TRACK 05: PLANNING FOR MOBILITY: ACCESSIBILITY, AFFORDABILITY AND SUSTAINABILITY

RESEARCH ON FUTURE URBAN COMPREHENSIVE TRANSPORTATION DEVELOPMENT STRATEGY: BASED ON WUHAN YANGTZE NEW TOWN (1056)

Gangyu Hu[1], Jianing Shi[1], Jianzhong Huang[1]*

[1] Tongji University College of Architecture and Urban Planning, Yangpu District, Shanghai, China; *huang03213@tongji.edu.cn

Abstract. Taking the master planning of Wuhan Yangtze New Town as an opportunity, we propose that the traffic development of Wuhan Yangtze New Town should conform to the four basic principles of 'regional co-ordination, multiple sharing, interaction and coordination, moderate advance'. Based on these four principles, we put forward three specific strategies which are 'building multi-dimensional transportation network', 'creating seamless mobility' and 'TOD+ short trip' mode. Among them, 'building multi-dimensional transportation network' refers to the construction of 'air-ground-underground' multi-dimensional transportation network. 'Seamless mobility' includes three basic elements of 'shared and autonomous driving', 'car electrification' and 'mass public transit'. 'TOD+ short trip' mode is actually a 'public transportation + slow traffic' mode of travel organisation, which could help to reduce commuting traffic and promote living quality.

Keywords: Future cities; Multi-dimensional transportation; Seamless mobility; TOD+ short trip; Wuhan.

1. The Future Development Trend of Urban Transportation in the Research

With the rapid development of science and technology, the future development of urban transportation will also face great changes (Singh and Gupta, 2015). Weng (2017) proposed that four major features of future transportation might be intelligent, networked, clean and shared. Wang (2017) believed that intelligent transportation will have three key development directions in the future: big data + traffic service, focusing on multi-perception and real-time collaborative processing of integrated traffic big data; mobile internet + comprehensive transportation, focusing on cooperative organisation

and operation optimisation of comprehensive transportation hubs, intelligent multimodal transport of goods, etc.; artificial intelligence + system collaboration, focusing on vehicle-vehicle collaboration and safety control, vehicle group collaboration and optimisation, three-dimensional unmanned intelligent transportation system, etc. Zhao (2017) believes that future transportation should be considered from the perspective of urban development, human needs as well as ecological system. Various modes of transportation should be combined effectively to realise people's on-demand travel.

As city is a changeable complex, the future traffic development strategy should be closely related to the overall urban development process. According to McKinsey & Co (2016): A comprehensive vision of the future travel mode (mobility) in 2030, three mobility models are expected to emerge in the near future for cities at the forefront of the mobility revolution: First, clean energy and sharing. Densely populated cities in developing countries like Delhi, Mexico City and Mumbai are undergoing rapid urbanisation and suffering from traffic congestion and air pollution. For cities like these, widespread adoption of autonomous vehicles might not a viable option, at least in the short term. The relatively viable option is to shift to clean energy transportation, namely electric vehicles. It also needs to limit the number of private cars, optimise shared mobility and expand public transport. Second: private self-driving cars. This mode of travel costs higher and might be suitable for cities expanding to the suburbs in developed countries, such as Sydney, Houston, Ruhr and so on. Third: Seamless mobility. This mobility pattern shows the biggest change compared to current travel patterns. It is most likely to occur in the short term in a number of densely populated, high-income cities such as Chicago, Hong Kong, London and Singapore. In this model, mobility is essentially ‘house-to-house’ and on-demand. Travelers have many clean, cheap and flexible options to choose from and the lines between private cars, sharing and public transport are blurring (Golmie,2009).

Under the discussion and exploration of future transportation development, this paper takes the Wuhan Yangtze New Town as an example to clarify how Wuhan try to build a future comprehensive transportation development system in the new urban area, hoping to provide certain reference value for other cities.

2. Four Principles of the Future Comprehensive Transportation Development for Wuhan Yangtze New Town

2.1 Promote an Integrated and Open Urban Road Network to Realise Regional Co-ordination

We should establish the concept of ‘growable’ urban roads, gradually open the original

'central closed-loop and radial' skeleton road structure and promote the formation of 'grid open' skeleton road network in Wuhan to effectively support the transformation of urban structure mode and promote the development of regional integration (Figure 1).

