Global Environment Facility 6
CHINA SUSTAINABLE CITIES
INTEGRATED APPROACH PILOT PROJECT

TECHNICAL SUMMARY SERIES

BEIJING
SUMMARY REPORT

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SUMMARY REPORT

GEF-6 CHINA SUSTAINABLE CITIES INTEGRATED APPROACH PILOT PROJECT

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Preface

The Sustainable Cities Integrated Approach Pilot was a worldwide program established by the multinational Global Environment Facility in its sixth funding round (GEF-6). As implemented in China, it was aimed at helping Chinese cities use the principles of transit-oriented development (TOD) to achieve sustainable land use policies and transit plans at the levels of city, transit corridor, and transit station. The five-year China project (GEF- 6 China TOD) ran from December 2017 to March 2023. It was managed by the World Bank and implemented by China's Ministry of Housing and Urban-Rural Development (MoHURD) and seven representative large cities: Beijing, Tianjin, Shijiazhuang, Ningbo, Nanchang, Guiyang, and Shenzhen.

The Beijing GEF- 6 China TOD Project Management Office (PMO) was managed by the Beijing Municipal Commission of Housing and Urban-Rural Development. The planning and design of the Beijing project was undertaken by several consulting organizations.* This report is prepared by the team from Beijing Jiaotong University, it summarizes and evaluates the technical outputs of the project.

* The city-level study was undertaken by the Beijing Institute of Urban Planning and Design.

The corridor-level study was undertaken by the Beijing General Municipal Engineering Design and Research Institute, Adeas Asia Limited, and Beijing World Union Junhui Real Estate Consulting.

The station-level study was undertaken by Beijing Urban Construction Design and Development Group and China Sustainable Transportation Center.

Abstract

As a pioneer in urban rail construction in China, Beijing has taken the lead in the integrated development of transportation and land. As of 2022, Beijing's urban rail transit system operated 27 lines with a total length of 861.4 kilometers, the second largest system in the country. Beijing's increasing population and employment scale has created a series of urban problems, among them traffic congestion and inadequate public transportation. Urban rail transit is the development direction for modern, large-city transportation; it provides an effective approach to solving urban ills and an effective approach to building green and smart cities. Beijing aims to improve the level of public transportation services. Although it has extensively incorporated the concepts transit-oriented development (TOD), it is still difficult to see the benefits expected from high-capacity public transportation and land coordination guided by these concepts.

This report summarizes efforts by the GEF-6 China TOD project in Beijing to address the shortcomings of the city's TOD programs at three levels—city, rail corridor, and rail station. At the city level, the effort is to use TOD to more thoroughly guide the transformation of Beijing's urban development model. At the corridor level, the report proposes coordinated development strategies for TOD projects along the Tongmi suburban railway. At the station level, taking the Life Science Park as an example, the report proposes optimization plans for comprehensive planning and improvement of the area. The report extracts distinctive experiences, providing a basis for future urban rail transit construction in Beijing, and serving as an example for TOD practices in other cities in China and in developing countries worldwide.


BEIJING

Part 1: TOD Strategy at the City Level

Beijing, the capital of China and a megacity with a population of more than 20 million, was the first city in the country to propose the goal of "development with reduced emissions." Central to realizing that ambition is the construction of an integrated and green urban transportation system. Using the organization of the transportation system to manage overall urban development is the core concept of transit-oriented development (TOD). Currently, Beijing has a large, dense network of rail transit lines and a rich variety of transit station types. However, the efficiency of the rail system in Beijing is hindered by an uneven distribution of passenger flows and low coverage of its commuting populations.

At the urban level, addressing the problems faced by Beijing's rail transit system will involve leveraging the existing framework to achieve the goal of green transportation and organic congestion relief.

1. Overview of Urban Development in Beijing

Beijing is directly under the control of the central government. It serves as the political, cultural, educational, and international exchange center of China, as well as the decision-making and management center for the country's economy and finance. Beijing is located in the northern part of the North China Plain, on the border of the Yanshan Mountains, and is surrounded by Hebei Province and the municipality of Tianjin.

Beijing is under the constant pressure of growth related especially to "noncapital" functions (that is, those unrelated to the city's national-level responsibilities and activities) such as manufacturing, logistics, and wholesale business. The result has been a host of urban ills, including overcrowding, a lack of supporting public service facilities, inadequate public spaces, and severe traffic congestion owing to an inadequate level of public transportation. Transportation is a major source of urban greenhouse gas emissions. Alleviating traffic congestion through a build-up of public transit and more strategic land-use decisions would make Beijing more economically and environmentally viable.

The *Beijing Master Plan (2016–2035)*, released in 2017, advocated a higher level of development through the process of relieving congestion. As such, it was the first city plan in the country to propose development with reduced emissions. The plan laid out measures for improving the arrangement of capital and noncapital functions, controlling population size, and optimizing population distribution.

The plan aims to correct the imbalances of urban development and sprawl by focusing in two directions: the redistribution of urban functions and the transformation and upgrading of existing urban areas. The *Beijing 14th Five-Year Plan for Economic and Social Development and the Outline of Vision 2035 (2021–2025)* picks up the theme. It prioritizes the concentration of convenience services, municipal facilities, and public services around rail transit stations. And it elevates rail transit to a guiding role in adjusting the urban spatial structure: optimizing the layout of various urban functions, such as business, education, medicine, and recreation; deepening comprehensive traffic management; and accelerating the construction of a green, safe, and efficiently integrated multimodal urban transportation system.

Connecting the Central Urban Area and Suburbs

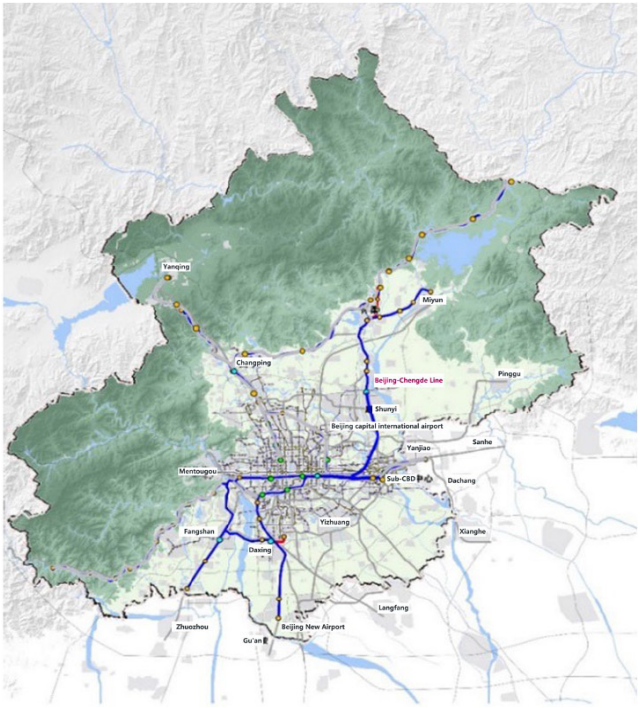
Beijing is a national leader in the integration of transportation and land development, and the city government has made large investments in the corresponding infrastructure. It has issued several plans since 2012 to address the developing needs for transportation (table 1). During his inspection of Beijing's rail transit construction and development in 2019, President Xi Jinping emphasized the need for Beijing to continue vigorously developing rail transit at an internationally advanced level to make Beijing a modern international metropolis. As of the end of 2022, Beijing's urban rail transit operated 27 lines with a total line distance of 861.4 kilometers—after Shanghai, the longest system in the country. The rail network in the central area of Beijing is expected to essentially be set when the overall length of the transit system reaches about 1,023 kilometers—projected to be in 2035, per the *Outline of Vision 2035*.

