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Regeneration Strategies for "Anchor+" Innovation District: A Case Study of the Tianhe Changban Plot

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Regeneration Strategies for “Anchor+” Innovation District: A Case Study of the Tianhe Changban Plot

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摘　要

在中国创新驱动发展战略的背景下，知识经济与科技创新在城市发展中的作用越来越明显。在产业转型、城市更新等发展需求的推动下，在中心城区集聚、以大学为锚定机构的创新街区，代表了一种独特的创新空间发展模式，得到了政府与学者的关注。创新街区是承载创新活动、推动科技和知识创新的重要空间载体。美国布鲁斯金协会较早对其进行阐释，其空间模型和特征得到了学者广泛的讨论。总的来说，大学锚定的创新街区作为一种典型的空间模型，在我国的研究还处在概念界定、现象分析、空间模式等探索中，尚未将其作为大学与城市合作的创新路径，较少关注大学社会角色的创新及其对创新空间模型建立的影响，创新街区的空间类型学及更新策略的讨论也不足。

本文结合中外学界的研究成果及中国产业发展的现状，明确了创新街区的定义：在小尺度城市化区域内，创新主体锚定、创新人才聚集、基础设施完备、功能混合多元、以创新功能为导向的无明显边界的开放街区，强调创新创业企业高度集聚并具有城市特质的两类特征。基于此，引入创新相关理论，介绍锚定型创新街区相关概念，结合西方与中国大学创新发展的历程，阐释大学作为锚定机构的发展由来，研究创新功能区规律构建空间类型学框架。本文认为，大学作为锚定机构参与城市更新代表了一种社会角色的创新；在大学锚定的区域建设创新街区代表了一种不同于工业用地更新的“城市更新”；锚定机构将影响创新街区的空间模型建立，需探索适应创新网络的空间类型，建立更新的策略框架。

大学锚定型创新街区的研究选择了三个典型案例：麻省理工大学锚定的大学园（University Park）、佐治亚理工大学锚定的科技广场（Tech Square）、复旦大学锚定的创智天地（KIC）。通过对三个案例的创新基础、空间组织模式、空间特征品质进行范式研究，总结了因地制宜促进锚定机构在创新街区实现知识外溢、功能互补、社区融合等的经验。文章进一步总结了创新街区的更新策略，包括产业更新、包容性发展、制度保障、空间和设施更新，通过与创新楼宇的设计、创新城市地区的愿景对接，形成承上启下的创新空间设计。

研究遵循“理论——案例研究——实际应用”的逻辑，在策略与模式的指导下，以华南理工大学五山校区北侧长湴地块为例进行更新设计。基于校城创新发展的政策方针、历史脉络、人群特征、现状情况及创新基础的评估识别，设计提出了在地性的更新策略：培育有竞争力的创新集群、提升人群包容性、创新制度保障、增加空间创新支持。

环华工创新街区具有因地制宜的设计特征及参数，通过混合的土地利用、开放的公共空间、高度可达的交通系统及分期的建设计划，逐步促进知识溢出和创新人群流动。设计呼应了环五山创新策源地的发展愿景，在街区层面将大学与企业的创新活动联系起来，形成研究与试验发展、专业技术服务、科技推广与应用服务三类功能组团的发展，打造高校周边地区的知识密集型产业集群，营造开放的创新氛围。

总的来说，论文以“锚定+”创新街区作为城市更新的新模式，对城市中心区大学锚定区域的更新进行研究，补充现有的学术体系，为大学锚定型的街区的更新提供了一个模板，以期最终将环五山创新策源地打造成教育、产业、城市融为一体，具有影响力的创新城市地区。然而，研究地块及锚定机构华南理工大学的校区边界存在着复杂的产权关系和管理问题，创新街区的实现具有很高的现实难度。本文在广州做地政策背景下，提出一个理想的概念化方案，对各利益相关者的平衡共赢缺少系统性的讨论，应在未来研究中完善补足。

关键词：创新街区；锚定+；城市更新；华南理工大学；环华工创新街区；环五山创新策源地

Abstract

In the context of China's innovation-driven development strategy, the significance of the knowledge economy and technological innovation in urban development has become increasingly pronounced. Driven by the imperatives of industrial transformation and urban regeneration, innovation districts centered around universities and concentrated in central urban areas have emerged as distinctive and noteworthy spatial development models, garnering attention from both governmental authorities and academic circles. These innovation districts serve as vital spatial conduits for facilitating innovation activities and propelling technological advancements and knowledge creation. The early exposition of innovation districts by the Bruce Katz association in the United States has engendered extensive discourse among scholars regarding their spatial models and characteristics. However, in China, research on university-anchored innovation districts remains in a nascent stage, encompassing endeavors such as concept definition, phenomenon analysis, and spatial patterns. Furthermore, discussions about the spatial typology and regeneration strategies of innovation districts remain relatively scarce. In light of the above, considering China's fervent pursuit of innovation-driven development, there arises a compelling exigency for in-depth exploration and inquiry into the unique spatial model epitomized by university-anchored innovation districts. This endeavor should encompass a comprehensive assessment of their societal impact, innovation potential, and the formulation of an integrated spatial typology and regeneration strategies aimed at fostering the vibrant growth and enduring sustainability of these dynamic and transformative spatial enclaves.

This article combines research findings from both domestic and foreign academia and the current status of China's industrial development to define the concept of an innovation district: an open district without clear boundaries, characterized by small-scale urbanization, where innovation subjects are anchored, innovation talents gather, infrastructure is well-equipped, and diverse functions are mixed, all with a focus on innovation. It emphasizes two key features: a high concentration of innovative startups and possessing urban characteristics. Based on this definition, relevant theories of innovation are introduced, and the concept of the “Anchor+” innovation district is introduced. Drawing on the experiences

of Western and Chinese universities' innovation development, the article explores the origin of universities as anchored institutions and researches the spatial typology framework of innovation functional zones. The article argues that the university's participation in urban regeneration as an anchored institution is a kind of social innovation. The development of innovation districts in areas anchored by universities represents a form of "urban regeneration" different from industrial land regeneration. The anchored institution will influence the establishment of the spatial model for the innovation district, requiring the exploration of spatial typologies that are suitable for innovation networks and the establishment of an updated strategic framework.

The research on university-anchored innovation districts selects three typical cases: University Park at the Massachusetts Institute of Technology, Tech Square at the Georgia Institute of Technology, and Knowledge and Innovation Community (KIC) at Fudan University. Through paradigmatic studies of the innovation foundation, spatial organizational patterns, and spatial characteristics of these three cases, the article summarizes experiences in promoting knowledge spillover, functional complementarity, and community integration in innovation districts based on local conditions. The article further summarizes the regeneration strategies of innovation districts, including industrial regeneration, inclusive development, institutional guarantees, and spatial and facility updates. By aligning with the design of innovation buildings and the vision of innovation urban areas, a comprehensive and innovation space design is formed.

Following the logic of "Theory - Case Study - Practical Application," the research is conducted to update the design of the Changban plot on the north side of the Wushan Campus of South China University of Technology. Guided by strategies and patterns, the study identifies and evaluates the policy guidelines for the innovation development of the university campus, historical context, characteristics of the demographics, current situation, and the foundation for innovation. Based on this assessment, the design proposes location-specific regeneration strategies: cultivating competitive innovation clusters, promoting inclusive development, innovating institutional guarantees, and increasing support for innovation spaces. The Peri-SCUT Innovation District possesses context-specific design parameters, gradually promoting knowledge spillover and the flow of innovation talents through mixed

land use, open public spaces, highly accessible transportation systems, and phased construction plans. The design aligns with the development vision of the Peri-Wushan Innovation Urban Area, connecting university and business innovation activities at the district level. It fosters the development of three functional clusters: research and experimental development, professional technical services, and science and technology promotion and application services. This will create a knowledge-intensive industrial cluster around the university and foster an open atmosphere for innovation.

In summary, this paper proposes the "Anchor+" innovation district as a new model for urban regeneration, focusing on the regeneration of university-anchored areas in the city center. It complements the existing academic system and provides a template for the regeneration of university-anchored districts. The ultimate goal is to transform the Wushan Innovation Urban Area into an influential innovation urban area, where education, industry, and the city are seamlessly integrated. However, the research faces significant challenges due to the complex property rights and management issues surrounding the study site and the anchored institution. The realization of the innovation district is highly challenging in practice. This paper presents an ideal conceptual plan within the context of Guangzhou's land policy. It lacks a systematic discussion on achieving a balance and win-win situation for all stakeholders, which should be further improved and addressed in future research.

Key words: innovation district, Anchor +, regeneration, South China University of Technology, Peri-SCUT Innovation District, Peri-Wushan Innovation Urban Area

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Chapter 1 Introduction

1.1. Research background

1.1.1. Synergy between innovation economy and urban regeneration

The formal implementation of the Outline of National Innovation-Driven Development Strategy[1] in 2016 clearly stated the goal of "becoming the top innovative country by 2030 and building the world power in scientific and technological innovation by 2050"; the 19th National Congress of the Communist Party of China further emphasized the importance of "innovation is the first driving force for development and the strategic support for building a modern economic system". At the same time, the 14th Five-Year Plan period is a key stage for the in-depth implementation of the national strategy and the sustainable construction of an innovative economy. From growth to development is not an inevitable spontaneous and linear process. The construction of innovative economy requires the government to carry out governance innovation in many fields such as economy, society and culture. Entering the era of innovative economy, the focus of investment has shifted from the agglomeration of population and land elements in the industrial age to the interconnection of talents and technology elements in the information age. In addition, under the current background, the space-time and subject of innovation have broken through the limitations of traditional physical space, derived more complex and multi-dimensional innovation mechanism, and the matching spatial development power mechanism and participants have also undergone qualitative changes. Under the guidance of the goal of innovative economy, openness, sharing and coordination have become the main theme of The Times. Spatial planning needs to re-understand the interactive logic between economy and space, and promote the innovation of planning thinking and technical methods by actively recognizing change, actively responding to change and daring to seek change. However, the current innovation economy is faced with challenges such as low market expectations, shortage of professional talents, imperfect intellectual property protection, and problems such as the lagging innovation system design, single space supply mode and the lack of planning flexibility, which further

aggravate the difficulty of renewing the urban central areas around universities. In recent years, new spatial models and planning studies of innovative areas, innovative urban areas, innovative blocks and innovative buildings have emerged widely. In general, the research on spatial planning for innovative economy is still in the exploratory stage, and the logical relationship between how to promote the development of innovative economy through the innovation of spatial mode and spatial planning needs to be clear.

With the continuous development of networking and information technology, innovative enterprises are showing a new trend in location selection: they are agglomerating in the downtown areas of metropolises, driving the emergence of new paths for urban center revitalization. A prominent example is Silicon Alley, where numerous technology and innovation companies gather. The prerequisite for this trend is that their research and development designs have high value creation capabilities, and they are allowed by government intervention to establish innovation research centers in the city center, with a reasonable economic rationality space to achieve the effect of "reducing costs and increasing benefits"[2]. The agglomeration of innovative enterprises in some metropolis downtown areas, represented by New York's Silicon Alley, differs from traditional models. Traditional models typically involve modern service industries like commerce and business driving urban center regeneration. However, this new path is propelling the revitalization of metropolis downtown areas in the context of industrial hollowing.

1.1.2. The transformation of innovation phenomenon around universities

In recent years, the construction of government, one enterprise, one university and tripartite cooperation has emerged in the areas of Shanghai, Wuhan, Chengdu and other places, and various concepts such as "knowledge economic circle around universities", "innovation economic circle around universities" and "smart economic circle around universities" have emerged[3]. The geographical location of this kind of space is close to universities, and the innovation goal is to develop innovative economy with the help of university talents and technological advantages. These concepts belong to the policy theme of innovation places in the Chinese government report, which has the same meaning as the innovation districts with anchored institutions discussed in the international academic community. In this paper, the

above concepts are collectively known as innovation districts. In Shanghai yangpu innovation interwoven zone "Peri-Tongji Knowledge Economic Circle", for example, it is not only an economic activity circle but also a harmonious space for the interaction and creative urban area of industry and city development. It has successfully integrated the campus with the city, meeting the demands of innovation through cross-disciplinary university activities, mixed land and space use, and the integration of campus-community-industry park[2].

In the era of knowledge economy, the cooperation between cities and universities has more and more become one of the paths of innovation. These partnerships are in the form of common initiatives such as online platforms, learning programs, entrepreneurial activities and projects to enhance bilateral cooperation in addressing social challenges. In order to stimulate innovation in socio-economic development, attracting and retaining talented students and highly skilled workers is arguably the most important common task between cities and universities[4]. So creating smart, healthy, inspiring and attractive environments is essential for both sides in the global competition for talent. Quality of life factors such as affordable and ideal housing, diversity of people and functions, convenient commuting, efficient transportation, cultural and green facilities contribute to the ability to attract and retain talent.

1.1.3. Driving urban regeneration through innovation

The innovation of Guangzhou's urban regeneration policy has brought it into a new historical stage. For a long time, Guangzhou's urban regeneration has been driven by the principle of "government-led and market-oriented". In 2020, the "three red lines" policy in the real estate industry, combined with the impact of the pandemic, and the "prevent large-scale demolitions and constructions" policy issued by the Ministry of Housing and Urban-Rural Development in 2021, led to a period of evaluation and rectification for urban regeneration in Guangzhou. Under these circumstances, private enterprises struggled, and regeneration projects stalled. On March 23, 2023, the General Office of the People's Government of Guangzhou issued the "Measures to Support Coordinated Land Development and Promote High-Quality Development in Guangzhou" (referred to as "the ten measures"). On March 30, the Guangzhou Planning and Natural Resources Bureau and the Guangzhou Housing and Urban-Rural Development Bureau jointly issued the "Work Plan to Support Coordinated Land

Development and Promote High-Quality Development in Guangzhou" [5](referred to as "the work plan"). Guangzhou's urban regeneration has entered a new stage led by state-owned enterprises.

"The ten measures" propose supporting the principle of "first do land and then reserve, and separate land development from land collection and reserve." "The work plan" states, "Land development refers to government-designated areas where state-owned enterprises raise funds and collaborate with local governments to carry out land acquisition, compensation, and resettlement work. After implementing supporting infrastructure construction such as roads, water supply, electricity, gas, drainage, communications, lighting, and greening, the land will be unified and collected by the government." These two land development models in Guangzhou, respectively, focus on phased development and investment promotion with pre-designed plans. They fully leverage the strength of the government and the market, providing robust support for urban regeneration.

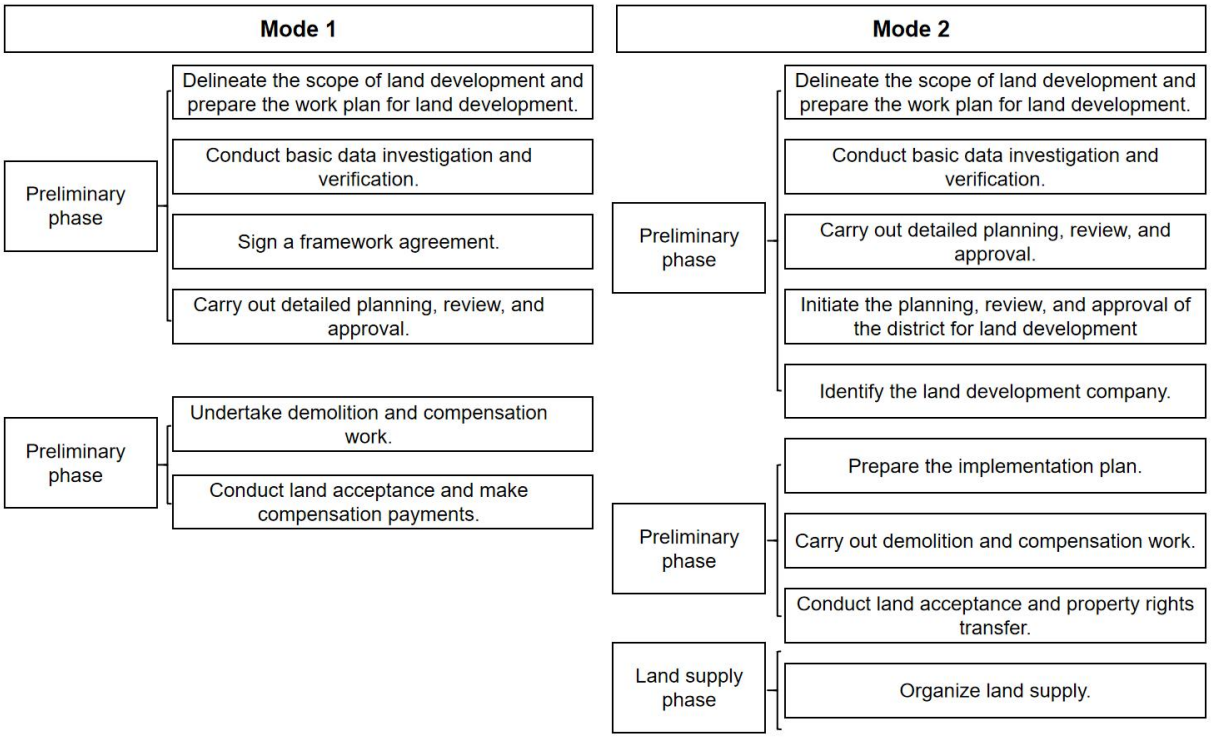
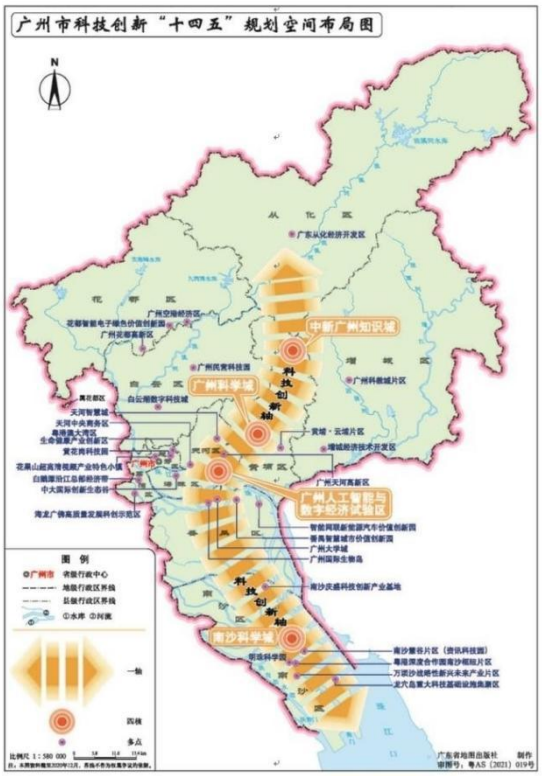


Fig 1-1: Two modes of Guangzhou’s land development policy

During the "14th Five-Year Plan" period, Tianhe District and the Wushan Shipai Higher Education Mega Center will play a leading role in promoting innovative development. The "Outline of the 14th Five-Year Plan and 2035 Vision Goals for National Economic and Social

Development in Tianhe, Guangzhou"[6] proposes to leverage platforms such as the Wushan Shipai Higher Education Mega Center, Guangzhou (International) Technology Transfer Tianhe Base, Keyun Road Software Industry Agglomeration Zone, and Tianhe Smart City (including the Tianhe High-tech Zone). These platforms will connect and interact with the Guangdong-Hong Kong-Macao Greater Bay Area, Guangzhou-Zhuhai-Macao Science and Technology Innovation Corridor, and Guangzhou Science and Technology Innovation Axis. The aim is to create a technological innovation belt characterized by "technology output creation - technology transfer and conversion - technology enterprise incubation - technology enterprise agglomeration development", forming a closed loop of "original innovation - technological innovation - application innovation" to support Tianhe's role as an innovation hub in the Guangdong-Hong Kong-Macao Greater Bay Area. Based on the functional layout of the "One Axis, Four Cores, and Multiple Points" for technological innovation spaces proposed in the "Guangzhou Science and Technology Innovation 14th Five-Year Plan" [7], Guangzhou aims to achieve the goal of constructing a globally influential city with strong technological innovation by 2025. According to the "Overall Plan for Land and Space in Guangzhou (2018-2035)"[8], land consolidation and integration will be used to transform dispersed stock construction land resources. Various methods, including comprehensive and micro transformation, will be employed to strive for a cumulative transformation area of approximately 300 square kilometers by 2035.



(a) (b)

Fig 1-2: One Axis, Four Cores, Multiple Nodes (a)

Fig 1-3: Tianhe District scientific and technological innovation "14th Five-Year Plan" spatial layout (b)

The construction of the Peri-Wushan Innovation Urban Area is of significant importance in promoting city-university collaboration, establishing a national demonstration zone for technology transfer and conversion, and accelerating collaborative innovation and technology commercialization. This area is located in the center of Guangzhou, surrounded by five mountains (Baiyun Mountain, Longdonggang Mountain, Shipaigang Mountain, Lashan Mountain, and Nanling Mountain), giving it its name. The region boasts abundant natural resources and cultural landscapes, providing an excellent ecological environment and spatial foundation for technological innovation. Concentrated in Tianhe and connected to Huangpu and Baiyun, it is part of Guangzhou's strategic plan to promote the integrated development of "innovation, industry, and city".

Under the "land development" policy[5], the Peri-Wushan Innovation Urban Area and its surrounding regions have encountered new development opportunities. The government can manage and gradually promote regeneration projects based on actual needs and development

plans, utilizing comprehensive transformation and micro-transformation methods to meet the growing demands for education and society. Over time, the area can be developed into a comprehensive educational, cultural, and commercial region. Simultaneously, attracting external investors through investment promotion can expedite the regeneration process and enhance implementation efficiency. Collaborating with businesses and introducing new commercial, cultural, and technological resources can create a thriving innovation ecosystem. On the other hand, increased resources and funding can improve campus facilities, enhance education quality, and provide a better learning environment, making the university-adjacent urban area a vibrant core of the city.

1.2. Theoretical significance

1.2.1. Transfer of innovation space

With the return of innovation to the city, it has become a trend that innovation activities transfer physically and tionally to the urban center. There is no undeniable fact that the diversity within the city can provide more stimulation and innovation opportunities for innovation activities. From the perspective of innovation elements, the city provides abundant human resources and industry cross-cooperation opportunities; from the perspective of innovation resources, it has perfect infrastructure such as convenient transportation, communication, energy, and various innovation resources such as universities, research institutions and maker space; from the perspective of innovation environment, the city provides rich living environment and working environment to meet the needs of creative people. This trend has driven the development of innovative geography, urban and rural planning, architecture and other disciplines. Scholars aim to provide guidance to policy makers, businesses, and academia by studying the physical layout, spatial allocation, resource allocation of innovative activities, and how these factors influence interaction, knowledge flow, and collaborative innovation among innovators. The return of innovation to cities can bring new opportunities for the sustainable development of cities, respond to the development trend of innovation, and bring new development prospects for the government, enterprises, universities and all sectors of society.

1.2.2. Demands for innovation space construction

In the past decade, the creation of innovation space has been strongly supported by the work of the Chinese government. Li Yingcheng et al. analyzed 3,200 government work reports from 2010 to 2021 in prefectural and above cities, and found that four types of policy themes, including innovative buildings, innovation places, innovation areas and innovation areas, have not been discussed in the policy documents of various cities in recent years. The discussion of the theme of innovation places (such as innovation blocks and innovation circle around universities) is not decrease, while the frequency of the other three types of themes has increased significantly, especially the theme of innovation regions is the most significant (Figure x). In recent years, some provincial capitals (such as Guangzhou, Wuhan and Chengdu) and some cities in developed regions (such as Zhuhai and Foshan in the Guangdong-Hong Kong-Macao Greater Bay Area) have also paid high attention to the theme of innovation places, mainly focusing on innovative blocks, innovative urban areas and innovative communities.[9]

Policy Theme	Spatial scale	Representative vocabulary
Innovation building	Micro	Incubators, accelerators, maker Spaces, etc
Innovation place	Micro	Innovation district, creative district, innovation community, innovation circle, etc
Innovation urban area	Meso	High-tech zone, characteristic industrial innovation Park, science and technology city, science city, university city, etc
Innovation region	Macro	Innovative metropolitan area, innovative urban agglomeration, innovation corridor, scientific and technological innovation community, national independent innovation demonstration zone, etc

Table 1-1: Innovative spatial policy topic dictionary based on government work report

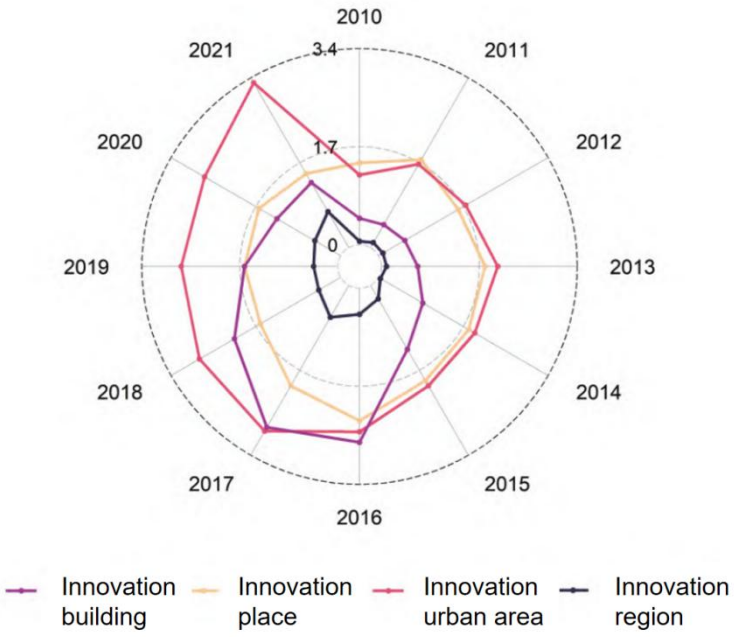


Fig 1-4: Word frequency analysis of four types of innovative spatial policy subjects based on Chinese policy documents[9]

From the perspective of cities, the government and planning departments have made positive efforts to create a space for innovation. First of all, we should attach importance to the construction of innovation ecosystem, and by planning and designing innovation Spaces such as innovation parks, science and technology parks, we should provide innovation activities with an environment of shared resources, common learning and professional cooperation. Secondly, focus on function mixing and configuration, meeting the needs of innovation activities while taking into account the spatial support for innovation services such as intellectual property protection, innovation project review and certification. Innovation space considers sustainability, and brings green transportation and green building into the goal of construction. The construction of innovation space is based on the integration of community, park, campus and other multiple space. The space design takes into account the openness, accessibility, versatility and inclusiveness, so as to meet the characteristics of multi-dimensional proximity of space development. From the perspective of universities, universities gradually pay attention to the development of different types of innovation space, such as Fab Lab, Makerspace, Co-working space, Living Lab, etc. By building spaces with these features on existing facilities, universities can create an opportunity to approach the industrial sector and promote collaborative communication, and a supportive environment for

learning and research.

1.2.3. Spatial experience for urban regeneration

Research on innovation districts is of great theoretical and practical significance for urban regeneration. Currently, in cities where urban regeneration policies have been released, the focus of urban regeneration is primarily on old residential areas, old industrial areas, traditional business districts, historical neighborhoods, etc., with less attention given to the regeneration and upgrading of low-energy-efficient industrial land around university campuses in the city center. In the context of Guangzhou's "land development" policy, the government's support for coordinated land development to promote high-quality development has created new opportunities for urban regeneration in the central areas of higher education districts, with particular emphasis on innovation space construction.

Adopting the construction of innovation districts as a model for spatial enhancement in the central areas of higher education districts directly addresses the pain points of enhancing competitiveness in current large cities. It provides targeted spatial construction proposals for industrial return and urban revitalization. Innovation districts focus on the spatial organization, accessibility, transportation, public spaces, and social interactions of the innovation ecosystem, aiming to create more dynamic and sustainable innovation carriers to promote urban innovative development and sustainable practices. Domestic and international large cities have accumulated some practical experience in the construction of innovation districts. Based on the trends of innovative enterprise agglomeration and development in classic cases, multifunctional complexes and smart integrated complexes can be constructed as types of innovation spaces, integrating various functions to maximize spatial efficiency and social interaction frequency.

1.3. Research object

Innovation space is an important carrier for the gathering and diffusion of innovation activities. Driven by the strategy of innovation-driven development, the discussion of innovation space is not reduced. Related research focuses on the policy theme[9], organizational patterns[10][11][12][13], distribution and evolution[14][15][16][17], and planning

strategies[18][19][20][21] of the innovation space. The agglomeration and diffusion of innovation activities in different ranges form the innovation space of different scales. According to the scale, it can be divided into innovation buildings, innovation districts, innovation urban areas, innovation regions, etc.[22]. The leading functions of different Spaces have different division of labor, and they together constitute the innovation space system. Based on the characteristics of small block size and high concentration of innovation and entrepreneurship, innovation district are selected for research.

Innovation Space	Scale	Type	Case
Innovation building	Micro	Incubators, accelerators, co-work, etc.	Cambridge Center for Innovation
Innovation district	Micro	Innovation districts, neigborhood, innovation circles around universities, etc.	Kendall Square, MIT Techonology Park, Tongji Knowledge Economy Circle
Innovation urban area	Meso	High-tech industrial development zones, science cities, etc.	North Carolina Research Triangle Park, Beijing Huairou Science City
Innovation region	Macro	Intercity scientific and technological innovation corridors, regional science and technology innovation communities, etc.	Shenzhen Science and Technology Innovation Corridor, Yangtze River Delta G60 Science and Technology Corridor

Table 1-2: Innovation space classification[22]

1.3.1. Concept of innovation district

Scholars at home and abroad began to pay attention to the phenomenon of innovative and entrepreneurial enterprises gathering in the central urban area early[23][24]. The landmark result of the systematic study is the Rise of the Innovation Zone released by the Brookings Institution in 2014, which first proposed the concept of "innovation District" : " A geographical area where cutting-edge institutions and companies gather and associate with

start-ups, business incubators and accelerators."Report will further innovation blocks is divided into three modes:" anchor + "model, to imagine the urban areas" mode, "urbanization science park" mode, the innovation blocks described as a method of stimulating economic growth of urban planning, and the university town construction, urban old industrial upgrade, suburban industrial upgrade of urban planning. At present, there is no unified academic concept of innovation block, and different scholars have different emphasis on their definitions and interpretations. Based on the perspective of economic geography, Katz & Bradley [25]corresponds to the concept of innovation district and industrial zone, and describes it as the area where innovation and entrepreneurial enterprises gather and the output of high-tech products. The corresponding spatial location is either in the urban center or in the technology park urbanized in the suburbs. Deng Zhituan[23] believes that innovative blocks refer to the block space with highly concentrated innovative and entrepreneurial enterprises within the city. The discussion on innovative blocks focuses on the shaping of small-scale material space, and emphasizes the two characteristics of highly concentrated and urbanization living environment. The important difference between the two definitions is whether they have urban characteristics (cityness), which includes complexity, high density, the diversity of culture and population structure, and the hierarchy of old and new things.

With the upgrading and transformation of China's traditional manufacturing industry, compared with the urbanization transformation of suburban industrial areas, the phenomenon is more common for enterprises to go out of the park and gather in the urban center. At present, the development of urban space has entered the stage of inner city revival, and the important role of industry introduction in urban center regeneration has been valued by more and more departments[26]. By leasing or transforming existing buildings, enterprises can form industrial agglomeration in the city, such as Beijing Zhongguancun, Shenzhen Huaqiangbei, and Shenzhen OCT Creative Industrial Park. This phenomenon also occurs in the old urban areas around the university, such as the design industry of Tongji University, the journalism and publishing industry of Fudan University, and the fashion industry of Donghua University [27]. From the perspective of industrial transformation, the proportion of manufacturing industry in the industry decreased, and new industries such as creative industry, high-tech industry, and urban manufacture appeared and showed an increasing trend. Unlike traditional

manufacturing, these industries have small space scale, do not make noise and pollution, and have high unit output value. Employees have a higher education level and higher income, and they have higher requirements for urban atmosphere, supporting facilities, convenient transportation, and community ownership. From the perspective of the integration of small and innovative industries with other urban functions and facilities at the block scale, the definition of innovative blocks by Deng Zhituan and others is more in line with the current spatial development relationship of the integration of industry and city in China. With the help of Katz et al.'s understanding and elaboration from the perspectives of economics, geography and sociology, it will help current planning scholars to understand the more macro material spatial characteristics needed for the development of innovative industry, and then regulate the urban spatial form and provide support for the development of innovative enterprises. However, there is already a concept of "innovative urban area" in China, so attention should be paid to avoid the confusion of word meaning when using the concept of innovative block, resulting in semantic confusion.

Based on this, this paper defines the innovation block as an open block with no obvious boundary, such as innovation subject anchor, innovation talents gathering, complete infrastructure, mixed functions and multiple functions in the innovation-scale urbanization area. Innovation block has two attributes: "innovation" + "block", that is, the block space with highly concentrated innovative and entrepreneurial enterprises and urban characteristics[28]. In general, the development of innovative blocks reveals the layout trend of innovation subjects at the spatial level, abandons the previous "enclave" mode of Silicon Valley, makes the innovation resources return to the metropolitan circle, re-gather in the central urban area, and become the engine to promote economic development[28].

1.3.2. "Anchor +" model

Innovative urban area is the product of the gradual return of innovation activities to the urban center area, and the transformation of urban innovation from "suburbanization" and "park" to "urban area". It is a type of urban stock space to realize innovative development. According to the concept of innovative block proposed by Bruskin Society, this paper proposes "university-anchored innovative district" on the basis of this prototype[29][30].

The "anchor +" mode refers to the development of large mixed-use areas centered on large anchored institutions and all kinds of related enterprises, entrepreneurs or universities engaged in innovation and commercialization. This pattern is particularly evident in the central city area of the central city. Universities often act as "anchored institutions" to revitalize surrounding communities and cities. This process can take a variety of forms, including improving tangible infrastructure, stimulating the local economy, strengthening research and innovation, enriching cultural and community engagement, and promoting social mobility. The aim is not simply to upgrade university facilities, but to comprehensively improve the material, social, and economic well-being of the wider community. Notable examples include Cambridge University's Kendall Square, which has experienced significant growth around institutions such as MIT and Massachusetts General Hospital. These regions demonstrate how the integration of anchored institutions with a diverse business ecosystem promotes innovation, economic growth, and urban revitalization.

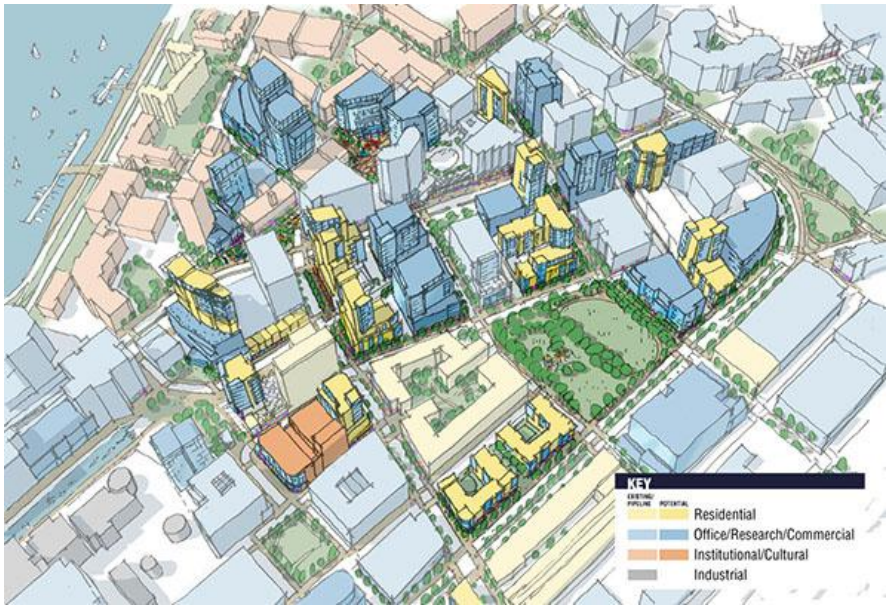


Fig 1-5: Kendall Square

1.3.3. Formal and functional characteristic

First, the characteristics of innovative blocks are mainly residential blocks. As a knowledge-intensive industrial cluster, the innovation space requires a small geographical space, and it is mostly located near the "anchored mechanism" of some urban centers (Down-town) and sub-centers (Mid-town). From the traditional low density, suburbanization

gradually compact, urbanization direction change. The second feature is the functional mixing of the innovative layout. Florida[31]The index system of innovation talent agglomeration area includes the attraction of innovation talents, casual lifestyle, education and cultural comfort, leisure and entertainment, etc. Innovation Block has no obvious boundaries, and provides rich supporting facilities such as office buildings, youth apartments, commercial housing, retail entertainment to help innovation talents achieve "Life-Work-Play" Balance. Its third feature is the open symbiosis of the innovation subject. Porter[32] pointed out that the key to the success of innovation lies in the full interaction between the innovation subjects. In the innovation block, enterprises, research and development institutions, laboratories, universities and other institutions gather to form an innovation community with geographical proximity, cognitive proximity, social proximity and cultural proximity, establishing common network links, producing network effects and innovation output produced far more than economies of scale and scope[29].

Through reading documents of urban planning, architectural design, urban design and real estate management, it can be found that the university-anchored innovation district has the following characteristics.

Formal / Functional Characterestics		Links with Theoretical Concepts of Innovation
1	Location and settlement	Clusters, Competitive advantage, Proximity, Connectivity, Accessibility;
2	Spatial and functional layout	Proximity (geographic, social and cognitive); face-to-face interaction; creativity;
3	Size and Density	Social interaction,Proximity,Diversity (of people, ideas, buildings andfunctions);
4	Block pattern	Creativity; Small blocks and Chances of encounter and interaction; Diversity;Walk-ability; Accessibility;
5	Appearance	Attractiveness of place; Added value of real estate (e.g. supporting image andculture)
Source	Theories on the built environment (Architecture,Urban design,Urban planning,Real Estate Management)	Literature review on the role of the built environment in innovation (Urban planning, Urban economy, Real Estate Management);

Table 1-3: Overview of fomal and functional characteristics of unversity-anchored innovation district in relation to relevant theoretical concepts linked to innovation[24]

1.3.4. Particularity in the case of China

Due to the differences in land system, government management system and planning system, there are some differences in the "anchor +" model at home and abroad, so the

regeneration of innovaon districts is also different. The innovation phenomenon around foreign universities is mostly reflected in the joint investment and development of universities and enterprises, and the innovation needs of various stakeholders are foreseen and balanced, so that the innovation subjects in the city have a strong intention to gather here, and the speed and efficiency of market interests driving the transformation of industry, university and research are improved. Take MIT in the United States as an example, universities can use donated funds to invest and buy land in order to build corporate offices and research and development parks to accelerate the transfer of technology to the commercial market. At the same time, MIT seeks to obtain better economic returns from endowments, create employment opportunities for students and graduates, and provide opportunities for cooperation or consultation for teachers. It seeks for profit-oriented developers to develop the purchased land with abundant social funds and professional investment decisions. The developer planned the development through competitive bidding, then signed a long-term development agreement with the university, and gradually returned the property to the MIT during the lease term. In China, universities need to obtain educational land through the approval and allocation of government departments, and the approval process of land development is relatively complex, which requires the communication between universities and local governments, planning departments and land management departments to reach a consensus. The current land management laws and regulations have very clear provisions: the land for colleges and universities is the land for education, which belongs to the state-owned allocated land, the allocated land transfer or change of use, must be reported to the people's government with approval power according to law, and the colleges and universities that use the allocated land shall not transfer privately. Therefore, it is difficult to promote the innovation of university education land through university-enterprise cooperation and the help of market forces. The construction of Peri-wushan Innovation Uban Area is one of the first projects implemented by Guangzhou's land development policy. Through the land development policy, state-owned enterprises can make the land first and then save, which can simplify the complicated problems of land ownership around universities, and provide planning flexibility and imagination space for the "anchored" innovation space of universities to a certain extent. Based on this background, the construction of Peri-SCUT Innovation

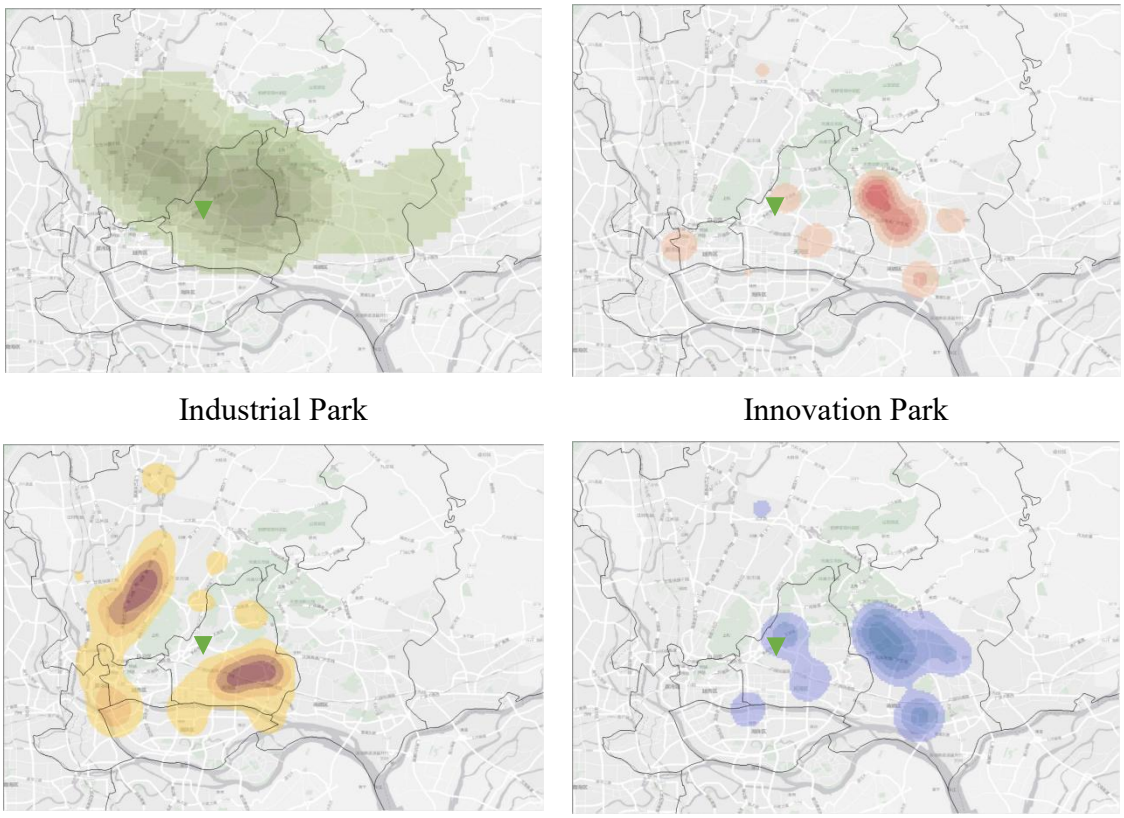
District has more realistic basis and institutional support.

1.4. Problem statement

1.4.1. Separation of urban innovation spaces and university

City and university innovation cooperation thrives on the interplay of innovation spaces and the multidimensional proximity of universities. The research centers on the distribution of innovation spaces at both building and block scales within the city. Utilizing Baidu Maps, data on four types of spaces, namely "industrial parks, innovation parks, creative parks, and incubators," were meticulously gathered as points of interest. Subsequently, a comprehensive Kernel Density analysis was performed using ArcGIS. Additionally, considering the comprehensive list of national universities released by the Ministry of Education in 2021[33], a Kernel Density analysis was conducted to study the distribution of universities across Guangzhou.

The analysis results reveal a remarkable concentration of innovation spaces in Tianhe, with the Peri-Wushan Innovation Urban Area being the epicenter of university distribution. Examining the overlap between the urban innovation space distribution map and the university distribution map, an intriguing discovery emerges—the Peri-Wushan Innovation Urban Area lies strategically amidst the transition zone, effectively bridging the core regions of innovation spaces and university campuses in. While this fertile ground boasts a solid foundation for innovation, it is yet to foster a direct and harmonious collaboration between universities and urban innovation area. Enter the proposal of the Peri-Wushan Innovation urban area—an intervention in innovation development through material space construction, a demonstrative innovation platform that becomes an indispensable asset to fortify the bonds between universities and the city. The envisioned future leads to a boundless horizon of enhanced cooperation and synchronized innovation.



Industrial Park　　Innovation Park

Creative Park　　Incubator

Fig 1-6: Kernel density of four kinds of innovation space in Guangzhou

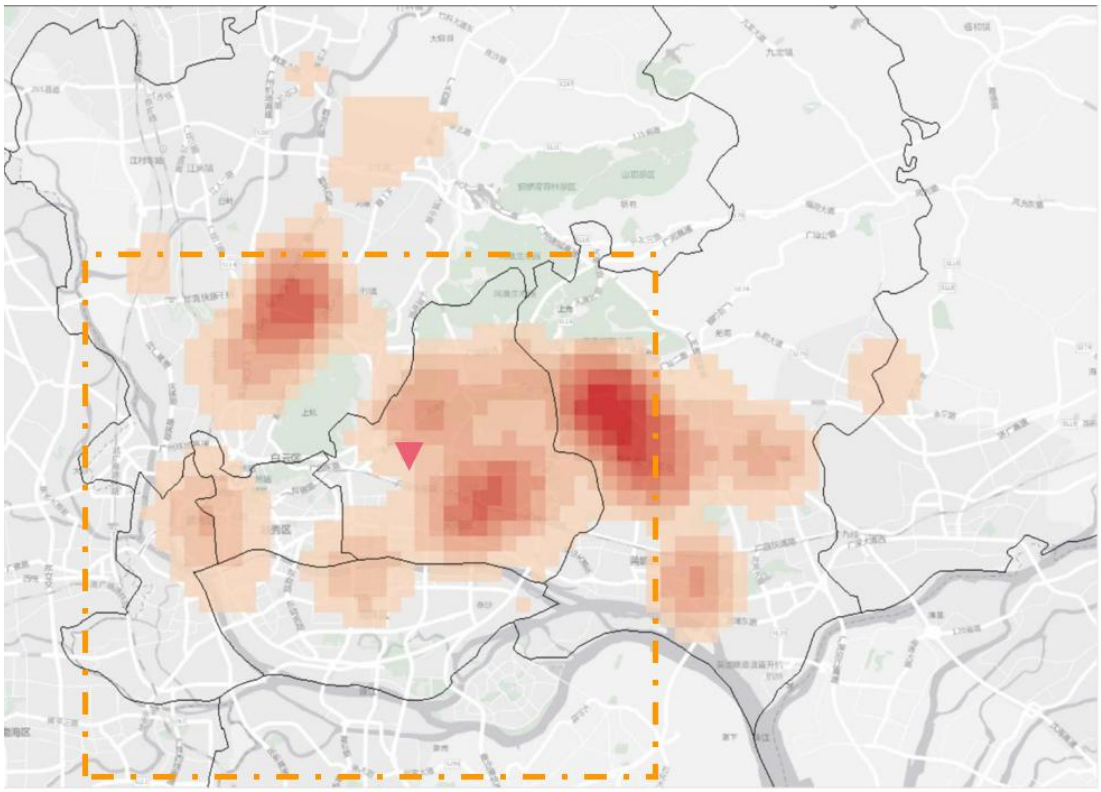


Fig 1-7: Kernel density of innovation space in Guangzhou

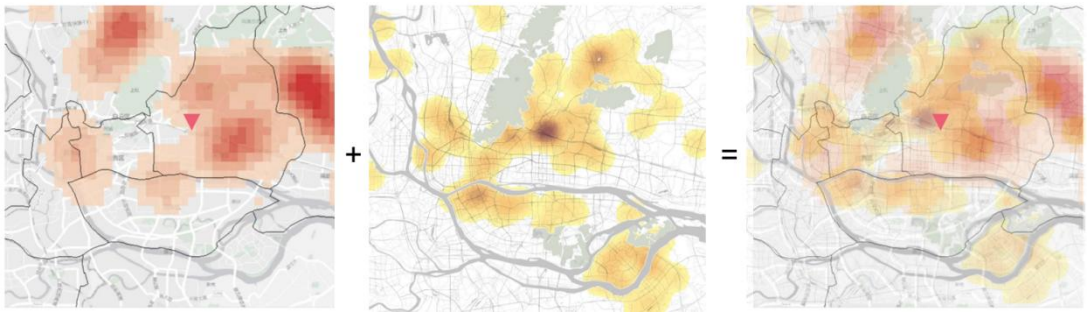


Fig 1-8: Kernel density of universities compared to innovation space in Guangzhou

1.4.2. Insufficient drive for technology transfer of innovation subjects

The Peri-Wushan Innovation Urban Area is home to many innovation subjects, which is conducive to establishing an innovation network and fostering a robust innovation ecosystem. From a geographical advantage perspective, it is situated at the center of Guangzhou's technology innovation axis. To the north, there are Guangzhou Science City, Sino-Singapore Guangzhou Knowledge City, and Tianhe Smart City. In the middle, there are Guangzhou Experimental Laboratory and Pazhou Laboratory. To the south, there are Guangzhou University City and Nansha Science City. This favorable location facilitates regional innovation synergy and enhances the city's influence. In terms of talent, disciplines, and platforms, the region boasts several original innovation subjects, including South China University of Technology, South China Agricultural University, South China Normal University, Jinan University, Guangzhou Institute of Energy Conversion - Chinese Academy of Sciences, Guangzhou Institute of Chemistry - Chinese Academy of Sciences, Guangzhou Institute of Geochemistry - Chinese Academy of Sciences, South China Botanical Garden - Chinese Academy of Sciences, the Fifth Electronics Research Institute of the Ministry of Industry and Information Technology, Guangdong Academy of Sciences, Guangdong Academy of Agricultural Sciences, and others. These institutions have accumulated academic achievements and a reservoir of talents. Moreover, the region is adjacent to South China Botanical Garden and the Phoenix Mountain and Huolu Mountain, providing a foundation of high-quality ecological and living spaces.