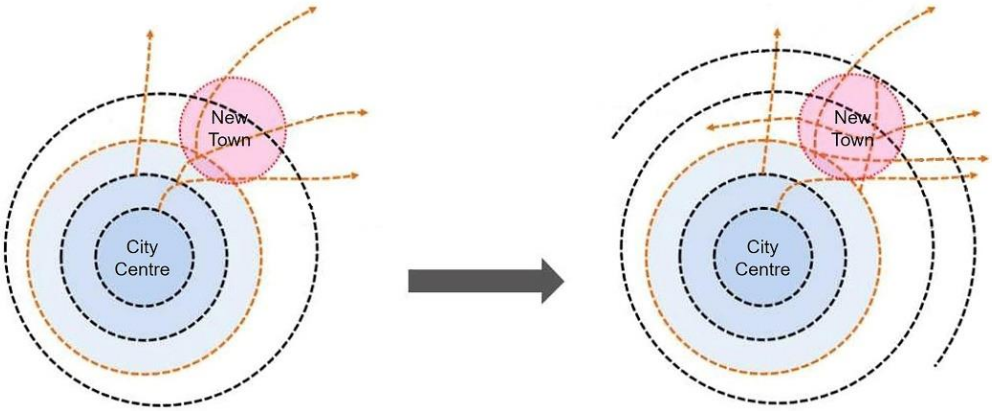

Figure 1. Partly 'broken loop into a network' expressway model
Source: Drawn by authors

2.2 Establish a Multiple Sharing and Public Transport Oriented Urban Transportation System

The transportation facilities construction of the new urban area takes urban rail transit and bus trunk (BRT (Bus Rapid Transit)/ ART (Autonomous rail Rapid Transit)/ conventional bus) as the backbone of the public transport system, supplemented by 'community bus + public bike'. It also creates a slow traffic system integrating traffic, leisure and recreation. Yangtze New Town focuses on building intelligent public transit routes and slow traffic corridors around the lake so as to achieve convenient, efficient, low-carbon and inclusive transportation system (Figure 2).

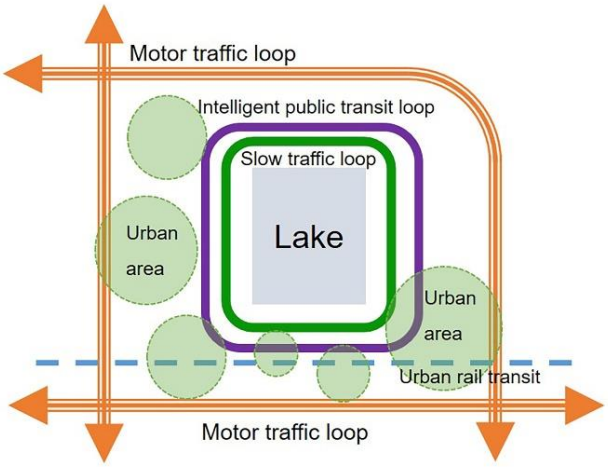

Figure 2. Organisational form of transportation around the lake
Source: Drawn by authors

2.3 Promote the Interactive and Coordinated Development of Transport and Land

We plan to construct large-capacity rail transit to strengthen the transportation links between the new town and the central city to improve the level of transportation services. Develop medium-volume public transport according to local conditions and improve the internal public transport system to drive the development of urban land and space (Figure 3). The planning focuses on the 'TOD+ short trip' mode as the basic mode, combined with the characteristics of land use and spatial layout of the new town to establish different types of traffic zones and provide different bus, car, pedestrian supply and management guidance strategies for each zone, so as to realise the interactive and coordinated development of transport and land.

Figure 3. Coordinated development of transport and land
Source: Drawn by authors

2.4 Provide Moderately Advanced and Flexible Transportation Facilities

Based on the protection of the lake district, we promote the elastic adaptation of urban transportation and land use through constructing the growable road network structure and the progressive supply of transportation facilities, so as to realise the smart growth of the urban development of the Yangtze New Town. We will try to adopt some international advanced new modes of transportation, such as capsule train, maglev train, WalkCar, balancing car, magnetic levitation skateboard, etc. in the planning of the new town to make it more technological, fashionable and full of vitality.

3. Construction Strategies of Comprehensive Transportation System for Yangtze New Town

Under the guidance of the above four basic principles, we put forward three specific strategies for building a comprehensive transportation system in Wuhan Yangtze New Town, which are ‘building multi-dimensional transportation network’, ‘creating seamless mobility’ and ‘TOD+ short trip’ mode.

3.1 Build Multi-dimensional Transportation Network

Considering the conditions of multiple low-lying land in Yangtze New Town, we try to construct a multi-dimensional spatial transportation network of ‘air-ground-underground’ by filling and lifting some land (Figure 4).

