation to urban vitality and economic prosperity (Jabos, Siknas). Ideally, the 50-60 meters long block will benefit urban cohesion, perform better than larger blocks because they produce finer-mesh circulation patterns, more potential frontages, more coherent block fabrics and finer-grained, continuous urban fabrics and both low and high-rise buildings. But a normal railway station needs at least 400 meters distance for organizing trains. (Fig.7)



-Changes in network density cause traffic congestion, and mixed-use by pedestrian and vehicle.

Due to the cost consideration, only a few roads are allowed to cross the railway (viaduct or tunnel). this change in network density causes traffic congestion, and mixed-use by pedestrian and vehicle. The image above shows the traffic condition in Leiden Central Station area. Red nodes represent the traffic congestion and mix-use by pedestrians and vehicles. (Fig.8)

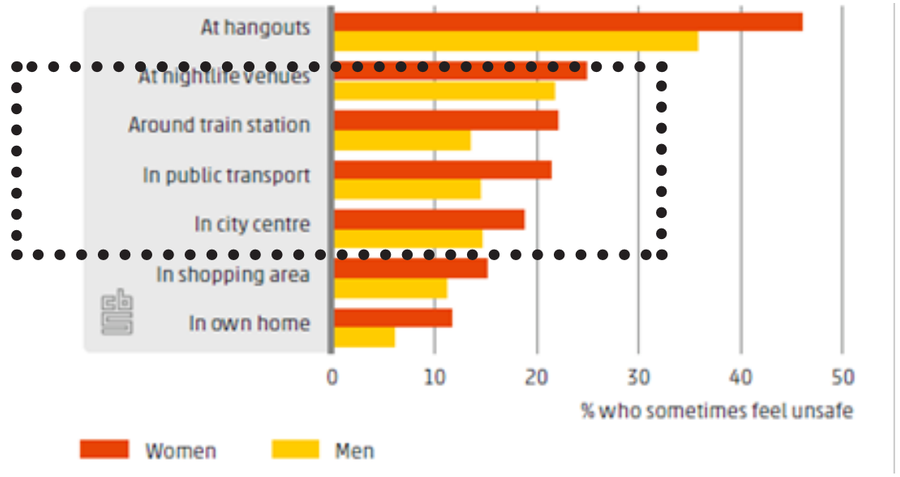


Fig.10 Perception of unsafety in the municipality of residence,2015
Source: Trends in the Netherlands 2016, Statistics Netherlands.

-Unregulated Brownfield land raises the security issues.

According to Trends in Netherlands 2016 (Statistics Netherlands, 2015) and a survey by Dutch Railway Company (NS, 1996), the most negative experienced place in railway areas is bridges and tunnels which cross the rail track area. Those areas easily cause the sense of insecurity, mainly for pedestrians.(Fig.10)

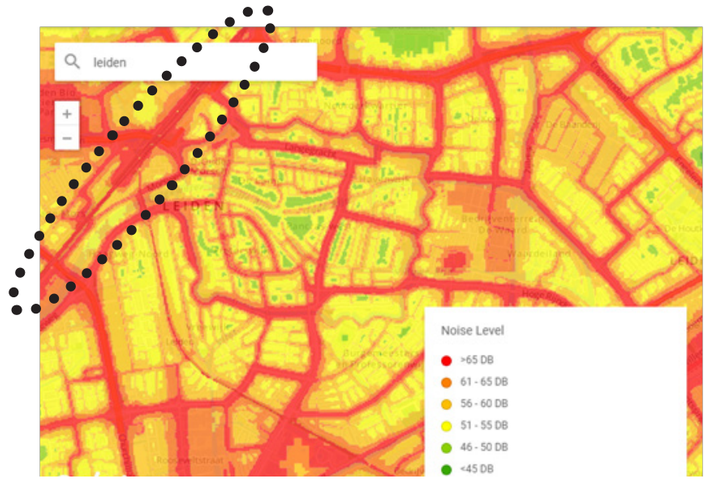


Fig.11 Noise Pollution in Leiden, published by RIVM (last update: 2016-01-05)

-Noise/Particles/Vibration/Visual pollution
influences environmental quality.

The tracks not only bring travelers and goods but also some negative effects, namely that, the noise issue, particles pollution, vibration issues and visual influence. All these effects influence the living quality around railway area. (Fig.11)

1.2.2 Why is Dutch experience valuable to China?

The 2007 Green Paper on Urban Mobility asserts that 'Towns and cities are all different, but they face similar challenges and are trying to find common solutions' (CEC, 2007: 1).

Randstad

Population: 7,100,000
Area: 8,287 km^2
Urban density: 1,500/km^2

First, the development of railway system in the Netherlands will be briefly introduced. The first rail track was built in 1839, linking Haarlem to Amsterdam. The Dutch government took the lead to construct a national railway network since the 1860s, which was completed in 1880 at the end. An increased growth of the city was booming in the 20th century. Since then, the railway networks started to superimpose on the urban fabric.

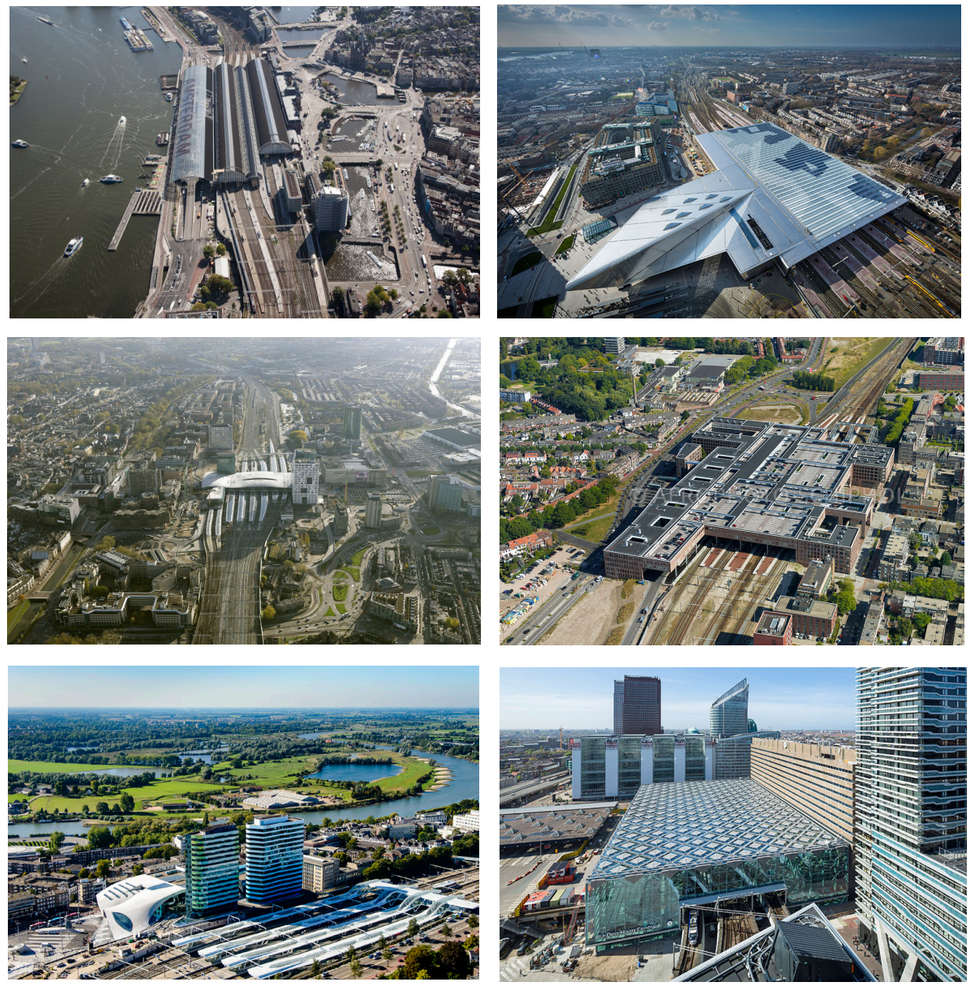
This development is also powered by the Dutch national spatial policy. For example, the Report on Physical Planning/Extra (Ministry of Housing, Physical Planning and Environment, 1991&2001) emphasizes the significance of the compact city, promotion of public transport networks. This suggests that station areas, as the most important mobility node, are increasingly perceived as a district with social function more than only with transport function.

Another factor which has promoted the development is the rapid growth of the European High-Speed Train (HST) network. Europe aims to triple the existing network by 2030(White paper of transport, EU). Increasing numbers of countries, such as the Netherlands, are connected with this international network. Meanwhile, as the nodes within network, railway station area attracts attention. Dutch rail station areas have had an intensive makeover. Six central stations – Utrecht, The Hague, Rotterdam, Arnhem, Breda and Amsterdam South – are called the New Key Projects since 1997. Currently, one after the other station has built up, defining themselves as 'city districts' in the center area. (Fig.12&13)

These train stations are also called 'cathedrals of a new era': traffic terminals that provide travelers and inhabitants with various commercial activities. The most powerful driving force behind this phenomenon is that privatized stations are looking for commercial exploitation. Profit-oriented development needs better connectivity to support.

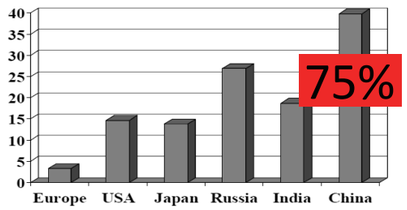
The New Key Projects

Fi.g 12 Amsterdam Centraal, Rotterdam, Utrecht, Breda, Arnhem, The Hague



Exploration of Connectivity Improvement

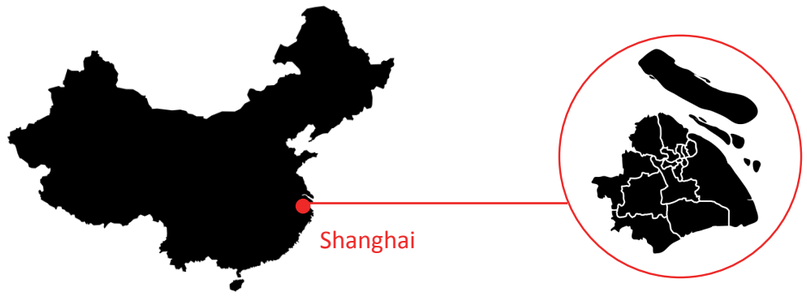
Fig.13 Amsterdam Centraal Station Tunnel, Utrecht Footbridge, Rotterdam Footbridge



2017 Traffic units/rounte-Km(mills), the World Bank

Shanghai

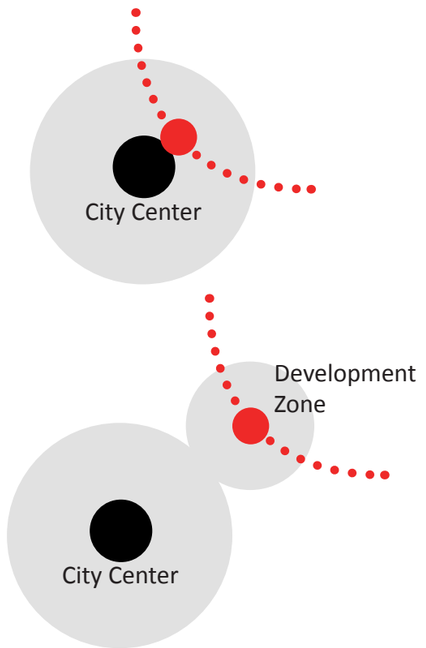
Population: 24,197,000
Area: 6,340.5 km²
Urban density: 3,775/km²



It is the busiest/biggest railway in the world

Whereas in China, after 30 years rapid and extensive development, many Chinese cities are facing the challenges of so-called ''urban disease'', namely urban sprawl, poor environmental quality and traffic congestion, especially for the megacities like Beijing, Shanghai, and Shenzhen. In order to overcome them through spatial transformation, many practices have been promoted such as adopting a polycentric urban structure, developing smart new towns, and encouraging the deployment of public transport. Hence, the interrelationships between railway system and spatial structure of city are considered as a critical factor in this transformation of cities. The rapid development of high-speed railway is not only acting as a driving force to promote the new town growth in the rural area, also are facing the request of technological updates and urban development in the city center.

So the development of the HSR railway stations areas has become a popular topic and also important growth in China. Even though China is the biggest railway construction site (in last 30 years, more than 800 stations were built up, new or upgraded). Considering the history of HSR in China is too short to summarize some rigorous conclusions. The impact is still blurred. So we need to look for the evidence of the actual impacts have happened, which is western Europe, since they started earlier from the 19th century, and then translating potential valuable design toolbox into a Chinese one, based on the unique Chinese context. Although the construction of HSR in China shares the common elements with Western Europe, the unique magnitude and pace of urbanization, present some differences which cannot be ignored. Thus, we must consider the performance of railway area redevelopment abroad before discussing the Chinese context.



In the Netherlands, the redevelopment of railway station area is seen as an opportunity to strengthen local economies of city center; for the improvement of the image of the inner-city; further for urban and social restructuring.

In China, the newly built-up railway station is placed in the suburb area, being expected to act as a driving force to motivate the new development. It means in the near future, those empty surrounding will be filled with urban fabric. So the dilemmas Europe facing now is the problems China will have in the future.

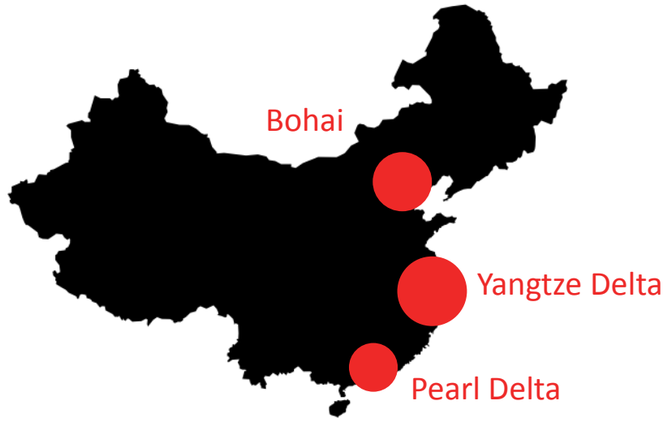
Fig.14 The different purposes of redeveloping railway area in the Netherlands and in China

After the Netherlands has completed the regional railway network in1880, the nation started to redevelop the major stations. Projects where not only the station building has been transformed, but also its vicinity. This integrated design creates the connectivity and vitality of the city. The station is reorganized as a part of urban fabric with logical walk paths, linking different city districts.

As the Netherlands is ahead in the process of urbanization and rail development, Dutch experience will be valuable to China(Fig.14). So the connectivity issue Europe facing now is also the dilemma that China is dealing with, which is even more challenging, since the larger passenger amount. How to apply the western lessons and also worldwide experience to China? The research by design, taking Shanghai station area as the example, would help to answer this question.

1.2.3 Why choose Shanghai station as the test object?

Four vertical & four horizontal corridors



Three MLTDP regional intercity systems

The Government approved the Mid and Long-Term Development Plan (MLTDP) in 2004

A. REGIONAL KEY NODE BOTH ON TWO NETWORKS

In 2004, the national railway department published the Mid and Loing-Term development plan of Chinese railway network. In both structures, Shanghai Railway Station plays significant roles. In four vertical and four horizontal corridors plan, Shanghai Station bears the transfer role of connecting North and South. In the intercity system, Yangtze Delta area, it links the city to its surrounding cities cluster with 20 million inhabitants, about an hour train ride or less.

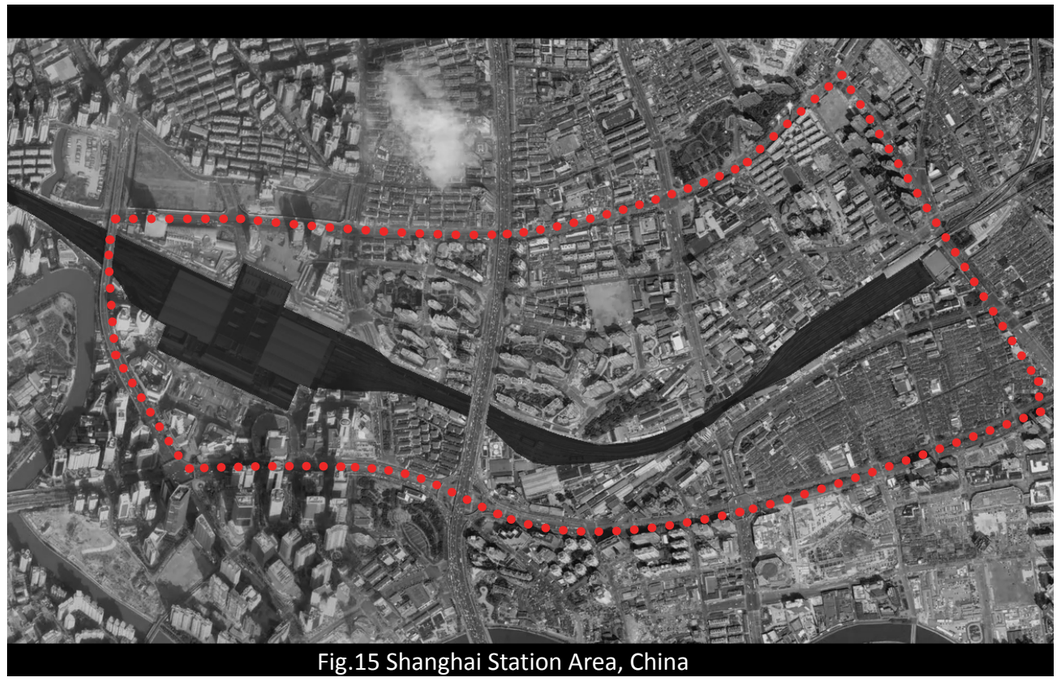


Fig.15 Shanghai Station Area, China

B. REPRESENTING CASE OF HOW DOES THE RAILWAY RESTRICT REGIONAL DEVELOPMENT.

"There is an obvious gap of development level between the South Square and the North Square in Shanghai Station Area."
Shanghai Station is located in the central part of Shanghai, which is also one of the most important railway stations in Shanghai Metropolitan Area. At the same time, this area owns three subway lines crossing, line1,3,4. This transfer station node will also connect to Shanghai Hongqiao high-speed rail station and airport in future. From the mobility aspect, the development potential here is huge. But the railway scheduling buildings, machine repair plants and the existing 18 rail tracks, acting together as a barrier, divides the surrounding into two areas, leading the traffic between north and south is not smooth. The unbalanced development on both sides could be clearly noticed.

C. THE OPPORTUNITY OFFERED BY THE NEW POLICY

The idea of redeveloping Shanghai Station area has started more than 10 years ago, but has not been further implemented, "Mainly because this area belongs to the railway system, while urban development is driven by the local government, the coordination between these two parties is not that easy." In August 2014, ***the General Office of the State Council*** issued the opinions on supporting the Comprehensive Development of Land in Railway Construction, and made it clear that "Support the revitalization of existing railway land to promote local development" and "Encourage the improvement of intensive use of railway land, Development of underground space, Compatible with a certain percentage of other functions" and a series of specific policies to the railway station in Shanghai has brought new opportunities to this area.

Fig.17 Shanghai Station Area, China

1.3 Problem statement

Due to large-scale and special facility form, Railway surrounding Area (RSA) including station always acts as a barrier, breaking city in pieces. As the result, urban operation issue and environment quality issue cause the physical fragmentation and social segregation. Railway acts as a barrier seems like an obvious conclusion, but what exactly do physical fragment and social segregation mean? How to further interpret the barrier effect of railway surrounding area? Discussing those questions becomes more and more valuable in the context of nowadays since High-speed train and city center are highly expected both from economic development and social improvement views. So how to improve the connectivity in Railway surrounding Area in Chinese city center by applying Dutch design experience is the main research question. Clarifying the multiple barrier elements and summarizing Dutch experience are the two main research bodies. Further, how to translate it into a Chinese design approach and how to apply it in China will be also addressed. Shanghai station area is chosen as a potential test subject since its surrounding condition is diverse and complex. (Fig.16&17)

A further definition: Railway surrounding area in city center including the railway station (within a radius of 1 kilometer from railway station)

1.3.1 Problem field

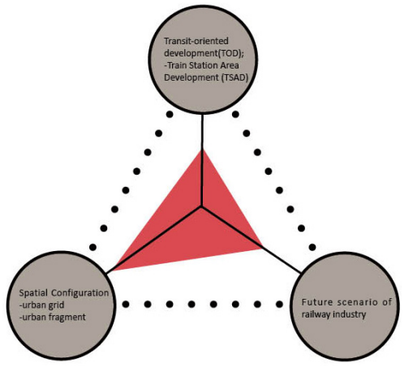


Fig.16 The research field this research will focus on.

The study of redevelopment in railway surrounding area will be well understood by an integrated insight including several disciplines; economics, urban planning, and spatial sciences, which might be the most relevant discipline: (Fig.16)

Transit-oriented development; Train Station Area Development (TSAD);
Connectivity between RSA and urban surrounding reflects how do we interpret railway? The theoretical review could help me to understand how does current research perceive this topic. The possible result is the turning attitude from shielding railway to embracing railway to cities.

Spatial configuration ;
Four main theories: urban grid + spatial fragment + Node & place + Scale & Layer
Possible result: Naturally, the RSA couldn't integrate into the local network.

1.3.2 Societal and scientific relevance of the study

The revitalization of railway station areas has been under the spotlight recently. The introduction of the high-speed train system has promoted the reinvention of not only railway stations themselves, but also their surrounding neighborhood.

But most of the previous studies are focusing on abstract planning level, like the concepts of ‘mix-function’, ‘density’, and ‘regional accessibility,’ or design guidelines for TOD. The spatial issue on how to arrange these functions and how the spatial layout accommodates urban network is not well explored (Camelia KUSUMO,2007). The redevelopment of railway station areas will be well understood by an integrated insight crossing disciplines; economics, urban planning and spatial configuration. This study of Railway area will be hoped to deal with the increased interaction between infrastructure and urban fabric, and also to boost the local economy by creating a high quality multifunctional urban place.

By this, the scope of the research needs to extend from a Dutch to a European perspective. Examples of railway station area redevelopment can be found throughout the world, in European countries like France, Germany, the Netherlands, and also in Asia, like China and Japan. Through this comparative study, I will summarize the existing experience of railway station area redevelopment, but also try to explore how to apply this Dutch lesson to China, benefiting both practically and academically.

Fig.18 Diverse topologies around Shanghai Station Area
request the connectivity differently.

1.3.3 Research aims

This research tries to tackle the urban operation and environmental quality in railway surrounding area, specifically the spatial connectivity issue. Based on the reviews of existing theories and overview of railway station redevelopment projects in the Netherlands, I would like to rethink the relationship between the railway and urban surrounding.

After clarifying the barrier elements both from physical side and social side, and critical reviews of existing projects/ designs in the Netherlands, a Dutch design toolbox for improving connectivity in railway surrounding area will be built up.

Due to the unique context of China, like more rapid development speed and bigger passenger amount, how to translate this Dutch design approach into Chinese one? Taking a specific case as an application design to test will be helpful for checking its practical value. Hopefully, this study will benefit Chinese railway surrounding area evolution, further help to think about city center redevelopment, both practically and academically.

1.4 Research questions and possible methods

How to improve the connectivity in Railway Surrounding Area (RSA) in Chinese city center by applying Dutch design toolbox? Taking Shanghai station as an example.

Q1: What is the relationship between TOD and city?
M1: Many researchers contributed their critical thinking about Transit-oriented development. Based on the literature views, hopefully, I could clarify and elaborate the existing perspectives on this topic, since my research will add to TOD research field.

Q2: How to define connectivity in RSA?
M2: The second sub-research question requires a literature review on spatial configuration. Specifically, the literature review of urban gird and spatial fragment can provide the current perspective about how we can analyze this barrier. Depth Map and urban grid which are based on the idea of spatial configuration theory will contribute to this part. (Hillier 1993)
-Urban Grid is a theory of route type suitable for a neighborhood scale, which can also be used to value the integration continuity and connectivity of the network.
-Depth map is a software platform to perform spatial network analysis for better understanding social processes within the built environment.

Q3: What are the barrier components that contribute to connectivity in RSA?
M3: In order to clarify the barrier elements, several methods should be used. Based on observation and study, comparative cases study of train station areas, which will be marked with a series of barrier elements, will be studied. In the end, this comparison of a series of maps will help me to build up an understanding of the barrier components which will contribute to connectivity in Railway Station Area(Fig.19).
Specifically, on this research stage, nine Dutch projects will be studied, and each one represents a specific component. Their existing problems and proposed solutions, from urban level to building level, will be analyzed. Interviews with locals will be employed.

Q4: What is the current design pattern tackling the connectivity issue?
M4: This sub-research question requires a critical review of existing projects and also current designs, mainly from Dutch context. Meetings with the designers will be necessary. These cases will be visited and subjected to morphological, infrastructural, social and economic analysis. Hopefully, the results from these analyses together with information from interviews will offer the material for summarizing the Dutch experience.

Q5: How to apply this Dutch experience to China? Taking Shanghai Station as the example.
M5: First, the translation from Dutch experience into a Chinese one will be important before application in China. Then, research by design will be adopted at this part, taking Shanghai Station Area as an example.

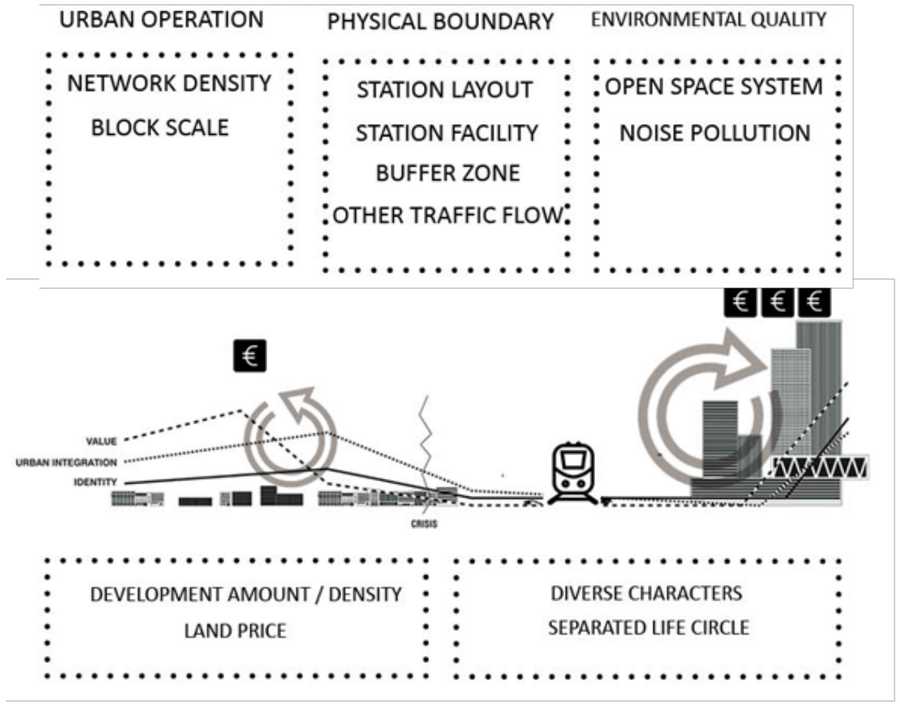


Fig.19 Possible Barrier Components

1. Railway facilities
2. Station layout
3. Pollutions
4. Block scale
5. Network density
6. Other traffic flows
7. Social and economic imbalance

1.5 Theoretical framework

*The full version is attached in appendix.

Title:
Interpretation of how railway areas promote barrier effect in high-density city center

Abstract
This paper tries to investigate how railway areas promote physical and social barrier effect in the high-density city center, by reinterpreting related spatial configuration theories. In Europe, railway stations were historically placed outside the city. As the city expanded, these transportation infrastructures were gradually pulled in and absorbed by the urban fabric, becoming a part of the expanded city center. However, due to their spatial features, railway areas usually act as the physical barrier, leading to the division of urban surroundings. Broken urban operation and downgraded environmental quality further promote urban fragment and even social segregation, restricting the renaissance of city centers.

How to overcome the spatial limitations and how to cooperate with railway station areas in the high-density city center have become heated topics of discussion in city redevelopment, this research anticipates that Interpreting how does this barrier effect come into existence will be a helpful premise of attempting to solve this problem.

By reviews of existing perspectives of connectivity, mainly from spatial configuration field, the idea that railway areas are intended to guarantee connectivity in the regional scale, at the expense of integration with the urban grid, could be clearly identified. Based on the understanding of the theories, the specific barrier components will be clarified from physical aspect to social-economic aspect, and a total of six elements in three categories could be summed up, which work together to form the barrier effect. Topics such as agglomeration of railway facilities, pollution coming from tracks, block scale, network grid and unbalanced development paces on both sides will be investigated. Through clarification of these barrier components, the corresponding solutions can be found purposefully, providing theoretical support for specific design.

Keywords:
Railway Station Area, Spatial Configuration, Barrier Components, Connectivity

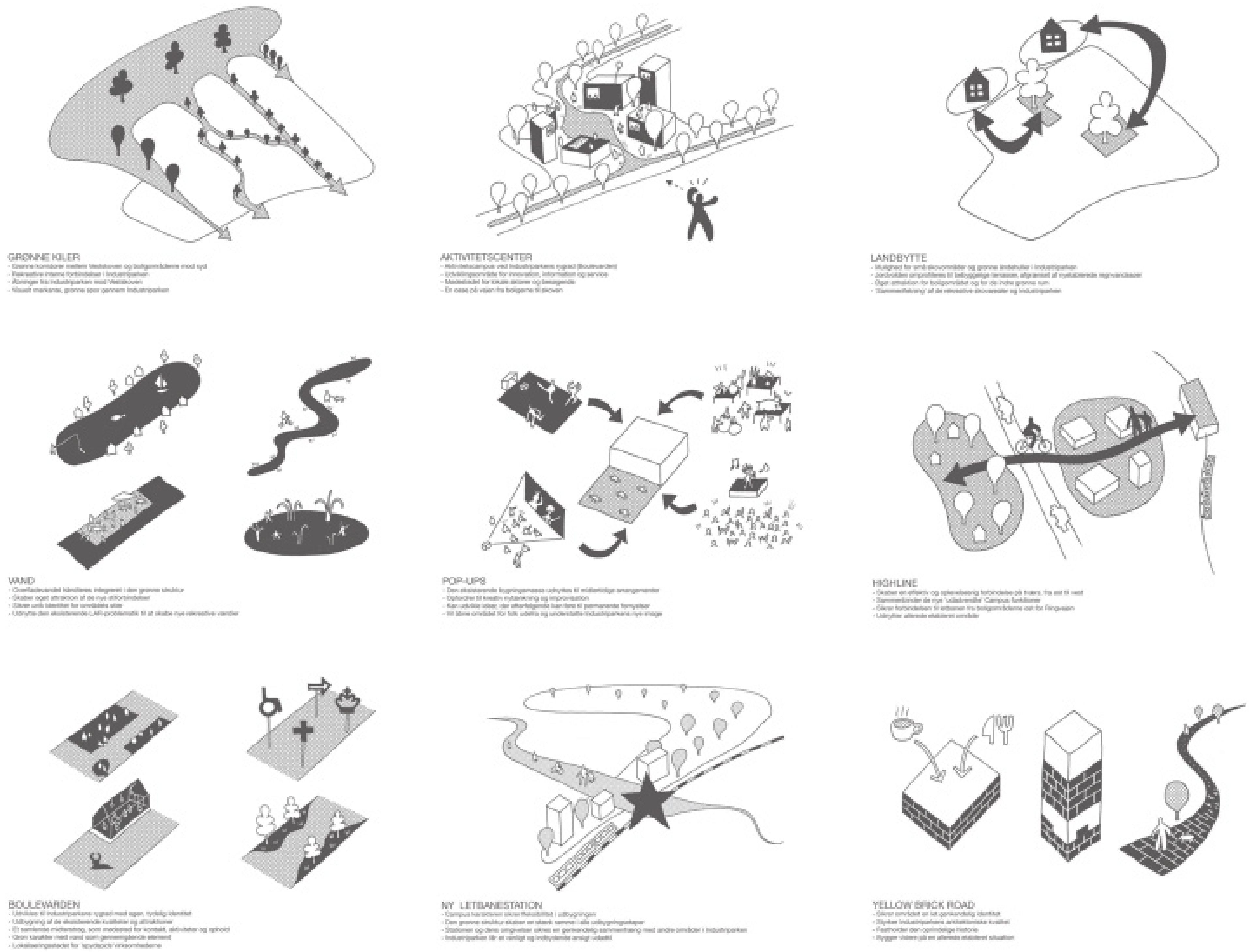
2

To what extent, and how, does the concept of connectivity play a role in railway station area redevelopment?

Dutch Experience

Theoretical study (Analyzing method)
-Node &place
-Butterfly Model
-Space Syntax
(Taking Rotterdam as an example)

Case study (Design tools)
-Functional, Visual, Spatial and Economic.



Example: design strategy for transforming a hersted industrial park by MAXWAN
Source: http://maxwan.nl/projects/hersted_industrial_parl/

2.1 The background of Dutch Urban Design Approach

'Dijkstra has a firm belief in 'the Dutch approach' to urban development. He believes that this involves: a sound prior analysis of the problem followed by straightforward collaboration, without any complex hierarchy. It's an approach that he learned from one of his guiding lights, Riek Bakker. He met her during one of the first and largest Dutch projects undertaken by his agency Maxwan Architects and Urbanists: designing the master plan for the new Leidsche Rijn residential estate in Utrecht. A main principle underpinning the project was that the designers listened to what all the parties involved had to say and shed light on all aspects of the design specification, before final decisions were made.'

Quoted from the introduction of Rients Dijkstra on TU Delft website
https://www.tudelft.nl/en/2015/bk/full-professor-rients-dijkstra-champion-of-the-dutch-approach-to-urban-development/

Working atmosphere

Freedom of speech (No authority)

Good start for research

Way of working

Always look for 'INTEGRATION' and 'BALANCE'
As the conductor, urbanist needs to Cooperate with different disciplines.

Visualization

Communication

Options/Alter

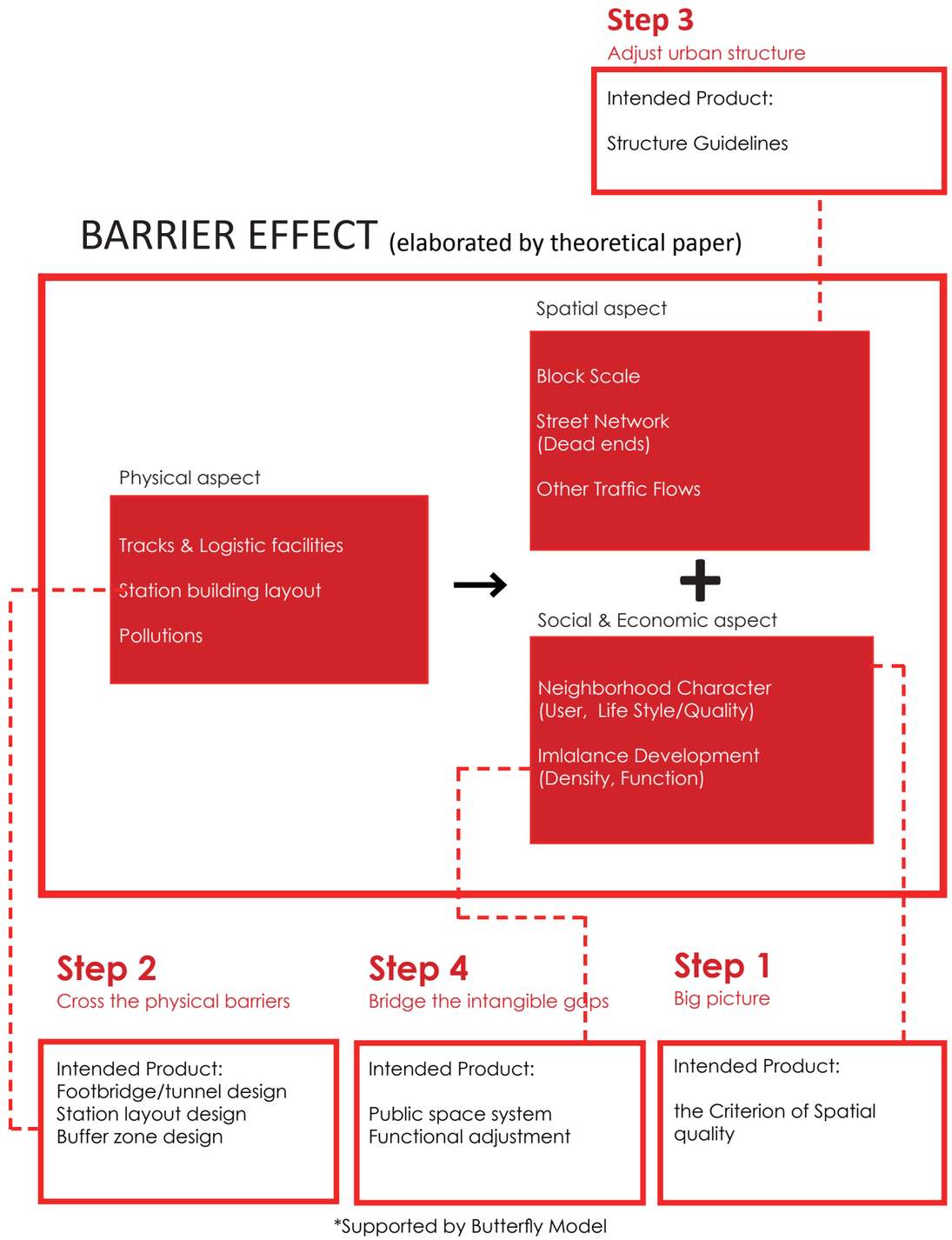
Repeat the whole process until the end

Research->Design->Presentation->Research->Design->PresentationResearch->Design->Presentation->->

*Summarized from the Interview with Rients Dijkstra

2.2 Exploration of Dutch Design Approach

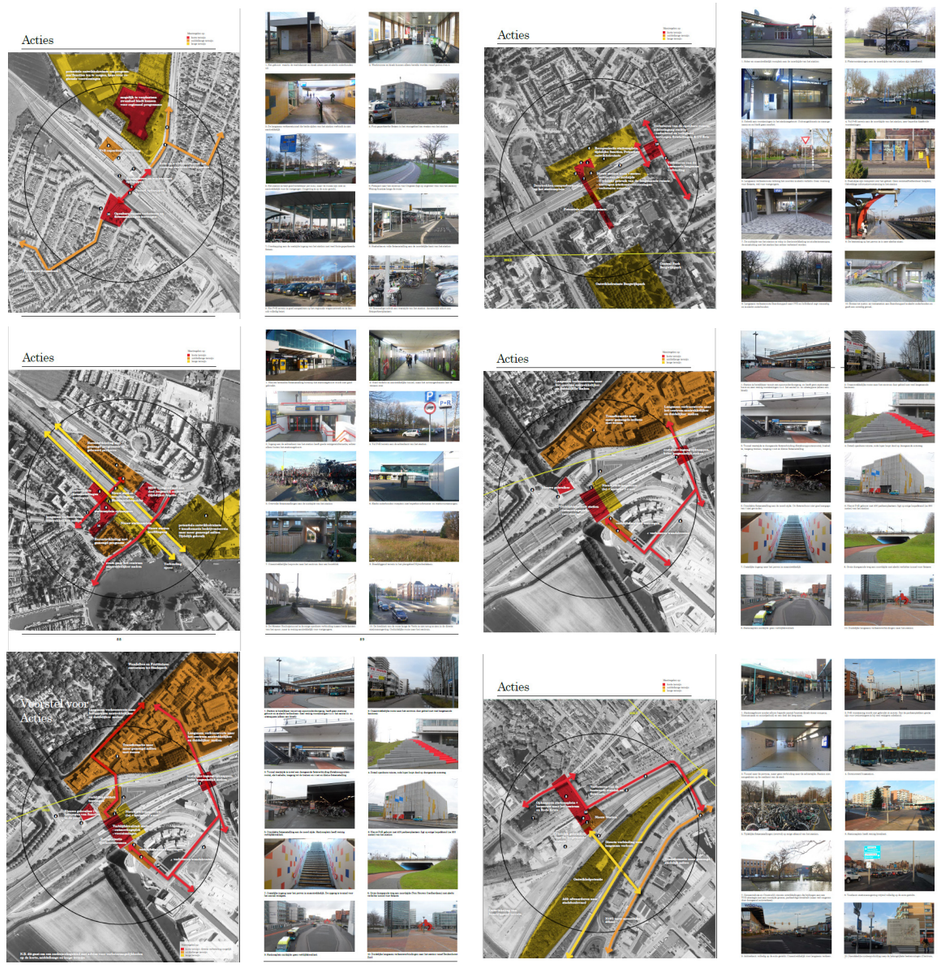
*Taking Rotterdam as the test case.



*Supported by Butterfly Model

2.3 Criteria for Spatial Quality Judgement

This report was published by the Delta Metropolis Association. 64 nodes which are located in North Holland have been investigated, focusing on the analysis of the development of the public transport network and the urbanization of stations surroundings. By summarizing this report, we can see how Dutch designers interpret this issue, further draw the conclusion about Dutch approach.



*Source: Loket Knooppunten WB°3WB°1 WERKBOEK N°3.3—03 | 2014WB METROPOLITAAN PROGRAMMA LANDSCHAP BEREIKBAARHEID DELTA METROPOOL

Summary1: Common location the new projects choose

Link newly developed area to

1. Historical city center
2. Key Points: Hospital, main church, central park and commercial center.

Summary2: Common problems around station areas

Station building

1. Poorly recognizable: Narrow and Unclear entrance
2. Inconvenient station hall
3. Inadequate services.

Routes across the rails

1. The unattractive routes with office buildings standing on both sides.
2. Narrow and dark tunnels.
3. Urban corridor stopped by traffic.
4. Narrow/unlogical route.

Low-quality public space downgraded by traffic

1. Low-quality square, due to being covered by bicycles.
2. Vehicle issue, car-oriented, unattractive to pedestrians.
3. Empty space next to the station, reserved for buses and car parking.

Summary3: Common proposals

Improve the spatial quality by reorganizing traffic flows

1. Downgrade traffic roads to city boulevard.
2. Improve the transfer between different flows
3. Compact bicycle parking area/ transfer vacancy to the potential area.
4. Street furniture, greenery, human scale, safety and quality maintenance.
5. Quality of tunnel, main square and back entrance of stations.

Upgrade the routes across the rails

1. Slow traffic route to the city center, more attractive, continuous and direct.
2. Highlight the entrance, making routes more accessible.

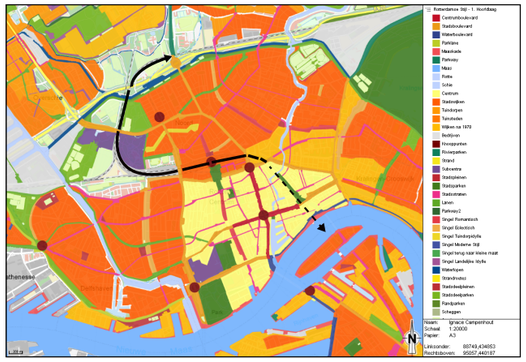
Multi-function station area

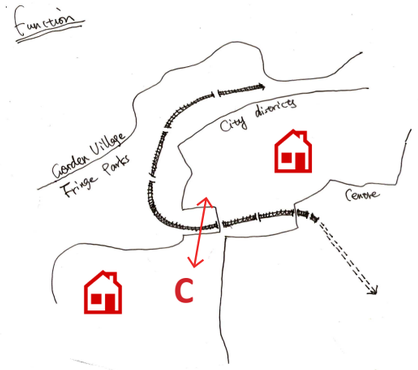
1. Redevelopment of the station, meeting place and providing services.
2. Transformation to a more mixed environment/ add more urban functions.
3. add residential are.
4. Improve the accommodation quality.

Different connections according to the different criteria.

*Numbering the streets: Capital letters indicate the streets on the south of the station, while lowercase letters represent the streets on the north.

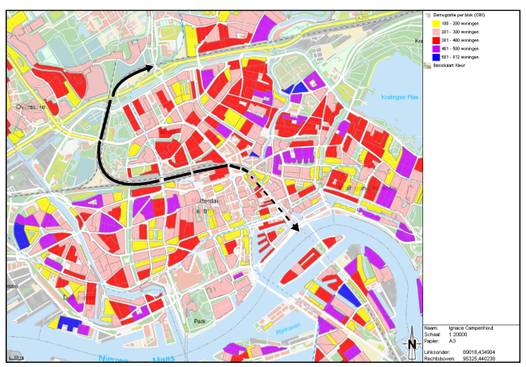
URBAN FUNCTIONS

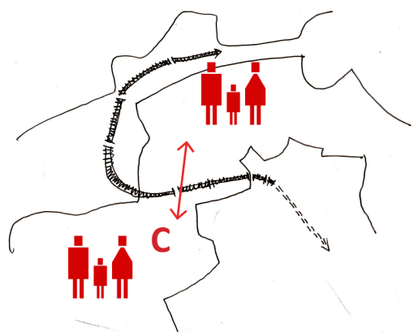




From the urban function perspective, Connection C should be highlighted, since it might reinforce the continuity of residential districts.

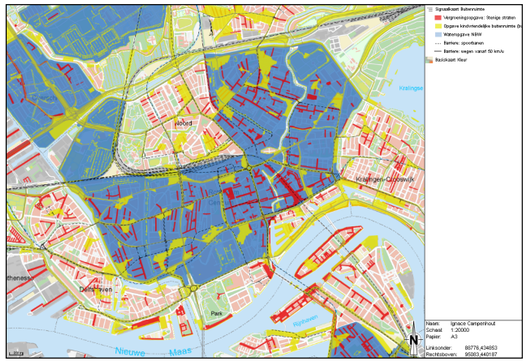
DEMOGRAPHY

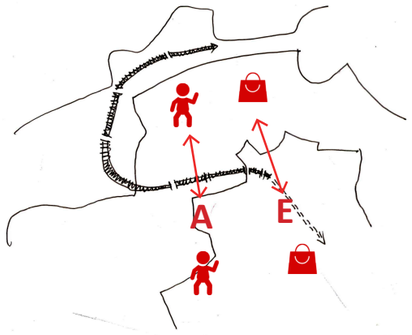




From the demography perspective, Connection C should be highlighted. Since the link between high-density neighborhoods is necessary for providing more convenient corridors for local life.

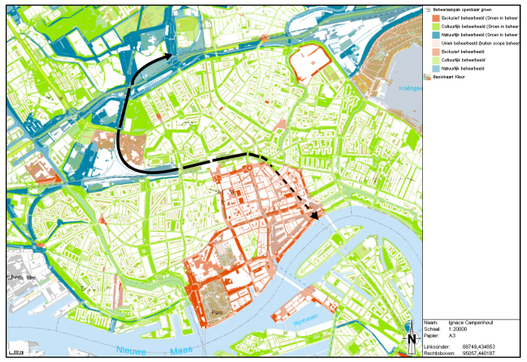
PHYSICAL EXERCISE & CHILD-FRIENDLY AREA.

