Research on Urban Autonomous Rail Rapid Transit Development Strategy based on TOD
-- A Case Study of Yibin City

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Abstract
With the large increase of urban population, the rapid growth of motor vehicles, traffic congestion has gradually become a common problem in the city, and the relative shortage of land resources, the strategy of urban blind expansion to the outskirts has been obviously not enough to solve the problems. The TOD urban development model with comprehensive consideration of public transportation and land resource utilization is introduced. Through the contrastive analysis of the successful cases at home and abroad, summed up the reasonable TOD development type, Yibin city as the research object, analyzing the Yibin city development present situation, the Autonomous rail Rapid Transit (ART) as the carrier, combined with the characteristics of five new district, Yibin city, analysis applied to each new TOD type, provide reference for the Yibin city development.

Keywords
TOD; ART; Yibin.

1. Introduction
In recent years, with the construction of Lingang Development Zone, the development of high-end growth industries, the introduction of colleges and universities and a series of policies, the economy of Yibin has developed rapidly. In 2019, Yibin has achieved a GDP of 260.189 billion yuan, ranking the third in Sichuan Province. However, with the rapid growth of urban population and the number of motor vehicles, the original traffic facilities are seriously overloaded, and the traffic problems become more and more serious, affecting the healthy development of the city [1]. Although local governments have tried to ease traffic by widening roads and increasing the density of road networks. However, due to the limited land resources and the demand of urban intensive development, new requirements are put forward for the coordination of the relationship between public transportation and intensive land resources. As a "public transport-oriented" urban development mode, TOD mode has achieved good results in solving urban traffic congestion, effectively utilizing land, optimizing urban structure and other aspects through the practice of Chinese and western cities since it was proposed [1]. Therefore, based on the analysis of the urban development status of Yibin City and the case study of TOD development mode at home and abroad, this paper discusses the TOD development strategy suitable for Yibin City from the perspective of studying the interaction mechanism between comprehensive land use and public transportation system.

2. Research Actuality
The concept of TOD was proposed in 1992 by Peter Calthorpe, one of the proponents of New Urbanism. Since then, it has been extensively studied and practiced in various countries and cities, and achieved good results. In recent years, the research direction has been developing
towards the analysis of TOD results and the more detailed improvement of TOD model. For example, in 2021, Hongwei Dong (America) evaluated the impact of TOD on the transportation expenditure of families in California and concluded that TOD families spent less on transportation than non-TOD families every year [3]. In 2020, Mohd Faridjaafar Sideka (Malaysia) determined the transportation distance, the important activity types of departure and destination, and the main transportation modes in and out of TOD station through questionnaire research [4]. In 2018, GloriasSerra-Coch (Spain) conducted an evaluation of the Paris-Saint Lazare Intermodal Station area based on the TOD criteria defined by the Institute for Transport and Development Policy (ITDP). Quantitative and graphical results are compared by georeferenced mapping and numerical data based on TOD standard scores to determine the supplementary information provided by the maps [5]. In 2017, Yamini Jain Singh (Netherlands) proposed to quantitatively measure the existing TOD level within the walking distance of traffic nodes through TOD index, and applied this method to the urban areas of Arnhem and Nijmegen in the Netherlands, and calculated the TOD index of the areas near 21 railway stations in the area [6].

In China, in 2021, Lu Ying proposed the TOD4.0 model, and put forward the planning strategy of "station and city people integration" from four aspects of functional composite development, humanized space design, multiple network connection and "unit overall planning" [7]. In 2020, Cui Xuchuan took the TOD station of Beijing New Aviation City as an example to introduce in detail the design essentials of public transport hub nodes, such as "inside and outside, people and vehicles, traffic and land, architecture and space" under the concept of station and city integration [8]. In 2017, Liu Peng et al. explored the surrounding development mode and strategy of rail transit stations in urban fringe based on the concept of e-TOD, and revealed the influence of station difference, coupling degree between station and surrounding land use, and connection mode on the radiation range of the station [9]. In 2011, Liu Chang et al. compared the changes in the travel characteristics of residents before and after the introduction of rail transit in Songjiang New City, tested the implementation effect of the development strategy based on TOD mode, and analyzed its existing problems [10].

To sum up, domestic and foreign researches mainly focus on the extension of TOD mode, the practical effect of TOD mode, and the TOD development strategy based on a public transportation, etc., while few researches focus on the development strategy of the TOD mode in a certain region. Therefore, based on TOD mode, this paper takes Yibin City as an example to discuss the strategy of urban development by using ART, hoping to provide some ideas and suggestions for solving traffic problems and urban planning problems.