Beijing has made significant strides in implementing TOD, but significant issues, including traffic congestion, persist. More generally, Beijing promotes the construction of new towns and urban subcenters, and urban functions are continuously shifting to the suburbs. Therefore, a key objective is to develop a rail network that connects the central urban area with the suburbs.

The rail network is still under construction, and the coverage and scale of the system are insufficient. To promote the full integration of urban areas with rail transit stations and maximize land utilization, the Beijing municipal government in 2018 issued *Opinions on Strengthening the Integrated Planning and Construction of Rail Transit Stations and Surrounding Areas*, proposing the creation of micro urban centers ("microcenters") around rail transit stations. The goal is to make the microcenters an important means of coordinating the development of rail transit and the city. Following the philosophy of "the city follows the rail," the Beijing Municipal Commission of Planning and Natural Resources closely coordinates with various districts to study and form the microcenters submitted to the municipal government. A total of 71 microcenters have been delineated, involving 14 districts.

A further advance came in January 2023, when the Beijing municipal government, together with the China National Railway Group, officially approved the *Beijing Metropolitan (Suburban) Rail Functional Layout Plan (2020–2035)*, delineating the larger rail pattern of public transportation development (figure 1). The suburban rail network is seen as a commuter-oriented, high-speed, and high-capacity system. Relative to the metro (subway) system, the distance between suburban rail stations is greater, the train speed is faster, and the service range is wider. Reserving space for system expansion, the plan lays the foundation for integrated development of the metropolitan area.

Figure 1: Connectivity Relationship between Suburban Rail and the Central Urban Area



Source: Beijing General Municipal Engineering Design and Research Institute, Adeas Asia Limited, and Beijing World Union Junhui Real Estate Consulting, *Research on Rail Transit Lines and Land Optimization Based on TOD Concept*, 2022.

Policy Guidance

At the *macro* geographic level, the Beijing municipal government follows the principles of center intensification, internal-external linkage, regional integration, and hub optimization. The key focus is on addressing network bottlenecks and level imbalances, making efficient use of railway resources, significantly increasing the mileage of intercity railways and regional express lines (including suburban railways), and orderly developing modern tram systems. At the same time, Beijing is also intensifying the planning of rail transit networks in key areas such as functional zones.

At the *intermediate* level, the municipal government focuses on improving the urban-suburban transportation connection. Beijing is adjusting its urban spatial structure and promoting the construction of multiple new towns and urban subcenters, which results in the continuous shifting of urban functions to the suburbs and the formation of new urban layers. It must therefore reduce and reorganize the huge commuting flows to better meet residents' travel, living, working, entertainment, and consumption needs. TOD at this level focuses on transportation hubs and can effectively address the imbalance between job and housing areas.

At the *micro* level, the municipal government aims to improve the integration of stations and the city. It pursues the integrated planning of rail transit stations and surrounding land use and promotes design of user-friendly conditions for public transportation connections and transfers. It also works to strengthen "last mile" access to rail transit stations.

Table 1: Summary of Beijing's Policies for Strengthening Public Transportation Construction

Policy Title	Year	Content Highlights
Opinions of the Beijing Municipal People's Government on Building a Bus City and Improving the Capacity of Public Transportation Services	2012	Defines the main responsibilities of relevant departments such as the Municipal Transportation Commission, the Development and Reform Commission, the Public Security Bureau, and the Housing and Urban-Rural Development Commission. It provides a clear development strategy, work goals, and tasks for implementing the strategy of prioritizing the development of public transportation and deepening its implementation.
Beijing Urban Master Plan (2016–2035)	2016	Promotes the development of a public transportation-oriented urban development model (TOD), adheres to the strategy of prioritizing public transportation, and focuses on improving the level of urban public transportation services.
Opinions on Strengthening the Integrated Planning and Construction of Rail Transit Stations and Surrounding Areas	2018	Creates microcenters around rail transit stations.
Beijing 14th Five-Year Plan for Economic and Social Development and the Outline of Vision 2035 (2021–2025)	2021	Builds an efficient and integrated comprehensive transportation network. Constructs an integrated transportation system with rail transit as the backbone. Strengthens the integrated development of land use and of space above and below ground around rail transit stations. Accelerates the construction of a layered and integrated rail transit network.
Beijing City's "14th Five-Year Plan" for Transportation Development and Construction	2022	Promotes high-quality integrated development of rail transit, building pedestrian and bicycle-friendly cities, advances the higher-level networking of road systems, and creates a convenient and efficient surface public transportation system.
Beijing City Regional (Suburban) Railway Functional Layout Plan (2020–2035)	2023	Covers the main spatial corridors of the Beijing metropolitan area, effectively connects the Beijing metropolitan area with cross-border urban clusters, reserves capacity for system expansion, and lays the foundation for the integrated development of the metropolitan area.

Note: The documents produced through 2022 were issued by the Beijing Municipal People's Government; the 2023 plan was issued by the municipal government in conjunction with the China National Railway Group.
Source: The policy documents.

2. Challenges of Urban TOD in Beijing

If TOD is to realize its potential for improving conditions in Beijing, it will have to tackle at least the following four problems with its transit system: *transit stations poorly adapted to their surroundings; inefficient layout of its rail network*; poor matching of *passenger flows* to station placement; and *indiscriminate high-density development* around stations.

Transit Stations

The primary focus of station construction has been on meeting the travel needs of residents, with less emphasis on coordinating station design with the surrounding urban functions. As Beijing's urban development continues with significant variations across areas of the metropolis, the need for stations that accommodate those differences and integrate with the conditions around them will only become more urgent.

