	<h1>VIAJEO PLUS</h1>
<h2>D5.2 - Global innovative public transport R&D and policy trends report</h2>	

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1. Executive Summary

This deliverable provides an overview of current Research and Development (R&D) initiatives on sustainable Public Transport solutions and related policies already implemented or to be tested in the coming years in Latin America, China and Singapore.

A number of relevant initiatives between Europe and these 3 regions are today on-going with the final objective of reinforcing international cooperation in science and technology by presenting their experiences and recommendations for an enhanced and more effective cooperation. During this process, a policy dialogue has also led to the identification of common obstacles, challenges and synergies.

In this context, the Viajeo Plus partners are committed to prepare the foundations for future collaboration between worldwide cities and PT stakeholders and deliver to the EC recommendations on future collaboration with the project target regions (i.e. Latin America, China and Singapore).

In terms of Public Transport solutions, this deliverable reports on the analysis of R&D projects, policy studies and demonstrations performed in the three regions to identify the range of public transport solutions available today as well as assess practices best-suited to meet existing and future mobility needs as a way to highlight the main future trends.

Strategic documents on national transport-related policies have been carefully reviewed and 6 local experts has been interviewed. Experts are representatives of the transport sector with a long experience in Research, Innovation and Development, with a deep knowledge of the current situation in the target regions, transport initiatives and main trends for the future.

2. Introduction

2.1. Viajeo Plus project overview

The main aim of the Viajeo Plus project is to identify and define clear implementation strategies for the successful deployment of sustainable urban transport solutions in European, Latin American, and Asian (China and Singapore) cities and in Mediterranean Partner Countries (MPC), fostering collaboration between these regions on a global scale.

To meet the Viajeo Plus vision, successful experiences of implementing innovative urban mobility solutions across the world have been identified and shared. Experience and knowledge has been exchanged through showcases, site visits, workshops and dissemination of learning materials.

WP5 focuses on the topic “Innovative Public Transport Solutions”. Overall, more than 15 candidate solutions implemented in Europe, China, Latin America and Singapore have been identified as relevant for the project tasks and some of them have been discussed and/or demonstrated during the 4 City Mobility Showcases organised during the project life time to allow project partners and international public transport stakeholders to learn about their implementation process and results achieved.

The Viajeo Plus consortium has developed and published on the web (viajeoplus.eu) a ‘Virtual Solution Book’ providing a detailed description of these initiatives and executive implementation plans for greater uptake by cities. Concerning public transport, the Virtual Solution book relies on 5 solutions (D5.1 - Best solution report on Global Innovative Public Transport) dealing with increasing both the level of service and the quality of service of PT systems.

They are not intended to give a comprehensive overview of the most innovative Public Transport trends worldwide but to present selected successful experiences in the field, namely:

- Redesigning the bus network in Barcelona;
- Shifting commuters travel patterns in Singapore;
- Implementing BRT systems in Brazilian cities hosting large events;
- Developing a network of underground interchanges in Madrid;
- Integrating mobile ticketing systems in a multichannel and interoperable technological platform in Rome.

Viajeo Plus also facilitates “cross-learning”, a two-way approach introducing innovative urban mobility solutions in European cities to both Latin American and Asian cities plus MPCs and vice versa, whereby European cities and industrial organisation gather first-hand experience of mobility solutions on the global stage.

The cross-learning process also develops a comprehensive understanding of state-of-the-art, R&D trends and policies in different regions, in order to empower European industry for future global competition and support European cities in their role to meet sustainable urban mobility objectives established by the European Union. The cross-learning process has also been extended to MPCs where European industry and researchers currently have limited knowledge and local contacts.

All of the above allows the Viajeo Plus project to actively contribute to prepare the foundations for future global collaboration between cities and PT stakeholders. The project will define clear implementation strategies for the successful deployment of innovative and sustainable urban transport solutions and deliver to the EC recommendations on future collaboration with the project target regions.

2.2. Overview of this Deliverable

Over the last few years, several activities have been undertaken in International Cooperation between EU and International Cooperation Partner Countries (ICPCs) aiming at fostering greater links between science, research and innovation, as well as businesses, research centres and networks. The steady increase over the last decade in Latin American and Chinese participation in EU Framework Programme (FP) projects facilitates this relationship between the EU and Emerging Countries with regard to R&D collaboration on different themes (ICT and Transport for example).

A number of relevant initiatives are now working towards common final objectives of reinforcing international cooperation in science and technology by presenting their experiences and recommendations for an enhanced and more effective cooperation. During this process, a policy dialogue has also led to the identification of common obstacles, challenges, synergies and future opportunities in international cooperation. In order to strengthen this cooperation, relationships should be re-appraised as partnerships which are driven by clearly identified interests, ultimately leading to mutual benefits.

This document provides an overview of current Research and Development (R&D) initiatives on sustainable Public Transport as well as policies already implemented or to be tested in the coming years in Latin America, China and Singapore.

Experts from the three target regions have been interviewed to report on local R&D projects, policy studies and demonstrations. The goal is to identify the range of public transport solutions available today and point-out practices or technologies best-suited to meet future mobility demand, as a way to highlight main future trends. The outcome of the interviews, presented in the following, represent also a valuable contribution to enhance the understanding of local policies and transport initiatives.

In order to maximize the contribution of the experts vis-à-vis the expectations of the project, a set of questions have been agreed with the project coordinator and addressed to the selected experts (Annex1). Selected experts are representative of the transport sector with a long experience in Research, Innovation and Development as well as a deep knowledge of the state-of-the-art in the target regions, transport-related policies adopted and main trends.

The contribution of the experts has been integrated thanks to the review of strategic documents on national policies impacting public transports. The experts involved in the task and the documents reviewed are listed in Annex 2.