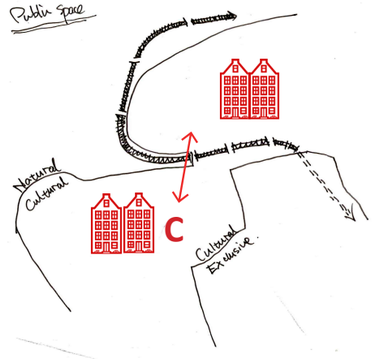




If creating a healthy and child-friendly environment is the city's new goal, Connection A and C will have the first priority.

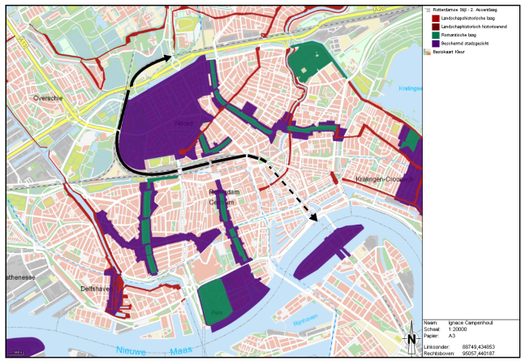
STREET ATTITUDE

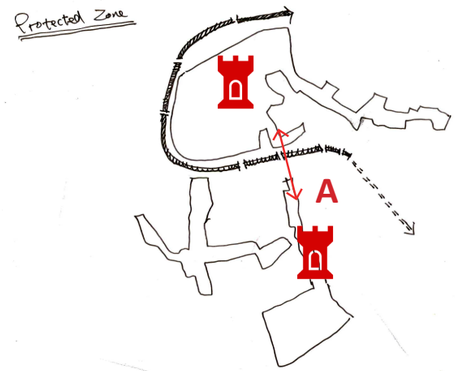




As for streetscape aspect, relinking the Connection C will help to create the continuous urbanscape.

HERITAGE AREA





The Connection A will relink the historical streets separated by railway tracks.

According to different evaluation criteria, different possible locations of new connection could be summarized.

Residential /Leisure **C** History/ Walkability **A** Commerical Benefit **E**

Street Quality

*Ewing, R., & Clemente, O. (2013). Measuring urban design : Metrics for livable places (Metropolitan planning design). Washington, D.C.: Island Press.

Step1: Sample selection

Taking central station as the center and one kilometer as the radius, within this range, the roads leading to the railway are chosen as the samples.

Step2: Subjective evaluation+Objective identification

Subjective evaluation

Theoretical method

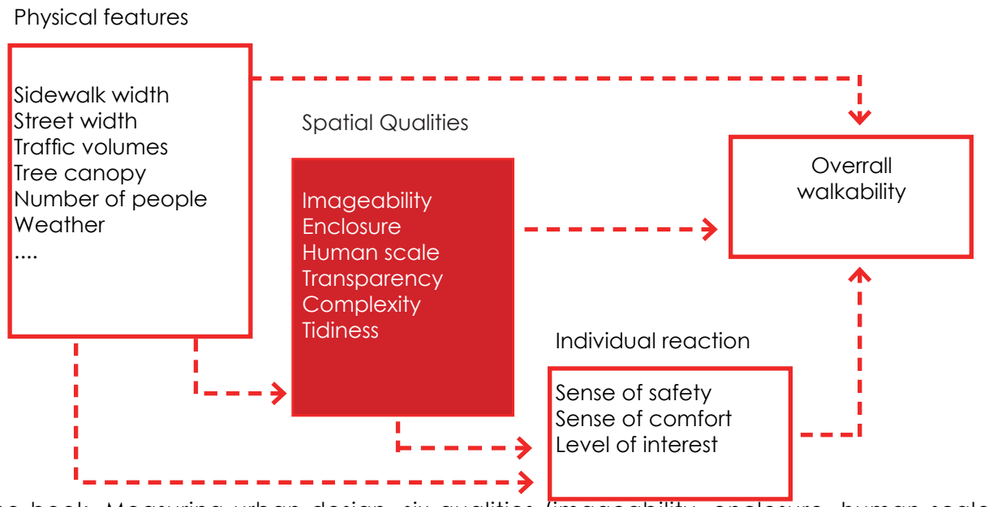
Technical Supports

Reid Ewing[1]

Alex Kendall[2]

Subjective evaluation	Objective identification	Google street view
Visual enclosure Human scale Transparency Tidiness Imageability Complexity	Proportion of greenery Proportion of sky Degree of motorization (Road+Vehicle-sidewalk) * Attendance of pedestrian * Attendance of bicycle * Attendance of vehicle	SegNet (This website is trained to classify each pixel of an urban street image to be one of twelve classes.)

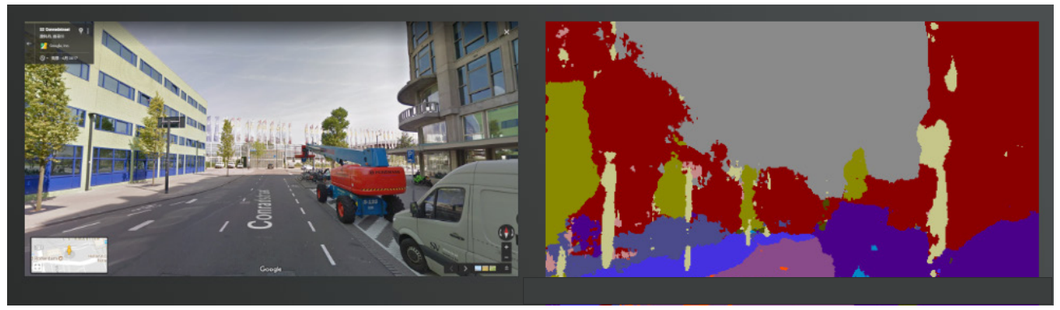
1. Reid Ewing is Professor of City and Metropolitan Planning at the University of Utah and the author of Pedestrian- and Transit-Oriented Design.
2. Alex Kendall, Computer Vision and Robotics Research Fellow at the University of Cambridge.



In the book, Measuring urban design, six qualities (imageability, enclosure, human scale, transparency, complexity and tidiness) were believed that could be measured in a manner that passed tests of validity and reliability.

Objective identification

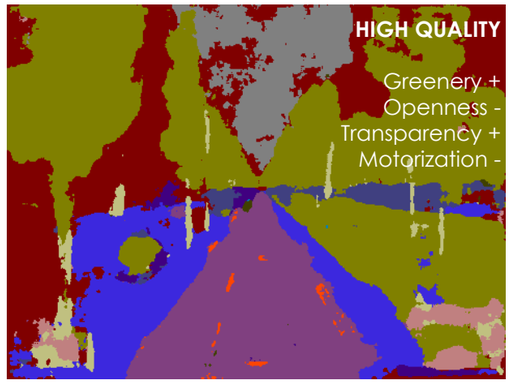
Sky Building Pole Marking Road Pavement Tree Sign Fence Vehicle Pedestrian Bike



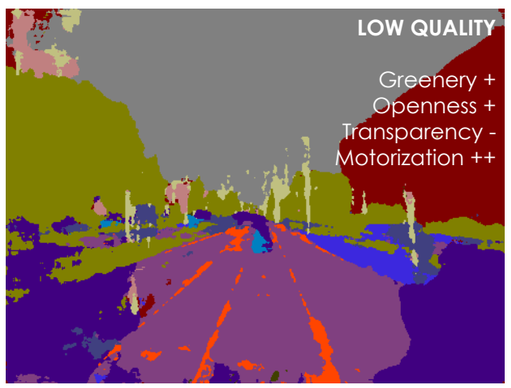
*Segnet: A deep convolutional encoder-decoder architecture for image segmentation
V Badrinarayanan, A Kendall, R Cipolla - arXiv preprint arXiv:1511.00561, 2015

With the help of image segmentation technology, the street view images can be identified with 12 categories including Sky, Building, Pole, Road Marking, Roads, Pavement, Tree, Sign, Fence, Vehicle, Pedestrian and Bicycle. According to the factors that affect the quality of the street, we choose the four indicators, namely **the proportion of greenery, the degree of street openness, enclosure degree of facade and degree of motorization**, to identify the quality of the street objectively.

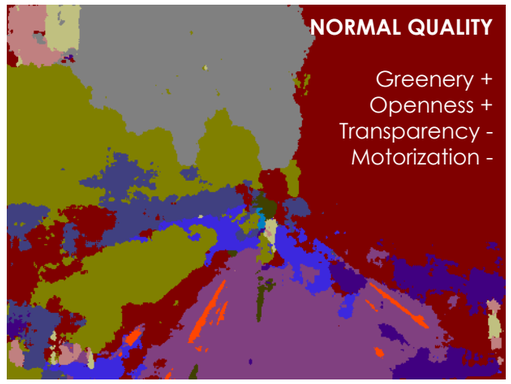
A: Kruisplein



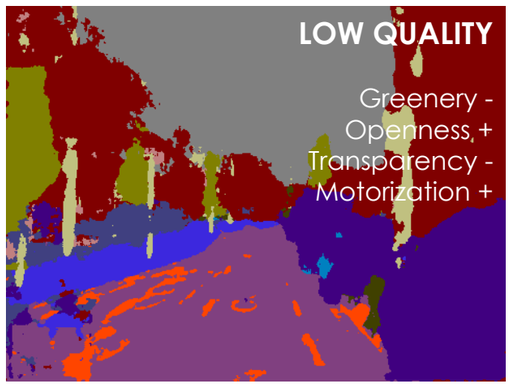
B: Heemraadssingel



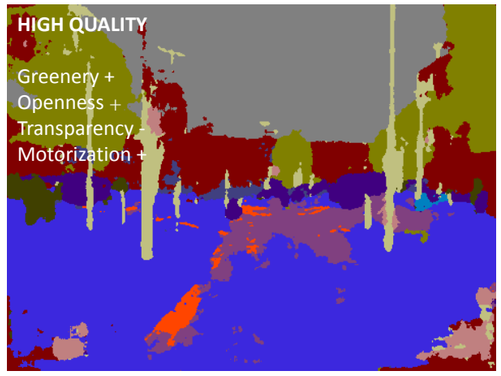
C: S113



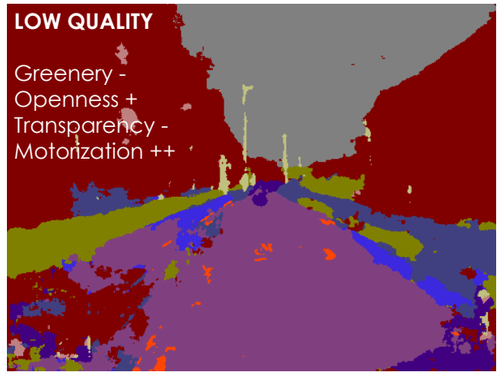
C1: unknown Street



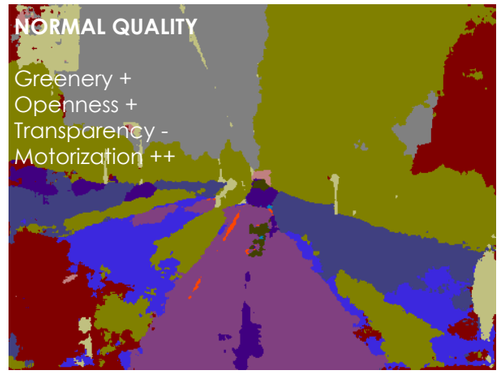
a: Spoorsingel



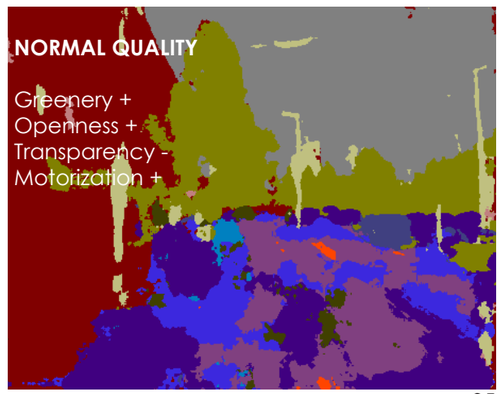
b: Van Aerssenlaan



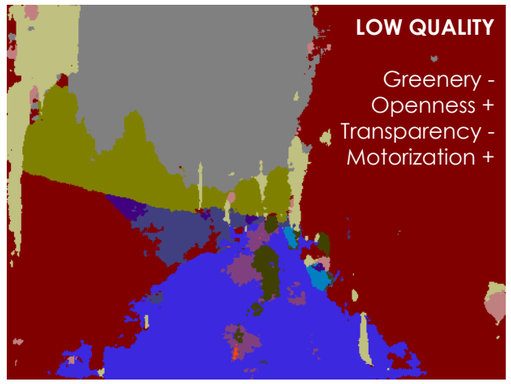
c: S113



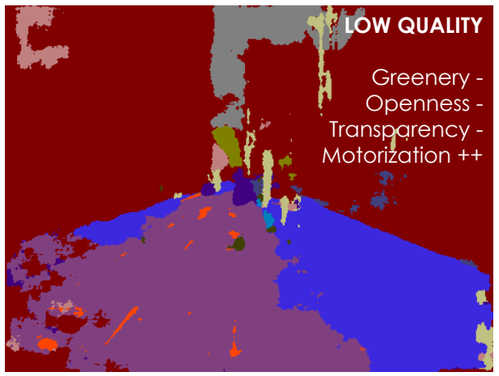
c1: Stationssingel



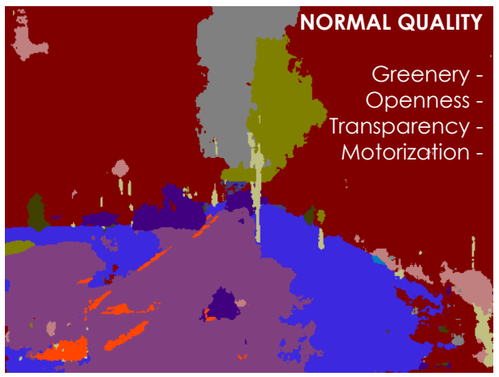
C2: Conradstraat



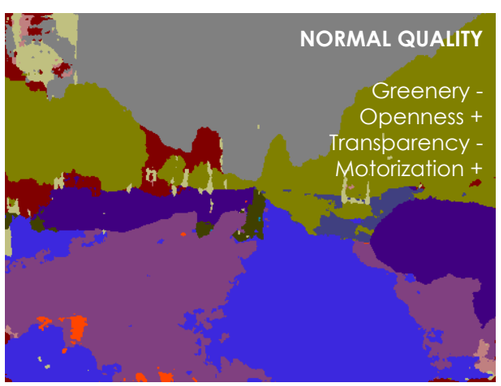
D: Delftse Poort



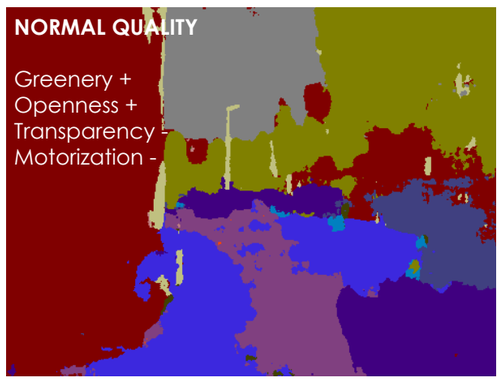
D1: Poortstraat



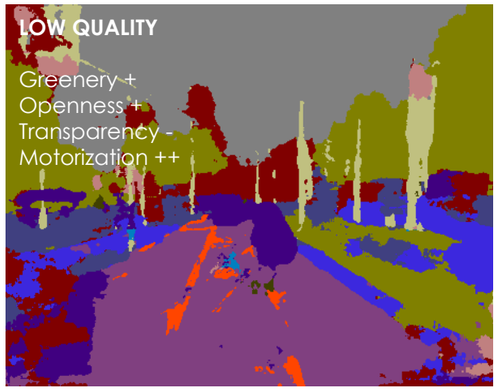
E:Schiekade



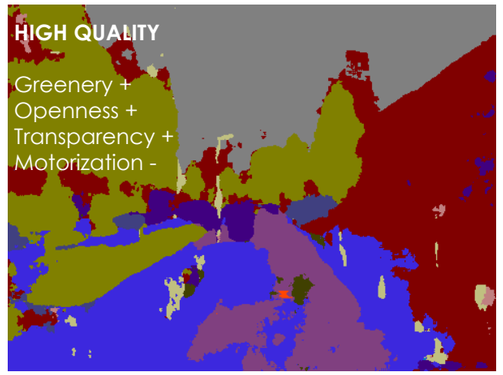
d: Molenwaterweg



d1: Schiekade



e:Katshoek



Step3: Results comparison

The most potential connection:

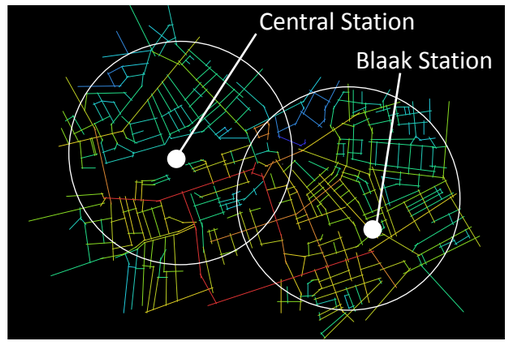
A > **E** > **C** > **C1/C2/D/D1** > **B**

2 highs | **Normal + high** | **2 Normals** | **Normal + Low** | **2 Lows**

Testing study of Space Syntax

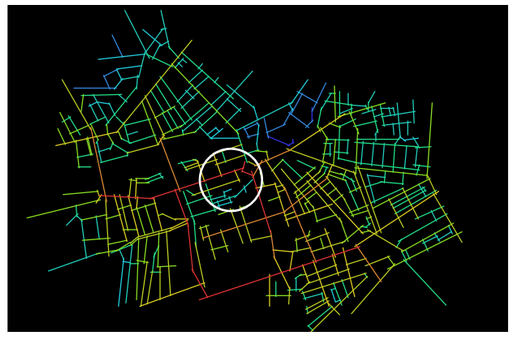
From geometrical aspect to find potential connections.

Current Status

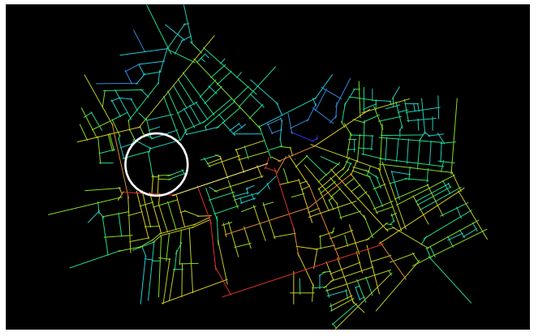


Taking two railway stations as the centers and one kilometer as the radius to determine the scope of the study area. By using space syntax software, the current status of connectivity and integration of street network will be calculated. Adjusting the network based on the previous analysis, the data before and after can be compared. This will theoretically help us to choose that relink which street will improve the overall connectivity at maximum.

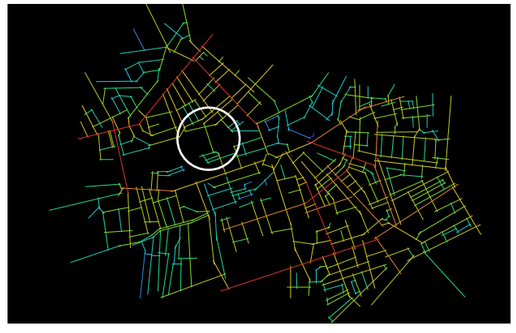
Connection A: Station hall



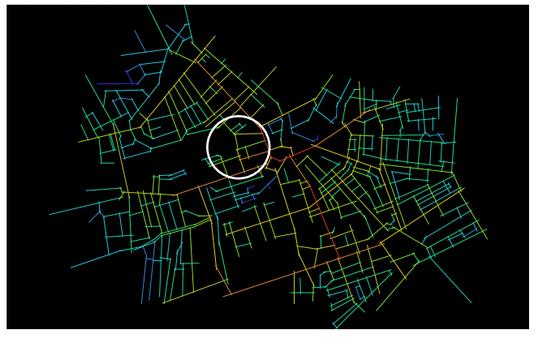
Connection B



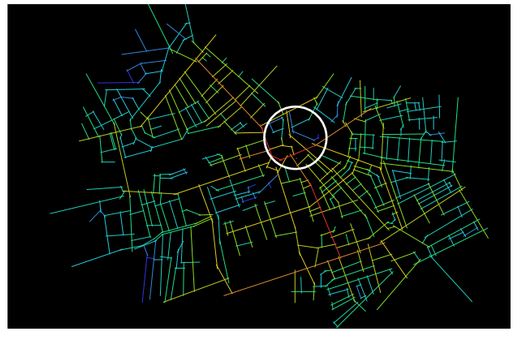
Connection C



Connection D



Connection E



All connections

Calculation Data & Conclusion

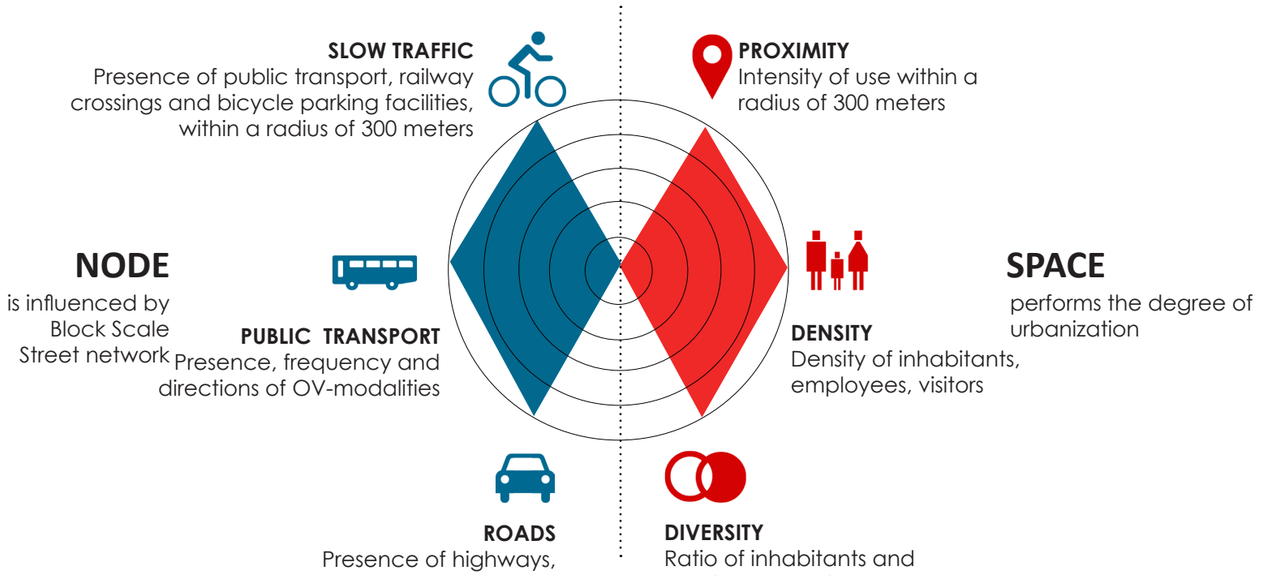
Current status	Minimum	Average	Maximum		Minimum	Average	Maximum
Integration[HH] :	0.373859	0.767399	1.16679	Choice[Connectivity Wgt]:	16	32560	812558
Integration[HH] R3:	0.333333	1.48251	3.07877	Choice[Connectivity Wgt]R3:	7	744.836	12188
Conection A							
Integration[HH] :	0.373344	0.77318	1.18337	Choice[Connectivity Wgt]:	1304	33021.3	837618
		+0.00579				+461	
Integration[HH] R3:	0.333333	1.48686	3.06841	Choice[Connectivity Wgt]R3:	7	752.239	12363
		+0.00435				+7.4	
Conection B							
Integration[HH] :	0.373244	0.760589	1.1611	Choice[Connectivity Wgt]:	1299	33541	828003
		-0.00681				+981	
Integration[HH] R3:	0.333333	1.48532	3.07877	Choice[Connectivity Wgt]R3:	7	745.98	12229
		+0.00281				+41	
Conection C							
Integration[HH] :	0.373772	0.76241	1.16178	Choice[Connectivity Wgt]:	1302	33428.1	824728
		-0.00498				+868.1	
Integration[HH] R3:	0.333333	1.4887	3.07877	Choice[Connectivity Wgt]R3:	7	748.271	12109
		+0.00619				+3.435	
Conection D							
Integration[HH] :	0.499194	0.867584	1.34329	Choice[Connectivity Wgt]:	1308	29885.3	610152
		+0.100185				-2674.1	
Integration[HH] R3:	0.333333	1.49686	3.04081	Choice[Connectivity Wgt]R3:	7	769.944	12747
		+0.01435				+25.108	
Conection E							
Integration[HH] :	0.507808	0.873842	1.35821	Choice[Connectivity Wgt]:	1312	29824.7	587973
		+0.106448				-2735.3	
Integration[HH] R3:	0.333333	1.49892	3.04081	Choice[Connectivity Wgt]R3:	7	779.872	12948
		+0.01641				+35.036	
All Conections							
Integration[HH] :	0.509225	0.879832	1.35925	Choice[Connectivity Wgt]:	1328	30175.7	592362
		+0115842				-2384.3	
Integration[HH] R3:	0.333333	1.50449	3.03264	Choice[Connectivity Wgt]R3:	7	789.749	13143
		+0.02198				+44.913	

Performance: E>D>A>C>B

Personal understanding of integration and connection from space syntax:
Integration reflects passing through, while connection represents arrivals. Integration represents the spatial distribution of attractions. The higher degree of integration, the more people flow passing through, the better commercial potential it has; The connection represents the spatial distribution of flows. As a destination, the higher degree of connection, the better accessibility.

From the results of space syntax, We further confirmed that connecting the streets on the east side can bring greater benefits from the perspective of geometry.

Urban structure & Urbanization



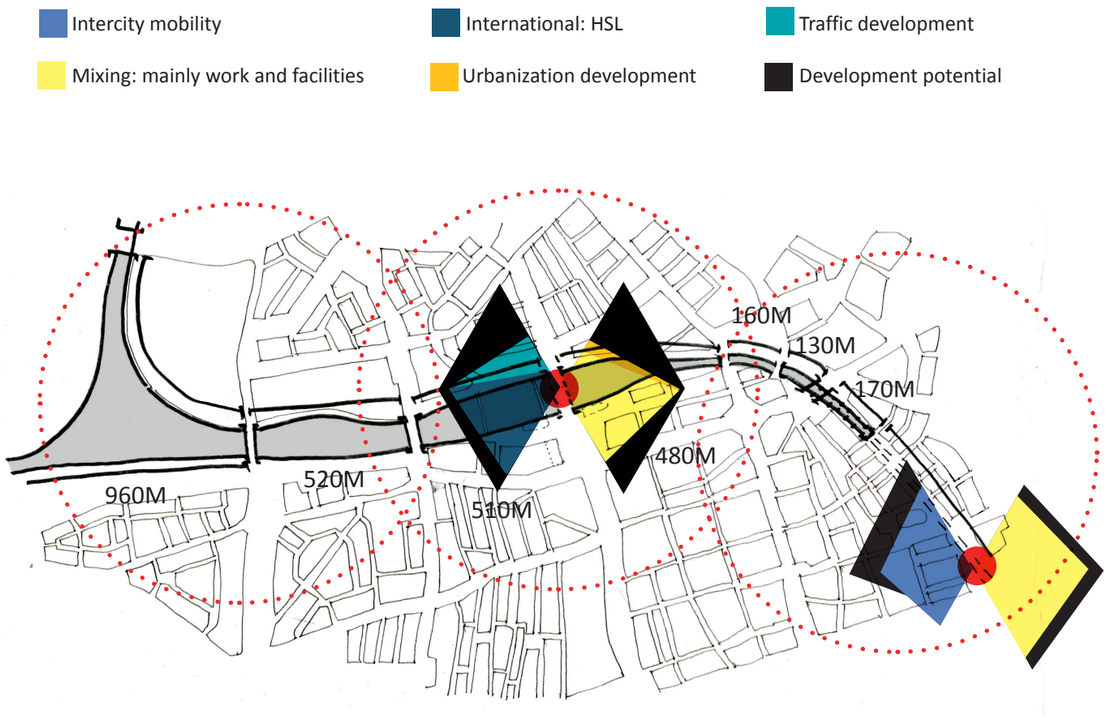
*Supported by ***Butterfly Model Theory***
(Maak Plaats!, Vereniging Deltametropool & provincie Noord-Holland, 2013)

NODE:

A node connects different modes of transport and links different networks with each other. A hub is, therefore, a place that must be easily accessible with as many means of transport as possible - not only by train, but also by bus, tram, metro, car, bicycle, walking or even by boat.
In order to make statements about the position of the node in the network, three indicators are important: the position in the public transport network, the position in the road network and the position in the slow traffic network for cyclists and pedestrians.

SPACE

'A place is tempting if you see a lot of different people during the day and in the evening and there are many things that can be done, and that requires density, function mixing and fungal' (Boomen & Venhoeven, 2012).
Different spatial characteristics have a direct relationship with the use and spatial quality of a node. In order to be able to make statements about the location value of a junction, three spatial characteristics are important: the intensity of residents, employees and visitors, the mixing and proximity.



CENTRAL STATION

slow traffic: 58
OV: 2.160
Vehicle: 308
Proximity:7%
Density: 436
Diversity: 17%

BLAAK

slow traffic: 150
OV: 1.295
Vehicle: 190
Proximity:23%
Density: 425
Diversity: 22%

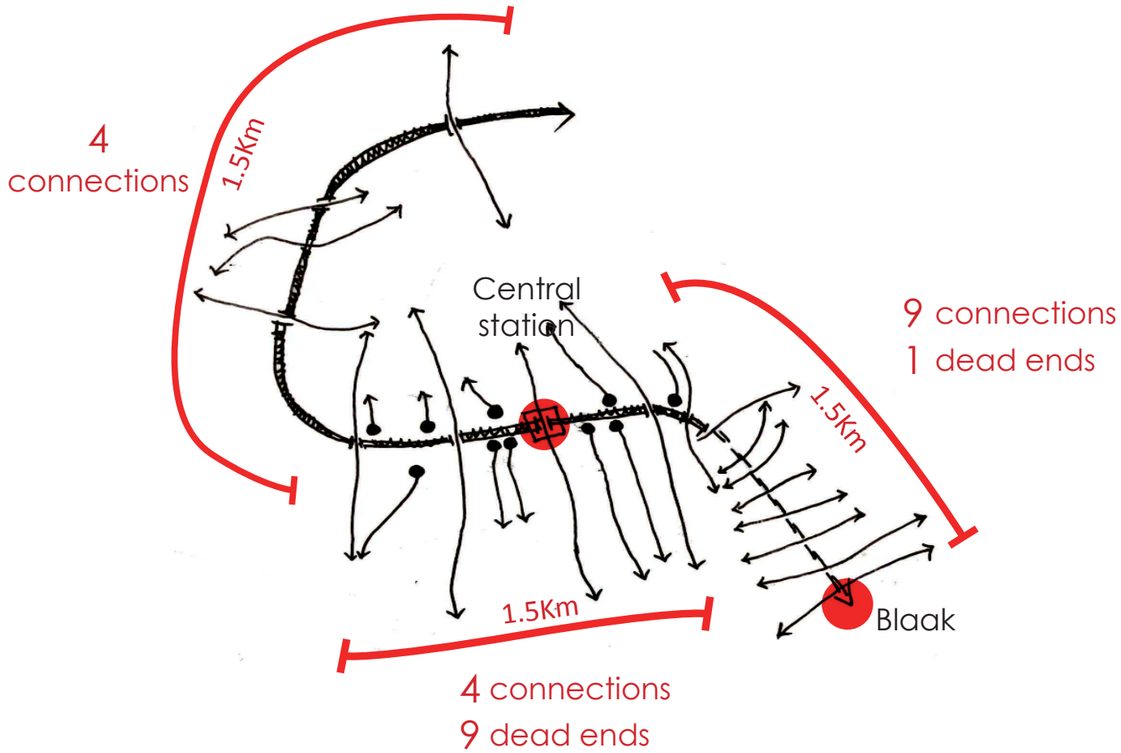
*Source: Data comes from the report, N***odes in the Rotterdam City Region***, Published on Jan 16, 2014

The bombing in 1940 made Rotterdam a 'city without a heart'. meanwhile, this also gave Rotterdam an opportunity to be a unique city center that, compared with other Dutch cities. There is more space for vehicle traffic and modern functions, for example, the Lijnbaan, the first car-free shopping district. Within this scope, there are two main railway stations, which define my research area.

Rotterdam Central is a destination station with increasing cosmopolitan development, which is the area of interest for international competitiveness. There are the top locations with international offices, high-density lives and a large variety of amenities. with the excellent public transport supports. Rotterdam Blaak is the Grootstad station of Rotterdam. It has an excellent position in the center of the city, a lively urban area with a high level of facilities and a lot of employment.

According to the indicators came from the Butterfly Model theory, the performance of urbanization in Blaak station is better than that in Central station. This result may relate to the gradual change of block scale from west to east. The block on the east has finer block scale.

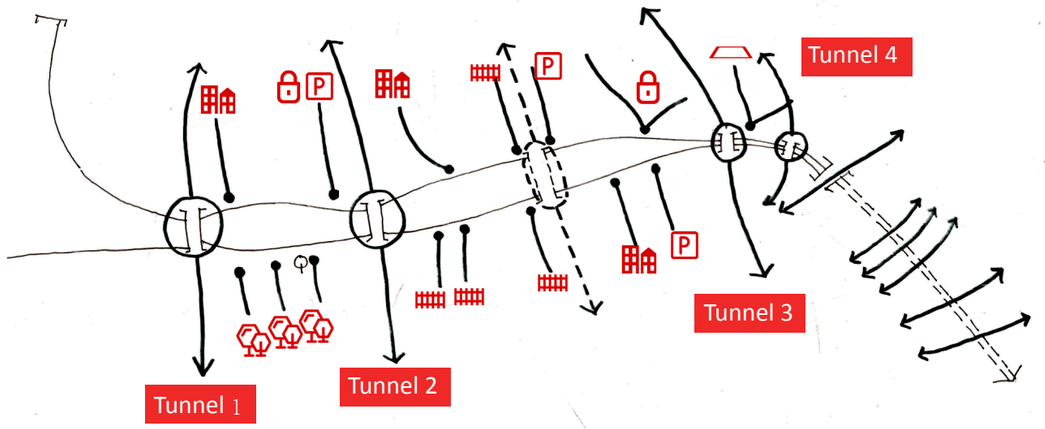
Street Network: Connection & Dead end



For cyclists and pedestrians, it is important how you can get straight to the node: fast and direct, without unnecessary detours. The more local roads there are, the finer the network is. This says something about the choice for both the cyclist and the pedestrian to reach their destinations and gives an indication of how well the station area is embedded in its environment.

However, in a number of cases, the options are very limited and there is room for improvement in strengthening the route structure around the station. When the city roads meet the tracks, the tunnels or viaducts appear. When the local roads meet the tracks, dead ends appear. So the nodes with dead-ends in their vicinity should be valued.

Dead end & Tunnel



LEGENDS OF TYPOLOGY

- Private Building
- Locked Gate (Logistics area)
- Buffer Zone
- Frence
- Parking Lot
- Concrete Base

ASPECT RATIO OF TUNNELS

- Tunnel 1, 100m:16m=6.25
- Tunnel 2, 110m:38m=2.89
- Tunnel 3, 27m:30m=0.9
- Tunnel 4, 27m:9m=3

Interview Results of Tunnel Spatial Quality Evaluation

Main interview questions: How is your safety perception of this tunnel?
What makes you like/dislike about this tunnel?

Main conclusions:

- Shape: Narrow or wide (Is there gaps on the roof of the tunnel?)
- Wind: relates to the shape of the tunnel.
- Slopes: Steep or not (Difficulty about going uphill with bikes)
- Maintenance: Graffiti, Rubbish, Broken lights, etc.
- Light: Sufficient illuminance level.
(Make users recognize movement and people nearby)

Comments:

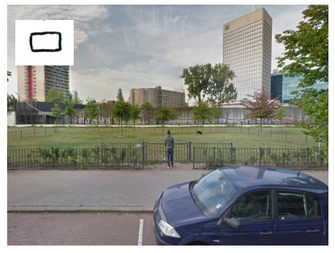
- People prefer natural elements when they choose their routes.
- Some people use the tunnel for a particular reason,
like using facilities nearby, namely parking lot.

2.4 The Physical Barriers that new connections will meet

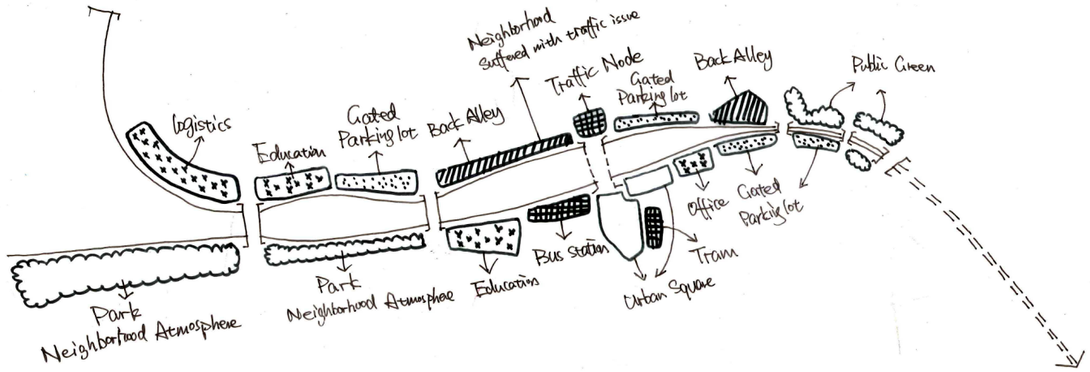
Neighborhood typology along the tracks








As huge interventions into cities, stations and their surroundings formed new spatial relationships with related neighborhoods. and neighborhood typology analysis could simplify them, summarizing common physical obstacles that may encounter.



Typology	Comments
Private Institution: Office/education/Logistics	○ Missing the image of Railway
Gated Parking lot	− Aggravate the barrier effect
Back Alley behind non-commercial functions	− Negative space
Traffic Node	○ Not friendly to pedestrian
Urban Square	○ Mainly used by passengers
Park	+ Soften the conflicts from the railway

Conclusion map of station area in Rotterdam

Potential Area
Current hotspot
Railway
New connection

Blijdorp district

This small park is the heart of Blijdorp district, with a church, the Prinsekerk , built in 1933 inside.

the lost Rotterdam Hofplein railway station
The ownership of the viaduct was transferred from the Dutch Railways to two Rotterdam housing corporations, and they are planning to give it a new future. The current functions are shops and cafes, with a theatre and an urban farming garden on the top.

Sportcomplex Nenijto
Sports complex Nenijto is the home of Rotterdam Athletics since 1935. As the only real athletic track next to Central Station, it should play more roles in this compact area, like cultural and leisure functions, instead of just being a closed sports place.

B+C

A

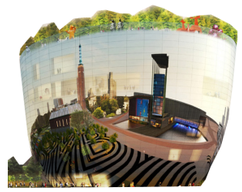
D

E

Westersingel
As the connection between museum park and central station, this boulevard more shows residential atmosphere, instead of an urban attitude. So the new link should increase more urban functions along this road.

Main Square around Blaak station

Markthal, Central Library, Cube Houses and Laurenskerk, all these functions make the area prosperous. The new connection could bring this advantage to the north part of the railway.

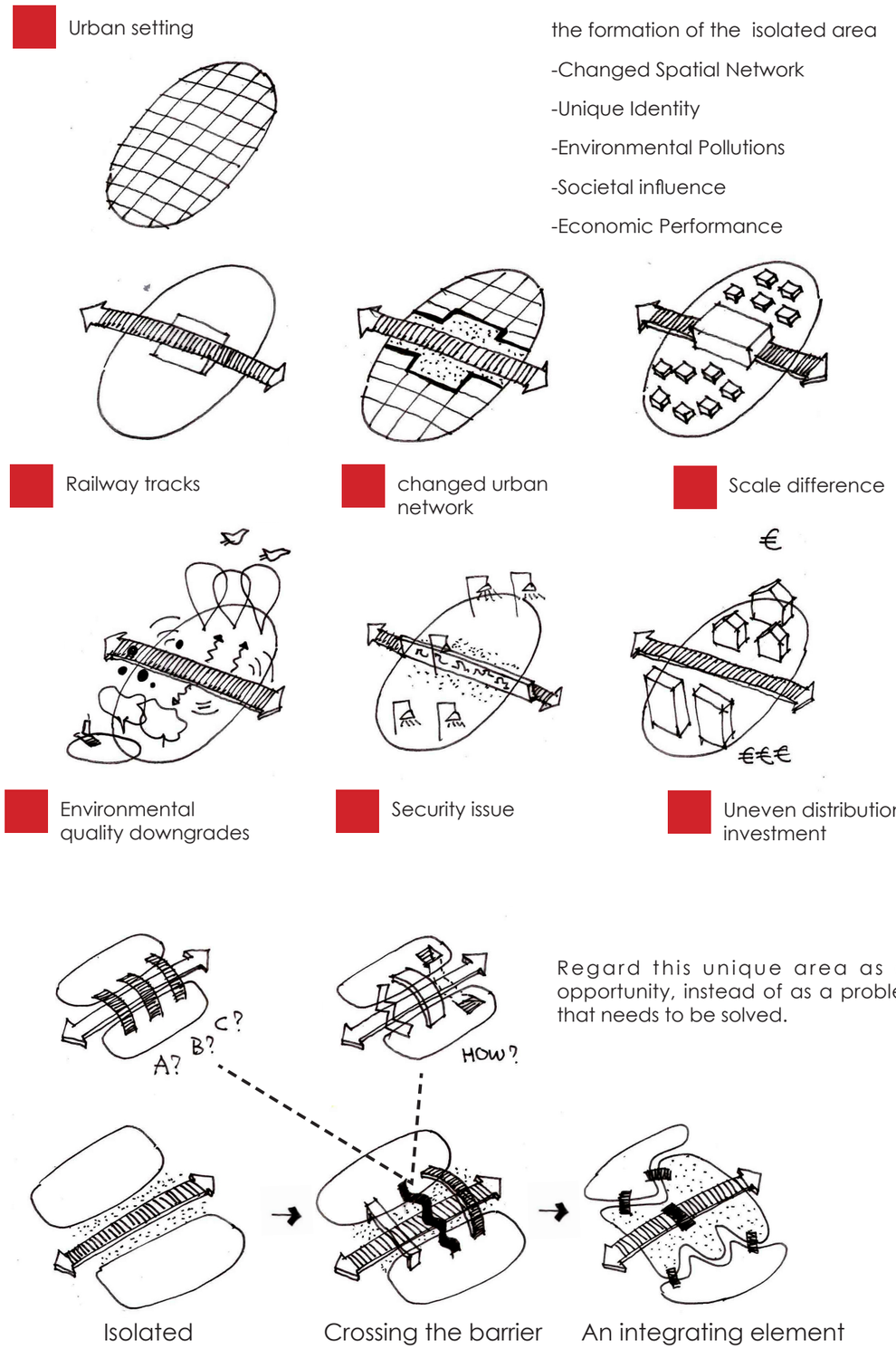


Museum Park
The Museumpark hosts the most important museums in Rotterdam, being a cultural icon of this city.

Community Parks
Pracinha D Quebrod and Heemraadspark play an important role in their surrounding neighborhood, Middelland and Nieuwe Westen.

2.5 Summary

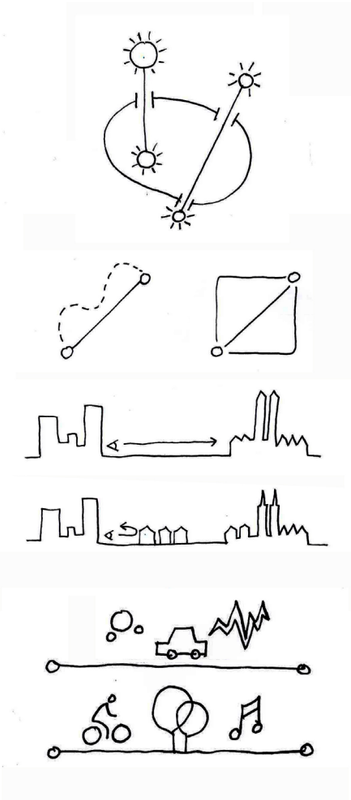
The significant improvement after studying the Dutch experience



	Before Dutch case study
Previous statement	Transforming from a barrier to a arrierless condition (Spatial, economic and socitial)
Sub-question	1. Cross this barrier at which specfic spot?(Method) 2. How to cross this barrier? (Design patterns)
	After study the Dutch experience
New question	How to transform this area into an integrating element, restructuring the urban setting as a unity?
Extra sub-question	How to improve the network operation, economic performance, environmental quality and urban identity?

1. The Netherlands has always dealt with a lack of land and so using the limited resource properly has always been a priority. The most inspiring experience I have learned is **allocating resources to maximize the value.**

2. Regarding the Dutch cases, station areas always have difficulties to integrate with their urban setting in four aspects, namely **traffic network, environmental quality, economic performance and urban identity**.
So the diversity of function and users, the spatial, visual integration and the quality of public space play a key role for helping railway station areas fitting into the urban setting.



3. The intention of connection:
The location of the connections and their purposes should be studied within city scale. Such connections can play a role only if they fit in the larger urban structures, either spatial network, economic structure or even mental map.

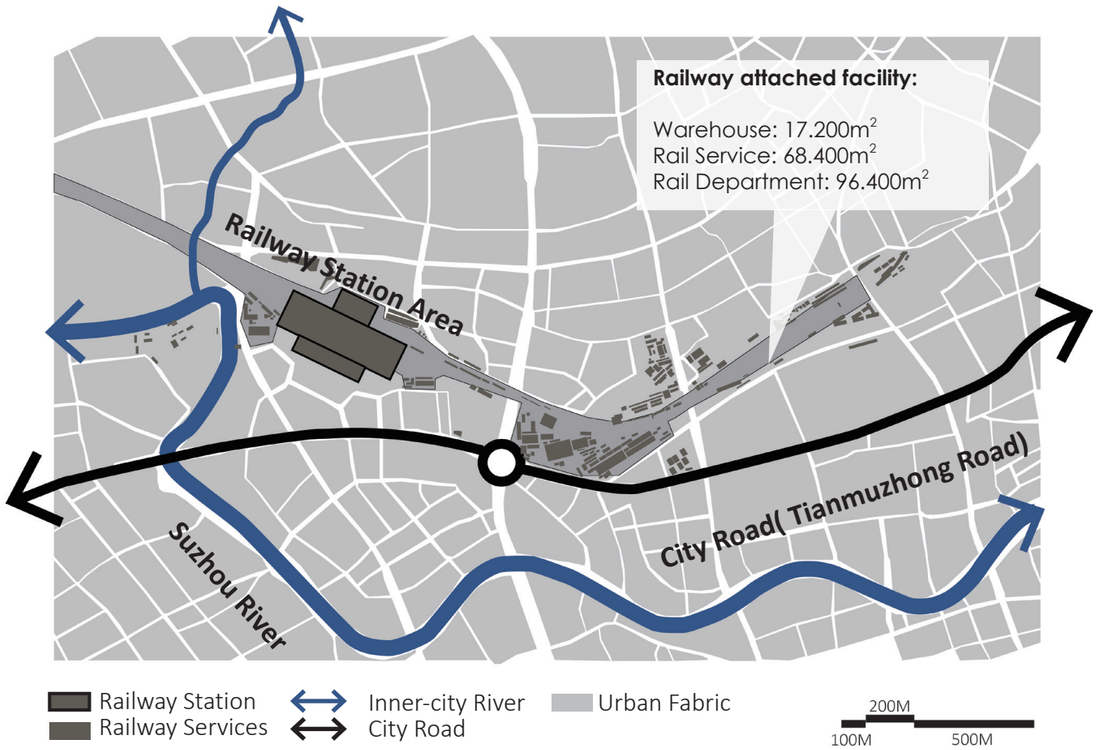
4. The space making and the spatial conveinence:
The geometric form and density of traffic network greatly influence the efficiency of network operation. So these physical features should be attached at the very beginning.

