

Wen-wu Yang

# Study of Sustainable Urban Rail Transit Development Model in China

**Abstract** As the grand urbanization rapidly progresses in China, Chinese government launches a magnificent urban rail transit development plan as the key part of the preferential public transportation strategy. It is very necessary to establish a viable public private partnership model for urban rail construction. The philosophy of transit-oriented-development (TOD) is discussed in this study by reviewing Hong Kong Railway + Property development model which is proved very successful in mass transit rail development in Hong Kong. This paper examines current practice of urban transit as of conventional public transport infrastructure in China and looks into ways of getting over the bureaucratic and technologic hurdles in order to generating synergy value and opportunity of rail oriented urban development. Taking the TOD and public-private-partnership (PPP) study of Shenzhen metro line 6 as an example, the sustainable urban rail development model is introduced and elaborated. It concludes that the sustainable urban rail transit shall be able to energize the great potential of rail and urban development at macro, meso and micro levels, through effective integration of administration and technology resources, and generation of win-win scenarios among government, metro company, people and stakeholders.

**Keywords:** urban rail transit, Railway + Property(R+P), sustainability, transit oriented development, private public partnership

## 1 Introduction

Development of a comprehensive public transport system in a backbone of urban rail system is a preferential strategy to tackle the urban transportation problems and environmental issues in China as set in the national strategic urbanization plan. Urban rail system, either metro or light rail, provides punctual and fast speed mass travel mode in a comfortable

and safe riding environment. It deserves great advantages of less land use and less energy consumption, which is meaningful for protecting the environment and sustaining urban development. As a mass transit system, urban rail network becomes the lifeblood of a modern metropolitan for its efficient, green and healthy operations. An efficient urban rail transit network would be essentially the key driver of the sustainable development of a city, as it profoundly impacts on people's daily commute, work, life, leisure and entertainment.

As the massive urbanization program progresses, China has been launching its urban rail transit construction as the key part of the preferential public transportation strategy in the national 12<sup>th</sup> five-year plan. The total mileage 1,714 km of the 56 urban rail lines as built in 14 cities up to 2011 has been recorded. At present, over 50 Chinese cities have planned urban rail transit systems in a scale of over 400 rail lines with some 13,000 km mileage in total (Annual report of China urban mass transit research group, 2012). China has become the most aggressive nation of developing urban rail transit construction in the world.

City authorities in China have to face the great financial challenges of building and operating their rail transit systems, as the great burdens of huge construction cost, prolonged construction period, high operation and maintenance costs. It is time to break through the financing arrangement as a bottle neck issue of the authorities and the industry. And this becomes a paramount issue for the sustainable development of urban rail transit and urbanization strategy in China (Chang, Z.; Yang, W., 2013).

This paper is to explore the sustainable urban rail transit development model in China, by studying the Hong Kong experience, and discussing the transit-oriented-development and public-private-partnership study for the Shenzhen metro line 6.

## 2 Philosophy of Railway + Property (R+P) model in Hong Kong

Hong Kong sets a great example of its strategic and sustain-

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Wen-wu Yang (✉)  
AECOM (Shenzhen) Co. Ltd, Shenzhen 518001, China  
Email: Morgan.Yang@aecom.com

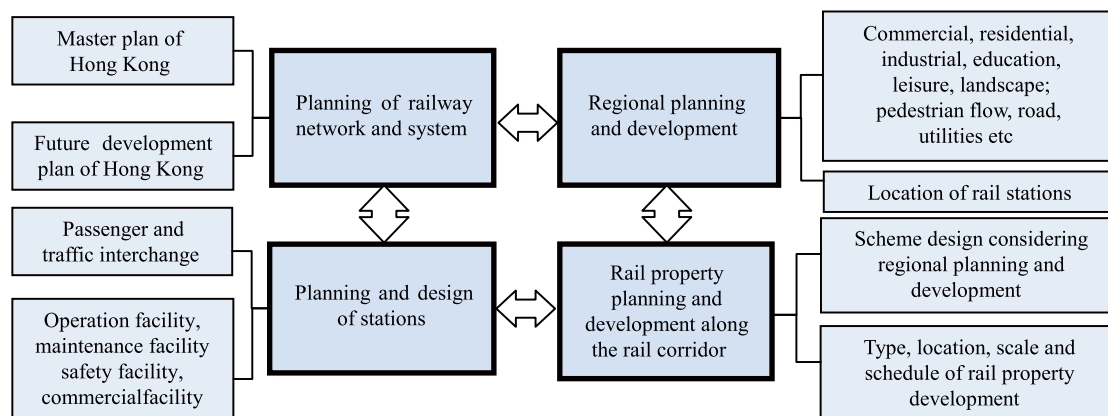
able railway development, by strong integration of railway planning and urban development, which creates an extensive synergy in broadening the living space for residents and promoting developments on various aspects in Hong Kong. The visionary development plan of public transport, land and environment in Hong Kong has been making true by collective efforts of the government, rail operator, private developers, citizens and all stakeholders. Through its urban rail development of over 30 years practice, Hong Kong has created a very unique Railway + Property (R+P) model and built a world-class mass transit railway (MTR) with high standard of safety, reliability, quality service and cost-effectiveness. Hong Kong is a metropolitan with a most convenient public transport system of reasonably low fares, which becomes a competitive advantage of this city. Hong Kong's R+P comprehensive development lays out a solid foundation for its sustainable development of mass transit, through integrating railway construction, operation and rail related property development.