3. R&D and policy trends for Public Transport in Brazil and Latin America

3.1. Societal challenges and PT trends

Latin America has a high urbanization rate, according to the "United Nations-Habitat". The rate of urban population in the region will reach 89% by 2050 and the number of cities in the region grew six times in the last 50 years. Most American Latin cities had growth without planning, which causes problems in infrastructure, sanitation and public transport. Another point is that the cities are becoming less compact and expanding more and more, which makes it difficult to maintain a high quality transportation service. While it is a challenge for development, also represents a huge opportunity to make public transport a key element in the planning of cities and sustainable growth.

Brazil is the largest country in Latin America, and the fifth largest in the world by land area and population (over 200 million). Public transport in Brazil is responsible for the daily commute of 46 million people. It is estimated that 87% of journeys are made by bus. Every day is a challenge for public managers and operators of these systems meet the requirements of society.

Popular movements in Latin America, has shown dissatisfaction with public policies and its leaders, including public transport, which is seen as a social policy. This scenario in Brazil peaked in 2013, where mass demonstrations took as big claim to improvement in public transport as an element to meet the social demands of the country.

A survey commissioned by the National Association of Urban Transport companies (NTU), in 2013, presented a scenario of the main social challenges in public transport in Brazil, based on the opinion of several opinion leaders. Among the many subjects they stood out: the ticket price, the quality and transparency of service.

The ticket price that is related to operating costs, in Latin America are almost entirely covered by ticket sales, subsidies are very low compared to other continents. For 40% of respondents, a social or affordable rate would be one that does not compromise the income of the employee. All segments argue that there should be a differentiation in the value of the ticket according to the social classes and subsidized in part by the government.

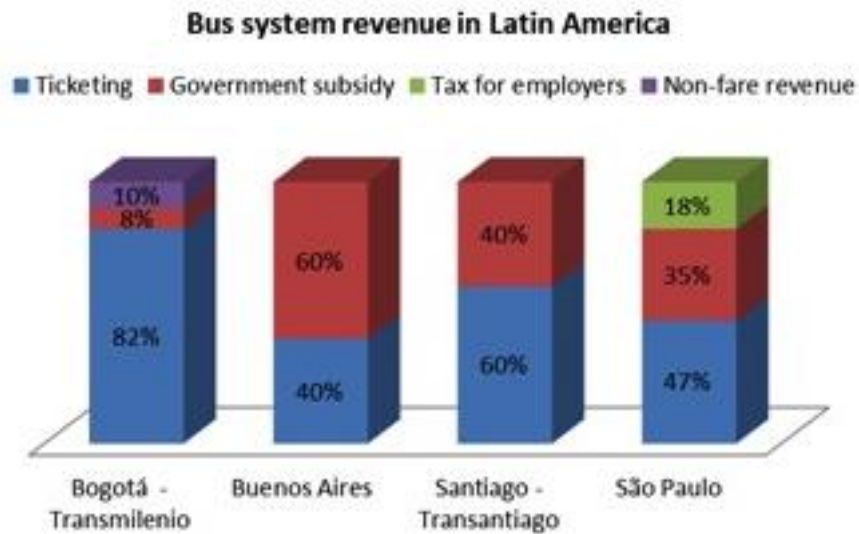


Figure 1. Revenue composition. Source: UITP Latin America

Regarding the quality of public transport, survey participants consider it necessary public investment in high capacity systems such as BRT and subway in dedicated lanes and technologies, such as intelligent transport systems and electronic ticketing. Among the main attributes of quality, in their view, the user considers as the most important: compliance with the scheduling of time, total travel time including waiting times and security inside and outside of vehicles.

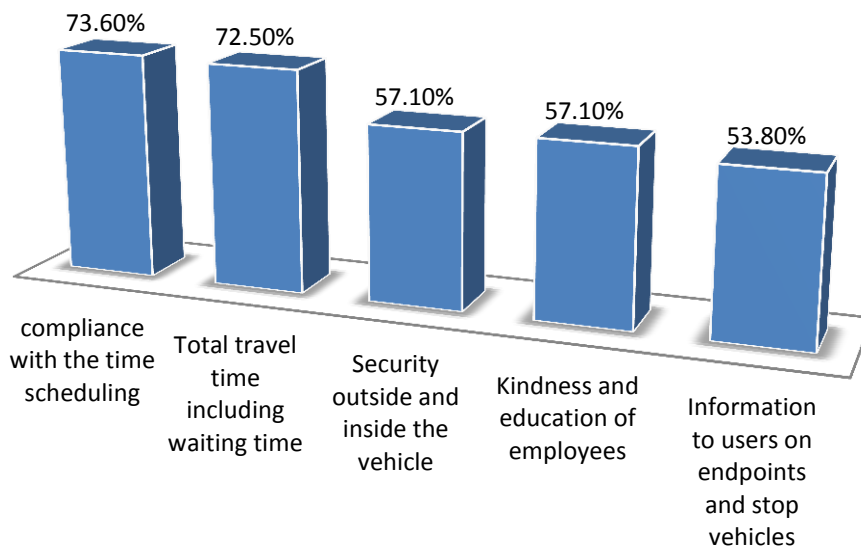


Figure 2. Most important quality attributes

Regarding social concerns in transparency in public transport services, the item "information services" is presented as the most important, followed by monitoring and dissemination of cost spreadsheets.