5. Added values-Comfortable walking:
Since the concept of slow traffic is accepted and promoted everywhere. So the comfortable walking experience should also be considered. The factors like the priority for slow traffic, a continuous level and a clear visual contact, contribute to form the comfortable walking environment.

6. Added values-Environmental quality and street life:
The above factors are necessary, but not sufficient, so the last but not least aspect is about the quality creating and street life programming.

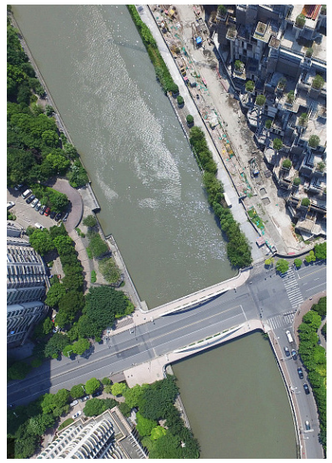
3

Application in Shanghai, China



1
Railway Track and services

2
Road parallels to the railway tracks



3
inner-city river

3.1 Barrier Elements

Those long continuous lines, especially the railway, the river and main roads with heavy traffic, form the main barriers in the city. In some cases, a separation of environments is desirable, for example as a border between industrial areas and residential areas. To which level barriers are being maintained depends on the location specific situation, but for Shanghai station area, backsides of the city form increase the barrier effects of the railway line, further causing the unbalanced economic performance and deprived neighborhoods.

For Shanghai station, the core (R=1000m) around the station is essential. At this scale, next to the basic conditions for a good station area like comfort, safety, efficiency, and legibility, it should also contribute to economic growth and social cohesion, which requires a view how to deal with scale differences and side effects that would occur with the realization of the station.

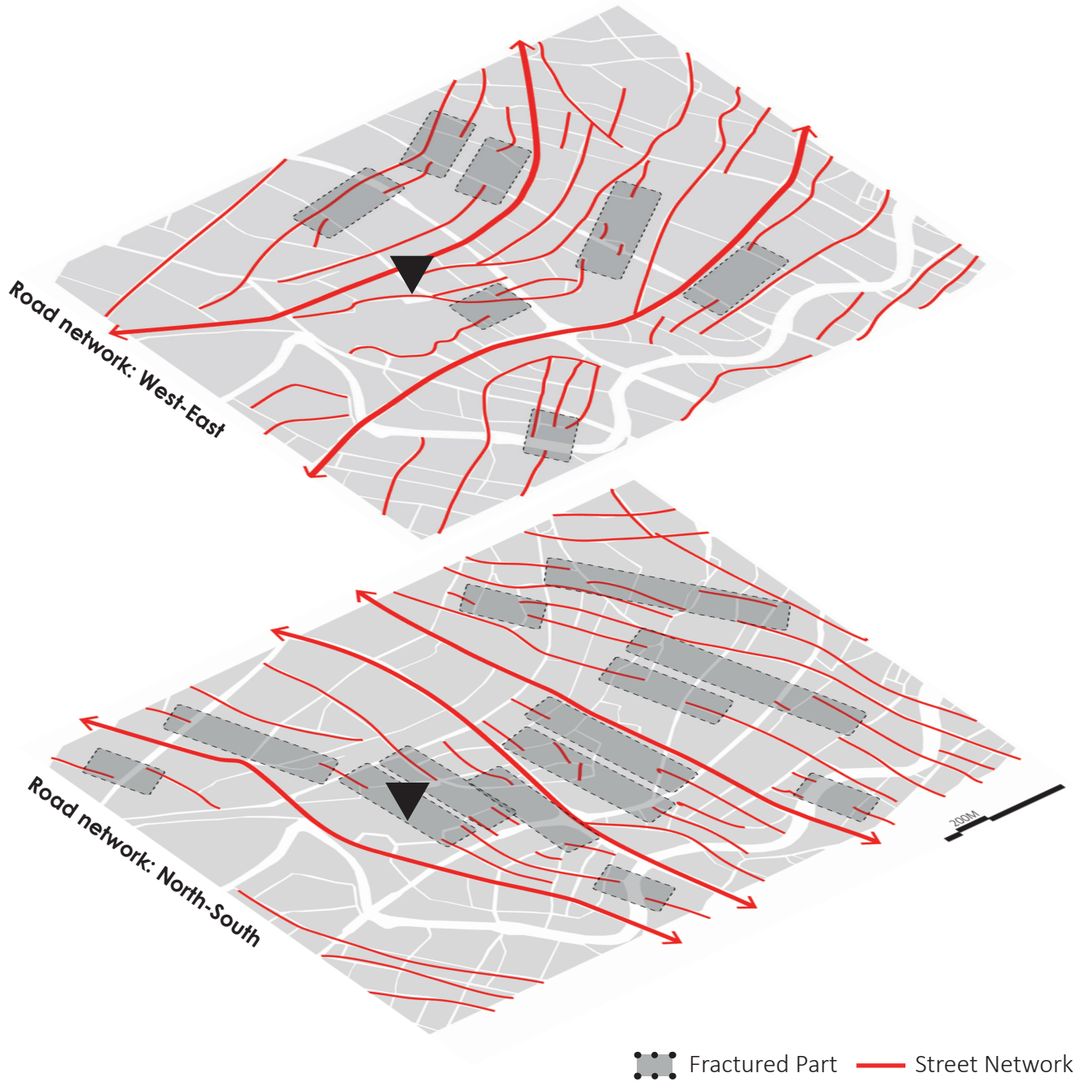
From a city point-of-view, improving the integration of these lines in the city would decrease their barrier effects and will increase the possibility to take full advantage of the value of working as a system.

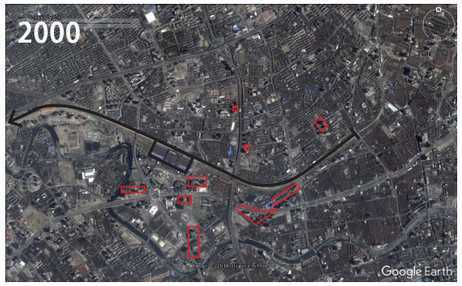
Side effect-1

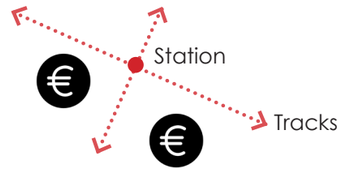
Discontinuous Road Network

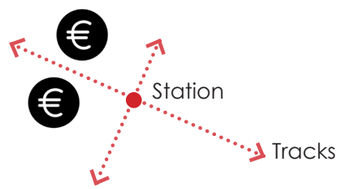
A short review of the available alternatives teaches us that the many crossings with the local road network and waterways make it technically impossible to place the infrastructure partially underground without creating new spatial barriers in the urban structure. Tunnels need to come back to surface once, which could lead to new barriers at these locations.

Operation in north-south direction doesn't work well.









Side effect-2

Unbalanced investment distribution

Because of the boundary effect of train stations and railroad tracks, four subareas were formed. Due to their different locations, the investment attracted is unevenly distributed. A Transit-Oriented Development will benefit most from a situation where areas on both sides of the development are being considered equally.

SHANGHAI Master Plan
2016-2035

EXPECTED VALUES
Planning guidance

Creative city

- Integrated facilities
- Smart traffic
- monitoring system
- Interactive information
- Environmental monitoring

Humanities City

- Function mix
- Convenient facilities
- Human scale
- Rich visual elements
- Street identity
- Slow traffic first
- Divided space
- Walkable street
- Safe crossing
- Bike-friendly

Ecological City

- Intensive resource
- Green traffic
- Sponge City
- Ecological resilience

SH Side effect-3

Perceivable segregations

This area is a relatively isolated area defined by a series of tangible and intangible borders; water, busy streets and the train tracks towards Shanghai Railway Station as the main divider. In this way, quality places and economic investments located on the south side of the rail tracks, do not form a shared condition for the residents living in this area. This leads to social exclusion, uncontrolled dead-end streets and spaces with no meaning for social cohesion. Newly developed buildings are often built very close to the railway, which simply denies attracting much attention in a visual sense.

'A poverty of connections limits a person' s or group' s ability to influence the rest of the urban web in time and space.'

---Graham & Marvin, 2003

3.2 Shanghai ambition

'SHANGHAI MASTER PLAN 2017-2035'

In China, the national government is currently encouraging the creation of special transit area planning districts. Many municipalities have further elaborated on this new national guidance. Hong Kong, Shenzhen, and Shanghai have the most extensive special provisions for station areas.

Shanghai encourages mixed-use zoning in specific conditions.

Shanghai's Technical Guidelines for Detailed Regulatory Planning (provision 3.3.1) states the following:

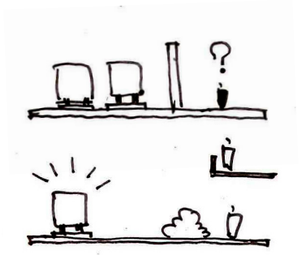
"To encourage public activities, central areas, historical districts, transit hubs, and waterfronts, should encourage such mixing of land use... Land use categories with similar functions, use, and environmental requirements, with no adverse effects on each other, and of mutual benefit to each other, should be mixed."

3.3 Vision with 3 concepts

1. High-density, mixed-use buildings clustered around mobility hubs provide an attractive and safe destination for all, establishing Shanghai station area as an inclusive one.

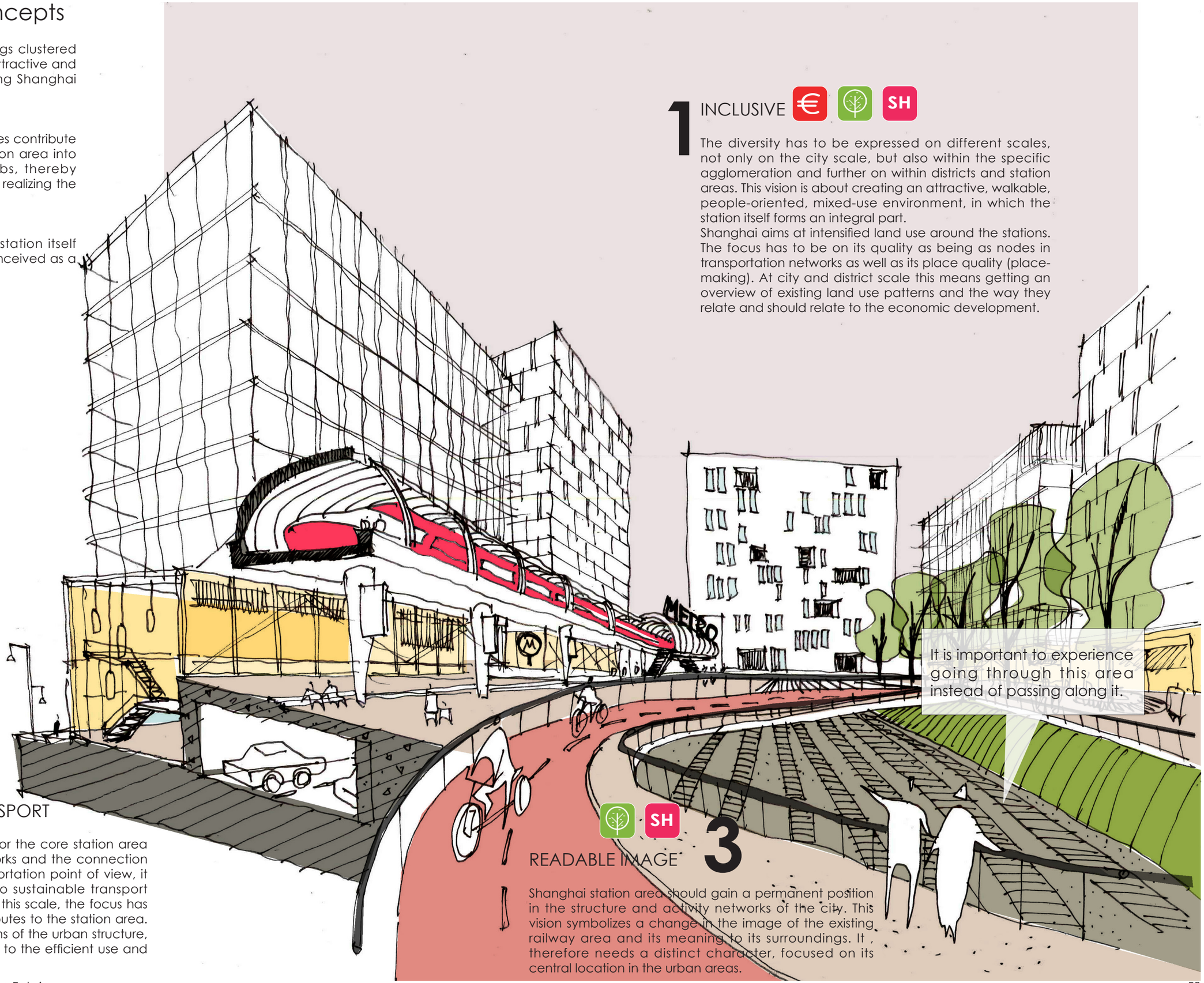
2. Biking roads and pedestrian zones contribute to transforming the Shanghai station area into multimodal public transport hubs, thereby reducing the reliance on cars and realizing the goal of 15 minutes life circle.

3. Readable railway image. The station itself opens its facade to this space, conceived as a centrality.



1 INCLUSIVE

The diversity has to be expressed on different scales, not only on the city scale, but also within the specific agglomeration and further on within districts and station areas. This vision is about creating an attractive, walkable, people-oriented, mixed-use environment, in which the station itself forms an integral part.
Shanghai aims at intensified land use around the stations. The focus has to be on its quality as being as nodes in transportation networks as well as its place quality (place-making). At city and district scale this means getting an overview of existing land use patterns and the way they relate and should relate to the economic development.



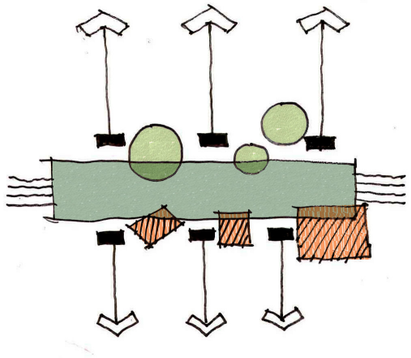
2 MULTIMODAL TRANSPORT

This vision requires an active role for the core station area within the local community networks and the connection to the city scale. From the transportation point of view, it means giving special attention to sustainable transport modes as walking and cycling. At this scale, the focus has to be on creating direct bicycle routes to the station area. It also means defining the limitations of the urban structure, especially barriers, that are threats to the efficient use and accessibility of the station area.

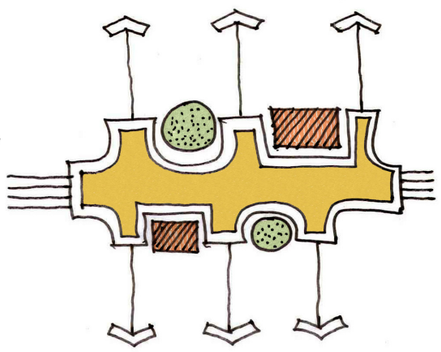
3 READABLE IMAGE

Shanghai station area should gain a permanent position in the structure and activity networks of the city. This vision symbolizes a change in the image of the existing railway area and its meaning to its surroundings. It , therefore needs a distinct character, focused on its central location in the urban areas.

Turn ‘urban barrier’ into an ‘integrating element’ by restructuring the fragmented urban fabric and urban operation.



‘Urban barrier’



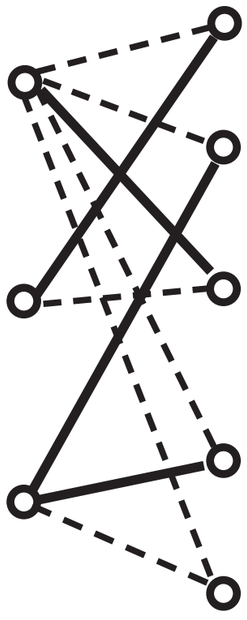
'Integrating element’

*Vision

Inclusive Area

Multimodal Transport hub

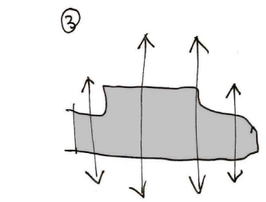
Readable Image

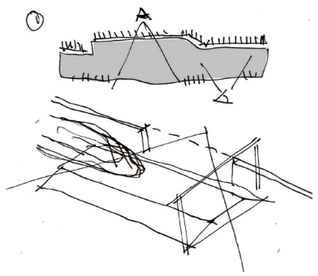


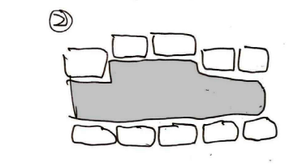
*Strategies

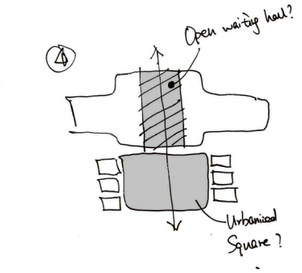
Each one is supported by a pilot project.

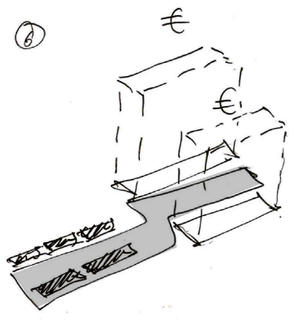
1. Create new urban axes
2. Redefine the boundary
3. Transform the surrounding neighborhood
4. Urbanize Station square
5. Free up space for possible developments.











3.4 Five Strategies

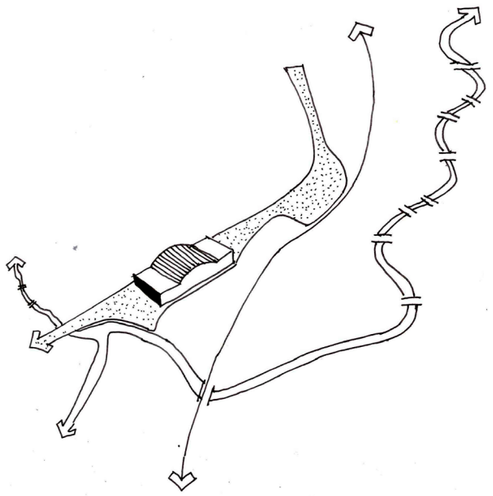
1. Highlighting new urban axes to adjust the urban operation, spatially and economically.

2. Redefining the boundary of railway area, dealing with the negative physical influence and creating a readable railway image.(including demolishing the enclosing walls)

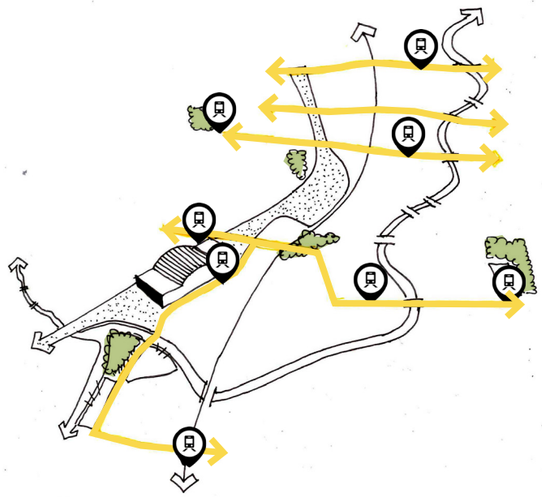
3. Transforming the surrounding gated blocks into a new typology which towards to a continuous urban fabric, integrating the scheme into the surrounding context.

4. Urbanizing station square. A well-integrated and characteristic destination where the comfort of travelers and local residents is put first.

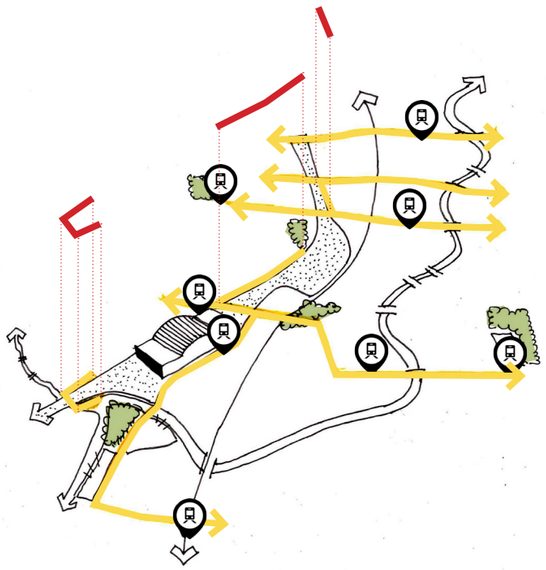
5. Consolidate the railway services and free up space for potential development, funding the previous improvement. Delimits the area with a frame. Different developers can take on the buildings, guaranteeing a diverse development. And the railway yard is left completely untouched, opening it to the future expansion or redevelopment.(Possible topology: parking, parks, creative industry workshop, office tower)



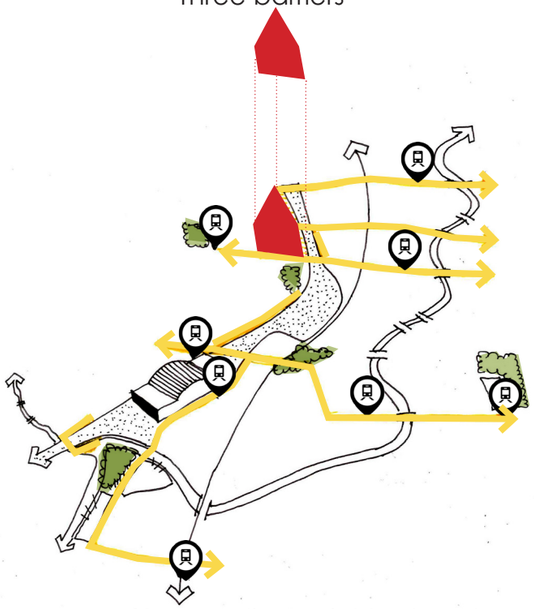
Three barriers



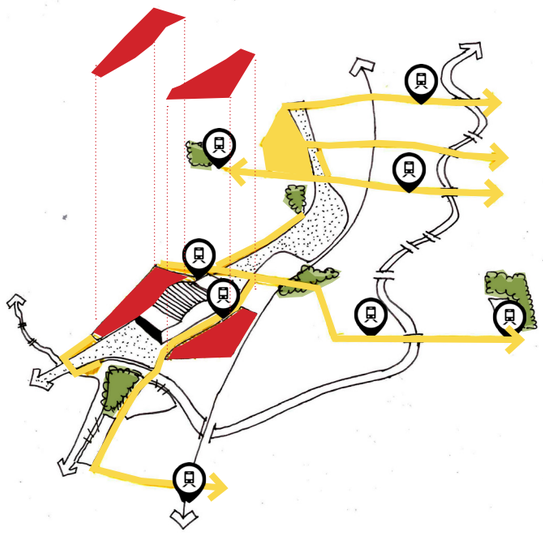
Axis



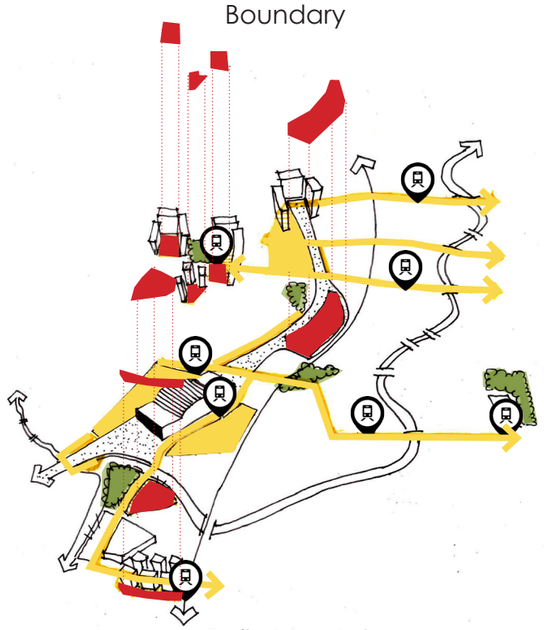
Boundary



Surrounding neighborhoods



Station square



Railway yard

Spatial distribution of Strategies

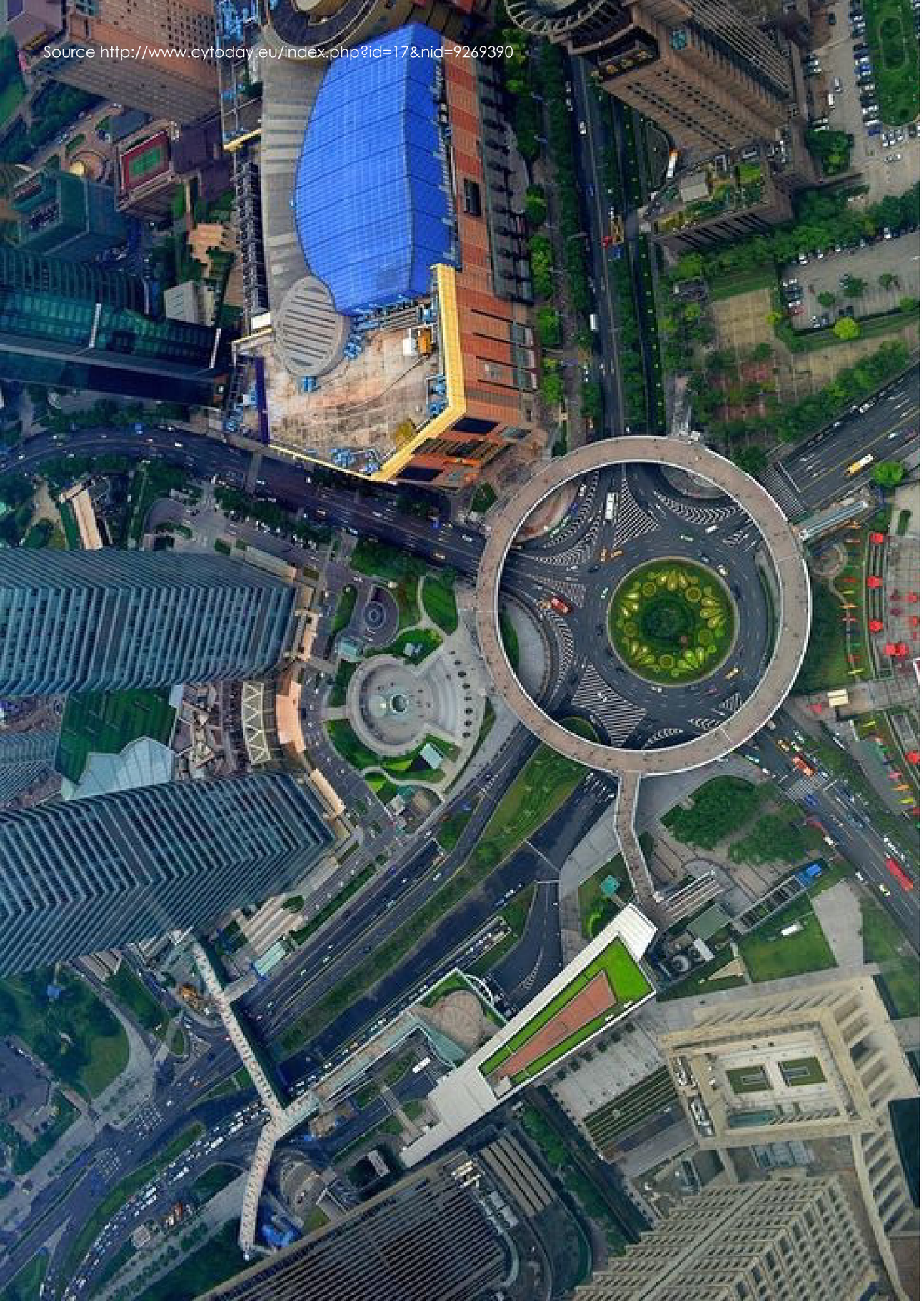
1. Highlighting new urban axes to adjust the urban operation, spatially and economically.

2. Redefining the boundary of railway area, dealing with the negative physical influence and creating a readable railway image.(including demolishing the enclosing walls)

3. Transforming the surrounding gated blocks into a new typology which towards to a continuous urban fabric, integrating the scheme into the surrounding context.

4. Urbanizing station square. A well-integrated and characteristic destination where the comfort of travelers and local residents is put first.

5. Consolidate the railway services and free up space for potential development, funding the previous improvement. Delimits the area with a frame. Different developers can take on the buildings, guaranteeing a diverse development. And the railway yard is left completely untouched, opening it to the future expansion or redevelopment.(Possible topology: parking, parks, creative industry workshop, office tower)



Source http://www.cytoday.eu/index.php?id=17&nid=9269390

3.5 Network operation

As a mobility environment, railway station areas are the places where many mobility flows interconnect, namely regional level flow, city-level flow and local-level flow. Although there is an interactive relationship between these three layers, this interaction presents more of a one-way effect. Among three levels, local level owns the largest amount of streets, but for guaranteeing the larger scale mobility, like regional scale or city scale, it still owns the lowest status given by urban supervisors and designers. Specifically, when conflicts arise across levels, larger scale grids get priority, while the local level is often sacrificed first. This understanding can well explain the existence of different types of intersections (tunnels and dead-ends) around the railway. Tunnels or bridge appears when the city-level network (e.g. Main road) needs to cross regional network (e.g. Railway). But when local roads hope to pass through the tracks, they are mostly cut off, due to the lowest status. Larger grids got the weakest interference, at the expense of connection on the local level.

3.5.1Network Operation

1. Car-oriented Road
2. Pedestarin Path

Vehicle-Oriented Network
Fragmented Walking Space

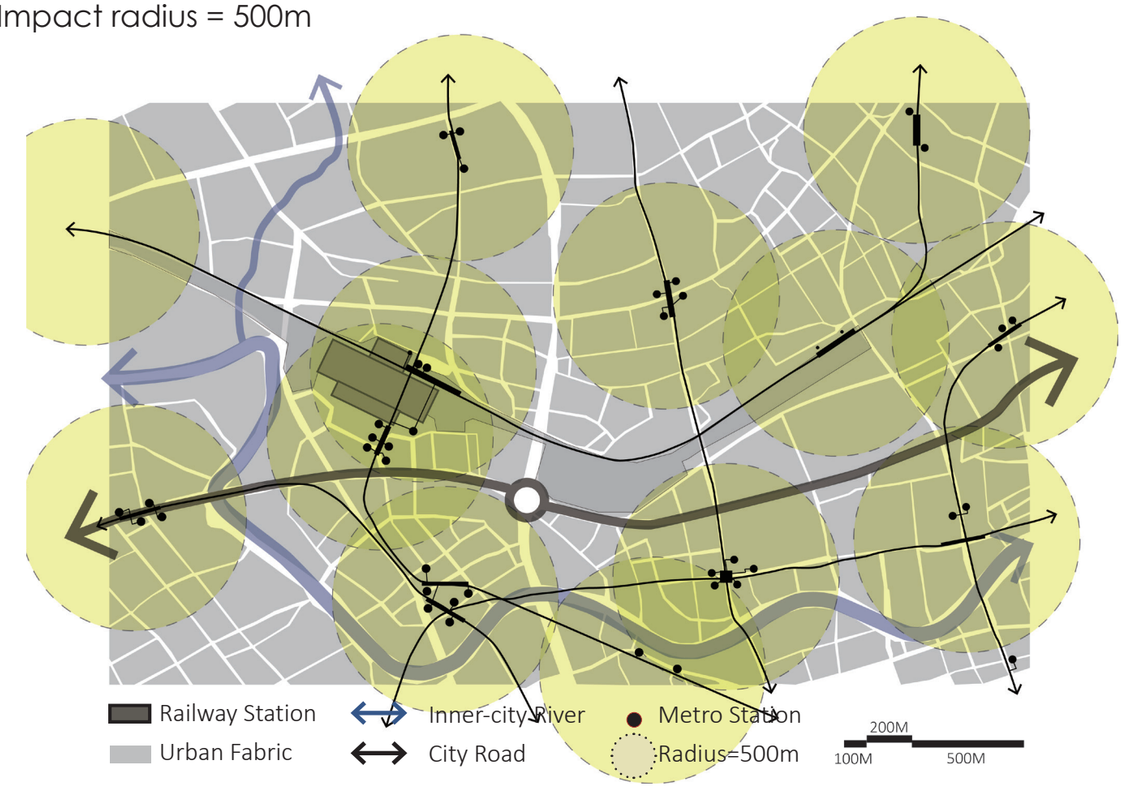
Traffic-oriented priority is not only reflected between motorized traffic, but also reflected in the fragmentation of the pedestrian system. In order to meet the maximum operational efficiency of motorized traffic, the pedestrian space was squeezed to lead a discontinuous walking system. Also shown as a tortuous route and detour situation.

Metro System & Bus System

Due to the agglomeration effect of the railway station, a large number of public transportation stops are concentrated around this area to meet people's transfer demands for multimodal traffics. However, as shown in the right figure, The coverage radius is selected by walking distance, 300 meters, and 500 meters respectively, some areas are still not well covered. The causes of these problems are either tortuous road network or the existence of large-scale gated communities.

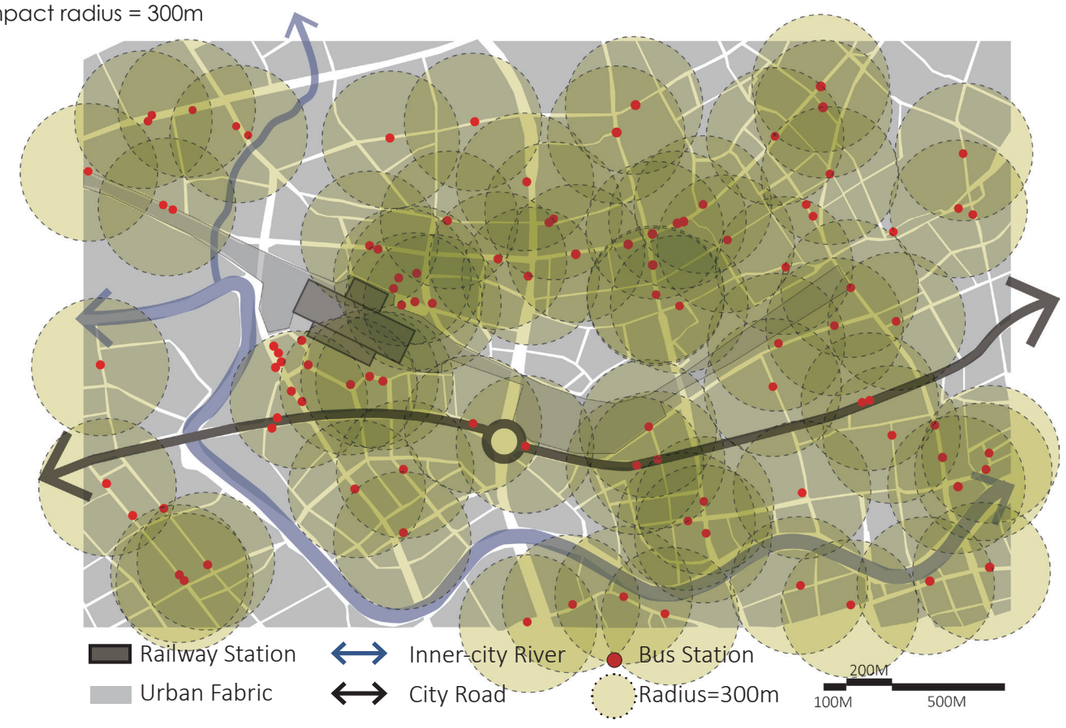
3.5.2 Metro Stations

Impact radius = 500m



3.5.3 Bus Stations

Impact radius = 300m

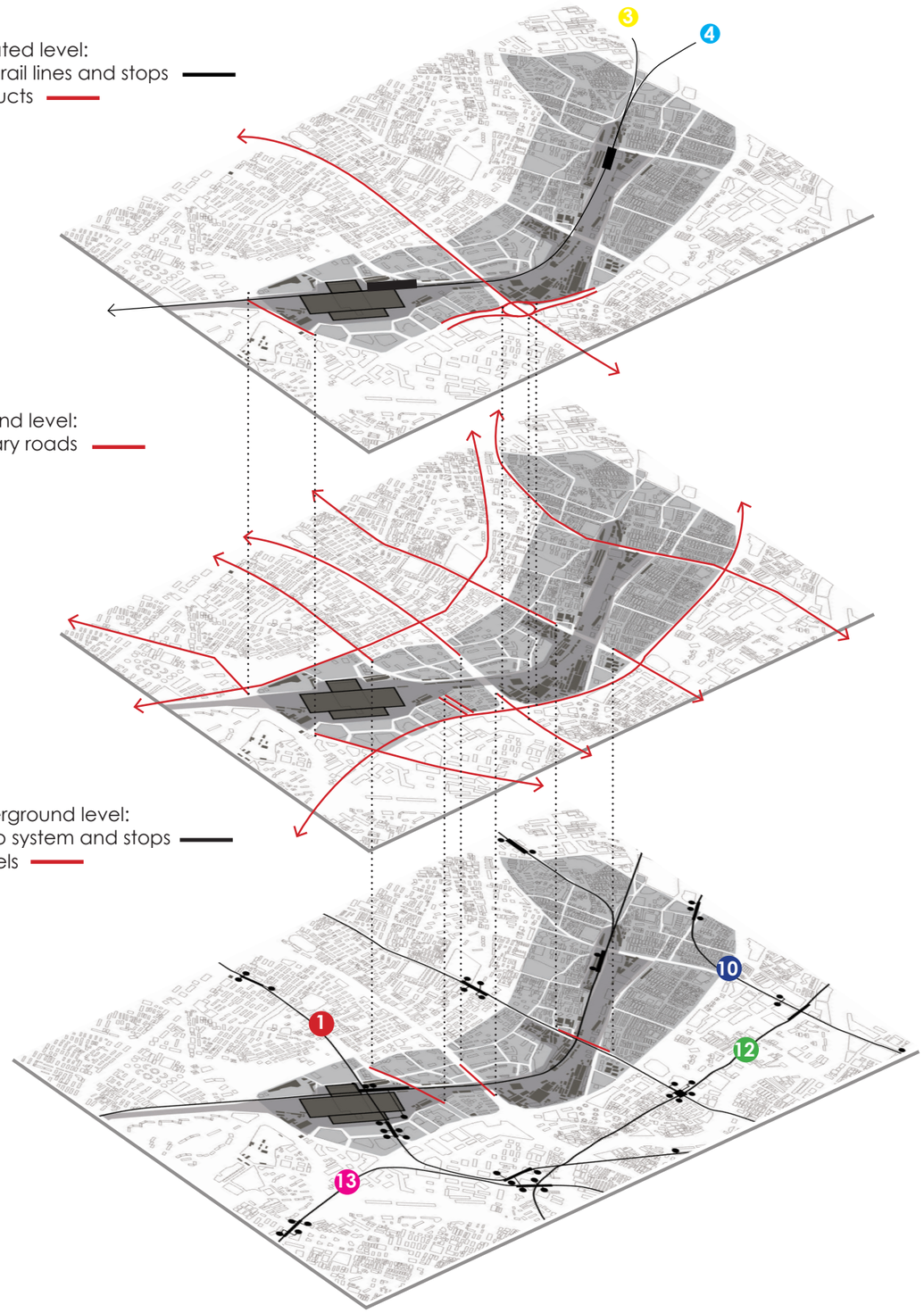


Layered infrastructure

Elevated level:
Light rail lines and stops
Viaducts

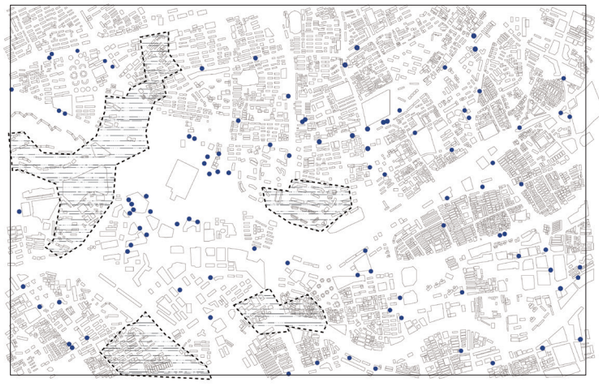
Ground level:
Primary roads

Underground level:
Metro system and stops
Tunnels

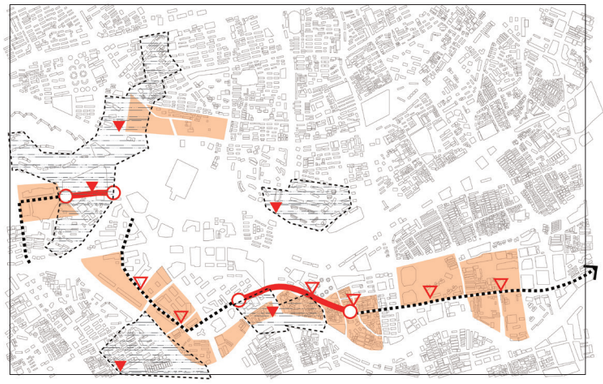


3.5.4 Issues and possible solutions

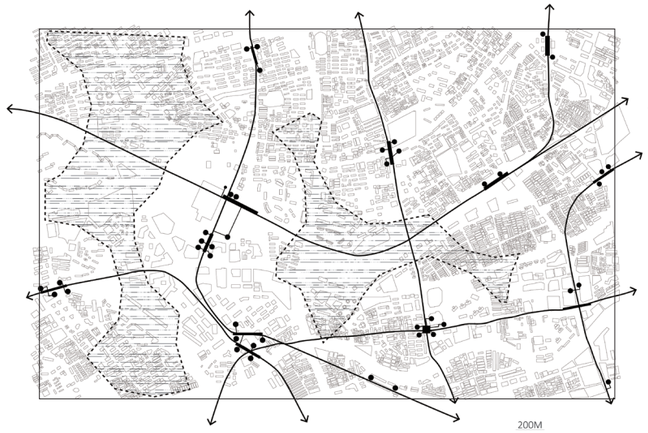
poorly connected area of bus system



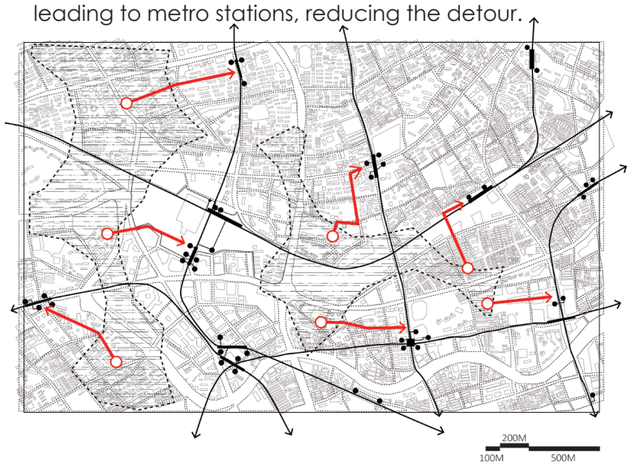
Introduce new bus stops and promote new bus lines in the developing blocks



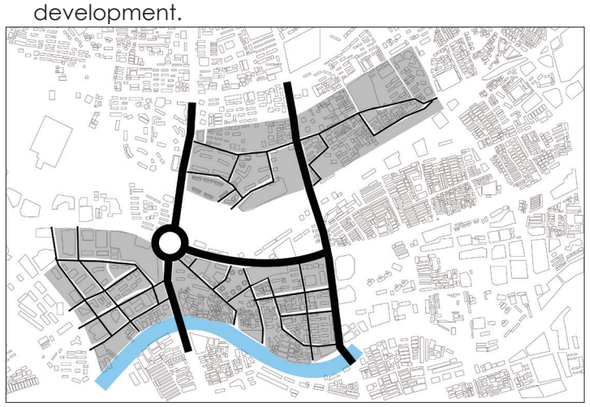
Uncovered area of Metro system



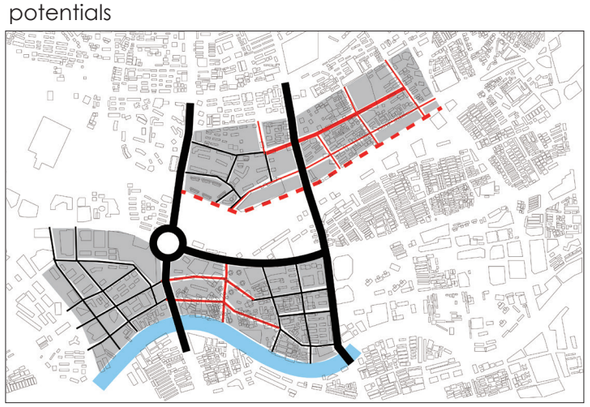
Open gated communities which block the routes leading to metro stations, reducing the detour.



Road system: Tortuous network
Strange shape blocks further lead to the difficulty of development.