According to the "China Annual Report on Technology Transfer 2021,"[34] the total contract amount of the top three universities and institutes in the Peri-Wushan Innovation Urban Area, including South China University of Technology, Jinan University, and

Guangdong Academy of Sciences, is about 2.45 billion yuan. Compared to the total contract amount of 6.9 billion yuan for the top three universities in Zhongguancun - Tsinghua University, Beijing Institute of Technology, and Peking University, there is still a considerable gap in the innovation achievements conversion momentum in the Peri-Wushan Innovation Urban Area.

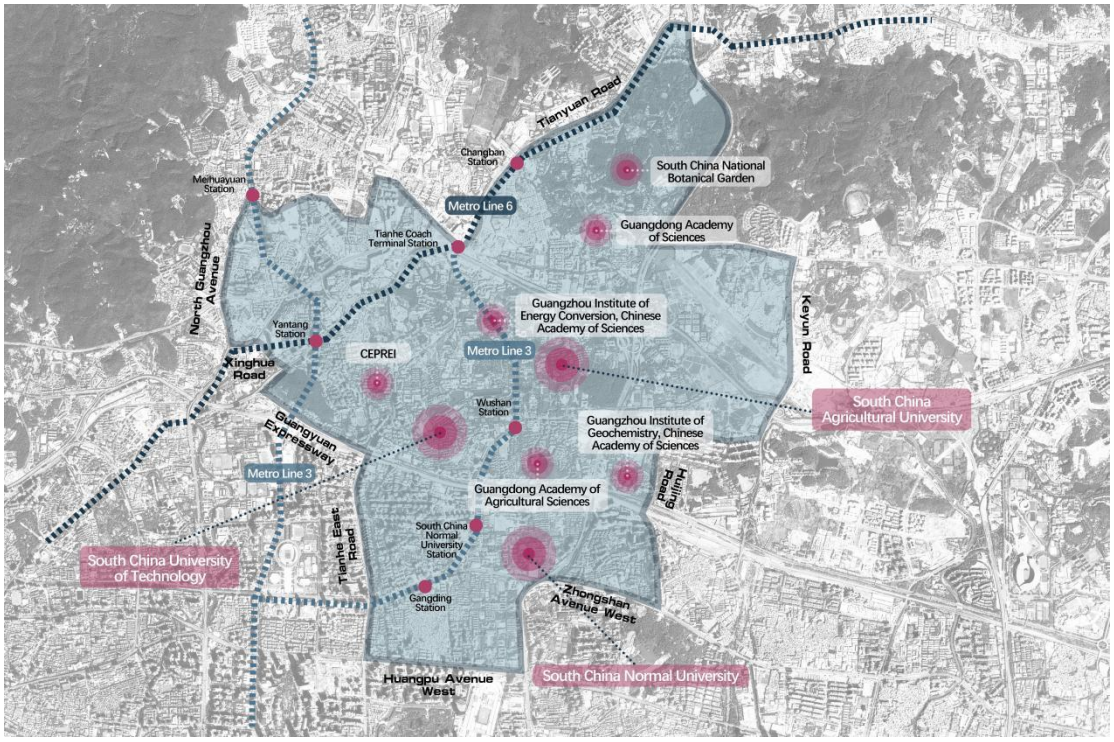


Fig 1-9: Innovation object in Peri-Wushan Innovation Area

Currently, South China University of Technology has achieved some accomplishments in promoting technology transfer and contributing to the high-quality development of the regional economy. It has the ability and responsibility to become a dynamic source of innovation in the Peri-Wushan Innovation Urban Area to promote the conversion of innovative achievements. According to the "China Annual Report on Technology Transfer 2020 (Higher Education Institutions and Research Institutes)"[34] in recent years, the university has undergone mechanism and system reforms, explored new paths, and innovated models, leading to the formation of a technology transfer demonstration area known as the "Five Institutes and One Park" (Zhongxin International Joint Research Institute, Guangzhou Modern Industry Technology Research Institute, Dongguan South China Collaborative Innovation Research Institute, Zhuhai Modern Industry Innovation Research Institute, Zhongshan South China University of Technology Modern Industry Technology Research

Institute, and National University Science and Technology Park). It has also established innovation clusters such as "university-enterprise joint laboratories." These efforts have significantly increased the university's participation and contribution to regional economic and social development, actively promoting the conversion of scientific and technological achievements in the Guangdong-Hong Kong-Macao Greater Bay Area. To enhance the momentum of technology transfer, having South China University of Technology as the source of innovation in the Peri-Wushan Innovation Urban Area to form an innovation district for technology transfer holds significant demonstration value.

(a)

(b)

Fig 1-10: The distribution of school-enterprise cooperation laboratory of SCUT in China (a)

Fig 1-11: Distribution of school-enterprise cooperation Laboratory of SCUT in Guangzhou and surrounding cities(b)

1.4.3. SCUT enters a new development era

The development of South China University of Technology's education has undergone five important stages of transformation:

In the early stages of the 1978 reform and opening-up, the university underwent a series of adjustments and reforms. The focus was on practicality in professional settings, emphasizing "science over humanities," enabling students to acquire more practical expertise. The curriculum became more comprehensive, incorporating both liberal arts and sciences,

leading to increased academic pressure. Renowned professors served as academic supervisors, focusing on cultivating students' innovative thinking and research abilities. The integration of theory and practice was emphasized, along with a focus on teaching capabilities. Simultaneously, the university became an important source of talent for universities and research institutions both inside and outside the province.

In 2004, according to the "China National Outline for Medium and Long-term Educational Reform and Development," the university underwent three transformations: from a teaching and research-oriented university to a research-oriented university, from a multi-disciplinary university to a comprehensive university, and from a semi-open university to an open university. The focus shifted to cultivating "three creative abilities": innovation, creativity, and entrepreneurship. At the same time, the university fully implemented an integrated education model combining industry, academia, and research.

In 2010, based on the "National Medium- and Long-term Education Reform and Development Plan (2010-2020),"[35] the university adopted a "knowledge learning, ability cultivation, and comprehensive development" approach to practical education. Through tiered and staged classroom experiments, students' practical and innovative abilities were nurtured. Emphasis was placed on off-campus internships to strengthen direct practical experience and establish a mechanism for industry-academia collaboration. International experiences were encouraged to enhance cross-cultural communication abilities.

In 2019, in line with the "China's Educational Modernization 2035" plan[36], the university implemented the "New Engineering F Plan" to cultivate creative talents with learning ability, thinking ability, and action ability. Open integration was promoted, interdisciplinary schools were established to facilitate the integration of disciplines, and a series of micro-programs were launched. Integration of science and education was strengthened, with deepened collaboration between the university and enterprises to innovate international collaborative education.

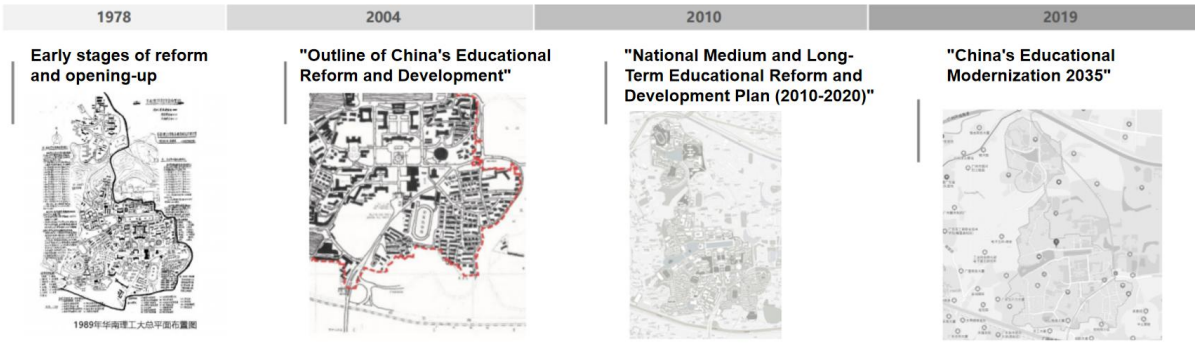


Fig1-12: History of innovation and development of South China University of Technology

Since 2020, the Guangzhou municipal government has proposed the plan to establish the Peri-Wushan Innovation Urban Area and designated SCUT as the leading university within this area. This has ushered in a new period of development for the university. In various meetings, the Guangzhou municipal government emphasized leveraging the research and innovation strength of SCUT to develop industries and attract industrial research and development bases to stay in Guangzhou, further promoting the city's development. For SCUT, it needs to tap into its potential, fully utilize internal and external resources, and seek support from relevant municipal government departments to address bottlenecks and issues in its development through the innovation urban area platform. Currently, there are still significant demand gaps in areas such as faculty apartments, student dormitories, and innovation parks. By adopting a cooperative model of joint construction with the government, the university can expand its development space around the campus, address issues related to technology transfer and industrial incubation, and achieve the common goals of resource integration and high-quality development.

1.5. Research aims and questions

Currently, there are notable institutional gaps concerning the revitalization of idle and underutilized lands surrounding universities. To tackle this issue, we can seek inspiration from successful domestic and international cases and involve universities in the urban regeneration process of their adjacent areas. By harmonizing top-down policy guidelines with bottom-up knowledge spillover and harnessing the momentum of technological and educational innovation, along with the implementation of the "land development" policy, the primary

objective of this article is to foster innovation collaboration and mutual benefits between academia and industry through the spatial development of innovation districts.

Furthermore, the innovation phenomena in China's university surroundings often manifest as informal innovation—an overflow of innovative resources from universities to the surrounding areas. These innovations tend to have smaller economic scales and more flexible physical space requirements. The social networks driving these innovations are mainly composed of university faculty, students, and graduates, connected through alumni networks. The challenge lies in providing small enterprises, organized as studios, with innovation platforms for collaboration with larger companies, attracting diverse businesses such as those in the legal, public relations, and consulting sectors, further enriching the diversity of the industrial ecosystem, enhancing innovation performance, and expanding the influence of the innovation district. These are crucial issues that need to be discussed and addressed at present.

1.6. Research methodology and framwork

1.6.1. Research methodology

1.6.1.1. Literature integration method

This method involves extensively reading and analyzing relevant literature, works, historical materials, policies, etc., related to innovation theories, innovation districts, university innovation, Gown and Town concepts, both domestically and internationally. The information gathered is then organized, analyzed, and summarized. The focus is on understanding the historical background, basic characteristics, and spatial patterns of universities as anchored institutions participating in the construction of innovation districts. Additionally, it includes an examination of the development trends in the Peri-Wushan Innovation Urban Area, the process of innovation development at South China University of Technology, and a comprehensive analysis of preliminary data for developing the Changban plot into an innovation district.

1.6.1.2. Case study method

This approach primarily collects case studies of three university-anchored innovation districts: University Park anchored by MIT, Tech Square anchored by the Georgia Institute of

Technology, and KIC anchored by Fudan University, etc. The analysis includes historical contexts, the foundation of innovation development, and spatial characteristics of these districts. The goal is to establish relevant regeneration strategies and design methods for university-anchored innovation districts. These case studies serve as practical foundations and experiential references for transforming the Changban plot into the Peri-SCUT Innovation District, ensuring the study's feasibility and targeted approach.

1.6.1.3. Comparative analysis method

This method involves comparing the innovation development processes of universities in both China and the west. It also examines the institutional guarantee mechanisms and spatial organization patterns of university-anchored innovation districts in both contexts. While acknowledging that China's university innovation development began later and its institutional support system for innovation district construction is not yet fully established, it highlights the shared objective of innovation-driven development. This objective involves utilizing universities as anchored institutions to promote cooperation between universities and cities and drive industrial revitalization in urban centers. The similarity in background between these cases makes the spatial experiential exploration relevant to the regeneration of SCUT's anchored innovation district.

1.6.1.4. Field investigation method

This method includes on-site inspections and explorations of the Tianhe Changban plot and the northern area of the Wushan Campus of South China University of Technology. The objective is to accumulate rich first-hand data for in-depth research. The on-site investigations encompass overall layouts, urban landscapes, boundary forms, and the characteristics of the population. Interviews are conducted with innovation talents in the region to understand the classification of current innovation activities in Peri-Wushan Innovation Urban Area and the types of innovative industries, as well as to identify spatial bottlenecks in development, thereby supplementing the findings from literature research.

1.6.1.5. Empirical research method

The university-anchored innovation district regeneration strategy and practice framework are applied to the update of the Changban plot, and a regeneration design is carried out to

validate the operability of this spatial model in practice. This case study provides a sample for South China University of Technology's anchored region to become an innovation district, achieving the integration of education, industry, and the city.

1.6.2. Research framework

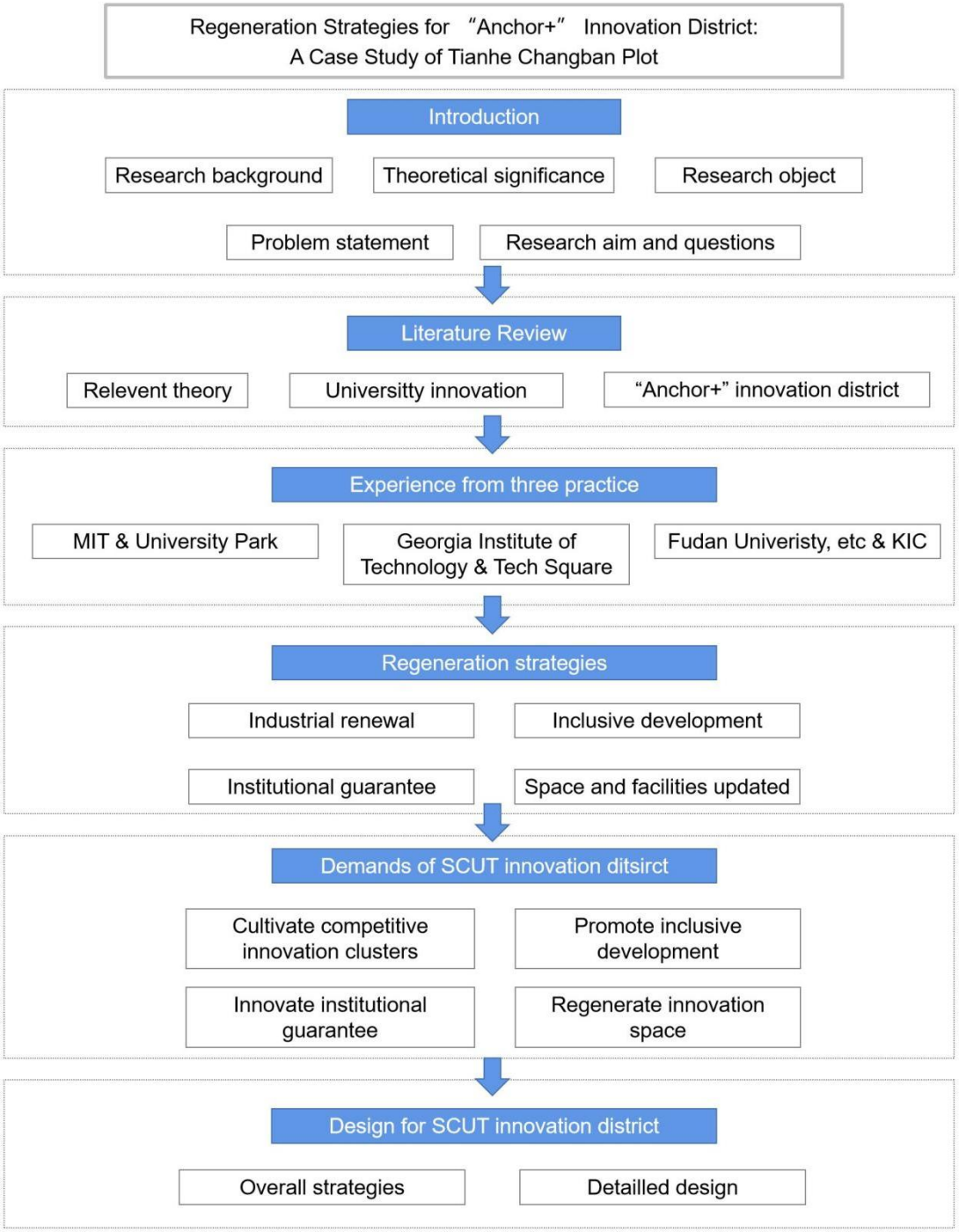


Fig 1-13: Thesis framework

Chapter 2 Literature review

2.1. Relevent theory

2.1.1. Innovation theory

In the early 20th century, Joseph Schumpeter introduced the "theory of innovation," which only regained attention in the 1950s with the development of technological and institutional innovation economics. Despite this, the spatial dimension of innovation remained a peripheral focus within research. It was not until Hagerstrand (1953) proposed the concept of three-stage spatial diffusion of innovation that geographers began to pay attention to the spatial aspects of innovation. Furthermore, Pred (1977) explained how innovation diffuses through the hierarchical urban system, emphasizing the cyclic advantages held by larger cities.

In the 1980s, against the backdrop of the development of the knowledge economy, the international economy became increasingly dependent on the production, diffusion, and application of knowledge and information. The driving force of growth shifted towards innovation and creativity. In the field of social sciences, there emerged a tendency towards "spatialization." "New regionalism" viewed innovation as a process of mutual learning[37]. At the same time, geography witnessed a trend towards "socialization." David Harvey proposed to perceive space as a social product revolving around economic activities. New economic geography introduced regional factors and incorporated "institutions" and "culture" to interpret mechanisms of innovation[38] (Storper and Scott, 2009). Human geography, by introducing sociological concepts, opened a new door to regional development, promoting the study of regeneration spatial mechanisms[39]. Since the 1980s, research on innovation and space has gradually deepened, giving rise to important research paradigms such as the environmental school of innovation[40] (Aydalot, 1988), the industrial and innovation cluster school(Das, 1998)[41] , the new indutrial district school (Granovetter, 1985; Amin and Thrift, 1992)[42], the national innovation system (Lundvall, 1992)[43], the regional innovation system (Cooke, 1992)[44], and the creative city theory (Scott, 1998; Yencken, 1988)[45]. The empirical

research and achievements during this period laid the foundation for subsequent contributions in innovation geography by Friedman[46].

In China, research on innovation started relatively late. In the early 21st century, scholars began conducting in-depth research on cluster innovation[47], technology diffusion, regional innovation systems[48], R&D innovation[49], and knowledge innovation[50]. Spatial concepts related to innovation, such as innovation districts and urban new industry spaces[51], were subsequently proposed. Discussions from an urban perspective have been on the rise. It started with the exploration of urbanization of innovation [52], followed by the introduction of China's urban innovation system [53], innovation linkages[54], and urban innovation functions [55]. Further research explored the concept of innovative cities[56], urban R&D clusters[57], and metropolitan innovation circles [58]. The study of urban innovation spatial patterns has become a hot research topic.

2.1.2. Multi-dimensional proximity theory

The Multi-dimensional proximity theory, proposed by human geographer Gunnar Olsson in the 1960s, is a social science theory that explores human interactions in both spatial and social contexts. Over time, it has become a valuable tool in the fields of urban planning and urban design. The theory suggests that people engage in social, economic, and cultural exchanges not solely based on physical proximity but also considering social and cognitive factors. These factors encompass spatial proximity, social proximity, and cognitive proximity. Spatial proximity refers to people's tendency to interact and collaborate with those nearby. Social proximity indicates a predisposition to connect with individuals or groups who share similar social characteristics, cultural backgrounds, or identity. Cognitive proximity involves people's preference to engage with others who share similar knowledge and ideas, facilitating knowledge dissemination and innovation.

The multi-dimensional proximity theory presents a comprehensive framework that integrates spatial, social, and cognitive factors, offering new insights for urban planning and design. It underscores the significance of diversity and inclusivity in urban development. Nevertheless, practical application faces challenges, such as quantifying social and cognitive proximity and balancing conflicting aspects of proximity in planning. Thus, future research

should further deepen our understanding and application of the multi-dimensional proximity theory to better guide urban planning and design practices.

Research shows that physical proximity increases the likelihood of collaboration among researchers. Taking MIT as an example, as scientific research becomes increasingly interdisciplinary, many universities are seeking to support collaborative activities through new buildings and institutions. The study examined the impact of spatial proximity on collaboration at MIT from 2005 to 2015: by assessing how discrete changes in physical proximity, resulting from building renovations, affected the likelihood of co-authorship among researchers. The findings indicate that relocating researchers to the same building increases their propensity for collaboration, and this effect tends to stabilize five years after the relocation. This impact is significant compared to the average collaboration rate between paired researchers, highlighting the importance of spatial proximity as a tool for supporting interdisciplinary collaborative innovation.

2.1.3. Innovation ecosystem

An innovation district's value is rooted in its innovation ecosystem, and comprehending the latter is crucial to understanding the former. Innovation ecosystems are intricate networks of organizations and individuals that collaborate to nurture ideas into successful ventures. Similar to natural biological ecosystems, they consist of numerous dynamic elements, including universities, research institutes, human capital, information technology infrastructure, financial resources, private enterprises, and government support. This diverse landscape includes subjects of all scales, from small startups to large multinationals and research institutions. All the actors in the ecosystem collaborate to drive advancements in products, technologies, services, and policies, with each component playing a vital role.

A flourishing innovation ecosystem facilitates the connection of visionary individuals with the necessary training, funding, spaces, support services, and talented employees needed to turn their ideas into reality. It goes beyond the sum of its parts, finding strength in a solid foundation built on human capital, culture, information technology infrastructure, and the interplay between these elements.Each innovation ecosystem is unique, and there is no one-size-fits-all model for an innovation district. Instead, an innovation district must be

tailored to reflect and harmonize with the local culture and norms.[59]

In addition, industrial diversification can drive the construction of an innovation ecosystem. Through the study of the Knowledge Service positioning changes in seven innovation districts,[60] it can be observed that the industrial transformation process has mainly undergone the evolution from "mechanical manufacturing industry - electronic industry - computer software and hardware industry - life sciences and biotechnology-focused industries" when transitioning from old industrial areas to relatively isolated office parks, to multifunctional mixed-use districts, and finally to livable and business-friendly innovation districts.

In this process, small enterprises contribute more to innovation, high-density clustering facilitates knowledge transfer speed, and industrial diversity fosters innovation[61]. Taking Kernel Square as an example, it has formed an ecosystem of symbiotic enterprises throughout the life cycle. With diverse participants, open knowledge sharing, effective collaboration mechanisms, abundant innovation resources, policy guidance, and market-oriented demand, small enterprises can collaborate with large enterprises on this platform. Creative researchers can find incubation space to commercialize their ideas, venture capital firms can seek investment opportunities, law firms specializing in handling intellectual property disputes and public relations companies adept at marketing and promotion can also thrive, creating a positive industrial innovation ecosystem.

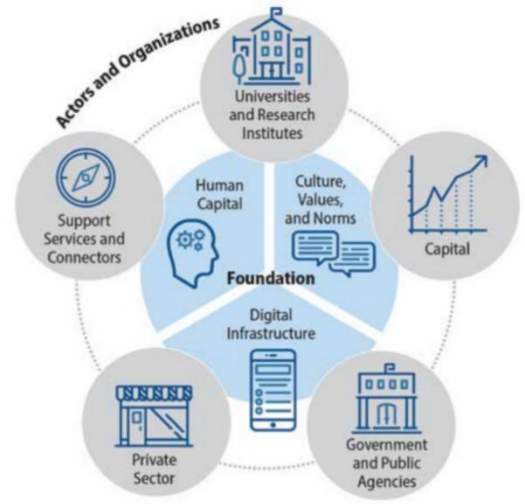


Fig 2-1: Innovation ecosystems

2.1.4. Triple Helix Model

The Triple Helix Model is a theoretical framework that describes innovation and development, proposing the concept of interaction and collaboration among the three main sectors of academia, industry, and government in the innovation process. The model was initially proposed by British scholars Etzkowitz and Leydesdorff in 1995 and was primarily used to describe the relationship networks in the field of technological innovation. The model can also explain the essence of innovation districts, which are regional innovation systems characterized by extensive interaction and knowledge spillover among multiple actors such as universities, governments, and businesses.

The model examines the process of knowledge capitalization from three dimensions: the Academic Helix, the Industrial Helix, and the Governmental Helix. The interactions and collaborations among these three sectors are critical elements of the innovation ecosystem. The model emphasizes the interactivity and interdependence of different sectors in the innovation process, highlighting that through cooperation and collaborative innovation, technological progress and economic development can be accelerated. The Triple Helix Model assigns a new role to universities, enabling them to drive innovation and foster entrepreneurship, which Etzkowitz refers to as the "second academic revolution".

The Triple Helix Model is a core model in innovation theory, and subsequent research has extended it to include additional helices such as the Civil Society Helix and the Knowledge and Culture Helix[62].

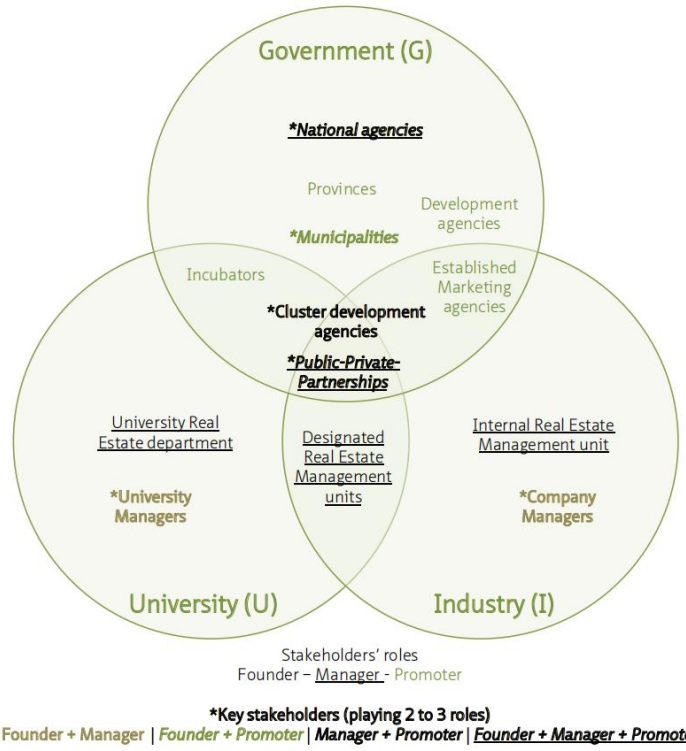


Fig 2-2: Overview of main stakeholders defining and influencing the demand for developing technology campuses framed into the Triple Helix model[72]

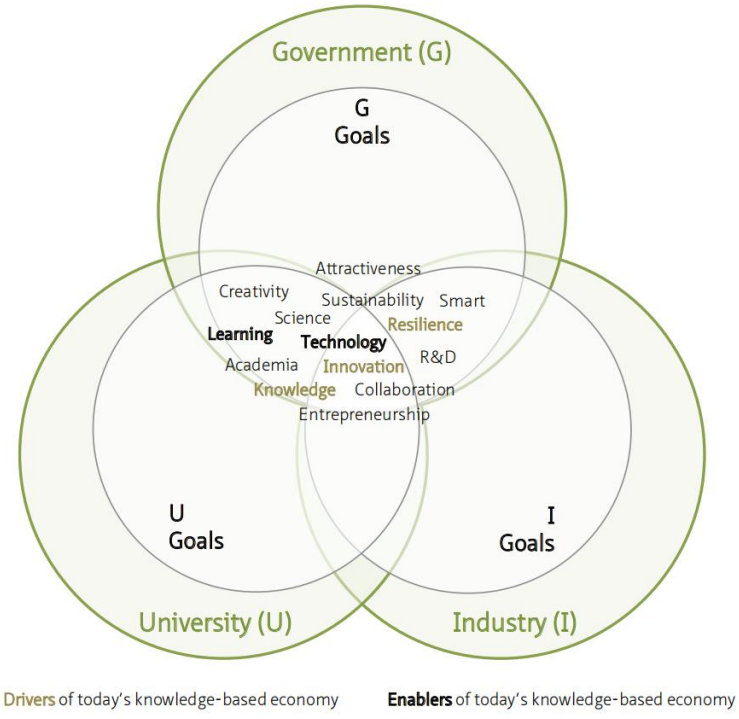


Fig 2-3: Cloud of words used to describe the goals of technology campuses and cities linked to the concept of the triple Helix and the aspects leading fundamental transformation in today's knowledge-based economy [72]

2.2. University innovation

The development path of Chinese universities in terms of industry-academia-research cooperation is indeed quite different from that of Western universities. The modernization of Chinese universities took place in the late 19th to early 20th centuries, while the modernization of Western universities was largely completed in the 19th century. Therefore, the time trajectory of cooperation in industry-academia-research also differs between China and the West.

2.2.1. Development of western university

The development history of Western universities can be summarized into five stages. The first stage was the medieval period when universities held strong religious authority. During this time, universities gained recognition from the papal government and obtained special privileges, leading to the establishment of private city schools. Universities provided education to trained scholars who served feudal courts and religious institutions. University life was closely intertwined with urban life, resembling monastic life.

The second stage was the early modern period, specifically the Renaissance, during which scientific advancements emerged and mechanical arts gradually evolved into applied sciences. The architectural style of college courtyards transitioned into Renaissance and Baroque styles, and external institutions preceded universities in providing excellent research opportunities for scholars and scientists.

The third stage witnessed the emergence of modern research universities in the 19th century. Political, social, and economic transformations during this period propelled radical reforms in the university system, giving rise to research-oriented and technical universities. University buildings were established in city centers, becoming important institutions for urban and national culture.

The fourth stage occurred in the 20th century when universities spread worldwide. In the first half of the 20th century, university designs combined traditionalism with modernity. Due to colonial aspirations, modern universities were constructed in almost all regions of the world, leading to significant growth in university size and enrollment. During this time,

important discussions took place regarding educational systems and research in various countries.

The fifth stage encompasses the globalization and digitization of universities. In this stage, universities transitioned from being knowledge providers to knowledge facilitators. Universities faced challenges such as the digital divide, quality assurance, and adapting to changes in the job market, necessitating global collaboration, lifelong learning, and innovation.

2.2.2. Development of Chinese university

During the 50-year period from the mid to late 19th century to the early 20th century, Chinese modern universities underwent a transition from the traditional academy model to the university model. The disciplines, campus functions, and spatial scale gradually improved. After the establishment of the People's Republic of China, universities went through the process of socialist transformation, nationwide restructuring of higher education institutions, learning and reflection on the Soviet model, and the Cultural Revolution that lasted for a decade. In the early stages of the reform and opening-up era, universities experienced a phase of campus revitalization and exploration. The relevant research during this period can be divided into three stages.

2.2.2.1. The initial stage through strengthen the country through science and education (1981-1999)

The relevant research began in 1981, during the early stages of the reform and opening-up era. Guided by the strategic principles of "science and technology as the primary productive force" and "strengthening the country through science and education," governments at all levels, from the central to local level, started to focus on transforming knowledge into technological achievements. Universities, as they possessed the core elements of the knowledge economy, were positioned as incubators for urban economic development. Additionally, the interaction between universities and industrial parks became increasingly close, leading to the emergence of the concept of "university cities" under the influence of various external factors[63].

Simultaneously, internal reforms in higher education also contributed to the development

of "university cities." The expansion of enrollment in higher education institutions created a demand for expanded land due to spatial constraints[64]. Reforms in university management and the consolidation of universities resulted in the formation of a series of comprehensive institutions with a wide range of disciplines and larger scales, providing a foundation for the development of the university city model[65]. Furthermore, the construction of initiatives such as the "211 Project" and the "985 Project" marked a new trend in interuniversity cooperation and generated a strong demand for spatial clustering.

2.2.2.2. The practical satge under the Background of Urban Expansion (1999-2010)

Starting from 1999, with the expansion of higher education enrollment on a large scale and the gradual adoption of the central-local co-construction model, university cities have gradually become an important force driving regional economic development[66]. Simultaneously, China has implemented a series of economic system reforms, including the land market, fiscal decentralization, and housing system, making university city construction an essential element of urbanization and economic growth in major cities. University cities have been tasked with goals such as integrating dispersed educational resources, investing in the education industry, supporting regional industrial restructuring, and driving the development of satellite cities[67].

During this period, there was a noticeable increase in research on the economic impact of university cities. However, due to the rapid development of practice compared to theory, many university city constructions were not well-planned, leading to issues such as the development of higher education in the form of development zones, growing debt pressures, and inadequate infrastructure development[68].

2.2.2.3. The development stage of innovation-driven Theory (2010-present)

In 2011, China's economic growth slowed down, and the global economy entered a sluggish state known as the "post-financial crisis era." To seize the opportunity for economic transformation and achieve high-quality development, China successively put forward development strategies such as "innovation-driven," "ecological civilization construction," and "green and low-carbon" development. During this period, the theoretical research on university cities began to develop in tandem with practical exploration.

The research scale shifted from the city level to the regional level, and the research scope expanded from "university city economy" to "university city economic-environment." The research focus also shifted from traditional factors such as population and land to innovation factors such as talent and technology. The research space expanded to include various innovation spatial carriers such as parks, communities, and scenic areas. Research hotspots emerged in areas such as the innovation cluster around Zhongguancun[69] and the knowledge economy circle around Tongji University[70].

In recent years, the construction of Chinese universities has gradually shifted from focusing solely on agglomeration effects to pursuing high-quality university innovation. The emphasis is on establishing innovation networks at various levels through a mindset of connectivity[13]. This includes creating a conducive environment for knowledge production, transformation, and output by linking innovation subjects, integrating campuses, parks, and communities, strengthening multi-party cooperation among the government, enterprises, universities, and research institutions, continually supplementing innovation spatial carriers, and promoting wide-ranging openness and cooperation while maintaining close internal connections. These efforts aim to drive the upgrade of an innovation-driven economy.

2.2.3. Gown and Town

The relationship between the university and the city, also called gown and town can directly reflect the functional layout and spatial form of the university within the urban space. On one hand, it embodies the planning concepts of urban governance and, on the other hand, it involves the institutional ideals of higher education. The concept of a unified gown and town, at one point, served as an "ideal" model for the planning of new-style universities in China. However, due to imbalanced functional layout, excessive spatial scale, and the absence of urban social attributes, it faced challenges[71]. The transformation of the relationship between cities and universities can be reflected in the characteristics of their physical location and functional positioning. The first transformation is the physical shift from peripheral cities to the city center, indicating the dynamics of urban growth and its impact on the accommodation of universities and other organizations within the campus. From a typological perspective, these transformations can be categorized into five types: equals, disjoints,

touches, contains, and overlaps [72].

The second transformation is the shift from a single-function campus to a multi-functional campus, assuming functions such as education and research, housing, retail and leisure, infrastructure, and other related services[73]. This transformation reflects the opportunities and risks of collaboration and competition in campus city planning[4].

From the perspective of China's system, the third transformation involves shifting the urban development focus from expansion to rejuvenation. The role of universities has evolved from being catalysts for the development of new urban areas to becoming anchored institutions for revitalizing the old city centers. This transformation has moved from driving real estate development and infrastructure construction in the era of growth to expanding facilities to promote joint development with surrounding communities in the era of consolidation. It also includes attracting high-tech and creative industries, encouraging investment by commercial services in the vicinity, and enriching the local cultural atmosphere through activities and events.

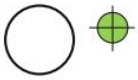
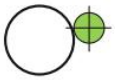
Relationship	Description
Equals 	*City is the same as the campus*. It includes those areas that were newly built as towns or cities. They were built and planned from scratch to accommodate clusters of technology. They are located only in Asia.
Disjoints 	*City shares nothing with the campus*. It includes those areas located outside the city limits but not distinguished as independent cities.
Touches 	*City touches the campus*. It includes those areas bordering on the city. In most cases they and the city are tangent. Touches and the city are usually tangent, but in some cases they are separated by a river, highway, or some other feature).
Contains 	*City contains the campus*. It includes those areas that are inside the urban fabric, but they are perceived of as a distinct campus with borders (e.g., roads, fences, waterfronts, or natural features).
Overlaps 	*City and campuses have multiple points in common*. It includes those areas integrated into the urban fabric, and in many cases the boundaries between the sites and the rest of the city are not clearly defined or perceived.

Table 2-1: Typology of five physical relations between the city and technology[72]

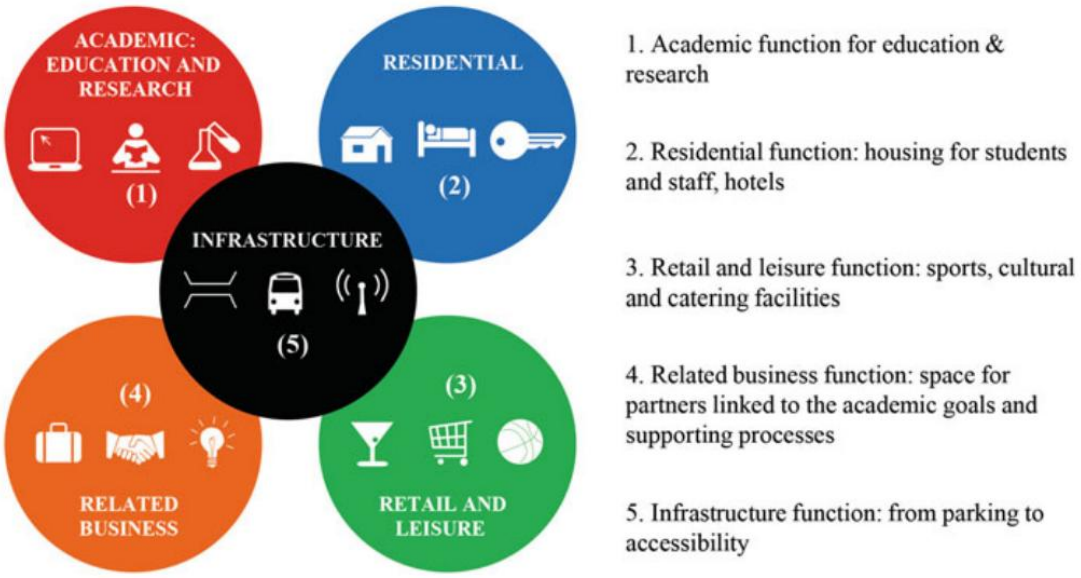


Fig 2-4: Space types on campus—the required functional mix for the future university[73]

Indeed, the concept of cities as ideal environments for supporting innovation activities is influencing the site selection of universities and other organizations. For example, some universities in Europe and the United States are relocating their campuses from the suburbs to the city, rather than solely relying on urban physical expansion. Van Winden and Carvalho (2016)[74] argue that there is a growing trend of mixed-use spaces, including residential areas and cultural facilities, emerging around campuses and science parks, indicating the unstoppable trend towards mixed communities.

This shift reflects the recognition that proximity to urban amenities, cultural resources, diverse populations, and potential collaboration opportunities can enhance the innovation ecosystem and foster creativity and knowledge exchange. By locating in urban areas and embracing mixed-use environments, universities can better connect with their surrounding communities, engage in partnerships with local businesses and organizations, and contribute to the overall vitality and development of the city.

The changing relationship between cities and universities indicates that universities and other organizations within campuses are increasingly sharing material and functional resources with the city. By effectively utilizing and managing these resources, common goals can be achieved, attracting students and knowledge workers to live in innovation neighborhoods near the campus and increasing the vibrancy of the region. It is important to

note that while the development of urban transportation infrastructure may facilitate connectivity, it can also hinder the self-sufficiency of these campuses in terms of functionality (Curvelo Magdaniel, den Heijer, & de Jonge, 2018). Therefore, it is necessary to consider campus boundaries and their transportation accessibility in the study of the relationship between campuses and cities.

2.2.4. University as an anchored institution

The evolution of the relationship between universities and surrounding science and technology spaces, where universities serve as anchored institutions driving the development of innovation districts, has gone through several generations. The first generation of university science parks consisted of small-scale buildings primarily attracting knowledge-intensive start-ups and providing research and office spaces. These parks had relatively lower construction standards and affordable rents.

The second generation of science and technology spaces placed greater emphasis on business and community development. These parks grew in size and accommodated both research and development companies and a limited number of commercial enterprises. They provided research and office spaces while integrating residential and commercial amenities, creating a more vibrant work environment that fused with elements of urban life.

The third generation of science and technology spaces expanded further in scale and enjoyed convenient transportation infrastructure. These spaces attracted research enterprises, commercial companies, as well as a significant number of financial and intermediary institutions. In addition to their research and office functions, these parks also offered commercial and residential facilities, establishing closer connections with the city and becoming an integral part of urban functions.

The fourth generation of university-anchored innovation districts is more comprehensive. These districts are integrated communities that bring together knowledge-intensive start-ups, research centers, corporate headquarters, and large multinational enterprises. These districts provide not only office and commercial spaces but also include residential, educational, and recreational facilities, forming self-sustaining communities with ample internal communication spaces.

Over time, the surrounding science and technology spaces of universities have evolved from small-scale incubators to more refined and comprehensive community models. These developmental processes reflect a continuous pursuit of innovation and entrepreneurship, as well as the demand for integration between technology spaces and urban development. These science and technology spaces have played a significant role in fostering innovation talents, promoting industry development, and driving urban economic growth.

	First Generation University science park	Second Generation Business & Community	Third Generation Neighborhood relationship	Fourth Generation Anchored Innovation district
Introduction	Small-scale buildings around the university and incubators are composed	The university and the surrounding area have a certain size	Large scale, with convenient transportation	University integrated community
Enterprise	Intellectual intensive entrepreneurship	Technology research and development enterprises, a small number of commercial companies	Scientific research enterprises, commercial enterprises, a large number of financial and intermediary institutions	Intelligence-intensive entrepreneurial enterprises, R&D centers and corporate headquarters, large integrated multinational enterprises
Function	Research and development, office	Research and development, office, small number of residential, supporting business	Office, research and development, business, residential supporting living facilities	Office, commercial, residential, educational, leisure places
Characteristic	Low building standards, low rents	Strong office atmosphere, integrated into the elements of urban life	The connection with the city is becoming more and more close, becoming part of the urban function	An integrated community that can be "self-sufficient" and can provide sufficient space for internal communication

Table 2-2: The development process of university and surrounding science and technology space

2.3.“Anchor +” innovation district

In the dictionary, the term "anchor" has several meanings: (1) Positioning or fixing: to secure something or someone in a specific location or state, keeping it stable or immobile. For example, a ship anchors itself to the seabed, and a building anchors itself to the ground through its foundation. (2) Reference or basis: using a particular thing or value as a reference point or benchmark for comparison, evaluation, or decision-making. For instance, data used in market research can serve as an anchor for decision-making. (3) Core or center: designating a

region, institution, or building as the central or significant reference point that leads, supports, or influences other elements. For example, a university can serve as an anchor for culture and knowledge in a city. (4) Safety or stability: firmly securing something or someone in place to ensure safety and stability. For instance, climbers use anchored devices to ensure their safety during the ascent.

In urban planning and design, "Anchor+" can refer to designating a specific area or building as the core or important reference point for the entire region. This area or building may have special historical, cultural, or economic significance and serves as the foundation for other developments or designs in the area.

This article will discuss the "Anchor+" Innovation District model with universities as anchored institutions. By analyzing its key characteristics and summarizing the planning elements of innovation districts, it aims to explore the potential of this model in future theoretical research and practical development.

2.3.1. Asset characteristics

The Brookings Innovation District model incorporates the physical location as a key factor into a variation of the three-helix model involving participants (Katz, 2014). It considers three categories of assets: economic assets, physical assets, and network assets. "Economic assets are companies, institutions, and organizations that drive, cultivate, or support the innovation environment." "Physical assets are publicly and privately owned spaces — buildings, open spaces, streets, and other infrastructure — that are designed and organized to stimulate new, higher-level connections, collaboration, and innovation." "Network assets are the relationships among actors, such as individuals, companies, and institutions, which have the potential to generate, strengthen, or accelerate the development of ideas."

2.3.1.1. Economic characteristics

The university-led innovation clusters consist of diverse entities such as businesses, research institutions, universities, and technology service organizations, which are interconnected through knowledge chains, industry chains, and value chains. These clusters

form relatively stable collaborative relationships, with lower transaction costs for knowledge spillover and information exchange, creating an ecosystem.

For example, in the Boston area, centered around the Massachusetts Institute of Technology (MIT), various innovation platforms and infrastructures have been rapidly developed. The region has leveraged the expertise of MIT to release a significant amount of research and development space through incremental updates, attracting a pool of innovation and entrepreneurial talents represented by MIT alumni[12]. This has led to the formation of a globally competitive innovation cluster[75].

In China, Beijing has fostered innovation clusters in the Zhongguancun Science Park, relying on the intellectual resources of prestigious universities such as Tsinghua University, Peking University, and the Chinese Academy of Sciences. This has resulted in the growth of leading enterprises and related companies. With a comprehensive enterprise innovation system and strong policy support, the innovation cluster in the Zhongguancun area has experienced rapid development[69].

The formation of innovation clusters around universities promotes the creation of a collaborative community among universities, diverse entities in the surrounding areas, and industry-academia research cooperation. It facilitates knowledge spillover and flow, contributing to the economic growth of the region and shaping its regional brand.

2.3.1.2. Physical charateristics

① Spatial composition

The innovation district anchored by universities consists of three functional areas: campus, park, and community. These areas integrate multiple zones to meet the spatial requirements for innovation activities. The campus serves as a magnetic pole for innovation, the community provides residential units for the innovation population, and the park serves as an industrial unit for research commercialization. The interconnection, mixing, and embedding of these functional areas create abundant and flexible spatial carriers for knowledge production, transformation, and dissemination. Due to the easier linearization of tacit knowledge in informal spaces, the mixing of functional areas accelerates knowledge spillover and diffusion between universities and the surrounding region, enhancing the

attractiveness of the area. Looking back at the development of the campus, community, and park, we can observe the historical evolution of their connotations and functions.

The notable transformation of universities involves shifting from teaching-oriented institutions to research-oriented and entrepreneurial universities, playing multiple roles in research innovation, community service, and industry collaboration. The changing times have expanded the "intrinsic logic" of the university mission from knowledge transmission (education) to knowledge creation (research) and the current commercial application of created knowledge (entrepreneurship)[76]. Research-oriented universities emphasize research and the discovery of new knowledge to address societal and economic challenges. By conducting high-quality basic and applied research, they provide innovation solutions for industries and government sectors, making significant contributions to social development. Entrepreneurial universities cultivate talents with entrepreneurial awareness and capabilities, facilitate the commercialization of technological achievements, and drive socio-economic development. They focus on transforming academic achievements into business opportunities, encourage students and faculty to engage in entrepreneurship, and provide support and resources for innovation and entrepreneurship. By creating an innovation ecosystem, they offer abundant opportunities for entrepreneurs and innovators, promoting technological innovation, economic growth, and social progress. Given the crucial role of universities in regional innovation and development, the Chinese government issued the "National Innovation-driven Development Strategy Outline" in 2015, aiming to build an innovation country with universities and research institutions as the main drivers, promoting the transformation of scientific and technological achievements and fostering innovation and entrepreneurship. China's industrial parks and science and technology parks are facing the need for upgrading and transformation. Discussions on intelligent management services, green environmental construction, and diversified industrial layouts are increasing, while the mission of innovation, entrepreneurship, and talent aggregation is also growing. The earliest batch of industrial parks in China appeared in the early stages of the reform and opening-up era. They were built with government investment or in cooperation with foreign capital, aiming to introduce advanced foreign technologies and management experiences, and promote the modernization and industrialization of the Chinese economy. With the continuous

development of the Chinese economy and the shift of global industries, China's industrial parks have undergone transformations and can be broadly classified into traditional industrial parks and innovative industrial parks. The innovation focus of traditional industrial parks mainly centers around production processes and management, with the main objectives of improving production efficiency, reducing costs, and enhancing product quality. The emphasis of these parks is to enhance the competitiveness and performance of enterprises through the introduction of new technologies and management models.

On the other hand, innovative industrial parks primarily focus on scientific and technological innovation and industrial upgrading. They aim to promote industrial and enterprise innovation, accelerate the transformation and application of scientific and technological achievements. The innovation focus of these parks includes conducting basic research, integrating innovation resources, strengthening technological exchange and cooperation, promoting the commercialization of scientific and technological achievements, and facilitating technological innovation and entrepreneurship. These parks typically attract high-tech enterprises and research institutions to settle in, establish innovation platforms and ecosystems, cultivate innovation talents, and form an innovation chain that integrates research, industry, and application. By fostering a close integration of industry, academia, and research, these parks play a crucial role in facilitating innovation, promoting technological advancements, and driving economic growth. They serve as hubs for knowledge exchange, collaboration, and the commercialization of research outcomes, contributing to the overall development and competitiveness of China's industries.

With the community moving towards innovation, the emergence of maker spaces has become increasingly prominent. More and more people are exploring and practicing innovation and entrepreneurship activities within their communities. On one hand, the abundance of technological tools and resources provides individuals with the possibility to transform creative ideas into tangible products and works through independent or collaborative efforts, thereby driving the development of community maker spaces. On the other hand, initiatives at the national level, along with local planning and support, have facilitated the widespread adoption and deepening of maker actions, transitioning from laboratories and schools to society at large, and evolving from small-scale interest activities

into a nationwide creative practice.