Inefficient Layout of Rail Lines

Currently, Beijing's urban development is unbalanced, and the urban spatial structure is still not rational. Some areas have low population density, making it difficult to obtain support and guarantees for the construction of rail lines. As a result, the coverage and density of rail transit lines are relatively low. A lack of coordination between urban planning and rail transit construction exacerbates the problem, leading to irrational rail transit line layouts, insufficient line density, and uneven distribution. Residents in certain areas unable to conveniently use rail transit. Overcrowding of train cars and inadequate station facilities inhibits passenger use. Beijing must strengthen its TOD capacity if it is to optimize the layout of rail transit lines, changing residents' commuting habits, and improving the quality of rail transit services.

Uneven Passenger Flows

Beijing is orienting rail development to the needs of urban development, but the population is rapidly migrating, and follow-up planning for supporting facilities around stations has been relatively slow. Moreover, growth around stations is uneven. The result is uneven passenger flows over the network, with some stations underused and others overcrowded.

Overemphasis on High-Density Development

Under TOD, construction in Beijing should shift its focus from indiscriminate high-density development, city planners should direct their efforts toward optimizing land use layout, upgrading supportive service facilities, building pedestrian-friendly systems, and revitalizing older urban areas. It is essential to closely align plans with the decentralization of noncapital functions in Beijing. Planners should improve the travel experience at the community and street levels for high-capacity public transportation stations and corridors. Currently, certain areas in Beijing experience traffic congestion, long commuting distances, and incomplete and inconvenient slow (that is, walking and cycling) transportation systems (figure 2). The integration of the pedestrian-friendly systems with public transportation has not been adequately established.

Figure 2: Traffic Congestion in Beijing's Central Business District

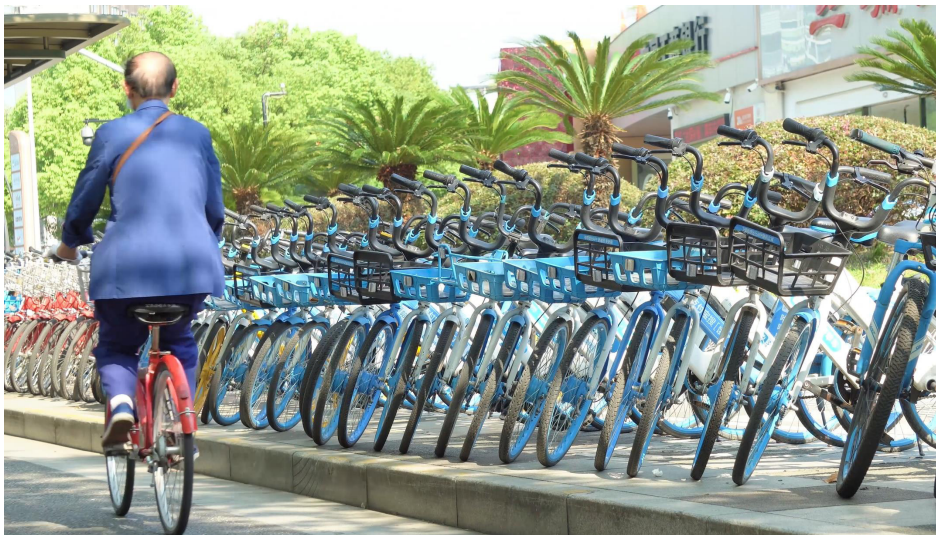
Source: Beijing Jiaotong University, 2022.

3. City TOD Planning Strategies in Beijing

The report of the 20th National Congress of the Communist Party of China states that an inherent requirement for China's high-quality development is the harmonious coexistence of humans and nature. Urban transportation development in China is at a turning point, as urbanization and private motor vehicles have brought unprecedented pressure on urban pollution and transportation infrastructure. It has become particularly important to establish an environmentally friendly, smooth, efficient, and economical urban transportation system with public transportation as the main component.

Beijing advocates the concept of green transportation, echoing the requirements of the 20th National Congress (figure 3). Developing new types of transportation that are environmentally friendly, low-carbon, and shared is important for energy conservation and the achievement of low-carbon transportation goals. The corresponding urban planning concept has been called "organic dispersion"— optimizing the urban transportation layout, reducing traffic congestion and car usage, implementing construction in phases, and moving commercial, residential, and industrial areas away from the city center to reduce traffic pressure.

Figure 3: Green Transportation in Beijing: Shared Bicycles



Source: Beijing Jiaotong University, 2023.

The Microcenter Concept for Stations

The coverage rate of rail services within 800 meters of rail stations and the per capita service area in Beijing both need improvement, especially between the Second Ring Road and Fifth Ring Road. Although areas with high job densities in Beijing are consistent with the overall city plan, the distribution of housing and job areas are mismatched, unnecessarily lengthening the commuting distances and travel times for residents. Moreover, the development of some stations does not conform to the principles of efficient transportation and intensive land use.

Given these issues, the technical team expanded the original node-place model of station development to form a three-dimensional model of node-place-guidance.

In addition, the team distributed the 297 metro stations in Beijing into seven types. From low efficiency to high, they were as follows:

- Low efficiency
- Potential for transit-adjacent development (TAD)
- Potential for TOD
- Transportation complex
- Cultural, scenic, and entertainment attraction
- Commercial
- Jobs and housing

Areas or corridors that are most likely to undergo TOD improvements or new investments are identified and ranked, deepening the specialized analysis of urban public transportation services. Inefficient stations and TAD stations account for about 48 percent of all metro stations, while potential TOD accounts for about 20 percent (figure 4).

Figure 4: Classification and Ranking of Beijing Metro Stations

Source: Beijing Urban Planning and Design Institute: *TOD Type Classification and Drawing Guidelines*, 2020, and *TOD Strategic Report*, 2023.

Enhancing Service Coverage and Optimizing Travel Experience

Combining Beijing's overall plan with its zoning plan reveals the city's layout characteristics, including urban spatial structure, transportation network, transportation demand intensity, and land development potential. The guiding strategy arises from investigating land resources along the rail lines, evaluating the current network's benefits, and classifying and defining stations based on factors such as natural disaster risk, land use, land ownership, planning, and ongoing projects.

Defining Rail Microcenters and Developing Strategic Plans

Planning ranges are defined for the scope of screening, for control (such as land-use regulation), and for microcenter development. The ranges are based on the rail corridor, city planning, and overall plan for the rail transportation network.

- Rail resource screening scope: Screening for resources with development potential is conducted within 800 meters of the rail corridor for the city center and subcenters and 1,000 meters for other areas.
- Rail control scope: The scope for control is within 300 meters of the rail corridor for the city center and subcenters and 500 meters for other areas. This scope is the main range for implementing general control of rail microcenters.
- Rail microcenter scope: The planning area adjacent to the rail stations, including land potentially integrated for development, is generally between 10 to 20 hectares. The goal is to avoid dividing construction land and minimize interference from highways and expressways.