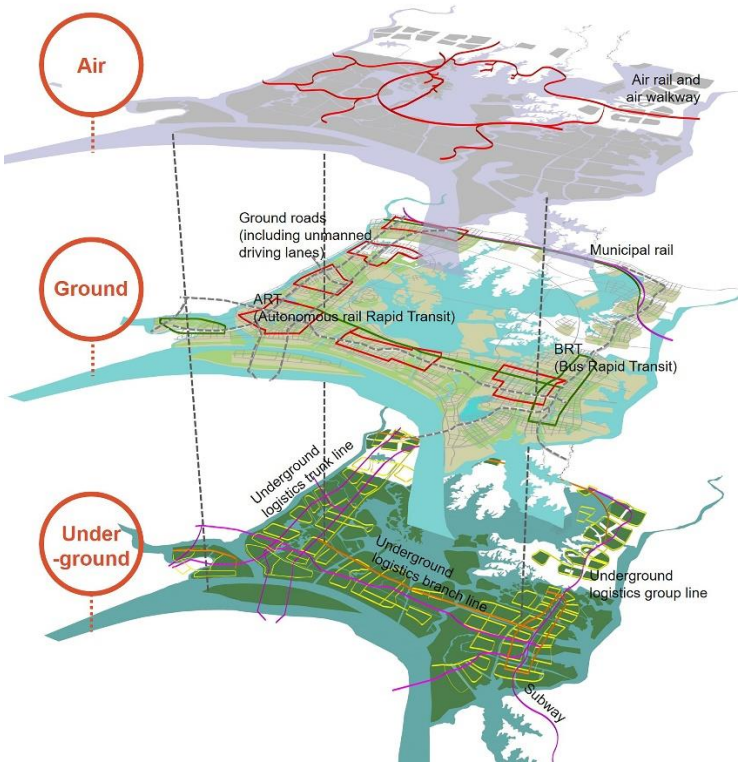

Figure 4. Multi-dimensional transportation schematic diagram

Source: Drawn by authors

The air traffic is mainly composed of air rail and air walkway, integrating rapid transportation and landscape sightseeing functions. The ground traffic is mainly composed of BRT, ART and ground roads (including unmanned driving lanes). High-capacity rapid transportation - medium speed traffic between nearby urban zones - medium and low speed traffic within a zone - slow traffic (walking and cycling) collectively form an integrated network of traffic on the ground. The underground part consists of subway, underground roads and underground logistics. Underground logistics transport and supply solid goods through large-diametre underground pipelines, tunnels and other channels, which are not easily affected by climate and can achieve intelligent

and uninterrupted transportation. We plan to put underground logistics trunk lines and rail lines in the same underground corridors to save space and improve efficiency.

3.1.1 Air Traffic

Air traffic systems combine with light vehicles, structures and technologies to personalise service. It can bypass congestion and connect land routes and water routes. Advances in battery and material technology may also enable lightweight elevated ramps to carry small self-driving vehicles and bicycles. In the planning scheme, air rails and air walkways are built in some areas (Figure 5). The form of air rail can include mounted monorail train, capsule train, etc. The planning scheme focuses on building intelligent air rails around Wuhu Lake, integrating rapid transportation and landscape sightseeing functions.