Typically located at the heart of communities, maker spaces attract a group of individuals with innovative and entrepreneurial spirits, offering a range of services including offices, workspaces, collaboration areas, exhibition spaces, and sales platforms. Behind this trend lies the pursuit of more autonomous, open, and collaborative work and lifestyle, as well as the quest for innovation, entrepreneurship, and societal value. The development of maker spaces has gone through a process of bottom-up growth, gradually transitioning to a top-down guidance approach. In 2013, the State Council of China released the "Opinions on Promoting Mass Entrepreneurship and Innovation," encouraging the establishment and development of maker spaces and supporting joint efforts by government and social forces in their construction and support. With the flourishing development of innovation and entrepreneurship, an increasing number of cities and local governments have begun to pay attention to and support maker spaces. These policy documents have promoted the development and standardized construction of maker spaces, fostered innovation and entrepreneurship, and provided a better business environment and resource support for more entrepreneurs.

② Spatial connection

The integration of campus, park, and community has become an innovative spatial model that promotes the enhancement of innovation capabilities[12].With the strengthening of entrepreneurial characteristics in universities and the rise of the concept of urban-industry integration, the connection between campuses and parks has become increasingly close, and the connection between parks and communities has also strengthened, resulting in the spatial agglomeration of the three areas. The key to driving innovation lies in the interaction and mutual development of these three domains through resource interaction and sharing, functional division of labor, and collaborative cooperation. This integration of the three areas has become an important driving force for promoting urban and regional innovation development and realizing economic and social development strategies.

The first model is the campus-led (park-community integration) model, which relies on prestigious universities to create a strong entrepreneurial atmosphere and develop knowledge-intensive industrial clusters in the surrounding areas. This model promotes

innovation by leveraging the knowledge spillover from universities and research institutions, the driving force of university-affiliated enterprises, and the entrepreneurial activities of university talents. In this model, the role of universities is crucial, and the integration of parks and communities further expands the levels and advantages of innovation. Examples of this model can be seen in the areas surrounding the Massachusetts Institute of Technology (MIT) and Tongji University in Shanghai.

The second model is the park-led (campus-community integration) model, which focuses on transforming existing industrial parks into science and technology cities and innovation parks by attracting universities, research institutes, and other knowledge institutions and talents. This integration of industry, academia, and research generates value-added effects on traditional manufacturing enterprises. The concept of "integration of industry and city" is the main goal of industrial park development, aiming to construct a new model of integration among production, education, and research. Many regions are competing to become national demonstration zones for independent innovation, such as the western part of Hangzhou and the Optics Valley in Wuhan, China. Through the integration of parks and communities, this model expands the levels and advantages of innovation, creating more convenient and cohesive innovation spaces to better promote the enhancement of innovation capabilities.

The third model is the dual emphasis on campus and park (campus-park coexistence) model, where both excellent universities and industrial parks play important roles in driving innovation. This model is comprehensive, combining the knowledge and innovation resources overflow from universities with the integrated development of industry, academia, and research in the park, thereby jointly enhancing regional innovation capabilities. Additionally, the mixed space between campus and surrounding communities provides diverse life services and low-cost innovation spaces for the innovation population. Silicon Valley and Beijing Zhongguancun are examples of such areas, where the comprehensive leadership of campus and park can drive disruptive and sustainable innovation, mutually influencing and promoting the region to become the most active hub of innovation.

The spatial form of multi-district integration within innovation districts has been validated in several practical cases. Taking the United States as an example, influenced by the large-scale urban regeneration plans in the mid-20th century, local governments in the United

States encouraged mixed-use development. The technology square around MIT in Boston underwent minor updates, transforming from purely office space into a multi-functional district centered around life sciences and technology research and development, integrating residential, research, commercial, and other functions. It attracted numerous excellent research teams and stimulated innovation vitality in the surrounding area of MIT.

In Beijing, China, Zhongguancun is home to multiple research-oriented universities, national university science parks, and scattered old communities. The communities provide low-cost office spaces for innovation talents in research institutions and industrial parks, creating a typical spatial form of multi-district integration and development[12].

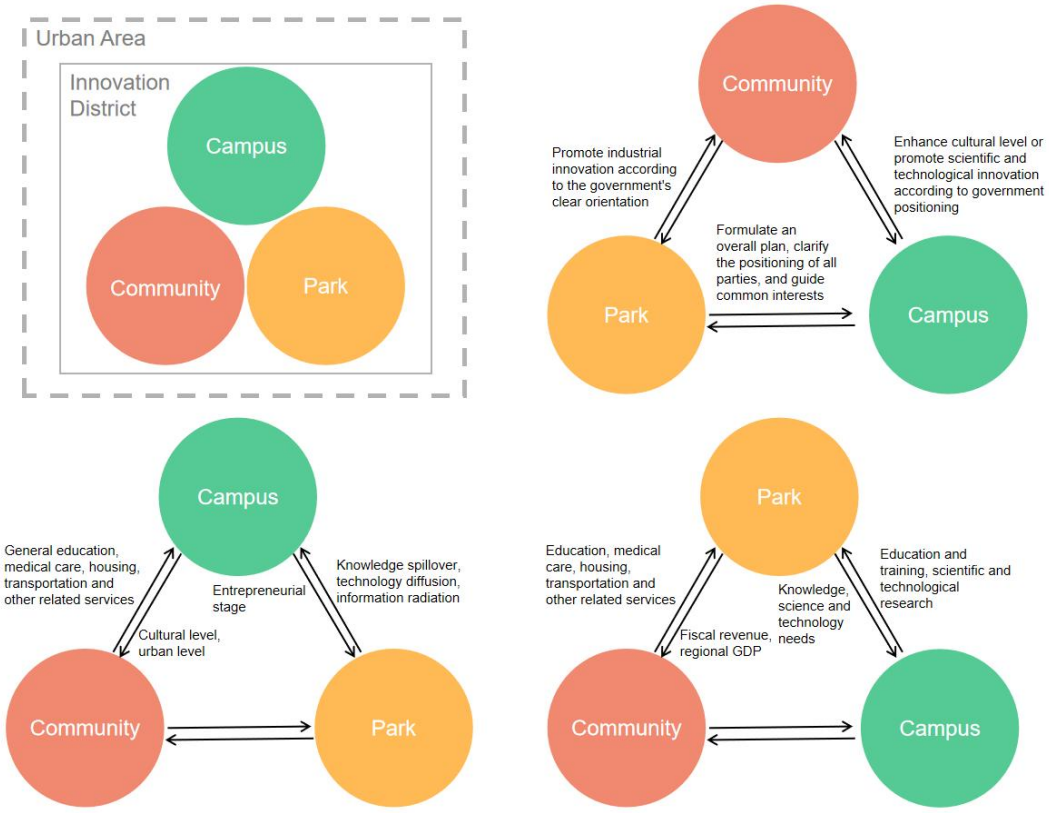


Fig 2-5: Intergration paradigm[12]

2.3.1.3. Networking charateristics

The knowledge production, spillover, and diffusion of universities can facilitate technology exchange, sharing, and transformation, and enable the coupling of knowledge chains and industrial chains within a certain region, thus forming an "anchor+" innovation district. On the one hand, universities create favorable conditions for the dissemination of tacit knowledge, allowing experiential knowledge to be transmitted based on geographical

proximity, cognitive proximity, and cultural proximity. On the other hand, the univeristy-anchored innovation district exhibits spatial characteristics of a triple-network integration, involving geographical ties, personal connections, and industry ties[3].

The innovation cluster formed based on geographical proximity is located within walking distance of the university's surrounding neighborhoods. It facilitates innovation activities through collaboration and resource sharing among various research and development institutions, technology parks closely connected to universities, research teams, and other entities. This reduces commuting and transaction costs and creates a living circle where various innovation talents gather.

The innovation cluster formed based on personal connections and social-cultural relationships is the fundamental reason for attracting a large number of talents to gather in the neighborhoods surrounding universities. Leveraging interpersonal relationships and resources such as hometown ties, alumni connections, and peer associations, knowledge and technological exchanges are facilitated, reducing the cost of social interaction and forming an alumni circle centered around identity recognition. The strong alumni resources of universities inject a continuous attracting force into the surrounding areas of universities.

The innovation cluster formed based on industry ties provides the technical support necessary for various innovation and entrepreneurship activities. It relies on the flow of high-end technical talents within the industry, complementarity and collaboration between technologies, reducing the cost of technology transfer, and forming a technical circle centered around technology exchange. The powerful intellectual resources of universities play an important role in promoting technological progress and innovation. In the era of informatization and economic globalization, beyond geographical agglomeration, the emphasis on connected technological cooperation and diffusion can enhance the core competitiveness of a region and promote the active flow of factors such as knowledge, technology, and capital.

2.3.2. Research on innovative functional area

2.3.2.1. Classification and land use scale

According to the different core functions of technological innovation, innovation

functional areas can be classified into five types, including knowledge-based, technology-based (manufacturing base), technology-based (manufacturing headquarters), technology-based (high-tech enterprise headquarters), and technology-based (defense and military research and production). The classification and functional agglomeration patterns of different core functional innovation areas are summarized. Among them, the knowledge-based innovation functional area is the focus of this study and can be divided into two categories: comprehensive university research centers and specialized research and development centers. There are some differences in their functional composition, such as comprehensive research centers usually having industry-university-research cooperation platforms and also performing some teaching functions[77].

Type	Core innovation function	Derivative innovation function	Peripheral package
Knowledge-based	Key laboratory, engineering technology research center	Production pilot, science and technology finance, business incubation services, scientific and technological achievements transformation services	Basic residential communities, basic productive services
Technology-based (Manufacturing base)	Enterprise technology center, enterprise laboratory, enterprise operation headquarters	Production pilot, production base	
Technical (Manufacturing headquarters)	Enterprise technology center, enterprise laboratory, enterprise operation headquarters	Production pilot, science and technology finance	
Technology (high-tech enterprise headquarters)	Enterprise technology center, enterprise laboratory, enterprise operation headquarters, flagship enterprise	Production pilot, science and technology finance, business incubation services	
Technology-based (R&D and production of national defense)	National defense military research institutions, military enterprise technology research centers, engineering laboratories, engineering technology research centers, military industry research institutes	Production pilot, science and technology finance	

Table 2-3: Different types of innovative functional areas[77]

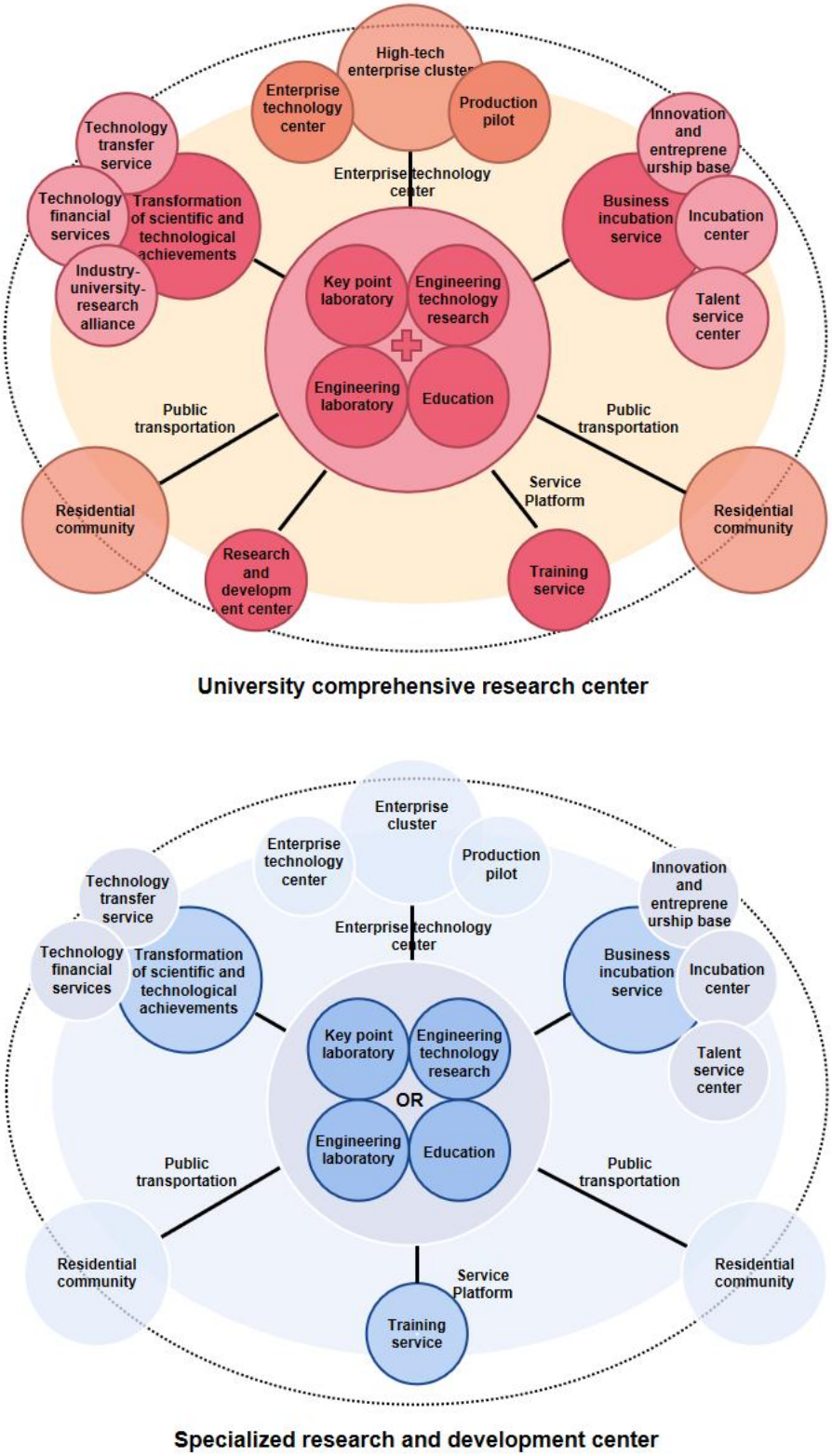


Fig 2-6: Agglomeration paradigm of knowledge-based innovation functional area[77]

According to the different land scales, innovation functional areas can be classified into three types: large, medium, and small-scale innovation functional areas. Each type corresponds to different construction objectives and spatial organizational characteristics. The

university-anchored innovation district studied in this paper belongs to the small-scale innovation functional area. Therefore, in its design, greater emphasis should be placed on the human scale, with the R&D function taking the lead in spatial organization while also considering the design of other supporting facilities.

Dimension	Sclae/hm²	Goal orientation	Spatial organization
Small scale	10-25	Human scale	R&d function leading
Medium scale	50-150	Functional recombination	Flexible organization, adaptable to change
Large scale	300+	A good place to live and work	Integration of industry and city

Table 2-4: Scale of knowledge-based innovation functional area[77]

2.3.2.2. Space layout model

The requirements of innovation industries for urban districts have evolved from basic physical space needs to environmental value demands. They have further transitioned towards soft environments such as technology, innovation, communication, information sharing, and smart operations. The selection of space by innovation industries is undergoing a process of de-materialization and cultural strengthening. The spatial layout of innovation districts is closely related to the internal organizational changes of innovation enterprises, exhibiting significant differences from traditional industrial agglomerations. In terms of internal organization, early industrial agglomerations were characterized by tight control, specialization, and centralization. In contrast, innovation districts are characterized by loose structures, low specialization, and decentralization.

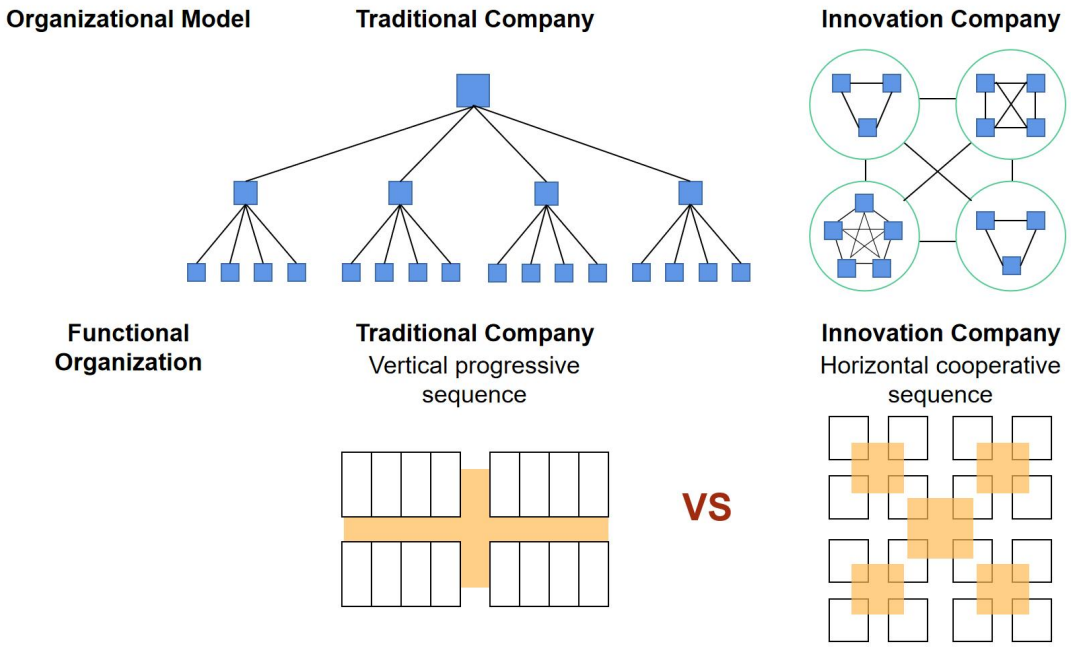


Fig 2-7: Organizational structure difference between traditional company and innovation company[77]

The existing small-scale industrial agglomerations were primarily focused on research and development (R&D) functions, with only a small portion of land allocated for supporting living and production facilities, resulting in relatively fragmented functionalities[77]. In terms of business composition, the dominant feature was the incubation function, with R&D activities taking precedence. Production support services were typically provided by comprehensive service facilities, while living support services mainly included small restaurants, cafes, and retail shops to meet basic needs. Regarding functional layout, R&D activities constituted the main part, and each building cluster should prioritize its connection with the core public open space of the district. Additionally, living facilities and social spaces were integrated to facilitate the use by innovation personnel. The innovation district, in conjunction with the organizational relationships within innovation enterprises, establishes a more flat and collaborative spatial order.

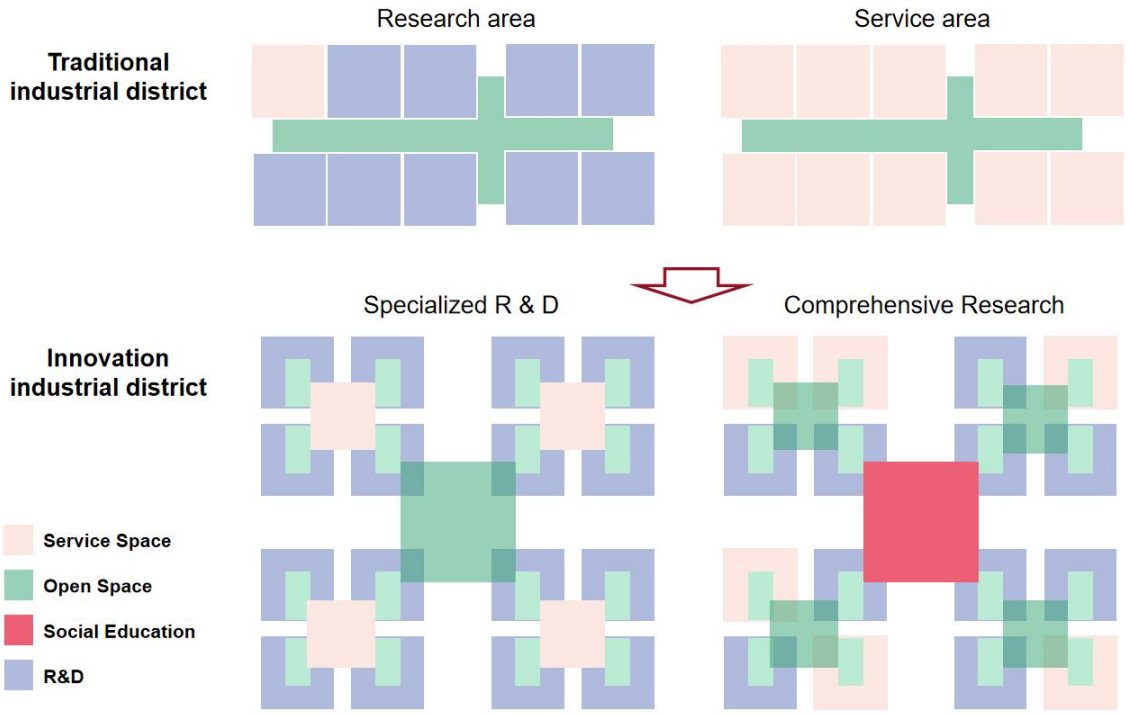


Fig 2-8: Functional layout difference between traditional company and innovation company[77]

Open space, as an informal venue for innovation activities, should consider the interaction habits between people and pedestrian accessibility when designing its spatial layout. In small-scale innovation areas, open spaces primarily consist of public open spaces and spaces enclosed by buildings. In terms of spatial scale, the length is typically around 300 meters (which takes approximately 3-4 minutes to walk) and the width is 25-30 meters (which is the most suitable dimension for pedestrian crossing). This scale is considered the most appropriate. The interaction spaces between buildings generally have an inward orientation, facing the central open space. Additionally, the effectiveness of space utilization can be enhanced by incorporating activity bases and related supporting facilities in conjunction with open spaces. Unlike homogeneous and single-core small-scale industrial agglomerations, innovation districts have multiple parallel levels of cores, thus providing a richer hierarchy of open spaces. In the construction of an innovation district, different types of core functions can be designed for research areas and residential areas based on the planning scheme to facilitate interactions among researchers and the convenience of residents.

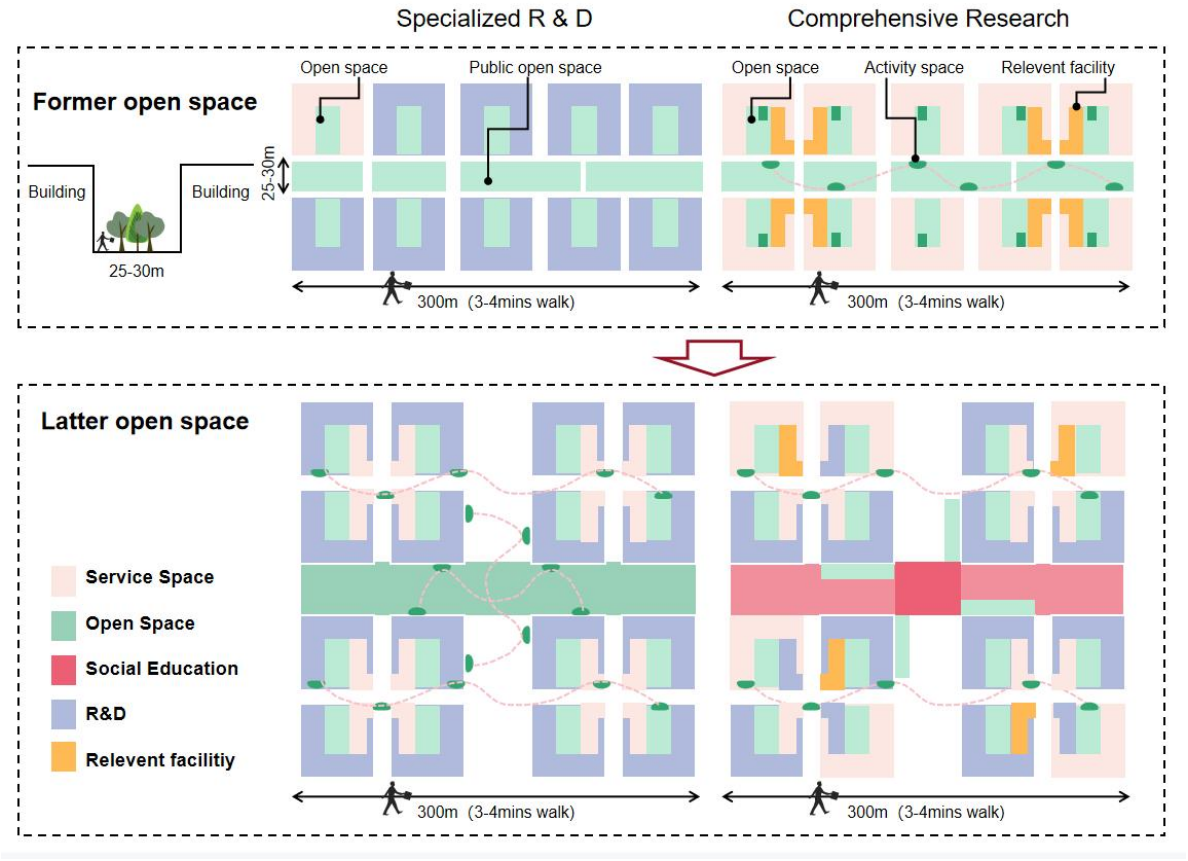


Fig 2-9: The function composition and the spatial layout of innovation enterprises

In small-scale innovation districts, it is advisable to adopt a traffic organization model that separates pedestrians and vehicles, with a focus on pedestrian traffic organization. The parking facilities should primarily be located underground to minimize surface parking. Surface parking lots are preferably situated along the peripheral roads to reduce interference with the internal pedestrian environment. Compared to industrial agglomerations, innovation districts place greater emphasis on pedestrian rights and have well-developed pedestrian systems. Vehicle access roads can adopt a serpentine shape to lower vehicle speeds.

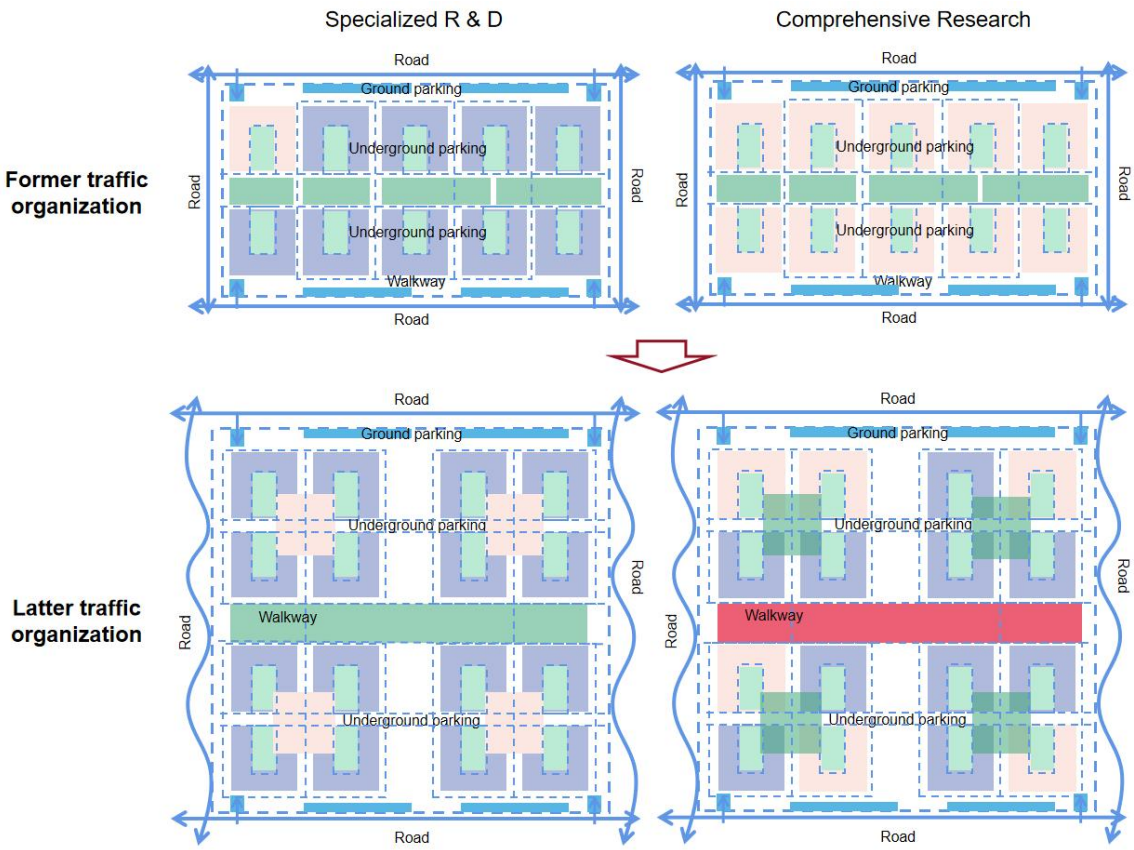


Fig 2-10: Traffic organization model

For small-scale knowledge-based innovation districts, integrating the research on functional composition patterns, open space patterns, and traffic organization methods, two models are formed for university-anchored innovation districts with public space as the organizational core: the "Corridor" model and the "Core" model.

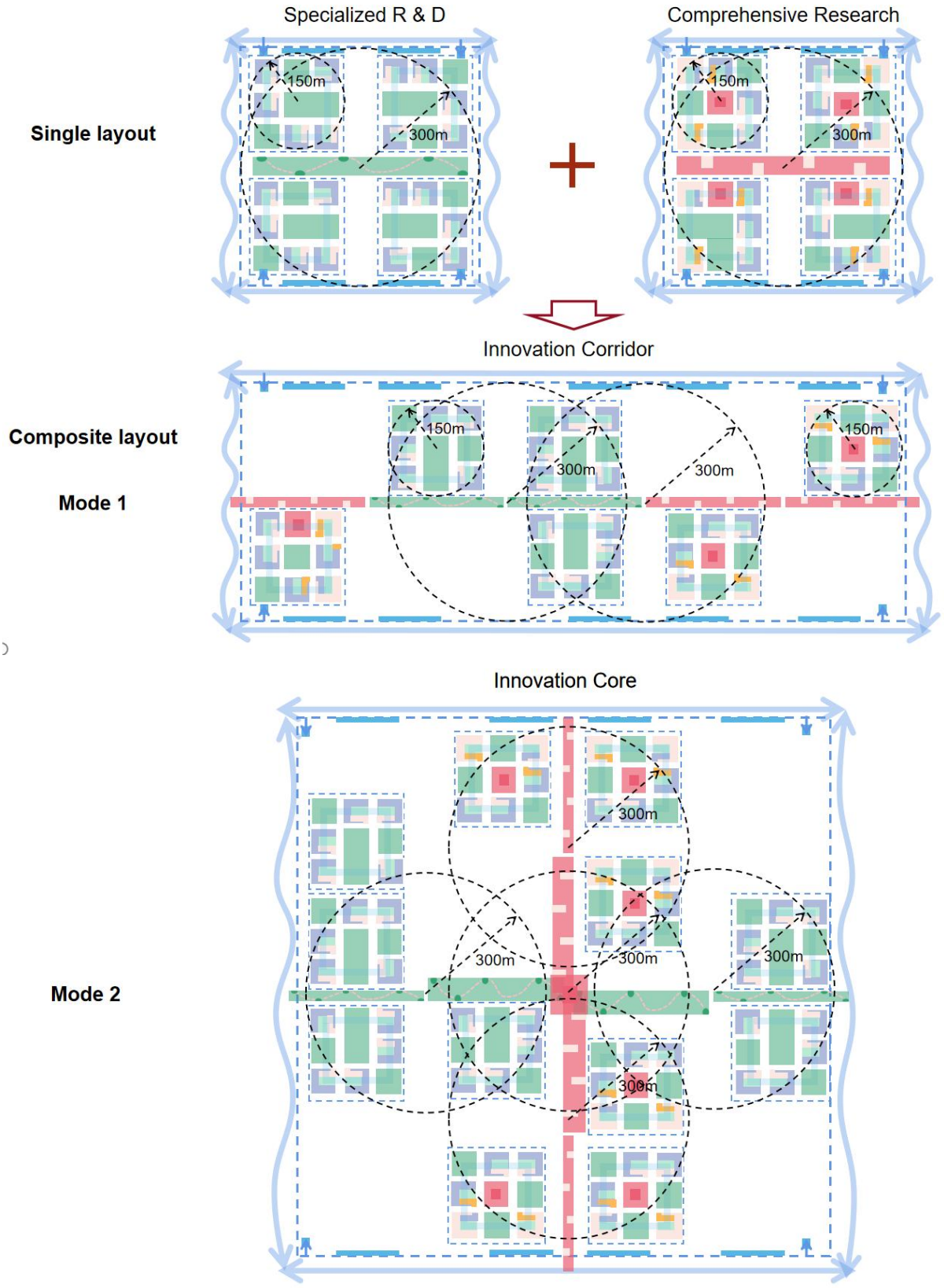


Fig 2-11: Typology of layout patterns

2.4. Summary

From current research, there is a noticeable gap in exploring the development of innovation districts, particularly in the context of urban regeneration, with regard to old urban universities. Many key science, education, and cultural centers in various countries are concentrated around universities, but there is a lack of research on the urban issues and dynamics resulting from university expansion and the development of surrounding campuses during periods of rapid urban growth[78]. Some scholars have pointed out that preserving old university campuses in city centers has led to varying degrees of vacancy, similar to the "hollow village" phenomenon observed during the urbanization process. The challenge lies in effectively leveraging the research advantages of these old campus areas and transforming them into forces of innovation, actively involving universities in the construction of innovation districts and the revitalization of urban core areas, and achieving innovation in social roles and spatial typology.

First and foremost, it is important to recognize that the development of innovation districts within university-anchored areas represents a unique form of "urban regeneration" distinct from industrial or underutilized industrial land regeneration. The participation of universities as anchored institutions in urban regeneration is an example of social innovation. As proactive participants, anchored institutions have the potential to influence the establishment of spatial models in innovation districts. Clearly, this form of regeneration primarily focuses on reevaluating resource utilization and development approaches. Understanding the value of anchored institutions and how they can be leveraged to aid community revitalization is crucial in the early stages of constructing an innovation district. By reimagining the potential of old university campuses, cities can harness their research capabilities and transform them into innovation hubs.

One crucial aspect of university-anchored innovation districts is the need for typology innovation in spatial design, establishing spatial typologies that are conducive to innovation networks. The current construction of innovation networks faces challenges such as information asymmetry among innovation actors and differences in value propositions, significantly limiting the enthusiasm for industry-academia-research collaboration.

Overcoming these challenges through spatial organization and promoting knowledge spillover and technology transfer is the mission of university-anchored innovation districts. Innovation districts need to bridge the gap between academic research and practical market applications, fostering effective collaboration between academia and industry. They need to establish mechanisms and platforms to facilitate the transfer of research outcomes, technologies, and intellectual property from universities to the private sector, encouraging commercialization and transforming academic innovation into tangible economic benefits. New spatial organization needs to adopt a mindset that goes beyond mere clustering [13]. Addressing the specific needs of innovation networks, conscious efforts should be made in the planning phase to compensate for any local loss of innovation resources. This can be achieved by introducing and creating functional carriers with spatial organizational effects, continually enriching the types of innovation actors and potential scenarios for innovation collaboration, and fostering an open and collaborative cluster atmosphere.

In terms of spatial development, it is necessary to break free from the traditional triple helix cooperation model and establish spatial collaboration and development models that involve non-traditional institutions. This involves coordinating the needs of various stakeholders, encouraging the participation of multiple institutions, leveraging the strengths of different innovation actors, and promoting the integration of innovation within the campus, park, and community.

Chapter 3 Experience from three practices

Different innovation districts has different innovation basis, spatial organization mode, spatial characteristics. The following practices choose three practices, one is leading Univerisity Park leaded by MIT , one is Tech Square co-leaded by university and park, the anthor is KIC leaded by itself. The study aims to learn from its development history, spatial characteristics, etc, to obtain the innovation space improvement strategy.

3.1. MIT & University Park

3.1.1. Introduction

MIT Park is a comprehensive development of business, private laboratory, incubator and residential functions, located northeast of Massachusetts Avenue in Boston, USA (Figure x). It was once the site of the Simplex Wire & Cable Company, a telephone wire and cable manufacturer established in Cambridge since 1888. In 1969, the business was sold to a New York company, and the business was moved to another —— New England state in Maine. Following its successful experience at Tech Square, MIT saw the potential to transform industrial areas into residential and commercial development. During the period of 1970-1970, MIT acquired 74,500 square meters of property. The MIT then conducted a study to determine the needs of the base, given the Cambridge community's interest in housing development, and the process went through complex negotiations with the city and the community. In 1983, MIT chose Forest City Enterprise (FCE) as the developer of the base. In 1985, the city council appointed a planning committee, including representatives from MIT, FCE, and the Cambridge community. In 1987, the parties completed a master plan, which was approved by the city council in 1989. Changes due to the replanning of the Port Cambridge Industrial area, in 1992, included more parks and student quarters. Today, University Park is a mixed-use community with 37,000 square meters of residential use, 115,000 square meters of commercial use, a large biotechnology innovation center and high-quality public space and green space.

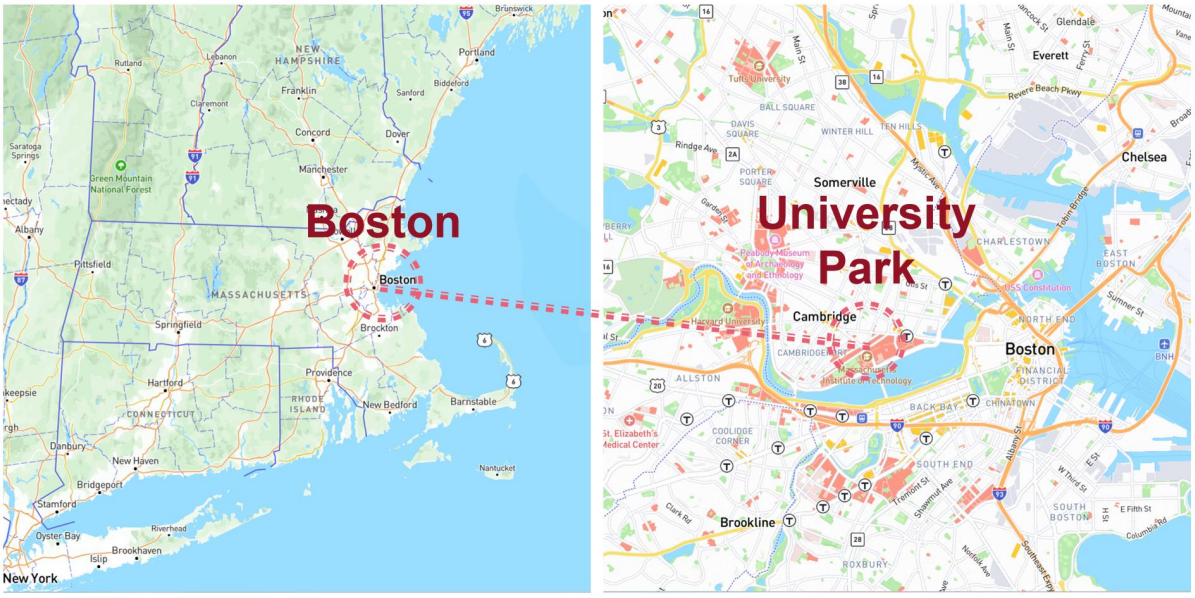


Fig 3-1: Location of University Park at MIT

Combined with the map of the MIT campus, we can see that the area around the MIT campus has academic property (academic property) and commercial property (commercial property) belonging to MIT, which are used for external use (external use), or for both internal and external services. According to the chronological order of the construction, ring MIT campus built in turn built the Technology Square (1959), Kendall Square (1968), University Park (1983) several innovation districts, the three districts to help Cambridge set up the identity of the innovation area, attracted innovators settled in campus near the Massachusetts institute of technology, increased the density of the city function, help to guide the flow of incentives, eventually promote the acceleration of innovation atmosphere.

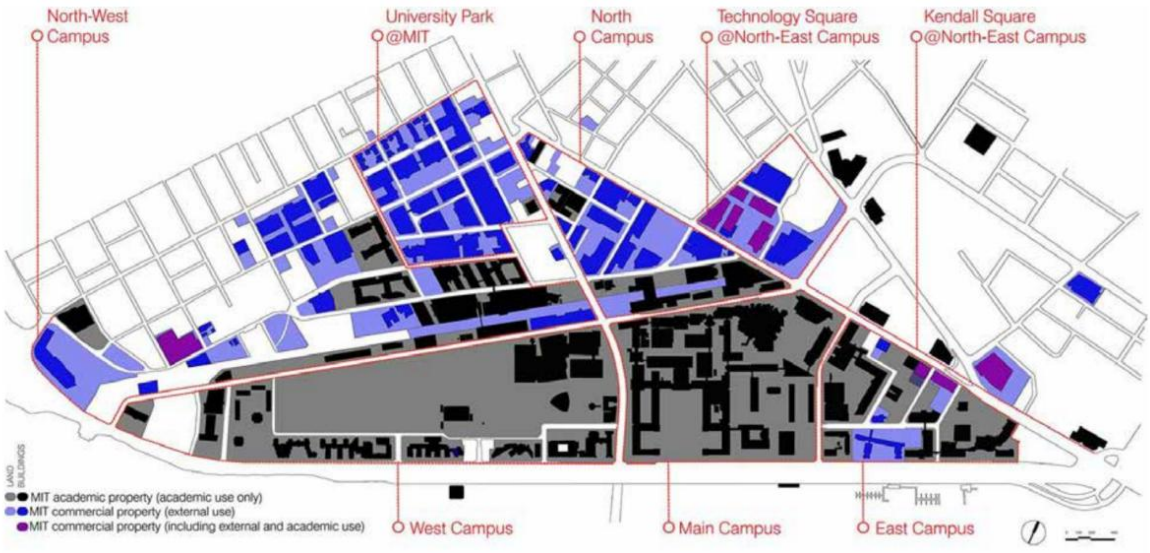


Fig 3-2: MIT Campus in two types of properties and seven main development or planning zones recognized over the years[79]

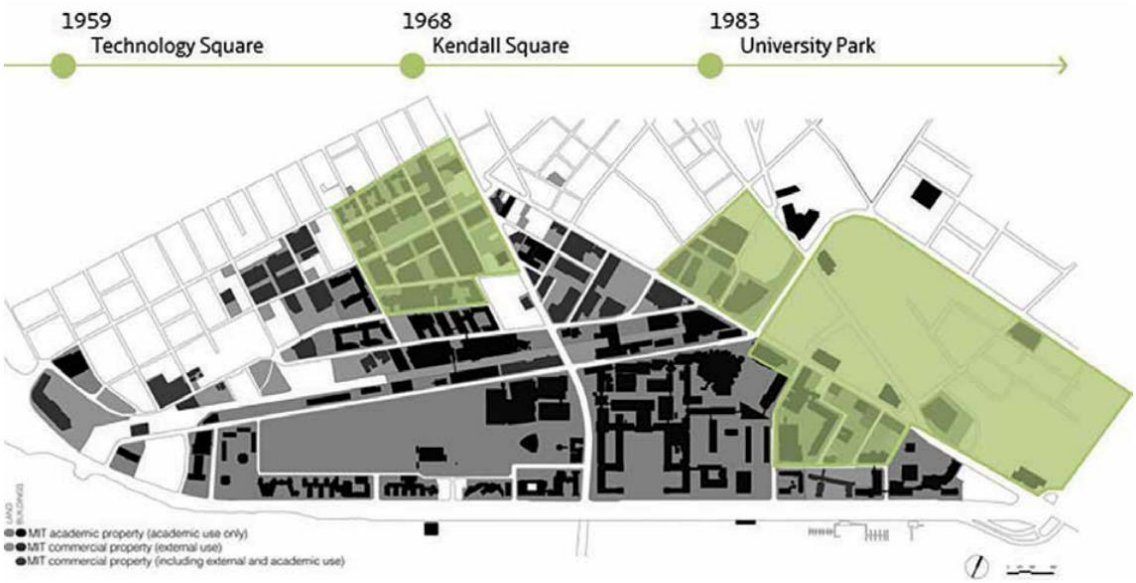


Fig 3-3: Location of urban areas developed by MIT in collaboration with public and private partners since 1959[72]

3.1.2. Spatial relationship with campus

MIT campus touches University Park space, which is separated by a street but with similar quality and continuous texture blurred the physical boundary between the two. The district is a campus-dominated construction mode, which relies on the knowledge spillover of MIT and its scientific research institutions, the driving role of school-run enterprises, and the entrepreneurship of university talents. In this model, MIT plays a crucial role, and the integration of the park and the community further expands the energy level and advantages of innovation.

Fig 3-4: Relation with MIT campus

Fig 3-5: Birdview from University Park to MIT

The surrounding area of MIT is an area full of innovation vitality, gathering many innovation subjects. Through the analysis of the innovation subjects in the MIT area, we can see that the surrounding areas are mainly technology giants in biomedicine, energy, information technology (IT), as well as venture capital and private equity investment institutions, which have the characteristics of leading technology, strong sense of innovation, rapid iteration and high risk.There are also a large number of startups and incubators around MIT, which are often founded by MIT students, faculty, or alumni, covering various industries and fields. Incubators provide office space, mentor guidance, resource support, and investment opportunities to help them develop from the concept stage to businesses with commercial potential. In addition, many laboratories and research institutions are also one of the characteristics of the region. These institutions and laboratories are committed to promoting scientific research and technological innovation, and conducting cutting-edge

academic and applied research. They work with MIT on collaborative research projects, share knowledge and resources, and provide technical support and expertise for innovation activities. Innovation subjects and MIT have jointly formed an innovation ecosystem with innovation vitality, high degree of commercialization and close communication, thus enhancing the comprehensive competitiveness of the whole region.

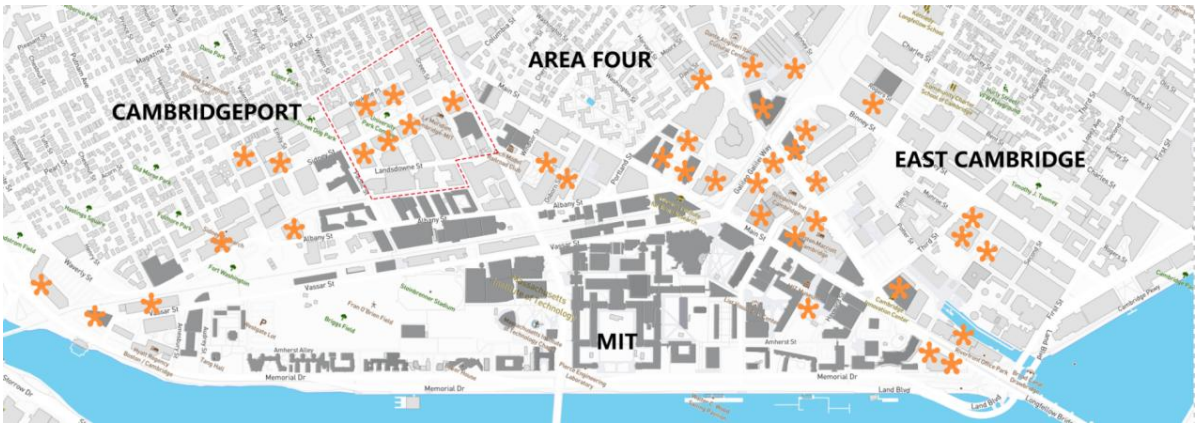


Fig 3-6: Innovation subjects around MIT

3.1.3. District characteristics

3.1.3.1. Transportation Traffic

The main modes of transportation on the MIT campus are the technology shuttle bus (Tech shuttle bus) and the bicycle (Bicycle). As the span of the school complex is very large in the southwest-northeast direction, the bus plays the role of connecting the main campus, east campus, west campus and northwest campus, shortening the commuting time on campus. The network of bicycle facilities radiates to the surrounding MIT, plays a role of connecting the campus with the surrounding parks and communities, and provides convenient transportation options for the close flow of students, teaching staff and residents.

Fig 3-7: Bike infrastructure in MIT campus and route of Tech Shuttle[79]

From the perspective of road planning, roads in University Park at MIT are designed to improve the connectivity of slow traffic and interior. Road sections of different levels are different: the main road has independent bus lanes or bicycle lanes, forming a coherent traffic network, and the wide sidewalk design ensures the smooth and safe pedestrian traffic. By setting up one-way loop and S-shaped road, the branch road can not only effectively manage traffic flow, improve traffic efficiency, but also reduce the number and speed of motor vehicles. Pedestrian branch roads restrict the access of motor vehicles through landscape design, with spacious sidewalks, smooth pavement, and rich street furniture and lighting facilities. At the same time, the old building is converted into a parking building in the area, which provides a lot of parking space, improves the utilization efficiency of the land, and enhances the beauty of the district landscape.