Strategic plans for TOD are developed for each rail microcenter, including overall and specific functional positioning and industry planning. The urban characteristics and functional positioning of each station are further clarified according to a comprehensive analysis of the development mode and prospects of the station.

Optimizing Station Connectivity and Enhancing Station Performance

Optimizing station connectivity and enhancing station performance is achieved through a multilayered process. Station area boundaries are delineated and refined according to the stations' functional positioning, classification, and connection with the transportation network. The surrounding slow travel networks, public transportation connections, and parking management systems are also analyzed and evaluated. Conceptual planning proposals are then designed for the station areas. The proposals include spatial layout planning, connectivity, mixed land use and building density, integration of internal roads and transportation, overall parking planning, physical infrastructure planning, landscape and open space planning, and architectural and urban design guidelines.

Assessing Environmental and Social Effects

The Beijing Municipal Government's technical team conducts environmental and social evaluations to assess potential project impacts within the rail station areas. The evaluations measure the development effectiveness of the rail station areas. The evaluation indicators cover four types: vitality (diversity of population, businesses, and cultural and entertainment resources), travel structure, transportation service quality, and social equity.

Part 2: TOD Strategy at the Corridor Level

Beijing needs to develop suburban railway networks to connect the central city with the suburbs and surrounding cities, as described in the latest master plan. The Beijing Suburban Railway was officially opened on August 6, 2008. In January 2023, the *Beijing Metropolitan (Suburban) Railway Functional Layout Plan (2020–2035)* was approved. According to that plan, the goal of suburban railway development is to build a commuting circle for intercity rail transit: change the travel radius in outlying areas, improve commuting and school travel efficiency, alleviate traffic congestion, and promote the revitalization of assets around existing railways through the integration of Railway + Property. The suburban railway serves as a platform to accommodate the relocation of noncore functions from the city center, facilitate the formation of a network development pattern with multiple centers, optimize the spatial layout of regional towns, and accelerate regional urbanization, thus achieving coordinated regional development.

Guided by the plan, the development of the Beijing rail transit network is proceeding, but the problems of insufficient passenger flow, lack of coordination with land development, and a slow pace of construction of the suburban network still exist. The TOD strategy for the development of transit corridors establishes a tight relationship between public transportation and land use. The aim is to optimize the urban spatial structure by reducing congestion in the central area and shifting functions to the periphery. Using the Beijing Suburban Railway's Tongmi Line as an example, this section examines how to develop the commuting circle under a strategy to achieve TOD corridor goals.

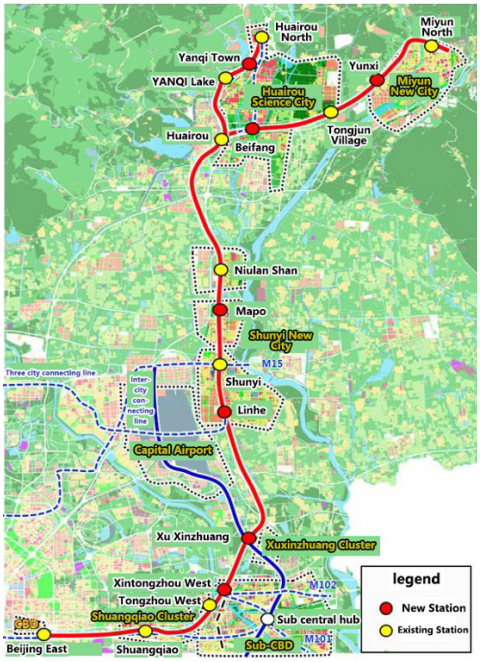
1. Overview of the Tongmi Line

When the Tongmi Line of the Beijing Suburban Railway opened on June 20, 2020, it became the backbone line in the northeast direction of the suburban railway network (figure 5). With a total length of 84.2 km and a planned total of 14 stations, it links Shunyi New Town, Miyun New Town, the three science cities, the International Convention Center, the northern part of the subcenter, the Capital Airport, and the central city. In the future, stations along the Tongmi Line will be classified into four types: urban, regional, neighborhood, and specialized function (figure 6). Each type will be strategically allocated within the Tongzhou, Miyun, Shunyi, and Huairou clusters to optimize overall land use along the corridor.

The development of railway microcenters is a specific measure to achieve the goals of suburban (regional) railway construction. Railway microcenters are characterized by high accessibility, intensive land use, diverse urban functions, and place-making characteristics. Ten of the planned stations along the Tongmi Line have been selected as railway microcenters, and they will serve as a demonstration for the subsequent development of microcenters in Beijing (figure 7).

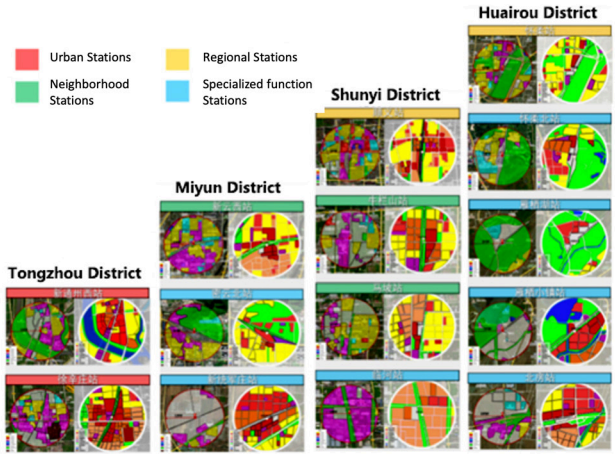
With high speed and a large capacity, the Tongmi Line has the potential to support the development of new peripheral cities, helps relieve population pressure, and promotes the relocation of the center's noncapital functions. But more work needs to be done.

Figure 5: Tongmi Line of the Beijing Suburban Railway



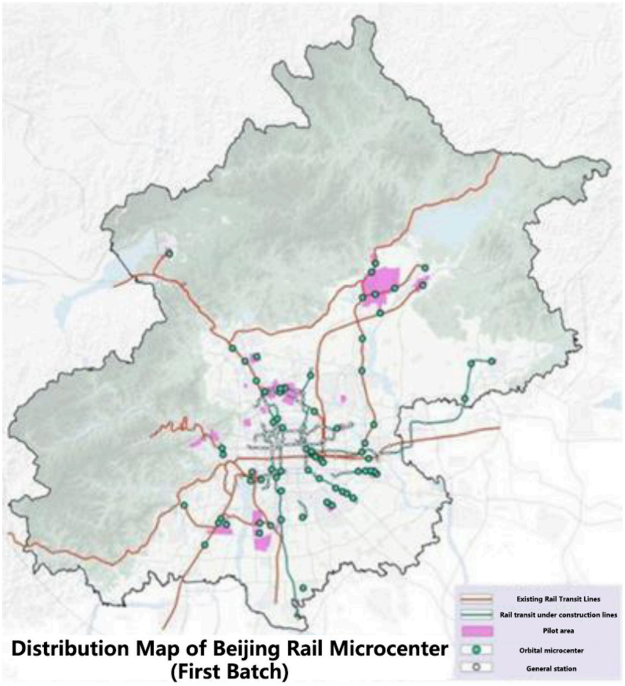
Source: Beijing General Municipal Engineering Design and Research Institute, Adeas Asia Limited, and Beijing World Union Junhui Real Estate Consulting, *Research on Rail Transit and Land Optimization Based on TOD Concept: Final Report*, 2023.