Hong Kong government would not subsidize the MTR Corporation (MTRC) cash fund to construct the railway lines, but in-stead to invite the bidders for the exclusive development rights on the site value of the market level. After assessing the proposal from MTRC, the Hong Kong government would grant the land development right of which the land premium at the pre-rail price then shall be paid off.

MTRC would carry out full planning, design, implementation and management of the metro and land development projects. The value of the land and property would be greatly increased and the reasonable net return would be yielded for investment to construct, operate and maintain the rail lines.

As a public listed company, MTRC operates on commercial principles, financing and operating railway services that are not only self-supporting but also that yield a net return on investment. Property development has been the chief tool for generating revenues that cover the costs of constructing railway improvements and provide net profits (Cervero & Murakami, 2008). It is through the rail property development that can MTRC attract private investors and remain financially solvent.

Hong Kong strategy plan and development of mass transit have been studied in *Figure 1*. A framework consisting of modules displayed are "Planning of railway network and system", "Regional planning and development", "Rail property development planning along the rail corridor", and "Planning and design of stations". These four modules are interactively studied so that full considerations of urban development, transportation, engineering, environment, economics and finance can be taken to come up with different scenarios and implementation schedules for the long term urban development of Hong Kong as a whole. This strategy forms a strong foundation of the R+P sustainable model.



*Figure 1.* Study framework of Hong Kong railway plan and development. Adapted from "Remarks on planning, legislation and development of underground space in Hong Kong," by Yang, W., Liu, Z., & Mao, R., 2008, *Science & Technology Progress and Policy*, 25, pp.180–183.

The R+P model is on the basis of economics principle of optimizing and effectively integrating resources, and internalizing the positive externalities, from there the win-win scenario of government, MTRC and Hong Kong Citizens would be achieved.

Through extensive R+P practice, Hong Kong has built well coverage and very efficient mass transit rail system serving quality communities around stations and new towns connected by new rails.

Hong Kong Metro lines of world class service level offer the people living in the rail communities the greatest convenience of their daily commute and in turn attract more people to reside in the rail communities, which maintain high rail ridership. This forms duo positive cycles of passenger and finance in the R+P model as depicted in *Figure 2(a)* explains the benign cycle of transit passenger flow and *Figure 2(b)* the positive cycle of capital fund which is the transit value captured as a sustainable mechanism for future rail transit

development.

The R+P comprehensive development, through its good quality urban design, contributes better city fabric formation of enhancing residence density around the stations, balanc-

ing work and life, lowering commuting time and costs. High quality rail property and associated business do capture value. But the essential goal is to create high-quality communities and enhancing station environments.

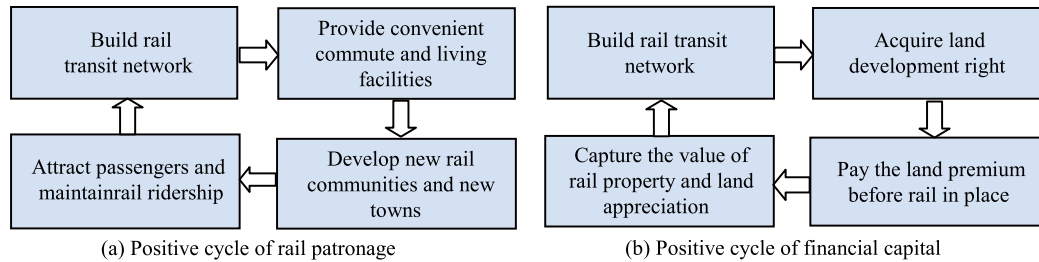


Figure 2. Positive cycles of passenger and finance in the R+P model. Adapted from "Engineering management on sustainability of urban rail transit development in China," by Yang, W., 2013, *Engineering Sciences*, 15, pp. 80–86.