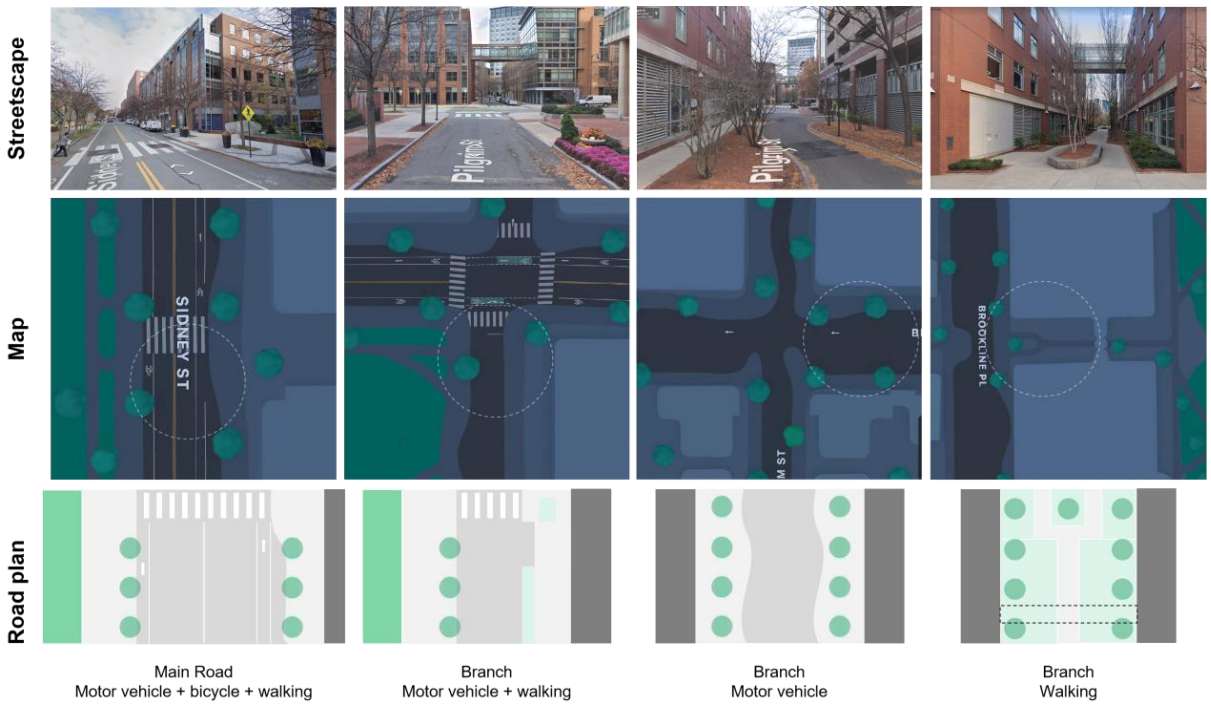


Fig 3-8: Road in University Park

3.1.3.2. Public space

University Park Focus on creating diverse and dynamic public Spaces. The center of the district is an open green space, which is the continuation of industrial historical memory and an informal space for innovation activities. Perpendicular to the long side of the open green space is a pedestrian landscape corridor, forming a small open green space of different sizes between the buildings. The streets are designed to be a spacious, unobstructed and friendly pedestrian environment with a reasonable layout that provides a good traffic flow for pedestrians and vehicles. In addition, squares, courtyards and parks are also carefully designed and planned to meet the needs and activities of different groups of people.

From the Main Street sidewalk to the central park, the designers created physical height difference transitions and differences in landscape features. From the office building into the courtyard, the ground pavement difference and the furniture layout are limited and built to the site. The paving around the office building is usually made of solid, neat materials such as stone or masonry to provide a sense of professionalism and business. The courtyard area has more use of grass and flower beds to create a more natural and pleasant atmosphere. At the same time, the street furniture layout will also be adjusted according to the function and atmosphere of the area. For example, more leisure seats may be arranged near the office

building, while more outdoor tables and chairs may be set in the courtyard area. University Park The public space creates different landscapes and space feelings for people, and promotes the occurrence of various activities such as leisure, social interaction and work. The diversity of public spaces and the differences in layout also provide a variety of venues to meet the needs of different populations and needs, making University Park an active, pleasant and sustainable place.

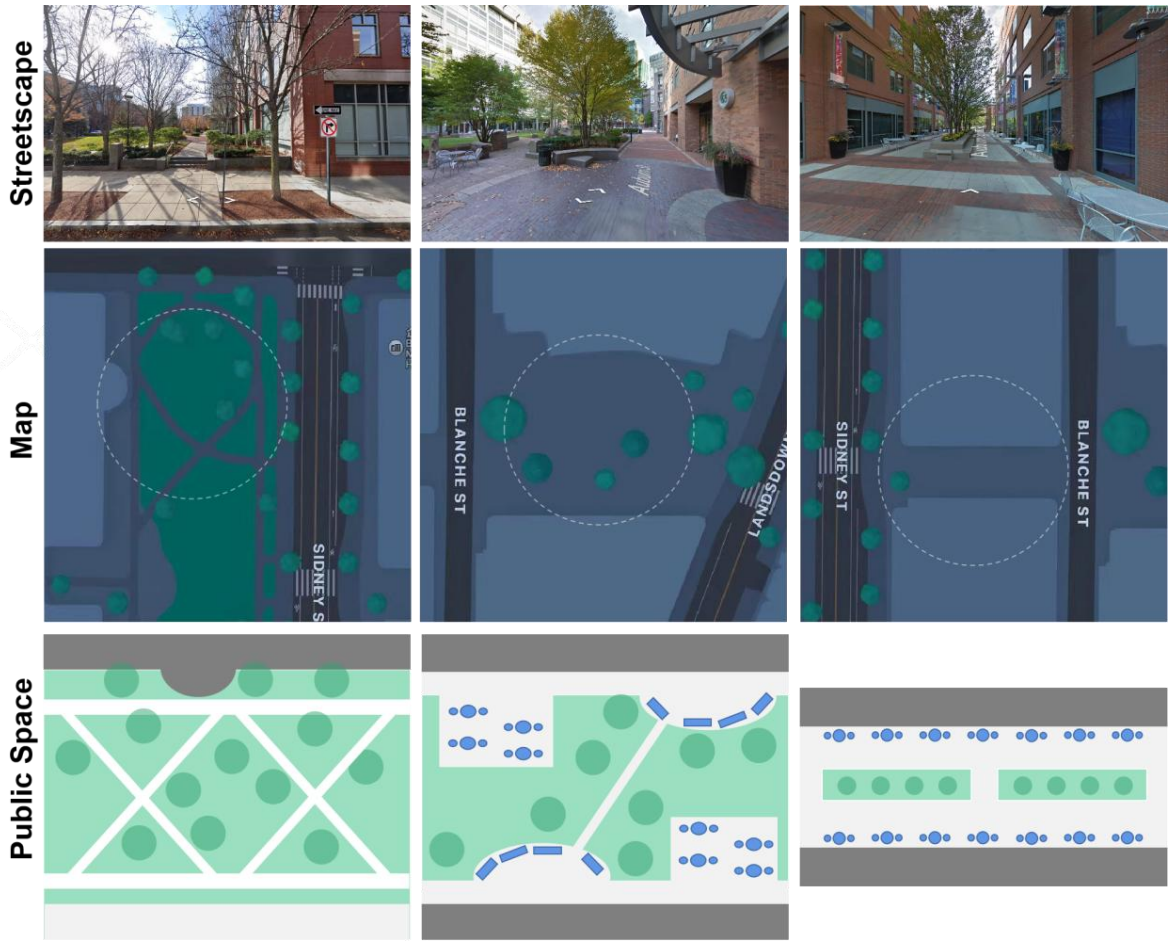


Fig 3-9: Open space in University Park

3.1.3.3. Mix-use

From the perspective of district planning, the district is mainly dominated by research-oriented buildings, with a large number of laboratory and office space, which is the spatial expression of MIT knowledge overflow. In the northeast, it is the residential function, and the multi-storey buildings have small volume, large building spacing and sufficient public space. There are three parking buildings on the edge of the district, which maximizes the area of the parking lot and improves the utilization rate of sustainable travel, providing

opportunities for high-quality walking space in the park.

Fig 3-10: Functional layout of University Park

From the perspective of architectural level, the architectural design of University Park mostly uses the ground floor for commercial retail, such as shops, restaurants, cafes, etc. This design encourages informal interaction and leisure. Above the ground floor, it is more than office space. These offices often adopt open office space and flexible layouts provide more opportunities for interaction and collaboration, encouraging people to share ideas, share knowledge and conduct innovation practices. Similarly, the parking building is connected with the surrounding buildings, which avoids long walking, shortens the time for motor vehicles to walk through the district, and provides people with comfortable and boundary traffic experience.

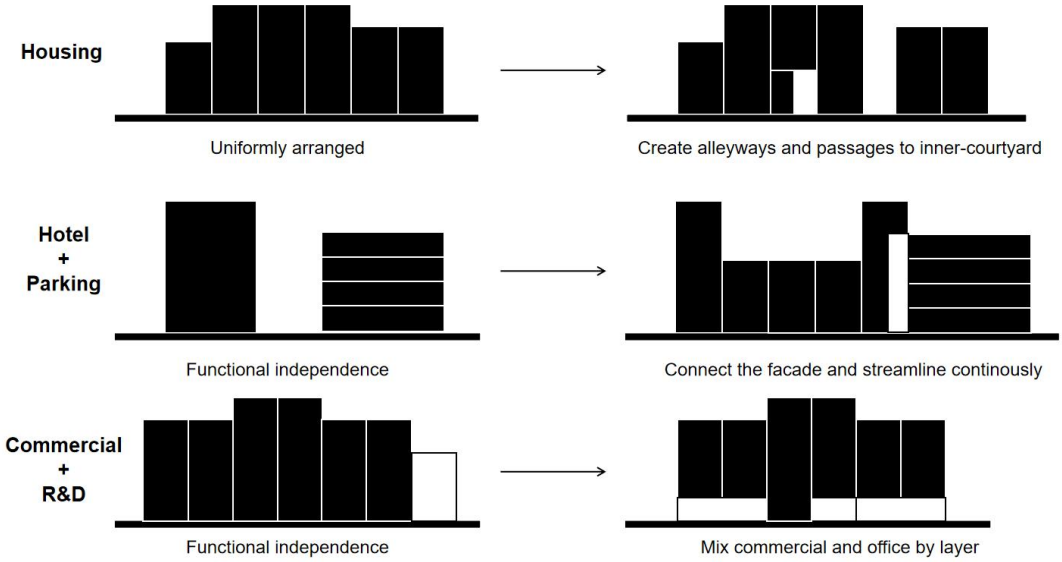


Fig 3-11: Mix of Fucntion in architecture

3.1.3.4. Building elements

Within the University Park, the buildings are designed to facilitate the occurrence of innovation. University Par k The architectural design with similar functions sometimes adopts the form of corridors, connecting the two buildings between the fourth and fifth floors. The interbuilding corridor provides a convenient corridor to easily move from building to building, creating a cross-departmental and interdisciplinary environment conducive to the occurrence of innovation and cross-field cooperation.

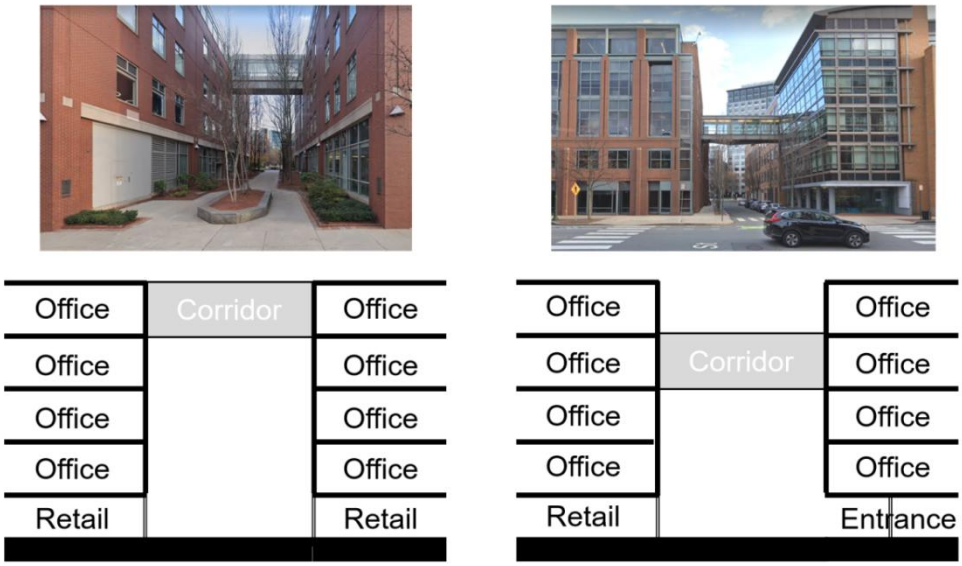


Fig 3-12: Typology of cooperative spatial connection in University Park

Another typical case that also facilitating innovation communication is Infinite Corridor on the MIT campus. It is a 25-meter-long corridor across the main building of the MIT campus. This double corridor is considered the spinal cord on campus because it is the most direct indoor route between the east and west areas of the campus. The corridor was designed as the central spine of the McLaughlin Building, which has been home to multiple MIT interdisciplinary laboratories, departments, and activities since 1916. The corridor has five floors, including the basement of the building, accessed through three different entrance halls, elevators, and many staircases. All of these elements in the Infinity Corridor system are spacious in space (such as high ceilings, spacious halls, and broad staircases).

In addition to the function of shortening the campus distance, the infinite corridor is also a main communication channel to arrange chance encounters. In the infinite corridors, people meet by chance and stop just to shake hands or share a little information. Similarly, people understand what happens on campus, because infinite corridors display information physically and electronically, hanging on the corridor walls. Eventually, people wander around the infinite corridor with the width changes of the corridors that allow for the placement of furniture that can serve as flexible workstations for the MIT community. Finally, this physical connector (physical connector) has a strong symbolic value to the MIT community, enhancing its identity in the field of innovation. For many years, this unlimited corridor has been a venue for research demonstrations, artwork, student hacking activities, and various events.

Fig 3-13: Layout and scenario of MIT Infinite Corridor[79]

3.1.3.5. Boundary typology

The MIT is functionally fused with the adjacent regions of the University Park. The campus boundaries are dominated by Educate, R & D and Office-commercial functions, while University Park has mixed state of office-commercial and residential-office. On the whole, the campus and the park are integrated with each other, and the innovation district is dominated by the campus for functional planning and development. From the perspective of spatial form, the architectural form difference between the campus and the park is small, the district is open, and the spatial quality is relatively close, which realizes the unity and integration of innovation space.

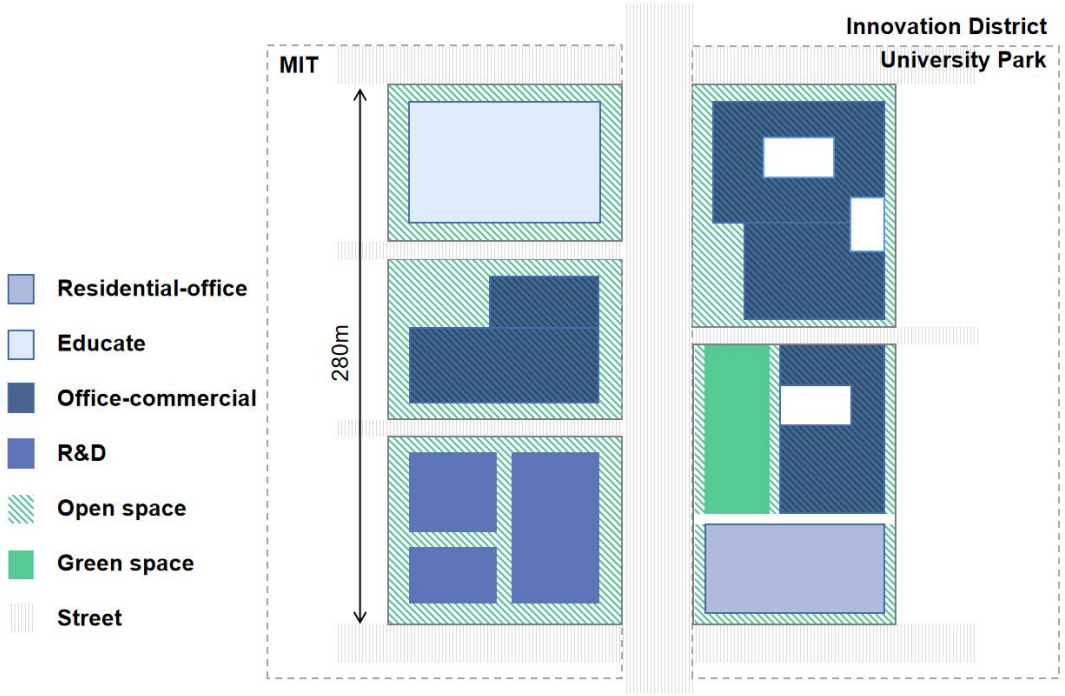


Fig 3-14: Boundary typology in between MIT and University Park

3.2. Georgia Institute of Technology & Tech Square

3.2.1. Introduction

Technology Square, commonly known as Technology Plaza, is a vibrant neighborhood spanning multiple districts in the center of Atlanta, Georgia, USA. Georgia Tech was founded to expand the industrial knowledge base, skills, and capabilities of Georgia. The period of reconstruction after the American Civil War (1860-1865) clearly showed that the southern

agricultural states needed to establish the capacity to produce technical and scientific knowledge. Economic development, knowledge transfer, and commercialization are all consistent with the purpose of the construction of the college. The college was originally built in 1885, but it was gradually surrounded by the city. In the 20th century, a major highway built along the eastern edge of the campus became a major physical barrier for the campus to connect with the rest of the city. In the following decades, suburban flights and urban declined, while the university was isolated from surrounding cities.

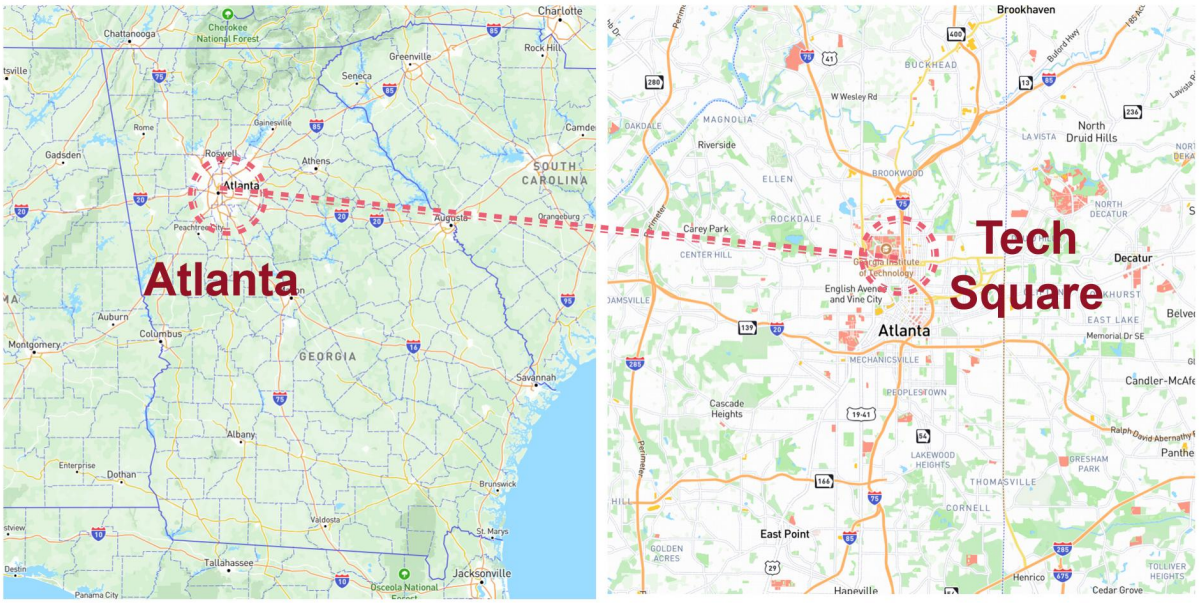


Fig 3-15: Location of Tech Square

The Innovation district in Georgia Tech Technology Square has a long history. Technology Square in Midtown Atlanta, originally a declining warehouse area. In the early 2000s, Georgia Tech saw the opportunity to redevelop the area as a hub for innovation and entrepreneurship. In 2003, then Georgia Tech worked with the Georgia government and the private sector to make the region a center of technological innovation and corporate development. The initial goal was to create an ecosystem that promotes academic research, innovation and entrepreneurship, and industrial collaboration. During the first five years, development work included the Technology Square Research Building and the Georgia Tech Hotel and Conference Center, and the business incubator —— Advanced Technology Development Center (ATDC). Tech Square Development was first focused on an area around the Georgia Tech campus to gradually build core facilities. The second phase of development includes the computer academy and invention studios, residential and retail space, etc.

Tech Square Committed to fostering and supporting the development of the entrepreneurial ecosystem. To this end, the region has incubators, accelerators and entrepreneurship centers, providing entrepreneurship training, resource support and business incubation services. These institutions work closely with academic research institutions, investors, and industry partners to provide resources and opportunities for entrepreneurs. As its influence expands, Tech Square has attracted many technology companies and research institutions to set up offices or research and development centers in the region. Tech Square The development has also led to the prosperity of the surrounding communities and the increase of cultural activities. The area features commercial, dining and recreational facilities, attracting students, entrepreneurs and residents to form a community with a vibrant and innovation atmosphere. Today, Tech Plaza is a thriving innovation and entrepreneurship center, home to a host of startups, enterprise innovation centers, and research facilities. Georgia Tech will continue to expand and develop the area, with plans to add residential and office space in the coming years.

Tech Square area, 2001　　Tech Square, today

Fig 3-16: Layout of Tech Square through the years

3.2.2. Spatial relationship with campus

Georgia Tech and Tech Square is an overlapping (overlaps) relationship. Georgia Tech is

developing to the east and has related academic assets in the Tech Square core. With the increase of Tech Square's influence, many enterprises enter and form a layout to north and south. Tech Square The construction of the campus scope of Georgia Institute of Technology has been expanded, teaching and research services have been expanded, and at the same time to build a bridge between school, enterprise, school and city, which is conducive to the diffusion of innovation knowledge. From the perspective of the construction mode, Tech Square belongs to the development mode jointly dominated by the campus and the park. The structure of the park and the campus is integrated, and the boundary between the site and the school is not clearly defined or perceived.

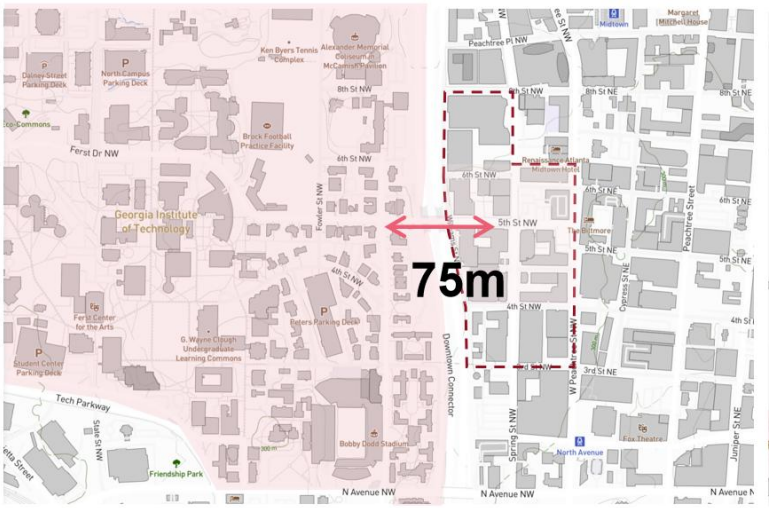


Fig 3-17: Relationship with Geogria Institue of Technology

Fig 3-18: Birdview from campus to Tech Square

Innovation resources are widely distributed in the innovation district. Tech Square There are many enterprise laboratories and technology centers (corporate lab and technology center) distributed within them, such as Anthem Innovation Studio, ATDC Fintech Program

sponsored by Worldpay, AT & T Foundry, Chick-fil-A Innovation Office, etc. There are also many corporate lab and technology center outside Tech Square several districts, such as Honeywell Software, Development Center, Flex Design Center, Stanley Black & Decker, Digital Accelerator, etc. Tech Square It is also the location of enterprise innovation, technology and headquarters, such as Anthem IT Center, Coca-Cola Company, Sage Software, Worldpay U.S. And Headquarters et al.

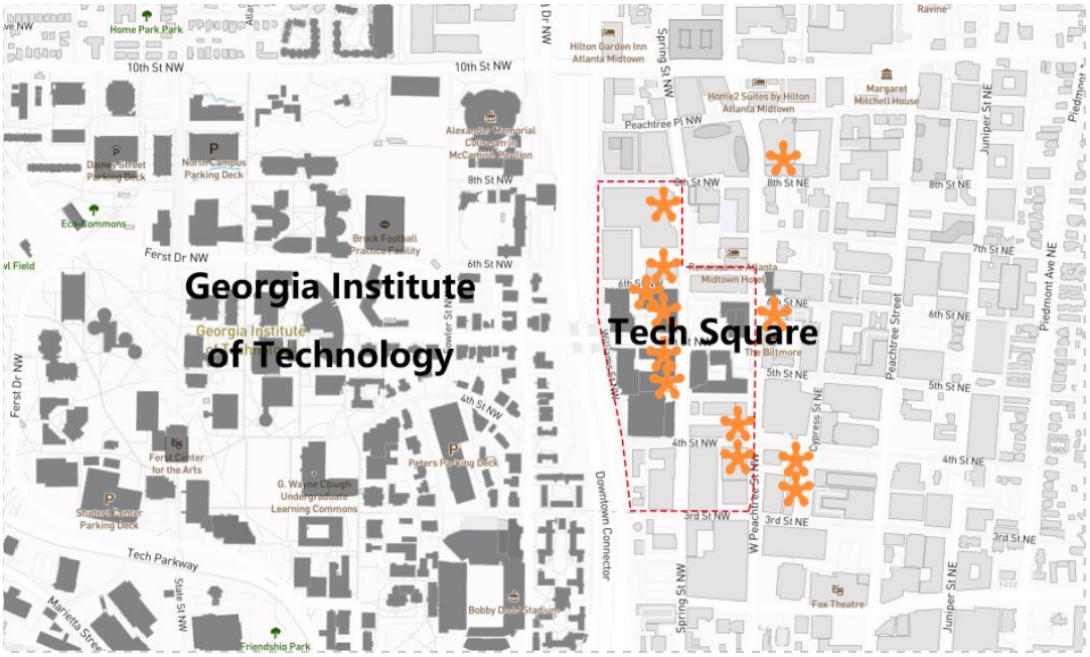


Fig 3-19: Distribution of innovation subjects in Tech Square

From the map, it is evident that the academic and research buildings of the Georgia Institute of Technology are spread throughout the city, comprising both traditional university campus structures and independent buildings situated outside the campus boundaries. However, it is in Tech Square where these buildings come together to form the core group, while another cluster can be found within a closed office park. Overall, the distribution can be categorized into Scattered Sites, Core, Campus, and Technology Subdivision.

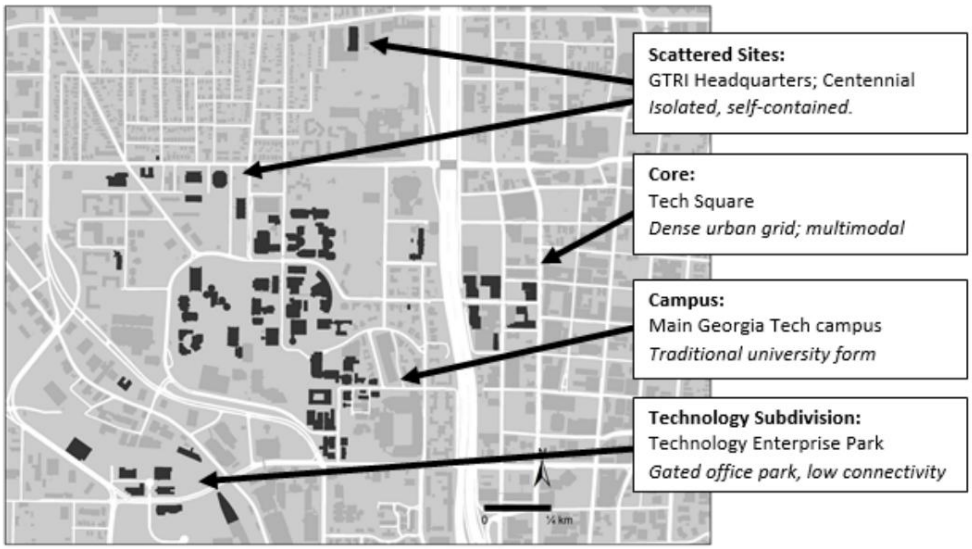


Fig 3-20: Map of all Georgia Tech academic and research buildings[87]

3.2.3. District characteristics

3.2.3.1. Functional Layout

While the leadership of the school institution (institution) drives the need for expansion, the final decision to expand the place is driven by a group of participants with extensive experience in private enterprises, so the functional layout shows the interests of the campus and the park. The Tech Square contains a portion of the Georgia Tech teaching buildings, and the Tech Square businesses are concentrated in the areas adjacent to the campus. Other areas within the Tech Square are private enterprises.

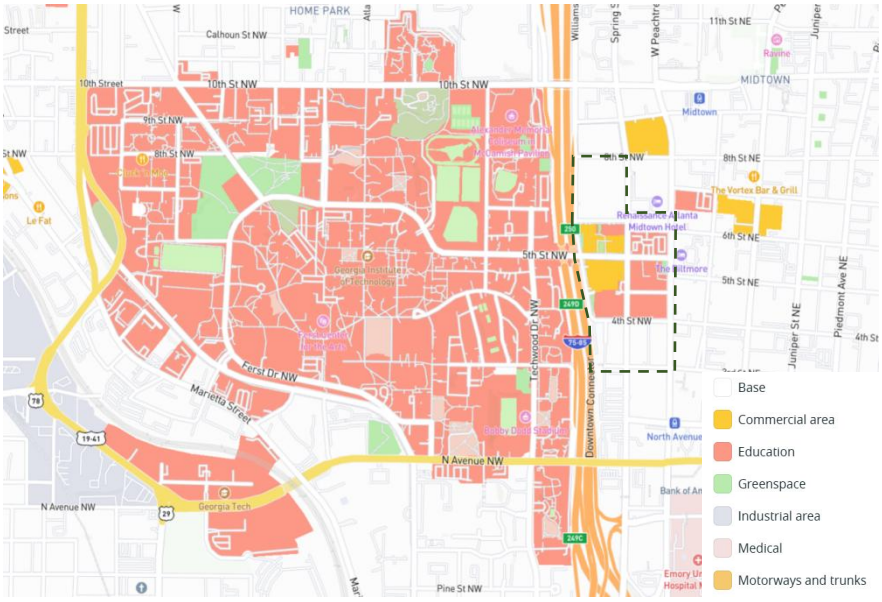


Fig 3-21: Functional layout of Geogria Tech and Tech Square

3.2.3.2. Slow transportation

In Tech Square, the roads in the east-west direction mostly consist of two-way lanes, while those in the north-south direction are predominantly one-way. The two-way lanes offer more versatility, featuring both pedestrian walkways and bicycle lanes, often complemented by linear landscaping with trees. Some roads have designated one-way bicycle lanes, while others may not have any at all. The pedestrian system is well-connected, with a priority for pedestrians, and the sidewalks include expanded waiting areas. The pedestrian spaces are harmoniously integrated with the ground-level commercial outdoor areas, street greenery, and street furniture. While covered spaces protecting against rain are relatively limited, the overall spatial quality remains high.

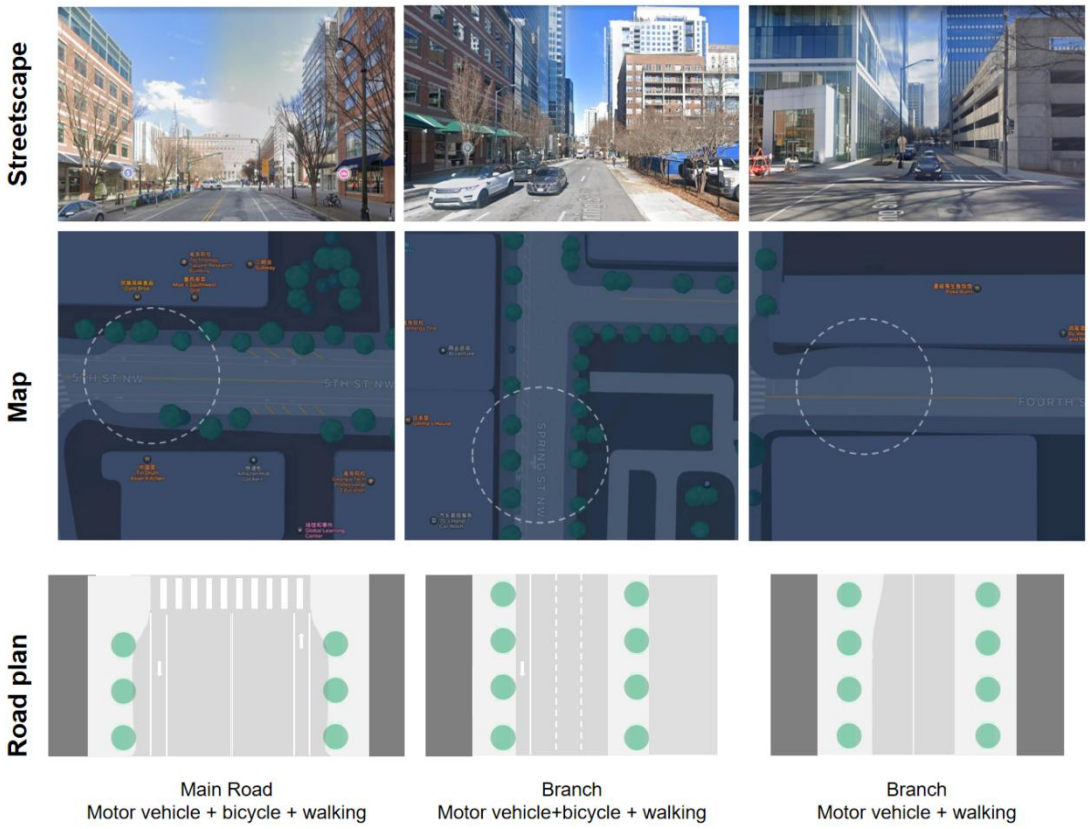


Fig 3-22: Transportation in Tech Square

Cycling serves as the primary mode of transportation, connecting the Georgia Institute of Technology campus with Tech Square traffic. This connection is achieved through a network of two-way bicycle lanes, facilitating the movement of teachers and students. This integration not only enhances teaching and research and development activities but also establishes an

ideal environment for innovation laboratories and entrepreneurship platforms, fostering students' future career development. Public transport operates in a loop within the campus and extends across the north-south highway to the eastern plot. Tech Square's bus routes are primarily located at the plot's periphery, focusing on north-south traffic while creating radial connections with the city. Fifth Street Plaza, situated over the highway, establishes a link between the campus and Tech Square. (Fig 3-23) This area, encompassing 5th St NW, is thoughtfully aligned with green spaces, providing an inviting location for leisure activities and creating a picturesque landscape with ornamental value.(Fig 3-24)

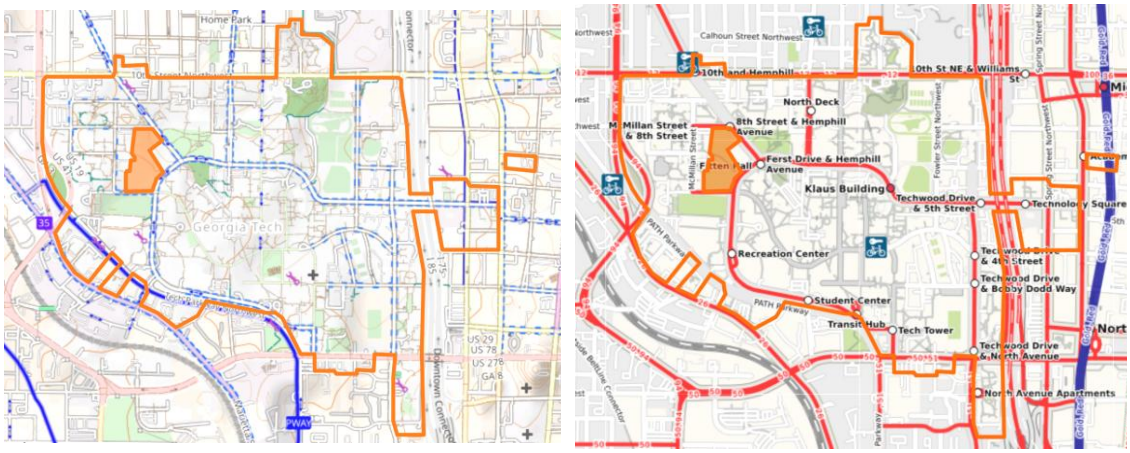


Fig 3-23: Bicycle and bus route around Georgia Tech

Fig 3-24: Fifth Street Plaza

3.2.3.3. Public space

Within Tech Square, there are no large standalone public spaces; instead, the main public spaces consist of open areas between buildings. Depending on the size of the area, these spaces are designed in different ways: linear entrances featuring greenery, landscape platforms combined with steps to create visual interest, leveling the site's height differences to form buffer zones for building entrances, or strategically placing resting corners facing building recesses. (Fig 3-25)

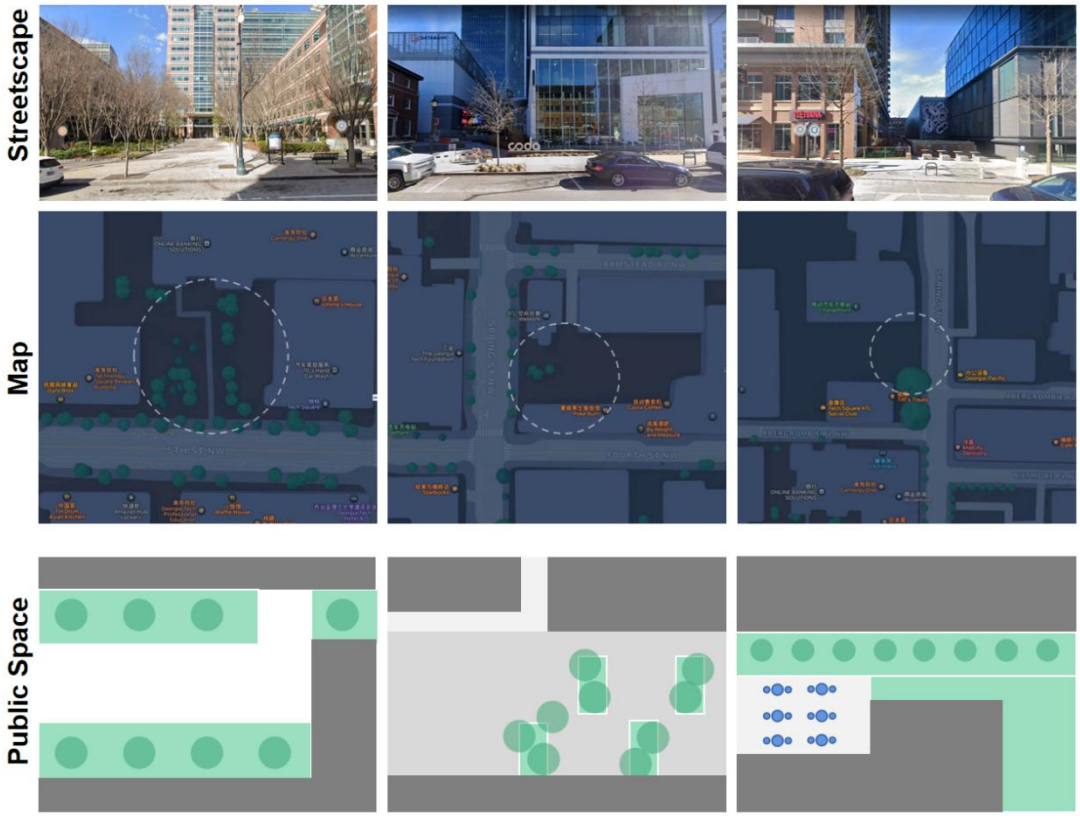


Fig 3-25: Public space in Tech Square

3.2.3.4. Mix-use

The Science and Technology Square primarily focuses on several functions, including residential-parking, research and development-parking, and business-research and development. The differentiation of these functions is adequately reflected in the facades of the buildings. This is achieved through distinct facade materials on different floors, prominent corner facades, and the incorporation of elevated levels. (Fig 3-26)

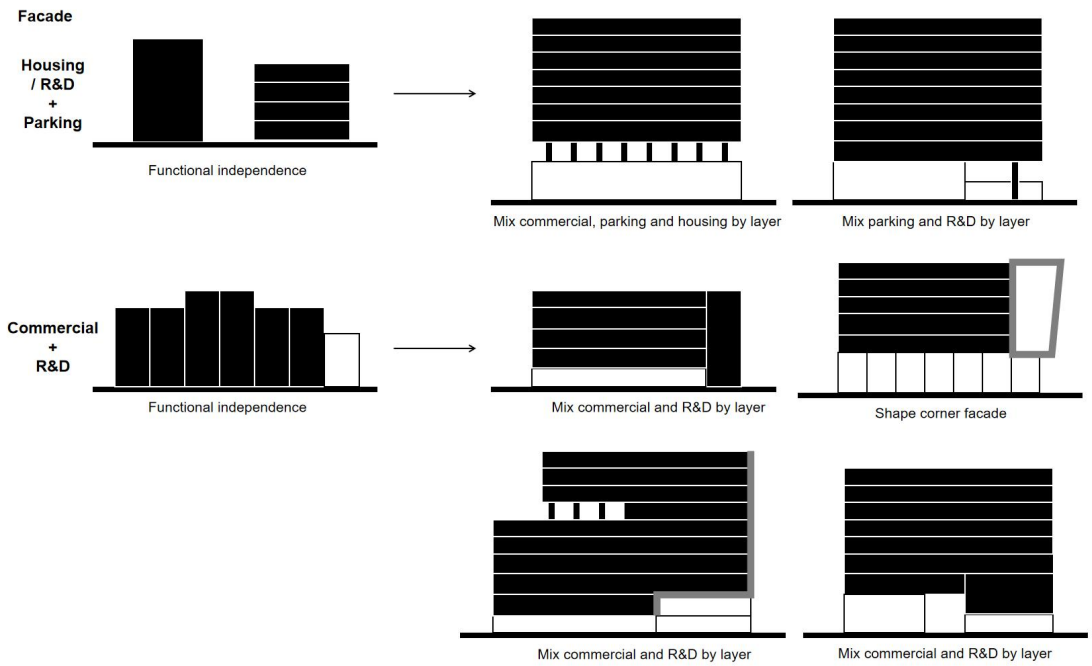


Fig 3-26: Mix-use and street facade

3.2.3.5. Building elements

Tech Square The communication between innovators is promoted by crossing the street and corridor and raising the ground floor. By setting up the street corridor on the ground floor, the movement obstacles caused by the blocking of the motor vehicle lane are eliminated, and the building space with closely related functions is continuous. For buildings with large side length, a flexible transition space is formed by setting up a local overhead layer, together with the bottom business. On the one hand, the local overhead makes the street facade recognizable. On the other hand, the overhead layer can become the entrance of the internal courtyard, the shared working area, the exhibition space, etc., which is conducive to the occurrence, display and communication of innovation activities.

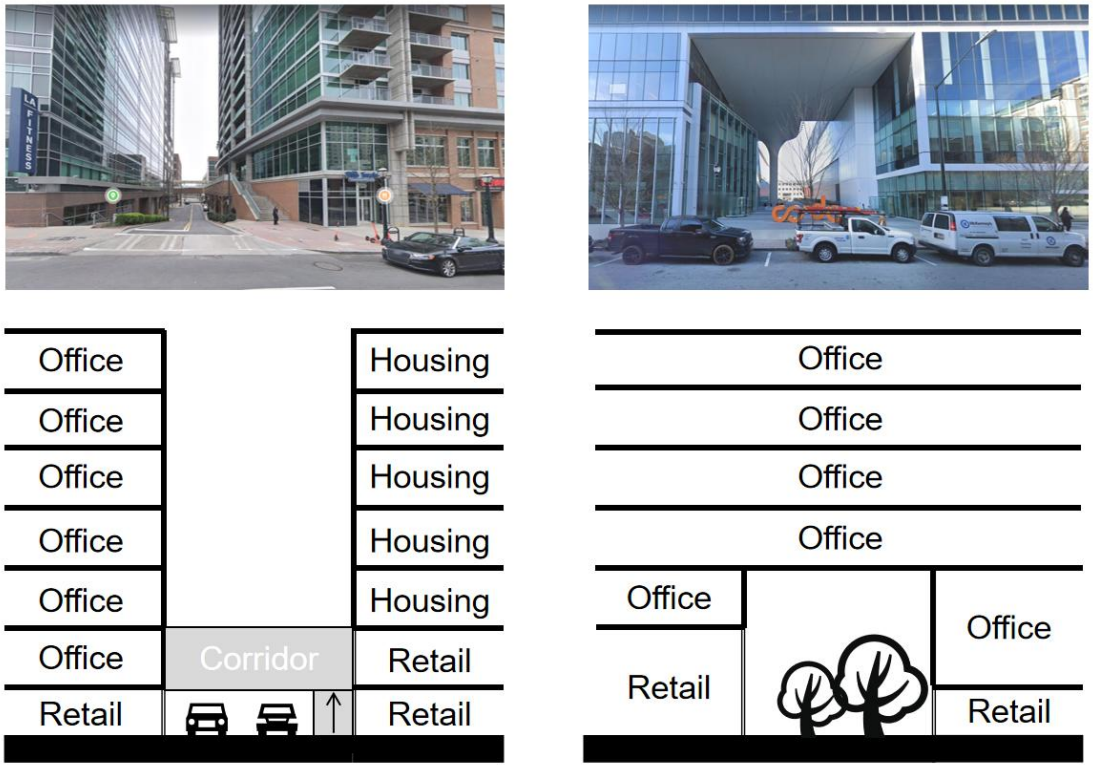


Fig 3-27: Typology of cooperative spatial connection in Tech Square

3.2.3.6. Boundary typology

Georgia Institution of Technology Is functionally complementary to the adjacent regions of the Tech Square. The campus boundary is dominated by the single teaching and residential functions, while the campus boundary is dominated by the mixed state of Educate-work-retail and live-work. On the whole, the campus and the park are independent of each other, and the innovation district takes the park for functional planning and development. From the perspective of space form, the building volume in the campus is small, and the layout is loose and flexible, while the building volume in the park is large, and the space use is more intensive. From the perspective of public space, there is a large area of green space and open space in the campus, while the park is driven by economic interests, and the configuration of greening only meets the rigid planning requirements.

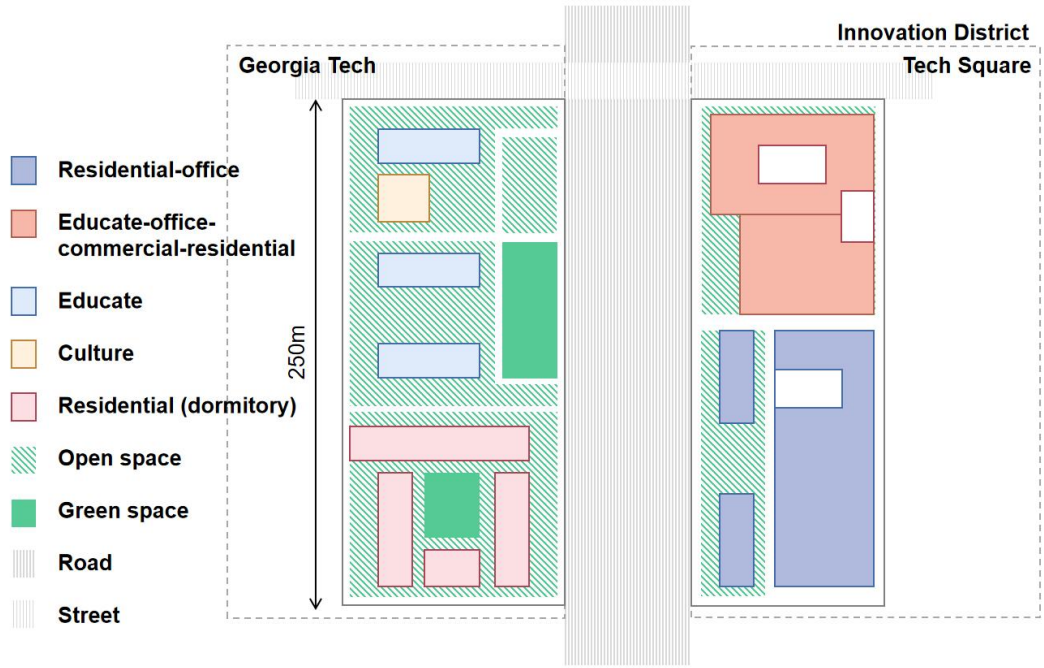


Fig 3-28: Boundary typology in between Geogria Tech and Tech Square

3.3. Fudan Univeristy, etc & KIC

3.3.1. Introduction

KIC is located in the core area of Wujiaochang City sub-center, Yangpu District, Shanghai, covering an area of about 840,000 m^2, The total construction area is about 1 million m^2. Shanghai creates heaven and earth is located in wujiaochang business circle core, close to fudan university, tongji university, Shanghai university of finance and economics, as the "three integration, linkage development" concept of benchmarking experiment project, under the cooperation of the government and developers, creates heaven and earth formed can attract, cultivate and retain the knowledge workers new knowledge community. As a typical case of open residential area planning, KIC takes the dense road network and small neighborhood as its concept, with compact space and mixed functions, showing a vibrant sense of public living place.

Fig 3-29: Location of KIC

The project is divided into four parts: Technology Park, University Village , The Hub, Stadium East. Among them, University Village is mainly residential, and a collection of multi-functional mixed areas such as office, retail, culture and entertainment. The case analysis object, as the overall planning and entrepreneurial office park, provides a comprehensive supporting community of "life, work and leisure". Chuangzhi Lane is divided into 7 blocks with an overall height of 6~7 floors. It is designed by different well-known firms at home and abroad. It is combined with multi-storey buildings and garden gardens, with rich and colorful facade and personality[80]. The district includes pure residential buildings, commercial offices and commercial and residential housing, as well as vibrant streets and street squares represented by University Road. It has also set up IPO Club in the workshop, which aims to provide a "general club" for entrepreneurs to gather, communicate and educate, and holds corresponding activities for a long time, which strongly supports the overall positioning of the creative community.