3. Urban TOD Mode Development Cases

3.1. America

As the origin of TOD model theory, public transportation in the United States originally appeared in the form of ground trams. Since most of the land in the tram and service area was privately owned at that time, the developers who wanted to increase the value of the suburban land could only connect the city center by providing a public transportation system, which was the original prototype of TOD [11]. In 1993, Calthorpe published The Next Generation of American Cities: Ecology, Community, and the American Dream, detailing the definition, types, design essentials, and a detailed guide to TOD [12]. Since then, the concept of TOD has gradually formed and expanded, and it has been practiced and achieved success in various cities. TOD types in the United States can be divided into three categories: first, the "central type" with regional center, city center, suburban center and town transit center as the main body. Second, it is a "regional type" dominated by urban neighborhoods, suburban transit neighborhoods, special use or employment areas. Third, the "corridor type" laid out along the traffic lines [13].
Among them, the more successful case is the development of San Francisco Bay Area. In 2005, the City of San Francisco adopted the Bay Area Redevelopment Plan, which aims to transform the San Francisco Bay Area into a multifunctional, transit-oriented and sustainable city. Remove old bus stops and elevated ramps to build the approximately 1.2 million-square-foot Salesforce Passenger Center, a hub for the state’s 11 regional bus systems, commuter rail systems and high-speed rail service. With the demolition and integration of the ramps, the continuity of the urban fabric is restored and some construction land is released, providing opportunities for regeneration and revitalization of the city. Today, the Bay Area has about 650,000 square meters of commercial space, 4,200 housing units and 1,000 hotel rooms, as well as nearly 9,000 square meters of retail and commercial areas, forming a true multipurpose city center.

3.2. Japan

Japan is one of the countries with the most developed rail transit in the world, but its land is highly privatized. In order to realize the efficient development between land and public transportation, private enterprises often coordinate land acquisition and storage, land planning and design, and track construction. As an urban builder, Dongsuo Electric Railway Company has been involved in the development of urban TOD earlier. The TOD project developed by Tokyo Electric Railway mainly has two modes. One is "hub node development in the central area", taking the redevelopment of Shibuya Station as an example. The second is "suburban residential new town development", taking Erzi Yuchuan Station as an example [14].

In the early 2000s, the number of passengers at Japan’s Shibuya Railway stations began to dwindle as the bubble economy and urban construction saturated. As a result, the Shibuya Station development plan began in 2008, with a total development area of about 930,000 square meters, through cultural exchange and tourism construction, community services, creative industries, international business services, cultural and urban infrastructure and other business functions. Increase the plot ratio of the block, which is mainly used for offices, commerce, culture, hotels and conferences, among other functions.

In March 2011, the comprehensive development project of Erzi Yuchuan Station was officially launched. The project is an open residential area driven by a transportation hub in the suburbs of Tokyo. This area is close to Shibuya, Shinjuku and other bustling areas, with a huge flow of people. Adhering to the development philosophy of "city to nature", the project aims to build a large, mixed-use urban complex on the outskirts of Tokyo, with Niko Tamagawa Station as the core. It focused on the use of natural resources and commercial natural extension and combination of Erzi Tamagawa Park to create the "shopping center + block" architectural form, forming the gallery, office, residential, commercial, film, roof ecological botanical garden as the main department store and subway commercial form complex.

3.3. England

The UK is also one of the early adopters of TOD model. London's public transport mainly includes subway, railway, city light rail, bus, etc. Due to the high housing price in central London, many job opportunities and other reasons, most people need to change several means of transport from the suburbs to work. Therefore, in order to solve this problem, London adopts three types of TOD in urban planning.

The first type is urban renewal, which is mainly aimed at the sites with dense buildings and few removable buildings around the old urban centers. Building on the core London Underground station, improve the commercial street for pedestrians, expand the station capacity, increase the extent of the pedestrian street, reduce the vehicular area, introduce pedestrian friendly facilities and landscaping, transform the old building, introduce new office areas and commercial complex.
The second type is the hub type. This type is dominated by large-scale comprehensive transportation complex, which is mainly aimed at the gathering place of employment and capital. Increase the carrying capacity and subway lines of the subway, support various public transport transfer, improve the accessibility of various traffic transfer, increase the plot ratio around the station, integrate more public activity space around the station, carry out urban building renewal.