Table 1. Most relevante transparency attributes

Information about services	75.8%
Public supervision	69.2%
Disclosure of cost spreadsheets	57.1%
Disclosure of corporate profits	38.5%

3.2. Policy and R&D trends

In order to outline policy and R&D trends in Latin America cities, three experts have been identified and interviewed: Mr. Juan Carlos Gonzalez (Manager of Transurbano Foundation, Chile), Mr. Claudio Luiz Marte (University of São Paulo) and Mr. Alessandro Santiago dos Santos (Institute for Technological Research of Sao Paulo State).

3.2.1. Interview to Mr. Juan Carlos Gonzalez

Mr. Juan Carlos Gonzalez has a degree in Law at the University of Chile, where he has been involved in several activities since 1998 as Executive of Areas Policy and Legal Advice Rectory in Economics, International Studies, Science, and Architecture. During the government of Sebastián Piñera (2010-2014) he has been working on several mobility-related laws and initiatives, among the others the reform of the PT subsidies scheme.

Between 2014 and 2015 he has been Legal Advisor for two main unions in Chile, working as International Relations Officer, and part of the Bus Economy Committee of UITP Latin America. He is currently advisor for several companies and manager of Transurbano Foundation, an influential organization in Chile that promotes sustainable systems and integrated mobility.

Mr. Gonzalez gives an overview of the policy and R&D trends in Chile.

National and local PT priorities

In Chile, the priorities of public transportation rely mainly on improving the quality of transport by bus, and in this sense, two examples can be highlighted:

- TransSantiago aims to promote the full integration of bus and subway systems, through the BRT system, being the main PT mode operating in the capital city. Its concession period is coming to the end and involves both bus operators and technological suppliers. Between 2017 and 2019 the contract will be renewed, therefore defining the conditions for the new agreement is a key priority.

- Several cities in the metropolitan region of Santiago, need to improve the quality of public transport in the coming years. PT operators certainly need new subsidies to guarantee the quality of service and new technologies have major role to play.

Main PT policies

In recent years, a major change to boost public transport in Chile has been the adoption of a policy which requires companies providing PT service to have a satisfactory financial balance. In this sense, a very important subsidy law was created that has already enhanced the quality of service for the users, thanks to more targeted subsidies.

In Santiago, a policy to develop an intermodal public transport network, integrating bus, train, subway and bicycles, has been implemented.

Cooperation with foreign countries

In Chile there is no official international cooperation programme. The only initiative is the participation of sporadic meetings in events or forums in regions such as Spain and Australia.

Key innovation domains

According to Mr. Gonzalez, the transportation system of public bicycles located in the metropolitan area of Santiago, Bike-Santiago, can be considered as one of the most relevant innovations. The system of public bikes is financed by Itaú bank and has been very well-received by the population, although the main concern of the promoters was about vandalism. The system is available in 16 municipalities, which are served by the metro network, and several metro stations are already integrated into the public bicycle model.

Innovation driver

The way subsidies are managed since 2013 is an innovation driver in Chile. In 2013 there was an important change in the conception of public transportation since before subsidies were taken as a kind of expense without return and profitability, and without being linked to the quality of service and users' satisfaction. In this new model, subsidies are a "social tool" to improve public transport. They allow operators to have a sustainable financial model and are fully integrated with quality issues.

This change was introduced by a law unanimously approved by the Congress (one of the few cases) in 2013 Regarding financial matters has been overcome and the Chileans understood and inserted in their culture, that subsidies for public transport are something fundamental for the quality of service and for its maintenance and continuity.

3.2.2. Interview to Mr. Claudio Luiz Marte

Mr. Claudio Luiz Marte is Professor of Transportation Engineering (PTR) at the University of São Paulo (USP). Graduated in Full Degree in Electronics from the Federal

University of São Carlos [UFSC] (1985) and Electrical Engineering (Electronic Mode) from the Polytechnic School of USP [EPUSP] (1988), master's (1994) and doctorate (2000) in Engineering electric (Digital Systems) by USP. Currently he is professor at the Polytechnic School of USP, member of ITS Brazil, a member of ITS Committees of the Brazilian Association of Technical Standards (ABNT) and the National Association of Public Transport (ANTP). In 2013, he has been the Innovation Hall coordinator at the 8th Congress of the Brazilian Association of Highway Concessionaires (ABCR). He has experience in Computer Engineering, with emphasis on Distributed Systems Architecture, acting on the following topics: Intelligent Transportation Systems (ITS) and Geographic Information Systems (GIS).

National and local PT priorities

For the World Cup the Federal Government and State Governments has identified BRT as a priority Public transport system to solve the mobility needs in most host cities.

Main PT policies

In Brazil, the National Policy on Urban Mobility (Law 12.587 / 2012) is an urban development tool, aiming mainly at the integration between different modes of transport and the enhancement of accessibility and mobility of people and goods in the municipalities.

Cooperation with foreign countries

There is no official cooperation programme with foreign countries in transportation sector, although international exchanges about R&D initiatives is quite common during congresses and international events as well as participation to funding programmes like the European FP7/Horizon 2020.

Key innovation domains

In Brazil, efforts are focused, among the others, on research and developments about dual-fuel engines, especially second-generation ethanol.

Innovation driver

The introduction of integrated ticketing systems in several Brazilian cities in the last decade has led the migration toward collective transport in large cities, mainly due to the possibility to use various modes of transport with one ticket. In this decade new biometric technologies like facial recognition have being successfully applied, mainly in medium-sized cities, for reducing illegal use of tickets and smart cards, mainly special cards for elderly and students since those users are eligible for reduced fares.

3.2.3. Interview to Alessandro Santiago dos Santos

Mr. Alessandro Santiago dos Santos is Research manager at the Institute for Technological Research of Sao Paulo State. He holds a PhD in Transportation Engineering and a Master Degree in Computer Science at the University of São Paulo (USP - Brazil). He works in international cooperation projects in transportation and ICT

area, helping with Latin America perspective. At national level , he is secretariat of ITS Committees of the Brazilian Association of Technical Standards (ABNT) and works on homologation processes of ITS equipment for busses, and coordinator of highway operator monitoring project.