Fig 3-30: Masterplan of KIC[82]

Fig 3-31: Distribution of innovation subjects

Innovation institutions are mainly distributed in Technology Park, University Village and The Hub. Technology Park consists of twelve Grade A office buildings, Focus on the introduction of headquarters-level R & D and sales centers, mainly for multinational companies, Such as EMC, IBM, Oracle, and Easy Security Software, At the same time, the introduction of the United Nations South South Global Technology Exchange and Environment and Energy Exchange and other international institutions; Second, University Village is dominated by Class B office buildings and apartment-type office buildings, Focus on the introduction of entrepreneurial enterprises with independent intellectual property rights, Outsourcing service enterprises, etc.; Third is the Hub, mainly customized headquarters level company office building mainly; Fourth, the Stadium East, mainly in historic protected buildings, Build an important public activity center in the northeast area of Shanghai.

Taking KIC as an example, we can see the development process of innovation block construction mainly based on park development. Reviewing the history of Changezhi Lane development, it is closely related to the evolution of University Road. There are several important time nodes, which enhance the vitality of the innovation block. The Changezhi Lane was originally a residential and chaotic factory area in the 1980s and 1990s without a clear road network. In 2004, Songhu Road on the east side of the site was widened to ten lanes, and University Road also started with Songhu Road as the starting point. Since the completion of the first phase of Changezhi Lane in 2006, University Road is no longer directly connected with Songhu Road, and both are blocked by a piece of land to be built. The second phase of Changezhi Lane was completed in 2009 and extended to Guoding Road. The open district without walls was placed into the site as a new building type, creating a new street interface. In 2010, University Road upgraded the positioning of the bottom store to improve the commercial quality. The opening of Metro Line 10 in 2010 brought higher accessibility to University Road. In 2012, with the efforts of the developer, the transformation from the original one-way lane to two-way lane reduced the difficulty of leasing; the concept of open-air catering was approved by the government, which influenced the design of other roads in Yangpu District by enriching street activities[81].

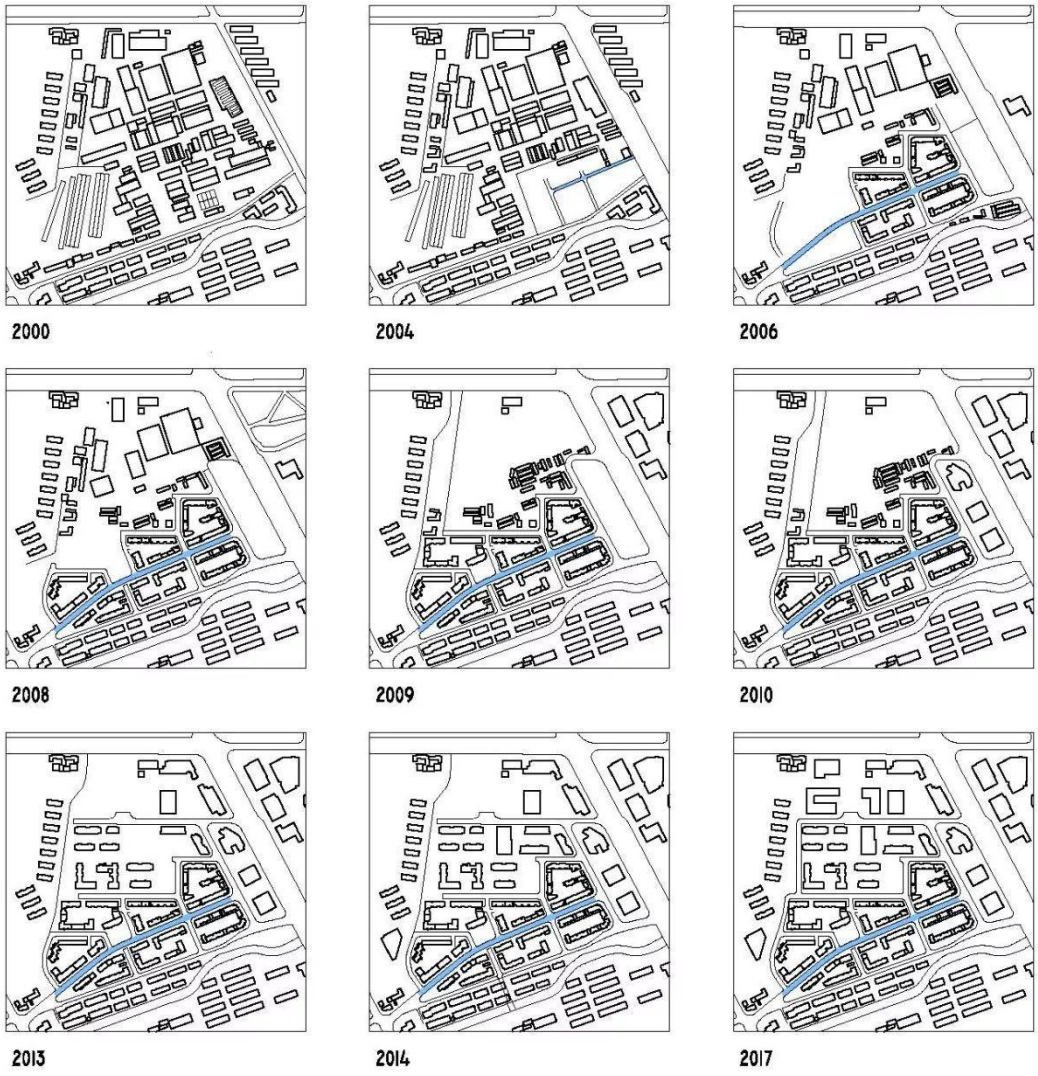


Fig 3-32: The texture evolution map of Chuangzhi Lane from 2000 to 2017[81]

3.3.2. Spatial relationship with campus

Fudan University and KIC is disjointed. As the core community in the central area of Yangpu District, KIC's development is dominated by developers and has certain independence. From the perspective of physical space, due to the barrier of rivers and roads, and the closure of the surrounding campus walls, there is only a geographical proximity between the campus and the park. With the help of university road lane widening construction, 10 subway line traffic and opening for the transformation of district business positioning, Chuangzhi Lane implements the functional diversity, traffic accessibility, facilities integrity, district openness, caused the campus innovation knowledge of spillover and innovation, promote the integration of campus and park.

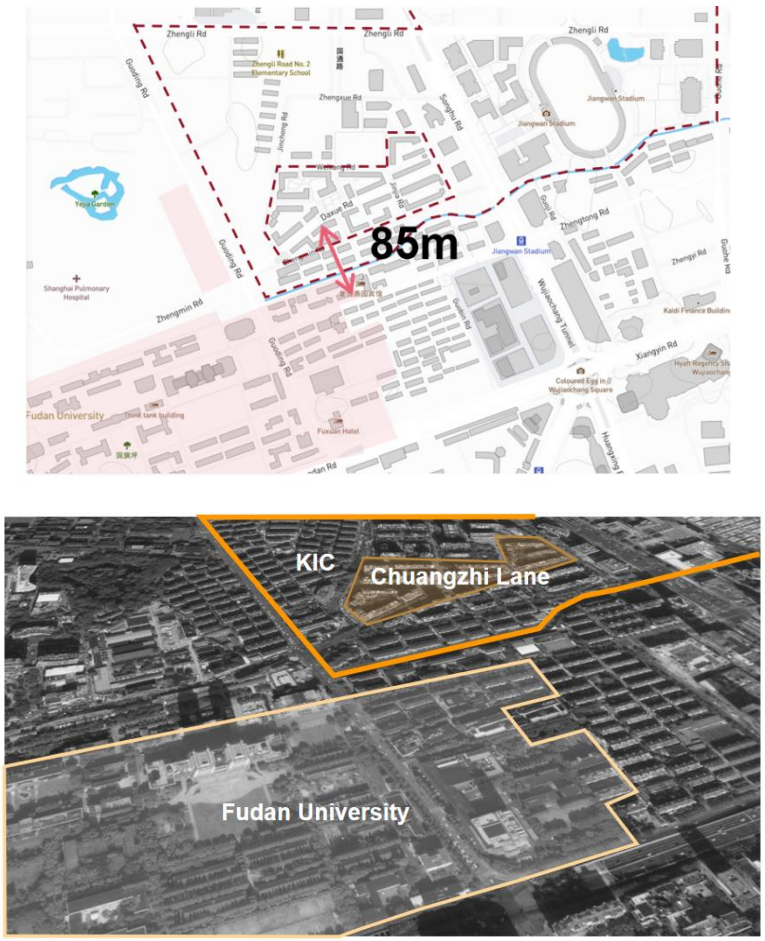


Fig 3-33: Realationship with campus

3.3.3. District characteristics

3.3.3.1. Mix-use

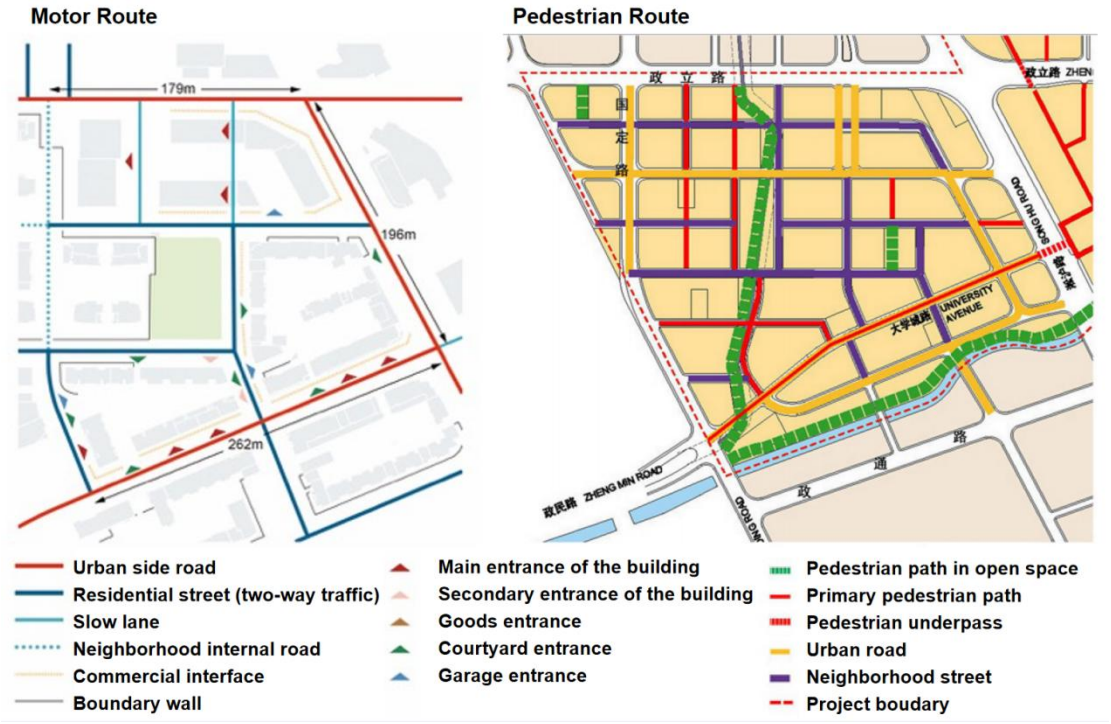
The district emphasizes the integration of work, study, residence and life, and pays attention to the multi-level functional composite. At the district level, it integrates different functional areas such as office research, living, business and leisure; at the neighborhood level, small plot development mode is adopted to accommodate various functions of symbiosis; at the building level, the public use along the street.

(a) (b)

Fig 3-34: Mix-use land use of Chuangzhi Lane schematics[80] and plans[82]

3.3.3.2. Slow transportation

KIC in Yangpu District of Shanghai is a model of mixed open districts with small scale and multiple functions. The regional road network density is 21.2 km / km² , the intersection spacing is 60 m~130 m (along the middle line of the road), the main roads are 28 m~37 m, and the branch roads are 24 m. Through the coordination of planning, design and operation, the community road mainly serves the land and parking in the road, the building along the street, the ground floor is mainly for commercial and other public purposes, office buildings, residential courtyards and basement entrances and exits are directly opened to the street, so as to build an orderly and dynamic open district.



(a) (b)

Fig 3-35: Transportation of KIC[80][82]

3.3.3.3. Public space

The public space system is composed of streets, courtyards and squares. Taking Chuangzhi Lane as an example, the buildings form the public space at the courtyard level, the building groups are arranged along the main street, and the enlarged open space in the main street to form the central node, forming the public space at the district level. The main street is rich in external pendulum space, gathering important activities, and the important squares of the surrounding blocks are connected to form a complete spatial structure.

Fig 3-36: Scence of open space in Chuangzhi Lane[80][82]

3.3.3.4. Building elements

Along the university road on both sides of the wisdom fang, keep the residential building appearance, and with the use of SOHO mode diversity function, relying on the road, with very high interface discount rate along the street, build the underlying continuous commercial space scene, and upstairs space can also continue business function, if do business can also be used as an apartment, or for the start-up individual, can also be used for office. With two rows of apartment buildings along the street, various functions give University Road to create infinite possibilities. The design strategy of vertical business format also makes University Road the birthplace of innovation and creativity in the whole area.

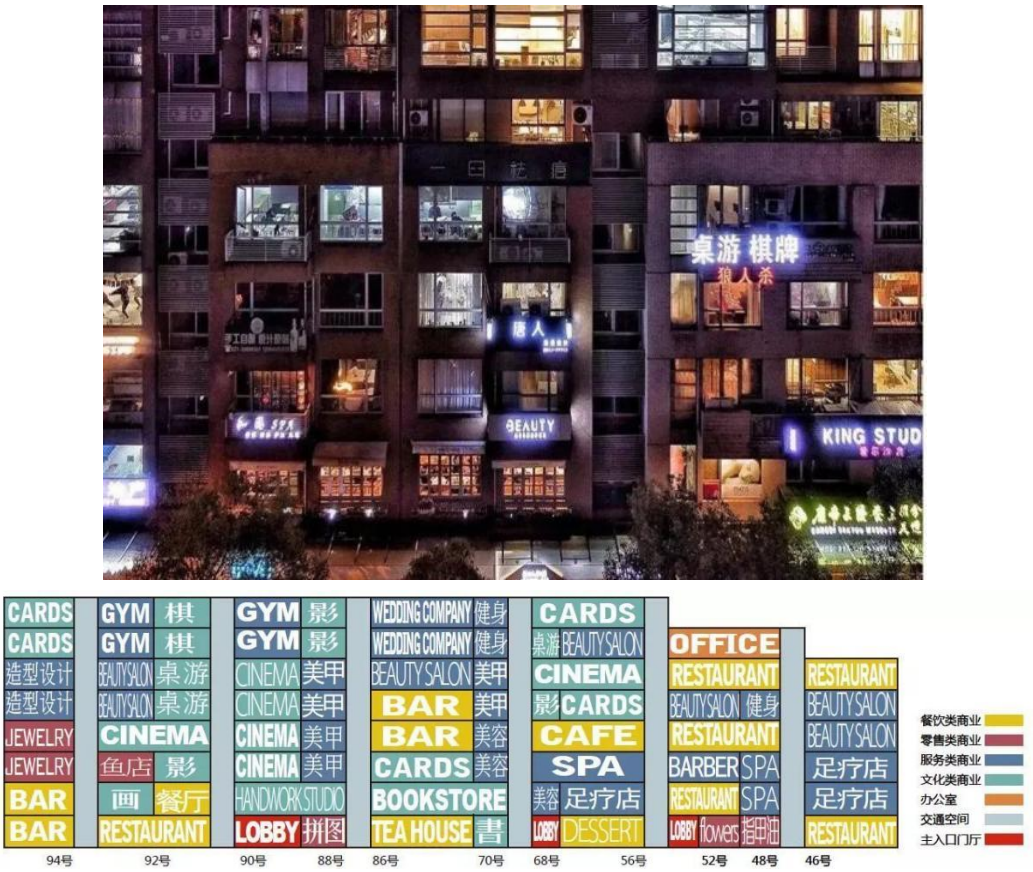


Fig 3-37: Function mix by layer in Chuangzhi Lane[81]

3.3.3.5. Boundary typology

KIC is adjacent to several universities, using Fudan University for example, their adjacent regions are functionally fused. The campus boundary is dominated by Educate and Residential functions, while the campus boundary is dominated by the mixed state of Residential-office-commercial, between the campus and the park is the community, mainly residential. In the context of open districts, the communication and cooperation between different institutions, organizations and individuals within the campus, the park and the community are fully stimulated, and the district becomes a place for sharing knowledge and exchanging resources. This open environment helps to promote innovation, entrepreneurship, and interdisciplinary collaboration. At the same time, a harmonious cultural and social atmosphere has been formed in the Innovation Workshop. Multiple subjects in the region participate in and hold various cultural activities, community gatherings and art exhibitions, which promote the cohesion and sense of belonging of the community.

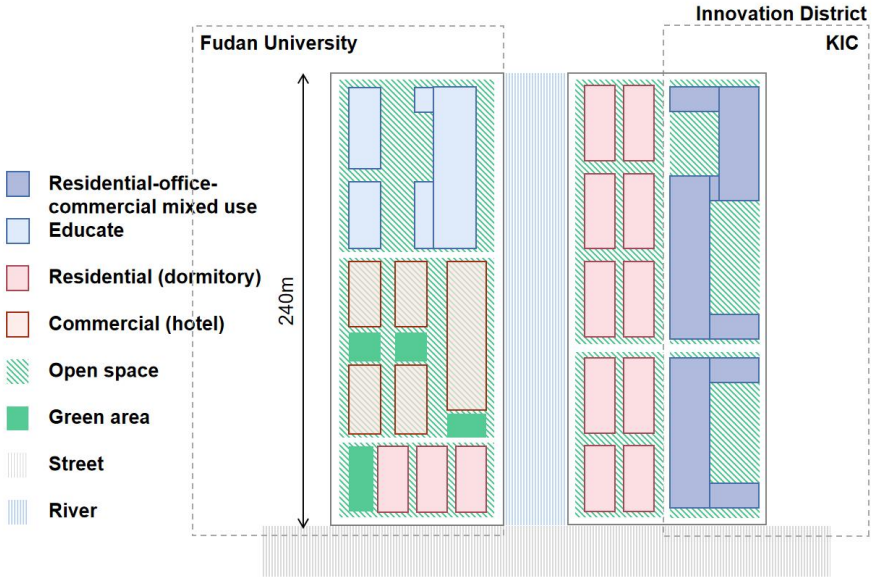


Fig 3-38: Boundary typology in between Fudan University and Chuangzhi Lane

3.4. Summary

In general, the reason why universities can participate in the construction of innovation districts as anchored institution to promote urban regeneration is due to the following characteristics: (1)Educational and research functions: Universities can facilitate the dissemination of industrial knowledge and ideas in the city. (2)Knowledge-intensive industry: As knowledge-based institutions, universities can help establish a multidisciplinary knowledge background, facilitating effective communication and coordination among various industries. (3)Influential voice: Universities possess certain influence and capabilities to challenge and coordinate existing local interests. (4)Communication bridge: Universities serve as excellent communication bridges, fostering effective channels for engagement with city public institutions, residents, and open-minded individuals. (5)Abundant policy and knowledge resources: Universities can seek favorable policy assistance and possess abundant knowledge resources, which can motivate and mobilize the enthusiasm of entrepreneurs. (6)Unique cultural exchange and educational atmosphere: Universities can promote urban training and exchange through their distinct cultural exchange and educational environment.

Through the in-depth analysis of the three cases, it becomes evident that the design of "Anchor+" innovation districts requires tailored approaches to fully utilize their spatial advantages in knowledge spillover, functional complementarity, and community integration.

Each case demonstrates different priorities, and by implementing measures that suit the local context, the districts can maximize their potential.

The innovation district anchored by MIT showcases effective knowledge spillover and spatial characteristics in the boundary space between the campus and the innovation district. The distinction between the two is blurred, and the adjacent public space is of high quality. The campus strategically places teaching buildings alongside office and research buildings, while the innovation district focuses on mixed functions like work-retail and live-work. This setup facilitates formal and informal scientific research cooperation, as both internal and external research groups possess similar or complementary resources. The open district, complemented by high-quality public spaces and retail businesses, injects vibrancy into the area.

Georgia Tech University's innovation district demonstrates the enclave's development potential in the boundary space of the school city, highlighting the significance of well-designed functional planning in promoting the complementary advantages of innovation subjects. The district serves as an extension of the campus construction while integrating into the urban area. By incorporating commercial development planning, space utilization is optimized, catering to market demands. The existence of multifunctional buildings that house educational, working, retail, and hub facilities serves as evidence of the district's success.

Furthermore, Fudan University and its anchored innovation districts exemplify the richness of spatial levels with the presence of campus, community, and park zones in the boundary space of the university city. The community and the functional complex buildings in the park provide diverse innovation space carriers for creative groups and research organizations to engage in exchange and collaboration. Additionally, the complex space construction of the community and the "live-work-retail" concept in the park create a rich third space, offering shopping and leisure opportunities for innovation-focused individuals within the campus.

These cases reveal how innovation districts, through the involvement of universities, establish a foundation for creating innovative spaces. They serve as valuable references for extracting design strategies and offer insights for urban planning and innovative space design.

Chapter 4 Regeneration strategies

4.1. Industrial regeneration

4.1.1. Gather and Cultivate innovation enterprises

Universities are academic and talent development centers. As anchored institutions, university-led innovation districts serve as high-impact areas for entrepreneurial clusters. The Tech Square innovation district in Atlanta is an example where the government guided the establishment of the Advanced Technology Development Center (ATDC), a business incubator affiliated with Georgia Tech University, within a privately developed area. This facility provides startup facilities and services for small and medium-sized enterprises. Additionally, the Yamacraw Electronic Design Center was established as part of efforts to make the state a leader in high-bandwidth communication system design. It includes institutions, commercial design technology demonstration studios, application research and development laboratories, and incubators and office spaces for industry representatives, aiming to facilitate technology exchange among enterprises. In the case of MIT's University Park innovation district, the focus is on fostering connections between innovation centers, laboratories, and startups in fields such as artificial intelligence, robotics, biomedicine, and energy. The district serves as a platform for physical space integration and resource exchange to facilitate technology development and innovation activities. University Park also engages in collaborations, licensing, and technology transfer to support businesses in achieving innovation and commercial success.

4.1.2. Stimulate knowledge spillover from “Anchor+”

"Anchor+" is the core engine driving innovation development and stimulating the spill-over of technology and knowledge, thus generating sustainable innovation capabilities. The University Park innovation district is jointly developed by local universities such as MIT, Harvard University, University of Massachusetts, research institutions like MIT Lincoln Laboratory, and technology companies including Microsoft, GE, and Raytheon. This collaboration has created a rich innovation ecosystem within the district, showcasing

outstanding innovation performance in areas such as startup incubation, technology transfer, commercialization, and interdisciplinary collaboration.

The KIC, anchored by institutions like Fudan University and Tongji University, provides a diverse community activity environment through the presence of enterprises and merchants, attracting young talents to gather. The "Public Innovation Joint Laboratory," jointly established by Tongji University and KIC, serves as a venue for the dissemination of implicit knowledge in the community. It hosts regular Open Talk events, bringing together practitioners and researchers from various disciplines in academia to share diverse innovation perspectives. Residents have free access to different spaces for communication. Such spatial platforms provide opportunities for the integration of campuses, industrial parks, and communities. Moreover, the "Public Innovation Joint Laboratory" aims to enhance the integration of classroom design and practical application scenarios through collaboration with the community, thereby improving students' practical skills and the efficiency of innovation implementation.

Fig 4-1: Joint laboratory for public innovation

In addition, introducing "innovation anchors" has become an important tool for enhancing land development value and promoting urban revitalization in some innovation districts. Many influential research institutions have recognized that establishing branches or departments in these districts can drive their development and enhance their own value. By introducing research institutions, the districts strengthen local innovation capabilities and further aggregate small and medium-sized innovation enterprises. Therefore, the introduction of new "innovation anchors" creates a win-win situation for both the innovation district and the anchored institution.

Tech Square has attracted many technology companies and research institutions to establish offices or research centers in the area, spanning fields such as information technology, life sciences, artificial intelligence, and robotics. They collaborate with the

Georgia Institute of Technology on research projects, innovation initiatives, and talent development. The development of Tech Square has also stimulated the prosperity of surrounding communities and an increase in cultural activities. The area features commercial, dining, and entertainment facilities, attracting students, entrepreneurs, and residents to gather and create a vibrant and innovation community.

4.1.3. Establish open and shared innovation resources

Open and shared innovation resources support the growth of enterprises. In the early stages, the cost of entrepreneurship is a crucial factor. High equipment procurement costs increase risks and suppress entrepreneurial willingness. Additionally, they can lead to financial difficulties and lower the survival rate of businesses. Moreover, establishing open and shared innovation resources prevents resource wastage and duplication, improving the efficiency of research equipment utilization. By providing access to shared resources, multiple enterprises can benefit, reducing individual financial burdens and increasing overall efficiency. This collaborative approach fosters innovation and enhances the success prospects for startups and established businesses[24].

Promoting the open access of experimental resources and sharing innovative facilities is actively encouraged. A survey conducted in 2012 on research parks in North America revealed that 75% of these parks had dedicated laboratory facilities. Innovation districts in locations such as Cambridge, St. Louis, and Eindhoven have successfully developed and shared high-cost innovative technologies by adopting practices like shared workspaces, shared laboratories, and technology centers. These initiatives foster collaboration and enable organizations to leverage shared resources, reducing individual costs and enhancing the overall capacity for innovation.

4.2. Inclusive development

4.2.1. Attract more innovation talents

Talent is the foundation of innovation and vitality, and innovation districts in cities generally prioritize attracting innovation talent as a significant objective. Young people serve

as the guarantee for vitality and are also highly potential creative talent. Currently, establishing youth-friendly cities to provide better development opportunities and living environments for young people is a key part of many cities' talent policies.

Cultivate a diverse and inclusive cultural environment. Research by Richard Florida suggests that the creative class prefers inclusive cultures and diverse urban services[83]. From an innovation perspective, the spirit of adventurous entrepreneurship is closely related to efficient innovation output, and the acceptance of failure is a key factor in attracting innovation talent. The success of Silicon Valley has already proven this point. From a lifestyle perspective, innovation districts have been striving to incorporate diverse cultures into urban life. For example, KIC encourages nearby universities to host public art projects and integrate artistic creation into environmental quality improvements, promoting the integration of the creative class and the innovation district. This creates an attractive environment that meets the needs of the creative class and the younger generation.

4.2.2. Promote employment of local residents

Promoting innovation for the benefit of the public and facilitating upward mobility for local residents. While innovation districts attract a large number of high-skilled professionals, the majority of residents belong to the middle and lower-income groups. Encouraging the participation of the middle and lower-income groups in the innovation industry is an important way to improve their income levels and achieve inclusive development.

The majority of innovation districts promote inclusive development by strengthening employment training and facilitating widespread job opportunities. For example, in KIC, there is encouragement for universities and professional organizations to collaborate on general education, particularly targeting young people, to equip them with the necessary skills for relevant technical jobs or community engagement. In the case of Chattanooga, USA, they have integrated key cultural and educational initiatives such as local schools, public education foundations, public libraries, and technology centers with vocational training to maximize residents' employment capabilities[84]. Encouraging businesses to hire local residents is an additional measure to promote employment among the community. In the transformation of the 22@ Barcelona Innovation District in Spain, the government actively promotes the hiring,

training, and support of local residents in the innovation sector, providing low-income workers with more upward mobility in their career paths[85].

4.3. Institutional guarantee

4.3.1. Strengthen the fiscal and financial support

Financial and fiscal policies are typically important tools used by governments to promote the development and construction of innovation districts. They are primarily utilized to reduce startup costs for businesses, lower living expenses for residents, and encourage developer investment. For businesses, this is often achieved through tax exemptions and the establishment of innovation funds. Universities, particularly public ones, often rely on non-profit foundations to raise private and charitable funds to support their funding and operational needs[86]. In the case of Tech Square, the Georgia Tech Foundation played a crucial role by providing funding through tax-exempt bonds and gradually transferring facility ownership to the Georgia Institute of Technology. MIT University Park also benefits from its network assets, including angel investors, venture capital firms, and entrepreneurial mentors, which provide funding and resource support. Developers receive support from the government through mechanisms such as land acquisition rights, tax incentives, or direct subsidies, which enhance their motivation for development and construction.

4.3.2. Flexible control system for use of space

Flexible land use control measures are the fundamental support for spatial regeneration in innovative districts and an important means to promote their vitality. Innovative districts often involve the transformation of space usage, such as converting industrial spaces into innovative spaces or commercial spaces, and residential spaces into exhibition spaces or production spaces. Flexible land use control can facilitate the compatibility of functions in space. By assessing and determining compatible land uses, it can enhance the intensity of land use, achieve functional diversity, and improve service comprehensiveness. For example, the original purpose of a site like "Chuangzhi Lane" was industrial, but through development and assessment, it transformed into a compatible model primarily focused on mixed land use for

office, commercial, residential, and living purposes. In further spatial enhancement, developers, governments, and communities engage in long-term communication and cooperation, resulting in the addition of lanes on University Road and the establishment of commercial spaces outside the street, effectively increasing the spatial vitality of the district.

4.3.3. Promote space development through public-private cooperation

Promoting public-private collaboration and introducing market forces can accelerate the commercialization of innovation outcomes and shape the influence of innovation districts. After establishing the development vision for an innovation district, government entities can solicit opinions and proposals from the public through public participation and open bidding processes. Policy promotion can attract innovation subjects to participate in and contribute to the development of the district. Universities can collaborate with nonprofit organizations or social capital to determine the layout of innovation spaces that align with their development objectives and actively create conditions for knowledge spillover. Social capital, following market development principles and investment trends, can provide insights into investment opportunities and the distribution of business formats within the innovation district.

Georgia Tech University recognized the opportunity to redevelop old industrial areas into centers for innovation and entrepreneurship, leading to collaborations with the government of Georgia and the private sector. From the government's perspective, on one hand, policy promotion and support helped build confidence among universities and developers, while on the other hand, strategic planning guided the layout of industries, providing targeted incubation platforms for regional specialty industries. From the university's standpoint, the nonprofit organization Georgia Tech Foundation provided financial support for university development. By purchasing new land and establishing collaborations with the government and private sector, the foundation helped the university overcome limitations in space caused by highway barriers, facilitating the expansion of disciplinary development. From the perspective of private developers, the region offered policy incentives and was anchored by a prominent technical university, presenting excellent investment potential in terms of talent output, technology transfer, capital flow, and policy support for innovation. From the standpoint of nonprofit organizations, due to restrictions on the use of tax-exempt bonds for

for-profit bonds, private sector partners were needed to contribute to the commercial office and laboratory spaces, as well as ground-level retail spaces. By setting development requirements, the private portion was ensured to have the same scale and external design as the south side of the street, despite having different owners. Ultimately, through the collective efforts of all parties involved, the region was successfully transformed into a center for technological innovation and business development.

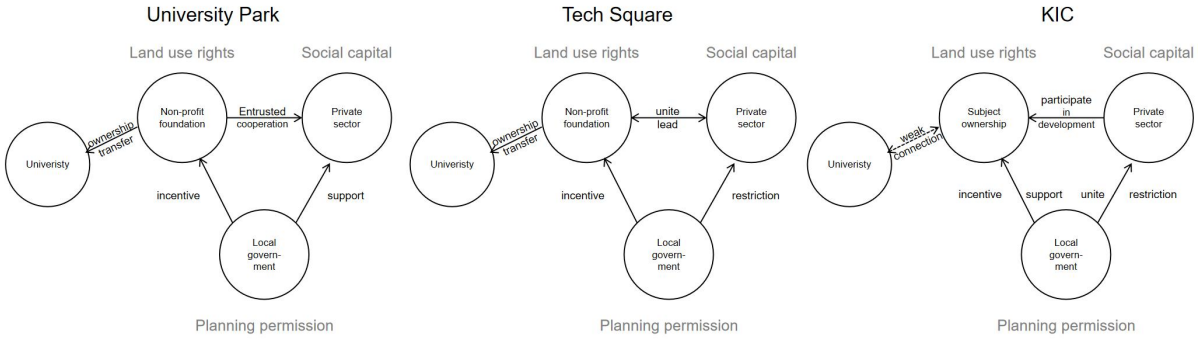


Fig 4-2: The development of innovation district with multi-subject participation

4.3.4. Promote the establishment of cooperation mechanisms

The collaborative development of innovation elements helps reshape places and establish an atmosphere of trust and collaboration. Enhancing innovation capabilities requires going beyond the boundaries of individual institutions and companies, surpassing existing collaboration frameworks, and encouraging innovative collaboration mechanisms and approaches. In the context of the original "Triple Helix" collaboration framework, excellent practices in innovation districts involve the inclusion of non-traditional participants or intermediary organizations to address the issues of insufficient development funds, limited positioning and assessment of academia, industry, and government, and the lack of diverse network resources. This inclusion is beneficial for establishing collaborative networks and promoting interdependent development among enterprises.

In the development of Tech Square, the following roles can be identified: the Georgia Tech Foundation, which raises private and philanthropic funds for the university's development; the university's funding foundation, which conceptualizes, plans, and finances major capital projects; the Georgia Research Alliance, which recruits top scientists and invests in research technology; the Downtown Alliance, representing downtown Atlanta property

owners and businesses; and alumni such as Kim King, who played multiple roles during the development of Tech Square, including real estate developer, board member of the Georgia Tech Foundation, and campaign chairman for the Governor of Georgia, making significant contributions to the development of Tech Square[87].

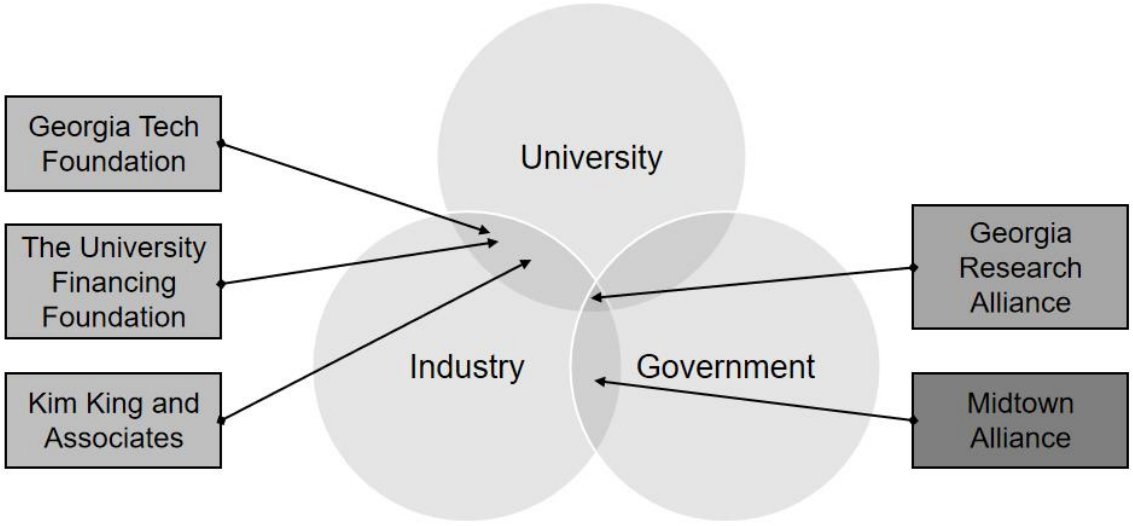


Fig 4-3: Conceptual model of traditional Triple Helix actors and overlap of non-traditional actors[87]

In China, while there might not be alumni foundations engaged in land buying, selling, and market operations, local governments can utilize policies like "land development" to carry out comprehensive transformations and operations through unified property rights. Big cities in China can draw lessons from Shenzhen's "neighborhood development model," which involves integrated development or one-time transformation of communities and parks adjacent to universities. This can create a demonstration base for scientific and technological innovation and technology transfer, providing startups with beautiful and affordable office spaces, thereby enhancing innovation vitality. Alternatively, market-driven transformation can be introduced to offer startups diverse office environments, ultimately transforming the innovation street into a multifunctional environment for the coordinated development of campuses, parks, and communities.

4.4. Space and facilities updated

4.4.1. Focus on different scale of innovation space

The innovation district belongs to the district scale of the innovation space system and is closely related to the innovation buildings and the innovation urban . It lays the foundation for the construction of innovation region.

In recent years, innovation complexes formed through a combination of buildings have also become a new trend. The former, such as the research institution buildings in MIT University Park, have relatively singular functions and forms. The latter may be interconnected through skywalks or share some communication, learning, and recreational spaces, ultimately achieving a mixture of different functions, including incubation, prototyping, showcasing, and venture capital. For example, the world-renowned High Tech Campus Eindhoven in the Netherlands has numerous interconnected buildings within the campus to enhance communication and collaboration among companies.

In terms of form, innovation spaces at the district scale often exhibit the characteristic of "boundaryless," meaning that there are no distinct geographical boundaries for the innovation spaces. Instead, they integrate with the districts and communities within the city. Examples include MIT University Park and Kendall Square in Boston. Additionally, innovation spaces at this scale often lack explicit spatial structures. innovation subjects, such as enterprises, typically revolve around innovation sources like universities and research institutes, with layouts centered around main streets or public spaces.As an important functional area supporting urban and regional innovation development, innovation spaces at the regional scale, known as Innovation Urban Areas, are typically a significant component of urban innovation hub systems. They often exhibit a "clustered" spatial form as a whole. In terms of spatial structure, innovation spaces at the regional scale often exhibit a clustered layout, such as the Peri-Tongji Innovation Economic Circle and the Peri-Wushan Innovation Urban Area.

The morphology of innovation spaces at the regional scale, known as Innovation Regions, often varies based on different types of innovation spaces. For example, in the case of intercity innovation corridors, which are a type of innovation region, the layout of innovation

resources is typically along major transportation corridors. As a result, they generally exhibit a "linear" spatial form as a whole. In terms of spatial structure, innovation spaces at the regional scale often display a "polycentric, networked" layout characteristic. This means that multiple innovation centers, closely connected in terms of transportation and innovation, are distributed within the region [88].

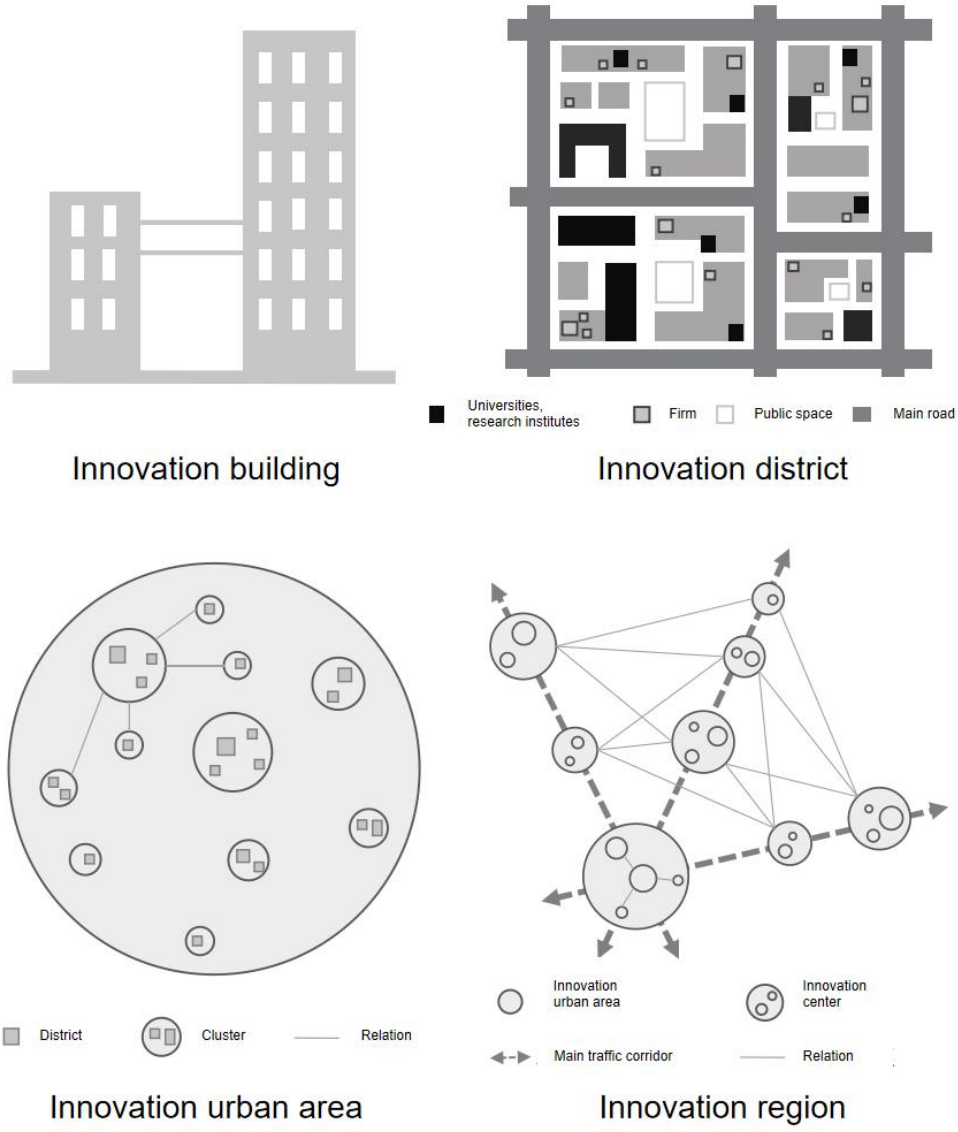


Fig 4-4: Morphological pattern diagram of spatial structures of innovation space at different scales[88]

4.4.2. Spatial characteristics of innovation district

Though innovation districts can no be the same in every single case, they tend to have similar characteristics. Wanger and colleagues at Brookings describe 12 guilding principles for innovation districts that focus on clustering, covergence, density, diversity, and

connectivity and area shaped by long-term thinking.They require a mix of programming and organic social interactions and bring innovation to the public[59]. (Fig 4-5)

Dense mixed-use spaces	Districts use mixed-use zoning to connect housing with work spaces and retail, instead of single use buildings. They are contained within a specified area but are connected to neighborhoods on the periphery.
Flexible and decentralized	In terms of planning, they allow for flexibility, continuous improvement, and design iteration instead of sticking to a rigid master plan.
Open and public	They contain ample public space and areas where people can interact informally. Organizations in innovation districts make use of shared working spaces and tend to include first floor retail and open spaces for both work and recreation.
Incorporating digital with physical elements	They use technologies such as Wi-Fi networks, radio-frequency identification tags, digital kiosks,and personal handheld devices to blend the digital world into the physical one. Additionally, they are well connected to the world via high-speed broad and internet.
A public place to test new technologies	Districts can serve as excellent places to pilot new technologies and practices in the public realm such as environmental sustainability, energy, health,mobility, water management, shared space, andother public goods such as public green space orgardens.
Strong in their sense of place	Good innovation districts express a strong narrative of their place and community. Innovation districts have features that make them distinctly local.
Community oriented	They bring economic growth,strong public spaces, vibrant street life, and arts to their surrounding communities. They can bring the surrounding community into growth and development plans, mitigating potential negative impacts from gentrification.

Fig 4-5: Characteristics of innovation districts[59]

4.4.2.1. Innovation parameters

Three experience in Chapter 3 shows that the university-anchored innovation districts have unique parameters for creating an innovative environment. And we can focus on several parameters to make a more innovative district. (Table 4-1) Land use is predominantly focused on office and commercial spaces, with some areas integrating living and working purposes. The building density in the district ranges from 45% to 60%, and the plot ratio varies from 2.0 to 4.0, indicating a generally moderate development intensity. The percentage of green space in the district is related to the planning of the development department. In general, an

environment with a green space ratio above 15% is more pleasant. Regarding setback lines, buildings below 20 meters adopt an overall setback approach to create a continuous street interface, while high-rise buildings adopt a combination of layered and overall setbacks. For buildings below 20 meters, the setback lines for side roads are usually around 3 to 5 meters, and for main and secondary roads, the setback lines can reach 6 to 10 meters. For high-rise buildings, the setback lines for side roads are typically 6 meters, and the setback lines for main and secondary roads should be at least 8 meters or more. If the street features a distinctive commercial layout, the establishment of outdoor commercial spaces is encouraged, leading to further increased setback lines.

Project	Land use	Plot Ratio	Building Density (%)	Green Space Ratio (%)	Building Height Limit (m)	Building Setback (m)	Area (ha)
University Park	Office / Commercial Land	2.0	45	16	35	3 / 4.5 / 6	8.67
Tech Square	Office / Commercial Land	4.0	60	5	75	6 - 10	15.49
KIC	Office / Commercial Land	3.5-4.0	50	10	50	3	78.17 (Chuangzhi Lane: 8.94)
	Mixed-Use Land for Living and Working	2.4- 3.2	50	7 - 8	24	3	

Table 4-1: Parameters of three practices

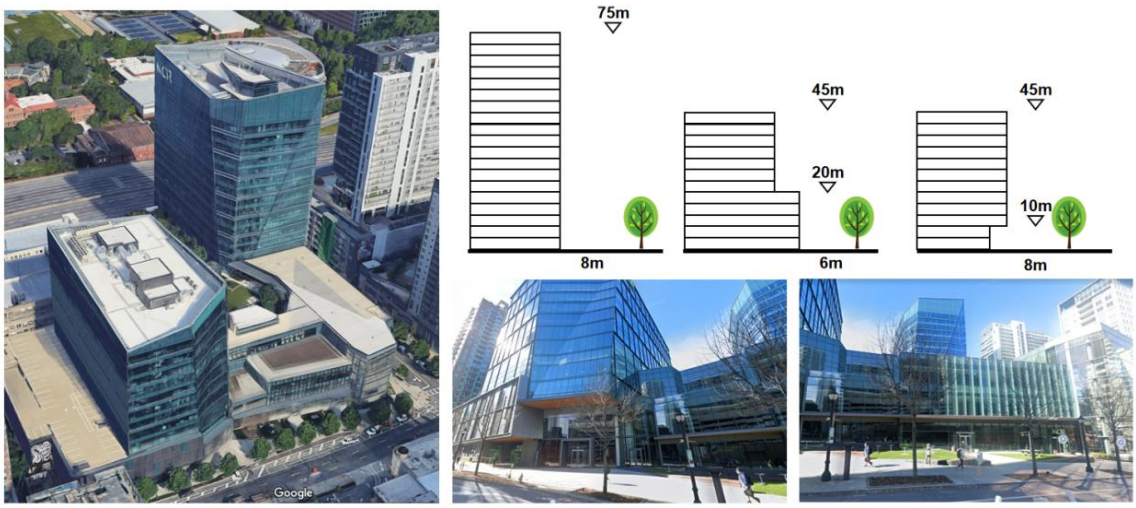


Fig 4-6: Building setback in the case of Tech Square

The proximity between university campuses and innovation districts facilitates physical closeness and close connections among innovation participants. Proximity promotes collaboration and interdisciplinary cooperation between talents and institutions from different fields, making cross-disciplinary exchanges and collaborations easier. By comparing the relationships between university campuses and innovation districts in the three cases, it can be observed that the spatial distance between them is no more than 100 meters. Additionally, universities can further promote resource exchange between academia and enterprises by embedding academic assets such as teaching buildings and office spaces in the innovation district, fostering a culture of innovation with cultural and cognitive proximity.

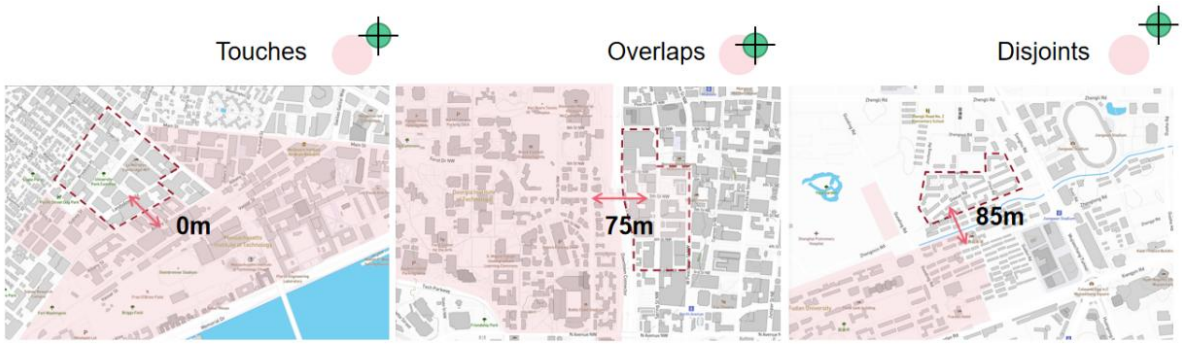


Fig 4-7: Physical distance of campuses and innovation districts

The high-quality boundary space of each functional area within the innovation district can significantly enhance the frequency of innovative activities. Firstly, functional similarities can blur the physical boundaries of spaces. Take the University Park, an innovation district

anchored by MIT, as an example, where functional similarities lead to a unified architectural scale and street quality. Secondly, innovation districts often feature open small blocks and a dense network of streets, and the accessibility of facilities within the district should meet the comfortable walking distance of 300m-500m. Lastly, the planning positioning of ground-level businesses, design guidelines for street facades, and the proportion of public spaces also influence the frequency of innovative activities occurring in the boundary spaces.