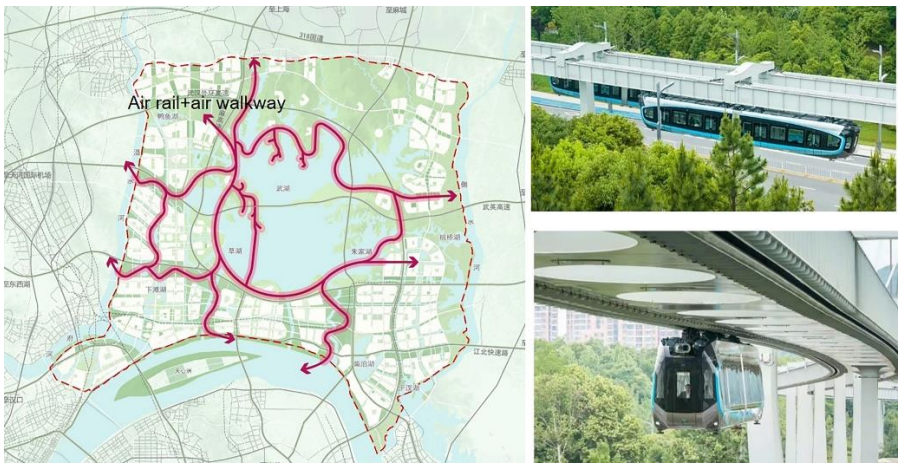

Figure 5. Air traffic schematic diagram

Source: Photos from《People's Daily》of China

3.1.2 Ground Traffic

Ground public transportation systems mainly include BRT lines, ART lines and conventional bus lines, aiming to realise the convenient transfer between different modes of transportation. ART system has the advantages of short construction cycle, low infrastructure investment, high urban adaptability and strong comprehensive capacity. It is a new solution for urban rail transit of medium volume. We try to open unmanned driving channel to transport multiple passengers efficiently through the network control. Initially, driverless vehicles can share High Occupancy Vehicles (HOV) with other vehicles, and when driverless vehicles become common, the lanes become exclusive for driverless vehicles (Figure 6).

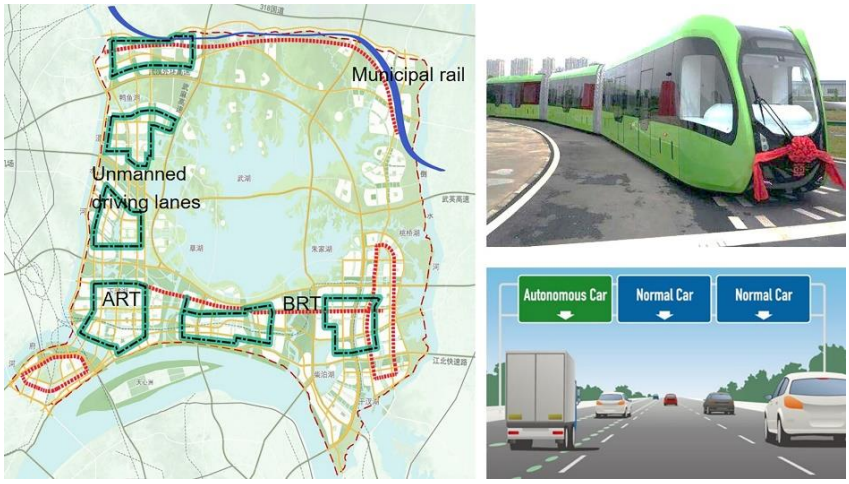

Figure 6. Ground traffic schematic diagram
Source: Photos from baike.baidu.com

3.1.3 Underground Traffic

Underground transportation systems mainly include subway, underground logistics and underground roads. In the case of Germany's CargoCap underground pipeline logistics system, the system driverless transport vehicle runs in an underground pipeline with a diametre of about 2 metres and the transport vehicle can freely enter and exit a transport group without reducing the running speed. The ultimate development goal of this system is to form a logistics network of underground pipes connecting various residential buildings or living areas in the city and to achieve a high degree of intelligence, so that people only need to click the mouse to buy any goods and the purchased goods quickly 'flow' into their homes like tap water through the underground pipes (Figure 7).

Figure 7. Underground traffic schematic diagram

Source: Pictures from www.cargocap.com

It is feasible for underground logistics system to cooperate with subway system. First of all, from the perspective of demand, there are many commercial enterprises with logistics business distributed along the subway, which may form effective demand for subway freight services. Secondly, from the perspective of time, the system can adopt the way of transporting people in the daytime and goods at night or reduce or increase the freight frequency according to the peak and trough of the flow of people in each subway line to strengthen the scheduling. Finally, from the technical view, when the subway lines and logistics lines are planned together, several special loading and unloading platforms should be designed according to the flow and distribution of logistics in the subway planning. It is better to plan the stations with two functions of passengers and freight. If necessary, special freight lines of subway can be built through key areas and be connected with freight connection lines of major suburban logistics centres and major stations.

We also plan to construct underground road system, which effectively connects with the surface transportation and realise the efficient conversion between walking and various modes of traffic. Underground transportation can effectively reduce the traffic pressure on surface roads and the scale of road facilities, reducing surface carbon emissions and surface vehicle noise, so as to improve environmental quality.

3.2 Create ‘Seamless Mobility’

On the basis of the construction of multi-dimensional transportation network, according to a comprehensive study of McKinsey & Co: A comprehensive vision of the future travel mode (mobility) in 2030, the study believes that ‘seamless mobility’ is more in line with the high target positioning of Yangtze New Town and the general trend of future urban life. Here, the ‘seamless mobility’ transportation includes three basic elements: first, sharing + autonomous driving. The sharing autonomous driving fleets will be gradually formed in Yangtze New Town. Second, cars will achieve a high degree of electrification. In seamless mobility areas, car electrification needs to reach more than 60 percent. Third, rail transit and bus rapid transit are still the backbone of long-distance travel. With a seamless mobility system, people may travel 20 to 50 percent more miles because of the low cost and ease of travel. However, the number of cars will remain the same or even decrease, as vehicle utilisation is higher and more people use the sharing model. By then, electric vehicles will account for two-thirds of total vehicle ownership and self-driving cars will exceed 40 percent (Figure 8).