National and local PT priorities

In the past, Brazil had experienced several incentive initiatives for the purchase of private cars, as a clear tendency towards individual transport, while public transport kept a very low quality. In recent years a shift in o target investments and policies to give priority to public transport rather than private transport can be noticed in several states and cities. The high investments made for the construction and implementation of BRT systems in large cities are a clear example of this tendency. The city of São Paulo has experienced a the reduction of road space dedicated to individual vehicles to make them exclusive to bus, the enlargement of the subway transportation network, as well the integration of traditional PT systems with innovative modes like monorail and BRT corridors.

Main PT policies

In Brazil, the control and management of public transport is done by the municipalities in line with state or federal guidelines. National policies for urban mobility are established by the federal government and used as a reference for the municipalities to create local mobility plans, as a pre-requisite to apply for funds to implement large mobility projects. The main national guidelines for transport-related policies can be summarized as follows:

- I. integration with urban development policy and its sectoral policies on housing, sanitation, planning and management of land use;
- II. priority of non-motorized modes instead of motorized and public transport services instead of individual transport;
- III. integration of various modes and urban transport services;
- IV. mitigation of environmental, social and economic costs of moving people and goods in the city;
- V. encouraging scientific and technological development and use of renewable energy with low emissions;
- VI. prioritization of public transportation projects and integrated transport and land use development ; and
- VII. integration between the cities located along the border with neighboring countries.

Big cities as Rio de Janeiro, São Paulo and Belo Horizonte have already adopted the priorities for public transport. They have created BRT lines, exclusive bus lanes and cycle lanes integrated to transport network as solution to attend the nation policies for urban mobility.

Cooperation with foreign countries

There is no official cooperation programme with foreign countries, although international exchanges and cooperation on research and innovation with European organization is fostered by the funding programmes of the European Commission (FP7, H2020).

Key innovation domains

The quality issue in public transport has become a desire of any public manager. Thus, the major cities are adopting buses that have embedded intelligent systems, as a fundamental basis for improving the management of the operation and increase user satisfaction. This equipment will be integrated into the Operational Control Center, becoming a standard for use in medium and large cities. Therefore, current innovation initiatives such as investments in BRT, integrated ticketing systems and ITS will lead to integrated models of city management, where transportation is a key element.

Innovation driver

The adoption of BRT as the main element to fulfill the demands of big events like the World Cup and Olympics games, denoted an important strategic decision, creating structural means to improve the quality of public transport through dedicated infrastructure with the possibility of incorporation intelligent transportation systems that provide new ways to deal with public transport.

3.3. R&D advances

3.3.1. Gondola Lift system

The gondola lift system is commonly used for tourist purposes, although the utilization of this system for public transportation purposes is an important innovation and brings several benefits to the inhabitants of cities where the topography favors such a solution. Gondola lift systems integrated into the city's public transport network provide quick and safe transportation for those who live in the neighborhoods situated on mountainous regions of the city's suburbs. Such systems have been already implemented in Colombia, Venezuela, Brazil as well as in Singapore and European countries.

In Rio de Janeiro, a gondola lift system is operational and runs through the Complexo do Alemão connecting the residents of the neighborhood to the city's rail network. In total, the line measures 3.5km and includes six stations. The system appears to have social mandates similar to those implemented in Medellin and Caracas. Residents can apply for a RioCard, which grants them two free trips per day, thus they can access the same jobs and opportunities as those living elsewhere within the city. In Rio de Janeiro, the solution was founded as part of the Brazilian infrastructure development plan known as the Growth Acceleration Program (PAC, in Portuguese).



Figure 3. Gondola Lift System, Complexo do Alemão (Source: the web)

3.3.2. EcoFrota Programme

The "Program EcoFrota" had its origin linked to the objective of meeting the requirements of the Law 14.933/09 Climate Change in the City of São Paulo in June 2009. It recommends that the entire system of public transport in the city should operate with renewable fuel by 2018 and, from 2009, gradually reducing the use of fossil fuels by at least 10% each year. The technologies to achieve this goal are varied, including biodiesel, ethanol, sugar cane diesel, electricity powered engines, hydrogen, hybrids and battery technologies. The diversity of technologies brings a number of advantages, such as better distribution of the energy matrix, further development of technologies, best option of choice due to the cost / benefit / use and, finally, lower costs due to competition.

The Programme was launched in February 2011. By February 2012, the Ecofrota already had more than 1,600 buses, divided into 200 lines, which corresponded to 11% of the total fleet of the municipality (15,000 buses). During this period, there was a 6.3% reduction in emissions of pollutants and a 6.7% in CO₂ emissions. The changes thus far in energy usage bring benefits to the city's economy, the quality of life of its inhabitants and the preservation of its environment.

3.3.3. BRT for large events

Cities often host large events, such as sport competitions, concerts, cultural festivals, demonstrations, religious pilgrimages and business conventions. Large events require major changes to the transport organisation of the host city since the existing transport infrastructure needs to cope with considerable additional traffic flows that are very intense and highly polarized. For the FIFA World Cup in 2014, 9 of the 12 host cities (Belo Horizonte, Rio de Janeiro, Porto Alegre, Curitiba, Natal, Fortaleza, Recife, Salvador and Manaus) chose to introduce or further develop BRT systems to ensure a high capacity public transport service.