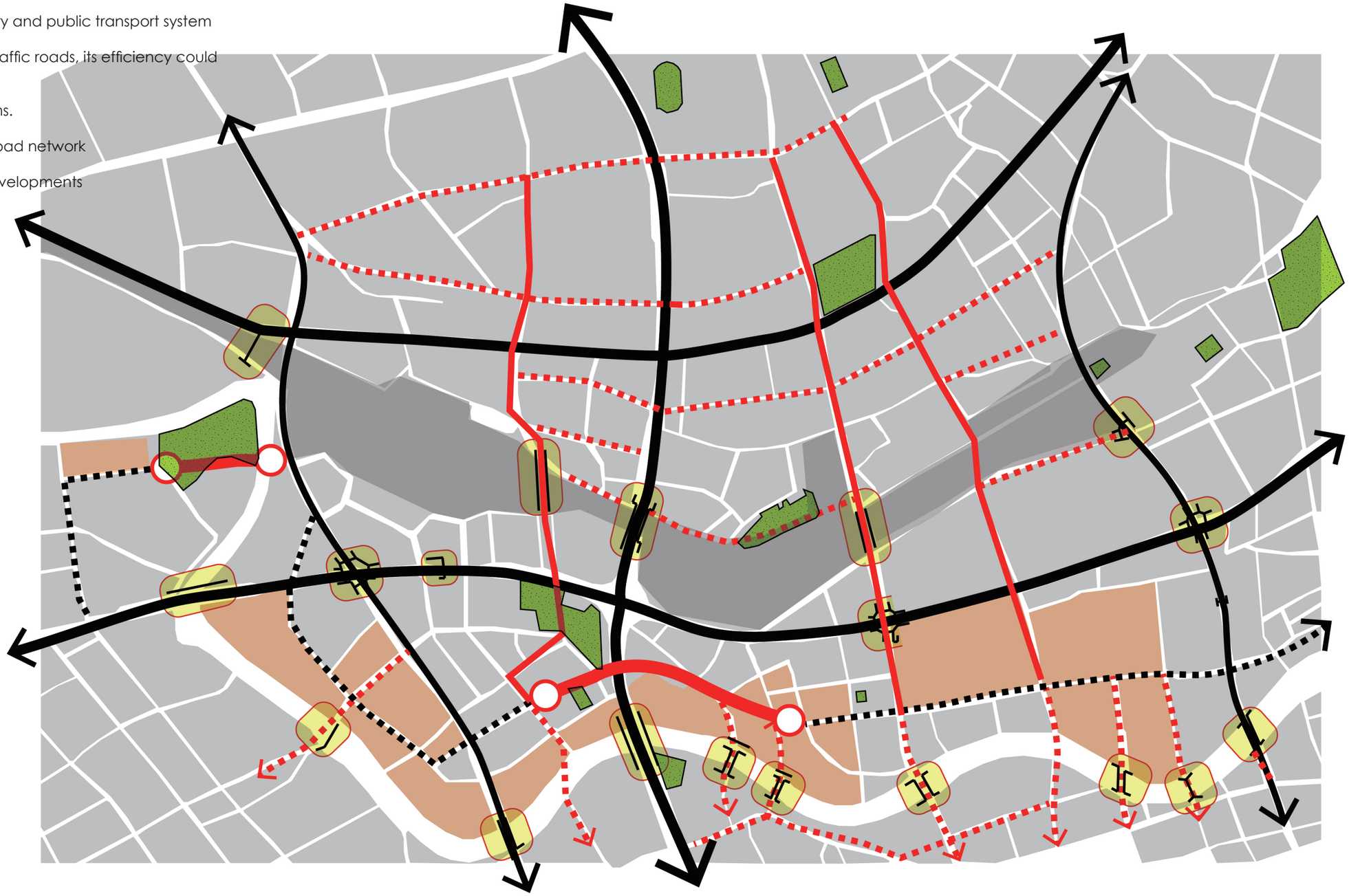
Adjust tortuous network which has high economic potentials



3.5.5 Proposed Traffic Structure

Conclusion Map

1. Walking routes based on greenery and public transport system
2. By reducing the pedestrians on traffic roads, its efficiency could be improved.
3. Links between the last two systems.
4. Adjust two parts of the tortuous road network
5. Add new bus routes for future developments



The approach needed for proposal is to ensure a dense enough pedestrian and bicycle network such that large detour factors are not imposed on cyclists and especially pedestrians. This can be achieved with a clear and direct network structure, increasing density of the street and path network. At the same time, the small-scale block also helps to provide a finer grid of public pedestrian paths.
All in all, for new proposal, the following movements are encouraged, namely block redistribution, adding extra roads, introducing slow traffic, the road section optimization and dead-ends relink.

Poor Walking Experience

How to promote walkability in the Shanghai Station Area?

Due to the broken links to other public resources, station square is regarded as an isolated enclave, instead of an integrated space in the urban setting. Due to the fragmented walking network, social resources are not well integrated.

Pilot project

Fragmented walking network
Poorly integrated social resources

Passenger Square
A huge amount of daily passengers

Dark underground tunnel
150 meters long underground tunnel

Only one footbridge for pedestrian

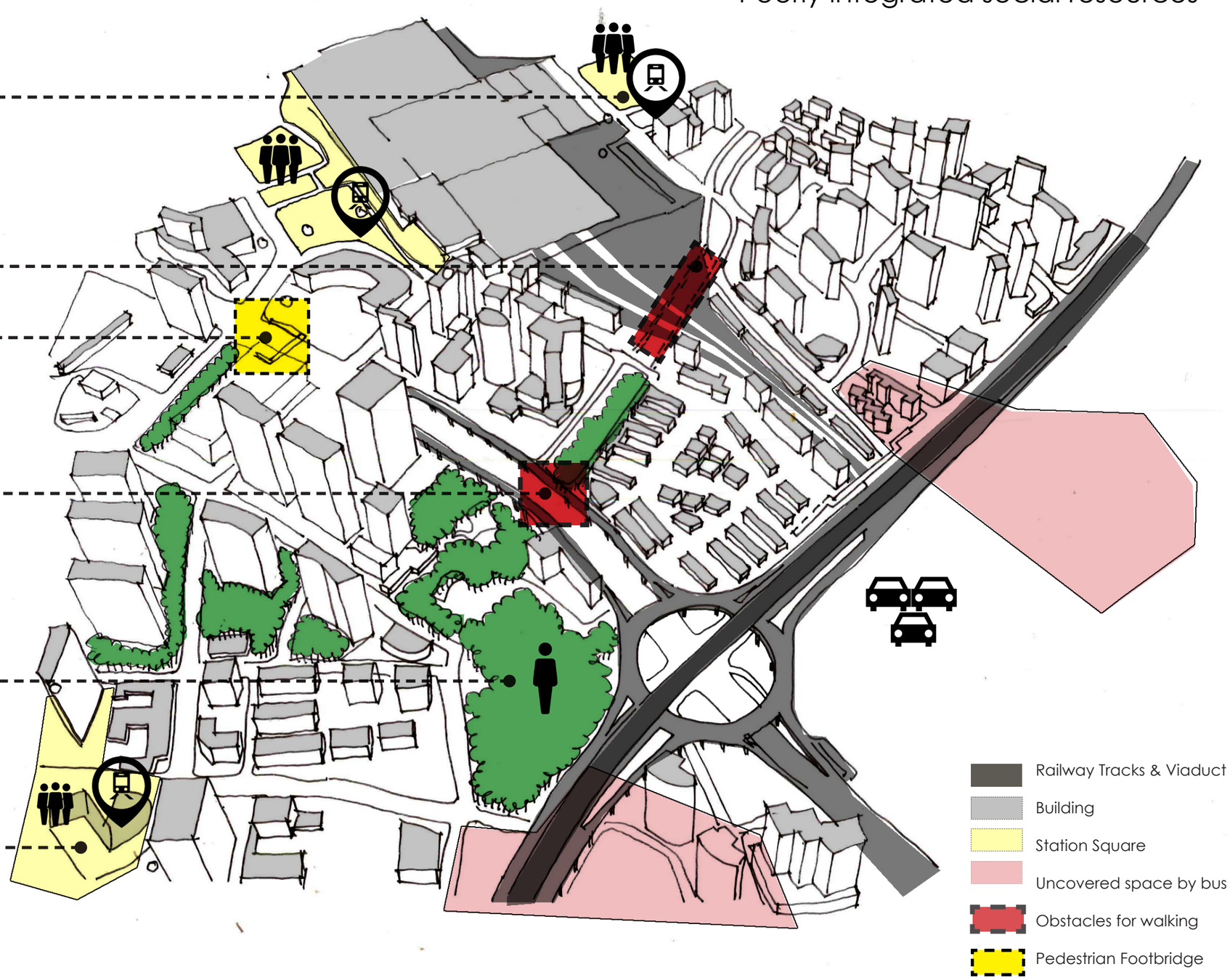
Vehicle-oriented urban environment
Huge traffic volume with a viaduct

Low Use of the City Park

Buyecheng Park is 500 meters far away from the Shanghai railway station, and is one of the biggest inner city parks. But with the poorly connected to public transportation, the usage is lower than expected.

HanzhongLu Business District

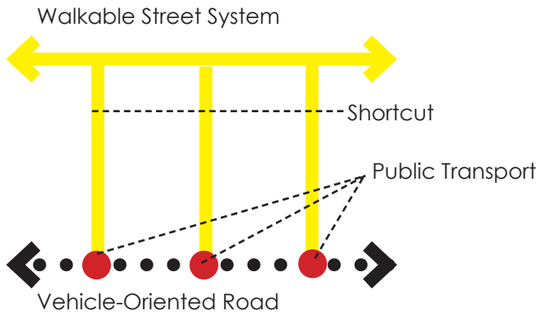
Hanzhonglu business district is a potential commercial center along the inner-city river, which is supported by the Shanghai waterfront development policy. Metro line 2 passes here, containing 10 exits.



Fish-Bone Shaped Walking System

How to achieve an Urbanized station square?

Due to the broken links to other public resources, station square is regarded as an isolated enclave, instead of an integrated space in the urban setting.



Creating a new walkable Street System

The new walking route should be designed along the existing public system, including metro stations and bus stations, and with the major metro stations as the key nodes.

Shortcuts as the link between the walking system and vehicle road

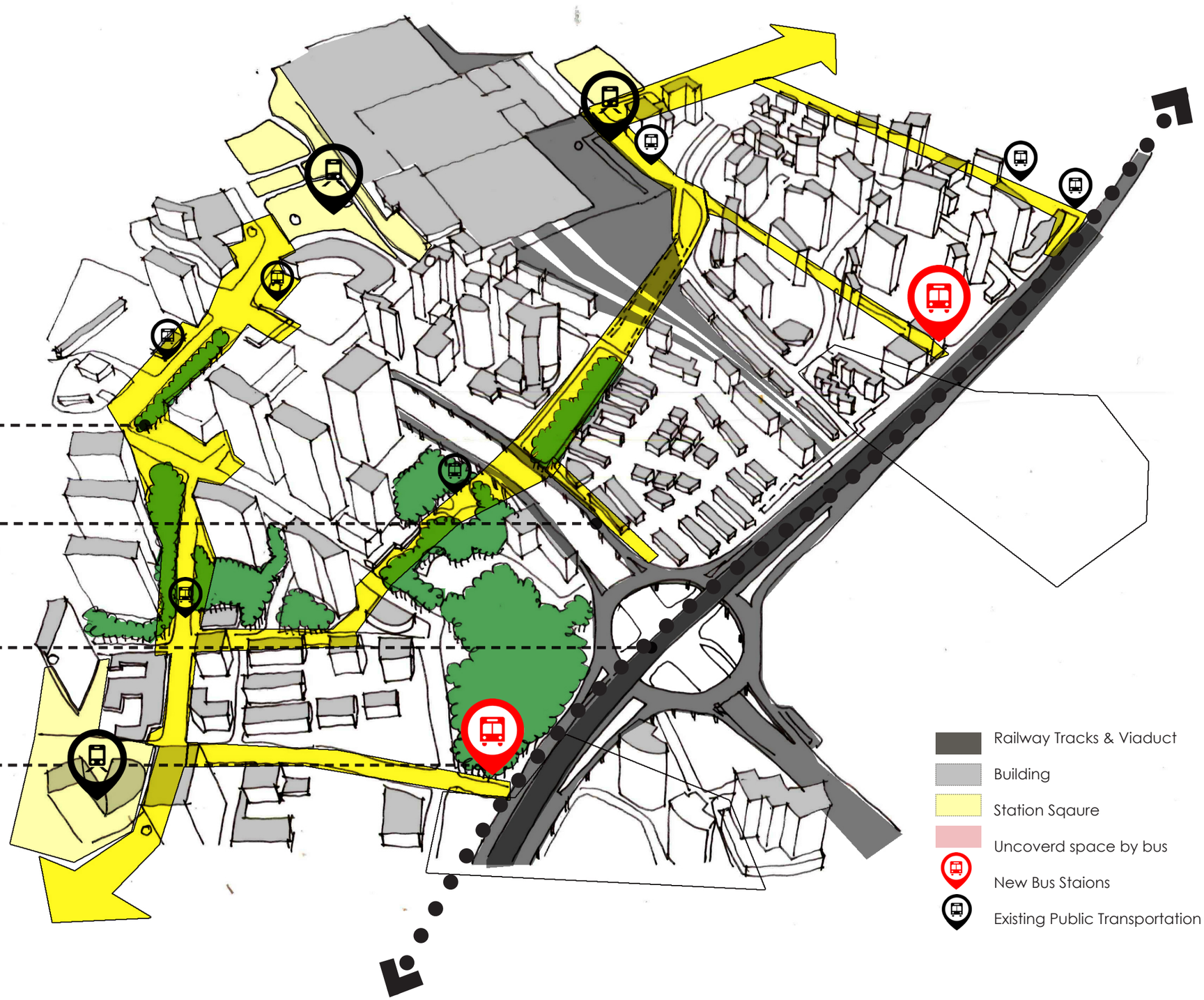
Maintain the Vehicle-Oriented Road

Adding new bus stops in the poorly connected area

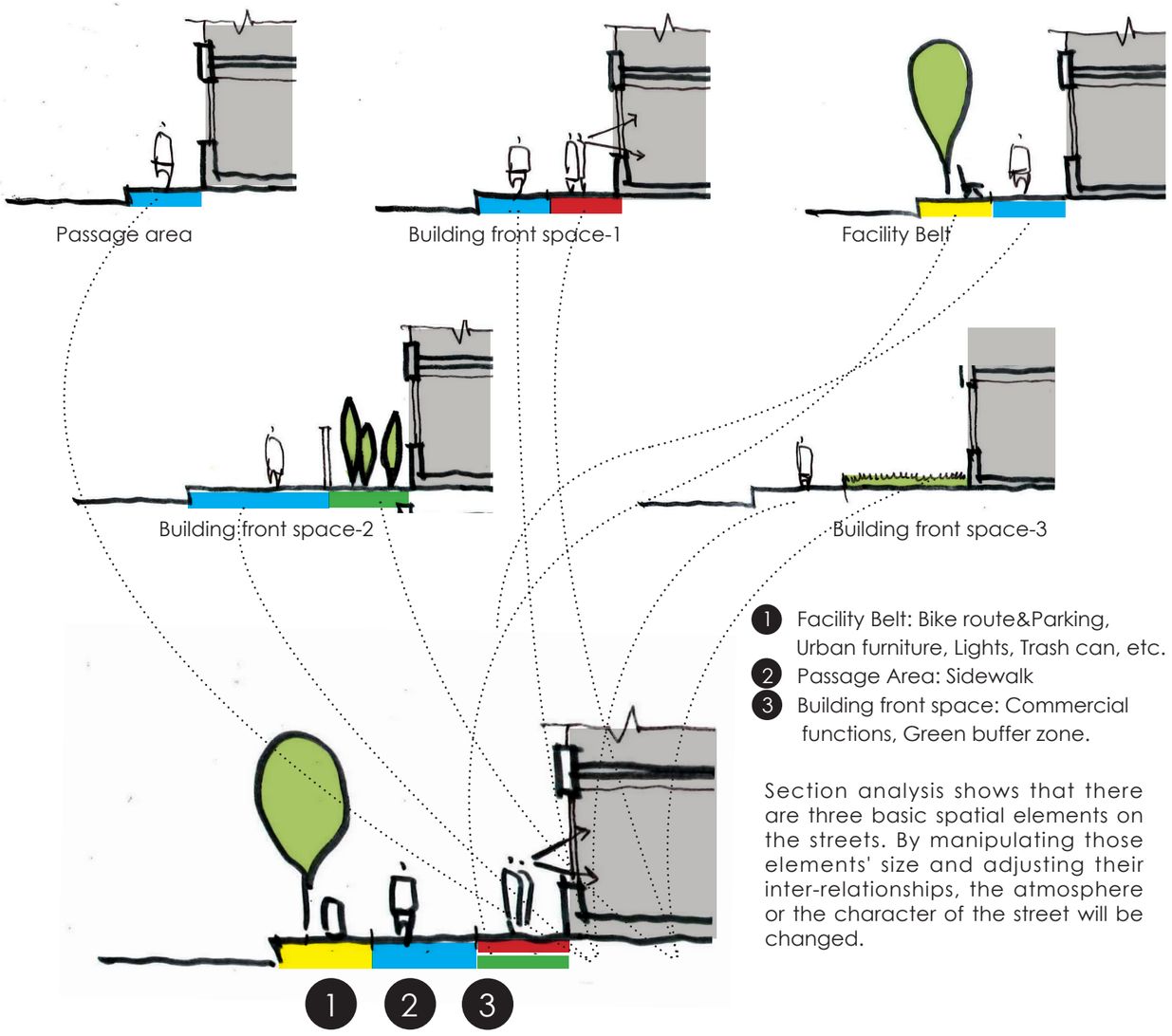
According to the traffic analysis, the red colored area is poorly connected to the bus system. So the new walking route should consider adding new bus stops there, completing the accessibility of the whole station area.

Pilot project

Multiple transport network



Street Spatial Elements

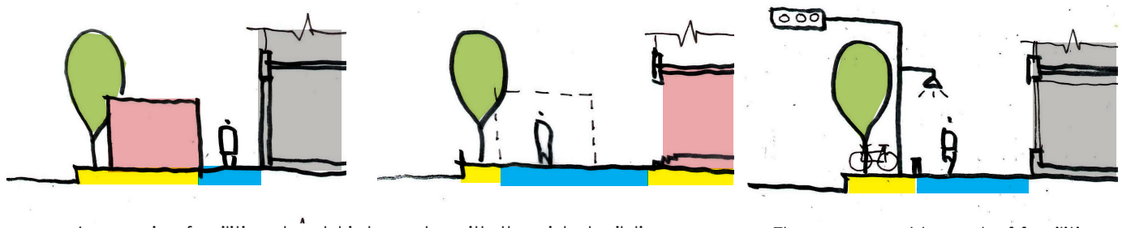


1. Facility Belt: Bike route&Parking, Urban furniture, Lights, Trash can, etc.
2. Passage Area: Sidewalk
3. Building front space: Commercial functions, Green buffer zone.

Section analysis shows that there are three basic spatial elements on the streets. By manipulating those elements' size and adjusting their inter-relationships, the atmosphere or the character of the street will be changed.

1 Facility Belt Design

Basic Design Principle: Facility belt should not occupy the passage space.

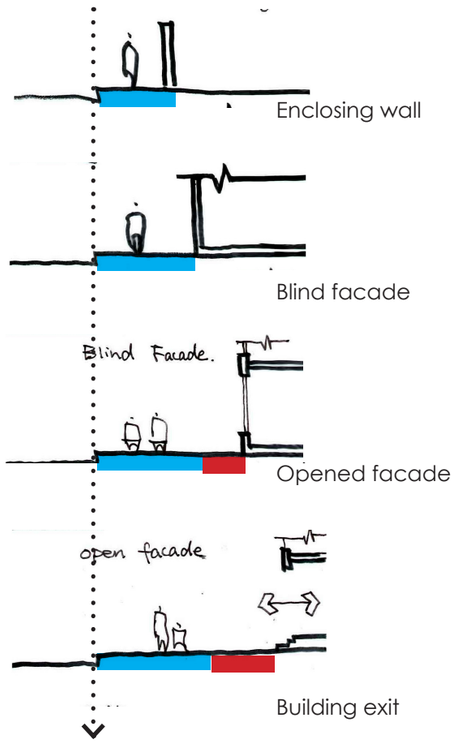


-Large size facilities should integrate with the side buildings.

-The compact layout of facilities

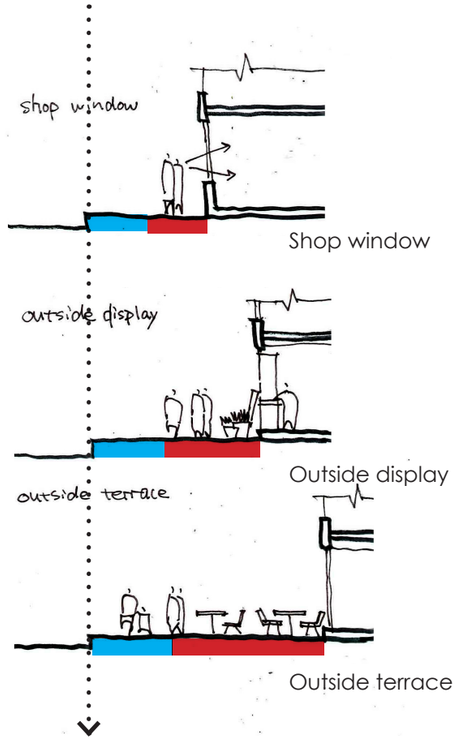
2 Passage Area Design

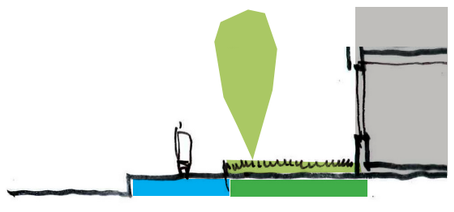
The width of passage area should flexibly change based on the feature of its side building.

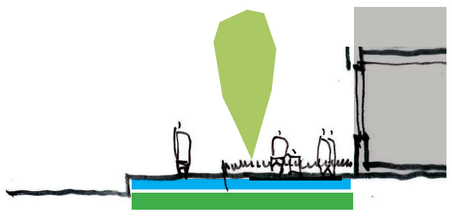


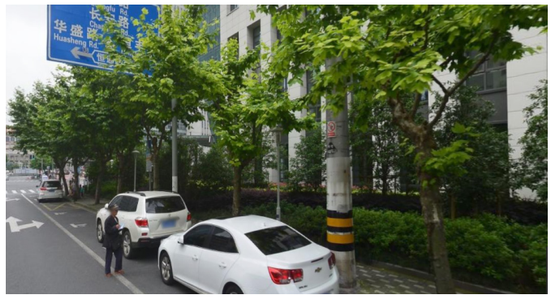
3 Building Front Space

Temporarily borrows space from facility belt.

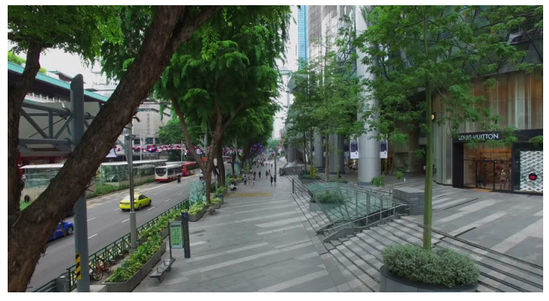




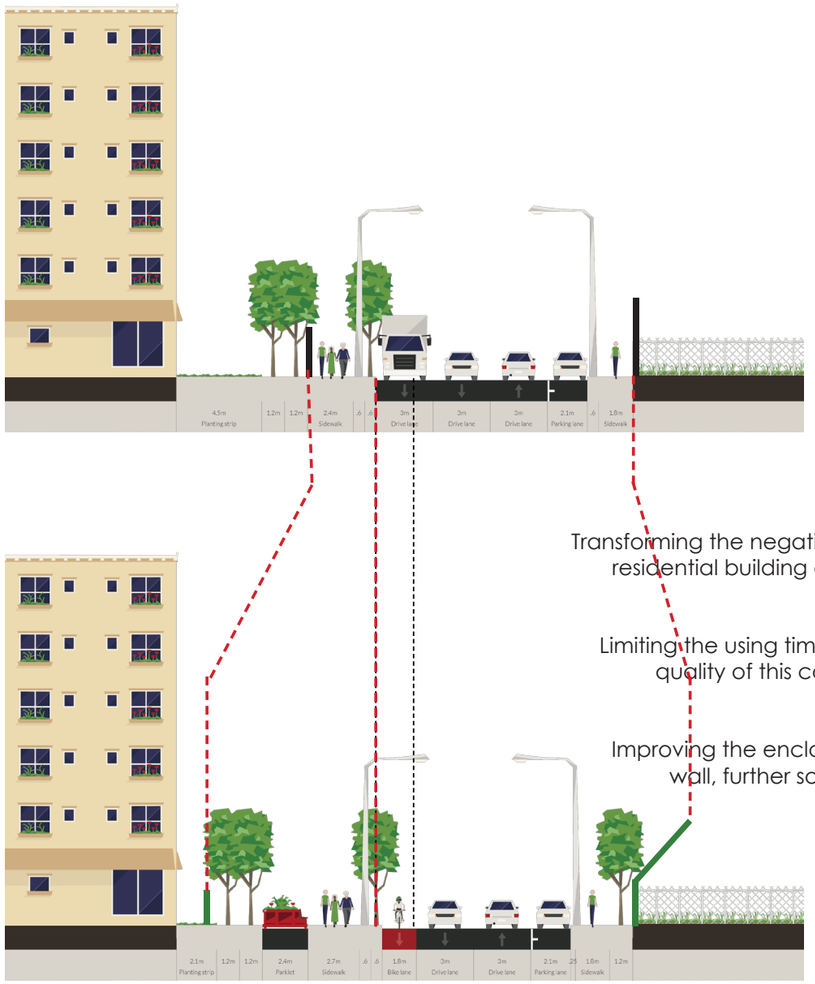




Narrow sidewalk and negative greenery



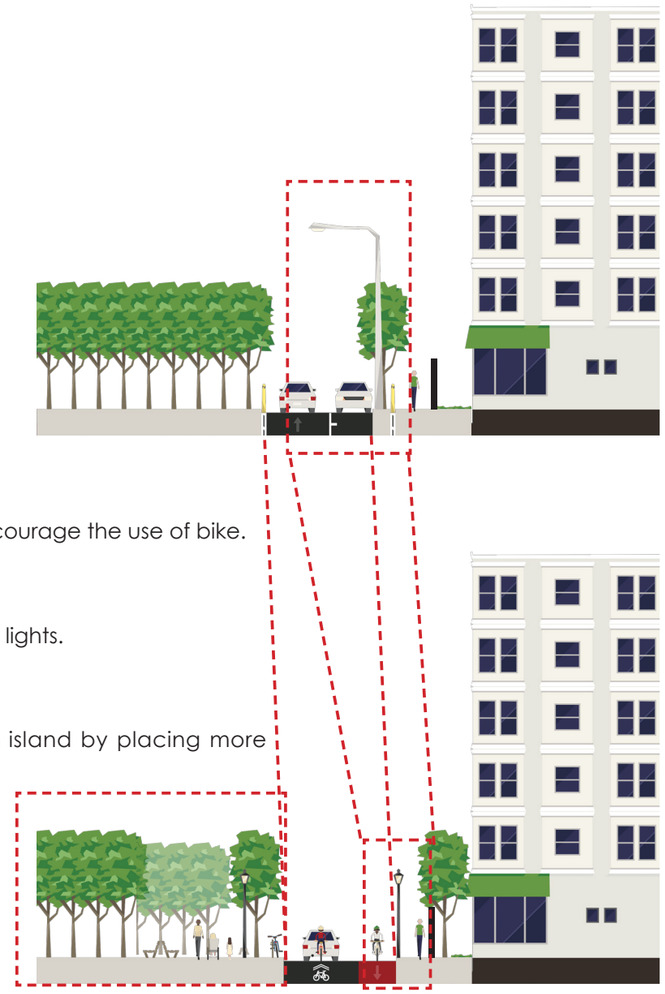
Combine side with and Greenery
Replace grass with Permeable brick



Action 1:
Transforming the negative greenery buffer zone between residential building and sidewalk into the leisure area.

Action 2:
Limiting the using time of truck, guaranteeing the living quality of this community road. Adding bike lane.

Action 3:
Improving the enclosing wall into a hanging greenery wall, further solving the dust and noise pollutions



Action 1:
Transforming vehicle lane into sharrow to encourage the use of bike.

Action 2:
Shrinking the size of urban furniture, like street lights.

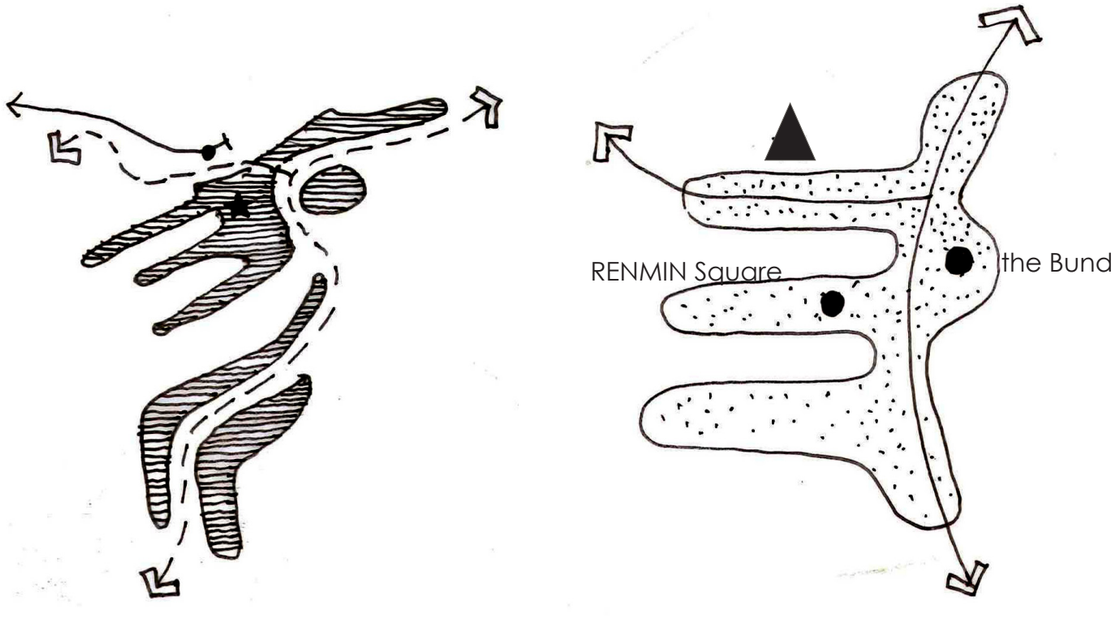
Action 3:
Encouraging leisure activities in the green island by placing more seats.

Source: http://www.heatherwick.com/projects/buildings/moganshan/

3.6 Economic Performance

Today, the development of high-speed railway technology releases a large amount of space, offering almost unprecedented opportunities for solving the current dilemma and introducing much needed space for city development. The long continuous lines along the railway embankment are considered as the important strengths that could provide public space and developable space. A transformation of current track yard could be considered if there is an urgent lack of development space or promote that highly profitable economic structure would be formed. A integration of the railway area into the city system will only be possible if the economic structure orients itself towards the linear area.

3.6.1 Economic Structure in Shanghai region

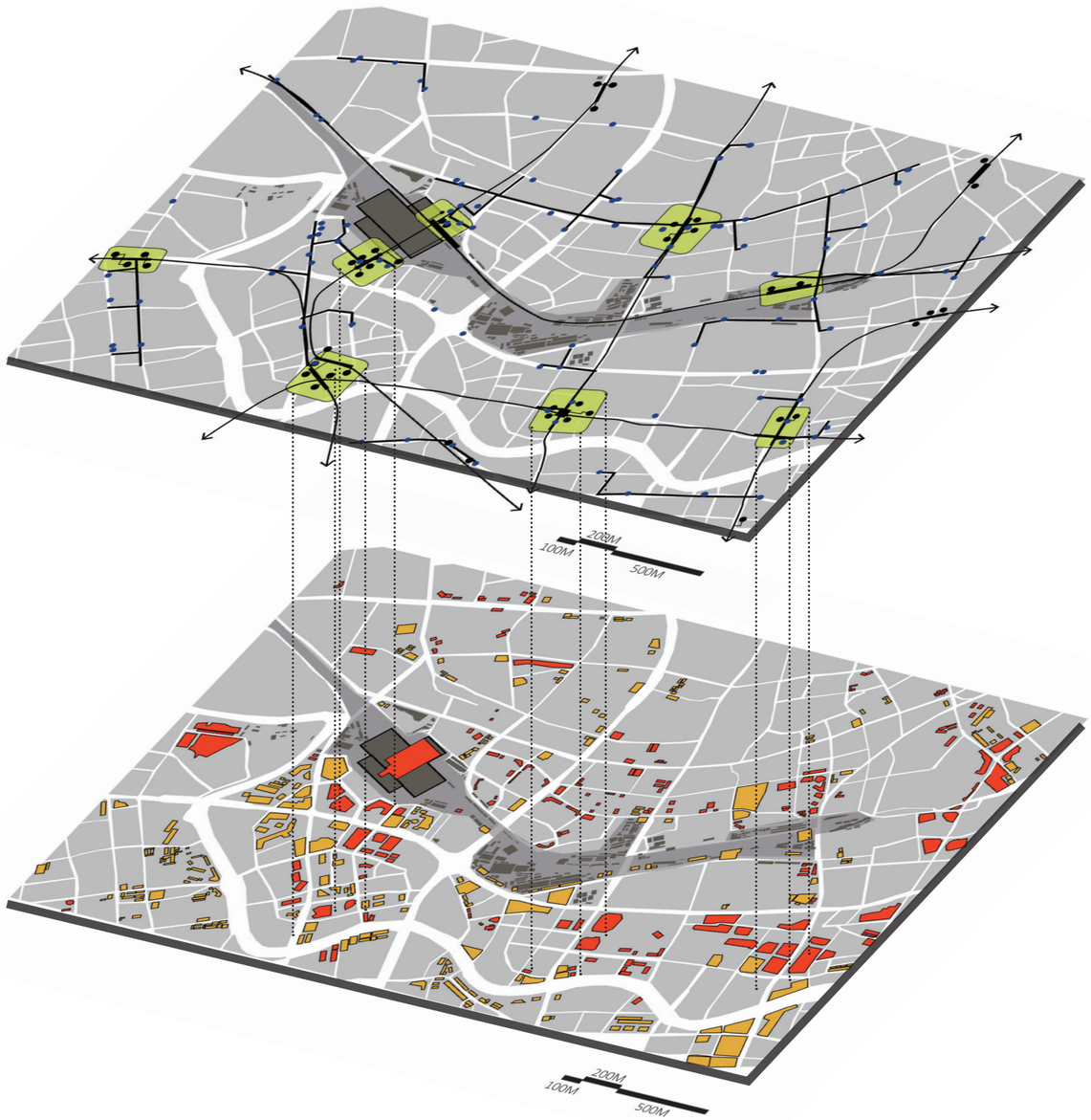


● Economical centers
▲ Site: Shanghai Station Area

Finger-Shape development along the Bund

As shown in the above figure, the economic structure of Shanghai shows a Finger-Shape parallel structure within the city region. however, the lack of vertical links between the north and the south has, to a certain extent, restricted the further improvement of Shanghai's economic structure. And the railway station area is one of the obstacles to the formation of the north-south axis.
At the same time, due to its transportation advantages and functional mix-use features, the railway station area is always prone to attract large amounts of investment and has great potential to become an economic engine.

3.6.2 Commercial Value offered by the metro system

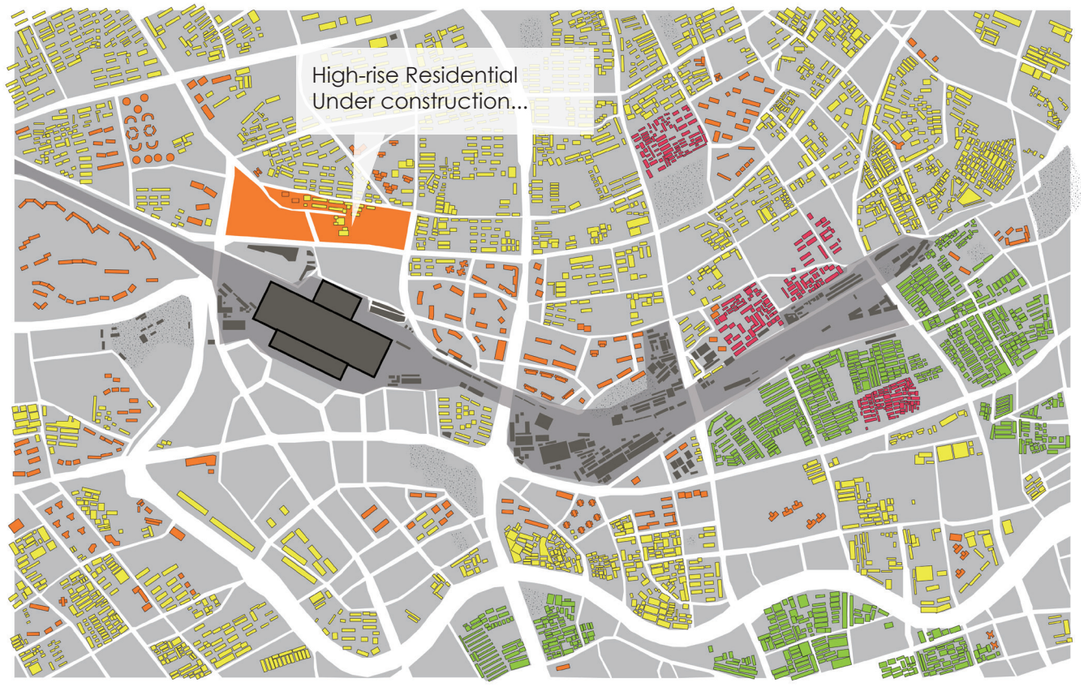


A strong relationship between economy and transport

Railway Station
Urban Fabric
Commercial area
office area
Bus network
Metro line
Bus Station
Centres with location values

3.6.3 Developable space

Low-quality building blocks offer the potential space for future development.



Developable areas and added values

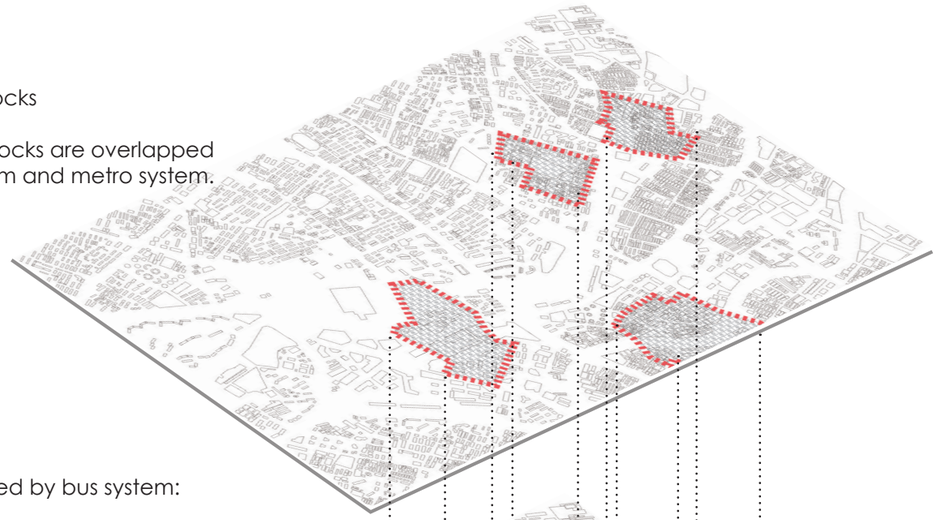
After demonstrating the positive promotion relationship between economic development and transportation system, the research starts to search for space for possible economic development. Based on the analysis of built-up time and building quality, it can be found that the older buildings with poor quality are mostly placed on the east side (as shown by the pink areas in the left page). Judging from the previous development of the Shanghai Railway Station area over past 20 years, these pink areas have a great potential to become the next batch of development land.

The above image further analyzed the preferred development order based on the added value. Sites which near transportation nodes, urban green spaces, and cultural facilities are considered to have priority for being exploited.

3.6.4 Economic potentials

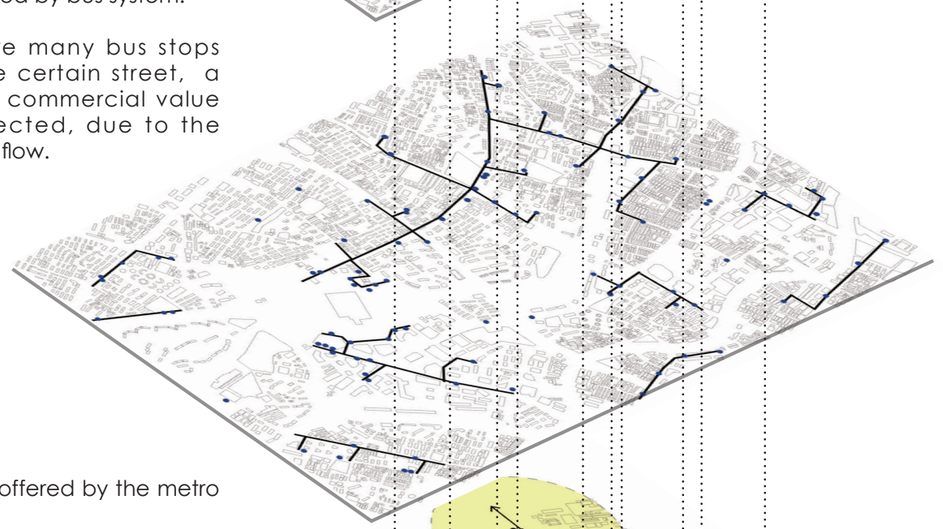
High potential blocks

These selected blocks are overlapped by both bus system and metro system.



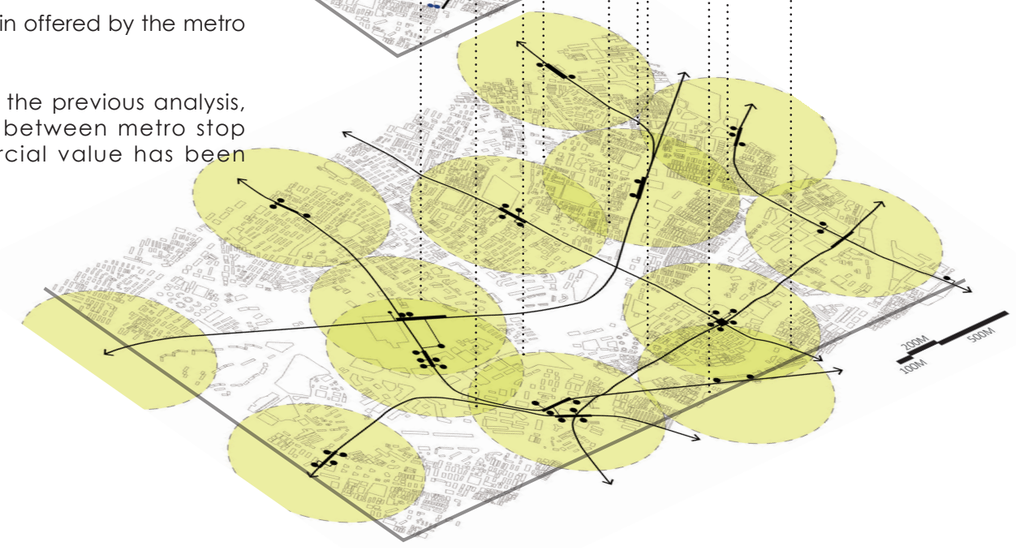
People flow offered by bus system:

When there are many bus stops placing on one certain street, a higher possible commercial value could be expected, due to the intensive people flow.



People fountain offered by the metro system:

According to the previous analysis, a strong link between metro stop and commercial value has been discovered

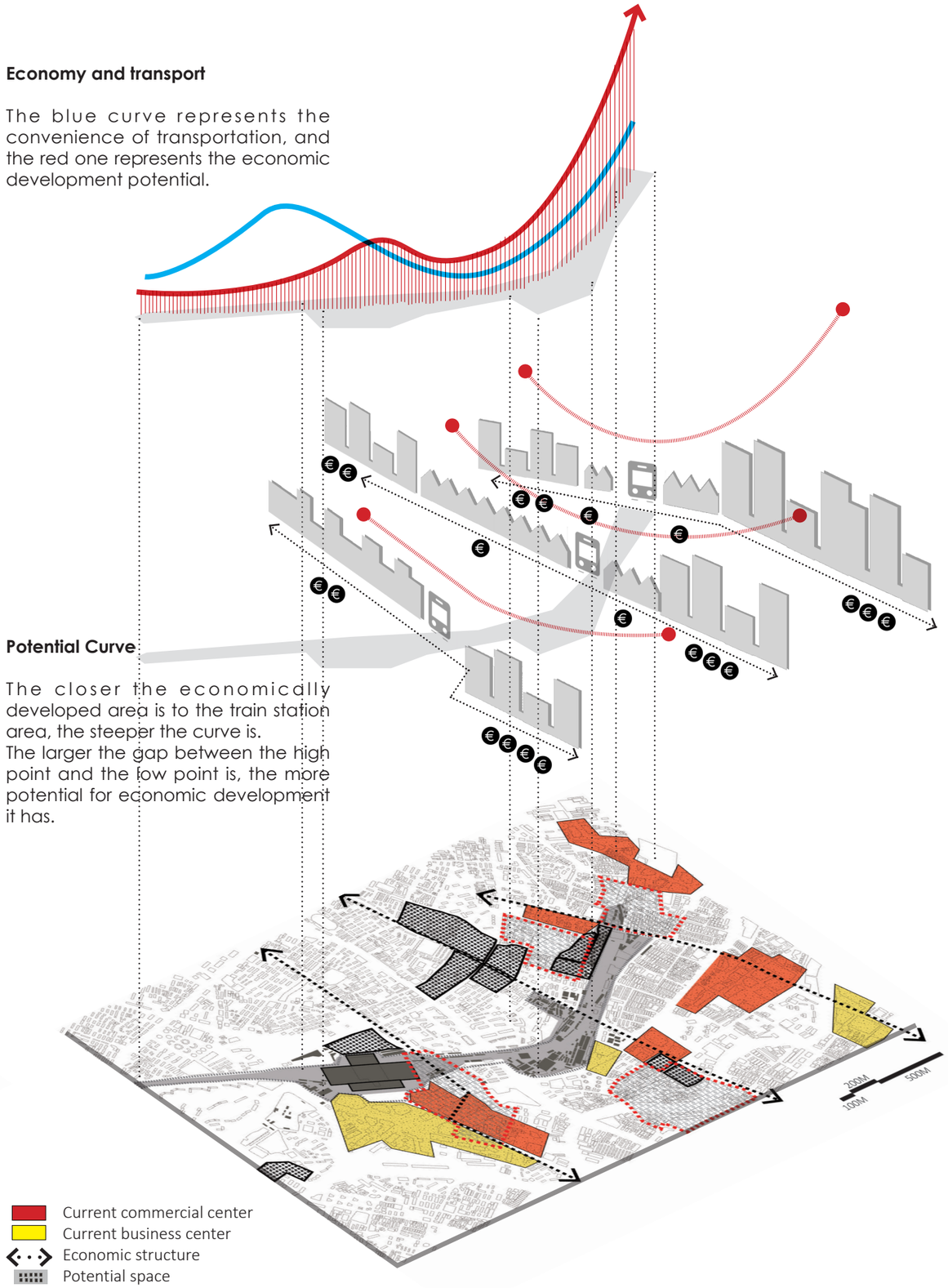


Economy and transport

The blue curve represents the convenience of transportation, and the red one represents the economic development potential.

Potential Curve

The closer the economically developed area is to the train station area, the steeper the curve is.
The larger the gap between the high point and the low point is, the more potential for economic development it has.



Current commercial center
Current business center
Economic structure
Potential space

3.6.5 Proposed Economic Structure

As the map above shows, on the north-south direction, the new economic development axis in Shanghai station area should focus on the east side of the station, which is the end part of the rail yard. It locates close to a metro stop, and also in the middle of the developed commercial street. Moreover, a large area of low-quality logistic function and low-rise bungalows offer the sufficient space for possible investment.

