

PROCEEDINGS OF THE  
INTERNATIONAL CARBON NEUTRALITY TRAINEESHIP PROGRAM  
Volume.01, Number.1, 2023, 113-119

## **Sustainable Public Transportation Planning: An Integrated Subway Uses Design Model for TOD**

**Tianyi YE**

Chang'an University, Xi'an City, Shaanxi Province, China, 610000

E-mail: 764621409@qq.com

**\*Corresponding author**

### **Abstract**

With the advancement of urbanization in our country, the situation of increasingly congested road in large cities is increasingly serious. Transit-oriented development (TOD) creates urban development plans based on transit systems, thus improving land use and transit operations. Urban public transportation is the main effective way to solve the problem of increasingly congested city ground traffic, and public transport priority is the important guarantee to realize the way. This essay analysis the successful urban rail transit policy in Tokyo and some suggestions have been proposed for the implementation of China's large cities public transport priority strategy.

**Keywords:** TOD; subway systems; urban rail transit policy.

## **1. Introduction**

To what extent can TOD use in improving integrated subway design in sustainable public transportation?

Transportation infrastructure profoundly influences urban development. Automobile-based development strategies increase commuting distances and reduce land-use efficiency (Lin, 2006). Since sustainable public transportation systems promote more efficient resource usage, cities are increasingly applying transit-based strategies to solve urban planning problems. A sustainable public transportation system designed to encourage public transit has been rapidly constructed to the effects of urbanization, such as urban congestion and excessive air pollution. Transit-oriented development (TOD) creates urban development plans based on transit systems, thus improving land use and transit operations (Lin, 2006). The cities which don't follow TOD-type planning may have negative impacts on public transportation, urban congestion, and excessive air pollution problems will be serious. This essay aims to analyze to what extent TOD can be used in improving integrated subway design in sustainable public transportation. This essay shows how developed countries made the successful integrated subway model designed by TOD and how developing countries such as China can use the successful experience of Seoul to create subway sustainable public transportation. This essay also analysis the issue of the experiences and achievement of Tokyo in implementing the public transport priority strategy which is donated by urban rail transit, and experiences are summed up.

## **2. The definition and basic situation of TOD**

American scholar Peter Calthorpe first proposed Transit-Oriented Development (TOD) in the late 1980s (Jamme et al., 2019). It is widely recognized as one of the most effective ways to reduce traffic congestion and environmental pollution. TOD is a planning policy of designing that concentrates on urban growth around transit stops to support higher public transportation usage. TOD is usually defined by comfortable walking distances to a designated transit stop (Calthorpe, 1993). Transit professionals have established heuristics of 5 to 10-minute walking distances to transit stops. Walking distances is usually a radius of 300–400 m (about a quarter-mile) or 600–800 m (a half-mile) around bus stops and rail stations (Stojanovski, 2020). It is suggested that a majority (50%) of travel movements need to be accommodated by the sustainable modes (walking, cycling, and public transit) for a location to assume the label of 'genuine' TOD (Hale, 2012). It is argued in ITDP (2022) that TOD has several vital features, for example, access for all to local and citywide opportunities and resources by the most efficient and healthful combination of mobility modes, at the lowest financial and environmental cost, and with the highest resilience to disruptive events. Through many years of practice and theoretical exploration, TOD has become a relatively mature principle of urban planning and design to harmonize urban traffic and development effectively (He, 2014).

## **3. The success of TOD at transit stations**

Following the publication by Calthorpe (1993) between mobility and urbanization, the TOD concept was popularised in urban planning and city development (Tamakloe, 2021). Developed countries such as the US, Canada, and Australia applied TOD projects during the 1990s and 2000s. The success of TOD in cities in the USA and developed counties of Europe generated a positive effect. As a result, transportation managers and policymakers have implemented TOD strategies in many urban cities worldwide (Tamakloe, 2021). However, not only the developed countries, Seoul, the capital of South Korea, was a successful case of TOD efficiency at transit stations.