The BRT systems already in place allow football fans much easier access to the stadia from the city centre; for example, in Belo Horizonte getting to the World Cup via BRT takes approximately 20 minutes, whereas travelling via car takes approximately 1 hour and 30 minutes. In Rio de Janeiro, two BRT corridors are already operational, with two

more expected to be completed by the 2016 Olympic Games. These corridors will encircle the city and move 1.6 million passengers per day.



Figure 4. Brazilian BRT system

3.3.4. Intelligent ticketing systems in Brazilian PT

The first initiative of ticketing system in Brazilian big cities dates back 1970. The new generation (smart card contactless) started on 2000 in Salvador and Recife city. The biggest case (Bilhete Único) began in Sao Paulo Municipality around 2001. Nowadays, those core solutions are mature and towns and metropolitan areas are adding new features to improve security and governance. Most common features in this models are: multimodal integrated system; flexible fare policies according to the user type, journey duration and transport modality; integration with parking lot; biometric technology for control of special cards (elderly / student).

For example, since 2006, the Bilhete Único is multimodal, and its ticketing system integrates bus, metro system (municipality) and CPTM (Trains for the metropolitan area).

Regarding parking lots, since 2009, the integration near the Metro stations allows users greater ease in shifts in São Paulo(E-Fácil). Upon access to the facility, a parking fee is debited and granted two trips on the public transportation system. These trips can be used in Metro, CPTM or Municipal bus from São Paulo and are valid during the period in which the vehicle remains in the parking lot. The value debited allows the permanence of the car for up to 12 hours; after the 12 hours is charged an additional amount for every hour spent. This system has more than 16,000 readers and 18,963,000 cards.

Another interesting feature is the control for reducing illegal use of special cards for elderly and students, since those users are eligible for reduced fare. Biometric solutions identify the legal user for the card. For example, Ilhéus city (Bahia State) deployed facial recognition in 2012, and the results were 17% of 10,000 special cards were blocked due to illegal use. Similar deployments are located in Fortaleza (220,000 cards), Limeira and Angra dos Reis. Managers and operators have a tool to compare the proposed transaction with held, help analyse the discrepancies and guide in formulating improvements. In summary, the electronic ticketing had a direct effect on the efficiency of the transport system and beneficial to all actors: managers, operators and users. However, undoubtedly, the pricing flexibility permits deriving the greatest benefit to users.



Figure 5. Facial recognition for ticketing system

4. R&D and policy trends for Public Transport in Singapore

4.1. Societal challenges and PT trends

Singapore's demographic and socio-economic landscape has changed considerably over the last decade. Resident population has increased significantly from 3.5 million in the late 1990s to more than 5.3 million in 2015.

With a small area of 716km², transportation has to compete for land use against other essential needs, such as housing, economic infrastructure and recreation uses. In the face of growing vehicle population and limited land for road expansion, Public Transport plays an important role to enhance transportation services and maintain delightful travel experiences.

Singapore is a city well known for its mobility master plan that is closely linked to the main urban development projects in the city. The mass transit system, including major bus lines, is used as the backbone for urban development. In 2013, the Singapore Land Transport Authority (LTA) published the new Land Transport Master Plan that sets out its vision for land transport in Singapore for the next 20 years. This vision is that by 2030, Singapore among the others will have:

- 8 in 10 households living within a 10-minute walk from a train station;
- 85% of public transport journeys (less than 20km) completed within 60 minutes; and
- 75% of all journeys in peak hours undertaken on public transport

In Singapore public transport will be the main mode of travel since it is the most space-efficient and environmentally-sustainable option. Today in Singapore, about 63% of all trips during the peak periods are made on public transport, aiming at 75% of trips during both the morning and evening peak hours by 2030.

To make public transport more attractive, LTA (Land Transport Authority) is focusing on improving the capacity and reliability of train and bus services. The objective is to spread travel beyond the peak hours and encourage off-peak travel for citizens who are able to do so.

The plan is to complement the PT network with more extensive infrastructure for cycling and walking as attractive alternatives to move around and to get to the train stations. With these measures, the City seeks to have 85% of journeys on public transport that are less than 20km (which is the distance from almost all parts of Singapore to the city centre) to be completed within 60 minutes by 2030. This will be an improvement from 76% of journeys today.



Figure 6. Singapore Urban Transport

The scope of such investment is to encourage travellers to use public transport and to rely less on private cars. In major cities around the world, the trend is towards reduced dependency on driving to meet travel needs. This is even more necessary in Singapore because it is not possible to build ever more roads to cater to private transport due to competing needs for the scarce land. Roads already account for 12% of the land area today, only a little under housing, which takes up 14%.

Under development is the next generation Electronic Road Pricing (ERP) system using global navigation satellite system technology to manage traffic congestion in a more targeted, flexible and fairer way. In the city centre, parking supply will continue to be moderated through parking standards for buildings.

In LTMP 2008, it was outlined the challenges that Singapore's transport system faces: increasing travel demand, limited land, declining public transport modal share, and

changing demographics and expectations of transport. The work was divided into three strategic thrusts to tackle the challenges: *Making Public Transport a Choice Mode*, *Managing Road Usage*, and *Meeting Diverse Needs*.

Public transport is key to meeting land transport needs sustainably, both as a nation with limited space and as a member of the global community helping to reduce resource consumption and pollution. Over the last years, Singapore has made public transport more attractive by helping commuters reach their destinations more quickly and conveniently.

LTA works with local communities and the bus operators, SBS Transit (SBST) and SMRT Buses (SMRTB), to identify areas where bus services can be improved.

To give commuters even more bus options and make it easier to connect to MRT stations and amenities, some bus routes have changed and new services have been added. The number of Premium Bus Services (see Diversification of services) has been doubled to 91 as of January 2013, up from 42 five years earlier.