Figure 6: Classification of Stations along the Tongmi Line



Source: Beijing Colliers International Real Estate Consultants, *Corridor Level: Study on Railway and Land Optimization Based on TOD Concept*, 2021.

Figure 7: Distribution of Railway Microcenters



Source: Beijing Municipal Institute of Urban Engineering Design and Research and Colliers International Real Estate Consultants, *Study on Railway and Land Optimization Based on TOD Concept: Project Final Report* 2023.

2. Challenges of TOD in the Tongmi Line Corridor

According to the *Functional Layout Plan for Beijing Suburban (Regional) Railways (2020–2035)*, the goal of suburban railway development is to build a commuting circle for intercity rail transit. The construction of suburban railways aims to change the travel radius in outlying areas, improve commuting and school travel efficiency, alleviate traffic congestion, and promote the revitalization of assets around existing railways. It serves as a platform to accommodate the relocation of non-core functions from the city center, optimize the spatial layout of regional towns, and accelerate regional urbanization, thus achieving coordinated regional development.

The Tongmi Line demonstrates ways in which the guiding role of rail transit in Beijing's urban spatial development has not been fully realized. The selection of rail routes and station locations has not been sufficiently coordinated with the urban structure, functional zones, and urban renewal areas.

Insufficient Integration of Transit with Functional Areas

The Tongmi Line primarily focuses on accessibility to support key industries in the region, but it is not sufficient to serve the entire new town area, including the Beijing Economic-Technological Development Area and the three science cities of Zhongguancun, Huairou, and Future Science City. The development of commercial supporting facilities in these areas has thus been relatively slow. In addition, the subway stations along the Tongmi Line are located on the outskirts of jobs areas and do not extend deep into the core areas of the commuting circle. Incomplete pedestrian systems and a low level of connectivity with public nodes creates inconvenience for commuters and an uneven distribution of passenger flow.

Inadequate Coordination between New Towns and Railway Transit Planning

Tongmi Line stations are surrounded mostly by industrial land, residential areas, village homesteads, and nonconstruction land. The wide green buffer zones and nonconstruction land on both sides of the corridor have to some extent severed the urban fabric. Although the Tongmi Line belongs to the railway transit line of the new towns, it lacks sufficient guidance for the efficient spatial development in the areas along the line. The development of the Tongmi Line lags behind the construction of the new towns. The timelines for peripheral land development and subway construction have not been synchronized, which, if not corrected, will prevent the full potential of rail transit advantages to be fully realized.

3. Corridor TOD Planning Strategies for the Tongmi Line

The technical team analyzed the Tongmi Line development and construction project in terms of the following four goals: achieving a mixed urban land arrangement, optimizing the functionality of station microcenters, establishing comprehensive connectivity, and creating supportive land uses that meet the unique character of key station areas (figure 8).

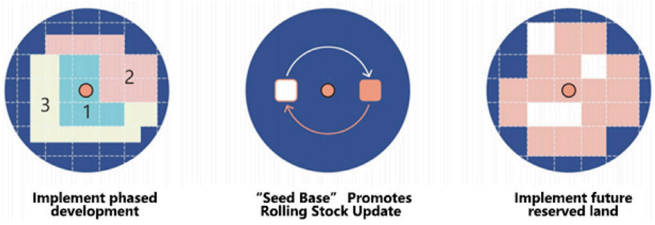
Figure 8: TOD Corridor Land Use and Function Diagram

Source: Beijing Urban Planning Design Research Institute, *TOD Strategic Report*, 2023.

Mixed Urban Land Arrangement

The early development and low development levels in existing stations and their surrounding areas can be addressed by using the stations as cores to drive urban renewal in the surrounding areas (figure 9). This approach will be activated through industrial development in the surrounding regions and improving supporting facilities and infrastructure. The aim is to improve the quality of living, increase land value, and leave room for future development.

Figure 9: Urban Renewal Strategy with Stations as the Core



Source: Beijing Sino-Union Joyous Property Consultants, *Study on Rail Transit Routes and Land Use Optimization Based on TOD Concept*, 2021.

Characteristic Functions of Rail Transit Microcenters

The urban functions of rail transit microcenters should be met by surrounding them with diverse leisure and entertainment services for residents. The functions incorporated into the station areas can create clusters or regional centers with distinct advantages, prominent features, and mixed functions.

Comprehensive Connectivity System

The Tongmi Line connects Huairou, Miyun, Shunyi, and Tongzhou, providing rail transit services for travel within the northeastern region. Bus transfers should be created at Shunyi Station and Shimen Station, thereby allowing a fast rail transit connection between Huairou and Miyun to the city center. Doing so will increase the availability of regional rail transit travel and help provide a reliable, efficient, and convenient transportation mode for connecting the northeastern new towns to the city center.

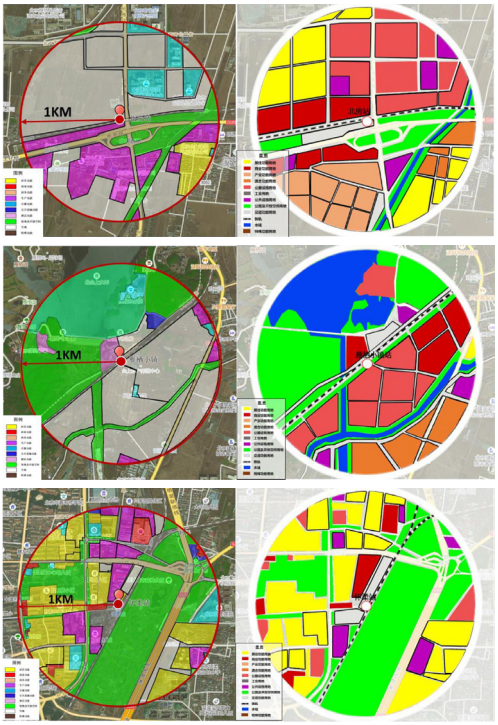
Quality of Space around Key Stations

The Tongmi Line should create a complete public space system tailored to local conditions, establishing close connections between the station areas and urban clusters. The Huairou District is a good example of the potential for this strategy of deepening the spatial environment (figures 10 and 11). The areas surrounding its three microcenter stations have a large amount of underused land with relatively few development constraints, and as detailed below, those stations have distinct functional orientations. The stations are Huairou, which represents the potential for commercial activity driven by rail transit; Beifang, which serves Huairou Science City; and Yanqi Town, which supports scientific research activity in the area.