### **3.1. The efficiency of TOD at transit stations in Seoul**

Seoul, in South Korea, has one of the most complicated and robust public transportation networks in the world. In the case of Seoul, TOD at transit stations show dense development patterns and a compact land-use mix (Tamakloe et al., 2021). A study written by Sung and Oh (2011) identified that aspects of western-based TOD features are applicable in Seoul despite its unique features. Station design, land use, and transit supply are the planning factors which increase public transit ridership. Sung and Oh (2011) also proposed the development of well-designed street networks and selecting appropriate land-use strategies. Developing well-integrated public systems of buses and subways would help boost TOD performance. Seoul has one of the most advanced and extensive transit systems globally (Tamakloe et al., 2021). Advanced and extensive transit system is the successful result of an integrated distance-based fare system which provides fare discount according to distance. The other two reasons are the well-planned transit stations based on TOD planning factors, and the Government keeps on investing a lot in the public transit system.

### **3.2. Implement urban rail transit policy in Tokyo**

Japanese cities implement the policy of public transport strategy which is dominated by urban rail transit. Tokyo is a typical representative city. Tokyo has the world's most complicated urban railway transport system with a dense flow of people and commuter station groups (Zhang, 2014). Urban sprawl has led to longer travel times and higher travel costs. In this case, the people living on the less convenient travel are very inconvenient. Yaolong Zhao and Yuji Murayama (2006) discussed the early urban layout, that is, the commercial district is located in the centre of the city, and the residential district is distributed around the commercial district. As the city continues to grow, commercial areas expand outward, and the residential land in the city centre gradually decreases. People on low incomes have to

live far from their workplaces. Remote communities and poor transportation will result in unemployment for low-income people.

The development of urban rail transit is an important measure to solve the inequalities in transportation accessibility among people in different areas. Suburbanites spend less money and time on transportation, according to the report. People with low incomes are more likely to find jobs in the city centre (Yao-lung Cho and Yuji Murayama, 2006). Japanese cities carry out the public transport strategy policy with urban rail transit as the leading. Tokyo is a typical representative city. Tokyo has the most complex urban rail transit system in the world, and a dense group of commuter stations (Zhang, 2014). Figure 1 is the Tokyo subway route map, it shows the high-density distribution of Tokyo subway stations. The Tokyo government attaches great importance to the construction of subways and trams, integrating light rail, monorail, automatic rail and other forms of urban rail transit in the centre of Tokyo. In addition, Zhang (2014) discussed that the coverage rate of the central area of the railway network in the Tokyo metropolitan area is close to 100%, and the high-density rail transit ensures the high efficiency of transportation. The table1 shows line scale and density, network speed combination, the coverage rate of the central area, number of transfer nodes of Tokyo urban rail transit.