The third type is the suburban town center and the "park city" community. This kind of site center usually takes the park and square as the core, surrounded by high-density residential and commercial buildings, forming the regional center. And a site is often not climate, through the combination of multiple sites to form a charming landscape urban life belt. At the same time, some distinctive places can be built between these sites, which attract people from the main urban areas.

3.4. China

Research on TOD concept in China started late, but the momentum of development is overwhelming. TOD practice has been widely carried out in Hong Kong, Beijing, Shenzhen, Guangzhou, Kunming, Chongqing, Chengdu and other places. Among them, Hong Kong was the first to explore the TOD model due to its rapid growth of population density and limited land resources. According to the development concept of "station city integration", the property development is carried out on 47 stations out of more than 150 stations of 11 subway lines with "track + property" as the main development mode. The completed TOD projects in Hong Kong can be divided into three types. The first type is "urban", which lays out the commercial and commercial areas in the center of the subway station, and then lays out the residential and public facilities land outwards. The second type is "residential", which mainly lays out commercial service communities and residential properties above commercial buildings; The third is "traffic type", in which the traffic station land is set in the center of the site, and commercial and residential land is set in the center [15].

Beijing Yizhuang Station is one of the earliest TOD projects in China. At the beginning of the 21st century, Yizhuang was identified as one of the three new cities for the future development of Beijing, in order to solve the urban development dilemma of "urban sprawl" in Beijing. At the initial stage of the planning, the way of using public transportation to guide the layout of urban functions was made clear. At present, a new layout has been formed through the subway, rail, rapid rail transit and other public transport systems. In terms of the integration of public transportation and surrounding land use, the project mainly adopts the mode of "rail transit construction and operation + land development and utilization along the line". Combined with the location advantage of the transportation hub, high-end characteristic retail, catering and entertainment functions will be developed around the project. Secondly, the project also pays attention to the construction of pedestrian traffic environment. Combined with the spatial layout of the station, the slow traffic system combining with the landscape corridor is established to pay attention to the comfort and safety of the environment [16].

In general, TOD in the United States, Japan, the United Kingdom and other countries has tended to scale, and various TOD modes suitable for their own development, such as "city type" and "community type", have been summarized, as shown in Table 1, and good practices have been achieved. However, TOD in China is still in the initial planning stage, and it is mostly practiced in larger cities. Moreover, city-centered TOD mode is mostly adopted, while other types of TOD modes are less practiced.
Table 1. Main types and characteristics of TOD

<table>
<thead>
<tr>
<th>Level 1 types</th>
<th>Level 2 types</th>
<th>Major characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>City type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>City-centric type</td>
<td>Urban center and cultural center; High building density; Large population density; Multiple bus lines and transfer points</td>
<td></td>
</tr>
<tr>
<td>Main urban hub type</td>
<td>Railway station, bus passenger transport center; An important link between the city and its suburbs; Excessive passenger flows</td>
<td></td>
</tr>
<tr>
<td>CBD type</td>
<td>Jobs and capital gathered</td>
<td></td>
</tr>
<tr>
<td>Regional city center type</td>
<td>A shopping center with adequate car access; Needs meticulous connection road; Diversity of land use</td>
<td></td>
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<tr>
<td>Community type</td>
<td></td>
<td></td>
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<tr>
<td>Suburban living type</td>
<td>Large population; Rich retail business</td>
<td></td>
</tr>
<tr>
<td>Park city type</td>
<td>Remote location, Certain natural resources</td>
<td></td>
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<tr>
<td>University center type</td>
<td>Good walking and cycling environment, walking system and shuttle bus connections</td>
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4. Urban Development Status of Yibin City

4.1. Urban Layout Analysis of Yibin City

Yibin City is a prefecture-level city in Sichuan Province, located at the junction of Yunnan, Guizhou and Sichuan provinces. Covering an area of 13,283 square kilometers, the central urban area is about 140 square kilometers. By the end of 2020, the permanent urban population will reach 2.341 million, and the urbanization rate of permanent urban population will reach 51.19 percent, with a relatively high population density. In recent years, with the Yibin in Sichuan province economy vice center as the goal, actively pushing forward the construction of the "two cities" depth fusion education development, promote foreign channel construction, the construction of the development of the national transportation hub and a series of policies, in 2019, to achieve GDP growth of 8.8%, total rise to the province's third, growth in the province the first bit. On the whole, Yibin has certain geographical advantages and has the prospect of developing into the economic center of southern Sichuan.