Figure 8. ‘Seamless mobility’ area schematic diagram

Source: Drown by authors’ project team

The ‘seamless mobility’ area should be a three-dimensional multilevel composite area and the underground space should be fully developed and utilised. The underground space will be efficiently connected to the surface space and also have intelligent characteristics (Fig.9).

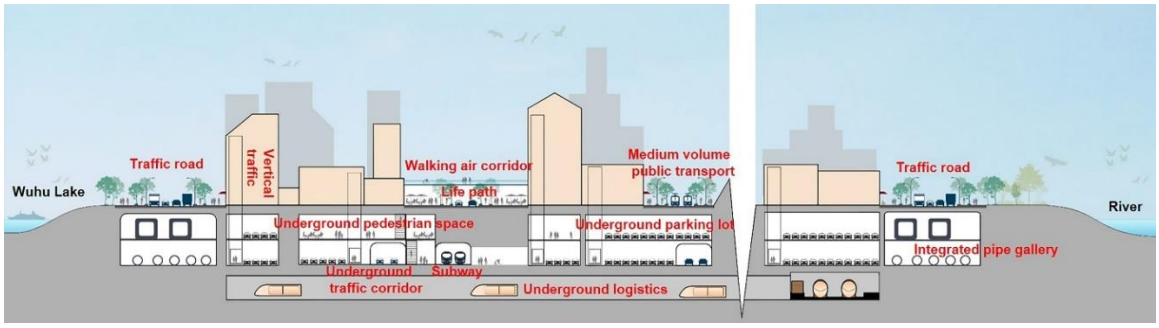

Figure 9. ‘Seamless mobility’ vertical traffic schematic diagram

Source: Drown by authors’ project team

The freight system also features ‘seamless mobility’. Urban freight transport mainly serves urban living consumption and high-end manufacturing industry. It is planned to form a logistics distribution system consisting of logistics centre, group distribution centre and community distribution node (a total of three level logistics nodes). We organise the freight according to the principle of ‘mainly underground form, supplemented by ground and underground forms’. We encourage the development of

underground pipeline transportation to build a modern fast logistics transportation system. We also set up some freight passages on the ground at night, as a supplementary way of urban logistics. Above ground, when underground logistics transport branch lines and household lines have not been fully completed, new technologies such as low-altitude UAV (Unmanned Aerial Vehicle) delivery will be used to solve the 'last kilometre' problem of logistics distribution in the near future (Fig.10).

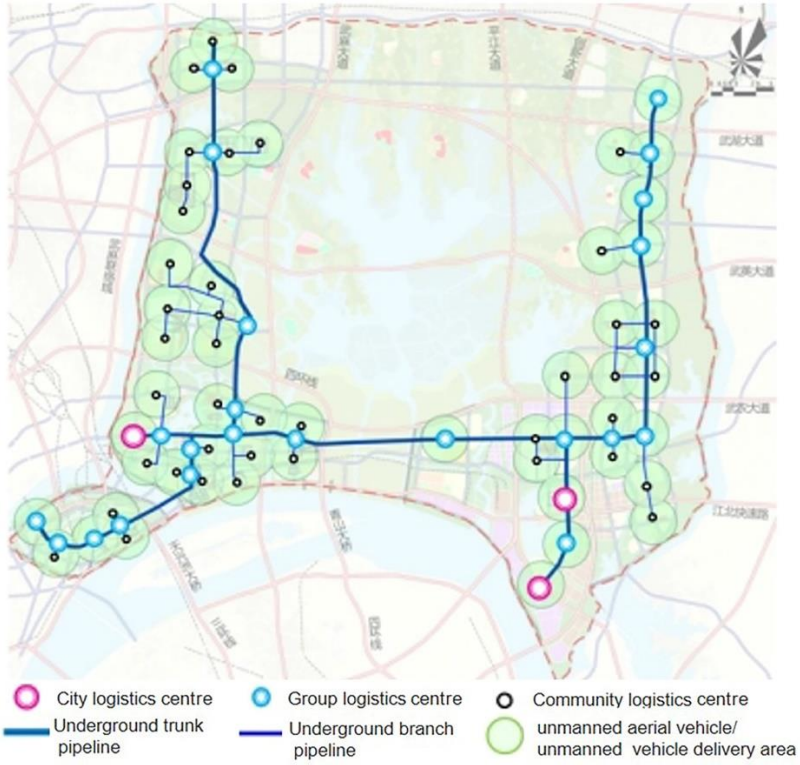

Figure 10. 'Seamless mobility' freight system schematic diagram
Source: Drown by authors' project team