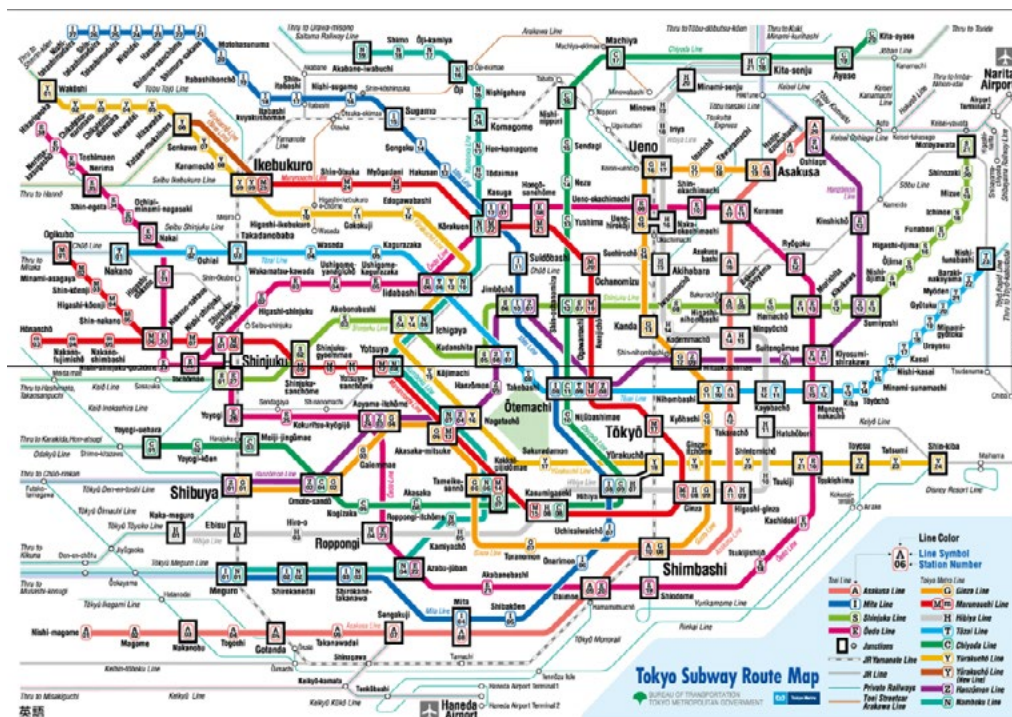


Fig. 1. Tokyo subway route map (Zhang, 2014)

Table 1. Overview of Tokyo urban rail transit

	Line scale and density	Network speed combination	Number of transfer nodes	Coverage rate of central area
Tokyo	2.2 km/km <sup>2</sup>	260 km/h	112 one line	100%

The ground public transport system is dominated by buses and taxis, which are closely connected with rail transit stations. For long-distance traffic, the efficiency of traffic transfer needs to be solved. The transportation hub building built by the government not only solves the traffic transfer problem but also forms a unique Tokyo urban hub public building. For example, Figure 2 describes the Shibuya station transfer system carefully. Different types of vehicles are designed to be parked in different places. It can ensure railway traffic security and rapidity. Passenger flow is organized reasonably, efficiently and orderly. In addition, as a complement to the subway line network, Tokyo has a large number of bus lanes. This helps to ensure the priority of the bus transportation system, and the bus operation is fast and efficient.

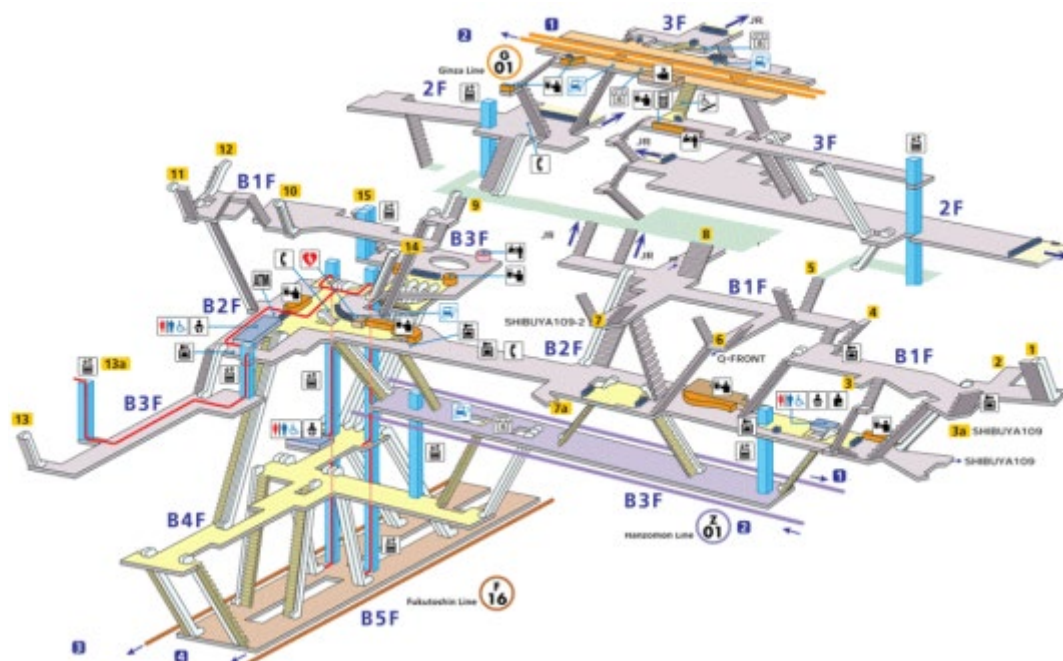


Fig. 2 Shibuya station transfer system (Zhang, 2014)