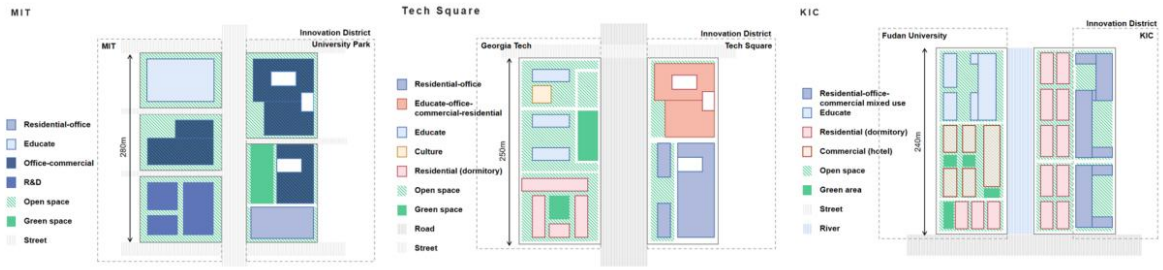


Fig 4-8: Layout of the boudary in three practices

4.4.2.2. Mixed use promotes open and communicative space

Open public spaces play a crucial role in facilitating innovative exchanges and enhancing community quality. Studies have shown that traditional commercial service spaces such as cafes and bars, as well as open spaces like parks and squares, contribute to establishing and strengthening social relationships, creating new venues for innovative exchanges, sharing ideas, fostering cooperation between enterprises, and promoting social interactions[89]. For instance, the central square in University Park preserves the historical memory of the former location of the Simplex company, creating a pleasant green space that serves as a leisure destination for creative individuals.

Well-developed public services and commercial facilities can increase spaces for innovative exchanges and maintain urban vitality. The diverse business formats and high-quality cultural and commercial services within Chuangzhi Lane attract innovation talents. Additionally, pedestrian streets, cinemas, bars, museums, galleries, and historical buildings all provide opportunities for talent exchanges and contribute to the prosperity of the district.

Promoting functional mixing within the district is essential. Chuangzhi Lane adopts a "compound block" model of "new industries + services + residential areas," which ensures ample housing, entertainment, and green spaces in addition to production areas. This approach

better sustains commercial development and enhances the vitality of public spaces, ensuring the overall coherence of social activities.[90]

Expanding urban open spaces is also vital. Open spaces serve as important gathering places for crowds' activities, interactions, and entertainment. Systematically constructing open spaces can enhance urban vitality, attract more people to public spaces, and ensure community safety. [91] Within Chuangzhi Lane, the systematic construction of hierarchical public spaces results in a multi-level vibrancy, and it fosters a closer connection with the surrounding urban spaces.

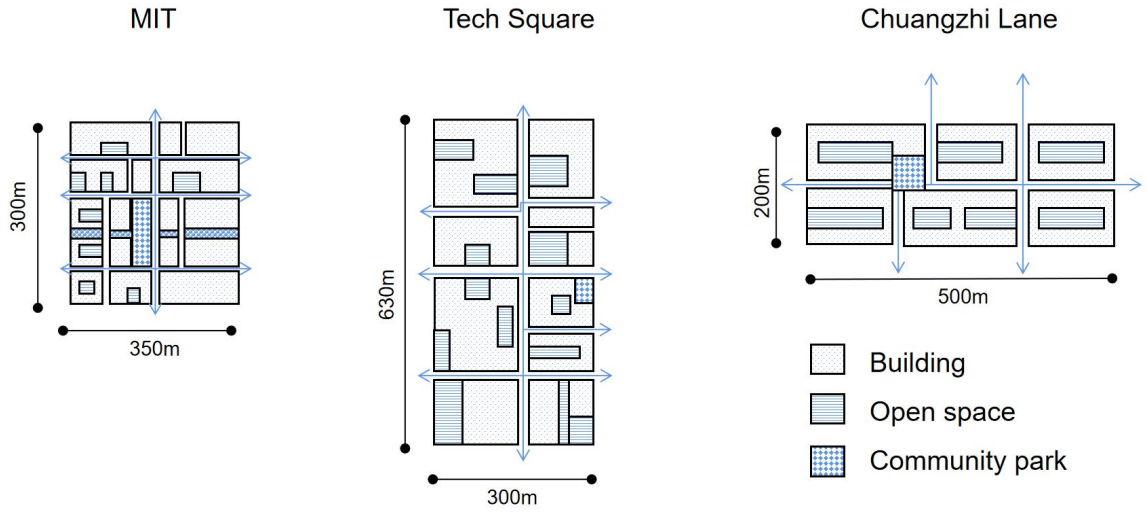


Fig 4-9: Public space distribution of three innovation districts

4.4.2.3. Provide a variety of housing services

The affordability of housing is a crucial factor affecting the ability to attract talent and the vitality of cities. Housing services are essential, and the supply of housing should not be limited to meeting the needs of high-end talents, such as innovators. It is equally important to focus on the general population. Therefore, providing a variety of housing options for different income groups is an important way to improve housing affordability.

By offering diverse housing choices and supporting them through fiscal and financial policies, the affordability of housing for middle- and low-income groups can be enhanced. In terms of housing supply, Pittsburgh's innovation districts encourage diverse forms of housing, including student apartments, senior apartments, single-family homes, rental housing, and live-work spaces, to meet the housing needs of various demographics. The student population,

in particular, is a target group that the districts aim to attract, so the plan includes the construction of student apartments and the provision of housing facilities that cater to students' lifestyles. Additionally, there should be further improvements in senior living facilities, the construction of barrier-free facilities, and the provision of services tailored to the elderly population. Building designs should also meet the requirements for elderly-friendly architecture.

Fig 4-10: A variety of housing types[91]

4.4.2.4. Reshape urban characteristics

Historic buildings serve as important symbols of local culture and uniqueness. Successful planning and construction of innovation districts often prioritize the preservation and utilization of historic buildings. When planning an innovation district, it is necessary to classify and protect historic buildings, highlighting the cultural value of local industrial heritage. Adaptive reuse of old buildings is also important.

For example, MIT University Park was primarily developed on formerly abandoned and unused industrial land in Cambridge. This 27-acre site was once marshland that was gradually filled in and used for industrial purposes. For a significant portion of the 20th century, the main occupant of the site was Simplex Wire & Cable Company, a manufacturer of telegraph cables, which left the area in the 1970s. In addition to renovating and repurposing industrial buildings with reuse value within the site, University Park's large-scale linear park serves as a reminder of the property's history as the location of Simplex Wire & Cable Company, commemorating the industrial heritage of the area.

By integrating historic buildings into the design and development of innovation districts, it is possible to preserve the local cultural identity, enhance the sense of place, and create a unique environment that blends history with innovation.

Fig 4-11: Layout and landscape of the garden

4.4.2.5. Build a green and accessible transportation system

The demonstration effect of an innovation district can drive businesses to expand their operations on a larger scale, increase opportunities for collaboration with external companies, and provide local residents with more choices for living and lifestyle. Looking at the broader context of an urban innovation area, open transportation channels can improve connectivity within the city's core functional areas.

For example, the Red Line subway in Boston passes through many renowned universities in the Boston area, such as Harvard University, Massachusetts Institute of Technology (MIT), and Boston University. This convenient transportation method encourages collaboration and academic exchanges among universities, as well as talent mobility between universities and technology companies. Additionally, the Red Line runs through several technology company clusters, such as Cambridge and Kendall Square. Tech entrepreneurs and investors can easily access different startup hubs, office locations, and innovation incubators using the Red Line. This geographical proximity and transportation convenience facilitate communication, collaboration, and resource sharing among entrepreneurs. The universities and research institutions along the Red Line corridor possess rich research resources and specialized knowledge.

By leveraging the proximity of universities, research institutions, and technology clusters, an urban innovation area can create a vibrant ecosystem that fosters innovation, entrepreneurship, and knowledge exchange. The availability of transportation options, such as subway lines, promotes connectivity, encourages collaboration, and enhances the overall competitiveness and attractiveness of the innovation district.

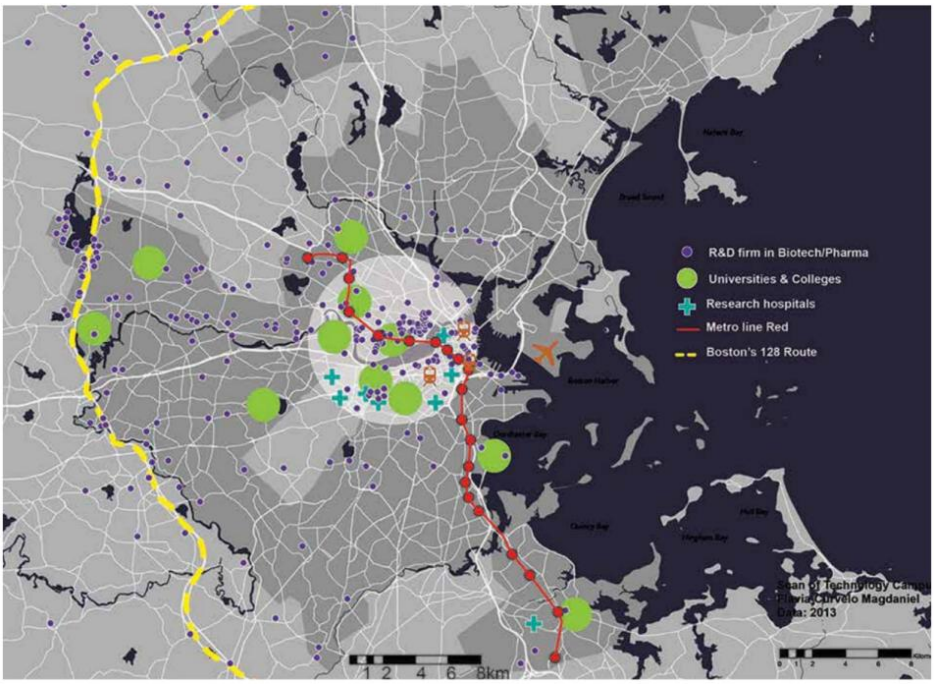


Fig 4-12: Innovation area around MIT campus[72]

Within an innovation district, there is a tendency to reorganize the area into smaller-scale, pedestrian-friendly, and open districts. By establishing a connected public transit system and bicycle network, promoting pedestrian-friendly transportation, and increasing open spaces, it is possible to create interconnected districts that link campuses, business parks, and communities. By comparing the transportation connectivity of three case studies, we can observe that regardless of whether the innovation district is adjacent to university spaces or physically separated by transportation arteries or rivers, establishing coherent pedestrian pathways with a focus on people can promote strong accessibility and foster innovative activities.

Through the optimization of the transportation systems in both the urban area and the innovation district, researchers can easily visit other institutions, participate in academic conferences and seminars, engage in exchanges with experts from different fields, and promote interdisciplinary collaborations. This academic cooperation contributes to driving innovation, sharing knowledge, advancing technology, and providing opportunities for students and professionals to access additional educational resources.

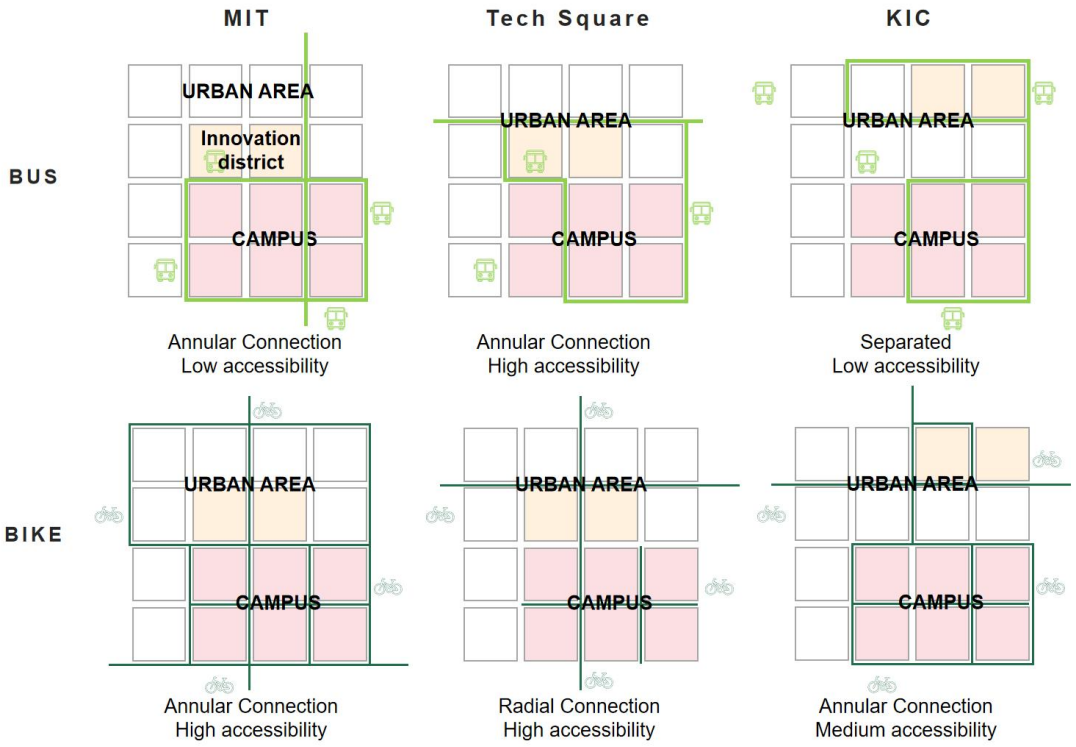


Fig 4-13: Traffic flow between campuses and innovation districts

4.5. Summary

From the perspective of constructing an innovative spatial system, the shaping of innovative districts is closely linked to the development of innovative buildings and innovative urban areas. At the building scale, functions should be combined to arrange physical space that connects different buildings. At the urban area scale, as a component of the innovation region, the innovative district serves not only as a demonstration area but also interacts with other functional areas in the surrounding city, driving business on a larger scale. It is also important to encourage the flow of innovation talent and further gather innovative resources through convenient transportation.

The construction of innovative districts can be explored from the perspectives of industrial regeneration, inclusive development, spatial and facility regeneration, and institutional guarantees. From the perspective of industrial regeneration, innovative districts gather innovative enterprises and cultivate innovation clusters, utilizing the knowledge spillover from anchored institutions to construct spatial structures and establish open innovation resources. From the perspective of inclusive development, innovative districts

should not only provide places for work, study, entertainment, and living for innovative individuals but also consider promoting local employment and providing diversified housing supply if conditions permit. From the perspective of institutional guarantees, strengthening financial and fiscal support is beneficial for enhancing development momentum, rational utilization of space, and the establishment of flexible regulatory systems to ensure the shaping of vibrant spaces. Establishing public-private partnership mechanisms promotes win-win situations for all parties, and innovative cooperation mechanisms facilitate the development, transformation, and regeneration of innovative districts. Industrial regeneration requires spatial support to provide innovative carriers and platforms.

From the perspective of space and facilities, innovative districts have certain unique characteristics in terms of spatial features and facility resources. The spatial form of innovative districts presents the characteristic of "boundaryless" integration with surrounding communities and campuses. The spatial structure of innovative districts is generally not explicitly defined, with innovation subjects such as enterprises centered around anchored institutions like universities and research institutes, and layouts are organized around streets. Based on case studies, innovative districts anchored by universities in city center areas have unique parameters for creating innovation, shaping people-centric spaces in terms of land use, plot ratio, building density, green space ratio, building height limits, and setbacks. Additionally, in the process of constructing the district, mixed functions can be incorporated to create open and interactive public spaces, diverse buildings can be provided to enhance community inclusiveness, distinctive spatial features can be reshaped to improve recognizability and a sense of identity, and green transportation connecting various functional zones can be developed to facilitate the flow of people.

Chapter 5 Strategies of Tianhe Changban Plot

5.1. Cultivate competitive innovation clusters

5.1.1. Basis of innovation cooperation

The achievements and shortcomings of science and technology transformation in South China University of Technology have been introduced above, and the historical process of innovation development of SCUT has been reviewed. In the following, three types of innovation activities related to anchored-university in Tianhe Changban Plot will be analyzed, and stakeholders of innovation activities will be interviewed, so as to obtain the basis of current innovation cooperation and evaluate innovation capability. Specifically, innovation activities related to anchored university can be summarized as "university-industry", "university-university" and "university-government" collaborations.

"University-enterprise cooperation" strengthens the important role of related laboratories at SCUT in technology research and development, improving the efficiency of technology commercialization. It also serves as a platform for companies, enhancing their technological capabilities and outputting achievements, leading to a win-win situation. Take School of electrical engineering as an example, the cooperative enterprises are mainly located in cities in Guangdong Province, such as Guangzhou and Dongguan, and cities in Guizhou provinces, Zhejiang province. Cooperation between the university and enterprises often requires students from the laboratories to visit the collaborative bases for on-site operations, and the frequency of communication during the cooperation is mostly on a weekly basis. Networking and collaborations often come through alumni connections and the influence of the laboratories.

"University-university cooperation" aims to leverage the strengths of various universities' key disciplines, dividing critical subjects into sub-topics for research cooperation. Combined with the geographic, industry-related, and personnel relationships between universities and nearby enterprises, they collaborate on tackling and testing sub-topics, achieving innovative performance greater than the sum of individual efforts. Collaborating universities are spread across the country, and the frequency of cooperation and exchange is on a semester basis, with professors in related fields jointly leading the research projects, which are relatively

independent.

"University-government cooperation" drives complementary and deep integration development between Guangzhou and South China University of Technology. The Guangzhou Science and Technology Library, co-built by the Guangzhou Municipal Government and South China University of Technology, is planned to be completed and put into use by September 2025. The Guangzhou Science and Technology Library is regarded as a new cultural landmark of Guangzhou and an important project for building a "library city" and a "city of reading."

Fig 5-1: Construction of Guangzhou Science and Technology Library

5.1.2. Innovation demands

To further advance "university-enterprise cooperation" in fostering innovation, a qualitative analysis method based on semi-structured interviews was employed to identify and engage key individuals in relevant positions. The interviewees encompassed essential stakeholders, including current postgraduate and doctoral students of SCUT faculty members from the university, employees of enterprises at Changban Creative Park, and government officials from Guangzhou municipal government. The interviews were conducted in April 2023, with each session lasting approximately 15 minutes. The discussions were recorded digitally and later transcribed manually into textual form.

The findings of the research emphasized a pressing need to establish innovative shared platforms, expand laboratory resources, augment research spaces, and provide essential legal and financial support. Cultivating the innovation cluster would greatly benefit from robust support in these aspects, thus creating an enabling environment that caters to the spatial and

service requirements of all stakeholders involved.

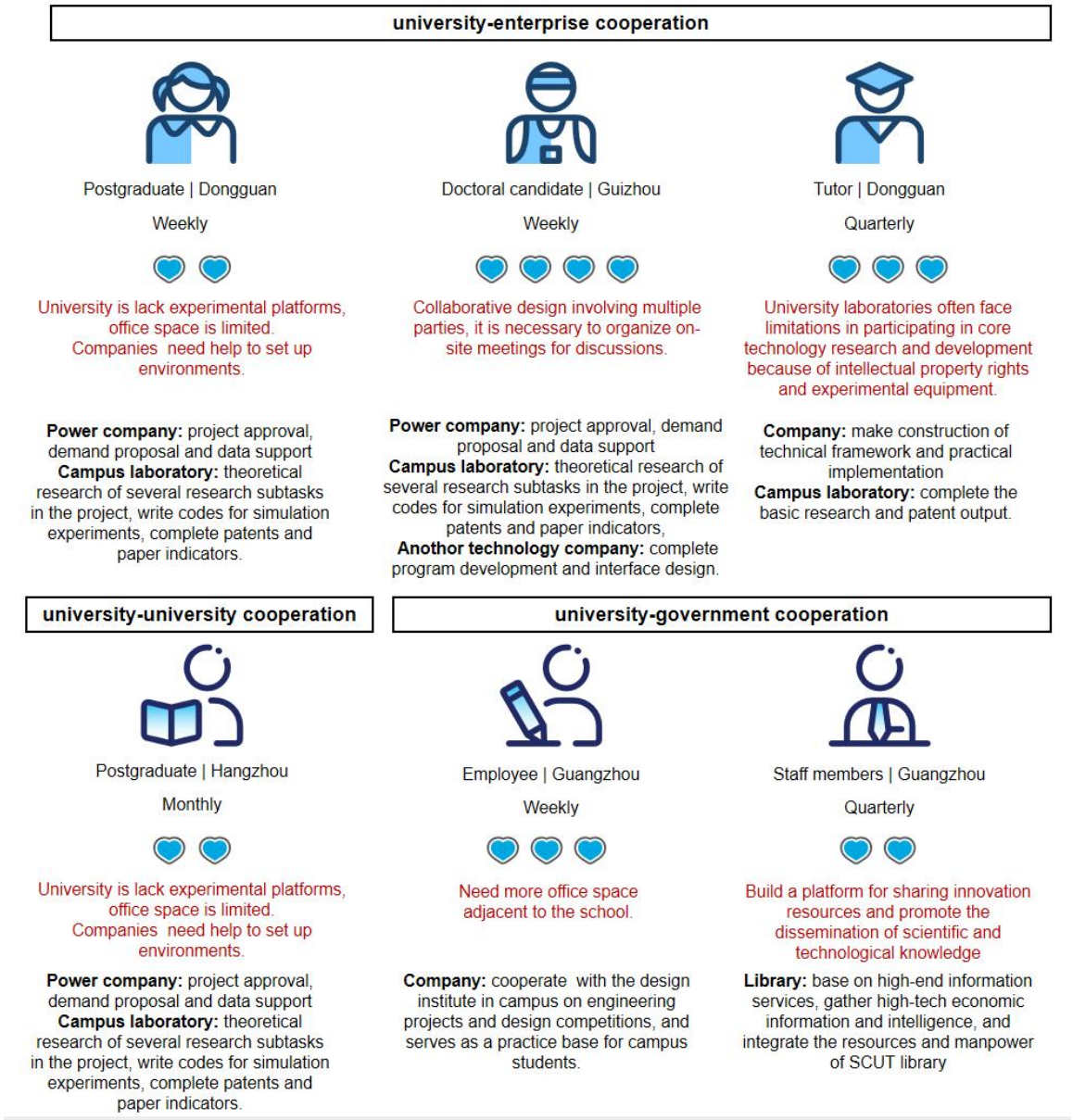


Fig 5-2: Innovation demands from six stakeholders

5.1.3. Stratgies for cultivating clusters

The Wushan Campus of SCUT is home to several competitive disciplines that maintain close ties with the industrial sector, exhibiting a strong demand and foundation for technology transfer. Considering SCUT's innovation development plan, the innovation district should focus on establishing connection platforms between innovation centers, laboratories, and enterprises in areas such as electric power, papermaking, machinery, and materials. This will facilitate the integration of campus functions with the innovation district and promote

physical space integration and interaction. Currently, northern part of the SCUT campus houses numerous scientific research laboratories, and its proximity and collaboration with the innovation district present opportunities for the gathering and upgrading of innovation clusters.

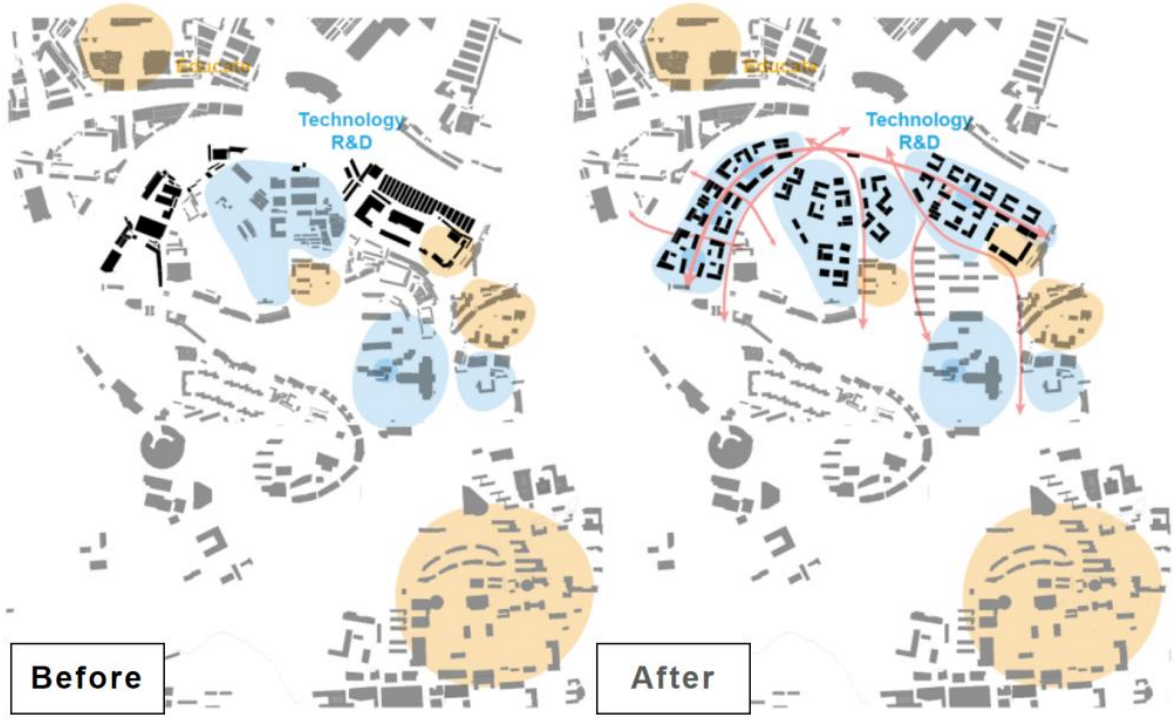


Fig 5-3: Distribution of R&D cluster before and after

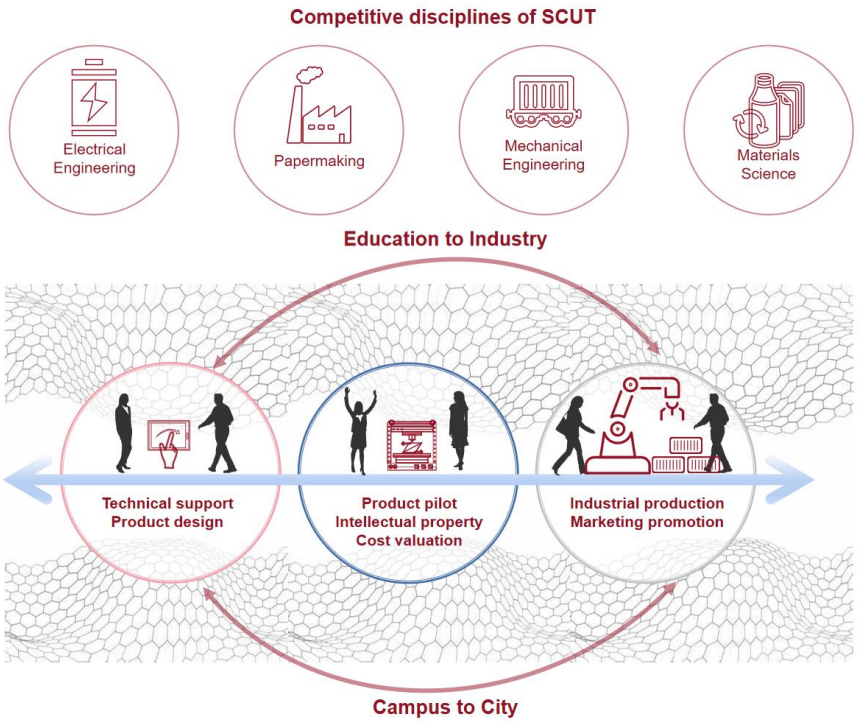


Fig 5-4: Agglomerate competitive industries near SCUT

The Tianhe Changban Plot should actively involve SCUT in its construction to facilitate knowledge spillover. For instance, by establishing public innovation laboratories and organizing popular science lectures, the district can serve as an exemplary point for general education. Additionally, integrating the management of the innovation district with the curriculum design of relevant disciplines at SCUT will promote synergistic innovation in teaching and administration. On the other hand, the Tianhe Changban Plot should actively attract technology companies and research institutions to set up offices or research centers, fostering personnel development and mobility through collaborative projects and innovative initiatives.

The establishment of open and shared innovation resources within the district is crucial. Research indicates that knowledge spillover from SCUT primarily involves small-scale workshops and start-ups comprised of alumni, faculty, and students. These ventures are sensitive to entrepreneurship costs, often choosing low-cost co-working spaces and favoring cost-effective research facilities like shared laboratories. To better promote knowledge spillover, the district should provide open and shared innovation resources, drawing inspiration from the experiences of North American university research parks. Creating shared

workspaces, laboratories, and collaborative technology centers will foster a vibrant knowledge atmosphere within the innovation district.

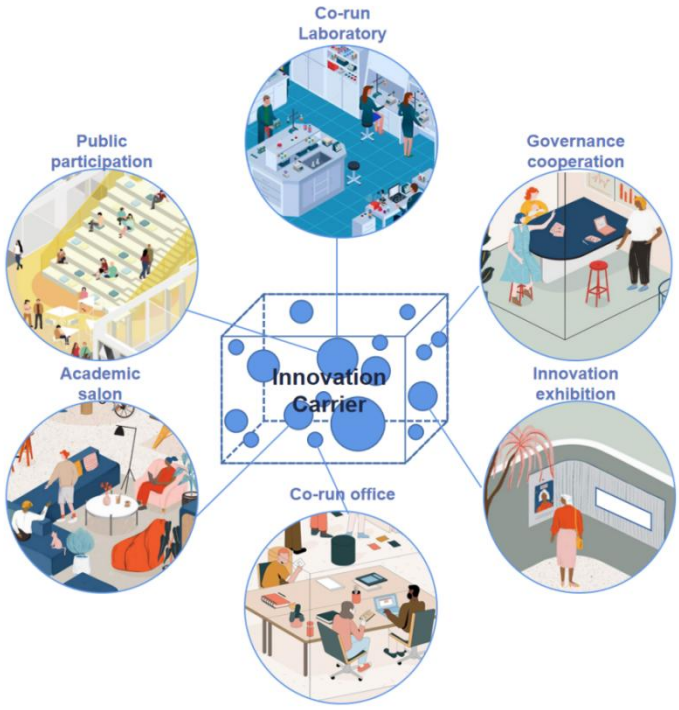


Fig 5-5: How university do to anchor and influence through innovation activities

5.2. Promote inclusive development

The population distribution in the Peri-Wushan Innovation Urban Area is mainly concentrated in the age group of 20-40 years old. According to the 7th population census, the practitioners in scientific research and technical services in Tianhe District, Guangzhou, are mainly divided into three professional fields: research and experimental development, professional technical services, and technology promotion and applied services, accounting for 21%, 61%, and 18% respectively. The age group with the largest number of practitioners is 20-24, 25-29, 30-34, and 35-39, accounting for 14%, 22%, 21%, and 16% respectively. In order to establish a better demonstration effect, the Changban plot will be positioned as an innovative service community to attract talents aged 20-40 engaged in "scientific research and technical services." During the design process, it is essential to create an active research culture atmosphere, incorporate elements for creative exchanges and technology exhibitions in streets, squares, and other spaces, while also catering to diverse urban services and meeting the needs of daily leisure and entertainment.

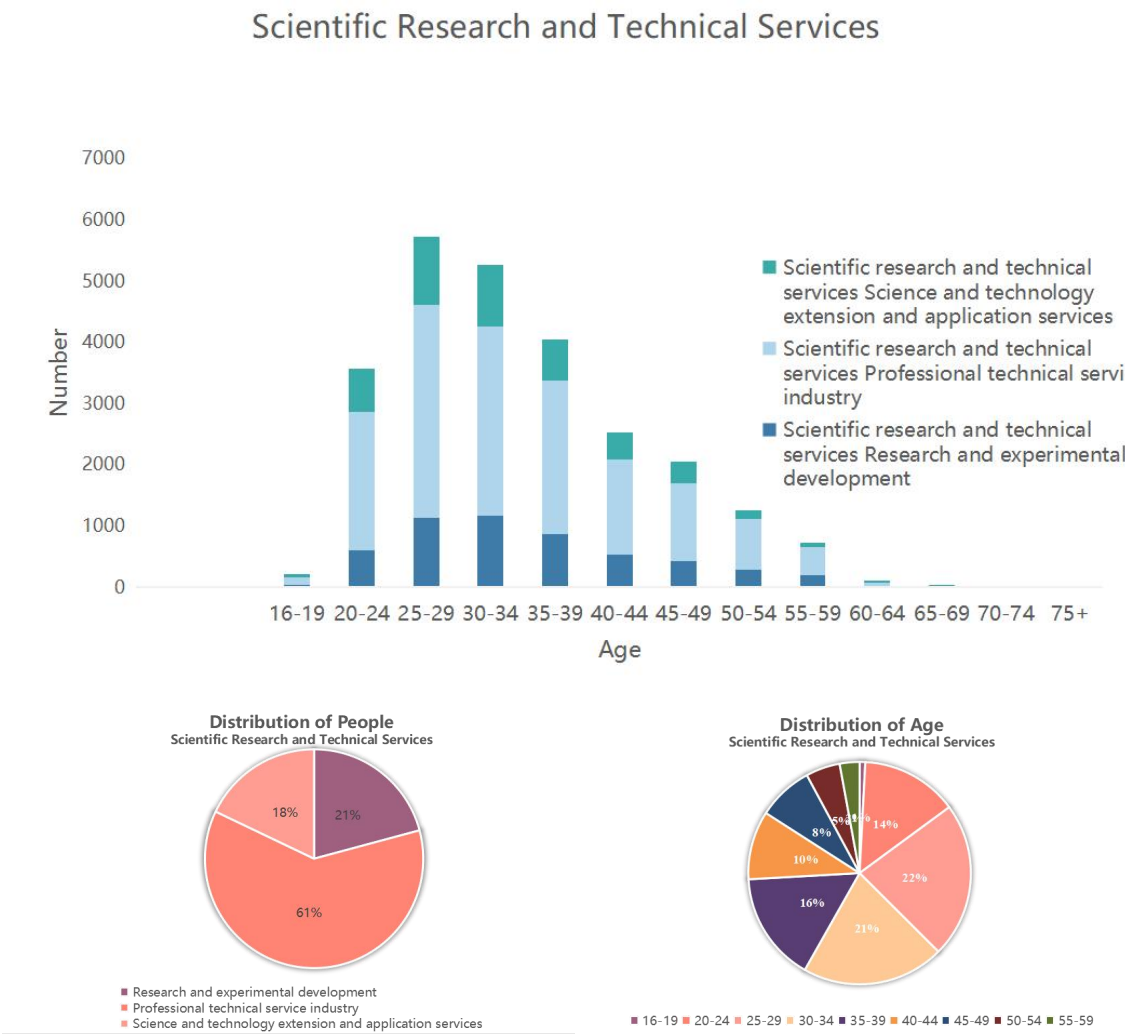


Fig 5-6: Scientific research and technical services

From an educational perspective, the Tianhe Changban Plot attracts a large number of highly educated talents. However, a significant portion of the surrounding residents have lower educational levels. The site is situated at the junction of Changban Street, Wushan Street, Yuangang Street, and Xinghua Street. According to data from the seventh national census, a study on the educational background of residents in these four streets reveals the following: Wushan Street has the highest proportion of residents with undergraduate, postgraduate, and doctoral degrees among the four streets. Yuangang Street has the highest proportion of residents with associate degrees, while Xinghua Street and Changban Street have over 90% of residents with educational backgrounds in junior high school, high school, and associate or undergraduate degrees, with less than 10% of research-oriented talents like postgraduates and doctoral students.

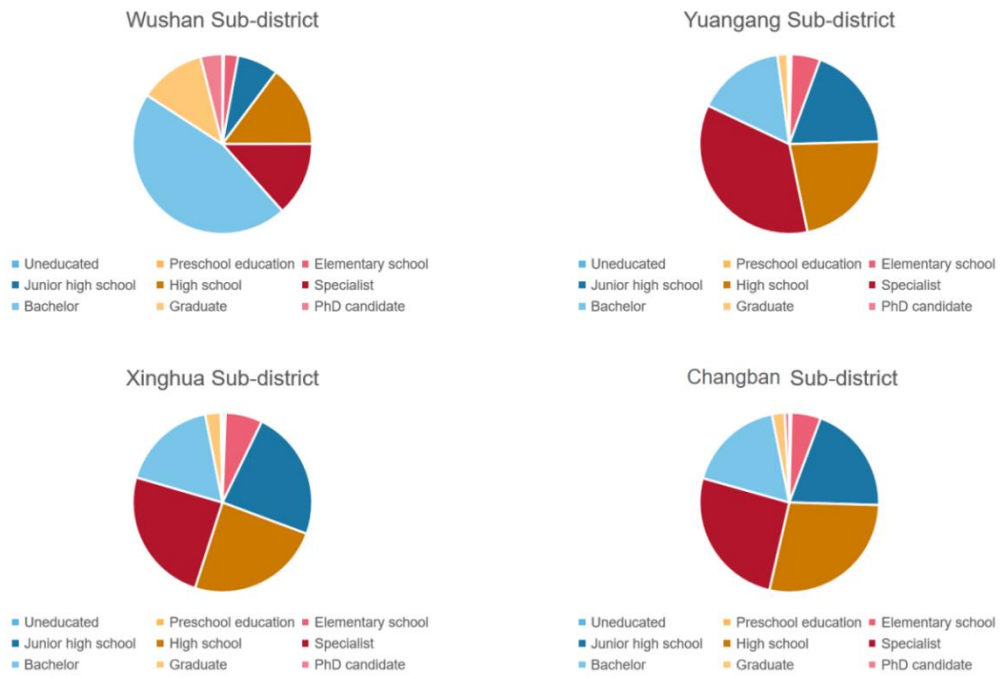


Fig 5-7: Education level in four sub-districts

To create a more inclusive innovation district, the Tianhe Changban Plot should integrate commercial and recreational services with employment opportunities, and combine innovative skills training with job quality enhancement. This approach will support local low-income individuals in improving their vocational skills.

5.3. Innovate institutional guarantee

Firstly, with the support of Guangzhou's "land development" policies, the development of the innovation district can make efficient use of a flexible spatial management system. The Tianhe Changban Plot is located in Changban, where the land use is relatively complex, involving industrial, logistics, residential, commercial, and public service facilities (Fig 5-8) . Through investigation and assessment, it was found that there is a high vacancy rate in the industrial and logistics areas within the site, a lack of green spaces and plazas, and a relatively low quality of residential environment. Additionally, the ownership of the land is relatively complicated (Fig 5-9), involving numerous stakeholders, and the planning and updating process has been pending for several years. In March 2023, Guangzhou city introduced measures and action plans to support coordinated land development for high-quality development. The Peri-Wushan Innovation Urban Area was identified as one of the four key

areas for land development, particularly emphasizing the construction of technology parks and university talent apartments. Based on this, the proposed design aims to comprehensively develop and manage the site, transforming its functions to serve the research-related needs of the innovation district.

Next, it is essential to promote the establishment of a collaborative mechanism among innovation subjects. In China, although there is no alumni foundation engaging in the buying and selling of land or market-oriented operations, a cooperation mechanism can be established for campus regeneration and urban development. Taking inspiration from Shenzhen's "neighborhood development model," integrated development or one-time renovation can be carried out for campuses, communities, and industrial parks. This will create a demonstration base for scientific and technological innovation and the transformation of scientific and technological achievements in the city, providing a beautiful and affordable office space for startups and offering educational environments and talent apartments for universities, thereby enhancing the vitality of the innovation district. Moreover, after the land development, market capital can be introduced to provide diverse office environments for startups, ultimately transforming the innovation district into a complex and integrated environment that fosters joint development among campuses, industrial parks, and communities.

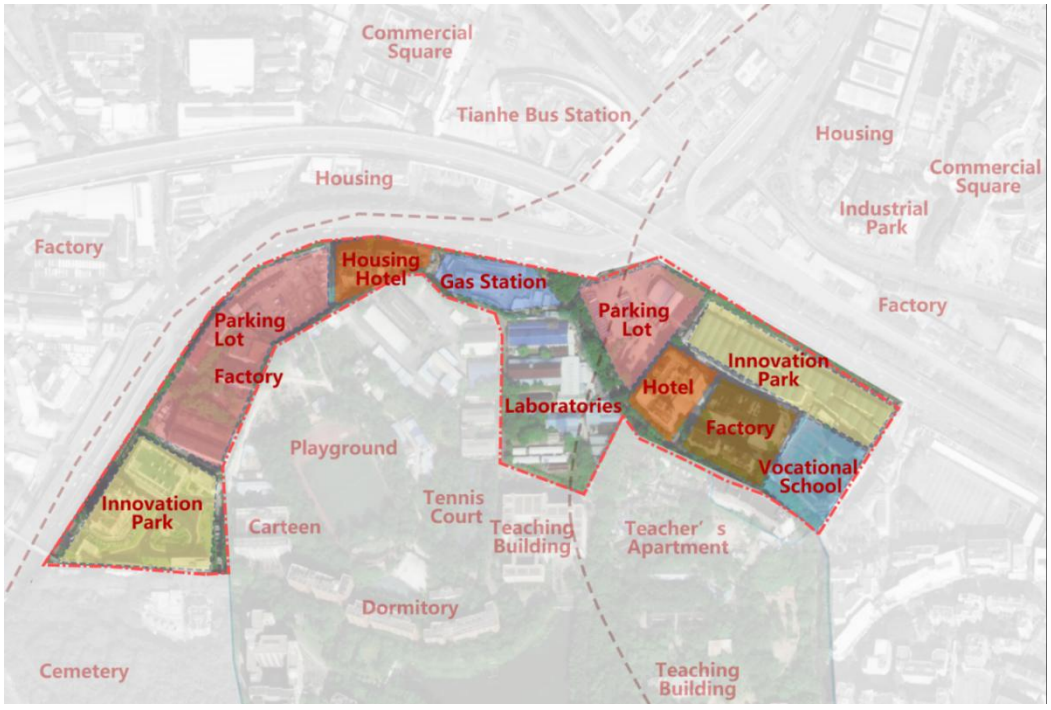


Fig 5-8: Functional distribution before land development

Fig 5-9: Complex property rights of the plot

5.4. Regenerate innovation space

Focus on the construction of innovation spaces at the building and district levels. In recent years, there have been some innovation spaces at the building level within and around the campus of South China University of Technology. The on-campus innovation spaces mainly involve the insertion of shared learning spaces, cafes, and cultural and creative shops into office buildings, creating informal spaces for interactions. However, it still demands for improvement in terms of building connections, architectural combinations, and functional integration. In the off-campus community, shared office spaces with brands like "RemixLab" have emerged, but due to complex reasons such as accessibility and economic considerations, their sustainability remains uncertain.

In the future, the Tianhe Changban Plot will address these shortcomings through innovation space creation at the building level, improved building connections, and better combination of functional spaces. It will play a significant role in safeguarding the last mile of innovation.

5.4.1. Mix use to promote innovation

The innovation district overlaps with the university. In terms of land use, the innovation

district is mainly focused on service-office mix, while the university campus is primarily a mix of teaching and office functions. Along the main road interfaces in the innovation district, commercial functions are added to enhance street vitality and improve the quality of life. Green spaces are provided at the junction of Yanling Road and Changfu Road, the main entrance of SCUT campus, and the area where the subway line passes underground, providing opportunities for creating public spaces according to the local conditions.

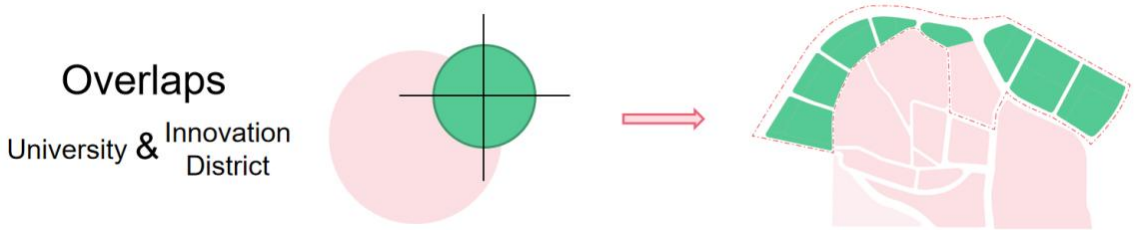


Fig 5-10: Physical relationship between university and Innovation district

Fig 5-11: Land use of Tianhe Changban Plot

The functions within the district are mixed, covering three sectors: Research and

Experimental Development, Professional Technical Services, and Technology Promotion and Applied Services. The district is dedicated to providing service platforms for various stages of innovation activities and forms spatial resonance with the experimental clusters within SCUT, creating an innovative corridor in the Tianhe Changban Plot. (Fig 5-12)

Block 1 focuses on the technology promotion and applied service industry, aiming to create an innovation cluster with research impact. Within the cluster, there are integrated functions such as technology training, technology exhibition, research offices, and supporting facilities for daily life. Below are the functional divisions and the proportion of each category of functions. (Table 5-1)

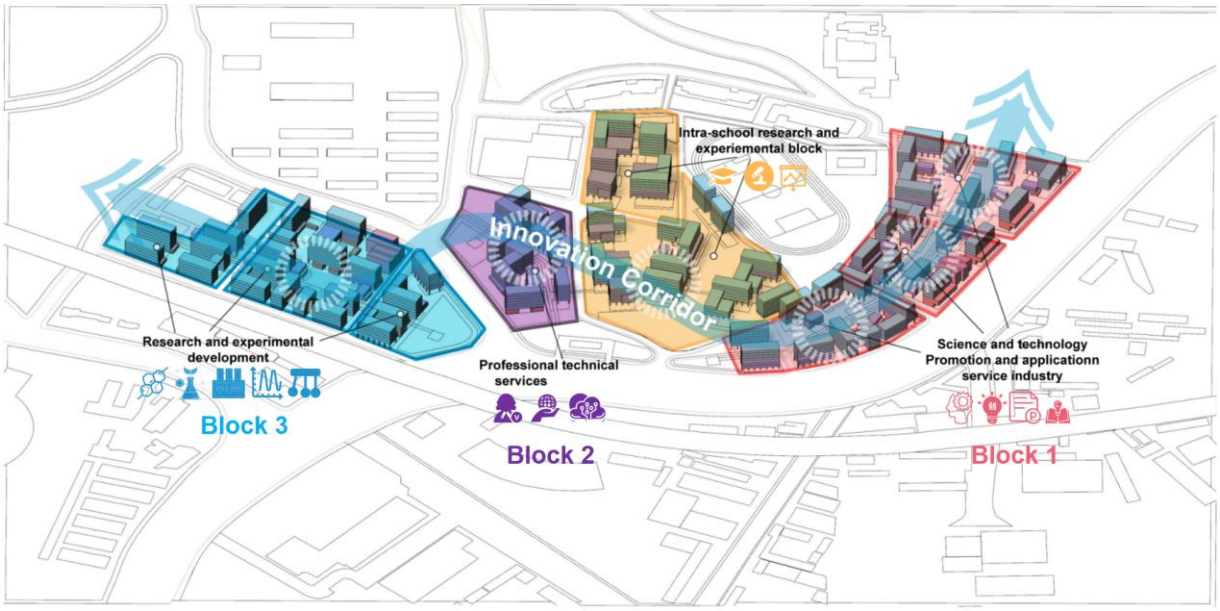


Fig 5-12: Functional zone of Tianhe Changban Plot

Science and technology promotion and application service block

Zone	Function	Percentage
Office spaces for technology companies	A scientific research base that provides aggregation and collaboration for technology companies and research institutions.	50%
Technical training center	A building used for providing technical training, education, and professional development.	20%

Science and technology exhibition center	A venue used for hosting technology exhibitions, scientific exchanges, and innovation activities, while also serving as a platform for popular science and technology education for the surrounding community.	15%
Supporting facilities for daily life services.	A place that provides facilities such as dining areas, entertainment activities, medical services, sports facilities, and furniture services for innovation talents.	15%

Table 5-1: Function arrangement description for Block 1

Block 2 focuses on professional technical education and services. Innovation in Block 2 embodies the role of SCUT as an anchored institution, serving as the source of innovation in the construction of the innovation district. The site serves as the teaching and office space within the university campus, and through the establishment of an external window for technology services, it combines educational training with technical consulting services. In this cluster, SCUT provides a platform for offering technical consultations to external parties in competitive disciplines, including but not limited to research technologies, intellectual property, and risk assessment. It also seizes this opportunity to promote innovative courses, better understand the new challenges posed by market changes, and further develop the disciplines.

Professional and technical education and services block

Zone	Function	Percentage
Technical consultation	Providing professional advice and recommendations in specific fields.	20%
Law consultation	Institution providing legal consulting and legal services.	15%
Accounting consultation	Institution providing accounting and	15%

	auditing services.	
Technology exhibition center	Research base for the aggregation and collaboration of technology companies and research institutions.	40%
Supporting facilities for daily life services	Venue providing catering, entertainment activities, medical services, sports activities, furniture services, etc., for innovation talents.	10%

Table 5-2: Function arrangement description for Block 2

Block 3 focuses on Research and Experimental Development, aiming to create an innovation cluster with research impact. Within the cluster, there are integrated functions such as research experiments, university-enterprise cooperation centers, innovation incubation, research offices, and supporting facilities for daily life. Below are the functional divisions and the proportion of each category of functions.