3.3 'TOD + Short Trip' Mode

'TOD + short trip' mode is actually a travel organisation mode of 'public transportation + slow traffic'. 'TOD' refers to 'Transit-Oriented Development' (Ibraeva et al, 2020). Here the 'transit' mainly refers to 'public transit'. The 'short trip' mode first need to divide the whole urban area into several areas and then form own centres within different areas to reduce long-distance travel and relieve axial traffic pressure. The 'TOD + short trip' transportation mode will be an important mode for the future transportation development of Yangtze New Town.

3.3.1 'Transit-Oriented Development' Mode

The bus corridors in Yangtze New Town are composed of rail transit or bus trunk lines.

The bus corridors are staggered with regional trunk roads and can serve major functional areas in the city. In these bus corridors, TODs with a radius of 500-800 metres are formed with rail transit stations and main ordinary bus stations as the cores. These areas are mainly urban TODs (Fig.11).

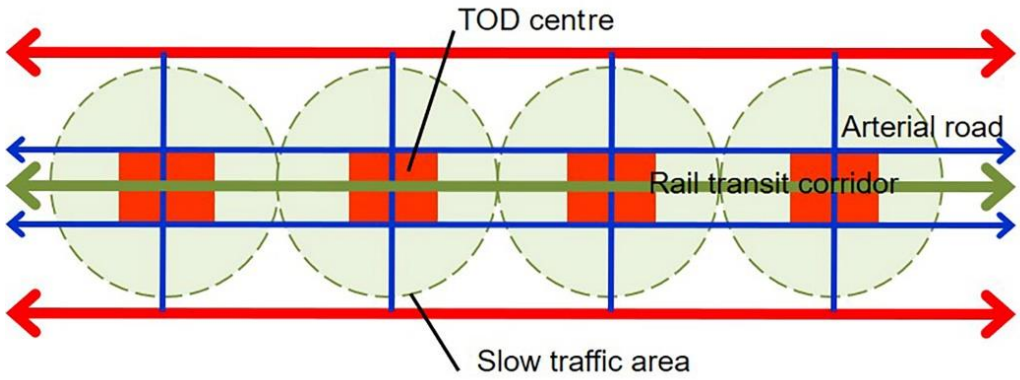

Figure 11. TOD axis development schematic diagram

Source: Drown by authors

Urban TODs are located in comprehensive activity centres in the city and are the cohesion points of urban public activities. These urban TOD areas work independently, or in pairs or even multiple groups to achieve economies of scale. Urban TOD's spatial organisation mode is mainly multi-rail transfer and three-dimensional mixing. It usually includes green space and arranges public service functions around the central park. In the TOD, multi-rail interchange station normally directly connects to central commercial complex. The central commercial complex may have radial corridors, improving the regional three-dimensional walking network to achieve seamless connection. The central commercial complex presents its outstanding image and normally gets high-intensity cluster development (Figure 12).