Source https://www.dreamstime.com/stock-photography-night-train-image15487662

3.7 Environmental Quality

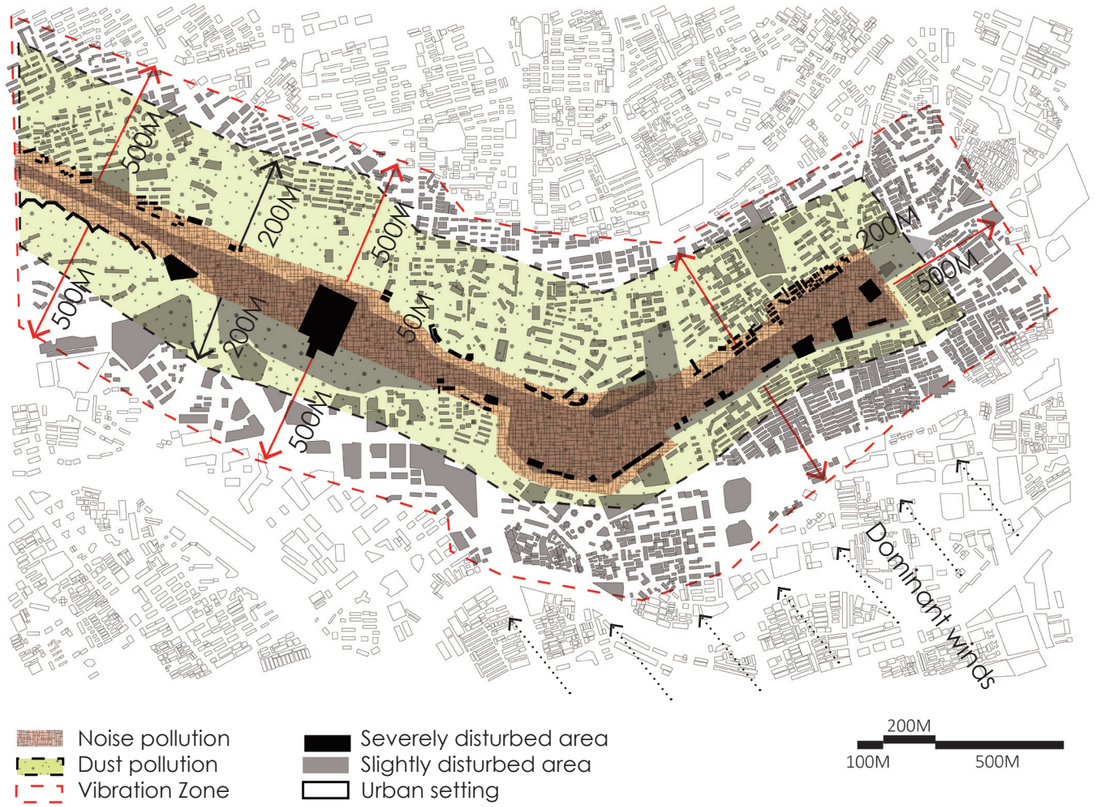
As for the environmental quality in railway stations, this study mainly focused on the pollutions caused by trains and railway tracks, including noise, dust, vibration, and visual pollution. The resulting security issues and maintenance problems are not within the scope of this research.

Noise, Dust, Vibration and visual pollution

Since there are a large number of residential buildings standing around the railroad tracks of the research area, and the above-mentioned pollutions have become the major issue affecting the daily life of surrounding residents. Therefore, after analyzing the theoretical influencing range of each pollution source, each solution for them, such as green belts that help absorb dust and reduce noise, the trench can effectively reduce the physical vibration generated by the train, and so on is also mentioned. Then by overlapping the range of pollutions and existing solutions distribution map, areas that are in urgent need of treatment are drawn up. In the end, the guiding principles are given according to space requirements and economic costs.

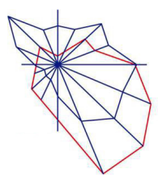
3.7.1 Pollutions came along with tracks

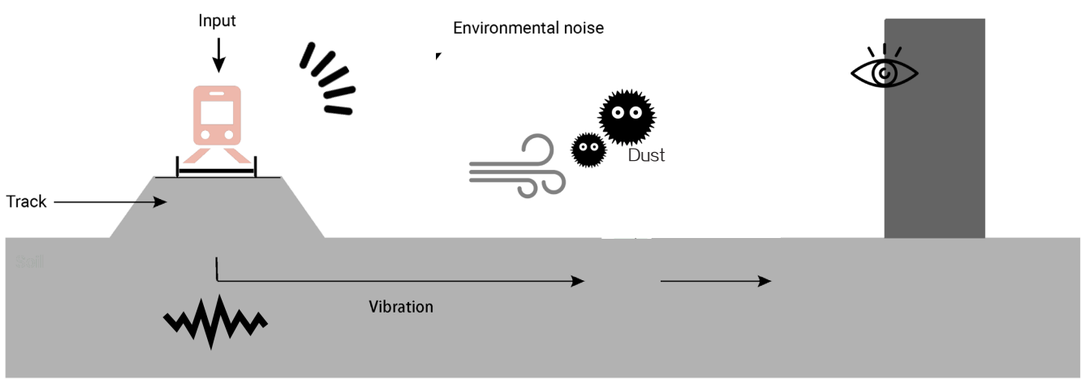
Different types of pollutions



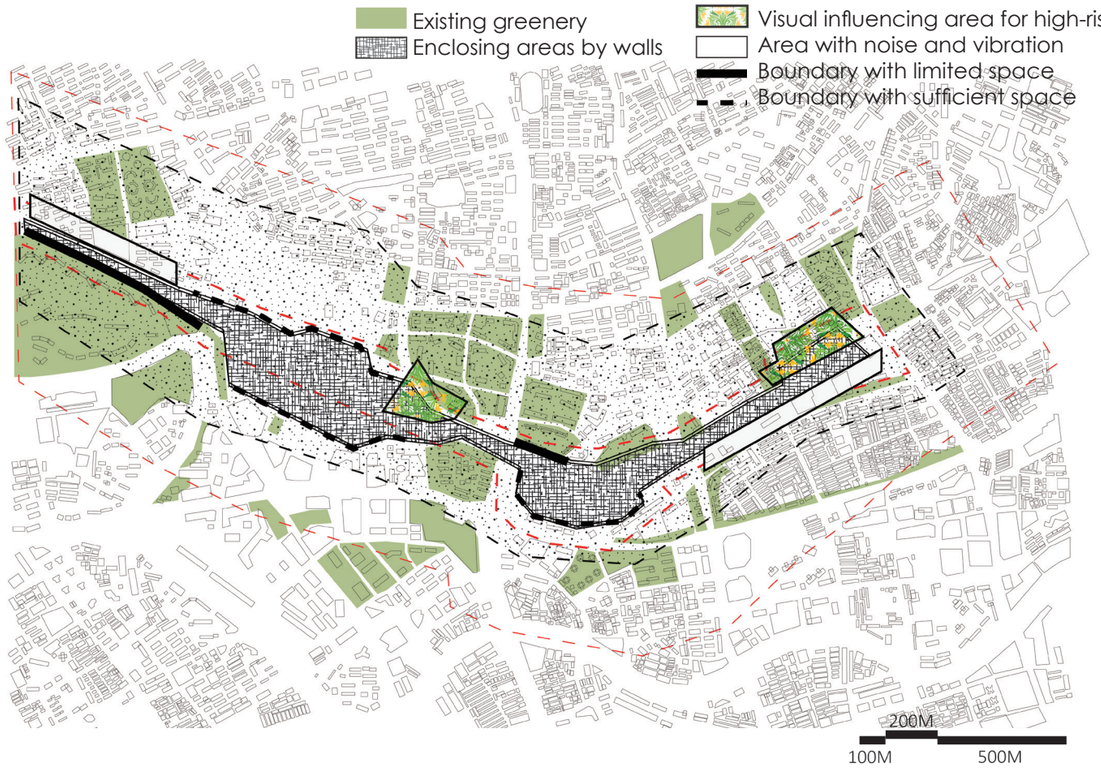
Physical influence of railway

1. Visual influence(mainly for the residential building on the northern side)
2. Dust pollution (Influenced by wind orientation)
3. Noise pollution within 50M (Reduce 3 dB per 10M)
4. Vibration (Theoretical range: 500M)

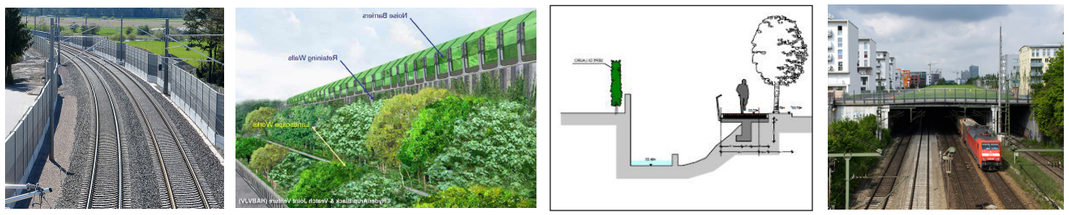




3.7.2 Corresponding solutions

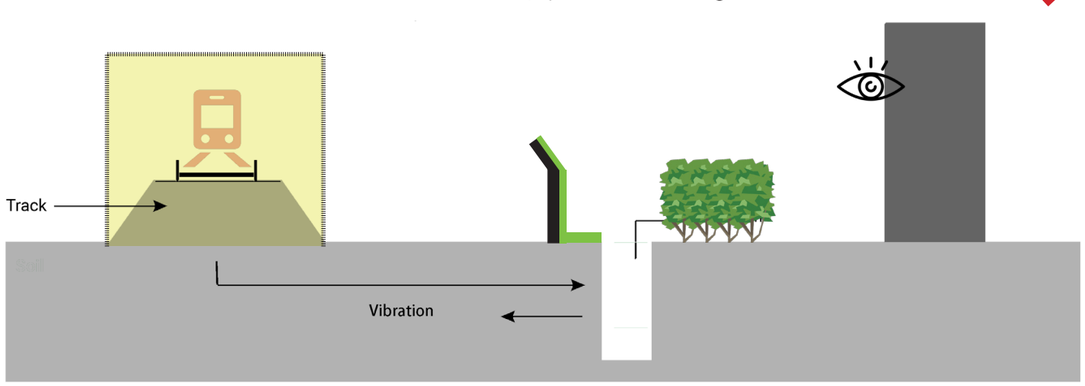


Regular solutions



1. Enclosing wall for noise 2. Greenery for noise and dust 3. Trench for Vibration 4. Cover for all kinds

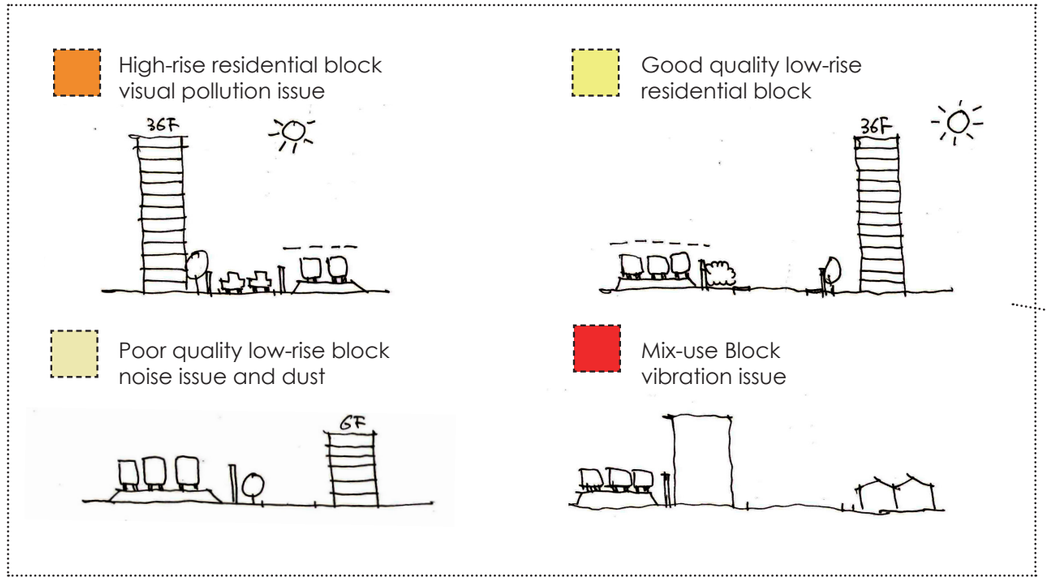
Financial cost/Space consuming



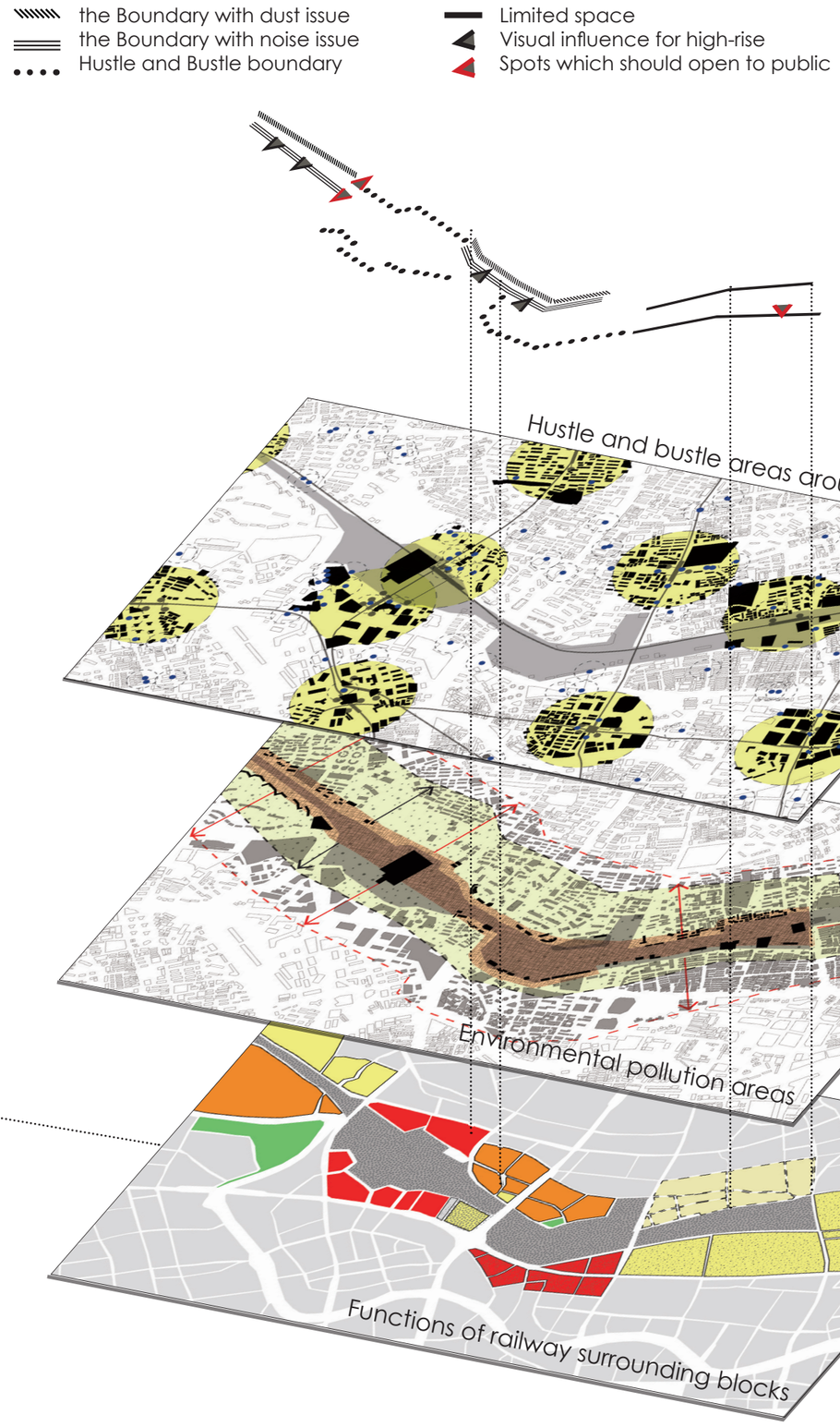
3.7.3 Principles of further improvment

Applying different solutions according to conditions

Element	Location	Condition	Solution
Existing enclosing walls	Boundary of residential function	Limited space	Hanging greenery
		Sufficient space	Trees, even trench
	Boundary of public functions		Open the walls for creating a readable railway area image
Existing greenery	Boundary of residential function	Limited space	Integrate with sidewalk
		Sufficient space	Add leisure functions
Cover for tracks panels	Boundary of public functions		Reduce negative green for offering more walking space
	Areas next to the high-rise building	Low financial profits	light sound-absorbing
		High financial profits	Superstructure

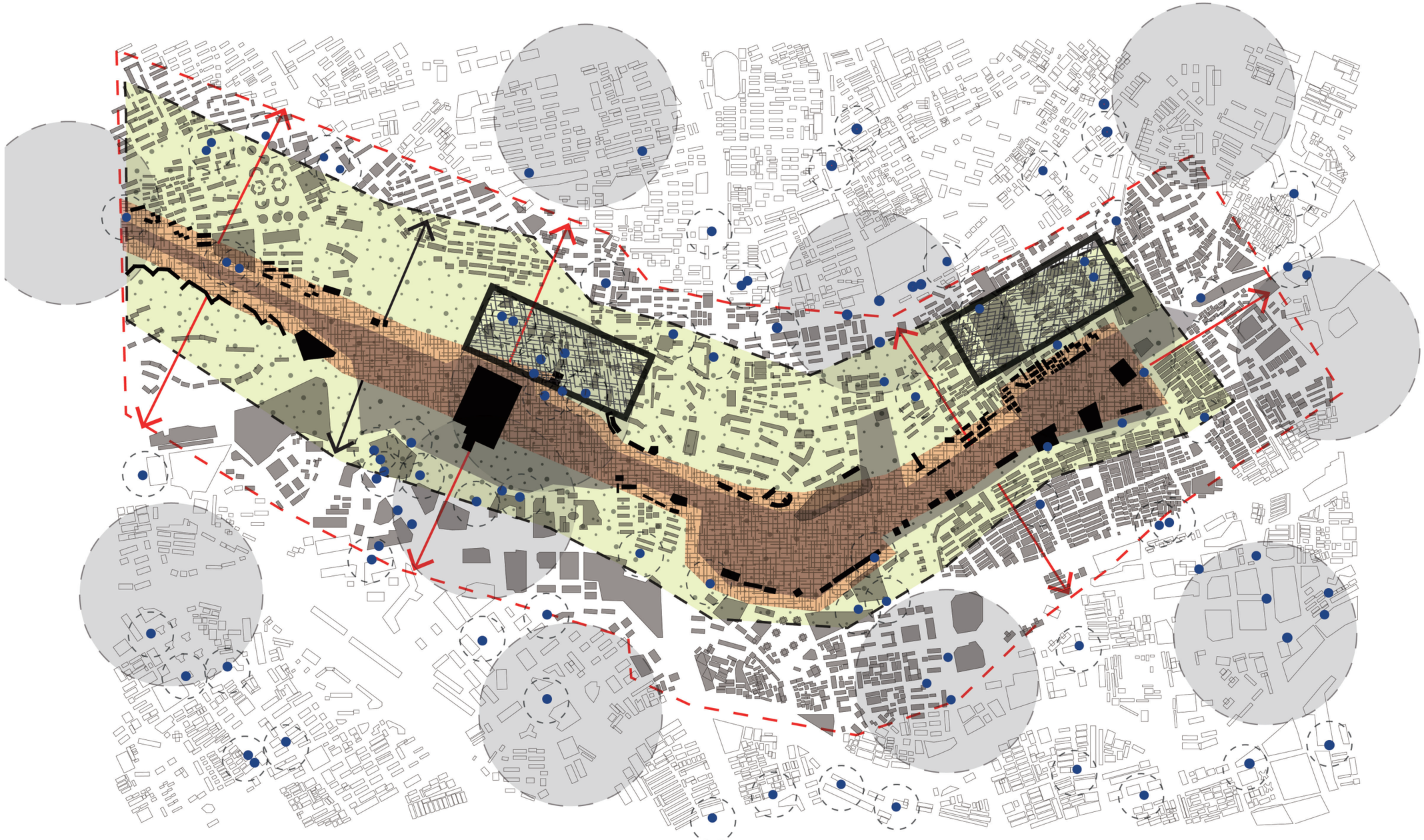


Dealing with the boundary



3.7.4 Environmental Quality Map

Mainly focusing on pollutions caused by trains



In addition to passengers, there are a variety of environmental pollutions along with the railroad tracks, namely dust, noise, vibration and visual impact. These physical effects greatly downgrade the surrounding space quality, especially for residential functions. Moreover, the agglomeration effect of the railway station also gathered other transportation facilities, creating a hustle and bustle environment with a large number of users.
After considering these effects comprehensively, the two regions which are suffering from the most prominent pollution, are selected

Source: https://www.nationalgeographic.com/travel/features/your-shot-travel-pictures/your-shot-street-art-pictures/

SH 3.8 Urban Identity

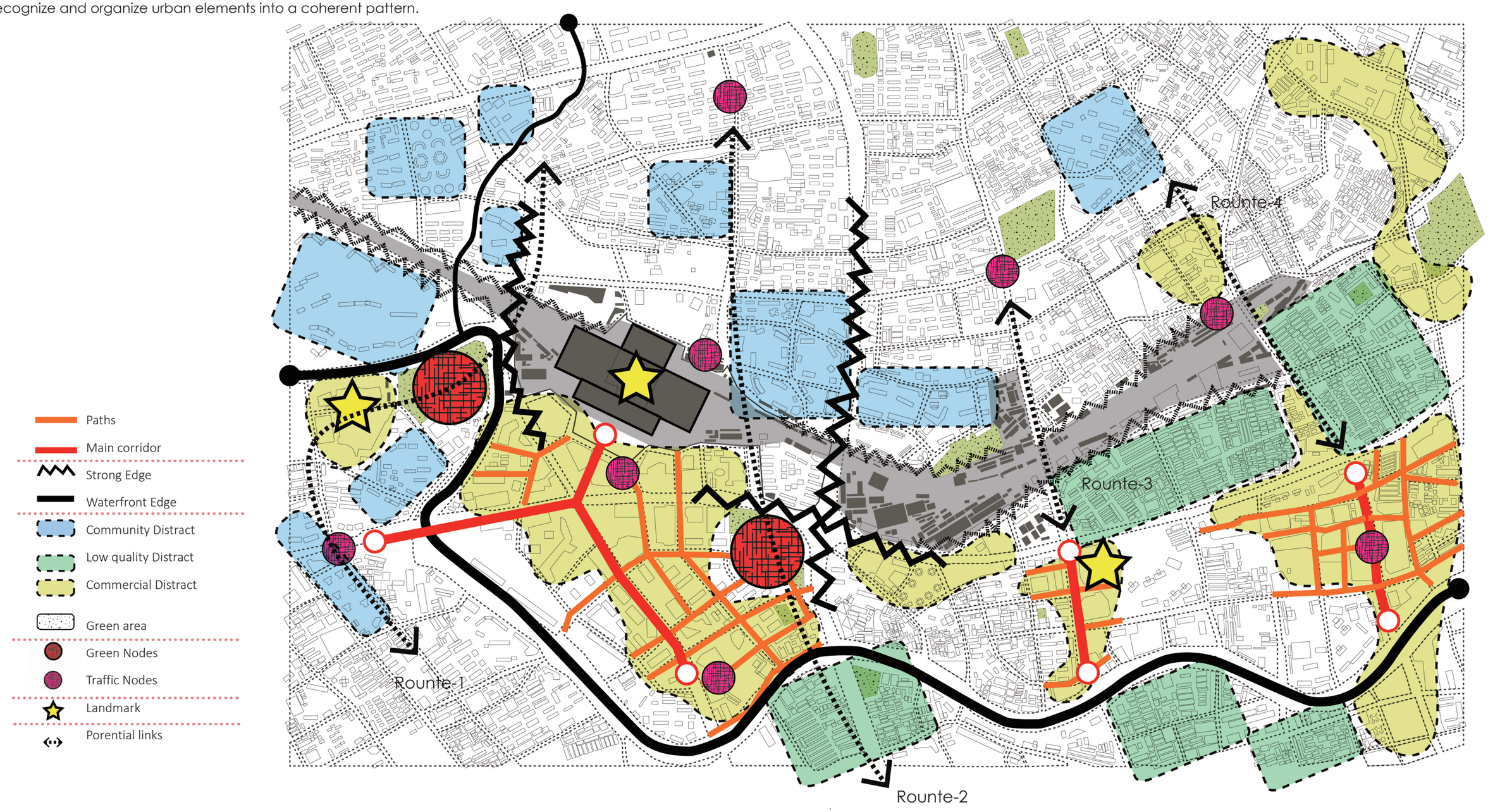
Cities are eagerly looking for some certain way to identify themselves and then to 'show off'. A strong perceivable street atmosphere is considered as one of the wise strategies for re-linking the urban fragmentation.

'The street design should reflect the type of urban atmosphere that is desired.'

Railway station area has a great potential as its central location and its extensions touching waterfront developing district. However, the street profile is not successful to attract visitors, due to the monofunctional character of the street (either traffic-related or residential). Moreover, for security consideration, the large amount of enclosing walls and infrastructures undoubtedly downgraded the appreciation for an urban image. The existence of inner-river even disappeared at the same time. All in all, this area fails to reflect its branding identity.

3.8.1 Identity Map

Five elements from Kevin Lynch
A central notion in this book is that of legibility (also called imageability and visibility). People who move through the city needs to be able to recognize and organize urban elements into a coherent pattern.



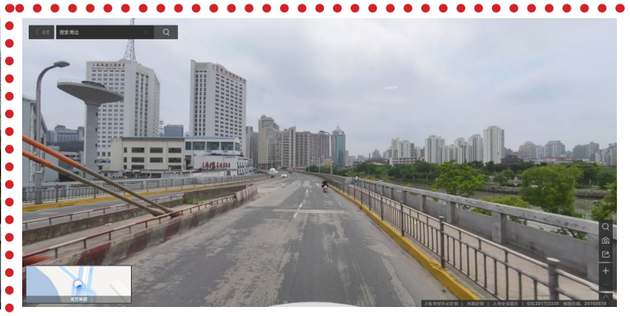
Lynch proposes that these mental maps consist of five elements: (1) paths: routes along which people move throughout the city; (2) edges: boundaries and breaks in continuity; (3) districts: areas characterized by common characteristics; (4) nodes: strategic focus points for orientation like squares and junctions; and (5) landmarks: external points of orientation, usually a easily identifiable physical object in the urban landscape. Among these five elements, paths are much more important, since they contribute to the urban mobility. According to his theory, four paths are standing out, showing more potentials due to the link more elements than the other paths.

3.8.2 Urbanscape tracing

Tracing along the selected routes-1

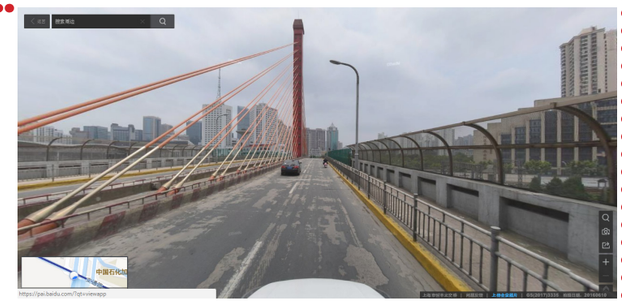
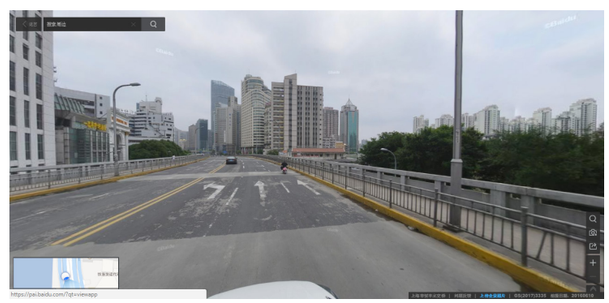
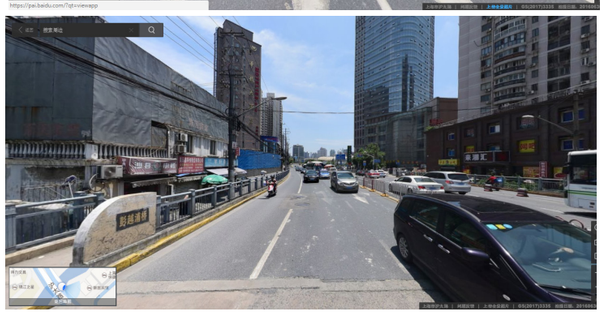


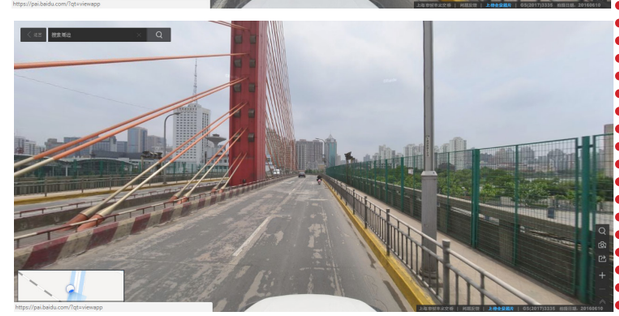









Railway station area

3.8.2 Urbanscape tracing

Tracing along the selected routes-2




















Railway station area

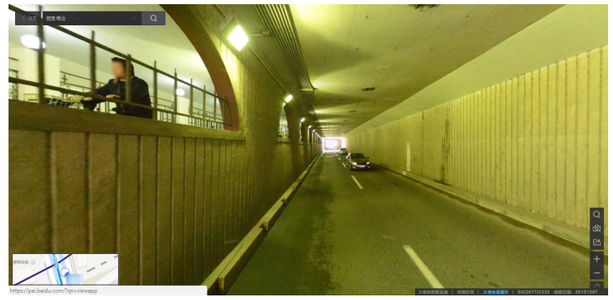
3.8.2 Urbanscape tracing

Tracing along the selected routes-3




















Railway station area

3.8.2 Urbanscape tracing

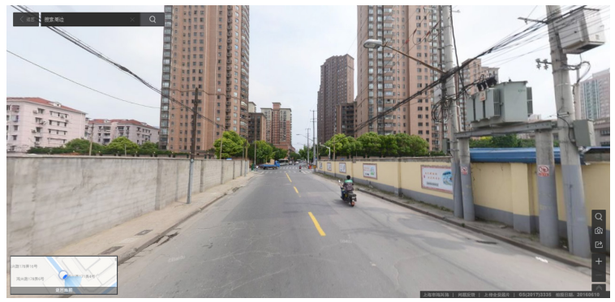
Tracing along the selected routes-4









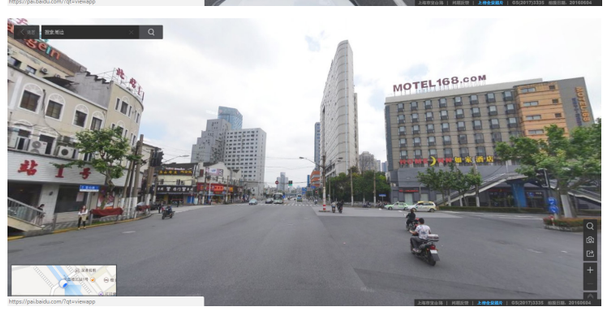








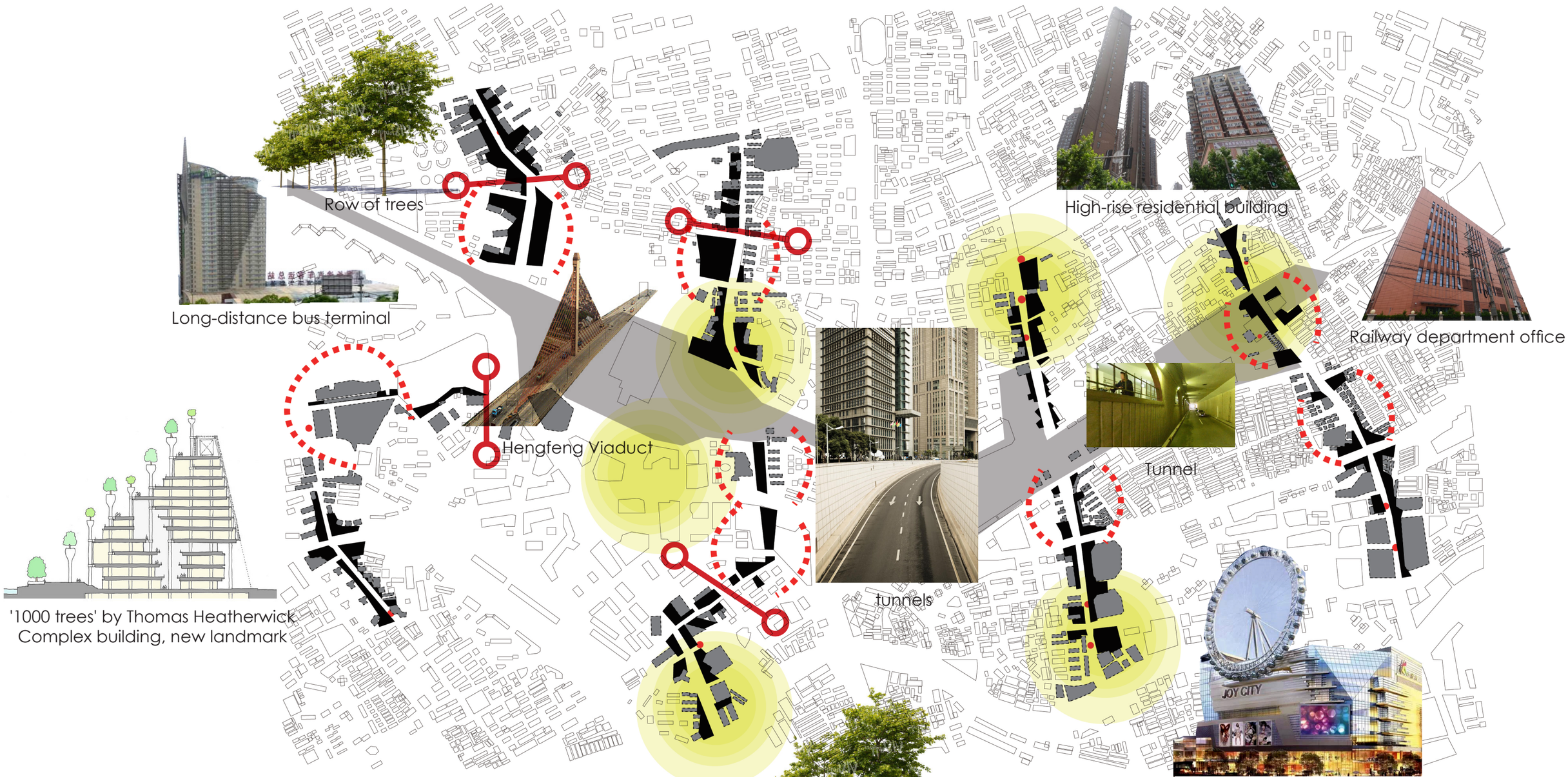


Railway station area

3.8.3 Visual elements extraction

High grey infrastructure and logistics dominated the scene.



As the observation gradually approaches the railway station area, the traffic system across the tracks, such as overpasses and underground tunnels, as well as other transportation infrastructure, such as transportation department buildings, warehouses and bus stations, etc, they dominant your sight as the main visual elements, dramatically change the urbanscape.

Public space Street life Traffic nodes

Street building Perceivable breakpoint of street profile

100M 200M 500M

3.8.4 Three indexes for describing the street atmosphere

Route 1:Hengheng North Road + Moganshan Road + Changhua Road

1 Problem: Decrease of Mix

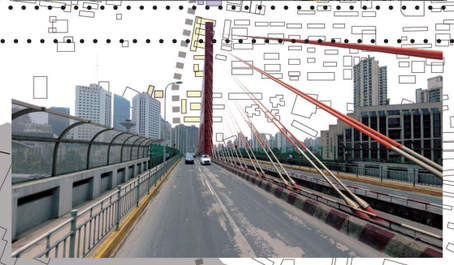
Suggestion: Increase the mix use of developing area

2 Problem: Radical changed skyline

Suggestion: Add some continuous visual elements to promote the contact and linearity, namely rows of trees.

Mix: High
Public: Medium
Skyline: Medium
Atmosphere: Living
Eye-catching elements: None

Mix: Low
Public: High
Skyline: High
Atmosphere: Business
Eye-catching elements: High-rise



Mix: Low
Public: High
Skyline: High
Atmosphere: Traffic
Eye-catching elements: Viaduct

Mix: Medium
Public: High
Skyline: Low
Atmosphere: Art
Eye-catching elements: Factory

Mix: Low
Public: High
Skyline: High
Atmosphere: Commercial
Eye-catching elements:
Famous design work

Mix: Low
Public: Medium
Skyline: Medium
Atmosphere: Living
Eye-catching elements: None

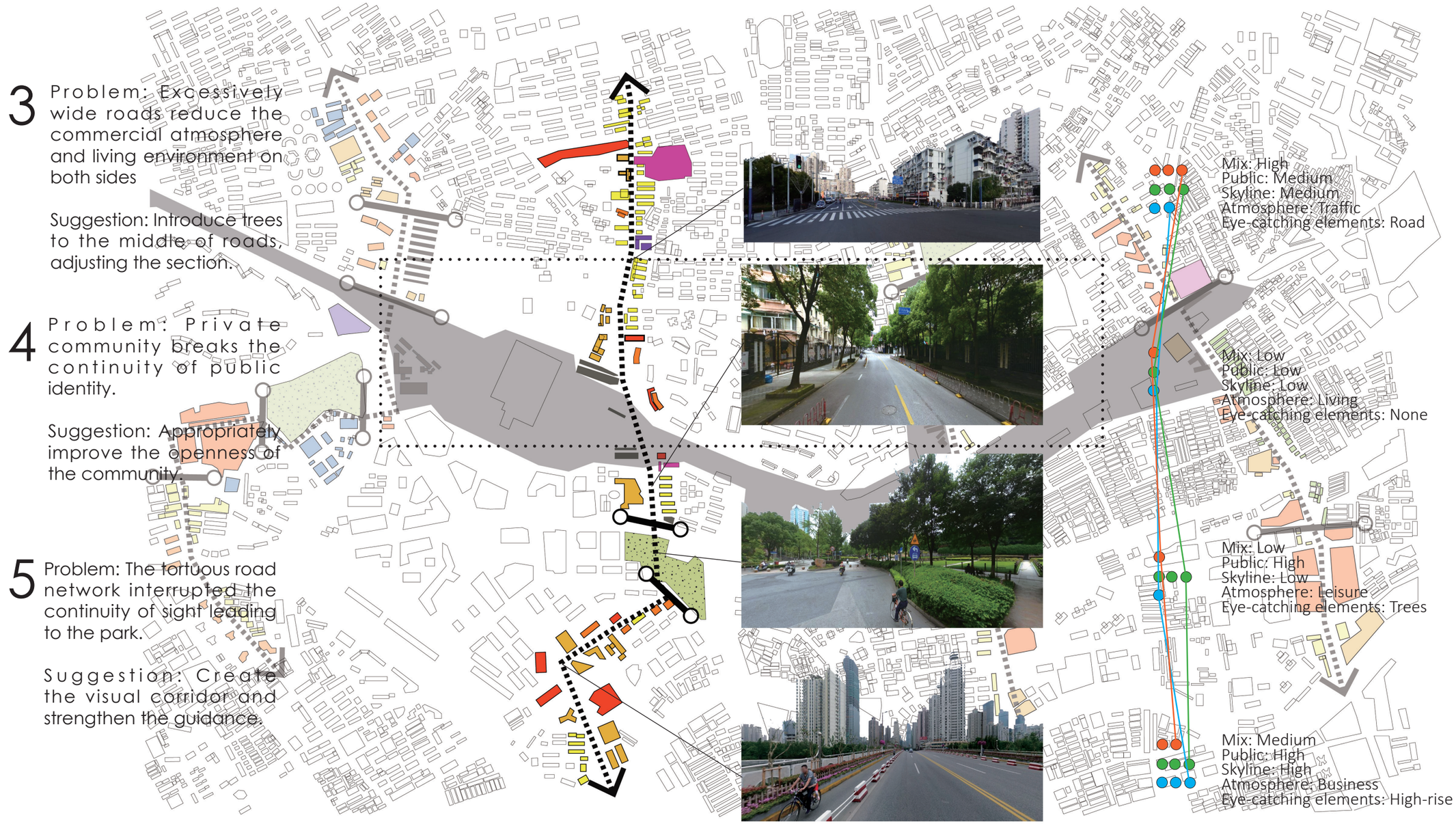
Three indexes for describing street atmosphere include:
the degree of mix use
the degree of public
the skyline

Commerce
Culture
Low-rise residential
High-rise residential
Medical
Park
Degree of 'Public'
Degree of 'Mix'
Skyline

100M 200M 500M

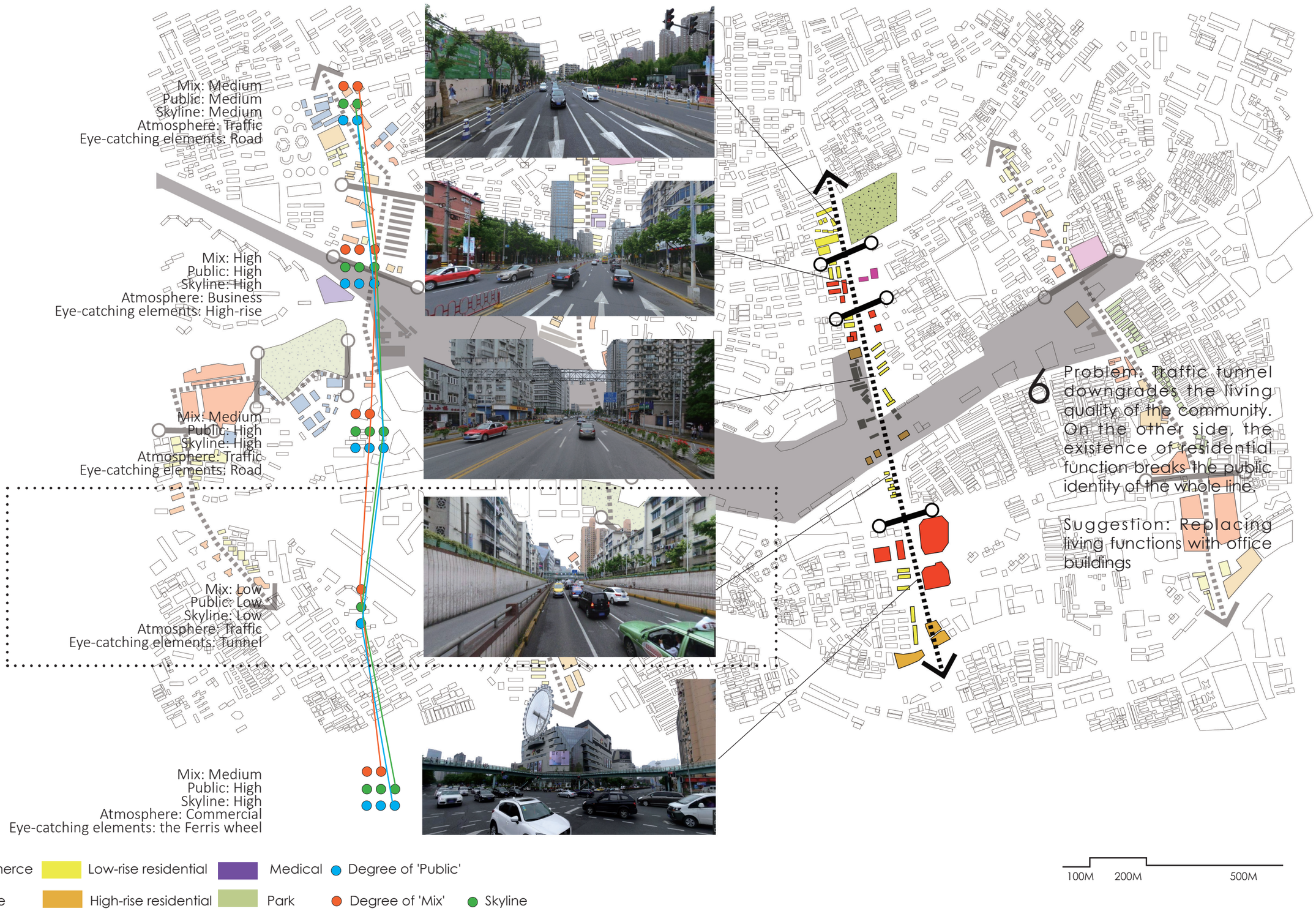
3.8.4 Three indexes for describing the street atmosphere

Route 2: Datong Road + Hanzhong Road



3.8.4 Three indexes for describing the street atmosphere

Route 3: Xizang North Road



3.8.4 Three indexes for describing the street atmosphere

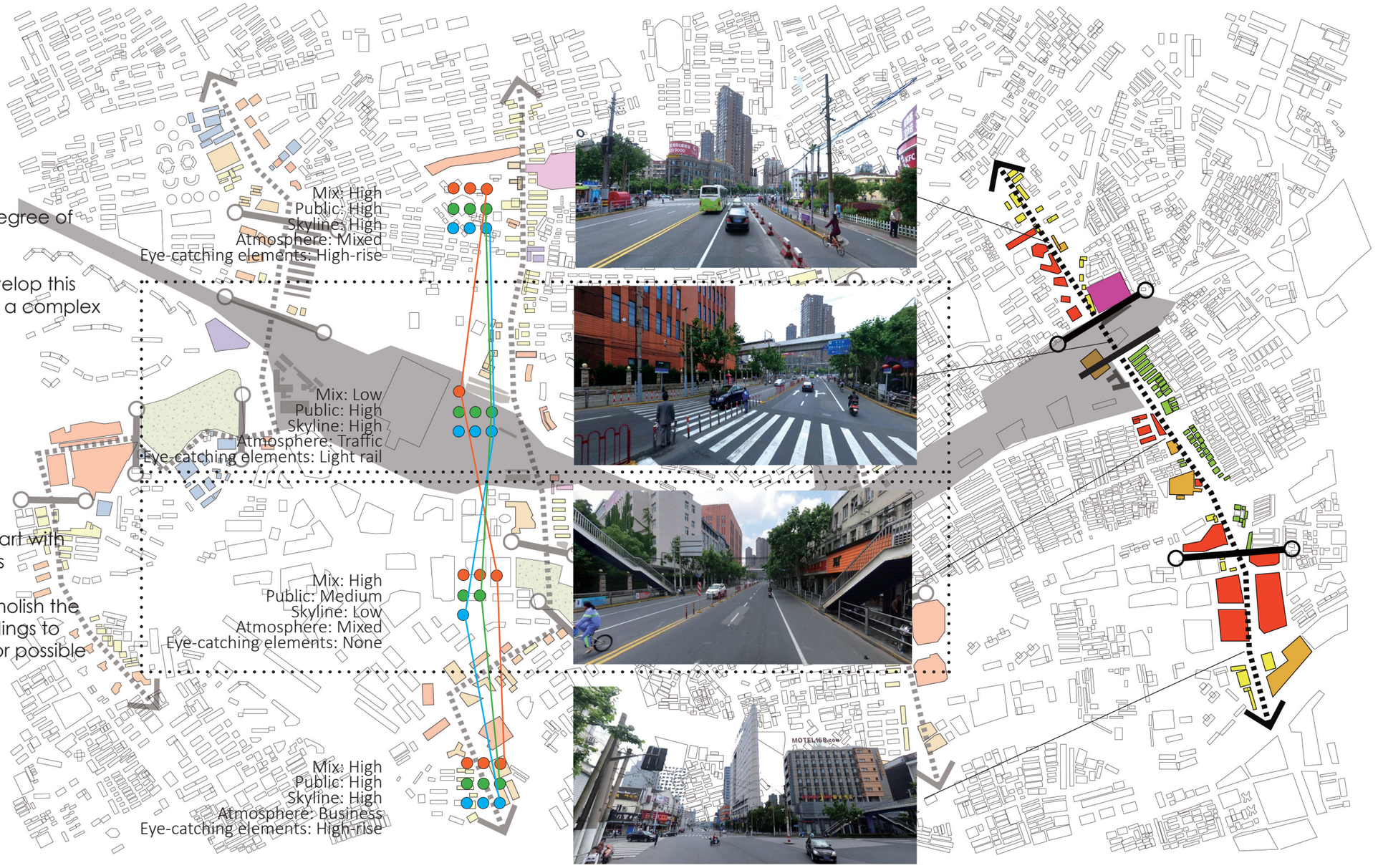
Route 4: Baoshan Road

7 Problem: Low degree of mixed use

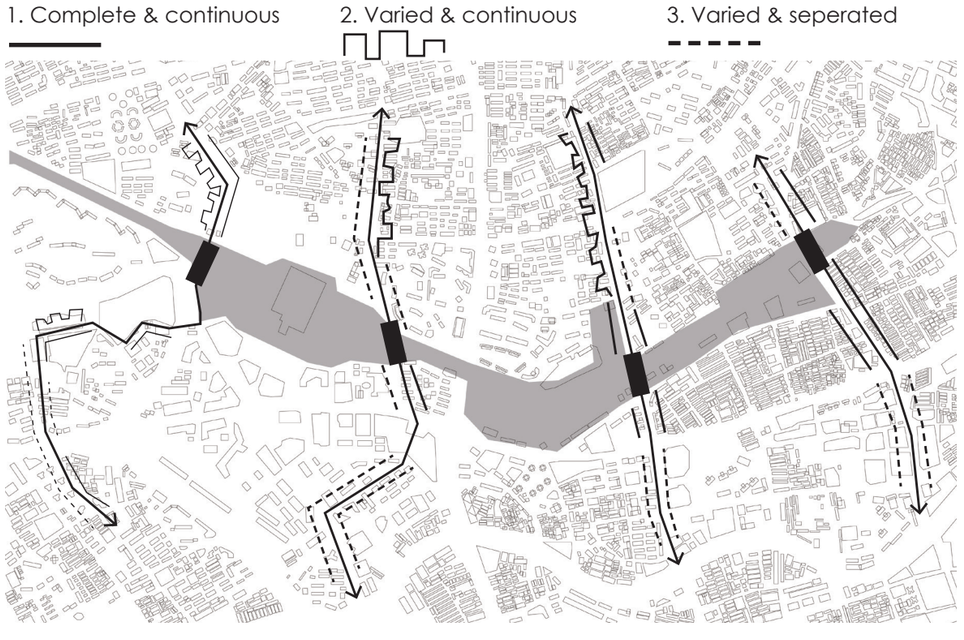
Suggestion: Develop this traffic node into a complex node.