Research and experimental development block

Zone	Function	Percentage
Research institute or laboratory	A place for conducting scientific research, experiments, and developing new technologies, products, or solutions.	25%
University-industry collaborative research center	An organization facilitating collaboration between educational institutions and companies for research purposes.	10%
Innovation center or incubator	A space that provides support, training, and resources for startups and innovative projects.	20%
Science and technology enterprise office space	A research base that fosters collaboration and synergy among	30%

	technology companies and research institutions.	
Supporting facilities for daily life services	A venue that offers catering services, entertainment activities, medical services, sports facilities, and furniture services for innovation talents.	15%

Table 5-3: Function arrangement description for Block 3

5.4.2. Tianhe Changban Plot innovation parameters

The Tianhe Changban Plot has a block area of 11 hectares, and as part of the campus-city cooperation demonstration, an additional 2.76 hectares within SCUT campus are also undergoing simultaneous regeneration and improvement. When determining the parameters for the creation of the innovation district, it is essential to consider the site's basic physical conditions and the surrounding environmental context, making appropriate arrangements accordingly.

Firstly, the anchored university features an organic layout with a relatively low overall development intensity and a dispersed arrangement of buildings. Secondly, the site is closely adjacent to Yanling Road and Guangshan Expressway, which limits the elongation and expansion of the plots. Moreover, the site is near the rail transit station, with a focus on public transportation and walking for residents' travel, requiring a high degree of openness in the block design. In summary, to establish a coherent transitional space and a unified spatial atmosphere in coordination with the anchor institution, and to better connect with the transportation system, the innovation district is better suited to adopt a high-density open block model with a primary emphasis on multi-story buildings.

Functional block	Block scale (m*m)	Building Density (%)	Plot Ratio	Greening Rate (%)	Building Setback (m)
Research and experimental	120*100	35-40	2.2	20%	5-10m

development block					
Professional technical services block	200*100	20-25	1.5	20%	5-10m
Science and technology promotion and applicationn service block	400*150	30-35	1.8	20%	5-10m

Table 5-4: Innovation district parameters of Tianhe Changban Plot

5.4.3. Build open space system

5.4.3.1. Problem of the plot

The urban space of Changban plot faces several issues. With the adjustment of industrial structure and the shift of economic activities, surrounding industrial areas have lost vitality or become deserted. Old transportation hubs like the Tianhe Bus Station are gradually replaced by new facilities, leading to the decay and disintegration of these areas. The urban space around the campus is in a disorderly state dominated by motorization. Some spaces are abandoned and unused, while others are extensively used for parking, automobile repair, and freight handling. Furthermore, nearby highways are dotted with gas stations, creating a large and fragmented spatial scale.Secondly, pedestrian spaces have shrunk. The presence of super-sized roads, urban expressways, and elevated roads further hinders pedestrian movement, as these structures cut through public spaces. Additionally, the increase in detrimental factors like exhaust fumes, noise, and visual pollution poses threats to human health. Lastly, the street facades are uninviting, and the public spaces lack constraints and hierarchical treatment, leading to a loss of spatial coherence and a decline in street vitality.

Fig 5-13: Low quality of space

The campus boundary space adjacent to the Changban plot is in a state of neglect. Firstly, the facades of the boundary streets are monotonous, and the buildings show signs of decay. The lack of maintenance and management in these spaces leads to a dirty and disorderly environment with outdated facilities, failing to provide a comfortable and pleasant place for students and staff. Secondly, the green spaces along the campus boundary are occupied for illegal parking, building expansion, unauthorized planting of vegetables, and clothes drying. This occupation disrupts the overall beauty and green environment of the campus. Moreover, the construction spaces along the campus boundary are left idle without effective planning and utilization, resulting in resource waste and lack of functionality. Lastly, there are missing pedestrian walkways within the campus, which may cause inconvenience in traffic for students and staff, increase safety risks, and affect the accessibility and usability of the campus. These issues may have a negative impact on the overall image, functionality, and user experience of the campus, therefore, appropriate measures need to be taken to improve and address these problems. (Fig 5-14)

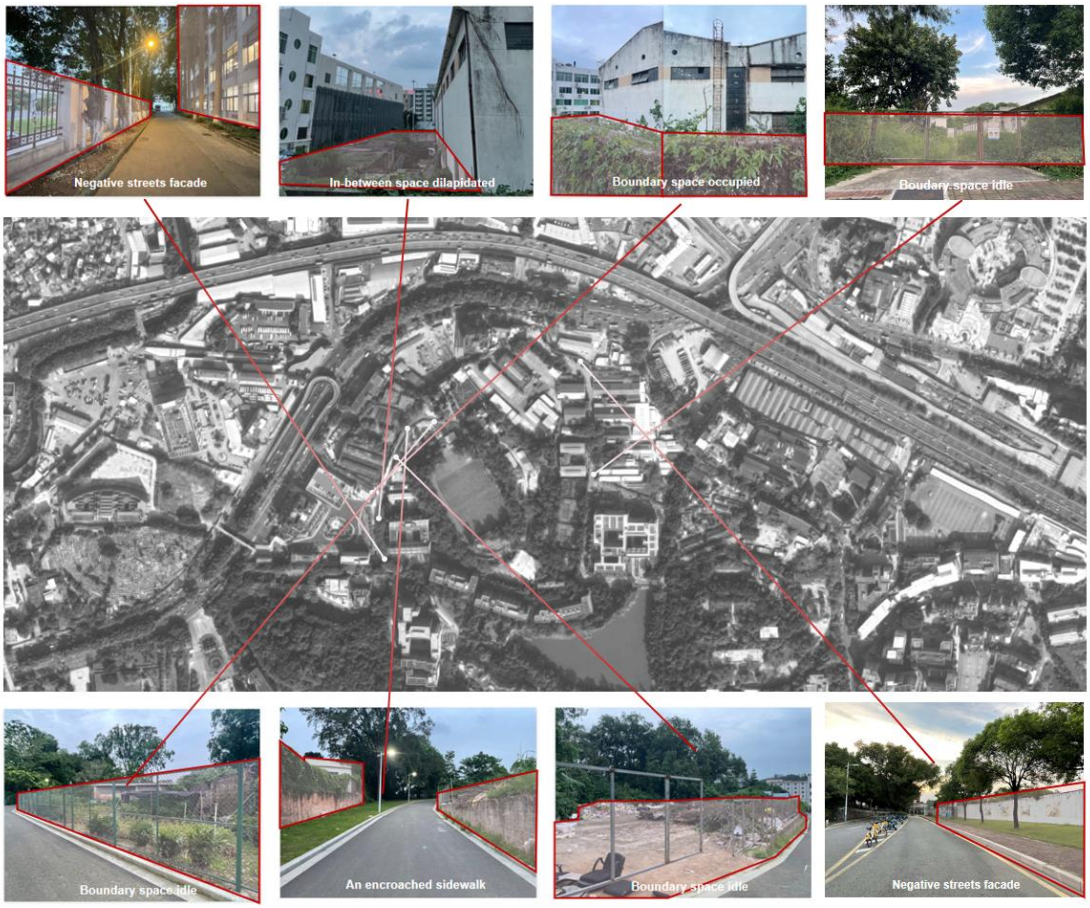


Fig 5-14: Lost boundary space

5.4.3.2. Build open space system

The open space should organizes organic social interactions and brings innovation to the public. Open space in innovation district is a place to test new technologies: it can serve as excellent places to pilot new technologies and practices in the public realm suchas environmental sustainability, energy, health, mobility, water management, shared space, andother public goods such as public green space or gardens.[59]

The multi-level and diverse public spaces make the innovation district more attractive. The public space system in Tianhe Changban Plot can be divided into green courtyards at the building scale, vibrant squares at the block scale, and innovative corridors at the district scale.

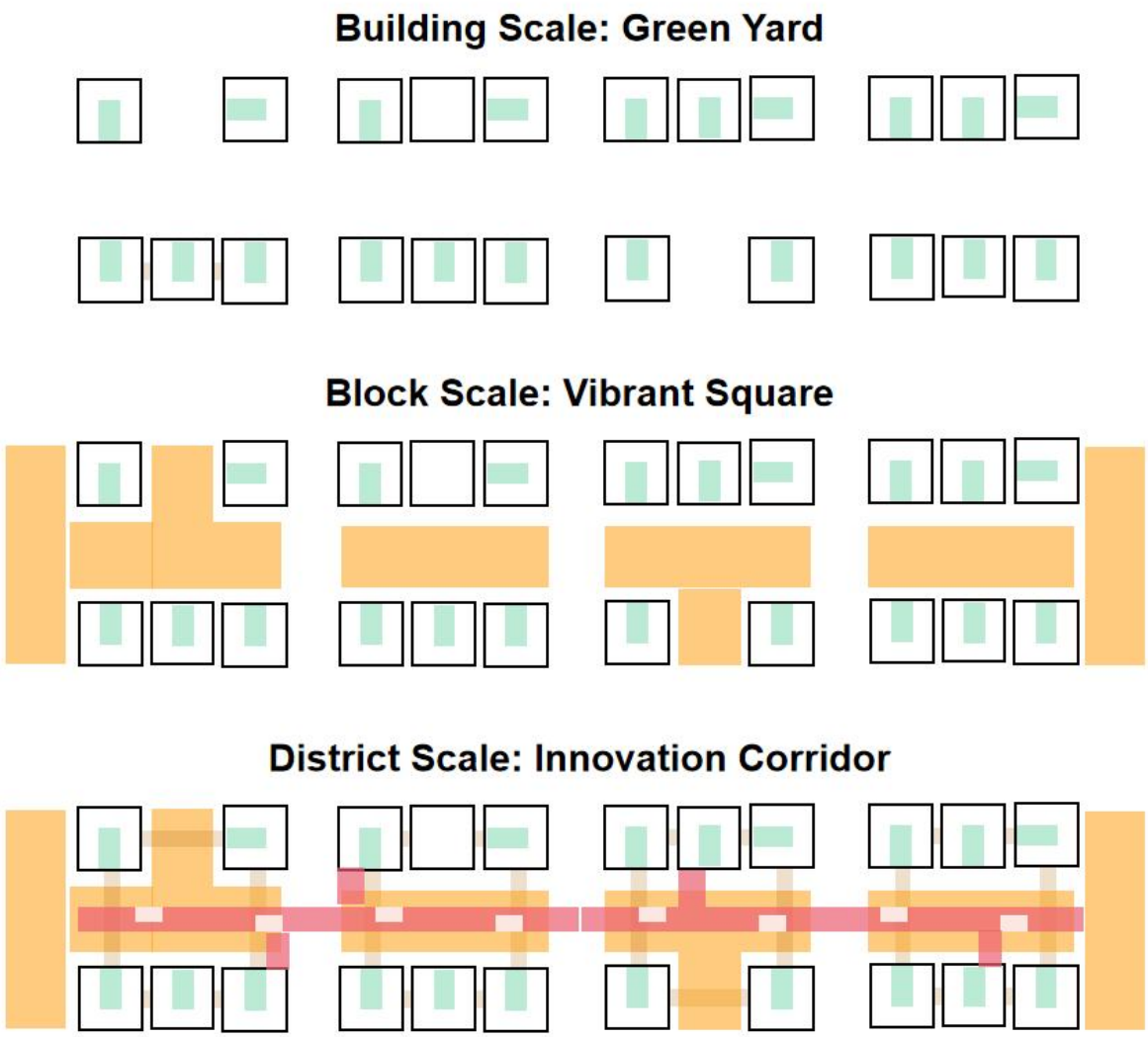


Fig 5-15: Three components of the public space system

At the building scale, green courtyard space can be divided into three types according to the shape of the courtyard, the proportion of green space and the distribution of street facilities. The rectangular courtyard prioritizes green space distribution and landscape effects, with walkways and lounge furniture as complementary features. A linear courtyard, on the other hand, prioritizes access and street seating, with green space as a secondary component. (Fig 5-16)

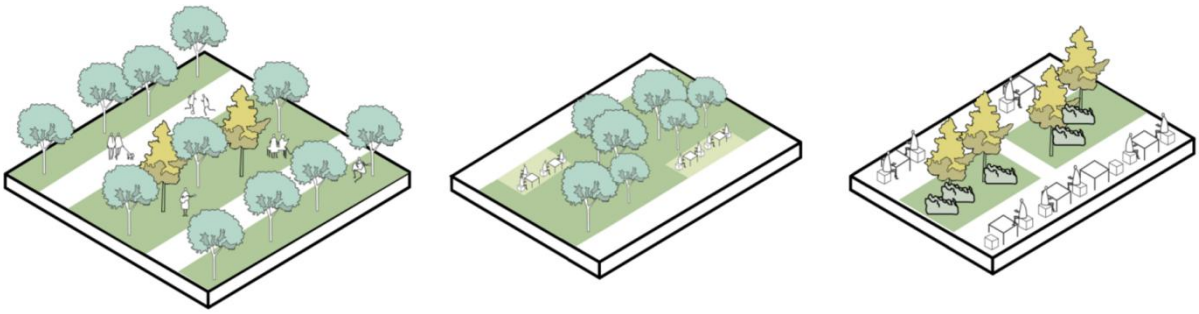


Fig 5-16: Three typologies of green yards

At the block scale, public space designs are tailored to different functions, complementing various thematic elements. The public spaces within the "Science and Technology Promotion and Application Service Block" emphasize technology displays and attracting crowds, thus adopting both a technology theme and a sports theme. (Fig 5-17)

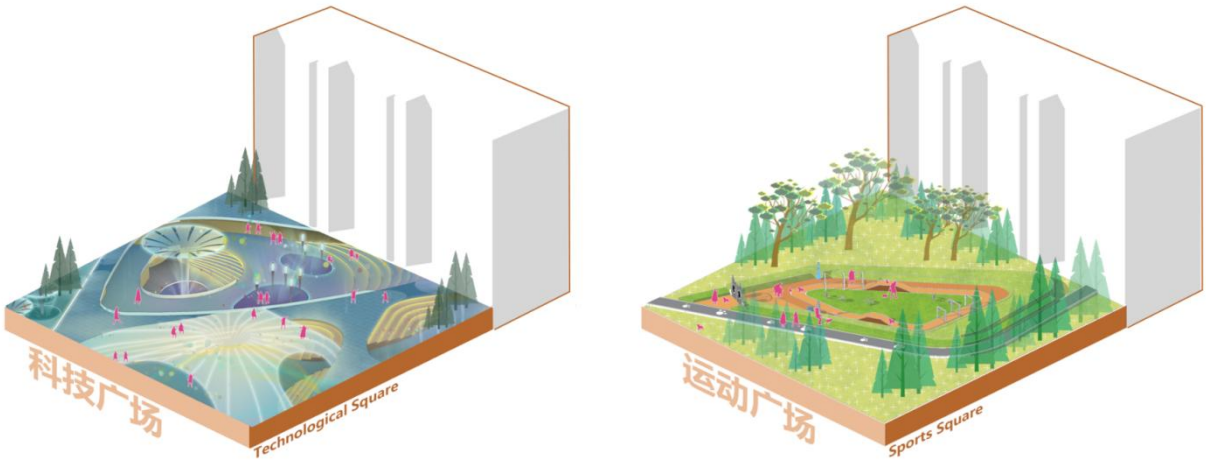


Fig 5-17: Two types of squares in Science and Technology Promotion and Application Service Block

The "Research and Experimental Development Block" prioritizes technical experiments and facilitating interactions, making it suitable for event-themed spaces and creative market-themed spaces. (Fig 5-18)

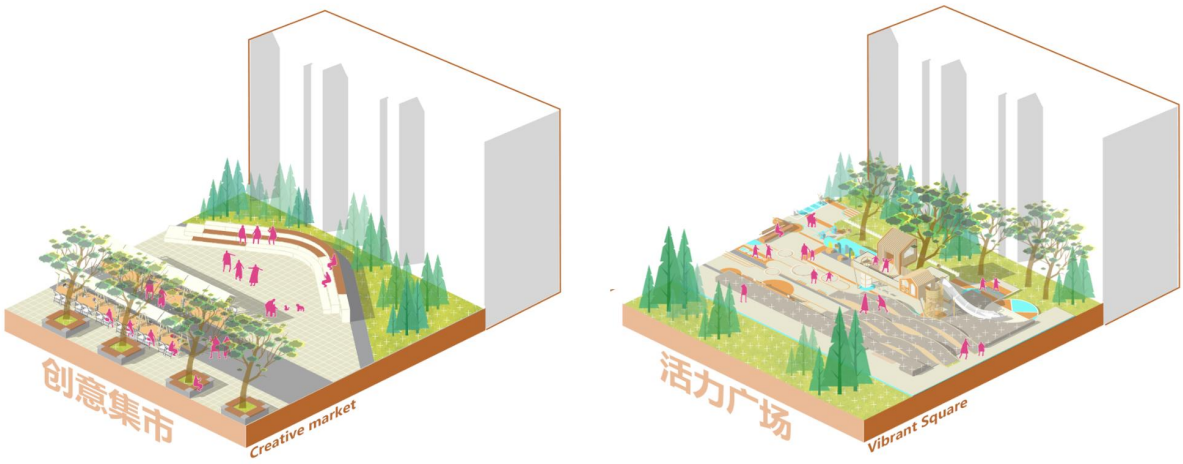


Fig 5-18: Two types of squares in Research and Experimental Development Block

As for the "Professional and Technical Education and Services Block," its public spaces should serve as educational hubs, focused on popular science education, thus adopting themes related to popular science and sustainable energy. (Fig 5-19)

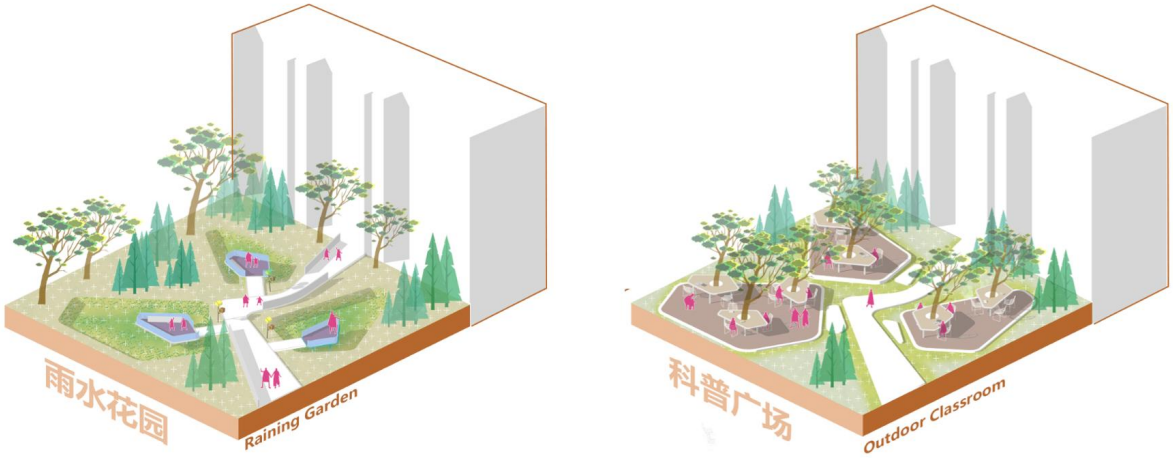


Fig 5-19: Two types of squares in Professional and Technical Education and Services Block

The innovation corridor runs through the entire innovation district, serving as a link between different building clusters. The corridor creates a weatherproof and informal social space. It features various thematic atmospheres through color changes and material textures. Inside the corridor, there are resting furniture, interactive installations, and scientific exhibitions, with shared rooms distributed in some areas for collaborative use. (Fig 5-20)

Fig 5-20: Elements in innovation corridor

Therefore, the design can form three blocks of public space system with their own characteristics. Block 1 and Block 3 has a rich spatial structure to support the communication in and around the innovation distirct, making connection to the campus. Block 2 has a rich spatial structure to support the communication between campus and the district, making the campus more open to the innovation district.

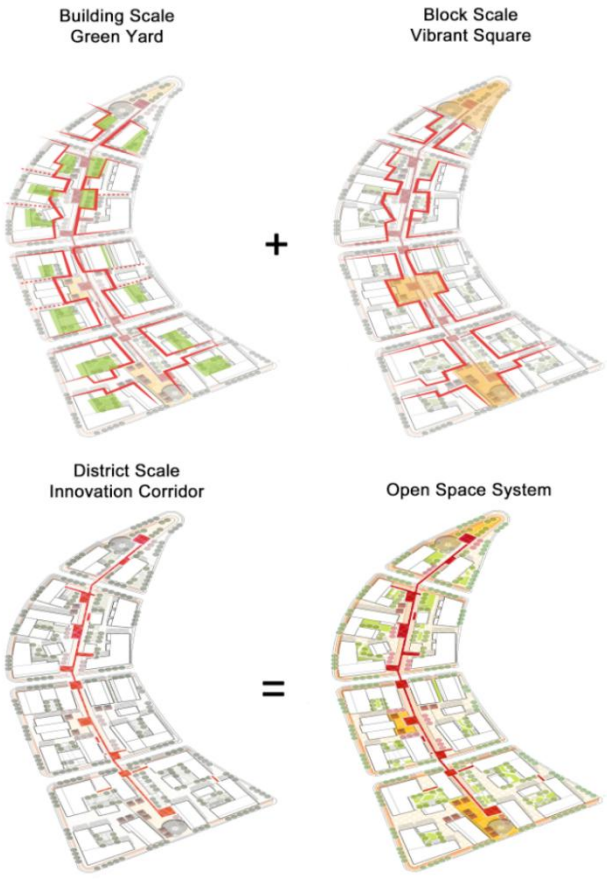


Fig 5-21: Open space system of Block 1

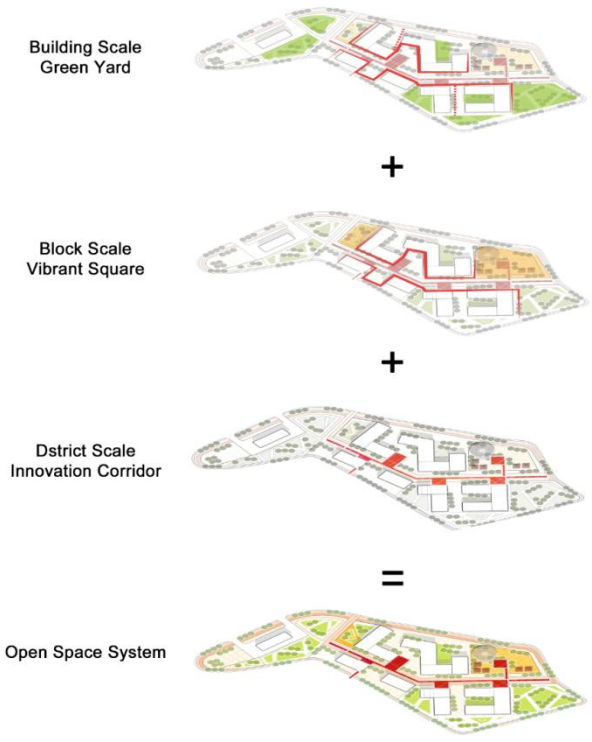


Fig 5-22: Open space system of Block 2

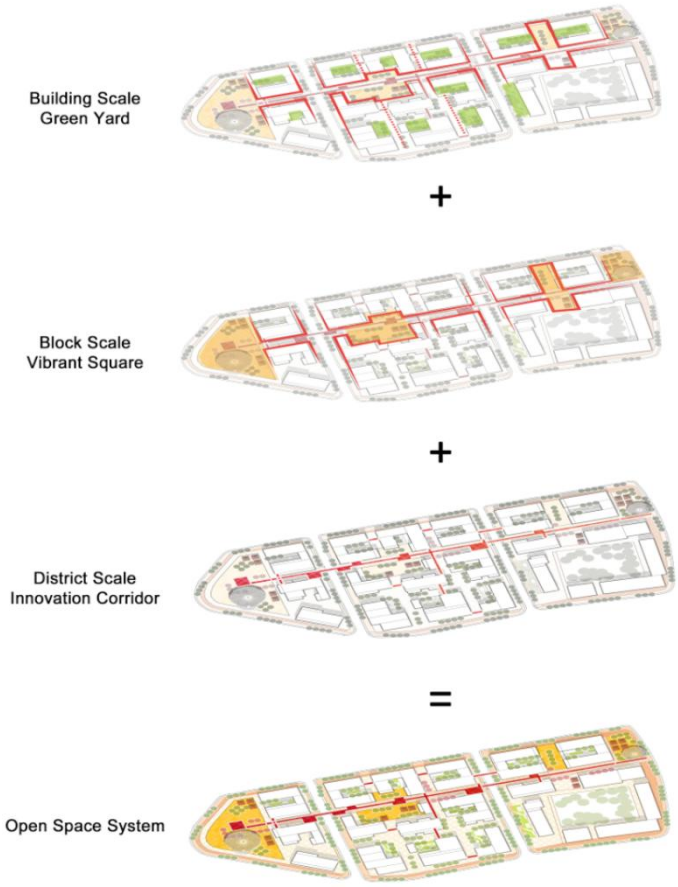


Fig 5-23: Open space system of Block 3

5.4.4. Build accessible transportation system

While establishing a system of public spaces and removing physical barriers, it is necessary to reorganize the road system to enhance accessibility. Due to physical barriers such as differences in terrain and enclosed communities, which hinder the flow of people and affect the street landscape, it is essential to first remove these obstacles and reestablish the spatial connection between the campus and the innovation district.

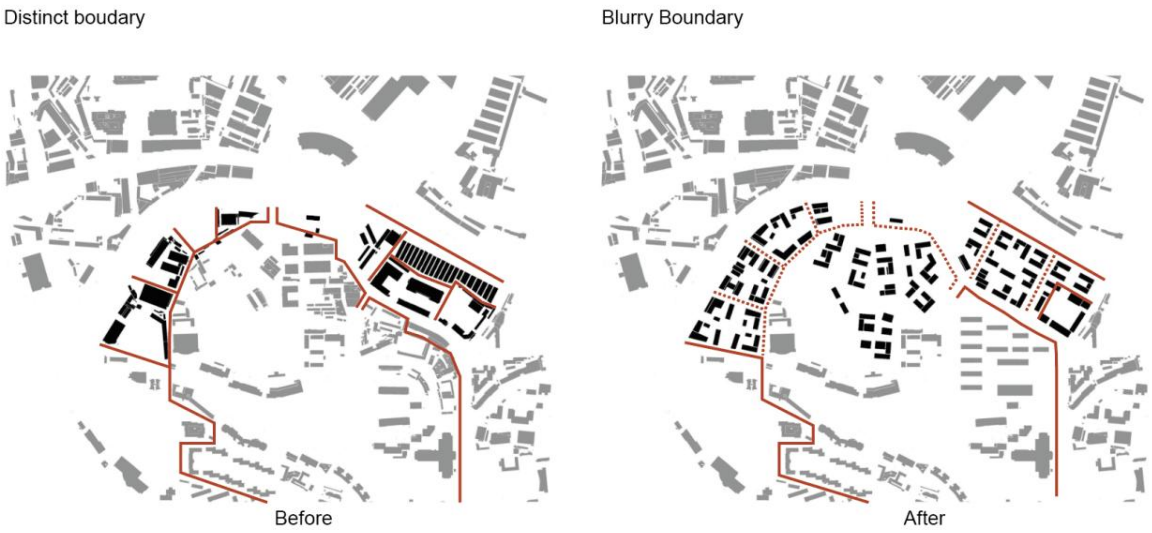


Fig 5-24: From distinct boudary to blurry boundary

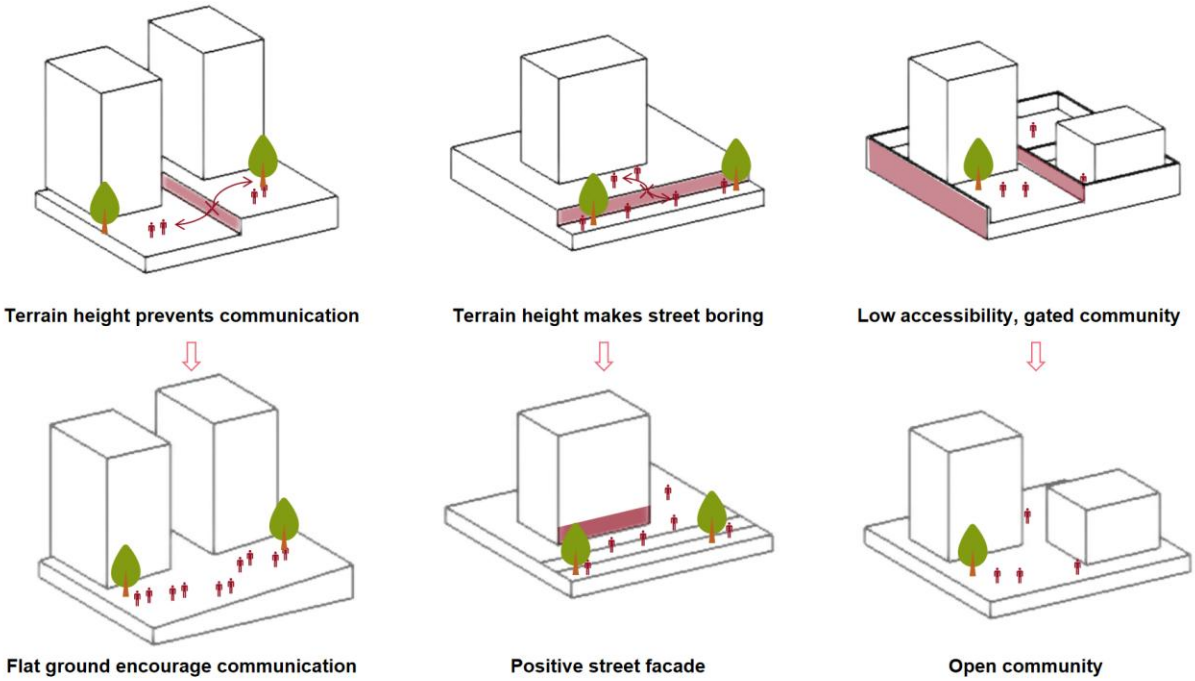


Fig 5-25: Three ways to blur boundary

The existing site has several dead-end roads, so reconfiguring the road system and addressing the isolation caused by changes in elevation is essential to improve the accessibility of the spaces on both sides of the campus boundary.

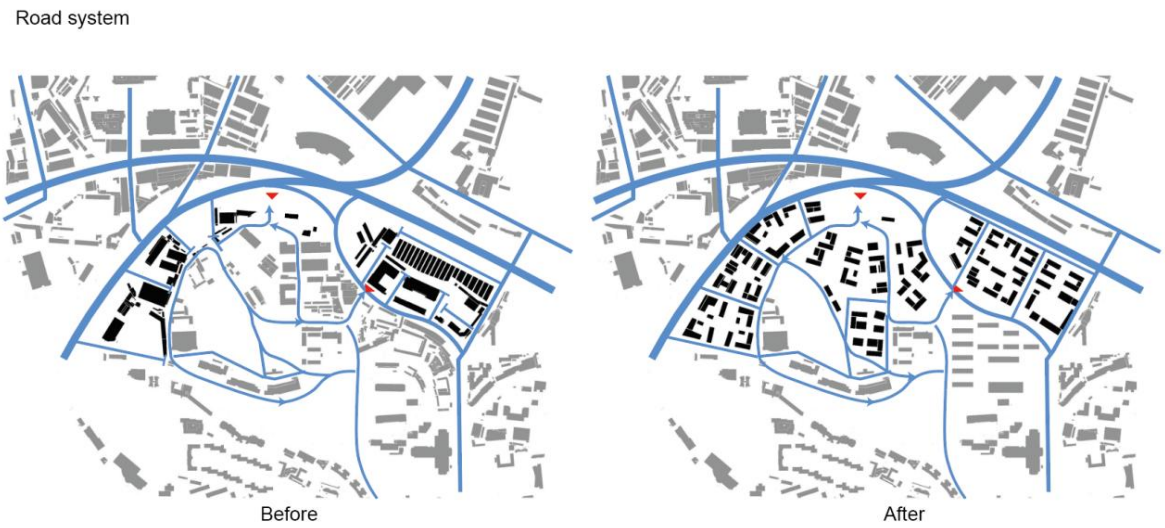


Fig 5-26: Road system before and after

The transportation system within the Tianhe Changban Plot needs to improve its accessibility, which is currently low. The design of public flow aims to address the issue of limited accessibility between the campus boundaries caused by separate public transportation systems. By including the campus boundaries in the service scope and extending the transportation routes within the campus, it will facilitate the mobility of researchers between the north and south campuses of SCUT. On the other hand, it reduces the transfer time between campus public transportation and city public transportation, thereby enhancing the accessibility of the campus to the surrounding urban areas.

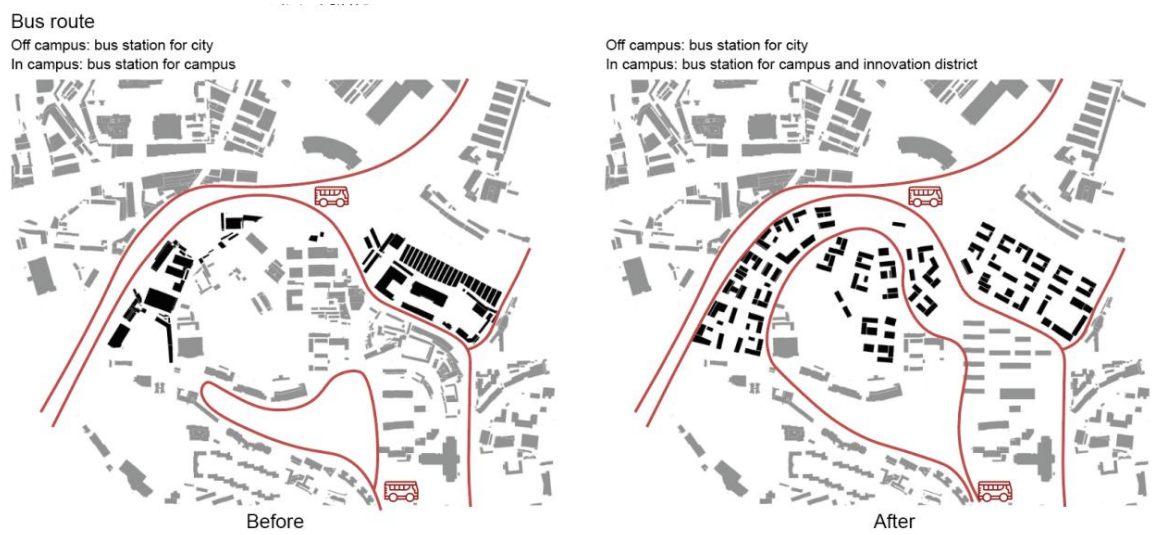


Fig 5-27: Bus route before and after

The design of bicycle flow aims to change the existing urban spatial condition that is unfavorable to bicycle transportation and contribute to the connectivity between the campus

and the innovation district. The innovation district is equipped with a dense network of bicycle lanes, creating a 1km linear transportation corridor that connects various functional zones and strengthens the connection between the district and the campus. This facilitates the mobility of personnel and promotes innovation exchange between research clusters within the campus boundaries.

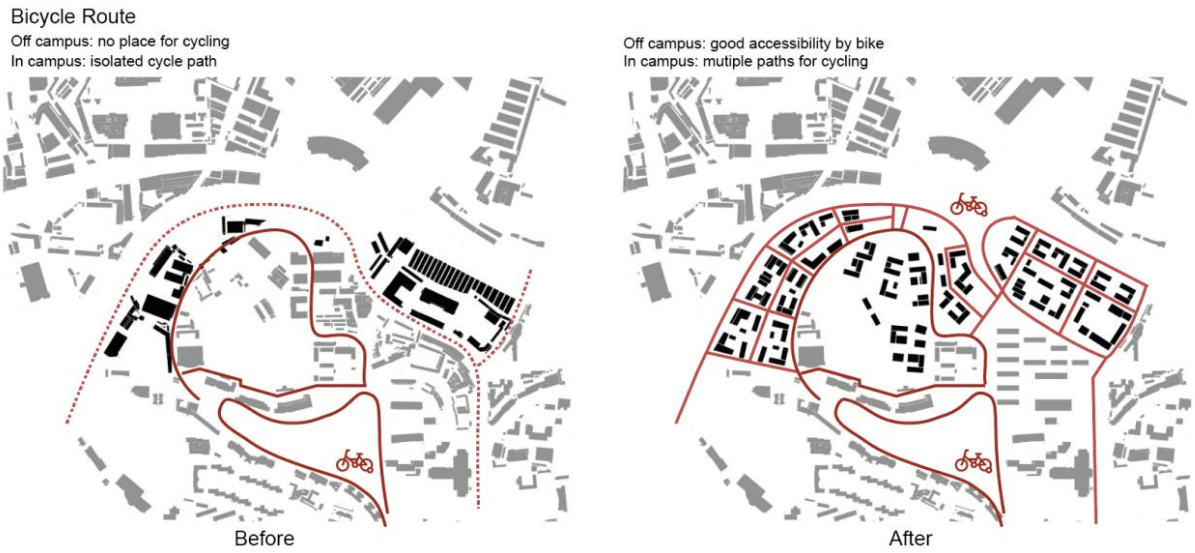


Fig 5-28: Bicyle route before and after

The design is not only create pedestrian-friendly and highly accessible streets but also has distinctive local character of the innovation district. The landscape design of the main roads will focus on technology exhibitions, utilizing lighting, screens, and models to display innovative achievements. Pedestrians and vehicles traversing these streets will directly experience the accomplishments and development outcomes of innovation. On the other hand, the landscape of the side roads will prioritize interactive engagement and technological experiences, using interactive floors, installations, and other means to test and promote innovative achievements. This design not only attracts active participation from pedestrians, allowing them to experience the joy and convenience brought by innovative technologies, but also serves as a platform to promote the development achievements of the innovation district to residents and tourists alike.

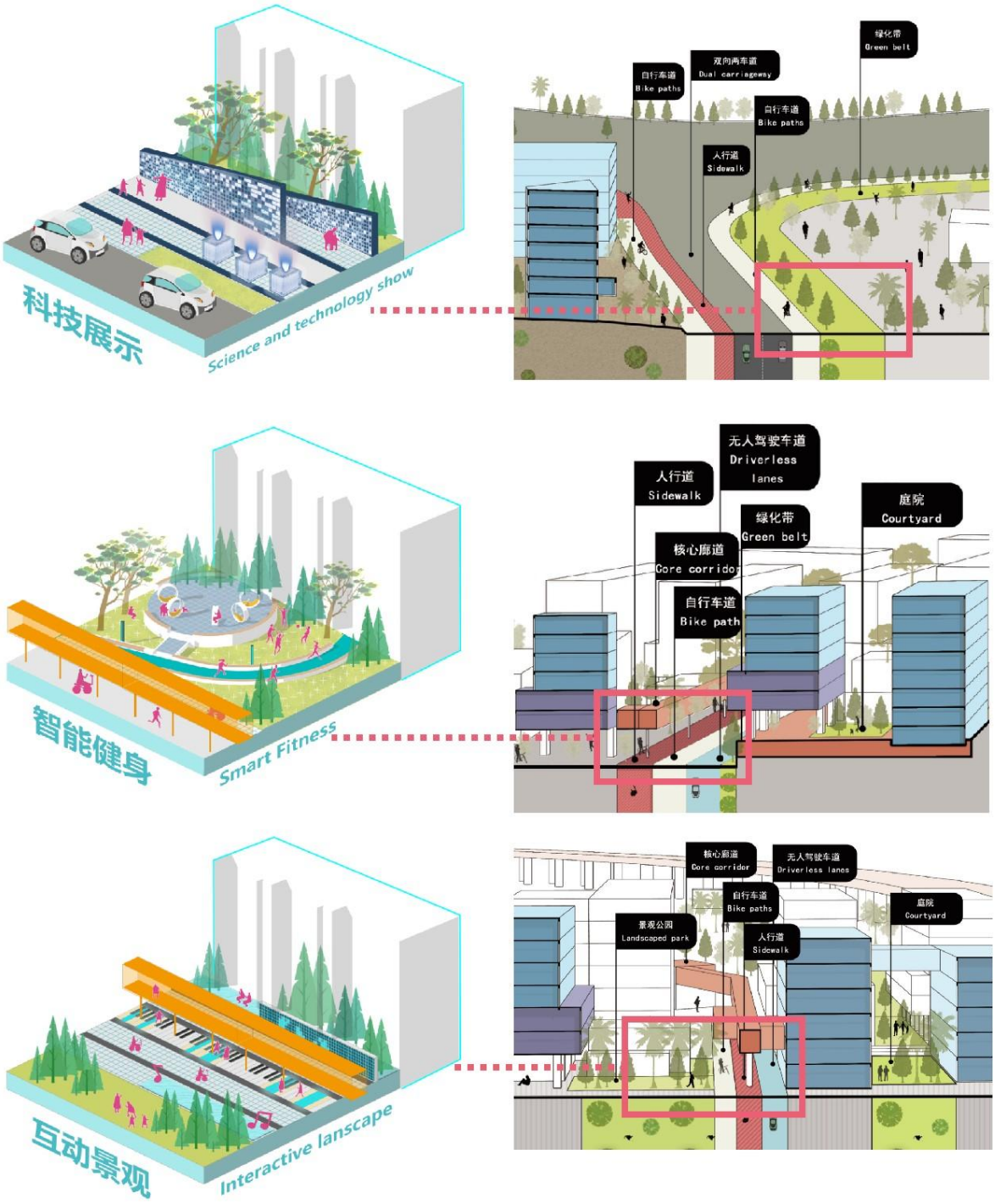


Fig 5-29: Three themes of street scences

5.4.5. Phased plan

Currently, SCUT is facing challenges related to insufficient space for innovation, as well as shortages of faculty and student housing. The construction of the innovation district can drive campus regeneration and facilitate university-enterprise cooperation in establishing the

innovation district. In the first phase of development, the government and the university are the main developers, focusing on constructing innovation spaces within the Tianhe Changban Plot. These spaces are intended to provide office facilities for technology and innovation companies, as well as startups. During the second phase of development, the university takes the lead in constructing faculty and student housing, aiming to enhance the living space for innovation professionals in the northern boundary campus area of SCUT. In the third phase of development, the university continues as the primary developer, with a focus on building laboratories and office buildings in the campus area adjacent to the Tianhe Changban Plot. The goal is to improve the spatial quality of the current experimental clusters, increasing the number and capacity of laboratory buildings. The construction goal is to promote urban regeneration through anchored universities, promote educational innovation and upgrading through cooperation between cities and universities. Therefore, they can jointly promote the construction of innovation districts, and form an influential knowledge-based community.

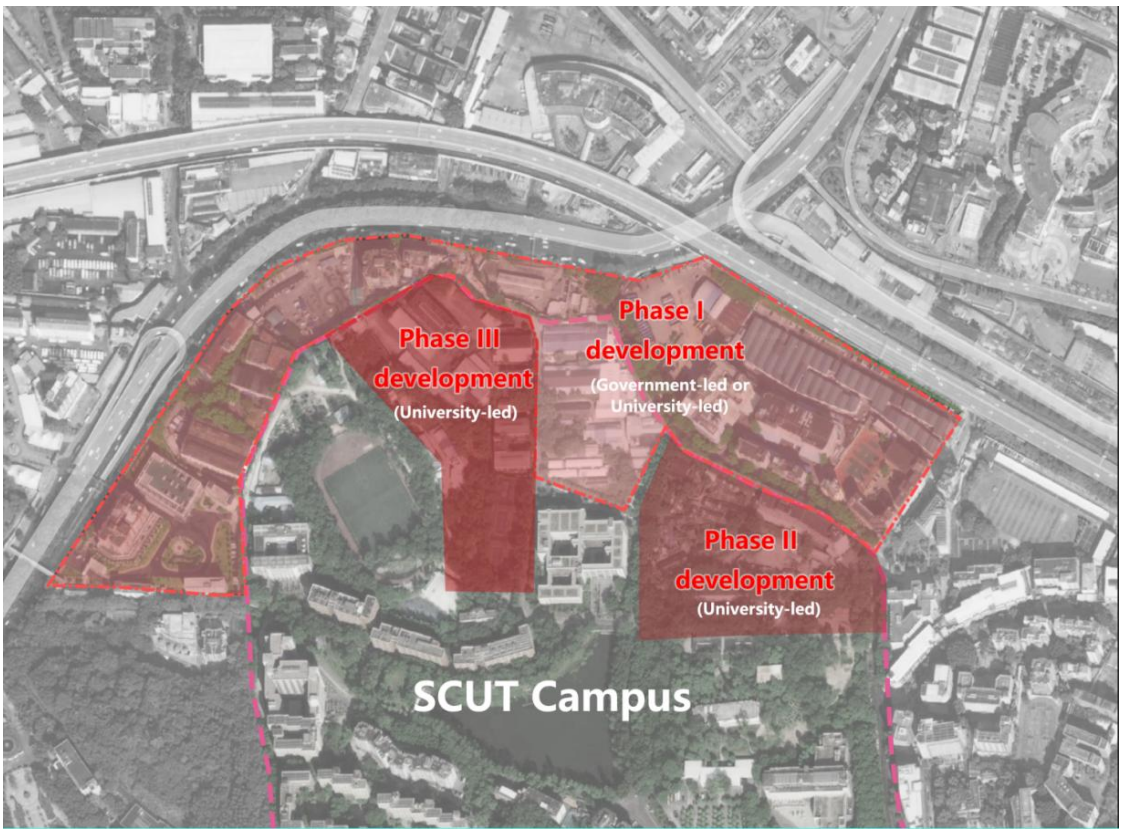


Fig 5-30: Regeneration scheme under the background of innovation district constrution

Chapter 6 Design of Peri-SCUT Innovation District

6.1. Typology generation

From the perspective of the city-university relationship, the innovation district model seeks to establish its identity by synergizing existing innovation resources within the central urban area. Leveraging the concentration of universities and communities in this region, an open-campus approach is embraced to facilitate the expansion of university functions into the urban area, encompassing both the community and industrial park. This results in a dynamic zone that intertwines functions and overlaps spaces, effectively embodying both a university and a city. Through enhanced functional integration, the district becomes increasingly appealing to innovative and entrepreneurial enterprises, thereby raising their expectations of the spatial benefits it offers. This, in turn, contributes to the establishment of a robust innovation engine within the central urban area, propelling its growth as a major center for innovation.

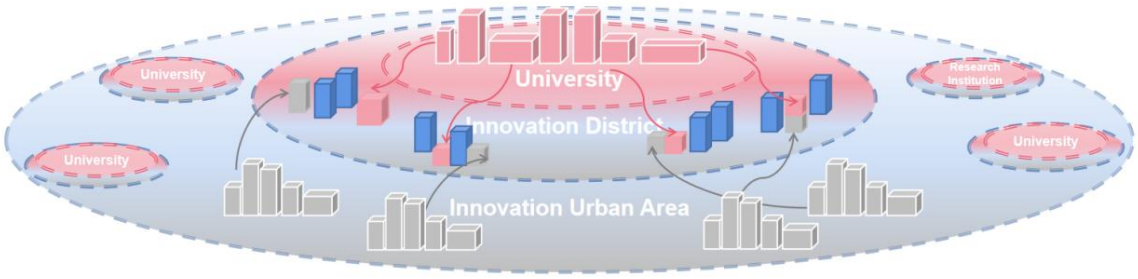


Fig 6-1: Typology pattern diagram of “anchor+” innovation district

As the anchored institution, SCUT serves as the primary source of innovation for the Peri-SCUT Innovation District. By fine-tuning the morphological pattern diagram, taking into account the physical boundaries of the plots, the design creates a dynamic zone where functions intertwine and spaces overlap, effectively serving both as a university and a vibrant city hub, as depicted in the diagram below. Furthermore, the design incorporates a section of the campus into the ongoing regeneration plan for the innovation district. This collaborative effort between the university and the district aims to elevate the spatial quality of educational facilities and expand the area dedicated to cutting-edge research and well-equipped office spaces. Additionally, the co-run area, serving as a pioneering experiment for open-campus

development, maintains a close connection to the Peri-SCUT Innovation District. With a primary focus on research and office spaces, complemented by innovative and consultative services, it serves as an experimental hub for fostering industry-academia collaboration, with SCUT firmly anchored in this endeavor.