From the discussion above, we could highlight the philosophy and success factors of Hong Kong R+P model below:

- (1) Visionary railway and development planning becomes the engine and driver of the sustainable urban development of Hong Kong.
- (2) Create good quality mass-transit oriented living environment and communities, through people-centered philosophy of planning, design and construction.
- (3) Fully implement the design and construction as planned, scheduled and detailed using programme management approach.
- (4) Well establish a sustainable business model in the principle of urban rail and development project life cycle and on commercial basis.
- (5) Strive for achieving win-win scenarios for the government, metro company, stakeholders and people.

### 3 Transit-oriented-development and public-private-partnership

Most cities gradually expand and mature by old town regeneration and new town development in the process of population growth and economic development. The success of a modern metropolitan very much relies on clear development strategies and goals, visionary planning and design, good implementation schedule and efficient administration. Taking Hong Kong as a great example as discussed above. The key performance index of a modern city shall be sustainability and of people-centered, which endeavors to building up good urban infrastructure and communities of people's livelihood, healthy leisure, ecological development, and convenient public transportation.

The livelihood of people reflects mixed-use development balancing commercial and residential needs with various estate densities and available job opportunities. A healthy

leisure infrastructure is to meet the citizen's education, healthcare, entertainment and cultural needs. Ecological development strives for natural preservation and environmental protection for evolving sustainable living environments. Convenient public transportation would rely on the development of a comprehensive transportation network with high quality public transports and interchanges.

The Hong Kong model and experience of integrated development as of R+P are a very good reference for us to explore a sustainable way of urban development in China. The current urban transit financing model of public funding or with partial subsidy of land is just not sustainable and a groundbreaking study should be made in an innovative way. The key of the study is to stimulate and generate the great potential and value of cohesively integrating rail and urban development, through a creative organization and management model, which is based on the Transit-Oriented-Development concept and Public-Private-Partnership. The ultimate goal is to create profitable investment opportunities for private capitals and make the urban transit construction be sustainable and become a win-win business for common good of leading the long term urban development.

Transit-oriented-development (TOD) is a concept of intensifying the mixed-use development around transit station area, via the intimately interactive planning and design of the rail and land development, for forming high quality communities and people-centered activities. As the strong intervention with TOD and urban development happens, there generates remarkable land value along the rail lines. TOD is in-fact the core philosophy of Hong Kong's R+P comprehensive development model and programme, through which the high density rail properties are developed and then extended to the new rail lines to develop new towns in Hong Kong.

With the excess value of the land generated by TOD, the public-private-partnership (PPP) arrangement would be becoming feasible and attractive. This shall be the way of sus-

tainable urban transit development in many cities in China many decades to come.

#### 4 TOD and PPP study of Shenzhen metro line 6

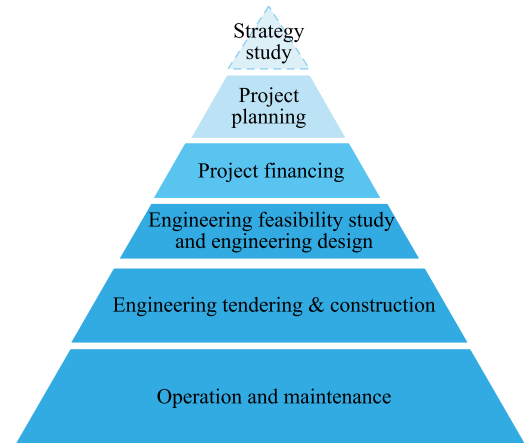
The urban rail construction in Shenzhen City is now at Phase III, in which the metro line 6 is selected to adopt TOD for studying the PPP model to develop, build and operate this transit line stretching from the core CBD downtown to a sizable new town Guangming. The mission of this study initiated by the governmental authority is to pave a sustainable way of multiple and marketable financing channels for planning the new line and so developing new towns. The excess value produced can be captured and feedback to the rail construction.