Figure 10: Microcenter Stations in the Huairou District

Source: Beijing Sino-Union Joyous Property Consultants, *Study on Rail Transit Routes and Land Use Optimization Based on TOD Concept*, 2021.

Figure 11: Planned Layout around Microcenter Stations in the Huairou District



Source: Beijing Sino-Union Joyous Property Consultants, *Study on Rail Transit Routes and Land Use Optimization Based on TOD Concept*, 2021.

Huairou Station: High-Quality Commercial Area

Huairou Station can leverage the regional advantage of natural resources to develop as a high-quality commercial center. It aims to create quality hotels, standard office spaces, and enhanced comprehensive urban supporting services. It will focus on introducing renowned commercial projects, high-end hotel chains, and well-known office property service companies to form a major regional commercial, business, and living mixed-use center. The challenges Huairou Station faces in terms of renovation and transformation are common for many stations in residential areas along the suburban railway line. Therefore, it is well-suited for research as a station of the hub type.

Beifang Station: Integration of Industry and Science

Beifang Station aims to meet the service needs of researchers through the development of two major functions: industry development services and multidisciplinary, cross-cutting technological innovation. It is aimed at the three major industries in Huairou Science and Technology City—life science and medicine, information and communication, and new materials— and connects with both the Future Science City and the Life Science and Technology Park to promote functional construction. It is a suitable model for creating stations in the industrial service category.

Yanqi Town Station: Conference and Tourism Services

Yanqi Town Station can use the scientific research activity of Huairou Science and Technology City to create comprehensive tourism services centered around scientific research forums. It aims to become an important venue for conferences and exhibitions in Beijing by creating a conference and resort center catering to both domestic and international audiences. Yanqi Town Station has immense development potential and abundant environmental resources. For such special stations, a low-density development model is suitable for integrating the city into the natural surroundings.

Part 3: TOD Strategy at the Station Level: Life Science Park Station

The Life Science Park Cluster is in the future science city area of Beijing's Changping District. TOD planning and improvement schemes for the area of the Life Science Park Station, along with integrated designs for surrounding major hubs and residential areas, show how the development of new industrial centers and suburban new cities can be guided by TOD.

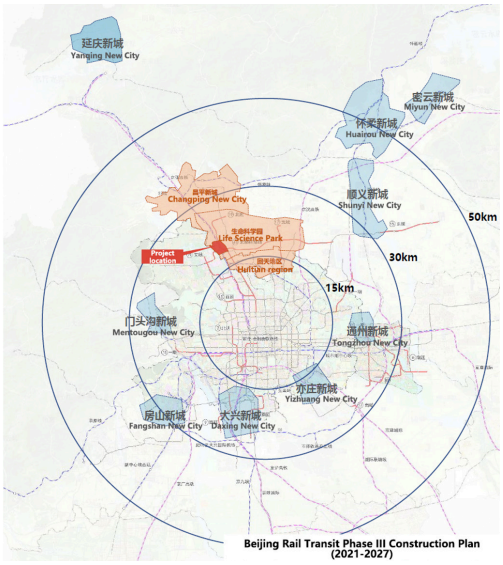
1. Overview of the Area

Life Science Park Station is an important node of the S2 suburban railway line in the northwest corridor of Beijing and is a key element in the overall planning requirements of Beijing (figure 12). At the end of 2019, the population within the research scope of the Life Science Park Station was 68,600, including 29,300 permanent residents. The employed population was 37,700. A major part of the residential population is a "floating population" of researchers, university students, and villa residents. The employed population mainly consists of employees of the Life Science Park, teachers, and wholesale and retail workers.

Station Positioning

At the macro level, the station connects to Beijing's central urban area and can help reduce that area's congestion by undertaking some of its functions. TOD is an important way to intensively and efficiently use land in a sparsely developed, low-density area. Multiple rail transit lines can alleviate traffic congestion in the area, alleviate passenger flow pressure on the Beijing metro's Changping Line, and improve the level of public transportation services in the northwest region.

Figure 12: Location of Life Science Park within Beijing Area



Source: Beijing Urban Construction Design and Development Group and China Sustainable Transportation Center. Consortium, *TOD Current Diagnosis and Evaluation Report within the Research Scope of the Demonstration Project*, 2020.

At the intermediate level, the TOD plan for the station aims to shape a concentrated employment area and achieve a balance between work and living in Changping. Life Science Park will be an important part of the future science city, which is one of the five comprehensive transportation hubs in Changping. By leveraging rail transit to drive optimization and improvement in the area, the station can promote the sustainable development of the western region of the future science city and drive the transformation and upgrading of the area.

At the micro level, the planned rail transit four-line interchange greatly expands transportation services. The rail construction drives urban renewal in the area, guides the optimization and development of the functional systems in the area, and assists in the overall improvement of the area's environment.

Low-Density Context

In the area surrounding the Life Science Park Station, development intensity is low, including within 500 meters of the station, where the aggregate floor-area ratio (FAR, the ratio of total floor area to the area of the parcel on which the building sits) is only 0.33. The ratio of work land to residential land is about 1:0.6, and the ratio of urban work land to residential land only 1:0.2. Agricultural and forestry accounts for the highest proportion of land use. These measures point to too few residences and an imbalance between work and living.

2. Station Area TOD Planning Strategies

To align the station area with the development vision at the city level, the technical team proposes that the station area encompass green transportation, employment, and families together with public services that support them all. To support its analysis of Life Science Park, the technical team developed a land-use index system for function allocation, layout, and development intensity (figure 13). The goal is to create the Life Science Park Station as a vibrant hub for science and innovation, demonstrating the integration of stations and urban functions. The plan focuses on five strategies for comprehensive planning and improvement of the urban renewal areas around rail transit stations: (1) hierarchical layout of functions with the station as the core; (2) graduated land-use density; (3) road density to support green transportation; (4) optimized pedestrian access; (5) complex, inclusive open spaces.