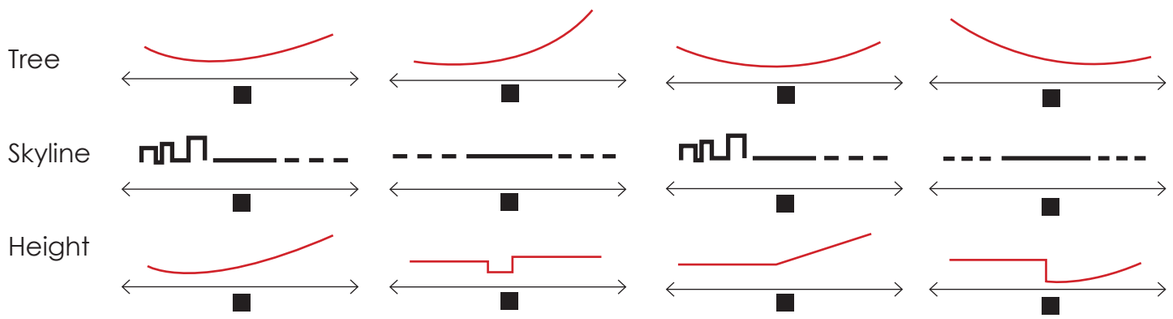
8 Problem: Only part with low-rise buildings

Suggestion: Demolish the low-quality buildings to free up space for possible investments.



3.8.5 Spatial features description



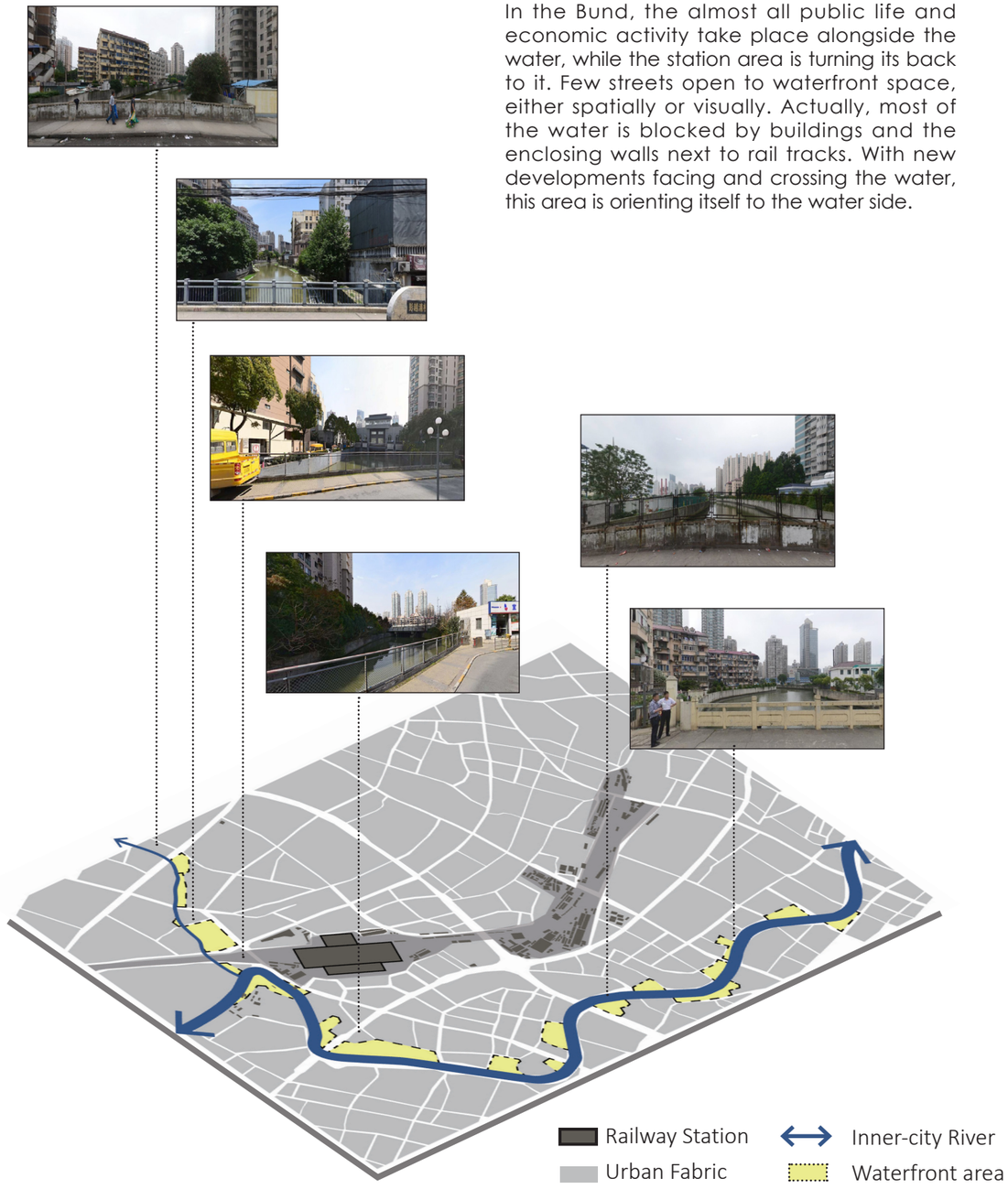


An abstract expression of street profile

Due to differences in the age, education, gender, and other factors of the observer, the atmosphere of the city streets can hardly be accurately described. Therefore, this study focuses on changes in street profile and uses relatively objective indicators, including the appearance of greenery, the skyline, and the overall height of the buildings. From the above image, it can be clearly seen that when the urban environment approaches the railway area, the landscape shows perceivable changes, such as the reduction of greening and the lowering of the skyline.

Backside and waterfront

Water plays an important role in the urban structure of Shanghai as main open space in a compact city, but also a strong preference for economic development
In the Bund, the almost all public life and economic activity take place alongside the water, while the station area is turning its back to it. Few streets open to waterfront space, either spatially or visually. Actually, most of the water is blocked by buildings and the enclosing walls next to rail tracks. With new developments facing and crossing the water, this area is orienting itself to the water side.



3.8.6 Potential links and selected nodes

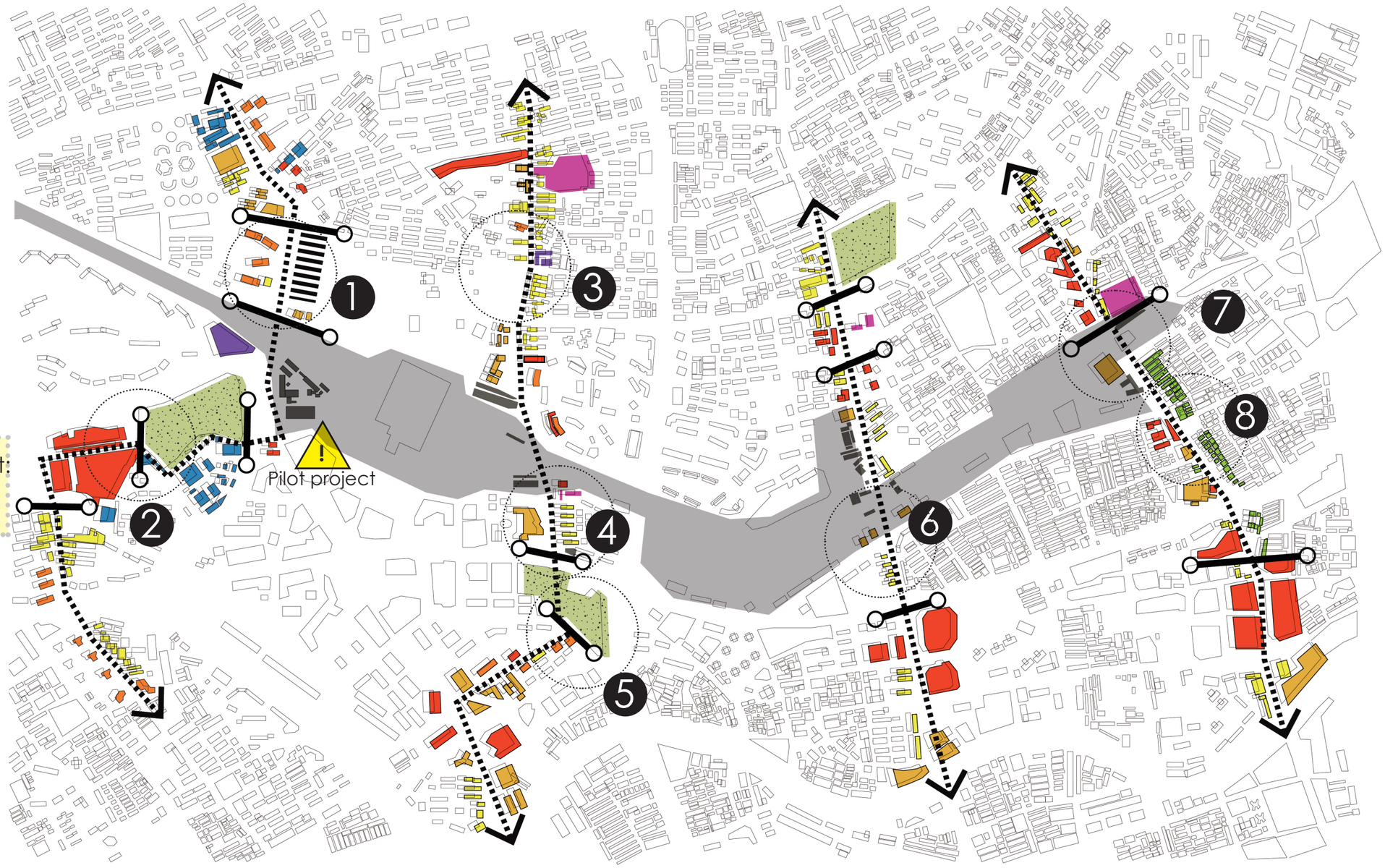
Inspired by the mental map of Kevin Lynch

Functional adjustment:
1 4 6

Visual improvement:
2 5

Road section adjustment:
3

New developments:
7 8



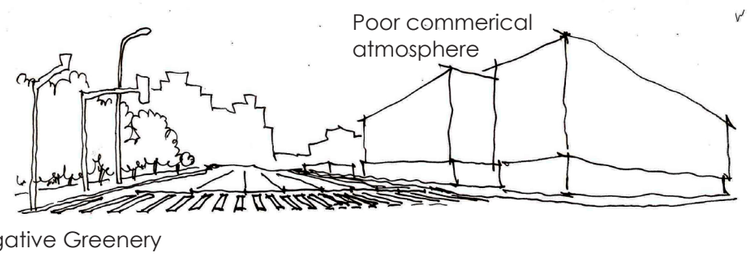
A cityscape is comprised of a series of physical elements, and a mutation of their combination may lead us to perceive a sense of boundaries. These boundaries are either sharp, subtle, or in between. The qualities of these edges directly affect the identity of neighborhoods and even the city.
From the public, semi-public to private, from open streets to narrow alleys, from hustle and bustle to quiet, from Gentrification to folk customs, varied barriers request different solutions.

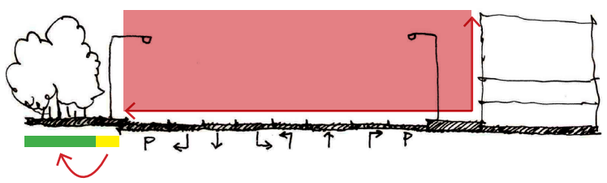
Commerce
Culture
Low-rise residential
High-rise residential
Medical
Park
Degree of 'Public'
Degree of 'Mix'
Skyline

100M 200M 500M

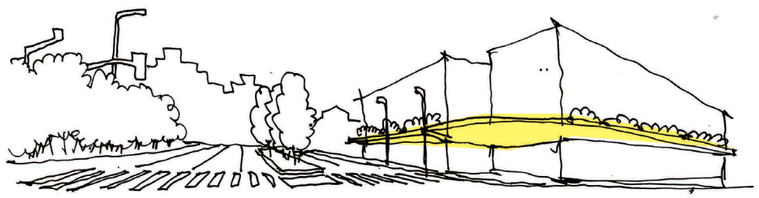
1 2

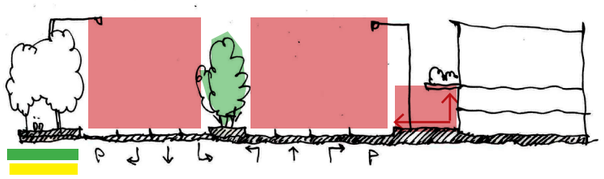
Problem:
Excessively wide roads reduce the commercial atmosphere and living environment on both sides





Suggestion:
Introduce trees to the middle of roads, adjusting the section from 8-lane roads into two four-lane roads.

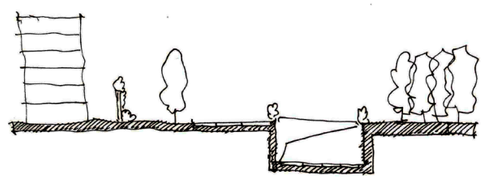


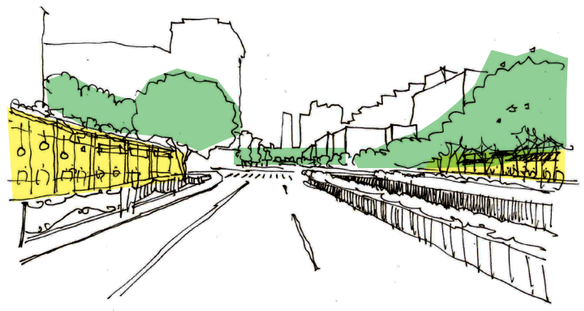


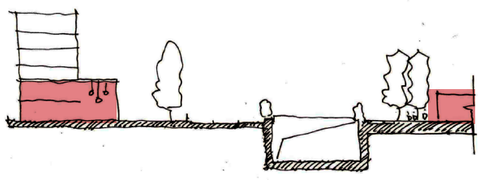
3

Problem:
Radical Change of skyline

Suggestion:
Elements like rows of trees that promote linearity and visual contact could be applied. The unified pavement materials for guiding the flow of people could also be useful. These actions make the concept of connection more legible.



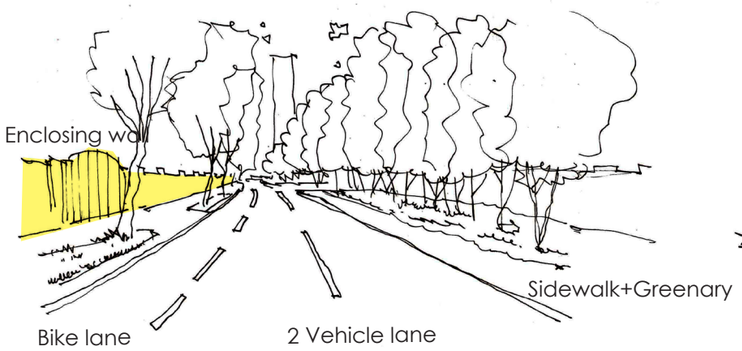


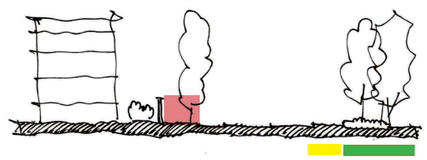


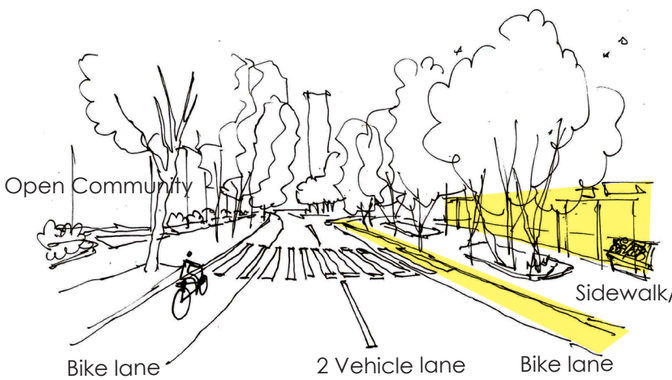
4

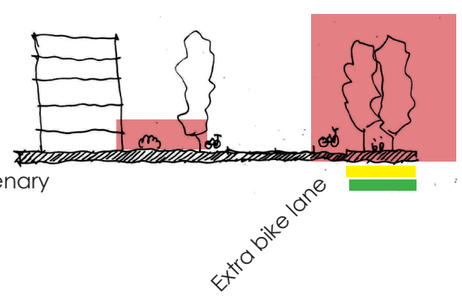
Problem:
Private community breaks the continuity of public identity.

Suggestion:
Appropriately improve the openness of the community.





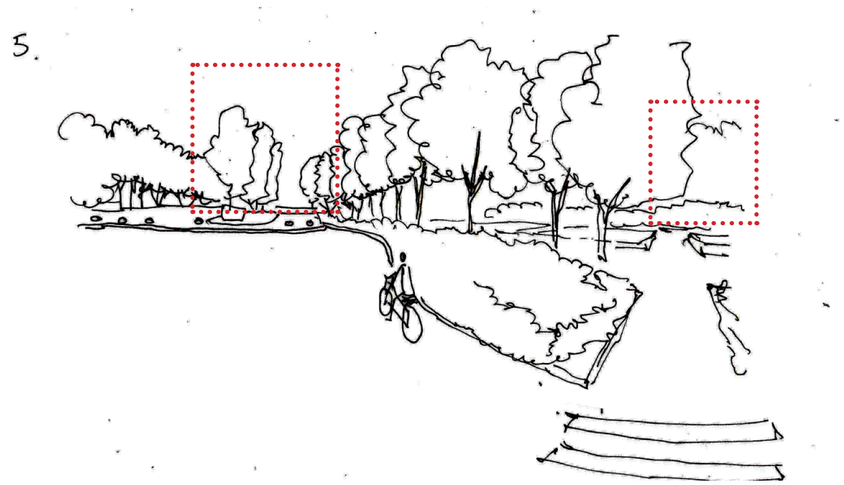


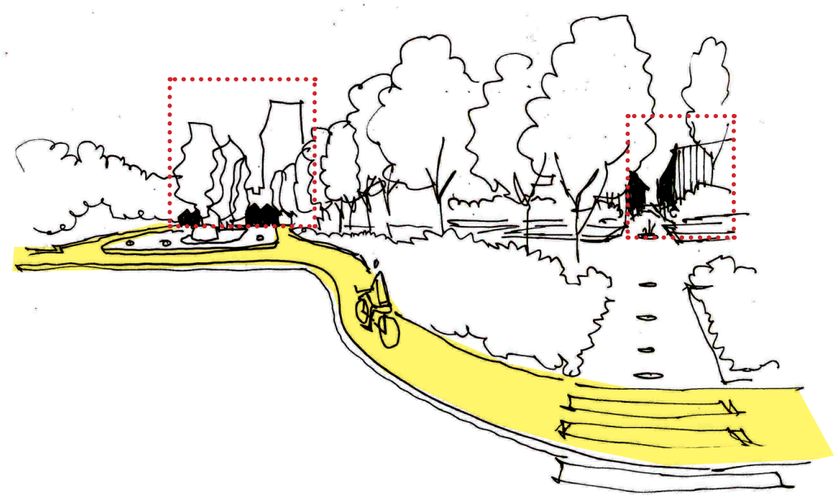


5

Problem:
The tortuous road network interrupted the continuity of sight leading to the park.

Suggestion:
Create the visual corridor and strengthen the guidance.

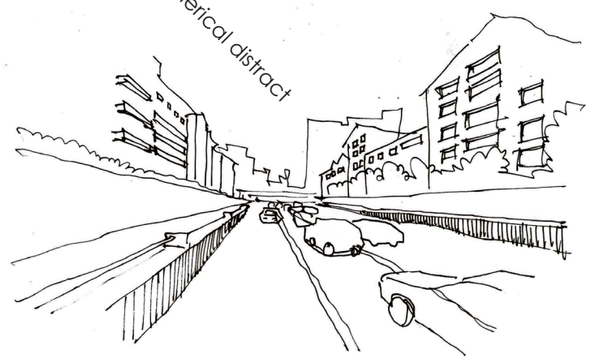


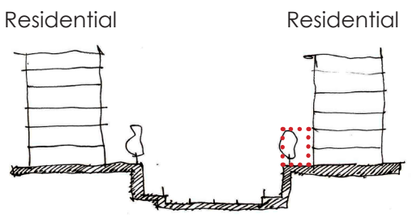


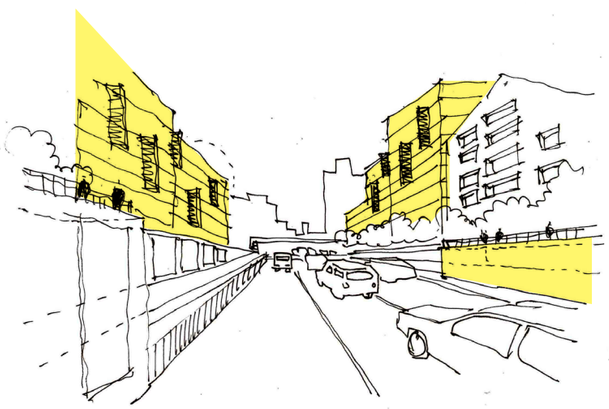
6

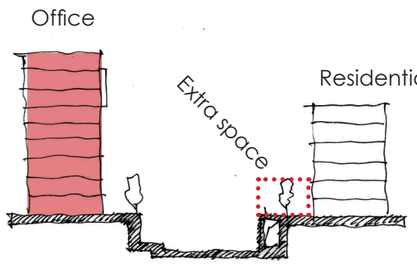
Problem:
Traffic tunnel downgrades the living quality of the community. On the other side, the existence of residential function breaks the public identity of the whole line.

Suggestion:
Replacing living functions with office buildings





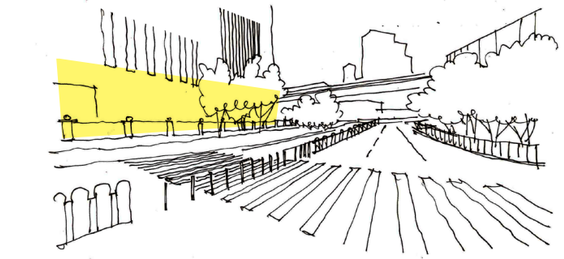


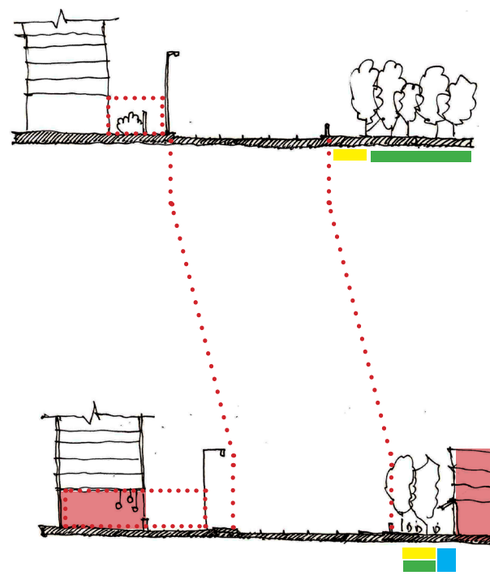


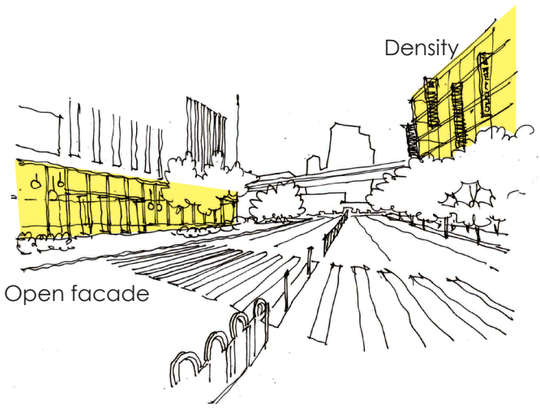
7 8

Problem:
Low degree of mixed-use, Low density

Suggestion:
Develop this traffic node into a complex node.
Demolish the low-quality buildings to free up space for possible investments.





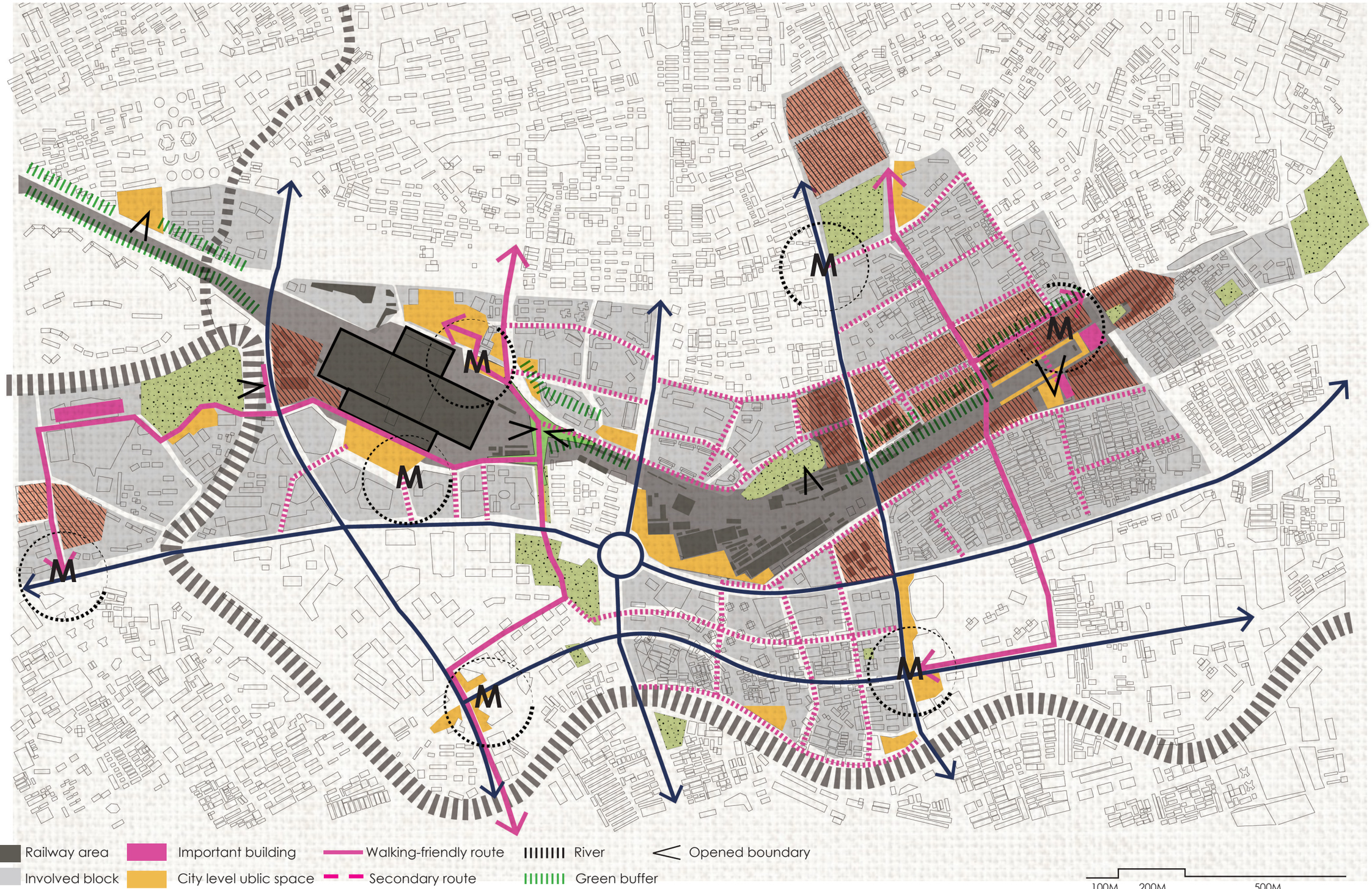


3.9 Pilot projects
The integration of four proposals

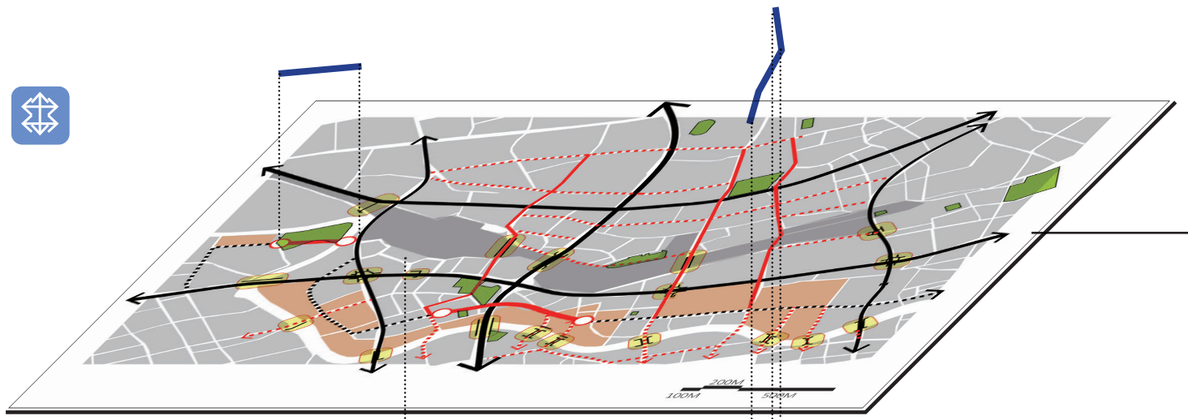
Breaking down the problem into portions can explain the causes contributing to form it and allow to give the corresponding solutions, but only by combining each part together again, the design, as a whole, could be tested that whether it is effective.

3.9.2 Integration of four proposals

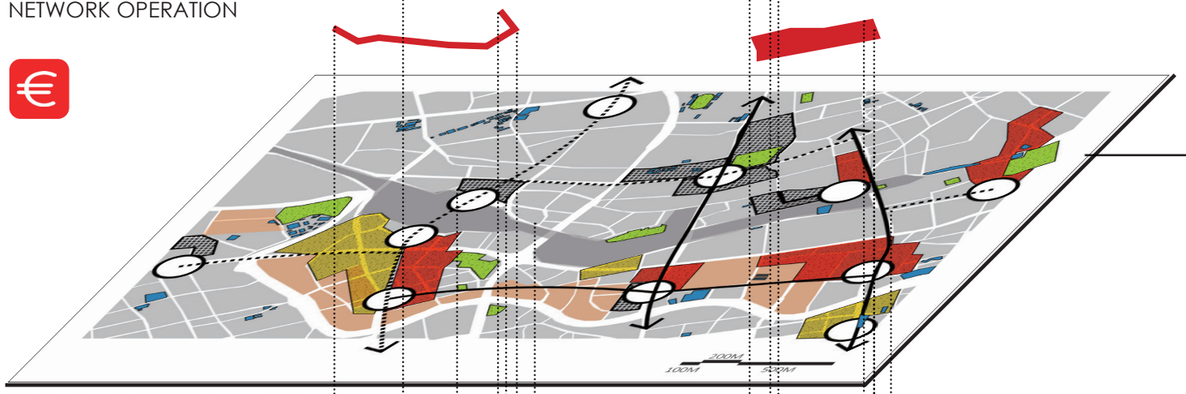
Turn isolated railway station area into an integrating element which restructures fragmented urban setting



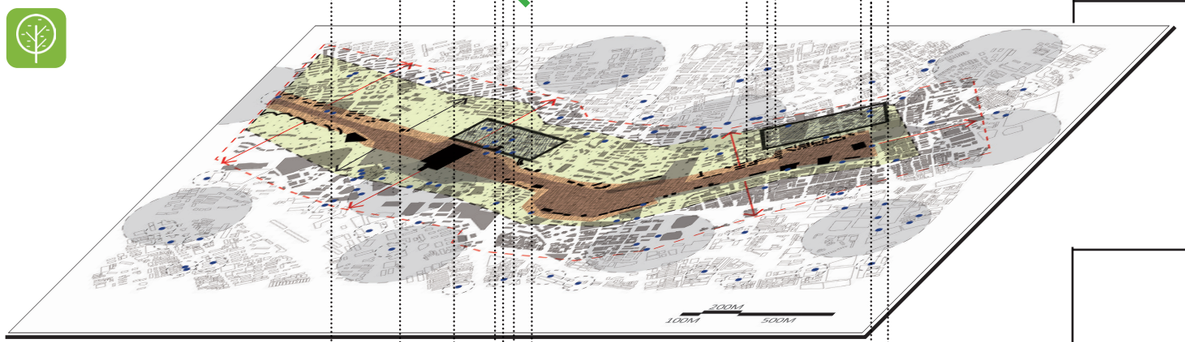
3.9.1 Interrelation between each proposal



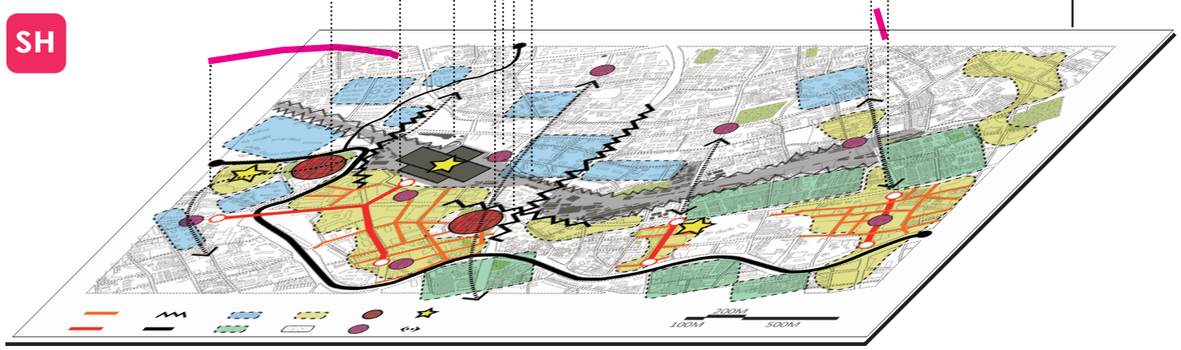
NETWORK OPERATION



ECONOMIC PERFORMANCE



ENVIRONMENTAL QUALITY



URBAN IDENTITY

Designs for network operation:

-Change the tortuous road network into a clearer one.

-Add new bus stops to improve the coverage of the public transport

-Open gated community that blocks the routes leading to the metro station for improving the accessibility of metro system.

-Promote new bus routes for further development.

Designs for economic performance:

-Transforming the surrounding neighborhoods for promoting a functional mix

-Free up railway logistic area for development

-Designing the new type of mix-use block with legible railway features

-Flexible superstructure above the rail yard

Designs for environmental quality:

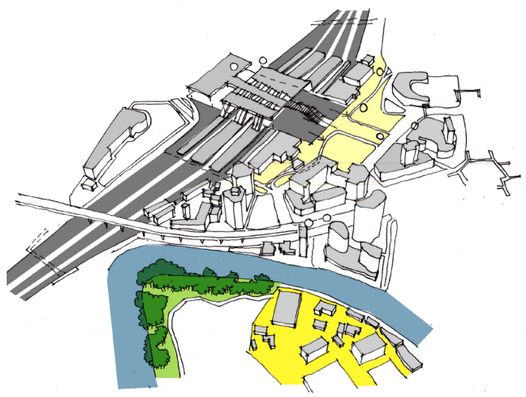
-Redefining the boundary of rail yard with more concerns of pollutions

-Adding extra quality to the existing tunnels and footbridges

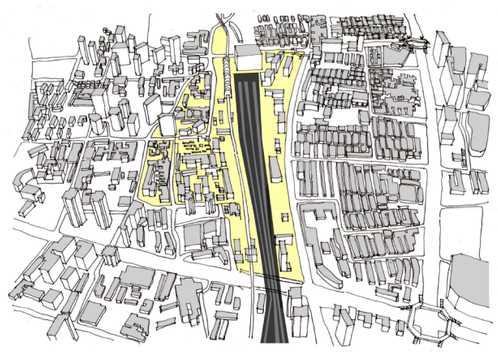
Designs for urban identity:

-Highlight several new city axes to strengthen the links with new city icons

-Urbanize the station square by integrating the public resources



PILOT PROJECT-1
Station square



PILOT PROJECT-2
Railway yard

Intention-stimulate unused public resources

How to achieve an Urbanized station square?

Due to the broken links to other public resources, station square is regarded as an isolated enclave, instead of an integrated space in the urban setting.

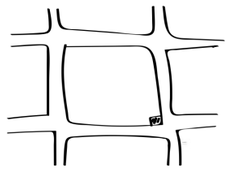
Pilot project-1
Station Square

Railway passengers
100,000 ppl/day

Metro passengers
90,000 ppl/day

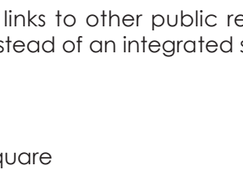
Passenger Square

The railway station, as well as metro station, bring the hung amount of passengers into the site, but the surrounding couldn't host them with a high-quality environment. So the most of passengers decide to leave as soon as possible instead of hanging out there, which means the commercial potential is losing and enclave conditions exist for sure.



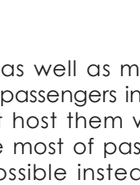
Inner River Dock

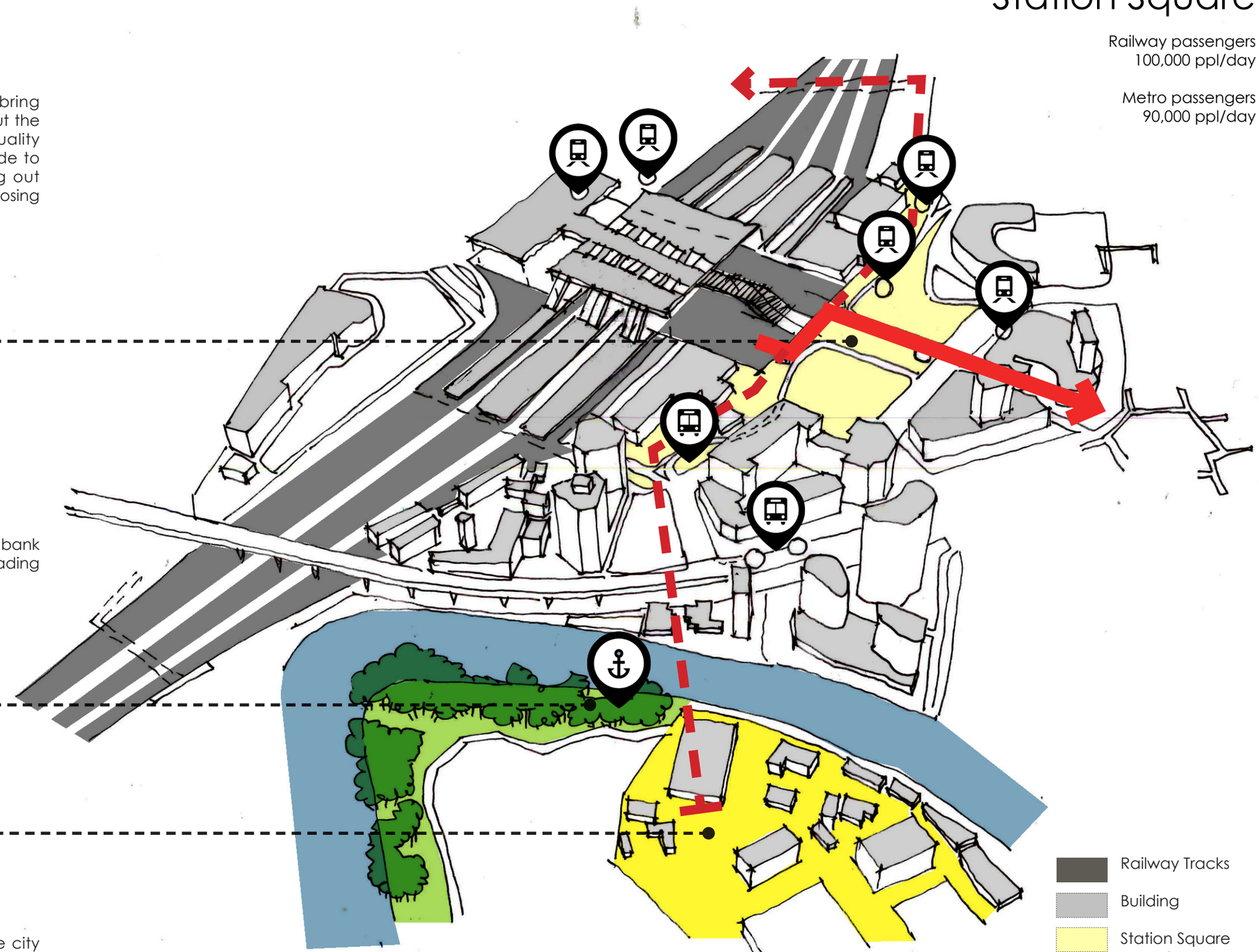
The inner-city river dock located on the opposite bank of station side. And there is no convenient link leading people to use this urban facility.



M50 Creative Park

M50 is an important growing art location in the city center of Shanghai. But due to its end position and blockiness of residential blocks, the accessibility is poor, which limits its development.





Railway Tracks
Building
Station Square
Main Public Space
Main movement direction
Poorly connected direction

Space-making: Overcome five Obstacles

Pilot project-1
Station Square

Railway passengers
100,000 ppl/day

Metro passengers
90,000 ppl/day

Public toilet

standing in the middle of the street.

65 spots+30 spots

The parking lot of Hotel and logistic departments

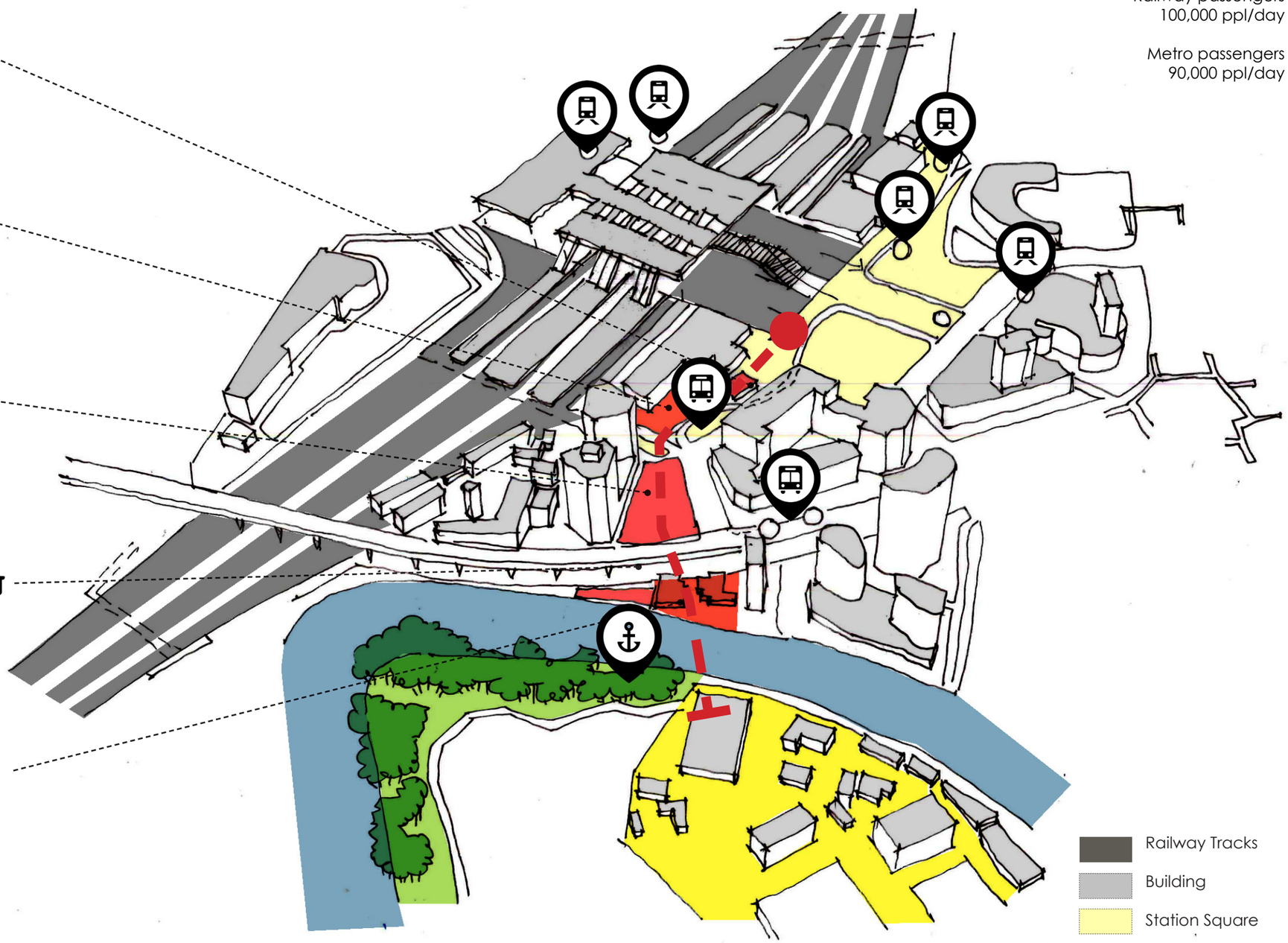
Front space of buildings in the city center often filled with ground parking lots. It assumes that people are driving, which results in an unfriendly walking environment.