##### 4.1 Energize the potential of TOD and urban development by integrating resources and overcoming administrative segmentations

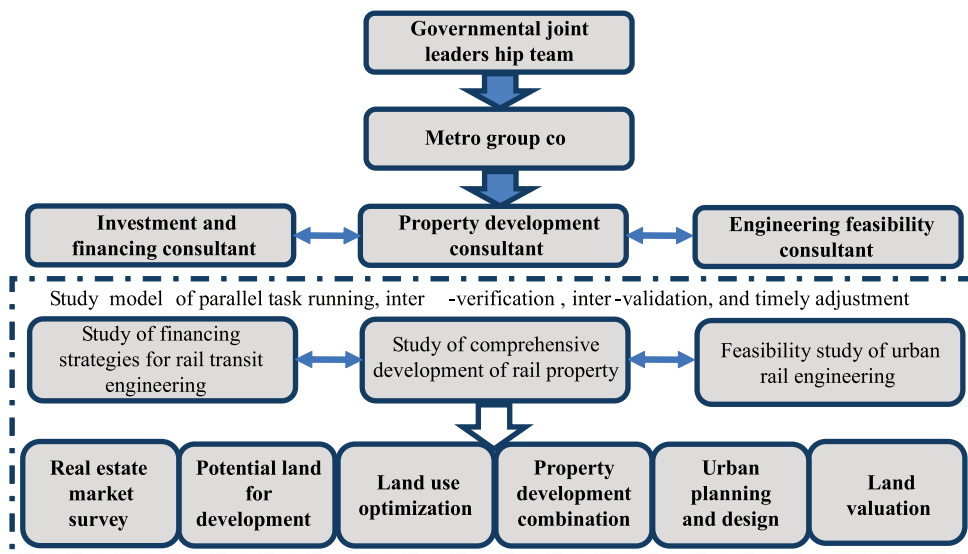
In current practice in China, urban mass transit as public transport infrastructure is traditionally funded by public capital with bureaucratic approval procedure within different governmental authorities. So generally, an urban transit project is treated as a conventional engineering project which would lose the synergy value and opportunity of rail oriented urban development. On the one the hand, the effective coordination is unlikely as the segmentation of the governmental administration. On the other hand, the marketable value would normally be dissipated due to the linear and segmented structure as the basic construction procedure for the public project as shown in *Figure 3*.

Therefore, we need to have a brand new mind set to effectively integrate resources for energizing the great potentials of urban rail transit development, by overcoming the intrinsic hurdles.

A joint team comprised of the key government departments from Planning and Land Resource Committee, Transportation Committee, and Reform and Development Committee is formed as a task force to lead the cross- authority approval and cross-disciplinary TOD studies from strategies to engineering implementation. As shown in *Figure 4* the project organization includes three technical consultants of studying rail property development, engineering feasibility, and investment and financing arrangement. This special organization is to crack the segmentation issues by effective coordination and integration among the governmental departments and technical consultants.



*Figure 3.* Traditional basic construction procedure for an urban rail project in China.



*Figure 4.* Organization structure and study model for integrating governmental and technology resources.

#### 4.2 Parallel studies by integrating multidisciplinary technologies

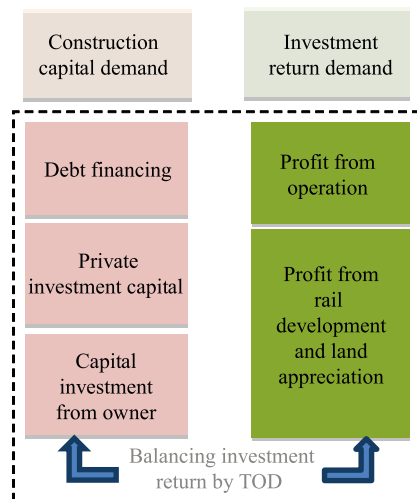
To strive for sustainable development of urban rail development, we need to carry out three key studies, namely “Feasibility study of urban rail engineering project”, “Study of comprehensive development of rail property”, and “Study of financing strategies for rail transit engineering”, in a way of parallel task running, inter-verification, inter-validation, and timely adjustment as necessary. The interaction of the parallel study tasks is illustrated in the dotted box in *Figure 4*.

To fully tackle various topics with diversified characteristics, we have great efforts to emphasize the technological integration in both lateral and longitudinal aspects, organization integration in communication and coordination during the whole study. The study team members include urban planners, traffic engineers, urban designers, architects, engineers and economists.

#### 4.3 Maximize the benefit and value of community and property developments along the rail corridor by all-around planning and quantitative market analysis

To maximize the externalities of the communities along the rail corridor and the station area development, we carry out qualitative and quantitative studies of potential land development assessment, property development combinations, design and planning optimization, and land valuation. This has been done in parallel approaches of design planning, and economic market analysis, together with techniques of quantitative modeling, scenarios comparison, and back-and-forward validation. The self-balance of capitals for the finance-build-operate urban rail transit project could then be figured out by transferring the positive external effects into internal benefits, as shown in *Figure 5*.