Figure 13: Planning Scheme and Land Layout Plan around Life Science Park Station

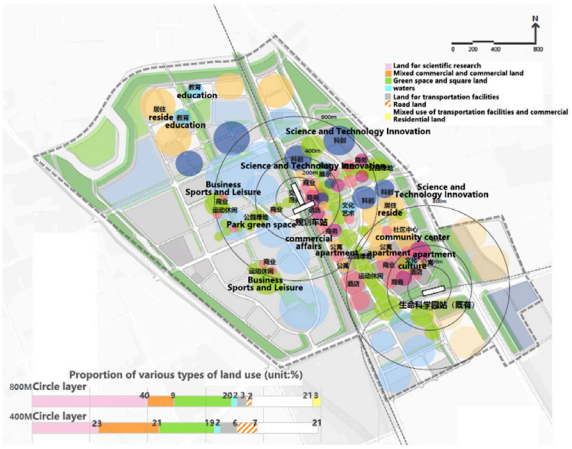
Source: Beijing Urban Construction Design and Development Group and China Sustainable Transportation Center Consortium, *Completion and Summary Report of the Demonstration Project for Comprehensive Planning and Construction of Urban Renewal Areas based on the TOD Concept*, 2023.

A Compound Functional System of Industry and City

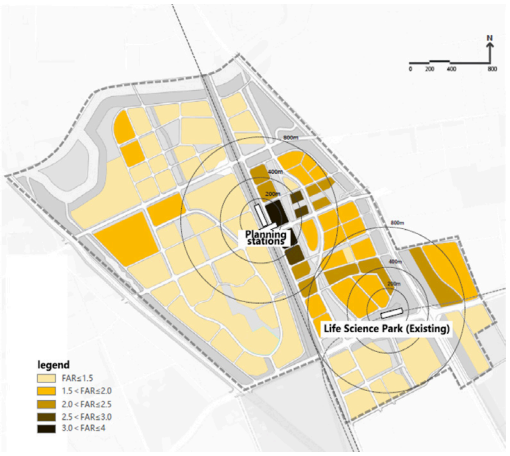
The planning scheme enhances the compound nature of the area by creating a hierarchical layout spreading out from the station. The plan establishes three concentric rings at 200 meters, 400 meters, and 800 meters from the station, with distinct functions concentrated in each circle (figure 14, panel a). The station is the junction point between phases 1, 2, and 3 of the Life Science Park, and the mixed layout is compact, efficient, and diverse.

Figure 14: Functional Layout and Development Intensity around Life Science Park Station

a. Functional layout



b. Intensity of use



Source: Beijing Urban Construction Design and Development Group and China Sustainable Transportation Center. Consortium, *Completion and Summary Report of the Demonstration Project for Comprehensive Planning and Construction of Urban Renewal Areas based on the TOD Concept*, 2023.

Graduated Building Density

Considering the construction status, actual project requirements, and market development needs of the corresponding areas, the plan gradually decreases density outward from the station (figure 15, panel b). Building height control is based on the plot ratio index, forming five graduated height levels.

Higher Road Density

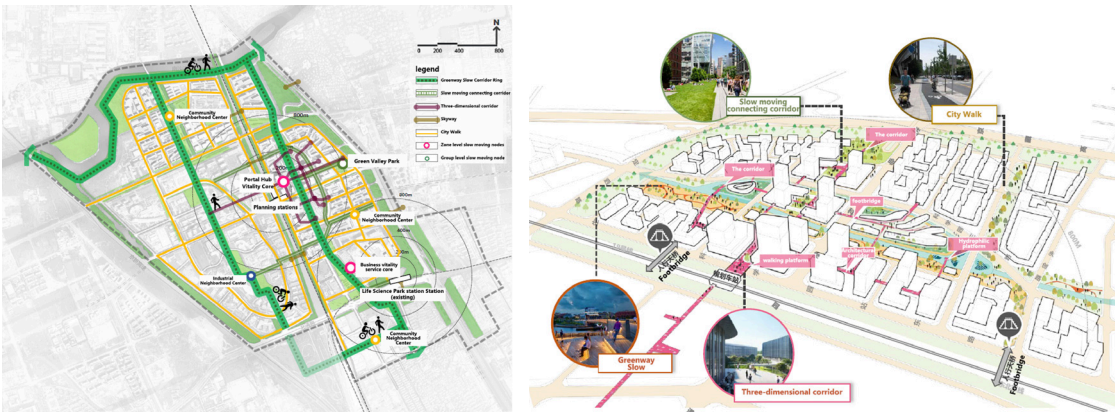
The road network system within the area is optimized through increased density and improved accessibility for vehicular and nonmotorized traffic. The road density in the planning area is about 8 km/km², and within Phase 3, the road density is approximately 11 km/km². Underpass roads are added to connect fragmented road sections, improving the accessibility of public transportation and pedestrian traffic.

- Public transportation connectivity: Three circular shuttle bus routes are planned for the stations, with two shuttle routes serving the Life Science Park Station. A bus terminal is set up in the northern residential area, which also serves as a parking facility with an area of 3,000 square meters.
- Bicycle connectivity: Bicycle parking is provided at both the planned stations and the Life Science Park Station. The facilities are dispersed around the station, with a total capacity of 4,000 nonmotorized vehicles.

Pedestrian Priority

A multilevel pedestrian system continuously transports pedestrians from the rail station to the centers of various functional clusters (figure 15). It starts at the second floor of the station and connects to a ground-level system of green spaces, parks, waterfront areas, and main streets, forming greenway corridors and urban footpaths.

Figure 15: Pedestrian Traffic System around Life Science Park Station



Source: Beijing Urban Construction Design and Development Group and China Sustainable Transportation Center. Consortium, *Completion and Summary Report of the Demonstration Project for Comprehensive Planning and Construction of Urban Renewal Areas based on the TOD Concept*, 2023.

Complex, Inclusive Open Space

A diversity of public features creates a vibrant open space system. Green spaces extend into buildings; and sunken plazas, second-floor rooftops, and elevated corridors form a multidimensional aerial garden. Orchards, pavilions, and activity areas provide various learning, socializing, and creative spaces.

Existing streets are transformed and integrated into a planned new street network. Green open spaces are endowed with a loop of ten thematic urban parks. Four landscape feature sections are planned to activate diverse waterfront spaces—natural ecological, urban vitality, shared industry, and community leisure. These spaces integrate with the surrounding buildings and site design, shaping a continuous and compound waterfront greenway that brings water into the park and people to the waterfront.

3. Area TOD Planning Strategies

The project developed a system by which to assess the sustainability of the TOD plan for the Life Science Park Station area. The system separately considered the relevance of the station-area plan for the local culture and institutions and the potential investment returns of the area plan.

Social Impacts

The social assessment considered the extent of mutual adaptation between the implementation of the planning project and society. It identified the risk factors related to (1) whether the project would be accepted by the local social environment and cultural conditions and (2) the level of support from local governments, organizations, social groups, and the public.

The assessment process involves four steps: determining measurement standards, estimating the impact factors, judging the impact levels using matrix method, and judging the impact levels using composite index method. The results overall showed that no major risks existed and that mitigation measures could eliminate less significant risks. The evaluation index for this planning assessment indicates that the overall environmental and social impacts are manageable and the negative potential environmental and social impacts of the station area plan are low.