Feeder bus services are also more frequent now with 90% of feeder bus services running at intervals of 10 minutes or less during the weekday peak periods, tightened up from 85 per cent. Since June 2010 the LTA together with the bus operators, SBST and SMRTB, has run a quarterly review process of the most heavily-utilised bus services. As a result, higher-capacity buses have been deployed and more bus trips operated to better match demand with capacity. As of the second quarter of 2013, 165 bus services under this initiative (110 SBST and 55 SMRTB) have been improved.

In 2010, the introduction of distance fares gave commuters a more equitable fare structure based on distance travelled regardless of the number of valid transfers made. With distance fares, commuters pay the same fare whether they travel directly to their destination, or make transfers during the journey. Commuters have the flexibility now to decide on the best route to reach their destination. Many are also paying less in fares. For commuters who make transfers, interchanges and stations have been transformed into lifestyle hubs where commuters can shop and have a meal before hopping on the train or bus to their next destination.

Those who live or work near Boon Lay (completed in 2009), Serangoon (2011) and Clementi (2011) are already enjoying these new integrated transport hubs.



Figure 7. Boon Lay Singapore Bus Station

In 2011, MyTransport.SG, a web portal that consolidates information and eServices for all land transport users, including motorists and cyclists was launched. MyTransport.SG Mobile gives commuters this information on mobile devices, including real-time bus arrival information that is also shown on display panels at over 50 bus stops across the island.

4.1. Policy and R&D trends

4.1.1. Vision of Singapore's Ministry of Transport

“Public Transport must make a quantum leap forward in the areas of rail and bus services, along with regulatory and policy frameworks”, said Transport Minister Khaw Boon Wan on Channel News Asia² in a recent interview (April 2016).

Mr Khaw Boon Wan³ was re-elected as a Member of Parliament in September 2015. He represents the Sembawang Group Representation Constituency (GRC) and is currently the Coordinating Minister for Infrastructure and the Transport Minister.

Speaking at the Committee of Supply (COS) debates, Mr Khaw, who is also Coordinating Minister for Infrastructure, explained the Parliament his priorities are on improving accessibility, point-to-point options as well as public transport excellence. He noted that there are four “major drivers” behind transport’s evolution in Singapore:

- the emergence of new technology like driverless vehicles;
- the introduction of new business models relying on shared mobility concepts like mobile apps Uber and Grab;
- the continued ageing population and the growing need to be environment-friendly.

² <http://www.channelnewsasia.com/news/singapore/singapore-s-public/2688044.html>

³ <http://www.pmo.gov.sg/cabinet/mr-khaw-boon-wan>

“These driving forces are already changing our transport sector in significant ways,” said Mr Khaw. “Changes will be incremental but over 15 years, we shall collectively experience a quantum leap. Private cars will likely start to go the way of horse carriages, if not in 15 years, definitely in 20 or 25 years’ time.”

To reach his objective the Ministry of Transport will progressively roll out legislative and policy changes to prepare Singapore for this transformation.

Excellence in public transport

For his first COS as Transport Minister, Mr. Khaw identified three main areas to address, beginning with enhancing accessibility for commuters. “In particular, how to make it hassle free for commuters to move from their homes to the nearest train station or bus stop,” he said. “We have taken some initial steps but these are not enough.”

In this aspect, Singapore must work to reduce the physical and mental distance from passengers and PT systems; European cities like Amsterdam and Copenhagen can be considered as good practices in this domain.

Also on his agenda was the need to enhance point-to-point transport options for commuters. According to Mr Khaw the sharing economy and in particular new business models like Grab and Uber are benefitting commuters globally, however since they are disrupting existing business models of taxi-operators they can cause havoc in many cities.

“Many countries have taken the wrong turn by banning Uber. But we should not obstruct innovation, especially when it benefits commuters. We should be mindful of the disruption to incumbents and help incumbents make the correct adjustments.”

He added: “We should seek to achieve win-win for both the disrupters and the incumbents, with commuter welfare as the underpinning principle. It can be done.”

Achieving excellence in public transport, especially in rail, is the third priority stressed by Mr Khaw: “to become car-lite, our current car-dominant transport model is not sustainable given our land constraints. It needs to be replaced by one that has as its foundation on excellent public transport system which is reliable, convenient and smart.”

Public Transport as “indispensable”

A car-dominant model cannot underpin Singapore’s development. Today Singapore houses one million vehicles and the vehicle population has almost reached its peak. “We need to facilitate new transport technology, change mind-sets and go car-lite”. he said. “At the same time, we must rethink and adjust existing car and car parking policies.

“Many other cities are making adjustments. Berlin, London, Paris, and many cities in Japan, have introduced more car-free days and either abolished minimum parking provision requirements or set them at very low levels. We should gradually adjust too.”

Above all, said Mr Khaw, the Government wants Singaporeans to eventually “cherish public transport as an indispensable part of their daily lives”.

“LTA (the Land Transport Authority) will continue to forge among Singaporeans this sense of ownership and pride in our public buses. And I will make sure this pride extends to our MRT too,” he said.

4.1.2. ITS strategic plan 2030

The Land Transport Authority (LTA) together with the Intelligent Transportation Society of Singapore (ITSS) have jointly developed a revised ITS (Intelligent Transport Systems) strategic plan for Singapore - **Smart Mobility 2030**. It seeks to provide the strategic leadership, guidance and support for ITS initiatives and programmes to achieve a more connected and interactive transport community. The ITS strategic plan outlines broad strategies and charts key focal areas for the initiatives to meet transport challenges in a systematic and coordinated manner.