Make a detailed valuation of the land prices and real es-



*Figure 5.* The self-balance of capitals for the finance-build-operate urban rail transit project.

tate market price, considering the architecture schemes, for the further return on investment and finance analyses to the selective rail property developments.

The all-around planning and quantitative market analysis include the following tasks below:

(1) Optimization of the existing urban planning along the rail corridor.

From the TOD philosophy and market perspectives, make a comprehensive optimization to the existing master plan and the approved statutory plan, in a full consideration of the interaction between rail transit and urban development. This is crucial to step up the industrial development potential by the rail infrastructure.

(2) Sort out of the potential land developments along the rail corridor.

Establish a quantitative model for sorting out the potential land plots which are suitable to adopt R+P comprehensive development. The selective land plots would be subject to further financing study.

(3) Survey and study of the real estate market along the rail corridor.

Carry out a detail survey and study of the status and trend of the real estate market of various districts along the rail corridor. Based on the regional market conditions, make fine tuning optimization to the property development combination, planning and associated facilities of the potential land plots and propose the development schedule. Based on the quantitative modeling results, prioritize five key land developments accordingly and carry out conceptual design and value analysis.

(4) Conceptual design of the key land developments.

Make initial land valuation, together with financing model, to the selected key land developments and conceptual planning and design. For the selective plots, detailed architecture schemes to the conceptual planning would be designed.

(5) Land valuation.

Make preliminary valuation of the real estate price and development profits of the selected rail property.

(6) Financing strategy and schemes.

#### 4.4 Build up a people-centered modern metropolitan with sustainable economics, ecologies and mass transit

Promote high density mixed-use development around transit station and spread out to lower density with green public space. Detailed studies focus on a 800m core area around a station for the land use optimization, urban design, property development combination at the key plots, for ultimately activate the property development potential and value.

On the planning design concept, very much emphasize the importance of seamless interchange between rail and other public transportation. Inside the rail station community, provide the slow traffic system and all weather pedestrian facilities.



#### 4.5 Establish sustainable transit finance model: rail transit impacts urban development and the urban development sustains rail construction

The key development regions along the rail corridor would be preliminarily ranked by further investigation and judgment in a macro view of urban land resource, regional macro-economy, regional industrial development, district land the property market, and on the basis of the above studies of potential land development. In turn, final rank of the key development regions would be given from the quantitative assessment of the land resources within the selected regions.

Assuming the new rail transit is in place, then the land around the station can be developed further. Conceptual urban design and integrated rail property development programmes can be used. From this point a detailed survey and investigation of on-site regarding land reserve, land ownership and existing constraints would be carried out so to make sure that the rail property development could be implementable. This would create the gain return of investment for satisfying the rail project financing needs and sustaining rail operations.

The establishment of sustainable transit finance model is based on two sides of the study achievements. First, the financial decision shall be supported by the solid data from the comprehensive investigations and analyses: ① Sort-out of the ownership of lands of the station core area; ② Site investigation for determining the potential land development and study of the market trend of real estate; ③ Land valuation. Second, maximization of land use efficiency, intensification and integrated development shall be achieved through the urban planning optimization, conceptual urban design, and development guidelines, in consistence with the master plan, approved statutory plan, regional urban plan, urban regeneration and spatial planning elements.

In summary, the highly efficient coordination and strong-cohesive interaction among the rail transit development,

land use /development and regional industrial development, shall be solid foundation for sustaining rail transit construction and operation.

### 5 Study of sustainable urban rail development model in China

The study of TOD for Shenzhen metro line 6 is to explore a PPP model to develop, construct and operate urban rail transit project, in a great vision to establish sustainable urban rail transit development model in China of creating diversified and marketable financing channels. Some preliminary results are summarized below.

(1) Totally 300+ potential land plots of about 950 ha are sorted out through on-site survey and market analysis of 800m radius area of 20 stations along the rail corridor.

(2) The Guangming New Town is identified as an urban core district to be developed by TOD and five stations areas including Changzhen station are selected as key development regions.

(3) The land development volume is improved by 10% by the land use optimization to the approved statutory plan at the station area. The population agglomeration is increased 13% by optimization of urban plan. And the passenger volume is increased 9% for short term and 18% for long term.