Four Lanes

road under a viaduct

350,000pp/year

Long distance bus station standing next to the inner-city river, blocking the view of water.



Added values: Waterfront Feature

Pilot project-1
Station Square

Railway passengers
100,000 ppl/day

Metro passengers
90,000 ppl/day

300Meters walkable route leading to waterfront

1. Moving the Toilet

Integrate toilet with the existing building

2. Shifting the Bus station

3. Integrating the Parking Lot

Move the front parking lot to the backside of buildings

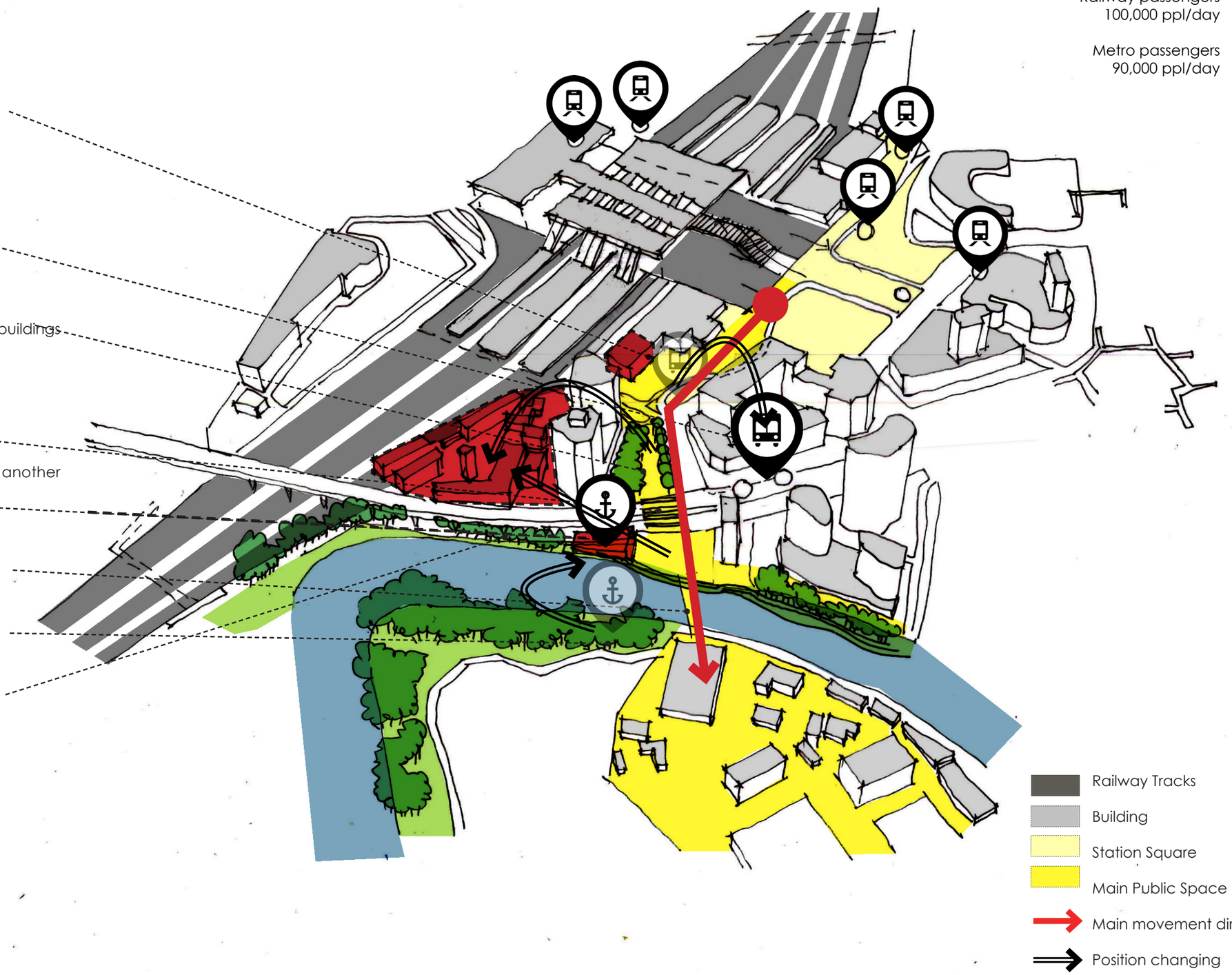
4. Adding zebra crossing zone

5. Remove the long distance bus station to another location

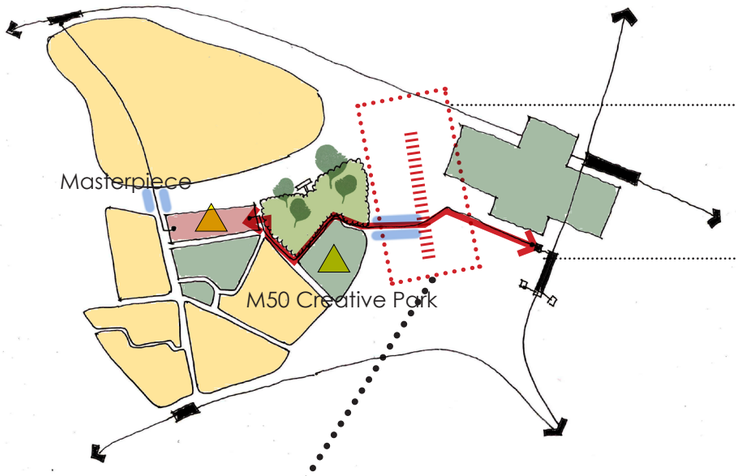
6. Adding a new footbridge crossing the river.

7. Moving inner-city dock to the station side.

8. Replacement of space under the viaduct.
(See the next page)



Waterfront feature design

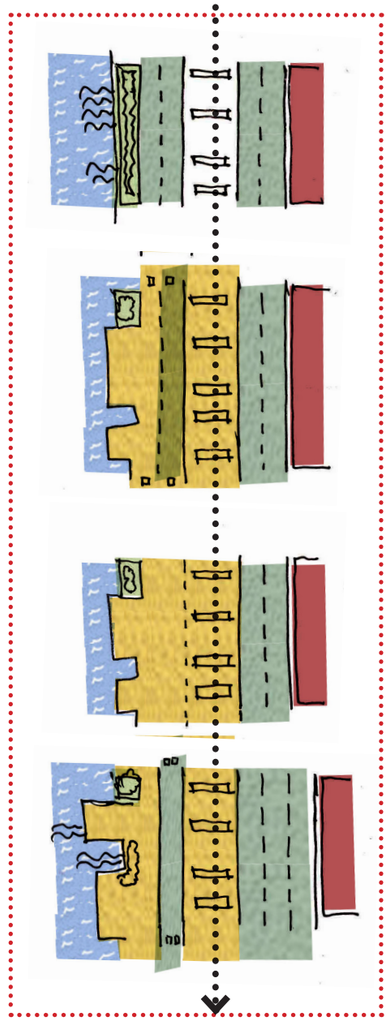


Added value

The commercial function could boost the liveness of the site.

Proposed link

This art park is the only site owns the open sightline of water and available waterfront space, but the problem is the poor accessibility.



Current situation

Space under viaduct is used for trash recycling, which is such a waste for this central location and also for the view next to the inner-city river. Both vehicle lane and greenery act as barriers, blocking the usage of waterfront space.

Testing phase

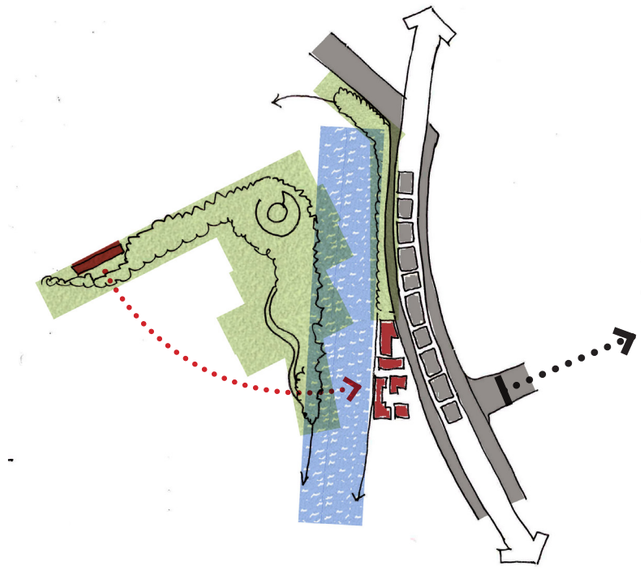
Remove the trash recycle function, and introduce the leisure functions, like cafe, shops and even creative industrials. Then employ the limit time strategy for the road between the viaduct and the river, only allow vehicle use during the rush hour. The other time and weekends, this area becomes a car-free zone.

Possibility 1

If the new functions perform great, and the traffic situation doesn't show further problems. The road can be removed forever.

Possibility 2

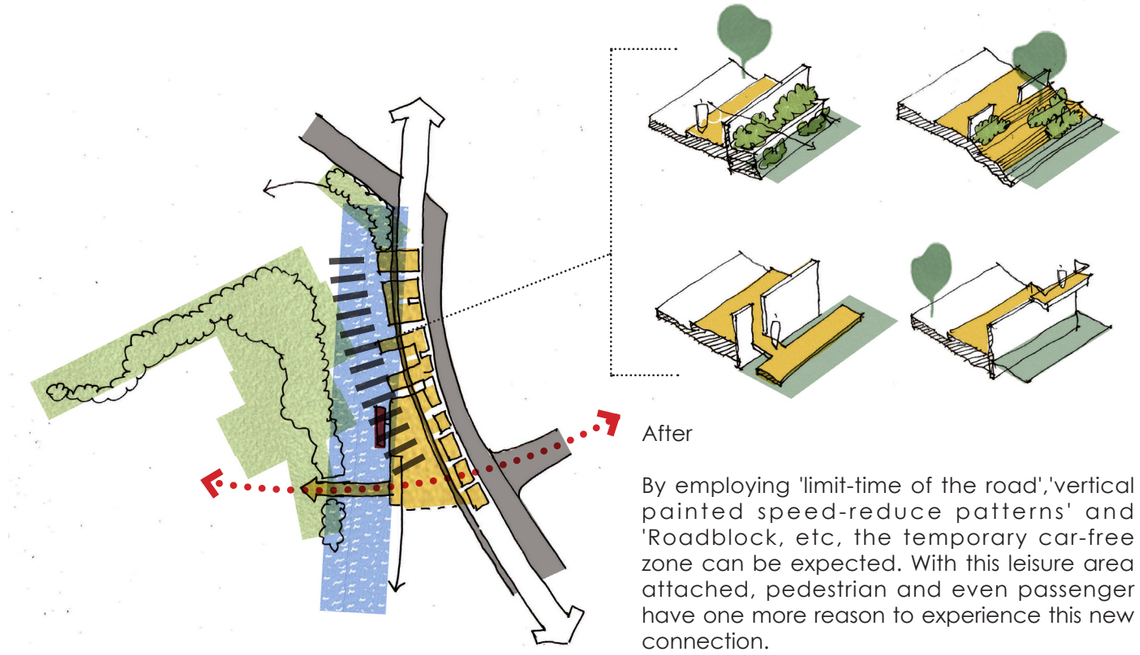
If the traffic volume still needs this road, we can adopt 'one time-limit road + three roads on the other side' model. Anyway, the priority should be given to space next to the waterfront activity instead of traffic.



Before

However, physical space does not necessarily mean liveliness. This is highly related to function, environment quality, and street atmosphere. If the whole width of the street was still given to cars, the added values are hard to achieve.

Ways to deal with the riverbank
1. Plant purification 2. diversify river banks



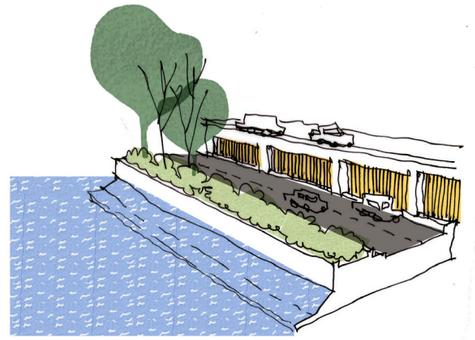
After

By employing 'limit-time of the road','vertical painted speed-reduce patterns' and 'Roadblock, etc, the temporary car-free zone can be expected. With this leisure area attached, pedestrian and even passenger have one more reason to experience this new connection.

Negative greenery
blocking the waterfront space

Functional replacement

Temporarily limit-use of the road
or even permanently remove



Before

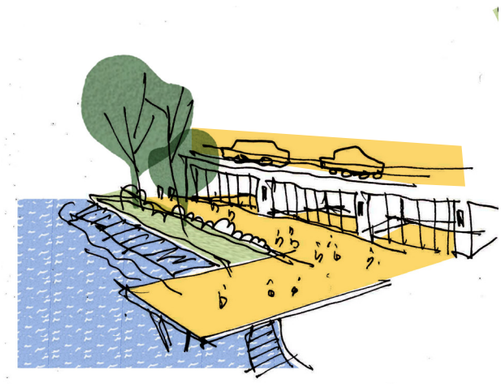
The viaduct formed a physical boundary.
Since it located in the middle of the proposed connection, this space under the viaduct and the road between it and river should be more ambitious and could contribute more to urban.

Sound barrier contributes to
create a friendly environment.

The little park-along-the-river

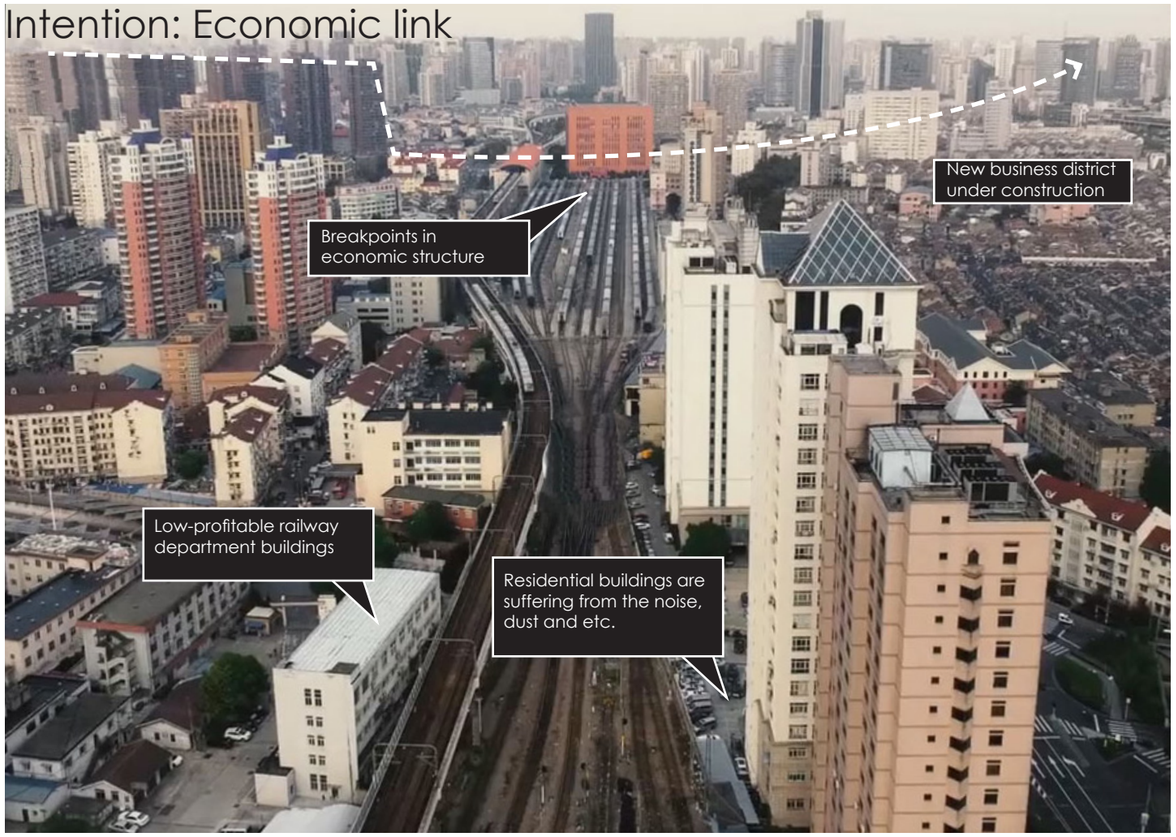
Most of the spaces underneath the viaduct are used by urban amenities that give the structure a certain meaning on ground level. The arches are being used by people-oriented uses as bars, restaurants, and small retail shops.

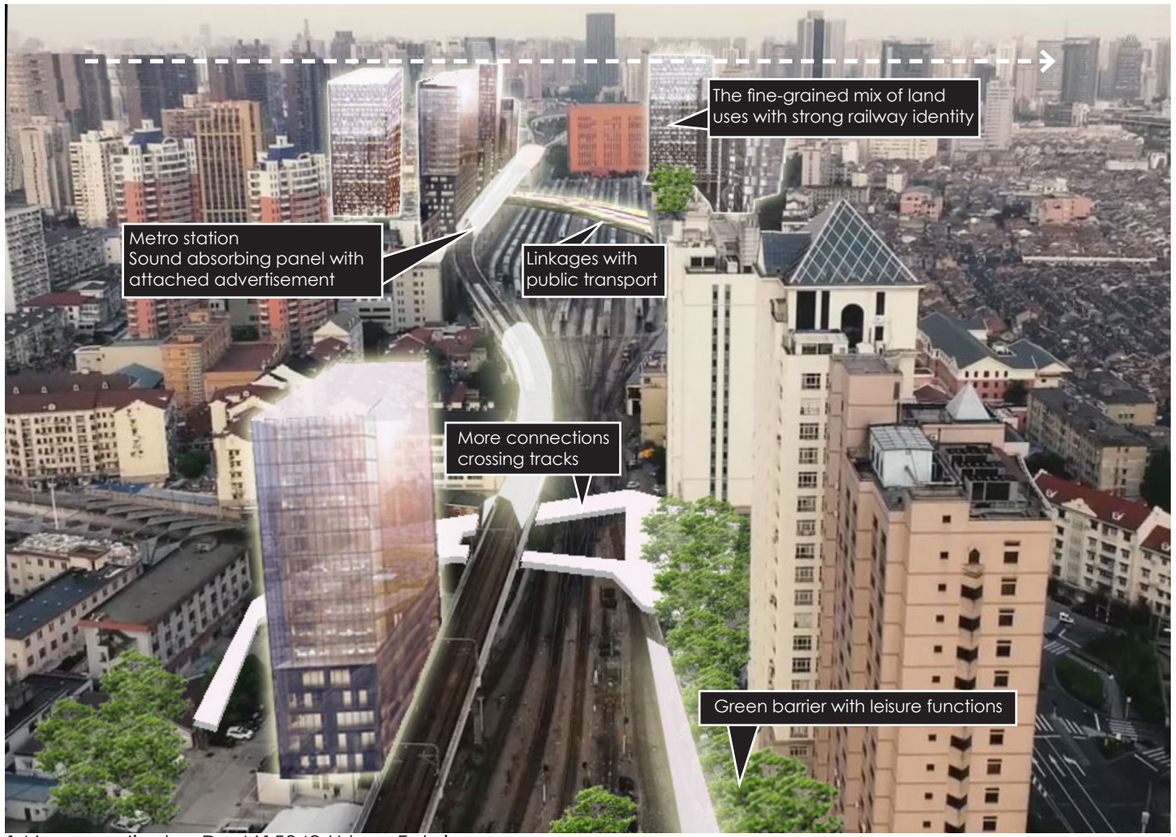
19:00
07:00
MON-FRI



Added values

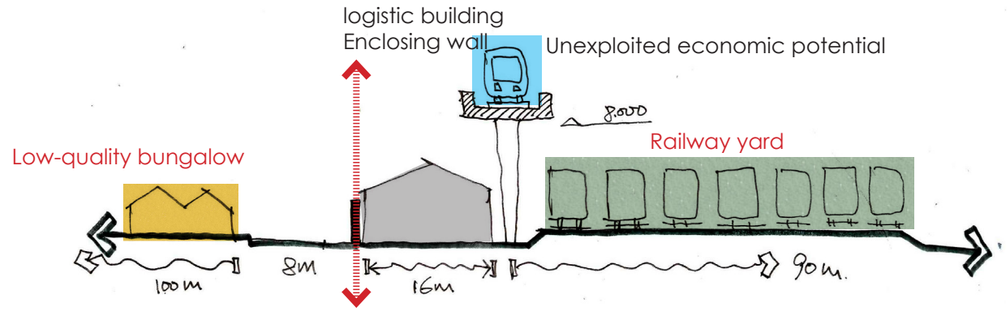
Establishing temporary or permanent street activities are the easiest ways that can contribute to create an urban identity and boost the economy. With decreasing the barrier effects, the road has to become a more integrated part of the urban structure.



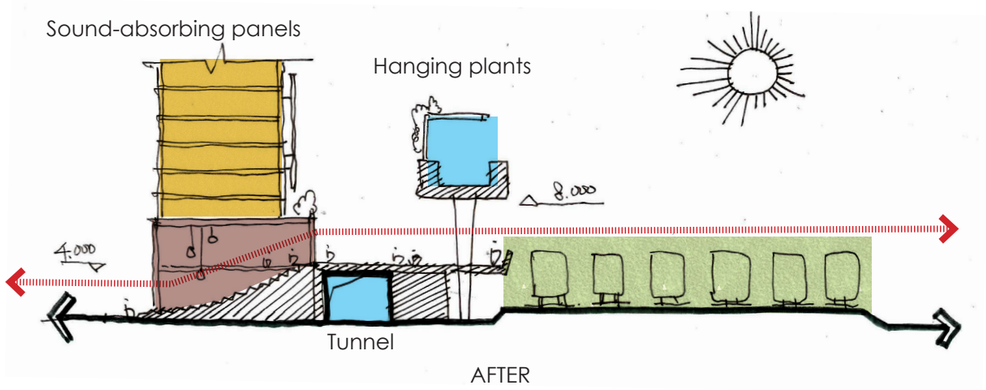


Pilot project-2
Railyard

Railyard area: 140.000.00m^2
Developable Neighborhood: 130.500.00m^2



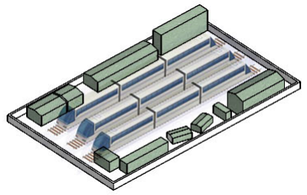
BEFORE
Declined neighborhood + Railyard



AFTER
Densified edge + Thickened platform

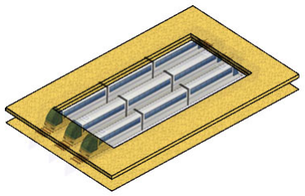
The transformed neighborhoods which encourage walking should exhibit following features:
-Easy and direct routes between destinations
-Dense networks of footpaths;
-Linkages with public transport;
-A fine-grained mix of land uses;
-High environmental quality with rich visual interests
-Street activities rather than shopping malls,
-Small parks instead of enclosed square
All these elements together make a huge difference, boosting a walking-friendly and urban atmosphere with legible railway area identity.

Space-creating in phases



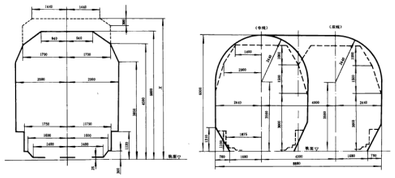
1. Free up space

This area is currently occupied by railway logistic buildings and low-quality bungalow. So the first action should be free up this area for further development.

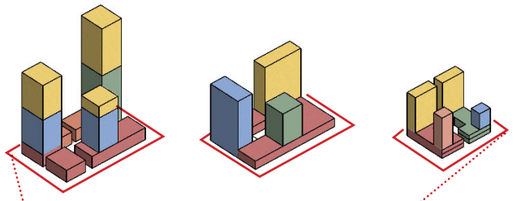


2. Elevated platform redefines the boundary.

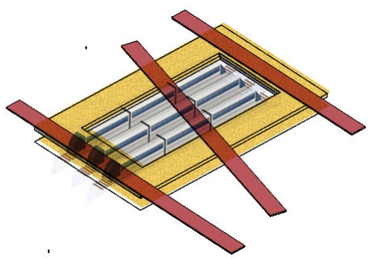
Commercial plinth as an urban catalyst, it blocks the negative pollutions, offering diverse function and appropriate street aspect ratio. However, this framework has to be extremely flexible to



*In China, relevant regulations stipulate that the minimum height of the bridge above the rail tracks is 8 meters, and that of the superstructure is 6 meters.

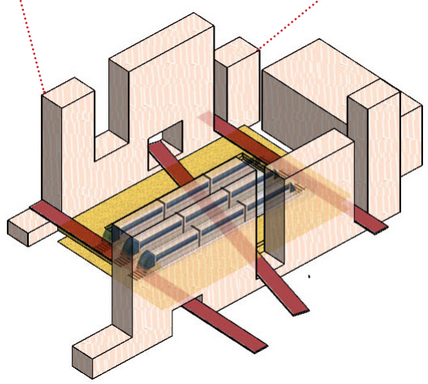


*Block's perimeter: 400m - 1000m long



3. Open network avoids being another obstacle to the city.

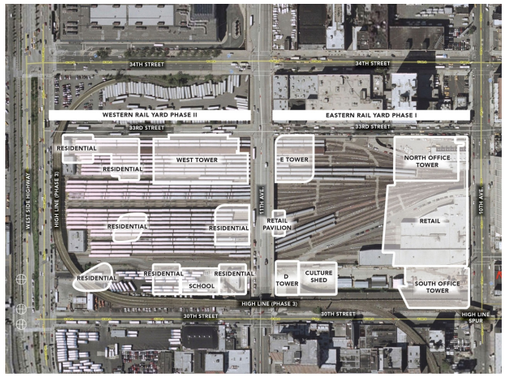
The fact that the new development is opening itself up to its surroundings, in a functional as well as in a spatial-visual sense, decreases the transition between the different domains. A strong border like train tracks, both overground and underground connections are possible. Spatial restrictions for the design of the overground connection are the height of the electric wires over the train tracks.



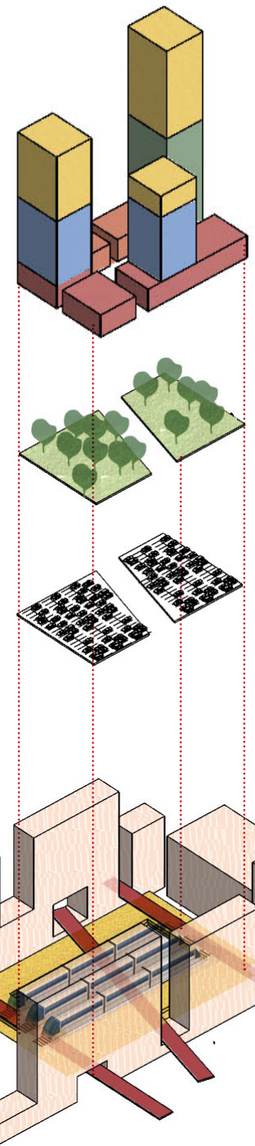
4. Densified edge guarantees economic benefit

One of the most important principles of the TOD Standard is “Mix”, so does "Density". With mixed land use, building typologies and services are within a short walking distance of where people live and work. In Shanghai, there are specific recommendations for keeping block sizes smaller in both transit station areas and public activity centers. “Encourage the establishment of small and medium-sized blocks: A single block's perimeter should be between 400m and 1000m long in total.”

From isloted to integrated - the research on connectivity of railway station area

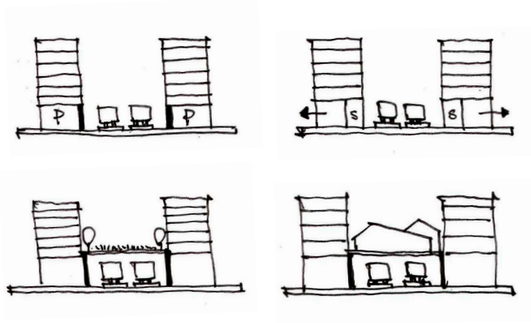


*The same type of development model: Hudson yards-NYC
Source: https://commons.wikimedia.org/wiki/File:NYC_Penn_Station_aerial_vc.jpg



Pilot project-2
Railyard

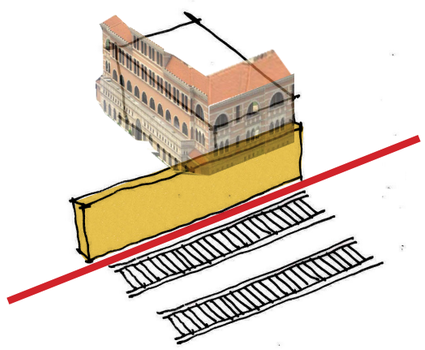
Railyard area: 140.000.00m^2
Developable Neighborhood: 130.500.00m^2



5. Flexible follow-up possibilities

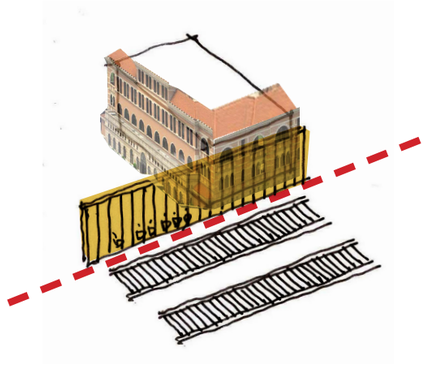
The follow-up developments above the railyard could be extremely flexible, depending on the first-period investment. The possible second phase may focus on parking facilities, since the newly coming large amount of office buildings and residential. It could also promote profit-less goals, like building a central park for Shanghai, or even urban farming fields. These kinds of function also play an important role in boosting the economy. If this area develops particularly well, which could even afford the higher financial cost, it can continue to develop building groups right on the rail yards.

Add values: Break down the walls in some special locations



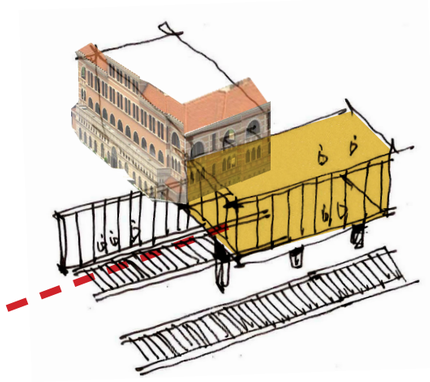
Current situation

Shanghai railway museum locates right next to rail yard, the selected pilot area. Even with such related topics and nearby locations, museum and rail yard don't have spatial and visual connections. A dull enclosing wall offered little to attract the public and gave few clues as to the content behind it.



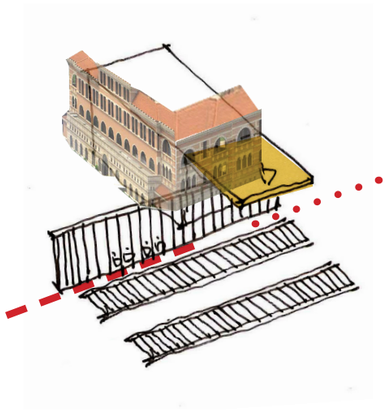
Testing phase-1 Transparency

As the testing phase 1, the brick enclosing wall could be replaced by a transparent material at least, creating a visual corridor first. The opened boundary that provides a series of experiences, can change the image of dull railway image and create the perceived unique identity to the public.



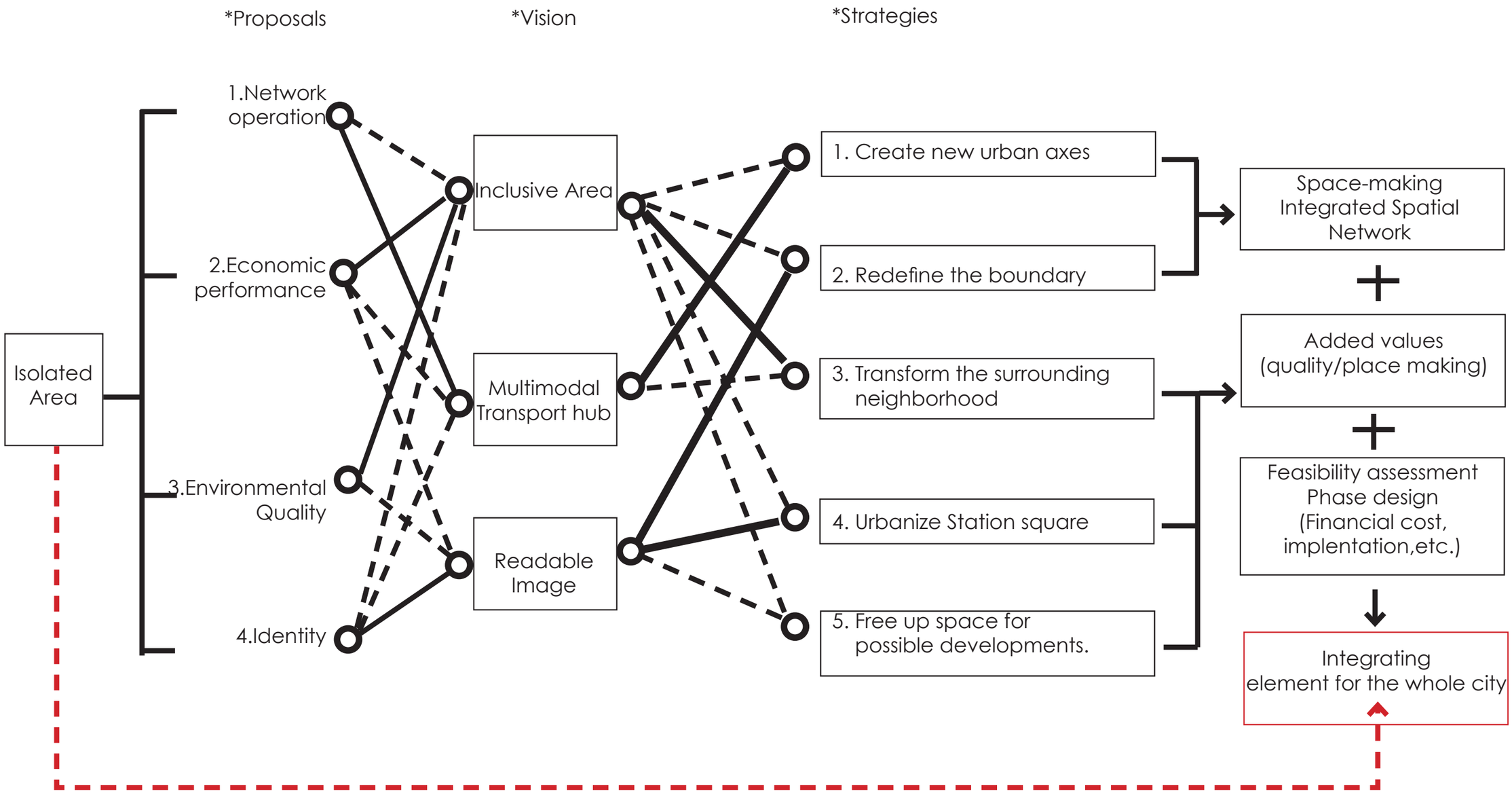
Testing phase-2 Try out

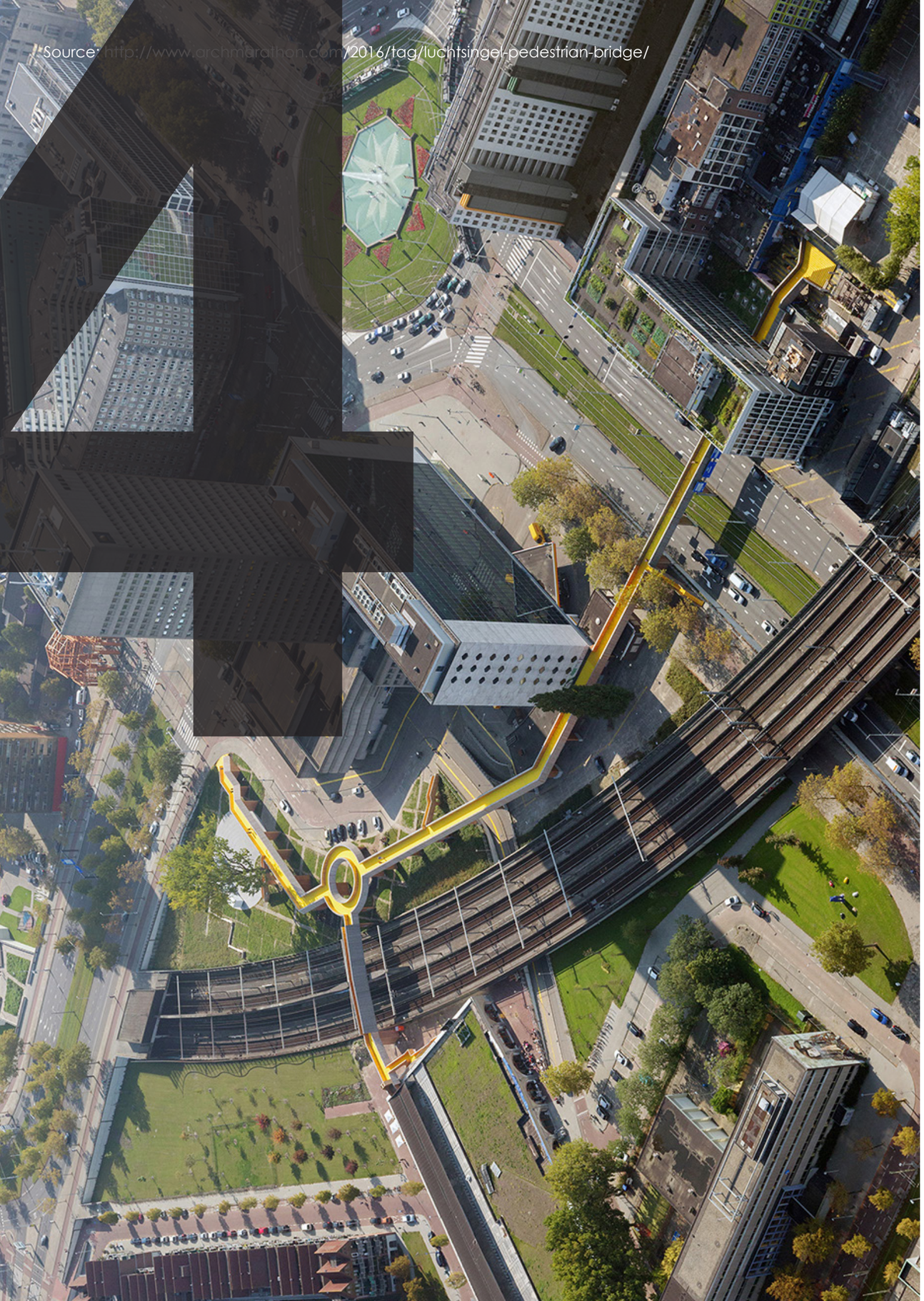
Some highly public functions, like an observation terrace, could extend over the railway area to exploratorily break through the border. Physical behavior is still restricted.



Testing phase-3 Bold crossing

By prioritizing the pedestrian and the bike lanes that connect the two sides of tracks at the main connections, people will undoubtfully feel that both sides of the tracks belong to the same shared territory.


*Proposals
*Vision
*Strategies
Isolated Area
1.Network operation
2.Economic performance
3.Environmental Quality
4.Identity
Inclusive Area
Multimodal Transport hub
Readable Image
1. Create new urban axes
2. Redefine the boundary
3. Transform the surrounding neighborhood
4. Urbanize Station square
5. Free up space for possible developments.
Space-making Integrated Spatial Network
+
Added values (quality/place making)
+
Feasibility assessment Phase design (Financial cost, implentation,etc.)
Integrating element for the whole city



Look back and ahead

Reviewing the entire design process, even though the starting points and the tactics are totally varied, most designs still share the same logic in terms of thinking structure.

1.Discovering potentials from the big picture
2. Space making, the physical basement of designs
3.Added values which maximize the overall benefits
4.Phase design by feasibility assessment

This research includes three parts: 'Dutch experience', 'Chinese application' and 'Reflection'. The Dutch experience chapter starts from the relevant theories study. By sorting out the classic theories, such as 'node & place', 'butterfly model', 'network layers', etc, the general analysis method of this specific problem could be clarified. The concept of connectivity could be defined as four aspects: network operation, economic performance, environmental quality and urban identity, according to the Dutch experience Then taking Rotterdam Central Station as an example to test the feasibility of these analyzing methods, I compared the theoretical result with the actual design plans. Afterward, the Dutch Railway Station area redevelopment projects were collected for understanding how the Dutch deal with the side effects of the train station areas within city centers. It is worth noting that in the second half period of the thesis, I changed the research question from how to reduce the barrier effect of the railway station area to how to use this area as a tool to organize the fragmented urban setting together, for not only solving the existing negative Impacts but also benefiting future development? (Fig.1)

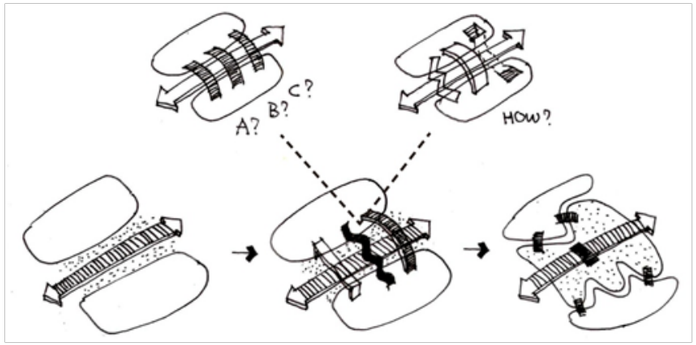


Fig.1 the shift of research questions

As for the application in China, Shanghai station area was selected as the study case. The analysis of the Shanghai railway station starts from the overall situation. First, it discusses which potential areas should be prioritized in terms of traffic operation, economic structure, environmental quality and urban identity. After discovering those precise locations, specific design can be used to correct, improve or upgrade them. These designs are not only for the current issues, but also present proposals in light of the vision for the future. In the integration of these four aspects, two pilot areas are standing out, showing more values for the overall public. This section emphasizes the value of combining the various components as an integrated system.

As for the feasibility of the Dutch experience for China, different from P2, the P4 period paid less attention to achieve a rigorous theoretic structured discussion, instead, emphasized my personal understanding of different design approaches, values behind designs, and the possible difficulties of implementation.

1. Summary of my design framework

Reviewing the entire design process, even though the starting points and the tactics are totally varied, most designs still share the same logic in terms of thinking structure.

1.1 Discovering potentials from the big picture, instead of only focusing on current issues.

Start with a big picture could help me to assess the priority and emergency issues for a city. Some current problems may be softened by themselves as time goes by, but some even worse. Only staring the current issues without considering for possible future may consume a lot of useless efforts without achieving a lasting effect, due to the changing trends. So a wise way to do it might be considering the big picture first. Two birds with one stone. Along the process of getting prepared for future trends, the current problems are solved as well. Right now, after almost one year's research, I see more potentials rather than negative sides when I look at the satellite map of Shanghai railway station area. Also from this point of view, I realized the value of scenario and vision. By creating a vision for Shanghai railway station area based on the master plan of Shanghai (2016-2035), a clear strategic framework could be made, which helps me much to organize small-scale and detailed designs.

In addition, the big picture helps me to do decisions since diverse results which based on the different perspectives confused me sometimes. For example, some certain road could be proved that it is able to contribute to the spatial connectivity most from the space syntax analysis. But it has poor performance when I use economic value to assess it. So if it is a real project, it has more possibilities to fail since people have less willing to walk along a street with lots of vehicles and few shops, even though it is a spatial shortcut.

From spatial, economic, environmental and network aspect, different valuable areas are selected. Without doubts, those areas which overlapped each other should have the priority, and the rest should be sequenced according to the city's aim. Like Shanghai Master Plan, the document shows the local government has more willing to reduce the vehicle usage and improves the walkability in the city center. Considering this intention, those narrow and fine-grid streets with less vehicle capacity are deserved more attention.

1.2 Space-making

Space is the material basis for design. After discovering the valuable locations, extra development space must be discovered both from city scale and street scale.

One of the most important tools I learned in TUD is mapping by layers. It helps me to be able to clarify the complex logic of urban formation and also the complex phenomenon of space use. Then combined with the further scenarios, I am allowed to predict the possible future. For instance, by overlapping the current economically developed areas and metro stations, a strong relationship could be discovered. On the other hand, those undeveloped metro nodes have more financial values than the others. Plus the low building quality map, some possible areas are selected. The final decision of whether to invest these areas is, of course, depending on a commercial behavior, but my theoretical research can at least offer the options which are worth to be considered, since those selected areas meet the general patterns of development and also might benefit more groups.

As for the street scale, my research mainly employed street section adjustment to create extra space. By tracing lots of street sections, I found most streets can be summarized into the combination with

three components: passage corridor, building front space, and facility belt. With these three types, all kinds of complaints on the street can be explained. So playing with those three elements, like adjusting the proportion and order of them, could act as a tool to do the design on street level.

1.3 Adding values to create urban quality

After space-making, it is still not a quality place yet. So except the spatial factor, other added values must be put under considerations in order to maximize the overall benefits.

One example from the chapter about transforming the surrounding neighborhood and opening gated community to reduce the barrier effect of the station area. I intend to demolish all the enclosing walls of residential blocks, but I also know this is too ambitious, so my design suggests first open those neighborhoods blocking the routes leading to metro stations. We can change the dull and monotonous atmosphere along residential functions, and also can improve the network operation in the regional scale. After those pilot areas, we can give further interventions according to the users' reactions. This proposal stems from network operation analysis, but ends at the neighborhood transformation action. This reminds me the value of mix things up. After we clarify a complex issue into different portions and give corresponding designs, it is also necessary and important to combine them together again.