Yibin City Master Plan (2013-2020) has determined the combined zonal urban layout of "one city, four districts, three rivers and multiple clusters" in the central urban area of Yibin, as shown in Figure 1. The main city of Sanjiang is positioned as the core area of natural and cultural landscape, the gathering area of modern service industry, the municipal administrative center, the regional business and financial center, the regional business center serving the hinterland of Sichuan, Yunnan and Guizhou, and the regional passenger transport hub with high-speed rail and intercity railway as the carrier. Minjiang new district is positioned as a world-class liquor industry base and liquor culture center, a regional aviation hub and modern logistics center, a high-tech industry concentration area, and a regional education, science, culture and health center. Lingang New Area is positioned as an important shipping center and logistics hub of water, railway and highway transportation in the upper reaches of the Yangtze River, and an industrial base based on the platform of the state-level Lingang Economic and Technological Development Zone. The function of Jinsha New Area is positioned as a landscape ecological new area focusing on the development of modern service industry, a regional logistics and trade center, a science, education, cultural and creative center, and a support center for hydropower development of Jinsha River facing the Panzhihua area in the upper reaches of Jinsha River. Nanxi New District is positioned as a new landscape ecological district, a new industrial base, an exhibition and exhibition center, and a logistics and business center facing the eastern region.
4.2. The Layout Analysis of ART in Yibin City

In terms of road traffic, Yibin has first rail public transit line since the opening of the first Autonomous rail Rapid Transit (ART) T1 line in 2019. ART is a complete transportation system with zero emissions and no pollution characteristics of light rail, subway and other rail trains, and supports a variety of power supply methods, with a design maximum speed of 70 kilometers per hour. The flexible marshalling mode of high-speed railway is adopted, and each marshalling section can carry about 100 passengers. Due to its advantages such as low investment, fast construction cycle, adjustable transport capacity, zero emission and no pollution, it is expected that the smart rail will become the main force of Yibin’s public transportation in the future. The specific planning routes of Yibin ART Track are as follows:

Line T1 (completed): T1 line includes two parts: main line and branch line. Both the main line and the branch line start from Yibin West Station of the high-speed railway, the main line ends at ART Industrial Park Station, and the branch line ends at Sichuan University of Light Chemical Technology Station, roughly in a northeast direction, as shown in Figure 2.

Line T2 (under construction): It starts from Minjiang Avenue and Jinshajiang North Road (namely Baixi Beer Square) and ends at the southwest side of Nanmen Bridge, roughly in a north-south direction, as shown in Figure 2.

Line T3 (planning): The first and second phases start from Tongji Hospital Station in Lizhuang and end at Hongba Interchange Station. The third phase is the east line and the north extension line, as shown in Figure 2.

Line T4 (under construction): it relates to Line T1. Phase I of the project starts from the ART Industrial Park Station in Sanjiang New Area and ends at the Nanxi District Government Station. Phase II of the project starts from the Nanxi District Government Station and ends at the Nanxi District High-speed Railway Station, with an overall east-west direction, as shown in Figure 3.

Line T5 (planning): it is connected with Line T1, starting from Chongqing-Kunming Yibin East Station and ending at Yiheng Expressway, running northwest.

Line T6 (Planning): It starts from Wuliangye Airport and ends in Tianyuan, running southeast, as shown in Figure 2.

Line T7 (planning): It starts from Hengliu Road, Donggang, and ends in Songjia Town, trending north and south, as shown in Figure 3.

From this point of view, with the gradual advancement of the ART construction, Yibin’s public transportation will become more and more developed, which also provides a new idea for urban development.
5. Discussion on TOD Development Strategy of ART in Yibin

By comparing the combined zonal urban layout of "one city, four districts, three rivers and multiple clusters" in the central urban area of Yibin and the planning map of Yibin ART, it can be found that the two layouts are very consistent. Therefore, TOD urban complex development can be carried out on the basis of smart track sites based on the planning characteristics of each region. Accordingly, the following development strategies are proposed:

(1) The main urban area of Sanjiang is located at the confluence of Yangtze River, Minjiang River and Jinsha River, spanning Jinsha River. It is one of the areas developed earlier in Yibin City, and the ART Line T1, T2 and T3 pass through here. This area is characterized by high building density, old residential buildings, narrow roads, concentrated population, traffic congestion and poor living experience. There are more historical and cultural buildings worthy of
protection; With a number of trains, bus hub stations, convenient contact with other groups; There are more administrative units located, but the location is more scattered. Therefore, it is difficult to carry out urban redevelopment in this area. Combined with the analysis of TOD development experience at home and abroad, the results show that this region is suitable for diversified combined development strategy. It is suitable for "residential (or community-type)" TOD mode in residential dense areas. With the transformation of the living environment as the main goal, we will develop commercial streets and high-density residences dominated by pedestrians around the wisdom rail station, allocate green spaces and residential squares to disperse the flow of people, build unified office buildings and concentrate administrative units. In terms of transportation, "slow traffic" mainly on foot and bicycle should be planned, and corresponding sidewalks and non-motorized lanes should be configured. Secondly, it is applicable to the TOD mode of "Main urban hub type " at the transportation hub stations such as railway stations and bus stations. This kind of site has a large flow of people, and it is the junction point between the city and the suburbs. Therefore, the development and construction should be carried out by means of increasing the passenger capacity of the site, implanting commercial space, introducing public space, increasing the density of surrounding buildings, and increasing a variety of transfer tools. Implant new forms of business to stimulate economic development. Development projects integrating office, hotel and business can be developed to make external communication and office more convenient.

(2) Minjiang New Area is located in the north of Minjiang River, close to the suburbs. There are large enterprises (Wuliangye), universities (Yibin College) and airports (Wuliangye International Airport) in this area. There are many residences, but the building density is not high; and there is a northwest direction of the expressway (Yinkun Expressway), ART T3, T6 line will also pass through here. Based on this characteristic, there are several TOD development modes suitable for this region: The first is "university center type ", which focuses on the construction of student activity center, sports center, catering and business center with students as the main body around the Yibin College station of the ART line. In addition, good walking and cycling environment should be provided, and a variety of connecting ways should be introduced to facilitate students' travel. The second is " Regional city center type " in the heart of the city, traffic network, enhance the connectivity of region, and the airport site to build shopping centers around the enterprise and mixed community, through the construction of the gym, garden market, such as low-density features of the market, can attract here will be the main stream of people, eventually form a regional center, reduce the flow to the city center, slow down the traffic pressure.

(3) Lingang New Area, located to the north of the Yangtze River, is the core area for the eastward development of Yibin's downtown area along the Yangtze River. In June 2016, it was listed as the Yangtze River Economic Belt Transformation and Upgrading Demonstration Development Zone by the National Development and Reform Commission, with a planned total area of 213 square kilometers. Now, this area has become an important new area in Sichuan, Yunnan and Guizhou region with high integration of education, scientific research, industry, port and city. The main line through this area is the smart rail T1 line. Suitable for the area of the main type of TOD " Regional city center type " in the heart of the city, the area developed into residential, office, teaching, business, logistics as an integrated regional city Centre, will be the main stream of people spread to this area, reduce the flow to the main flow, but also connected with public transportation, slow traffic jams.

(4) Jinsha New Area is located to the west of Jinsha River. The building density and traffic pressure is not high, there are reservoirs, villages and other natural landscapes, and the Line T5 will pass through here. Therefore, this area is suitable for building a "Park City type" TOD project. Build district centers around the suburban sites. Some of these centers will create unique places that attract people from the main urban area, while others will be urban centers
that provide complex living and business services for the entire suburban area. A number of ART sites work together to create a charming landscape urban life belt. Improve block plot ratio by building cultural and urban infrastructure with functions of cultural exchange and tourism, community life services, creative industry services, international business services, commerce and so on. Nanxi New Area is located to the north of the Yangtze River and to the east of Lingang New Area. It is relatively remote, and the T4 line of the ART Line will pass through it. Therefore, this area is also suitable for the "Park City" community-type TOD.

6. Conclusion

In recent years, due to the increasingly prominent urban traffic problems and land resource utilization problems, TOD mode, as one of the ways to solve this problem, has been well applied in some cities at home and abroad. Based on the comparative analysis of successful TOD cases at home and abroad, this paper summarizes the TOD type suitable for urban development. Taking Yibin City as the research object, this paper analyzes the urban development status of Yibin City and finds that the main urban area of Yibin City has the phenomenon of excessive population density and traffic congestion. Therefore, taking the ART as the carrier, this paper analyzes the characteristics of the five new districts in Yibin City, and summarizes the TOD types suitable for each region, which provides reference for the urban development of Yibin City. In the future, we will further study how to solve the problems of traffic station connection, parking and transfer based on TOD model.

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References