(4) The value of the station area lands is remarkably appreciated by the optimizations, as the quantitative assessment model projected. E.g. the land value of Changzhen station is increased about 200%. Improvement is also observed in the job opportunities in local districts, increase in GDP economic value, property tax etc.

(5) This study demonstrated that add-value generated by TOD could provide adequate capital for funding the initial construction of civil and rail engineering of Shenzhen metro line 6.

This TOD study adopts a quantitative economic model

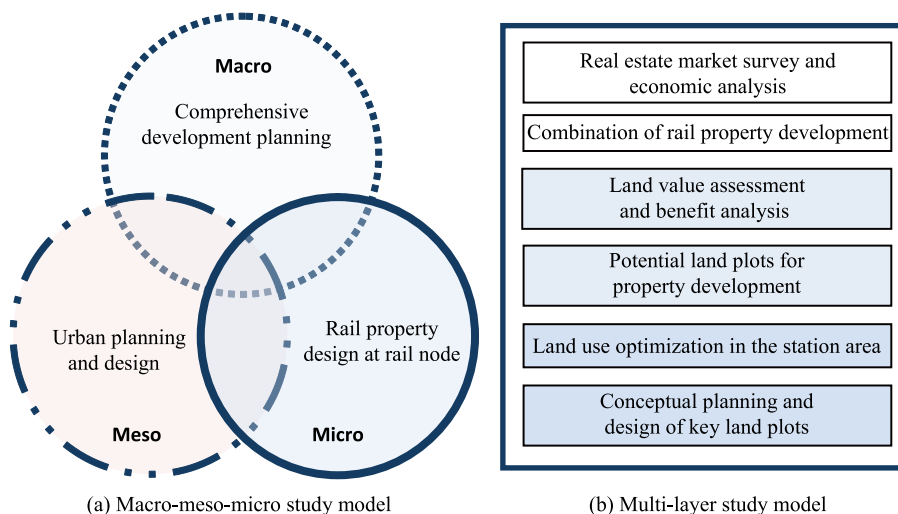


Figure 6. Comprehensive TOD study at macro, meso and micro levels and multiple layers.

of multiple study layers in macro, meso and micro levels as shown in *Figure 6*.

(1) Taking the whole rail corridor as a macro level, best fit the rail transit into the macro urban development condition and elevate the urban plan by fully understanding the trend of real estate development, socio-economy development. Clearly define the long term development vision and strategy of the district through full analysis and comparison of the urban form, diversity and association of the usable land resource, land development potential.

(2) At the meso level, effectively integrate the economic market, land planning and transportation system, by fully exploring optimization potential, strategy and directive of the existing approved statutory urban plan. This is to improve the urban development along the rail corridor by visionary using urban rail engineering opportunity.

(3) Look into the land value, value premium and commercial terms in a micro level. Study in great details of rail property development, spatial design and optimization. Also traffic interchange and open space for the key station development.

(4) Maximize the value of rail property development by good quality conceptual design of the key station area development based on the best development combination as recommended. This lays a good foundation of PPP arrangement and provides strong technical conditions for the future optimization of the existing approved statutory plan as necessary.

## 6 Concluding remarks

An efficient urban rail transit network is the key driver of the sustainable development of a city. It profoundly impacts on people's daily commute, work, life, leisure and entertainment. The sustainable urban rail transit development is very essential for implementing the national strategy of comprehensive public transport system and the grand urbanization plan.

City authorities in China have to face the great financial challenges of building and operating their rail transit systems. Also they should consider the great burdens of huge construction cost, prolong construction period, high operation and maintenance costs. The conventional public financ-

ing arrangement for urban rail transit in China is just not sustainable. It is necessary to break through the financing arrangement which is a bottle neck issue of the authorities and the industry. This becomes a paramount issue for the sustainable development of urban rail transit and urbanization strategy in China. A groundbreaking study must be made in an innovative way and mind-set.

The key is how to stimulate and generate the great potential and value of cohesively integrating rail and urban development, through a creative organization and management model. The ultimate goal is to create profitable investment opportunities for private capitals and make the urban transit construction be sustainable and become a win-win business for common good of leading the long term urban development.

By understanding Hong Kong's R+P philosophy and elaborating TOD and PPP study of Shenzhen metro line 6, the sustainable urban rail development model in China is explored and introduced. It concludes that the sustainable urban rail transit shall be able to energize the great potential of rail and urban development at macro, meso and micro levels, through effective integration of administration and technology resources, and generation of win-win scenarios among government, metro company, people and stakeholders.

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