Project Investment Returns

The evaluation required analyzing the economic and social characteristics of the TOD development areas, such as rental rates and commercial consumption levels and residents' income, spending habits, travel modes, and preferences for TOD usage. Given the prospective growth of population resulting from implementation of the station area plan, the evaluation had to assesses the future impact of TOD and consider how to avoid gentrification and its impact on rail transit.

The evaluation also estimated the investment returns of TOD projects. It analyzed the policies and investment returns of TOD projects and discussed the models and pathways for reinvesting in rail transit and infrastructure.
The evaluation yielded the following main conclusions regarding the outlook for the Life Science Park Station:

- The existing density, diversity, and refinement index of planned station areas are all below the national average, indicating significant development potential. According to the evaluation of 344 existing stations in Beijing, the Life Science Park Station currently ranks 277th in housing rent, 294th in shop rent, and 55th in inefficient use of land,
- demonstrating the considerable potential of the station area.
  Project improvement effects: Indicators such as job density, development compactness, public service facilities, ground-floor commercial density, and road network density have shown significant improvements. In the 2021 TOD assessment, the station's ranking rose from 214th to 61st among Beijing's stations.


BEIJING

Part 4: Summary of Achievements

The Beijing TOD project has made significant progress over the past five years. In the central urban area, the implementation of urban rail TOD has supported the goal of reducing noncapital functions and promoting balanced development. In the suburban areas, the integration of the urban agglomeration has been advanced through the planning of the city-wide (suburban) rail transit system.

At the city level, TOD types have been classified according to the differentiated characteristics of rail transit stations, including functions, passenger flow, and land use; differentiated planning strategies have been developed accordingly. At the implementation level, the focus has been on guiding new land allocation toward microcenters of rail transit. The TOD approach gradually adjusts the spatial structure and functional layout around stations, thus driving urban renewal in the inner city and the development of new areas in the suburbs.

1. Key Successes

The major areas of accomplishment have been the inclusion of TOD in city planning, city adoption of measurement methods developed by the Beijing Project Office, and the advancement of the original TOD goals of the Beijing project, including function offloading and new city development.

Incorporating TOD into Urban Development Plans

Since the implementation of the project, the Beijing Project Office has successfully included TOD in various urban development strategies, specialized planning initiatives, and general planning policies. The TOD-influenced city plans included *Beijing Rail Transit Network Planning (2017–2035) and Beijing Bus Station Planning (2020–2035).* In December 2022, the Beijing Municipal Government and China National Railway officially approved the TOD rail study *Beijing City (Suburban) Rail Functional Layout Planning (2020–2035).*

The study *Beijing Rail Transit Network Planning (2017–2035)* highlights key construction priorities for the coordinated development of rail transit and the city in the future, including the integration of the central urban area with subcenters, multipoint connections, and cross-border urban clusters through regional rapid transit lines. It emphasizes anchoring functions to the hub stations and promoting TOD development centered around rail transit stations. It also aims to improve existing lines and stations while constructing new ones to enhance service levels.

The study *Beijing Bus Station Planning (2020–2035)* proposes the creation of comprehensive public transit facilities centered around bus stations, combining transportation services and daily-life conveniences. It envisions smart-mobility and smart-living operations, unified brand display, and standardized management. The plan promotes coordination between housing and transportation, achieving seamless integration between public transit services, slow transportation systems, and convenient services. It transforms public transit providers into diversified and high-quality urban convenience service providers, aligning with the capital city's development strategy.

The project has provided support to various specialized planning efforts, such as the *Beijing Land and Space Near-Term Planning (2021–2025); Beijing Commercial Consumption Space Layout Planning (2022–2035)*; and *Beijing Urban Renewal Special Planning*.

City Adoption of TOD Measurement Methods

The technical team of the Beijing Project Office has developed a quantitative measurement theory for the urban core system and urban network, guiding research projects such as *Beijing Rail Transit Implementation Evaluation and Research on the Network Classification of Beijing Rail Transit Stations*. It has also provided support for the promulgation of *Beijing Urban Renewal Regulations* and the special report by the Beijing Planning and Natural Resources Committee, *Commuting and Residential Studies Based on Big Data of Rail Transit*. Other supported works include *Annual Beijing Big Data City Check-up Report and Beijing Commercial Consumption Space Layout Planning*.

Supporting Function Offloading and New City Development

At the urban level, the Beijing Project Office has introduced a series of policies to improve work-life balance, enhance coverage for commuting populations, and improve the surrounding environments of rail transit stations. The *TOD Microcenter Classification and Construction Guidelines*, based on the big-data platform, have ensured the achievement of the overall goal of green transportation and organic offloading.

At the corridor level, with the preliminary achievement of function offloading goals, the focus of the technical team shifted to the TOD of rail along the urban agglomeration. It conducted in-depth analyses of land use, transportation conditions, and travel demand in characteristic station areas along existing rail lines. The research has supported the layout of large-scale and high-intensity city-wide (suburban) commuting corridors. This has optimized the urban spatial structure, promoted urban reduction, and facilitated high-quality development.

At the station level, the project has focused on the development of new industrial centers and new cities around TOD. It selected the Life Science Park cluster in the western area of Beijing's Changping District to propose spatial design solutions for the integration of industries, transportation, and residential areas in suburban TOD new cities.

2. Future Improvements

Future efforts should continue the work on developing TOD, expand and improve public engagement in planning, and tighten the connection of Beijing's TOD data platform with the MoHURD platform.

Continue Developing TOD for Beijing

The continued pursuit of TOD should include strengthening connections within the Beijing-Tianjin-Hebei urban agglomeration—optimizing transfer facilities, improving transfer efficiency, and enhancing overall transit efficiency. At the same time, Beijing should continue to optimize land use along TOD corridors under the TOD microcenter policy, transforming idle land and abandoned factories along railway lines into various functions such as commerce, residences, and culture. This will improve land use and give passengers a more convenient and comfortable travel experience.

Deepen Public Involvement in TOD Planning

Creating innovative mechanisms for participation and including them in updated action manuals will promote collaboration among multiple stakeholders and further deepen TOD practices. Strengthening public participation will allow more residents to share the economic, social, and environmental benefits of TOD.

Strengthen the Linkage between the Beijing TOD Digital Platform and the MoHURD Platform

The TOD evaluation and monitoring platforms operated by Beijing and by the Ministry of Housing and Urban-Rural Development (MoHURD) collect and analyze big data, support the scientific design of evaluation indicators, and visually express monitoring and evaluation results. They play crucial roles in proposing further development strategies for rail transit. Strengthening their connection and coordinated maintenance will be critical to future research and practices related to TOD.

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