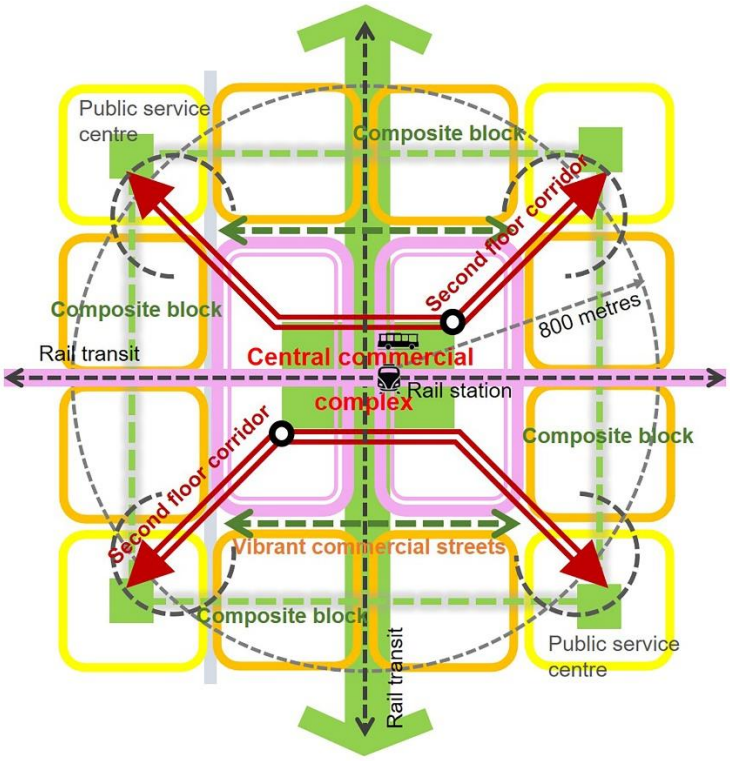

Figure 12. Urban TOD schematic diagram

Source: Drown by authors' project team

3.3.2 Short Trip Mode

Short trip transportation system is composed of slow travel system and public transportation system. Firstly, a continuous and high-density slow traffic system should be constructed to cover the whole slow traffic area. On the one hand, it provides the basic skeleton for the slow traffic space and on the other hand, it is easier to connect with public transportation. Secondly, we should improve the density of public transit network and the coverage of bus stations. Furthermore, 'P+R' and other measures are adopted to achieve efficient connection of various modes of transportation. For example, parking lots (for motor vehicle or non-motor vehicle) will be set up in combination with a rail transit station or a bus station to connect the slow traffic system with the public transportation system.

For short trip mode, due to the difference in travel distance, its travel structure has different characteristics (Figure 13).

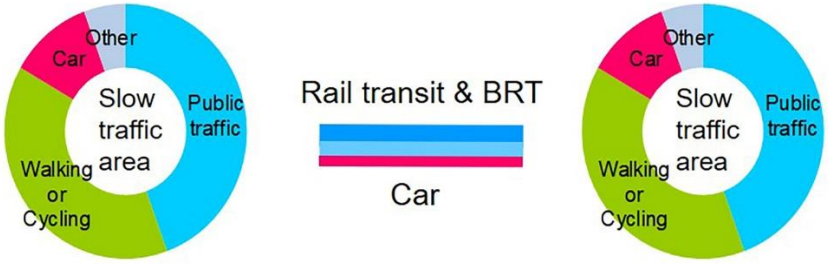

Figure 13. Short trip mode schematic diagram

Source: Drown by authors

(1) Inside the short trip area: The short trip area centre can meet certain needs of daily life and production. Most trips take place within the area and the travel distance is short. Therefore, green travel modes such as public transport and slow travel (walking or cycling) occupy a large proportion in the internal travel structure of short trip area.

(2) Between short trip areas: the travel distance between short trip areas is longer, which exceeds the advantage of slow traffic modes such as walking and cycling. Therefore, cars and public transportation (rail transit) are the main transportation modes between short trip areas.

The areas-based development makes the internal development of each area relatively independent. There are employment centres and residential land in one area, which can solve certain employment problems internally. The increase of residential land promotes the development of industrial land, which in turn promotes the generation of new residential land, thus constantly forming new clusters (areas). These areas are independent and closely related to each other, forming a balance between jobs and housing in development and reducing commuting traffic.

3.3.3 An Example of 'TOD+ Short Trip' Mode -- Central Vitality Zone of Yangtze New Town

Two longitudinal and one horizontal main transportation corridors are formed along the planned rail transit lines. Rail transit undertakes long-distance and large-capacity transportation between areas. ART and conventional buses shuttle between each area and undertake the medium speed traffic between nearby areas. The community bus mainly operates within the area and undertakes the medium and low speed traffic travel within the area. The water system combined with green space becomes the main ecological corridor in the area. Public bicycle lanes can be set up to protect the ecological environment and meet the needs of residents for leisure and entertainment. Commercial land and green space inside residential land will become the main human flow attraction points in the community. These nodes are usually the centres of the

community and the core nodes of slow travel (Figure 14).