1.4 Feasibility assessment based on financial cost and the difficulty of implementation

Concerning one research question, one year long continuous thinking leads me to realize that many designs should not be a binary opposition, either achieved or abandoned. Taking into account the reality, economic costs and difficulty of implementation, we, as designers, should not think of compromises first, but must identify which values cannot be changed even facing the resistance. In fact, we can gradually achieve an ambition by setting priorities and phases. Identifying which locations need to be implemented first can bring greater benefits and serve as a showcase. For example, one of my visions is to open the railway fence to form a readable railway image. This proposal obviously has more social significance, but the design should not just stop here. First I consider the reasons for its existence: due to the huge population, using fences to limit people's behavior and possible crimes is the simplest measure to ensure the security of the railway region in China. However, for this basic requirement, we were forced to abandon other added values. So I started to think about which part of enclosing wall should be and could be removed first, on the premise of guaranteeing safety. I discovered the railway museum which next to the railroad tracks. It could serve as a window to visually open the railway area to the public. At least the brick wall can be changed into a transparent material, and even platforms, cafes and so on can be elevated standing out of the boundary, in order to test the public's reactions to this opened-up border.

2. Look back and look ahead
2.1 The difficulty of implementation

First, the overall urban design is necessary. The existence of a master plan already could help developers to perceive economic benefits and lower risks. So the local government plays a significant role, who largely defines the overall urban structure of the area and the functional programs. However, when looking back at the entire study, I also recognized the bottom-up value of Dutch design. Only if every individual project is able to absorb the expected or unexpected changes, and they are all under a common framework, many ambitions can be realized gradually like this. At the same time, the long time period of Dutch design and project discussions ensure that as many aspects as possible are considered and as many voices as possible are heard. In the case of China, the design cycle of a large-scale project may be only one year or even less. But once completed, it will affect the periphery for a long time whether successful or not. Therefore, the bottom-up design method has shown more value to China. I look forward to a vision, which top-down and bottom-up, can meet at the midpoint. At least, I should work and think in this way.

2.2 Research limitation

The conclusion of the Dutch experience is from a personal perspective and very subjective. A lot of values might be different due to the change of cultural environment. Personal acceptance does not represent the social environment is ready. So learning from Dutch design methods is more help to shape my personal design approach.

In addition, due to the limitations of the data collection, only a few relevant design plans for Shanghai Railway Station have been found. So this research lacks horizontal comparison, and also didn't show in the report.

2.3 Other Gains

In addition, some other skills have also been trained.
-How to tell a good Story? A logic framework could avoid your audients lost in the middle, but some sparkling elements could amuse them and keep them maintain high interest.
-The richness of diagrams and drawing techniques are not only for beauty, but also represent the diverse angles of analyzing, which can expand my own thinking and also contribute to putting my concept much clearer.

2.4 Next step

In the P5 phase, the report will be simplified into a few specific proposals, and is expected to be sent back to Chinese designers and officers. By their possible feedbacks, the feasibility and the possible inadequacies of my design could be further discussed.

5. Relevant bibliography/ Literature

Alexander, M., & Hamilton, K. (2015). A 'placeful' station? the community role in place making and improving hedonic value at local railway stations. Transportation Research Part A: Policy and Practice, 82(4), 65-77. doi:10.1016/j.tra.2015.09.006

Bertolini, L. (1996). Nodes and places: Complexities of railway station redevelopment. European Planning Studies, 4(3), 331-345. doi:10.1080/09654319608720349

Bertolini, L., & Spit, T. (1998). Cities on rails : The redevelopment of railway station areas. London: E & FN Spon.

Bertolini, L. (1998). Station area redevelopment in five european countries: An international perspective on a complex planning challenge. International Planning Studies, 3(2), 163-184.

Bertolini, L. (1999). Spatial development patterns and public transport: The application of an analytical model in the netherlands. Planning Practice and Research, 14(2), 199-210. doi:10.1080/02697459915724

Bertolini, L. (2007). Knots in the net: On the redevelopment of railway stations and their surroundings. City, 1(1-2), 129-137. doi:10.1080/13604819608900031

Bishop, P., & Williams, L. (2016). Planning, politics and city making : A case study of king's cross. London: RIBA Publishing.

B., G., M., & M. (1990). Space station freedom crew training. Acta Astronautica, 22, 65-70.

Bruinsma, F., & European Regional Science Association. Conference (45th : 2005 : Amsterdam, Netherlands). (2008). Railway development : Impacts on urban dynamics. Heidelberg: Physica-Verlag. doi:10.1007/978-3-7908-1972-4

CLARK, D. (2006). Externality effects on residential property values: The example of noise disamenities. Growth and Change, 37(3), 460-488. doi:10.1111/j.1468-2257.2006.00332.x

Edwards, B. (1997). The modern station: New approaches to railway architecture. London: Spon

E., D., K., H., T., & K. (2016). Connectivity and physical activity: Using footpath networks to measure the walkability of built environments. Environment and Planning B: Planning and Design, 43(1), 130-151. doi:10.1177/0265813515610672

E., & S. (2011). Railway station role in composing urban conflicts. Tema: Journal of Land Use, Mobility and Environment, 4(4), 47-58. doi:10.6092/1970-9870/530

Ewing, R., & Clemente, O. (2013). Measuring urban design : Metrics for livable places (Metropolitan planning design). Washington, D.C.: Island Press.

Garmendia, M., Ribalaygua, C., & Ureña, J. (2012). High speed rail: Implication for cities. Cities: Supplement 2, 29, 31. doi:10.1016/j.cities.2012.06.005

Gramsbergen, E., Rogic, T., Groenewold, S., & De Vries, M. M. (2013). Train station as integrated urban element in Koog-Zaandijk: Retrieved from Item Resolution URL http://resolver.tudelft.nl/uuid:4d532115-5965-4695-a0a6-11ded36db568

Harris, N., & Callaghan, M. (1997). Railway profitability and station closures. Transport Policy, 4(1), 41-47. doi:10.1016/S0967-070X(96)00033-9

Hamm, M., & Binney, M. (1984). Great railway stations of europe. London: Thames and Hudson.

Hillier, B. (1996). Space is the machine : A configurational theory of architecture. Cambridge, UK: Cambridge University Press.

Jacob Trip, J. (2008). Urban quality in high-speed train station area redevelopment: The cases of amsterdam zuidas and rotterdam centraal. Planning Practice and Research, 23(3), 383-401. doi:10.1080/02697450802423633

Jones, W. (2006). New transport architecture. London: Mitchell Beazley.

King, K. (2013). Neighborhood walkable urban form and c-reactive protein. Preventive Medicine, 57(6), 850-854. doi:10.1016/j.ypmed.2013.09.019

Kusumo, C. (2007). Railway station, centres and markets: change and stability in patterns of urban centrality. [s. n.], [S. l.]: Retrieved from WorldCat.org

Klaassen, L. (1981). Infrastructure design and urban form: An exercise in geometry. De Economist, 129(1), 105-105.

Lloyd, D., & Insall, D. (1978). Railway station architecture([New rev. ed.]. ed.). Newton Abbot England: David & Charles.

L., L., L., Z., K., & 2012 2nd International Conference on Green Building Materials and Civil Engineering, GBMCE 2012 2012 2nd International Conference on Green Building, Materials and Civil Engineering, GBMCE 2012 SanYa, CHN 2010 08 22 - 2010 08 23. (2012). Multi-criteria decision analysis: Beijing south railway station. Applied Mechanics and Materials, 193-194, 876-881. doi:10.4028/www.scientific.net/AMM.193-194.876

Kusumo, C. (2007). Railway station, centres and markets : change and stability in patterns of urban centrality. [s.n.], [S.l.] : Retrieved from WorldCat.org.

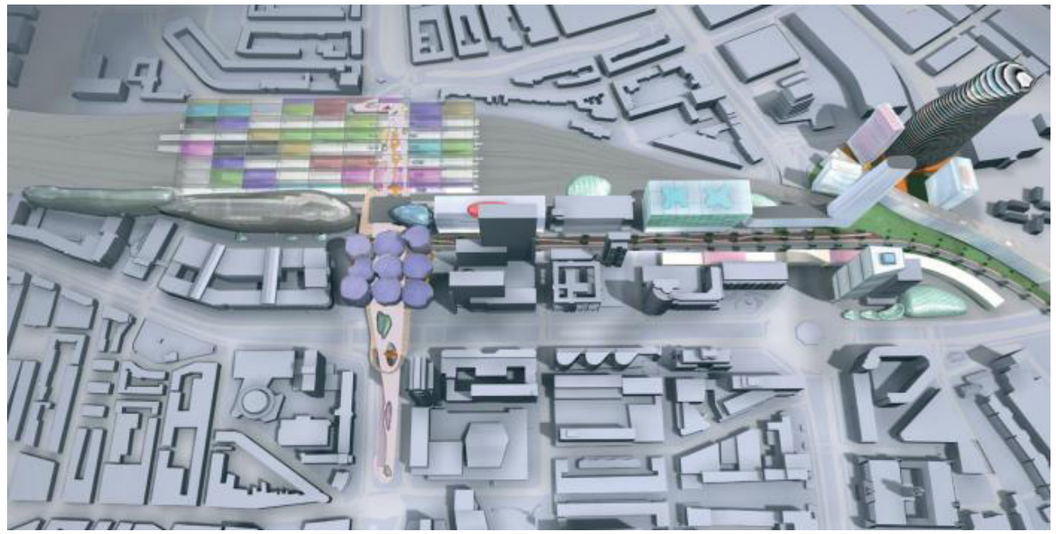
Maylin, M., & Shanmuganathan, S. (2004). New station brings trains back to auckland's centre. Proceedings of the Institution of Civil Engineers - Civil Engineering, 157(4), 164-171. doi:10.1680/cien.2004.157.4.164

Mohajeri, N., & Amin, G. (2010). Railway station site selection using analytical hierarchy process and data envelopment analysis. Computers & Industrial Engineering, 59(1), 107-107.

M., O., & L. (2013). Efficiency and spatial equity impacts of high-speed rail extensions in urban areas. Cities, 30(1), 18-30. doi:10.1016/j.cities.2011.11.002

Appendix-1:

Collection of Dutch projects
Masterplan of Station Area, station layout, tunnels and footbridges.



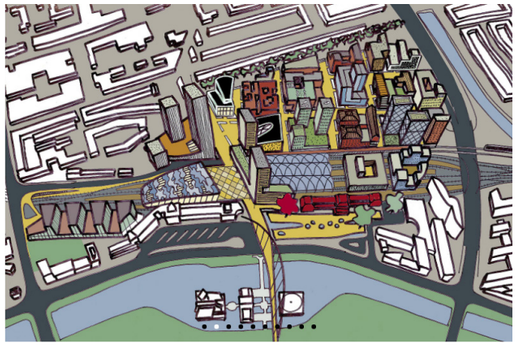
Rotterdam central station Masterplan, Alsop Architects, 2001
From the scheme, we can find this masterplan also select Connection A and E as the two main develop area, which is same as our previous analysis.

Name: Rotterdam central station
Design office: Alsop Architects, 2001

PROJECT INTRODUCTION:

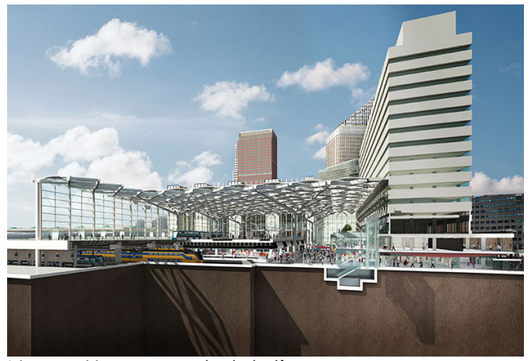
For improving the connection between the station area and the inner city, further upgrading the urban quality as a whole, the objectives of the project went beyond the station itself. It also includes the redevelopment of the wide surroundings of the station, like traffic area and some unattractive space in its vicinity.

Eventually, Alsop Architects from London was selected to make an elaborated design. In April 2001, Alsop presented his Masterplan Rotterdam Centraal. It included a real estate programme of 641,000 m2, consisting of 195,000 m2 of residential area, 318,000 m2 of offices, a hotel and 125,000 m2 of ‘urban entertainment’, entailing various amenities such as shops, catering and a theatre. This would imply a considerable increase in density that should improve the liveliness of the area and provide environmental and financial advantages. As a highlight, the station entrance would be marked by a group of giant ‘champagne glasses’. Alsop’s Masterplan was not so much an architectural design, as a flexible framework.



Name: Station forecourt and bike shelter
Design office: KCAP
Proposal: a dynamic urban zone

Name: RER Station Nanterre, France
Design office: KCAP



Name: Hague central station
Design office:BENTHEM CROUWEL ARCHITECTS

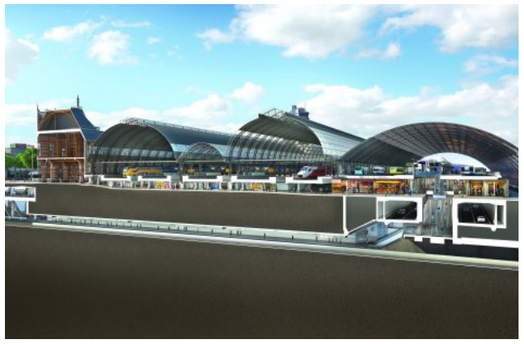
Name: Breda Station
Design office: Koen van Velsen architects
Proposal:
Specific condition: firmly interwoven with the surrounding buildings

Name: Tampere Travel and Service Center
Design office: KCAP

Name: OZ Nature Urbaine in Montpellier
Design office: KCAP
Proposal: Urban development of an area around future TGV station
Specific condition:
a strong underlying framework of public spaces with the landscape as an important base and driver. This framework, that carefully incorporates the new infrastructure, allows for a phased development that is open for change, but that creates a strong identity at the same time.

Name: Rotterdam Central Station
Design office: BENTHEM CROUWEL ARCHITECTS

Name: Central Station
Design office: MVRDV



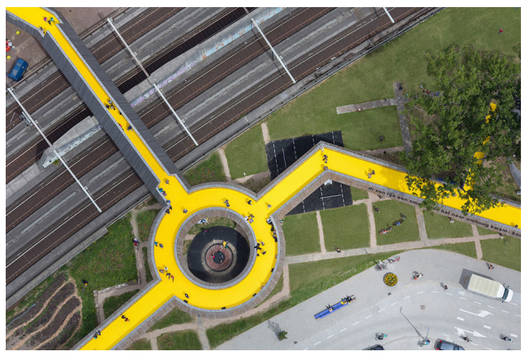
Name: Amsterdam Station
Design office: BENTHEM CROUWEL ARCHITECTS

Name: Utrecht Central Station
Design office: BENTHEM CROUWEL ARCHITECTS

Name: Delft station

Name: Cuyperspassage, Amsterdam Central Station
Design office: Benthem Crouwel
Proposal: connects the city and the waters of the IJ-river.
Specific condition:The gratings are impossible to litter with posters and flyers and their open structure reduces the risk of graffiti.

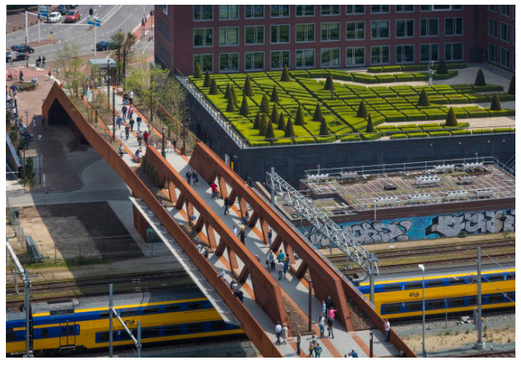
Name: 'The Moodwall', close to the Amsterdam Bijlmer subway station.
Design office: Studio Klink
Specific condition: The curves in the wall make it less vulnerable to graffiti and improve visibility.



Name: Luchtsingel
Design office: MAXWAN(ZUS)
Proposal:
Specific condition: Rotterdam Central District carries the advantage of being a prime location in the city, however it is dominated by abandoned open spaces and vacant high rise buildings.

Name: Waalhaven footbridge
Design office: IPV Delft
Proposal: the marshalling yard has been a barrier for pedestrians wanting to get to the Waalhaven port.

Name:Moreelsebrug, Utrecht
Design office: Cepezed
Proposal: Connecting the Croeselaan and the Moreelsepark with each other across the railway tracks. The trees on the bridge form a raised continuation of the avenue of trees.



Name: The Paleisbrug (palace bridge)
Design office: Benthem Crouwel
Proposal:t is designed to connect the old town centre and the new Paleiskwartier (Palace district) of the city 's Hertogenbosch and at the same time meant to create unity with the surrounding historic green landscape.

Name: Hovenring Eindhoven
Design office: IPV Delft
Proposal: This spectacular circular cable-stayed bridge offers cyclists and pedestrians an exciting crossover.

Appendix-2:

Theory paper

Interpretation of how do railway areas promote barrier effect in high density city center.
13-12-2017

Abstract
This paper tries to investigate how railway areas promote physical and social barrier effect in the high-density city center, by reinterpreting related spatial configuration theories. In Europe, railway stations were historically placed outside the city. As the city expanded, these transportation infrastructures were gradually pulled in and absorbed by the urban fabric, becoming a part of the expanded city center. However, due to their spatial features, railway areas usually act as the physical barrier, leading to the division of urban surroundings. Broken urban operation and downgraded environmental quality further promote urban fragment and even social segregation, restricting the renaissance of city centers.

How to overcome the spatial limitations and how to cooperate with railway station areas in the high-density city center have become heated topics of discussion in city redevelopment, this research anticipates that Interpreting how does this barrier effect come into existence will be a helpful premise of attempting to solve this problem.

By reviews of existing perspectives of connectivity, mainly from spatial configuration field, the idea that railway areas are intended to guarantee connectivity in the regional scale, at the expense of integration with the urban grid, could be clearly identified. Based on the understanding of the theories, the specific barrier components will be clarified from physical aspect to social-economic aspect, and a total of six elements in three categories could be summed up, which work together to form the barrier effect. Topics such as agglomeration of railway facilities, pollution coming from tracks, block scale, network grid and unbalanced development paces on both sides will be investigated. Through clarification of these barrier components, the corresponding solutions can be found purposefully, providing theoretical support for specific design.

Keywords:
Railway Station Area, Spatial Configuration, Barrier Components, Connectivity

Fig. 1 The aerial view of London. Is railway station area a barrier to the urban environment?
http://www.alamy.com/stock-photo-aerial-view-of-railway-junction-outside-london-bridge-train-station-55117428.html

1. Introduction

In most European cities, railway stations were originally sited at the urban fringe. However, city tissue often overlapped stations when it extended. Over time, they find themselves immersed in the dense city center. This dramatically changed positional relationship leads transformation of their roles within cities- they are acting as the major components in urban regeneration currently. On one side, railway areas gain an increasing multifunctional role over time, but on the other side, there are paradoxically physical scars and urban blights. (Fig. 1)

Is railway station area a barrier to the urban environment? The answer is so obvious. Due to the different spatial features between the railway areas and urban settings, they have difficulties to well connect to their surroundings. These railway areas thus are seen as isolated spots lacking the healthy relationship with the city. Traffic congestion, mixed-use space of pedestrian and vehicle, disarray urban environments and low spatial utilization in high property value distracts. All these conflicts could be commonly perceived in railway station areas around the world, Western Europe and Asian countries, especially in those densely built-up city centers which mean conflicts have become even more acute. But how exactly do railway areas contribute to form these barrier effects? How does previous research works interpret this topic?

The second chapter introduces the methodology employed in this thesis. The main body of related research addresses station building itself, like discussing its transformation, expansion and improvement. Meanwhile, the conceptual planning strategies which aim economic redevelopment are also widely concerned. However, the spatial study on the connecting area of railway stations in the city center is limited. Hence in this research, the problem of integrating railway stations and their surrounding areas into the urban grid is the subject. After the definition of key concepts, a brief review of related theories is followed in Chapter Three. The theory of hierarchy from Stephen can explain the reason for sacrificing low-level connectivity due to the urban operation, which is a major impediment to the connectivity of the railway station area. Hillier and Bertolini demonstrated that the railway station area more concerns with passenger transportation and lost its focus on local life, from two different perspectives.

Agglomeration of railway facilities, pollutions coming from tracks, station layout, block scale, network grid and unbalanced development paces, the Chapter Four elaborates that by manipulating these six physical components, we can form a universal framework to improve the spatial connectivity. Moreover, this theoretical framework could also provide a clear guidance about how to optimize connectivity in specific projects for achieving better environmental quality and urban operation efficiency, particularly in high-density metropolises. This further interpreting of barrier effect formation and clarifying barrier elements could be the key premises of solving current problems and also guiding the future renaissance work.

Considering the possibilities caused by their strategic locations, railway areas that used to be treated as 'urban barriers', now, can be seen as ' potential areas' to integrate fragmented urban fabric. So, reconsidering this 'obvious' question may bring us some fresh air, among the ongoing trends of redeveloping city centers.

2. Methodology:

Before introducing the relevant theories, the definition of connectivity needs to be discussed first. Through this chapter, we can clearly see what specific factors can affect the 'connectivity', and then elaborate it to railway station area.

2.1 Concept Definitions:

-Connectivity (or permeability) refers to the directness of links and the density of connections in a transport network. A highly permeable network has many short links, numerous intersections, and minimal dead-ends. As connectivity increases, travel distances decrease and route options increase, allowing more direct travel between destinations, creating a more accessible and resilient transportation system. (Online TDM Encyclopedia, http://www.vtpi.org/tdm/tdm116.htm, viewed 5/12/2017)

-From the view of spatial syntax, Connectivity is the simplest metric for assessing ranking of nodes within a connectivity graph. It equals the number of directly linked or neighboring

nodes.(Hillier, 2007)
In addition, there is broad consensus that high connectivity could be perceived when an area exhibits clear and direct routes between destinations. Southworth (2005) has suggested that some attributes of connectivity are: dense networks of streets; fine-grained blocks and the mix of land uses and high environmental quality.

2.2 Elements Clarification based on Definitions
No matter depending on which definition, connectivity of spatial structure in the cityscape, especially in high-density city centers will be influenced by block scale and street network. Changes of the block scale caused by the presence of station and tracks affect the degree to which transportation networks such as roads, walking streets and cycling paths. Good connectivity could be achieved by proper block scale and street network density. Specific to railway station areas, physical elements and structural aspects can be summed up now. The existence of track, station building and the pollutions coming with tracks are main three physical components of barrier effect, and they cause the changes of block scale and urban grid network. (Fig. 2)

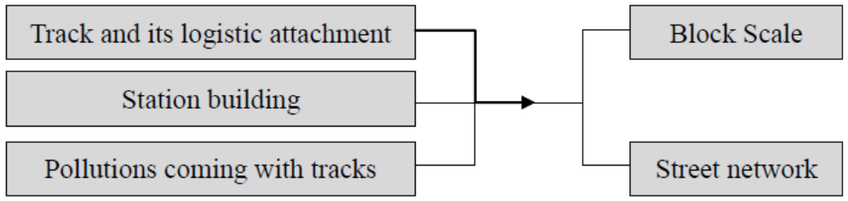


Fig.2 Physical interventions cause the structural changes.

3. Re-interpretation of Previous Theory
This chapter employs theoretical review, trying to explain how railway areas promote barrier effect, mainly from spatial configuration aspect.

Railway station area contains increasing commercial values and social benefits have been widely discussed (E. & S. 2011, Jacob Trip, J. 2008). Based on this general agreement, some scholars further studied the interactive relation between railway area and urban grid. This paper mainly focuses on the theories of Stephen Read, Bill Hillier and Luca Bertolini.

3.1 Layer concept from Stephen Read:
a. Explanation of Theory
After research on spatial structures of Dutch cities, Read (2000, 2002) has claimed that the movement grid of city is organized by different scales of movements. This grid could be interpreted as a spatially layered network, which intends to transport different scales of movement (Fig. 3).

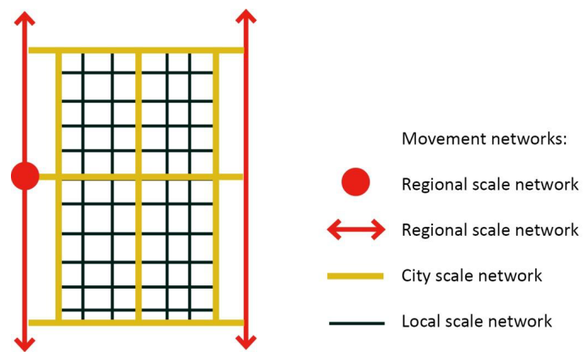


Fig. 3 Different scales of movements
Source: Made by the author according to Read, 2000

At least three hierarchies can be recognized, namely regional layer, city layer and local layer. The first one is regional scale network which provides mobility between cities, with railway network and highway network as the typical representatives. The second level is the city-scale grid, which is designed for carrying medium-distance traffic within an urban area. For example, the vast majority of major roads, as well as particularly busy secondary roads. As the backbone of the mobility structure, they are bearing a great volume of traffic flow, compared with local streets. Thus, this city-scale grid cannot be easily interrupted, presenting a strong spatial linearity and continuity. (Read, 2001). And the third one is the grid at a neighborhood or local level. This classification is represented by the streets in neighborhoods. Distinguishing from the city-scale grid, this grid more services local inhabitants, supporting short distance transportation.

b. Personal Interpretation
Although there is an interactive relationship between these three layers, this interaction presents more of a one-way effect. Among three levels, local level owns the largest amount of streets, but for guaranteeing the larger scale mobility, like regional scale or city scale, it still owns the lowest status given by urban supervisors and designers. Specifically, when conflicts arise across levels, larger scale grids get priority, while the local level is often sacrificed first. Through these two triangular illustrations, we can clearly distinguish the hierarchical relationship between three levels (Fig. 4). It is precisely because of this relationship that we can further specify that railway is primarily an obstruction to the local network, instead of for all grids.

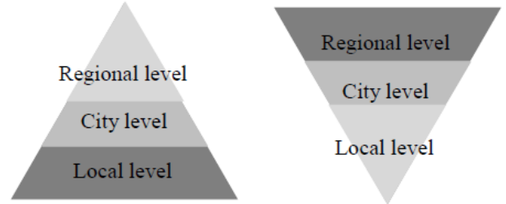


Fig.4 Two triangular diagrams show the hierarchical relationship among three levels.
Source: Made by the author.

This understanding can well explain the existence of different types of intersections (tunnels and dead-ends) around the railway. Tunnels or bridge appears when the city-level network (e.g. Main road) needs to cross regional network (e.g. Railway). But when local roads hope to pass through the tracks, they are mostly cut off, due to the lowest status. Larger grids got the weakest interference at the expense of connection on the local level.(Fig. 5)

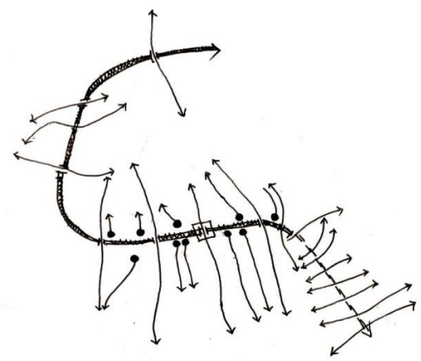


Fig.5 The street network analysis of Rotterdam city center shows, city level streets could cross the railway by tunnels and viaducts, but local level streets become dead-end when they meet the tracks.
Source: Made by the author.

3.2 Node & Place theory from Luca Bertolini
By focusing on policy-making and spatial planning for railway station areas across Europe, Bertolini and Spit (1998) introduced 'node' and 'place' as two key features. A good example is a railway station. As the public transportation hub in the city center, a railway station and its surrounding exhibit both 'node' attribute and 'place' attribute. (Fig.6)

a. Explanation of Theory
The node describes the accessibility and the place represents the intensity of activities. Yet this kind double-attribute causes dilemmas. Some railway areas are 'isolated nodes' for their adjacent urban fabric. They function well as important transport hubs, but fail to be the places where can host different groups. They only attract or used by travelers and commuters. They have a weak relationship with urban context.

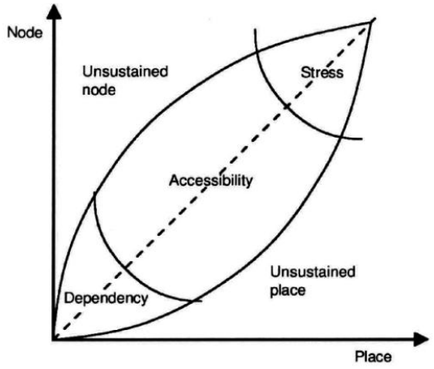


Fig.6 Node/place model
Source: Bertolini 1999

b. Personal Interpretation
From this angle, Bertolini's theory further explains the root cause of how does the railway fragment the urban context, and also expands the term 'connectivity' from a spatial concept to a social one. The imbalance between 'transport attribute' and 'social attributes' causes rupture of spatial structure, as well as the social life.

Railway area is not only a node of mobility network, but also a place where people meet and social life happens. But all the facilities and space around railway areas mainly service the passenger, rather than the local. Over-valuing mobility and neglecting the local life fail to achieve the place-making in this unique public area. Thus, in the limited space of railway areas, railway station areas require integration between transport function and social function, fixing them into their urban context firmly and deeply. Both passengers and residents must be accommodated together in the area.

3.3 To-movement & Through-movement theory from Bill Hillier
When we talk about station area, our impression is always about arriving and departure. Since we perceive station as urban gateway or landmark, we almost never consider how to cross them. Hillier uses the term 'to-movement' and term 'through-movement' to clarify this delicate preference.

a. Explanation of Theory
According to Hillier (2007), the spatial configuration of the street grid directly determines movement pattern of people and somewhat affects commercial activities (Hillier, 2007). Specific to the topic of this research, when a station with a more integrated network performs more to-movement potential, more commercial activities (more place value) appear in this area and attract more people access there (more node value). However, at the same time, through-movement potential is also expected, which helps station area to be an accessible pass by zone for people (more node value) and promotes more activities to occur (more place value).

b. Personal Interpretation
These two unbalanced attributes have a reasonable excuse for their existence. A railway station is mainly for the purpose of transporting long-distance travelers. So nothing is wrong with that to-movement overwhelms through-movement. However, as the functions of the railway station area being expected by the society increases, the inclined balance must be gradually adjusted to a new equilibrium.

4. Barrier Elements Summary
Based on the analysis above, we can start the clarification of influencing factors on the barrier effect in this chapter. Block scale and road network density are two important structural factors. Specific to the railway station area, their appearance is due to the existence of railroad tracks. At the same time, in addition to passengers and goods, along with the railway, there are all kinds of environmental pollution. This article summarizes these two elements as material ones. Due to the spatial structure and environmental impact, the communities surrounding the railway station also proactively differentiated. The commercial areas with high environmental requirements are selected in front of the station while the "low" functions such as residence have no choices. Spaces with specific features, in turn, generate distinctive social influence that impacts back on the physical environment. Different functions gradually lead to economic and social imbalances. At this point, we divided the barrier effect of the railway station into six elements of three major categories. They have a causal relationship and promote each other to form a circular logic at the same time (Fig.7).

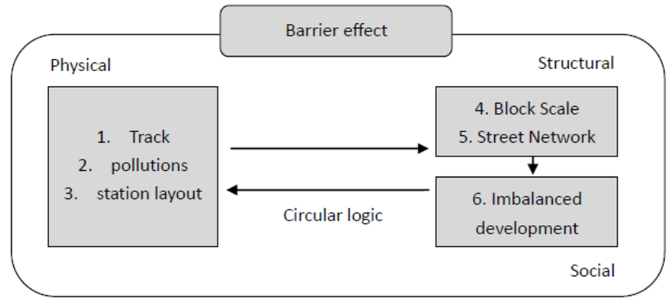


Fig.7 Six elements of three major categories

4.1 Tracks and related logistics facilities
Tracks and related logistics facilities may be the most intuitive explanation of why railway area is a barrier. For safety and security concerns, these huge areas prohibit casual passage of non-staff members. At the same time, designers ' hands are tied. Generally speaking, tracks and related logistics facilities have been treated as a fixed component, since they have strict engineering standards which are hard to be modified. There are two means to cross over them-either by tunnel or by bridge, but both ways have their corresponding disadvantages, namely, low environmental quality, security issue and high cost.

All in all, even with these ways to cross over, railway tracks and related logistics facilities still pose the particular difficulty to spatial connectivity.

4.2 Environmental pollutions coming with tracks
The railway tracks are often accompanied by various environmental effects, namely noise, vibration, particulates and visual pollution, which may downgrade the local living quality. (CLARK, D. 2006)

For solving these environmental problems, a buffer zone is employed. In some cases, the whole area is even settled underground for minimizing its influence. But the fact that the station disappears from sight does not mean that trains can be hidden properly, whether you set it underground or cover with the fence. Because unfortunately, except relieving adverse

effects, the spatial consequences caused by these solutions have also hindered connectivity to some degree, even became certain blight features of neighborhoods.

4.3 Station layout

Large areas of urban settings separated by the tracks can be only crossed by footbridges, viaducts, tunnels and stations themselves. The stations, therefore, should also act as a key connection between urban parcels. In the specific designs, the spatial layout of the railway stations, especially the relationship between the track and the ground in the section, has the greatest impact on the connectivity of the surrounding environment (Fig.8). Many modern stations have been designed as a part of urban context, stitching them into both the physical and social network of the city.

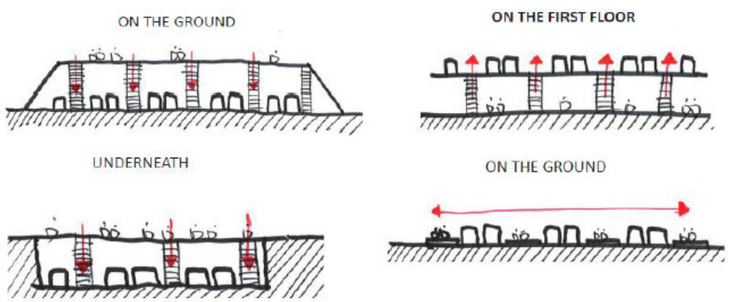


Fig.8 The four types of station layout
Source: Made by the author.

4.4 Block scale

The blocks of the railway station area are mainly determined by the platform length and train length. Within inner-city stations, the platform length is normally around 240m, up to 300m at maximum. With such huge volume, they have no doubts to be isolated from the much of urban surroundings. They stand in the middle of 'Dwarfs', showing sharp contrasts of scale, activity and atmosphere.

Camelia's Ph.D. research uses comparison study of two Dutch cities to state that only if railway station block fit into the local network, their potentials could be stimulated, both on economical aspect and social aspect (Camelia, 2007). Kusumo studied the how the spatial configuration of station area impact on the generation of urban vitality and on commercial prosperity. Her study indicated that fine-divided and well-integrated network structure at the local level could benefit commercial activities. (Mulders-Kusumo, 2005, 2007).

4.5 Street network density

Meanwhile, street network density changes along with block scale. The larger block scale, the sparser street network. This causes the obstacle to various kinds of traffic operations, vehicles, trams, bicycles and pedestrian. Among them, pedestrians are affected most. Even though, a reasonable walking distance likely depends on many physical factors, like location, topography, purpose and the walking environment including pedestrian facilities, many people accept 400 meters as an "acceptable" distance for walking. Where connections meet major barriers, such as railway track, the network distance should be ideally no longer than 500 meters between intersections. But the reality is hard to meet this request.

4.6 Unbalanced development

Finally, the social impact caused by the above spatial and structural elements should be clarified. Generally, there are two types of station neighborhood, one on the 'right' and another one on the 'wrong' side (Bertolini, 1996). The residential blocks are often placed on the so-called backside where hosts all the logistic functions, while the front is often occupied by offices, retails and other commercial uses. It suggests that society has responded to space by putting specific functions in specific locations.
Hillier (1993) and Paksukcharern(2003) have identified these features and have used the term "blight" to describe this negative result caused by barrier effect of railway tracks, assuming that the areas behind railway are negative. As the obstacles within the urban grid, railway areas cause interruptions to relevant network operation, creating a place where no prosperity can flourish or grow.

Stations change the city at two scales. The first impacts are superimposed onto the urban fabric with much contrast. While at the micro-level, local impacts shape the identity of neighborhoods, commercial activities and social life. These differences in building density and land use suggest space and society are closely related. Specifically, it is spatial features of railway areas that fundamentally determine the forms and functions on the two sides of tracks, bringing barriers to city operations and social life

5. Conclusion:

Through reviewing spatial configuration theories, why do railway areas promote barrier effect to high-density city center could be further investigated. Overvaluing the regional mobility and neglecting the local level might be the main reason causing this barrier phenomenon. Emphasis on the role of transportation while ignoring the place making also played a role.

The barrier effects working on the urban tissue at least manifested at three aspects: As for physical aspect, railway infrastructure, station layout and various pollutions coming with tracks downgrade the connectivity nearby; From the spatial perspective, building blocks and street grid are disturbed-specifically shown as the different sizes of the block patterns, while the obstruction of street network is often evident in the degree of fragmentation and incoherence; unbalanced development structure on both sides of track from the social-economic aspect. And the causality between spatial, economic and social aspects is also clarified- there is a circular logic among these three aspects, they strengthen each other and work together to form the barrier effect.

In conclusion, this study reveals that the railway station areas, due to their physical structures, have interrupted the continuity and Integrity of their surrounding urban fabric in various ways. So during the design process, how to cross the physical barrier is not the only target, how to bridge the economic gap and how to promote the social harmony should also put under consideration. The six elements offered in the paper form a universal framework to improve the spatial connectivity in railway station areas.

Reference & Bibliography

Alexander, M., & Hamilton, K. (2015). A 'placeful' station? the community role in place making and improving hedonic value at local railway stations. Transportation Research Part A: Policy and Practice, 82(4), 65-77. doi:10.1016/j.tra.2015.09.006

Bertolini, L. (1996). Nodes and places: Complexities of railway station redevelopment. European Planning Studies, 4(3), 331-345. doi:10.1080/09654319608720349

Bertolini, L., & Spit, T. (1998). Cities on rails : The redevelopment of railway station areas. London: E & FN Spon.

Bertolini, L. (1998). Station area redevelopment in five european countries: An international perspective on a complex planning challenge. International Planning Studies, 3(2), 163-184.

Bertolini, L. (1999). Spatial development patterns and public transport: The application of an analytical model in the netherlands. Planning Practice and Research, 14(2), 199-210. doi:10.1080/02697459915724

Bruinsma, F., & European Regional Science Association. Conference (45th : 2005 : Amsterdam, Netherlands). (2008). Railway development : Impacts on urban dynamics. Heidelberg: Physica-Verlag. doi:10.1007/978-3-7908-1972-4

Bertolini, L. (2007). Knots in the net: On the redevelopment of railway stations and their surroundings. City, 1(1-2), 129-137. doi:10.1080/13604819608900031

CLARK, D. (2006). Externality effects on residential property values: The example of noise disamenities. Growth and Change, 37(3), 460-488. doi:10.1111/j.1468-2257.2006.00332.x

Edwards, B. (1997). The modern station: New approaches to railway architecture. London: Spon

E., D., K., H., T., & K. (2016). Connectivity and physical activity: Using footpath networks to measure the walkability of built environments. Environment and Planning B: Planning and Design, 43(1), 130-151. doi:10.1177/0265813515610672

E., & S. (2011). Railway station role in composing urban conflicts. Tema: Journal of Land Use, Mobility and Environment, 4(4), 47-58. doi:10.6092/1970-9870/530

armendia, M., i alay ua, ., & re a, J. (2012). High speed rail: Implication for cities. Cities: Supplement 2, 29, 31. doi:10.1016/j.cities.2012.06.005

Hillier, B. (1996). Space is the machine : A configurational theory of architecture. Cambridge, UK: Cambridge University Press.

Jacob Trip, J. (2008). Urban quality in high-speed train station area redevelopment: The cases of amsterdam zuidas and rotterdam centraal. Planning Practice and Research, 23(3), 383-401. doi:10.1080/02697450802423633

King, K. (2013). Neighborhood walkable urban form and c-reactive protein. Preventive Medicine, 57(6), 850-854. doi:10.1016/j.ypmed.2013.09.019

Kusumo, C. (2007). Railway station, centres and markets: change and stability in patterns of urban centrality. [s. n.], [S. l.]: Retrieved from WorldCat.org

Klaassen, L. (1981). Infrastructure design and urban form: An exercise in geometry. De Economist, 129(1), 105-105.

Lloyd, D., & Insall, D. (1978). Railway station architecture([New rev. ed.]. ed.). Newton Abbot England: David & Charles.

Mohajeri, N., & Amin, G. (2010). Railway station site selection using analytical hierarchy process and data envelopment analysis. Computers & Industrial Engineering, 59(1), 107-107.

M., O., & L. (2013). Efficiency and spatial equity impacts of high-speed rail extensions in urban areas. Cities, 30(1), 18-30. doi:10.1016/j.cities.2011.11.002

Pels, E., & Rietveld, P. (2016). Railway station and urban dynamics. Environment and Planning A, 39(9), 2043-2047. doi:10.1068/a4093

P., & N. (2012). Train station area development mega-projects in europe: Towards a typology. Built Environment, 38(1), 12-30. doi:10.2148/benv.38.1.12

Read, S., & Kanellos, L. (19uu). Learning from amsterdam : Axes and centres in the dynamic city. Delft: Technical University.

Read, S.A. (1996). Function of Urban Pattern, Pattern of Urban Function. Delft: Publicatieburo Bouwkunde, Delft University of Technology.

Read, S.A. (1999). Space Syntax and the Dutch city. Environment and Planning B: Planning and Design, 26, 251-264.

Read, S.A. (2000b) Space movement and scale in the Dutch city. In A. Nieuwenhuis & M. Van Ouwerkerk (Eds.), Proceedings of Research by Design conference in Delft University of Technology. Delft: DUP Satellite.

Read, S. A. (2001). Thick Urban Space: shape, scale and the articulation of 'the ur an' in an inner-city neighbourhood of Amsterdam. In J. Peponis, J. Wineman & S. Bafna (Eds.), Procedings of International Space Syntax 3rd Symposium in Georgia Institute of Technology, Atlanta.

Ross, J. (2011). Social sustainability in urban areas: Communities, connectivity and the urban fabric. Australian Planner, 48(3), 245-246. doi:10.1080/07293682.2011.595061

Stangl, P., & Guinn, J. (2011). Neighborhood design, connectivity assessment and obstruction. Urban Design International, 16(4), 285-296. doi:10.1057/udi.2011.14

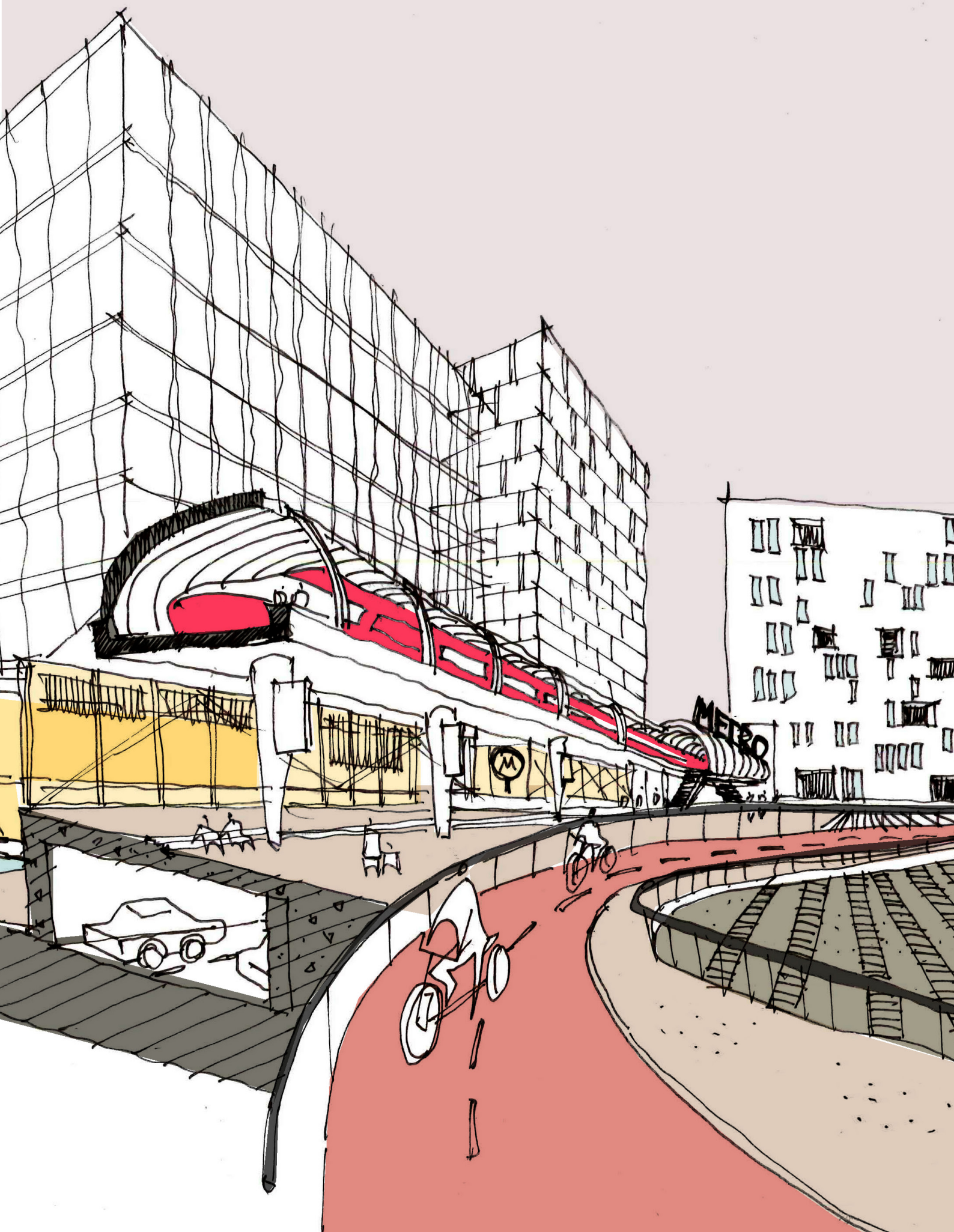
Ureña, J., Menerault, P., & Garmendia, M. (2009). The high-speed rail challenge for big intermediate cities: A national, regional and local perspective. Cities, 26(5), 266-279. doi:10.1016/j.cities.2009.07.001

r, L., & Snijder, H. (2001). Railway station structures designed for densely populated urban areas. Structural Engineering International, 11(2), 128-138. doi:10.2749/101686601780347156

Ye-Kyeong, S., & Hye-Jin, J. (2015). New spatial possibilities of railway station: Everyday heritage, enjoyable landscape. Procedia Engineering, 118, 377-383. doi:10.1016/j.proeng.2015.08.437

Zacharias, J., Zhang, T., & Nakajima, N. (2011). Tokyo station city: The railway station as urban place. Urban Design International, 16(4), 242-251. doi:10.1057/udi.2011.15

Online TDM Encyclopedia, http://www.vtpi.org/tdm/tdm116.htm, viewed 5/12/2017


METRO