Key broad strategies and focal areas are identified to provide the leadership, guidance and support to help Singapore achieve this vision:

- **Implement Innovative and Sustainable Smart Mobility Solutions**, through cost-effective smart mobility solutions for diverse transport users and broader application of big data analytics for better travel planning and transport management.
- **Develop and Adopt ITS Standards**. Data standards and protocols are necessary to ensure overall system efficacy and interoperability.
- **Establishing partnerships and collaborations between both public and private sectors**: this allows leveraging on the expertise and strengths of every member. This is key to innovation. It also helps align the thoughts and needs of stakeholders and serves as an effective platform to promote ITS awareness.
- **Enhancing Integration between Public Transport and Road Operations**. Public transport service reliability and road network performance have an effect on travel experience. By having an integrated transport operations and management system, transport operators will be better equipped to quickly address any abnormal situation. Data from various ITS can be aggregated and analysed at the integrated transport operations and management system. This allows a more complete situational picture and enhances operational efficiency through coordinated response to crises or incidents. Bus arrival times at bus stops can be improved through prioritised movement at junctions and reduces bus bunching.
- **Promoting Higher Usage of Public Transport and Active Mobility**. Promoting public transportation as the choice mode will help reduce the amount of carbon emissions as public buses and trains are more efficient mass people movers compared to private vehicles. This also means more land can be preserved for other economic infrastructure and recreational uses. Greater effort will be placed on promoting public transport to reduce reliance on private vehicles.

- **Facilitating walking and cycling** is another way to encourage the use of public transport and as alternative modes of transport, thereby reducing our carbon footprint. More than 200km of sheltered walkways are being planned for 2018 under the Walk2Ride programme to improve the walking experience of commuters to MRT (Mass Rapid Transit) stations, bus interchanges and some bus stops. The Government is also building a comprehensive network of cycling paths across the island that will extend over 700km in 15 years' time.

4.2. R&D advances

4.2.1. Cooperation with Research Centers

Singapore's R&D challenges are also in autonomous vehicles and seamless mobility, aiming at trips that can be made in self-driving buses or pods, as and when citizens need it or at a smart mobile application that tells the user exactly what transport options he/she has available within a 200m radius.

On this purpose, the Land Transport Authority (LTA) is beefing up its research capabilities, and will intensify efforts to collaborate with universities, professional organisations and industry players to conduct research and technical trials on innovative policies, technological applications and sustainable practices in the transport industry.

According to the LTA's chief executive, Mr Chew Men Leong, even as Singapore continues developing into a liveable city with a high quality of life, it also means creating a well-connected people-centred land transport system that meets the diverse needs of commuters with less reliance on cars. To achieve this LTA has to step up its capability and investment in the area of research, to adopt the latest technology and create smart transport choices.

To support this vision LTA has establish a collaboration with the research community and Transport Research Centres are being planned for Singapore's three local universities, namely National University of Singapore (NUS), Nanyang Technological University (NTU) and Singapore Institute of Technology (SIT).

Dr Lee Der-Hong, Director of NUS-LTA Transport Research Centre and Professor from the Department of Civil and Environmental Engineering at NUS Faculty of Engineering stated⁴that "one example of the research that will be embarked on is the design and development of a new community-based mobility system. This is to address the need of bridging the last-mile gap for commuters, and could be implemented in residential or business enclaves. Key areas of collaboration are also mobility behaviour and 'green' transportation".

Professor Simon Yu, Programme Director, Sustainable Infrastructure Engineering (Land & Building Services), SIT said, "At SIT, we are excited to contribute towards building such research capabilities aimed at creating a new vibrant future for Singapore's transportation system. We will work together with LTA in developing simulation-based learning on railway and transportation systems so that both SIT students and working

⁴ source: LTA web site

professionals can master important aspects such as signalling, route planning and system engineering through simulated MRT networks.”

To encourage innovation among youth and build up the engineering pool for the Public Transport industry, LTA is also launching the LTA Engineering Challenge for Sustainable Future Mobility where tertiary students and engineering professionals can use their creativity, innovation and engineering skills to co-create projects to help create an attractive and robust land transport network. There will be two challenge topics - “Sustainable Mobility” and “Future Mobility (Self-Driving Vehicles)” - for which participants are invited to rethink how our transport landscape would be like in the years ahead. Under “Sustainable Mobility”, the participants could explore how to make Singapore a “car-free” walkable city, where our street space is centred on pedestrians instead of drivers. Under “Future Mobility (Self Driving Vehicle), participants could imagine how on-demand, door-to-door mobility service provided by self-driving vehicles would transform our transport landscape.

The LTA Engineering Challenge will be carried out with support from the Institution of Engineers Singapore. It is open to students from the Polytechnics, Universities, Junior Colleges and the Institute of Technical Education, and will have an open category for interested professionals in the engineering field.

4.2.2. Diversification of services

Premium Bus Services (PBS) are bus services that offer more comfort versus other bus services or other forms of transport. They cater towards commuters who do not mind paying higher fares for a more comfortable and direct journey to their destinations. Almost all Premium Bus Services concentrate on catering towards commuters heading to and from the Central Business District (CBD) during the morning and evening peak hours. The direct nature of Premium bus routes makes it more appealing than ordinary bus routes or taking a train, as passengers are assured of a seat onboard, plus it costs a lot less to travel by Premium bus than by taxi. Premium buses are operated by both public and private bus companies. Currently, a total of about 70 PBS operates from various major residential areas to the CBD (source: <http://www.publictransport.sg/>).



Figure 8. Singapore Premium Bus Service

4.2.3. Travel Smart

Travel Smart is a programme addressed to commuters and companies to influence travel behaviours, to shift travelling commuters to off-peak periods, encourage a switch to more sustainable modes of travel (e.g. public transport, carpooling, car sharing, walking and cycling) or reduce travel demand altogether.