In conclusion, a perfect urban rail transit system is of great significance. It will not only reduce the distance between the city centre and the suburbs but also provide employment opportunities for low-income people, thus alleviating the transportation equity problems caused by regional differences.

### 3.3 Construction toll and subsidies in Tokyo

Tokyo is a densely populated large city, depending on highway transportation alone is far from adequate and is easily jammed. On the other hand, a high level of private vehicle related expenses is impractical. Based on the situation of development, Tokyo had formulated the development strategy, mainly to develop rail transit network and supplement the network by vehicles.

Data from World Bank showed that the total railway system is privately owned. In the early stage, the railway system of Tokyo was invested by government. With the construction of the whole system, the operation of railway becomes private gradually. The largest private company JR, was formed after the resolution of Japan National Railways in 1987. The construction consumption was paid by those private companies, which leads to great financial pressure. On the other hand, Li (2010) mentioned that the government stipulated that transportation companies are not allowed to raise prices until they make a loss. The price adjustment rate should be based on the change of price growth index, with a maximum of 20%. This makes those companies have less or no profit. Thus, some companies may close routes to remote areas and do harm to equity.

Government can adopt public support policies to ensure public welfare and marketability of private railways. Subsidies can be offered in construction and maintenance to encourage the investment in public transportation construction. Li (2020) encouraged that as railway system is positioned as main mode of transportation, the scope of subsidies can be extended to construction and maintenance for all railways whether built by government or private. In addition, subsidies can be available for renovation projects used to expand rail capacity and reduce traffic congestion.

## 4. TOD used in developing countries

TOD has been used in dozens of projects in the US, Canada, and Australia since the 1990s. In Europe, it is

considered the best practice for controlling urban sprawl. TOD has been widely used in developed countries in the last forty years. After the 2000s, the concept of TOD was promoted in Chinese cities. In addition, Johannesburg and Cape Town in South Africa has begun using the TOD concept (Ogra & Ndebele, 2014; Wilkinson, 2006). However, TOD is now decades old, and interested practitioners need to face the future with a firmer quantitative base. Hale (2012) calls it "a more dexterous approach to analysis and conceptualization". It shows that developing countries apply a more dexterous TOD system to urban congestion and excessive air pollution. However, as a developing country, Seoul has one of the most advanced and extensive transit systems globally. China and other developing countries will gain experience from the successful case in Seoul.

## **4.1. How to improve the situation of traffic in developing countries**

Developing countries usually build an integrated transit system by TOD in capital or megacities. There will be a problem that the neighbouring cities primarily rely on capital or megacities because of their social-economic needs. Seoul is an especially example of it. Seoul's neighbouring cities primarily rely on it for their social-economic needs, just like many other capital cities worldwide (Jang et al., 2017). This dependence relationship leads to congestion in the city. However, the Seoul Metropolitan Government formulates a TOD strategy in Seoul to encourage residents to go out by public transportation. This strategy can be used in China's capital, Beijing capital, or in megacities such as Shanghai, Shenzhen, and Hangzhou. The Seoul Metropolitan Government also built an integrated transit system of subways and buses as an intervention to solve the congestion problem. In recent years, an integrated transit system of subway and bus has been rapidly built in China. The best-designed Bus rapid transit (BRT) systems worldwide offer service comparable to rail transit and at a lower cost (Deng & Nelson, 2011). However, BRT is not a single technology. A bus network adopts many features that are usually only used in subways. BRT applied successfully in Korea, and China might be an excellent policy for Africa's developing countries. Currently, the transport system covers most parts of Seoul.