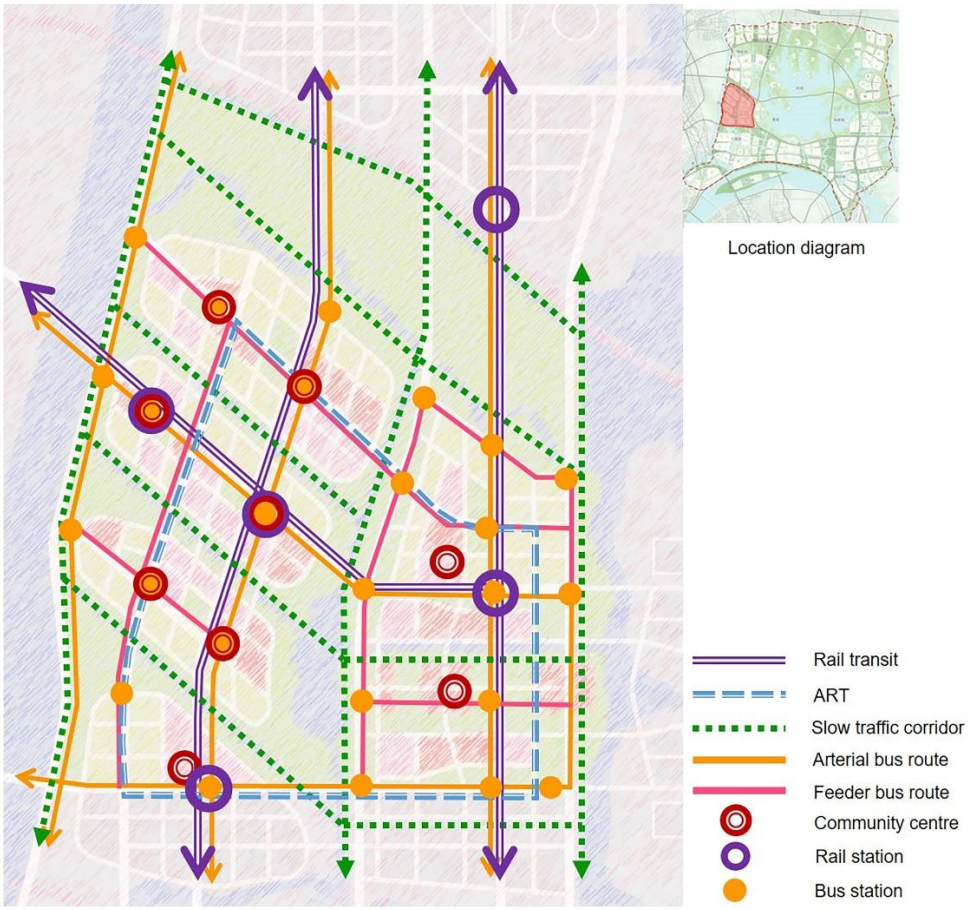

Figure 14. Central Vitality Zone 'TOD+ short trip' layout schematic diagram

Source: Drown by authors

The slow traffic system is the most basic and important traffic system in the area. We plan to improve the connection between the slow traffic system and the public transportation system, build the slow traffic corridor by the use of water system, so as to optimise the slow traffic environment and provide people with good leisure experience of slow traffic. In the future, the plan of 'clearing car congestion out of the city centre' proposed by Stockholm, the capital of Norway, may be followed to realise complete walking in the centre of the area in order to reduce car space in the urban streets, extend pedestrian streets, improve bike lanes, give people more public space to enjoy the urban public facilities and encourage more exercise and healthy travel.

4. Summary

Based on Wuhan Yangtze New Town, we propose four basic traffic development

principles of ‘regional co-ordination, multiple sharing, interaction and coordination, moderate advance’. And based on the four principles, we put forward three specific strategies to meet the needs of future traffic development, which are ‘building multi-dimensional transportation network’, ‘creating seamless mobility’ and ‘TOD+ short trip’ mode. Due to the unpredictability of the development of science and technology, the future urban transportation development has infinite possibilities. The future-oriented urban comprehensive transportation development strategies proposed in this paper are also an attempt and exploration from a limited perspective, which needs to be constantly updated, discussed and advanced in the future urban development.

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References

Golmie N (2009) Seamless mobility: are we there yet. IEEE Wireless Communications, 16(4), pp.12-13.

Ibraeva A, de Almeida Correia G H, Silva C and Antunes A P (2020) Transit-oriented development: A review of research achievements and challenges. Transportation Research Part A: Policy and Practice, 132, pp.110-130.

McKinsey & Co, Bloomberg New Energy Finance (2016). McKinsey & Co: A comprehensive vision of the future travel mode (mobility) in 2030. Report, McKinsey & Company, October.

Singh B and Gupta A (2015) Recent trends in intelligent transportation systems: a review. The Journal of Transport Literature, 9(2), pp.30-34.

Wang Y (2017) Medium and long term plan for intelligent transportation. World Transport Convention 2017——Forum on the Future of Transportation, Beijing, China.

Weng M (2017) The future of transportation will be more intelligent, connected, clean and shared. Future Transportation Conference 2017, Hangzhou, China.

Zhao F (2017) Human needs are fundamental, not for technology's sake. World Transport Convention 2017—Forum on the Future of Transportation, Beijing, China.