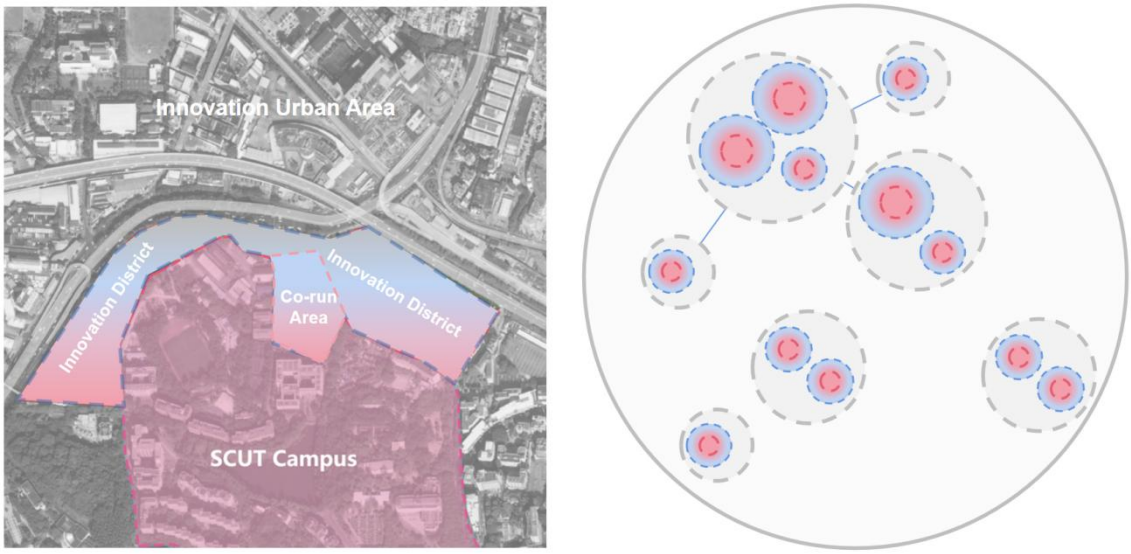


Fig 6-2: Typology pattern diagram of Peri-SCUT innovation district

6.2. Morphology generation

Based on the basic geographical information of the plots, the design forms a linear configuration with a total length of 1 km, connecting eight basic building clusters with a diameter of 150 meters each. By integrating the innovation functional zone model and the public space model, a 1 km long innovation corridor can be derived.(Fig 6-3)

Due to its location in the Wushan area, the site has rich variations in elevation. Through on-site investigations, it was found that there are several steep slopes from south to north within the original plot, resulting in isolated and enclosed building clusters at different heights. Based on the principle of spatial coherence in the district, the design involves excavation and backfilling of the site to achieve a balance between economy and practicality.(Fig 6-4)

After earthwork balancing, by opening up dead-end roads and adding internal branch roads on the existing road basis, a continuous street network is formed within the Changban plot. The Changban plot has truly become a transitional zone connecting the city and the university, achieving the integration of the SCUT campus and the city.(Fig 6-5)

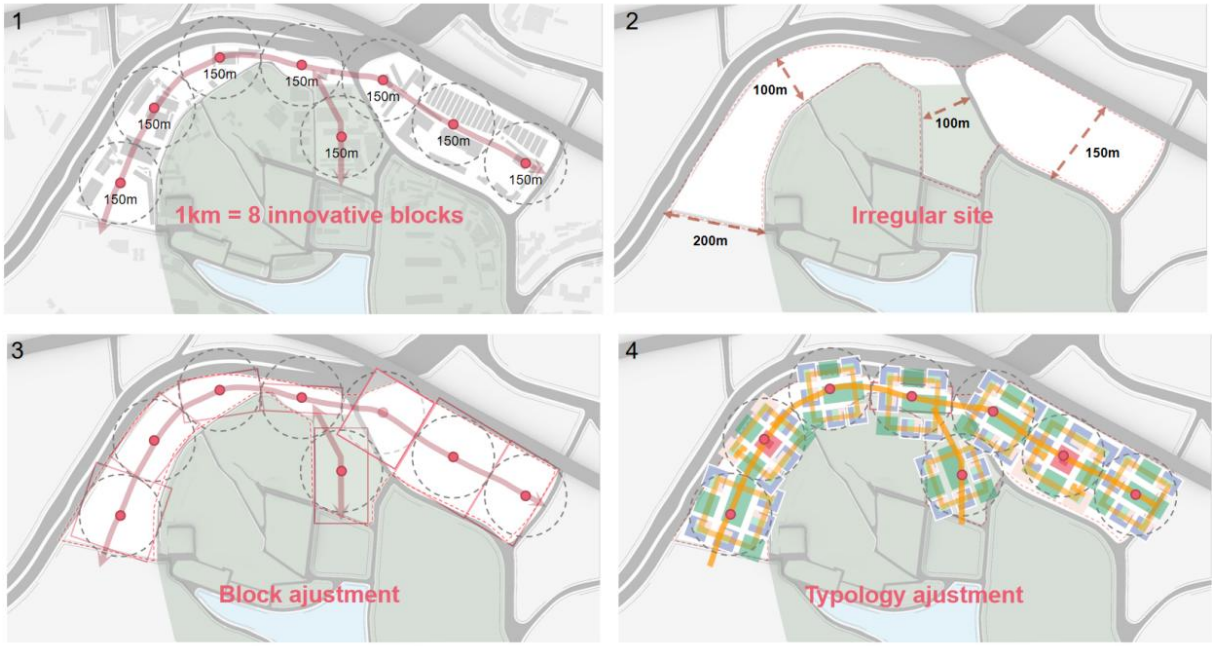


Fig 6-3: Morphology generation based on geographical information

Fig 6-4: Earthwork balance before and after

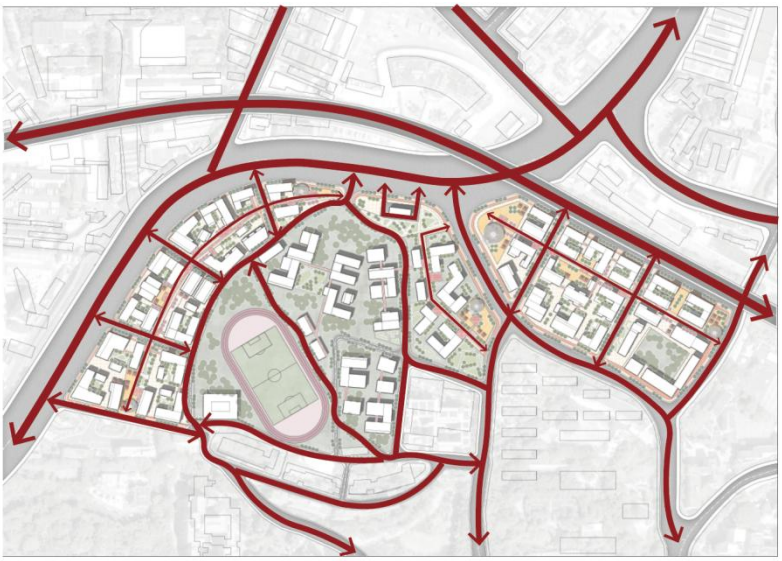


Fig 6-5: Road structure

6.3. Masterplan

Fig 6-6: Masterplan of Peri-SCUT Innovation District

The master plan showcases the overall layout of the Peri-SCUT Innovation District, a low-rise, high-density open neighborhood strategically situated around the northern boundary of SCUT's campus. This innovation space seamlessly integrates with the organic campus structure of the university, weakening distinct geographical boundaries or unique spatial structures. The district primarily focuses on scientific research and applied experimentation, while also encompassing functions such as consulting and public education. Additionally, the design includes a conceptual representation of the adjacent campus area, envisioning the future creation of an integrated innovation cluster that seamlessly merges with the university's campus. As an important node of the Peri-Wushan Innovation Urban Area, the Peri-SCUT Innovation District aims to become a model of integration for education, industry, and the city.

6.4. Block 1 design

Block 1 is the transition space between Yanling Road and the boundary of South China University of Technology. The site functions as research and experiemental development, The cluster has four industries: eletronic engineering, papermaking, mechanical engineering and material science, which is similar to the formation function of scientific research groups in the university. One of these building clusters, shown below, will provide start-ups and smes with shared labs, enterprise collaboration platforms, and co-working Spaces to facilitate knowledge spillover and external technology presence on campus.

Fig 6-7: Loctaion and space proportions of the Block 1

From the perspective of volume generation, the design of the building group follows the site topography and the original road path, surrounded by C-shaped buildings to form several courtyards. Also, there is a university-enterprise cooperation center with display function and science popularization function. The ground floor of the office building is dominated by commercial services and facilities supporting services, creating a good scientific research atmosphere together with public space.

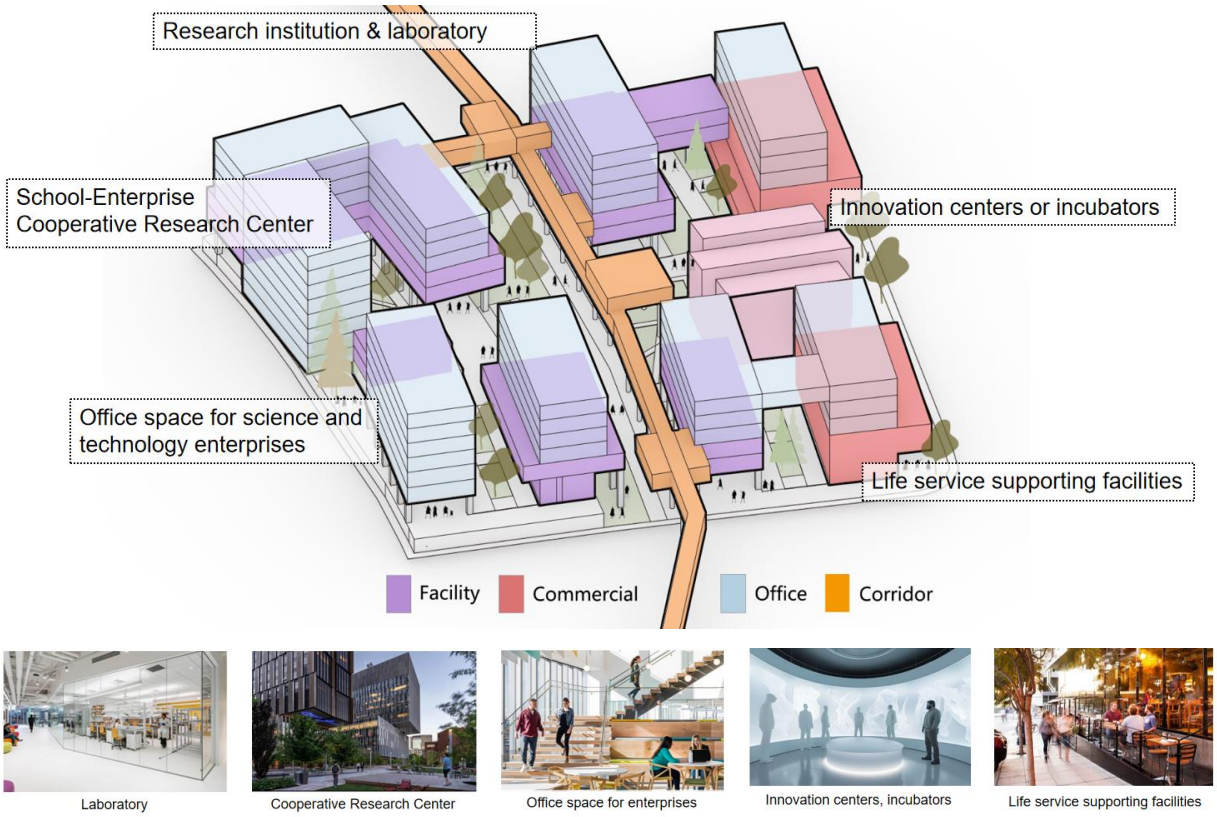


Fig 6-8: Function axonometry and scene intentions of a building group

The public space is an important space for the group's informal communication and product display and testing. Within this Block the innovation corridor will act as a traffic space connecting the buildings, as a wind and rain corridor and provide a shared learning space. The road below the innovation corridor is divided into sidewalks, bicycle lanes and unmanned lanes, which serve as a pilot area for the products of mechanical innovation enterprises, and also provide a variety of transportation options for the construction group commuting within the innovation block. The courtyard enclosed by buildings is the main place for enterprise interactive technology testing. Through intelligent facilities such as lighting control, landscape interaction, and sensors, information such as climate, human flow, and precipitation can be detected, which not only improves technology, but also promotes the landscaping of the park.

Fig 6-9: Scene 1 - People near innovation corrridor

The courtyard enclosed by the C-shaped building is the public space of the smallest unit and a leisure place for innovation talents. Large areas of greening beautify the environment, linear roads form access to the entrance, and street furniture is arranged along the paths, which is an important place for informal communication. In the courtyard, through the coverage of WiFi, people can leave social information in the environment to build a personal forum of the exclusive courtyard.

Fig 6-10: Scene 2 - People near innovation corrridor

The section design responds to the relationship between the site and the surrounding city. Section A-A embodies the following aspects: (1) The relationship between the block and the surrounding urban environment. The first is adjacent to Yanling Road. Through building setback, a buffer space was created to reduce noise and air pollution disturbances from the viaduct. At the same time, it creates conditions for technology display and crowd gathering activities along the urban road interface of the plot. (2) The green space within the block can be divided into three scale: linear street greenway, central green park and courtyard green space. The street's linear greenway creates a tree-lined landscape that provides a comfortable environment for walking and biking. The central green park within the street, adjacent to the core corridor, combines with the enclosed building to form an expanded node of public space, providing a place for activity and exchange. Enclosed courtyard green Spaces offer the highest level of privacy, and local hard surfaces provide informal meeting places for workers, bringing them closer to nature. (3) The design of the main motorized block roads and the inner streets dominated by non-motorized traffic is quite different. The road adjacent to Yanling Road is dominated by slow and friendly motorized driving, and the landscape is showy, while the internal road allocates part of the space to technical testing and focuses on the sense of experience, forming two street atmospheres with differences in scale, landscape and sense of experience.

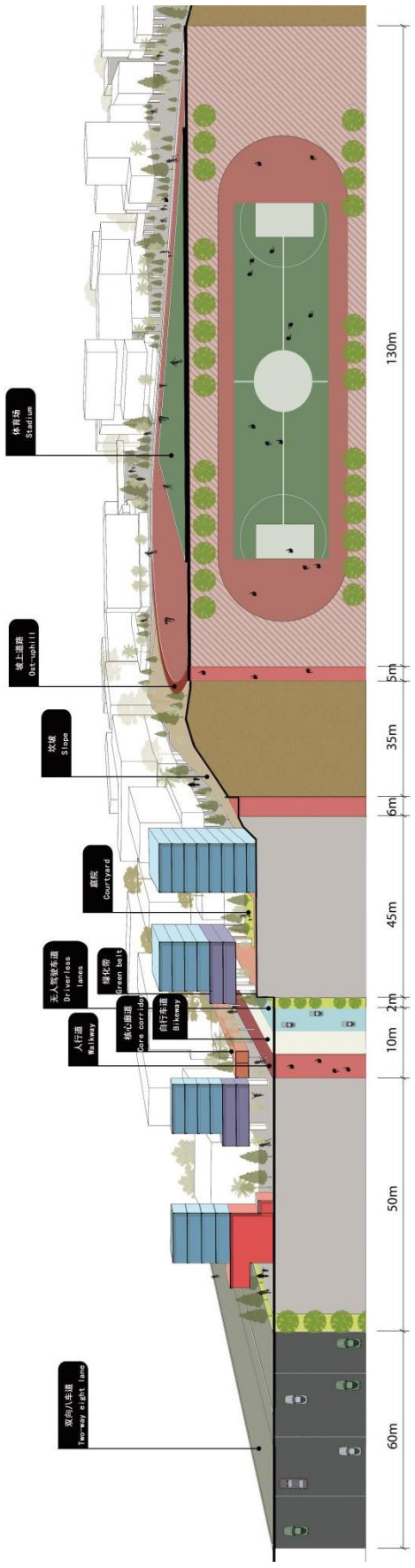


Fig 6-11: Section A-A

6.5. Block 2 design

Block 2 is the transition space between Changfu Road and the boundary of South China University of Technology. The functional orientation of the site is technical services. Besides the consulting departments with four types of industries, there are also legal and accounting consulting departments. It is an important base for anchored institutions to provide services in the site and improve course design and discipline development. The following figure shows one of the building groups, which will provide technical consulting, legal consulting, accounting services for start-ups and small and medium-sized enterprises, and provide technical and legal support for knowledge spillover and external technology on campus.

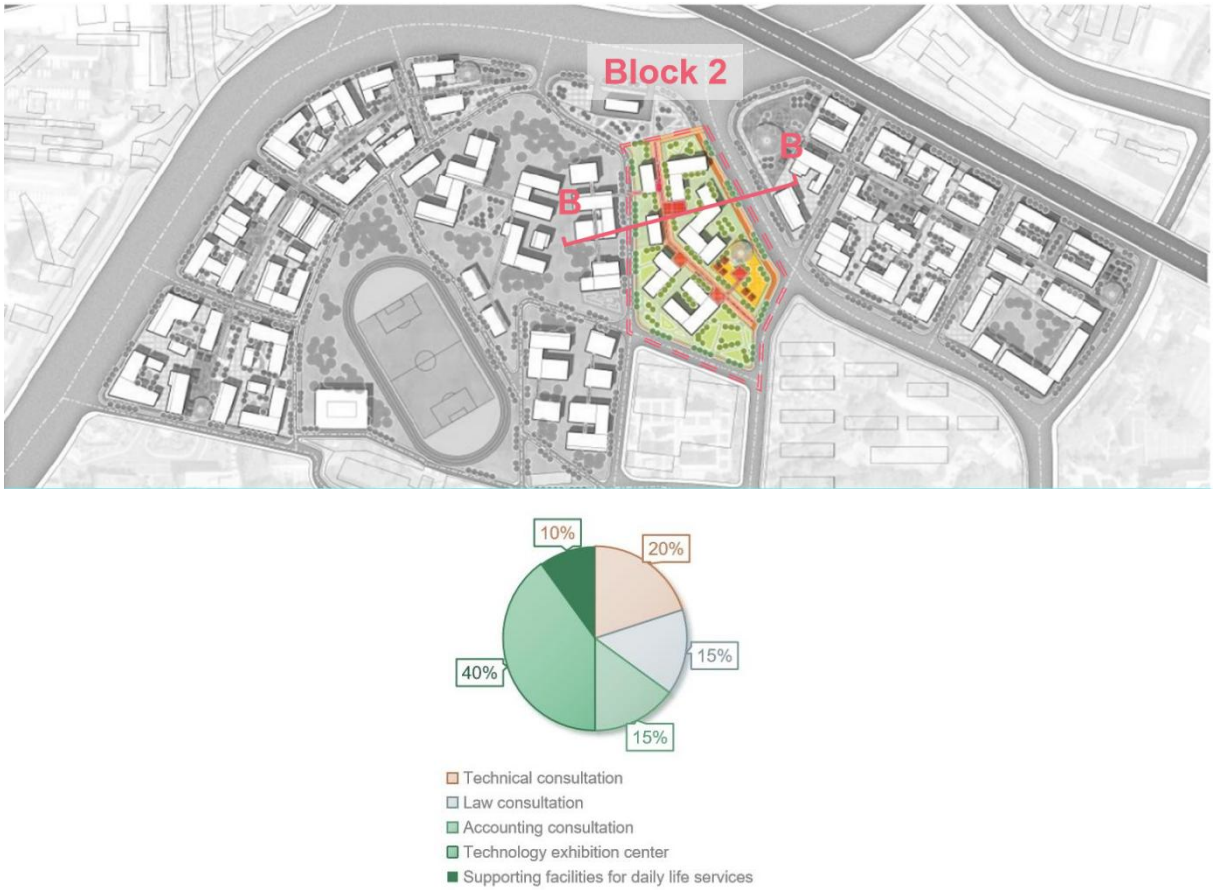


Fig 6-12: Loctaion and space proportions of the Block 2

From the perspective of volume generation, the design of the building group follows the site topography and the original road path, and the buildings are arranged in a fishbone shape along the central axis and enclosed to form a courtyard for communication. Since there is a subway line construction plan in the southeast of the plot, there are no buildings within 15m

above the plot, and they are covered by green Spaces and squares, which meets the requirements of urban construction. It also forms a vibrant square that promotes the integration of the campus and the innovative district. The ground floor of the building is mainly for consulting services and commercial facilities supporting services, while the upper floor is for scientific research office and professional practice teaching land. As a co-construction part of the university's participation in urban regeneration, the group belongs to the university, and at the same time, it becomes an important node in the innovative block with an open block form.

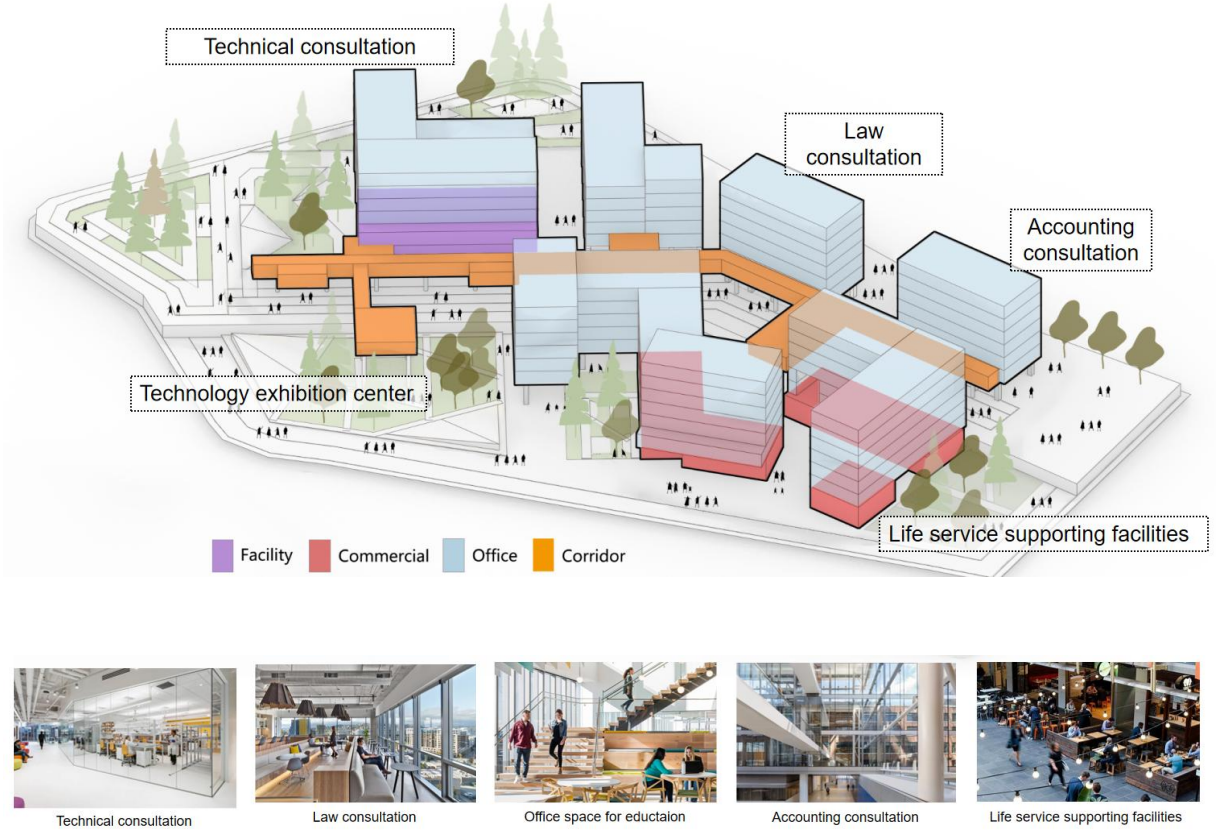


Fig 6-13: Function axonometry and scene intention of a building group

Public space is an informal place where the theories and practices of anchored institutions are combined. In this block, in addition to the innovation corridor, the public space has also become a container for activities. Through curriculum innovation and space opening, regular lectures with popular science and professional threshold are held, and it has become an important place for free sharing or paid consultation. As the following figures shows, the southeast corner of the site is adjacent to the campus, and below the square, there is a subway line passing through. Through design concessions, a science popularization

square is formed.

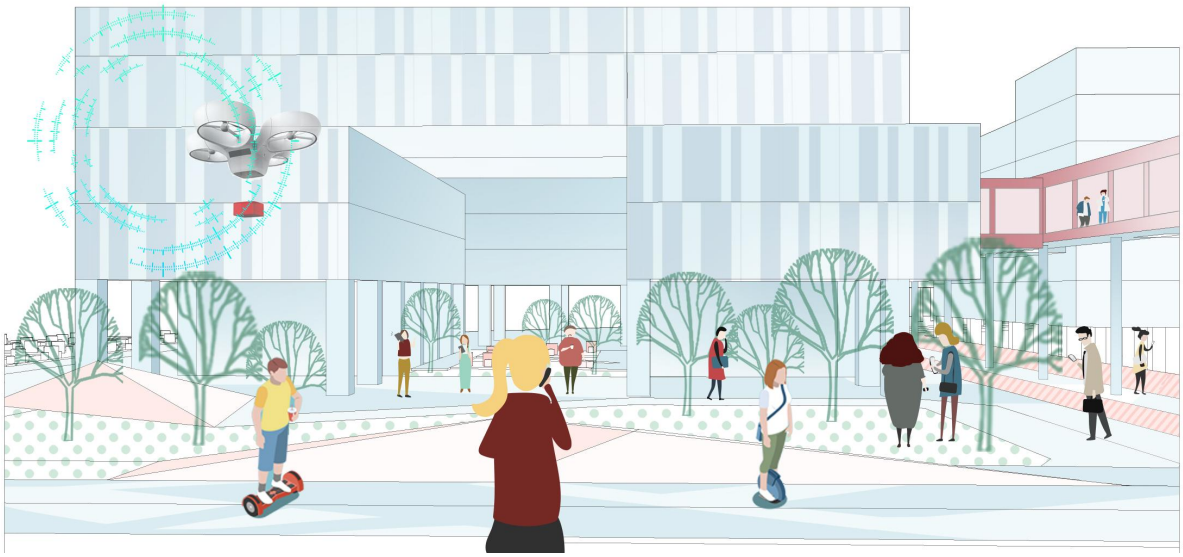


Fig 6-14: Scene 1 - People in the square

The undulating terrain on both sides of the Outdoor Classroom Square creates an enclosed landscape and defines the spatial boundaries, providing a unique sense of place for the square. The greenery in the square emphasizes sustainable development, and the runoff design of the rainwater garden contributes to science popularization and education. Additionally, this is an experimental base where the innovation district integrates with the open campus. Therefore, by installing sensors to monitor the behavior of people in the district, it can also help shape a safe and open boundary to a certain extent.

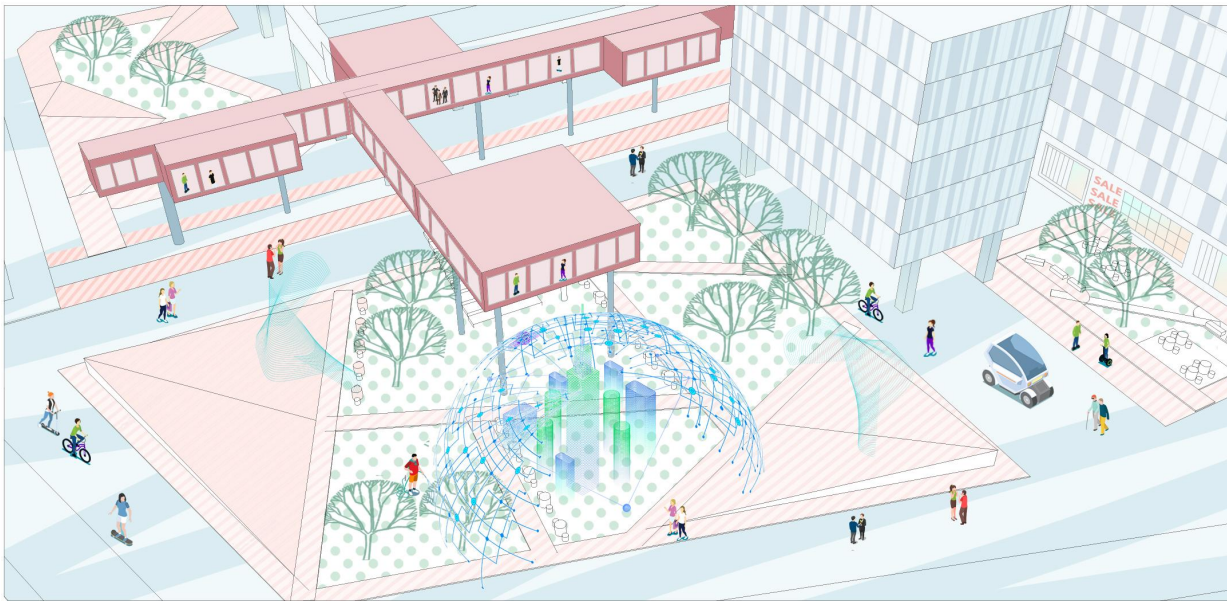


Fig 6-15: Scene 2 - Aerial view of the Outdoor Classroom Square above the subway line

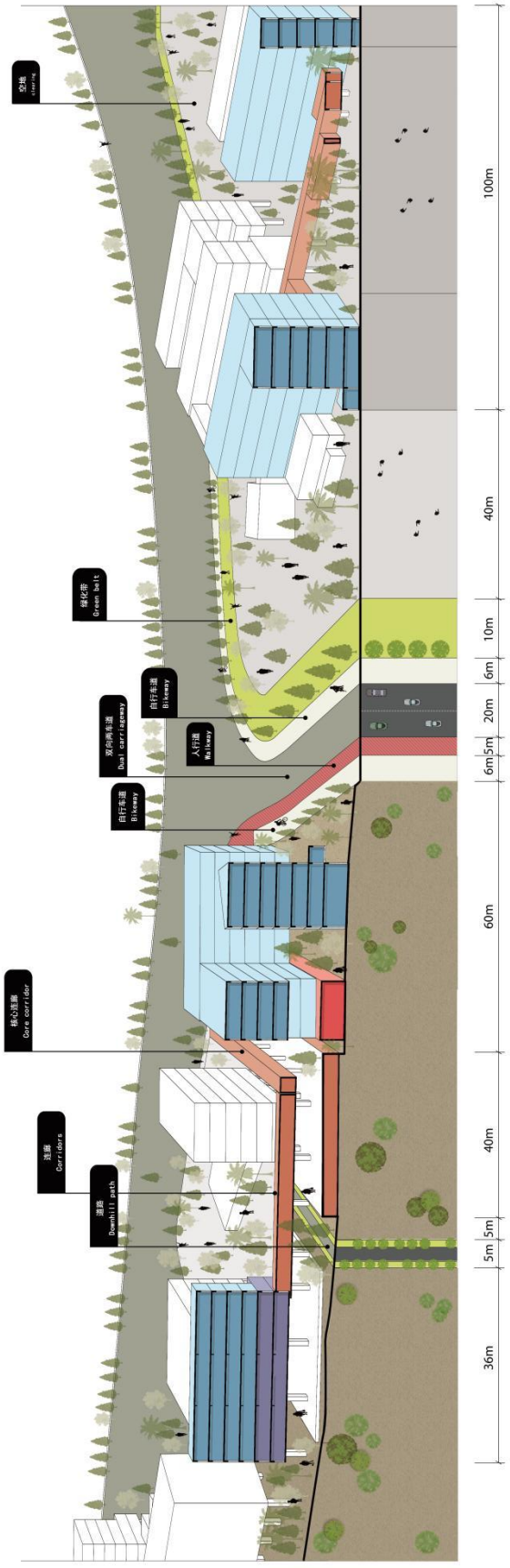


Fig 6-16: Section B-B

Section of the Block 2 shows the integration of campus and innovation district. As an important part of campus regeneration to integrate into the construction of innovation district, Block 2 is next to the east gate of the Northern campus, which is the experimental base for building an open campus. The lower floors of the building are freely accessible and are collaborative Spaces for students to practice professionally and businesses seeking consulting services. The square within the block serves as a dynamic place at the university's boundary, equipped with running tracks and sports facilities, as well as a venue for exchange activities, attracting creative people and surrounding residents.

6.6. Block 3 design

Block 3 is the space between Changfu Road and Shen-hai Expressway Guangzhou branch. The function orientation of the site is science and technology promotion and application service, gathering offices of large and medium-sized enterprises with four types of industries and school-enterprise cooperation platform, which is a space for intensive research and development and rapid transformation of production and research. It provides a platform for small and medium-sized enterprises and start-ups to cooperate upward. The picture below shows one of the buildings, which will provide office space, experimental bases and technology display centers for large and medium-sized enterprises.

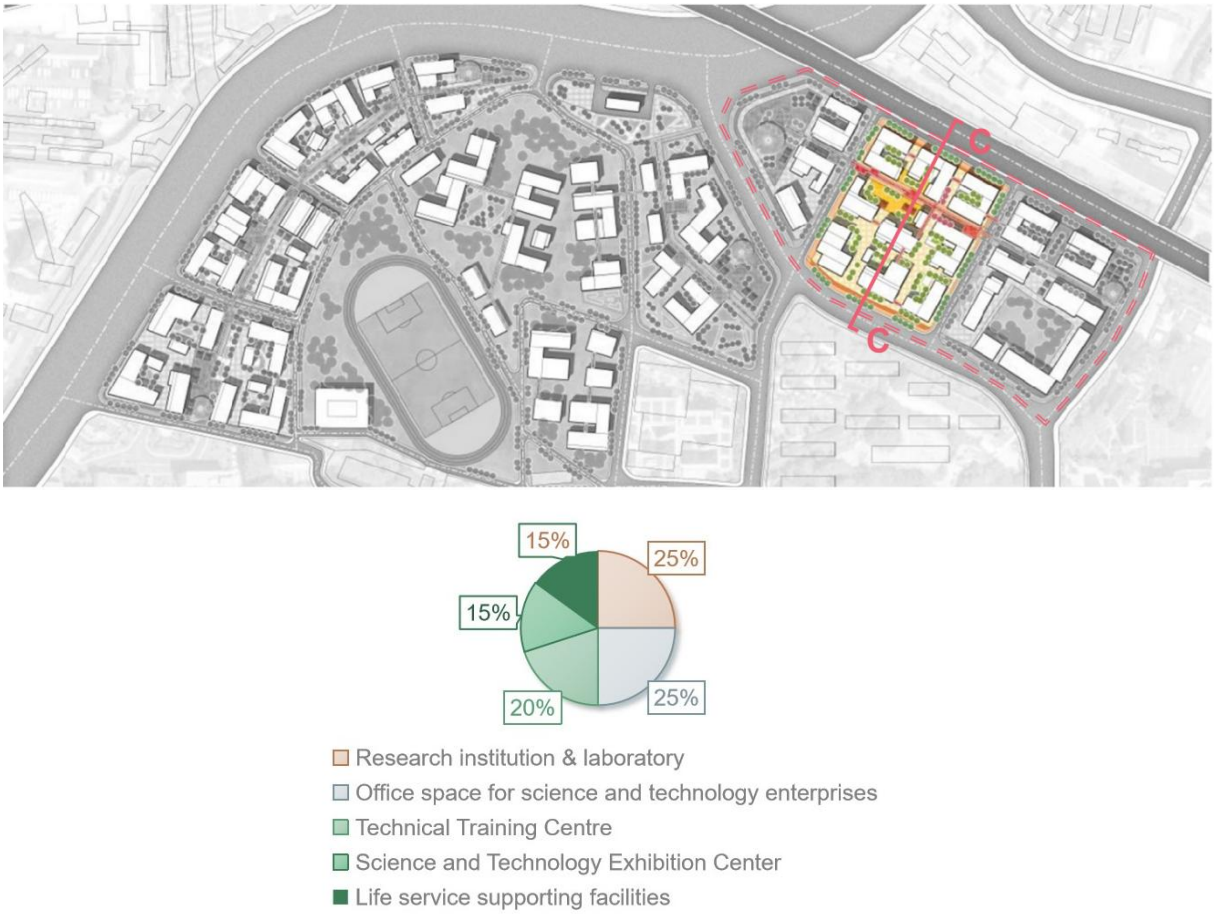


Fig 6-17: Loctaion and space proportions of the Block 3

From the perspective of volume generation, the design of the building group follows the site topography and the original road path, forming an average grid layout. The public space within the group has rich levels, which is conducive to stimulating informal communication

among innovative people. The ground floor of the building is mainly for consulting services and commercial facilities supporting services, and the upper floor is for scientific research office.

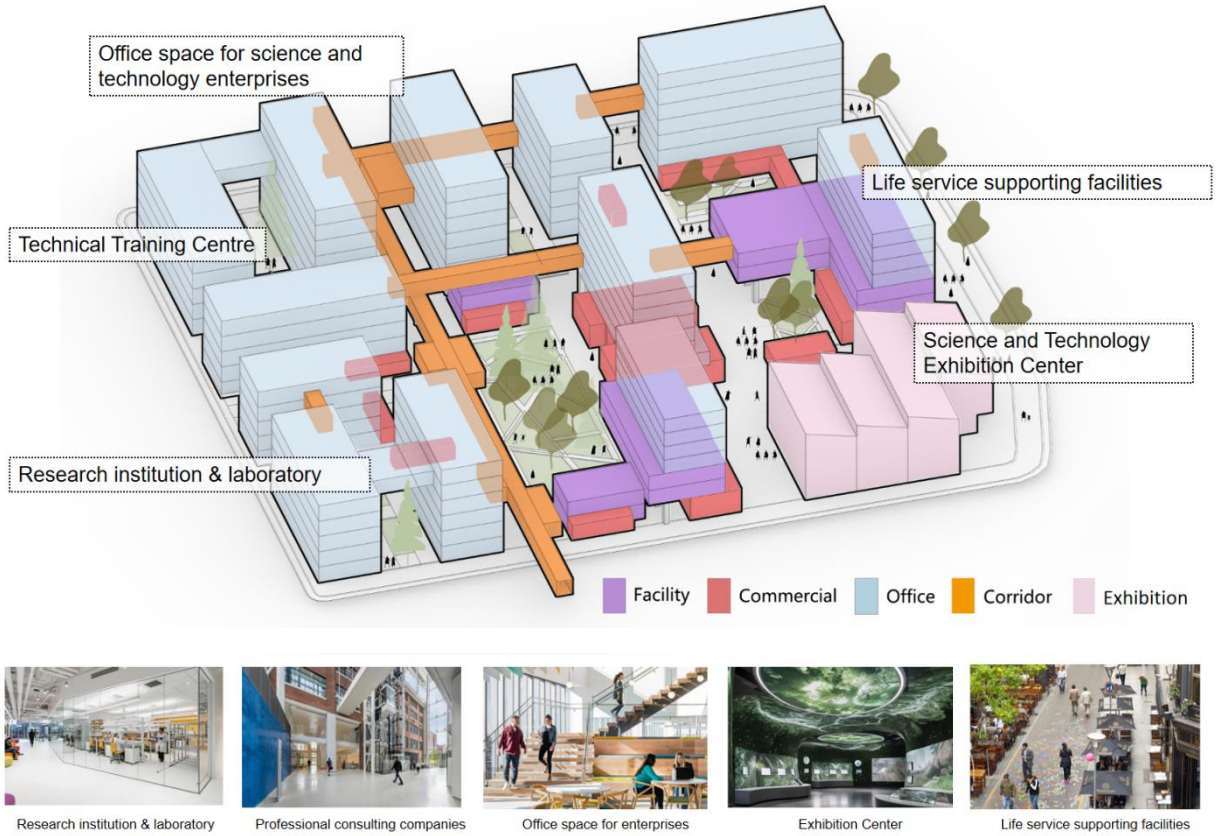


Fig 6-18: Function axonometry and scene intention of a building group

Fig 6-19: Scene 1 - People meet in the central square

The square in the center of the site, as a gathering place of science and innovation, has a certain life atmosphere and commercial heat. As an important node along the innovation corridor, human-computer interaction and increasing the fun of activities are realized by embedding the intelligent landscape.(Fig 6-19)Another vibrant courtyard in the group is an external extension of the exhibition space, which can serve as a place for technology display and creative activities.(Fig 6-20)

Fig 6-20: Scence 2 - People in the commercail yard

The C-C section is shown in the following figure: (1) It reflects the relationship between the block and the surrounding urban environment: Block 3 is adjacent to the Guangzhou branch of the Shenhai Expressway. By creating building setbacks and planting green belts, a buffer space is created to reduce the noise and air pollution interference from the elevated bridge. At the same time, it also creates conditions for future activation and linkage of the under-bridge space between the block and the elevated bridge. (2) The innovation corridor combines pedestrian paths, bicycle lanes, and lanes for autonomous vehicles to form the central axis of the site, creating a three-dimensional pedestrian space and interactive space. The central green park within the street, adjacent to the core corridor, is integrated with enclosed buildings to form an expanded public space node, providing a place for activities and interactions. (3) The interior of the block prioritizes non-motorized traffic, encouraging walking and public activities, while the exterior of the block forms a traffic loop connected to the city roads.

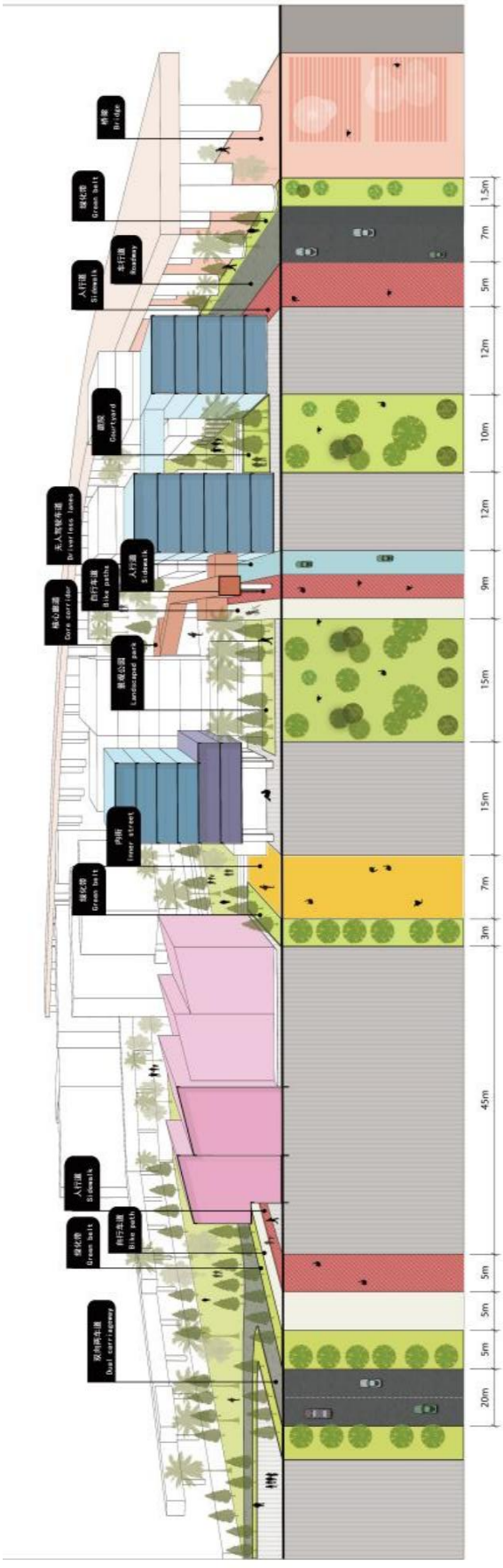


Fig 6-21: Section C-C

6.7. Aerial view

Fig 6-22: Aerial view

The aerial view presents the panorama of the Peri-SCUT Innovation District, where the transition and integration between the city, innovation district, and the campus are clearly visible when viewed from above the Tianhe Bus Station towards a bird's-eye view of South China University of Technology. The Innovation District is divided into three major sections. Within each section, the layout is compact and well-connected by transportation. The northern part is adjacent to urban main roads and expressways, while the southern part is linked to the campus boundary roads. The district features a cohesive network of pedestrian pathways and non-motorized vehicle routes, boasting high accessibility and openness. Situated within the Wushan area, the urban region has gentle terrain and more human-made interventions, whereas the campus area has varied topography and natural scenic beauty. Thus, the design of this site acts as a transitional zone, incorporating a well-organized layout and public spaces harmonizing with nature, aiming to blend seamlessly with the surrounding texture.

In the future, Peri-SCUT Innovation District will undergo further expansion and development. It will evolve from an office community within the innovation cluster to a research community for innovative disciplines and ultimately into a residential community for the innovative talent. Leveraging the developmental opportunities of the Peri-wushan Innovation Urban Area, and driven by land-use policies, the urban renewal of the university's surrounding region will be realized. This will attract high-tech and creative industries back to the city center, collaborating with the university to jointly create a competitive and innovative hub.

Conclusion

Currently, China's urbanization development has shifted its focus from pursuing "speed" to pursuing "quality." Many major cities both domestically and internationally have utilized well-established innovation ecosystems in their central urban areas, forming innovation districts where high-tech enterprises and universities are concentrated. This has changed the traditional path of urban regeneration, accelerating the transformation and revitalization of central urban areas and providing new options. The adjustment of industrial structure and the rise of high-tech industries have provided a pathway for reallocating and organizing social resources. Constructing university-anchored innovation districts as interactive spaces between universities and cities are based on the overflow of disciplinary resources and the matching of industrial markets. The transformation of research achievements overflowed by universities will become a new driving force for urban regeneration and development in the new era.

Through the study of well-known universities and their anchored innovation districts, such as University Park at MIT, Tech Square at Georgia Tech, and KIC at Fudan University, it is found that cooperation between universities and cities in central urban areas requires innovation resources, geographic proximity, facility configuration, innovative mechanisms, and other foundations. In spatial construction, certain objective rules exist, forming innovation districts that have a higher level of compatibility with urban space, meeting the diverse needs of innovation talents in terms of work, life, and education. Innovation districts not only provide innovative services in small-scale and small-sized innovation around universities but also offer high-level services to support innovation activities in urban innovation areas. In the process of updating innovation districts, attention should be paid not only to policy construction, such as industrial regeneration, inclusive development, and institutional guarantees but also to guiding spatial and facility updates to provide space carriers for knowledge overflow and innovation activities that align with the characteristics of innovation activities.

With the help of the "land supply" policy in Guangzhou's urban regeneration, unified planning, requisition, acquisition, construction, and other management measures based on plots or areas can effectively implement changes in land use, helping to break the difficulties

in the turnover of low-energy-efficient land around universities in the Peri-Wushan Innovation Urban Area, promoting the supply of innovation land, and advancing innovative operating models for university-city co-construction. The innovation district anchored by South China University of Technology has complete urban facilities, a convenient living environment, and high-density talent resources, making it easier to gather new technologies, products, and industries. Environmental assessments and site-specific updates are conducive to cooperation between cities and universities, achieving convergence in terms of technology transfer and research value, and forming a university-city community. On the other hand, in the context of the transfer and relocation of manufacturing industries in the central urban area, strengthening the intensive use of land and the efficient development of innovative knowledge-based industries can promote the prosperity and growth of Guangzhou's central urban area through the linkage of emerging industries. Building university-anchored innovation districts is conducive to establishing mutual development and promotion between South China University of Technology and Guangzhou, achieving win-win results.

In summary, the construction of university-anchored innovation districts needs to consider multiple factors. First, the location of the university campus, whether it is connected to surrounding public spaces and brownfields, and whether it has a good transportation foundation. Second, policy and institutional guarantees, whether there are institutional supplies to promote educational innovation and university-city cooperation to coordinate multiple interests. Third, concentrated financial investment, whether can promote long-term development and adjustments. Fourth, planning and architectural design, involve the relationship between public areas and buildings, implementation and coordination of design specifications, management of public spaces, and the sustainability and coherence of architectural spaces. Fifth, integration of academic planning, industrial planning, and physical space planning, promoting platforms for innovation activities, laboratories, multimedia spaces, and other supplies. The construction of university-anchored innovation districts is a complex process that requires thoughtful planning and a vision for sustainable development. No innovation district is the same, so after considering the above factors, it is necessary to conduct sufficient research and public participation with relevant stakeholders to promote social fairness.

This article mainly focuses on shaping the physical space to enhance the efficiency of innovation districts and provides design guidance based on objective experience. However, there are still many shortcomings: the research site and anchored institution South China University of Technology's campus have complex property rights issues and management problems, making it difficult to implement innovation districts. This article proposes an ideal conceptualized plan with the support of Guangzhou's land supply policy, blurring the resistance of stakeholders to the development of the site, and lacking consideration of social fairness and public participation, resulting in shortcomings in systematic discussion. Additionally, in the process of promoting the construction of innovation districts, the research lacks quantification of the spatial behavior of innovative people and relies heavily on empirical values to argue whether there may be more optimal explanations for the supply of innovative spaces. The supply of innovative space is not only based on the overall allocation of physical resources but also on the joint action of economic resources and network resources. Establishing a mechanism for building innovation districts requires multiple efforts over a long time to ultimately turn the region anchored by South China University of Technology into an influential innovation district that integrates education, industry, and the city. The author hopes to make improvements in future research to address the spreceding hortcomings.

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Appendix A

Semi-Structured Interview

Peri-SCUT Innovation District Science and Technology Innovation Background Investigation

1. Introduction and Background

a. Explain the purpose and significance of the interview.

b. Briefly introduce the background and current situation of technology innovation in the Peri-Wushan Innovation Urban Area.

2. Interviewee Information

a. Personal information of the interviewees: name, position, affiliated organization, etc.

b. Interviewees' experience and background in participating in research activities.

3. Types of Research Activities

a. Inquire about the specific research fields and topics that the interviewees are engaged in.

b. Understand the methods and techniques commonly used by the interviewees in their research.

c. Discuss the interviewees' views on research results transformation and application.

4. Innovation Demands

a. Learn about the challenges and issues encountered by the interviewees in the research process.

b. Explore the interviewees' understanding and expectations of technology innovation support policies.

c. Inquire about the interviewees' needs for research facilities, resources, and team collaboration.

5. Innovation Motivation and Vision

a. Inquire about the motivations and sources of enthusiasm for research activities among the interviewees.

b. Understand the interviewees' expectations and visions for the future development of technology innovation.

6. Challenges and Solutions

a. Discuss the main challenges that the interviewees believe technology innovation is currently facing.

b. Explore the interviewees' ideas and suggestions for addressing these challenges.

7. Institutional Support and Collaboration

a. Learn about the support policies and measures for technology innovation in the interviewees' institutions.

b. Inquire whether the interviewees have experience in research collaboration with other institutions.

8. Conclusion

a. Express gratitude to the interviewees for their participation and contribution.

b. Confirm the confidentiality and privacy protection of the interview information.

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