Moreover, Seoul has a mature shared-bicycles system in the public transport system to help solve the first-and last-mile problem. The first-and last-mile problem usually means how to get to and from the public transit stops to the final destination. Solving this problem successfully is also a perfect solution for developing countries to solve close range of traffic problems.

## **4.2. Change the way of travel and build a multi-core city**

As the political center and the largest economic center of Japan, Tokyo's geographical location and political and economic status make it a region connected with the surrounding cities, known as the Tokyo Metropolitan Area (TMA). As a center, Tokyo is closely connected to surrounding cities for life, freight and many other commercial activities, and transportation is the link that builds these links. In addition, the formation of TMA has made people from surrounding cities are more willing to come to Tokyo. As a result, several "dormitory cities" were built around Tokyo, that is, people here go to Tokyo during the day and return to "dormitory cities" at night (Hideo, 1995). People tend to travel by car, and the large number of private cars and relatively concentrated travel times have resulted in severe traffic congestion in Tokyo.

Some cities have tried to vigorously develop car sharing and online car hailing to ease the pressure brought by private cars. However, due to the space limitation of car sharing and the peak period of online car hailing, these measures are not effective (Ikezoe, 2021). Ikezoe et al. (2021) found through the survey that 66.8% of residents only need 10 minutes to get to the station, but still insist on driving. It is not difficult to see that convenient public transportation and shared transportation do not strongly attract private car owners. To alleviate this problem, it is an effective way to reduce residents' desire to use private cars to travel. For example, reducing the number of parking Spaces in the central area, raising parking fees, establishing a congestion charge system and restricting private cars from entering the city center are all good choices.

The reduction of car ownership can improve traffic congestion, and more people will choose to share transportation, which will cause the congestion of public transportation and the difficulty of taking a taxi. In addition, as a relatively novel way of travel, shared transportation has the fairness problem of low usability of special groups such as the low class and the elderly. Eppenberger and Richter (2021) mention that only a small number of people are

good at sharing transportation services, and most of them are middle and upper income people with higher education.

To solve the contradiction between private cars and shared transportation, it is important to change the urban form. Zhou and Gao (2020) mentioned that the future development trend of Tokyo is to build a multi-core and multi-level city cluster. The change of traffic mode will affect the choice of functional location, thus redistributing the economic, cultural and commercial activities of the city, leading to the aggregation and decentralization of urban functions, and promoting the formation of new urban forms.

## **5. Conclusion**

This essay has discussed how TOD can be used to improve integrated subway design in sustainable public transportation. This essay gives Seoul's sustainable public transportation planning designed by TOD as a successful example to developing countries. The analysis of TOD policy in Seoul here has extended our knowledge of TOD and the solution to urban congestion and excessive air pollution problems. The research has also suggested that developing countries can gain the successful experience of Seoul and develop their particular policy on public transportation. The successful experience in Seoul has five essential factors. 1. Seoul Metropolitan Government formulates a TOD strategy for Seoul. 2. The development of well-designed street networks and selecting appropriate land-use strategies. 3. Developing well-integrated public systems of buses and subways. 4. An integrated distance-based fare system provides fare discounts according to distance. 5. Mature shared-bicycles system to solve the first-and last-mile problem. These five factors can improve the situation of TOD in developing countries, and the government formulating a suitable TOD strategy is the most important. This essay also analysis the issue of the experiences and achievement of Tokyo in implementing the public transport priority strategy which is donated by urban rail transit, and experiences are summed up. It effectively alleviates the urban ground traffic congestion problem by using advanced rail transit. On the basis of it, some suggestions have been proposed for the implementation of China's large cities public transport priority strategy. A perfect urban rail transit system is of great significance. It will not only reduce the distance between the city center and the suburbs, but also provide employment opportunities for low-income people, thus alleviating the transportation equity problems caused by regional differences. Developing countries which want to develop their public transportation systems by TOD can gain successful experience in Seoul. A dexterous TOD strategy helps solve problems of urbanization, such as urban congestion and excessive air pollution.

## **References**

- [1] Calavita, N. 1994, Calthorpe: "The Next American Metropolis: Ecology, Community, and the American Dream" (Book Review), American Planning Association, Washington, D.C.
- [2] Cao, G. & Zhou, J. 2018, "The goal, concept, and strategy of urban transportation Development -- the experience and inspiration of developed countries and cities ", Shanghai Urban Planning Review, vol. 1, no. 3, pp. 86-91.
- [3] Deng, T. & Nelson, J.D. 2011, "Recent Developments in Bus Rapid Transit: A Review of the Literature", Transport reviews, vol. 31, no. 1, pp. 69-96.
- [4] Hale, C. 2014, "TOD Versus TAD: The Great Debate Resolved.(?)", Planning, practice & research, vol. 29, no. 5, pp. 492-507.
- [5] Institute for Transportation & Development Policy (ITDP), 2022. What is TOD? Available at: <https://www.itdp.org/library/standards-and-guides/tod3-0/what-is-tod/> (Accessed 7 May, 2022).
- [6] Jamme, H.T., Rodriguez, J., Bahl, D. and Banerjee, T., 2019. A twenty-five-year biography of the TOD concept: From design to policy, planning, and implementation. Journal of Planning Education and Research, 39(4), pp.409-428.
- [7] Lin, J.J. & Gau, C.C. 2006, "A TOD planning model to review the regulation of allowable development densities around subway stations", Land use policy, vol. 23, no. 3, pp. 353-360.
- [8] Ma, X., Chen, X., Li, X., Ding, C. & Wang, Y. 2018, "Sustainable station-level planning: An integrated transport and land use design model for transit-oriented development", Journal of cleaner production, vol. 170, pp. 1052-

- 1063.
- [9] Mcdonagh J. 2006. Transport policy instruments and transport-related social exclusion in rural Republic of Ireland. *Journal of Transport Geography* 14(5):355–366.
  - [10] Ogra, A., & Ndebele, R. 2014. “The role of 6Ds: Density, diversity, design, destination, distance, and demand management in transit oriented development (TOD).” Neo-international conference on habitable environments.
  - [11] Stojanovski, T. 2020, "Urban design and public transportation - public spaces, visual proximity and Transit-Oriented Development (TOD)", *Journal of urban design*, vol. 25, no. 1, pp. 134-154.
  - [12] Sung, H. & Oh, J. 2011, "Transit-oriented development in a high-density city: Identifying its association with transit ridership in Seoul, Korea", *Cities*, vol. 28, no. 1, pp. 70-82.
  - [13] Tamakloe, R. and Hong, J., 2020. “Assessing the efficiency of integrated public transit stations based on the concept of transit-oriented development.” *Transportmetrica A Transport Science*, 16(3), pp.1459-1489.
  - [14] Tamakloe, R., Hong, J. & Tak, J. 2021, "Determinants of transit-oriented development efficiency focusing on an integrated subway, bus and shared-bicycle system: Application of Simar-Wilson's two-stage approach", *Cities*, vol. 108, pp. 102988.
  - [15] Wilkinson, P., 2006, “Transit oriented development”: A strategic instrument for spatial restructuring and public transport system enhancement in South African cities? 25th South African transport conference.
  - [16] WuDUNN, S. 1995, *On Tokyo's Packed Trains, Molesters Are Brazen, late (East Coast) edn*, New York Times Company, New York, N.Y.
  - [17] Zhang, B.Y., Wang, S. & Yue, H. 2014, "Experience and Reference of Implementing Public Transport Priority Strategy Dominated by Urban Rail Transit in Tokyo", *ADVANCES IN TRANSPORTATION, PTS 1 AND 2*, vol. 505-506, no. *Advances in Transportation*, pp. 813-819.
  - [18] ZHAO, Y. & MURAYAMA, Y. 2006, "Effect of spatial scale on urban land-use pattern analysis in different classification systems: An empirical study in the CBD of Tokyo", *Theory and Applications of GIS*, vol. 14, no. 1, pp. 29-42.