Travel Smart is based on the concept of travel planning, which is widely implemented by companies worldwide. Essentially, travel planning is a means of evaluating how the employees of an organisation currently travel to work, and during the day as part of their work. Based on the analysis of existing patterns and attitudes concerning travel, an action plan for improved transport efficiency and sustainability is prepared.

LTA is launching a new Travel Smart Network to intensify efforts and encourage more companies to implement measures such as flex travel arrangements to support employees who may wish to travel during off-peak periods. For a start, LTA will partner companies with a staff strength of more than 200 employees in major employment centres located near MRT stations and that are willing to trial travel demand initiatives (Source: <http://www.lta.gov.sg>).



Figure 9. Singapore Travel Smart Initiative

4.2.1. Automated vehicles

Singapore transport operator SMRT is getting involved in developing automated vehicles, with an eye on using them to mainly take commuters from their homes to bus interchanges and train stations. There is a growing national push for mobility solutions that meet first and last-mile connectivity needs in the country. In this respect,

automated vehicles will complement the existing multi-modal transport operations to bring about seamless connectivity for commuters.

SMRT has entered into a joint venture with the Netherlands-based automated-vehicles company 2 Getthere Holding BV (2getthere) to market, install, operate and maintain the vehicles here and across the Asia-Pacific region (April 2016). Called 2getthere Asia, the partnership, which is 51 per cent owned by SMRT Services, will be based in Singapore. However, the automated vehicles are not expected to hit public roads anytime soon. Right now, some of 2getthere's automated vehicles are operating in "semi-controlled" environments overseas, such as the Rivium Business Park in Rotterdam, the Netherlands.

At the park, for instance, intersections and the speeds of road-users are fully controlled, and access to roads and road-user behaviour partly managed. 2getthere Asia aims to showcase a 3rd-generation Group Rapid Transit (GRT) automated vehicle here by the end of 2016. 2getthere, which rolled out its first automated vehicle system at Amsterdam's Schiphol Airport in 1997, has a history of developing and rolling out such driverless systems in different locales.

The third-generation Group Rapid Transit automated vehicles, set to be showcased in Singapore by the fourth quarter of 2016 can operate without a driver in challenging weather conditions. They navigate with the aid of artificial landmarks – thumb-sized magnets fitted every two or three metres along the route. Each vehicle can accommodate up to 24 passengers and travel at a speed of 40 kilometres per hour. They can run as part of a low-cost automated transit system, ferrying up to 8,000 passengers every hour in one direction. However, the vehicles are not set to hit public roads anytime soon. Similar vehicles are currently being used only in closed environments, such as the Rivium Business Park in Rotterdam, Netherlands. An earlier variant, the Personal Rapid Transit system, has been in operation in Masdar City in Abu Dhabi since Nov 2010. The four-passenger vehicle has completed more than 2 million passenger trips there so far.



Figure 10. A second generation of Personal Rapid Transit (PRT), April 2016

5. R&D and policy trends for Public Transport in China

5.1. Societal challenges and PT trends

In 2011 Chinese urban population exceeded its rural population for the first time. About 350 million new urban residents are expected to migrate to cities over the coming 20 years. These processes have led to a massive increase in transport volume, making air pollution, congestion, traffic accidents and noise nuisance characteristics of Chinese metropolises that affect the newly gained quality of life. In addition, much of the growth in transport GHG (Green House Gases) emissions is generated in cities and urban growth is bound to continue for the next decades to come. Reducing GHG emissions from urban transport is therefore a necessity for sustainable development.

However this rapid urbanization also represents an opportunity, since the recognition of urban transport's spillover effects has led to a new policy emphasis on public transport priority and sustainable urban transport development. National policy has been promoting a 'people-centered' development concept, which emphasizes the movement of people rather than the movement of vehicles. It also calls for developing a "resource-saving and environmentally-friendly" society in line with the national CO₂ intensity target of a 40-45% reduction from 2005 levels by 2020.

Given these goals, Chinese cities have an opportunity to plan the development of their urban environment in a way that minimizes the need for travel and directs a large share of investment towards the development of safe, clean and affordable transport systems. A transformation in urban transport policy and practice in China is already ongoing by supporting development of national level policy frameworks, piloting

institutional and technological innovations with potential for scale up, and accelerating the shift to more sustainable forms of transport.

The climate change imperative has further strengthened the attractiveness of public transportation. At reasonable levels of vehicle loading, a bus or metro system can provide far more energy- and carbon-efficient transportation than the average car, per passenger kilometer. However, individual citizens with the freedom to choose their own mode of transport will usually not seek to maximize global environmental benefits. Rather, they will choose a mode that maximizes comfort, reliability, speed, convenience, and cost.

The only public transport alternative to cars for most people in China is a bus service steadily degraded by ever-increasing traffic congestion. Not surprisingly, for those with a choice, public transport is rarely competitive, and an overwhelming majority of public transport users today are “captive” users with few alternatives. However, as economic development continues, today’s “captive” riders will have choices tomorrow and only a high-quality system will be able to keep them from choosing individual transportation alternatives. Ultimately, the goal is to provide public transport quality to also attract customers away from cars and taxis. Such a public transport system that has the capability to attract customers from private automobiles is often a necessary political prerequisite for cities to consider restrictions on auto use.

All urban strategies for low-carbon growth will require a large share of passenger traffic to be carried by an upgraded public transport system, even as increasing income levels make auto use a viable choice for increasing numbers of people. Naturally, the definition of “upgraded public transport” will vary based on the context; a commuter in Shanghai has different expectations (and the city has different resources) than a commuter in a small city. For this reason, the appropriate program for public transport improvement will vary over time for any given place and will depend on the context.

In October 2005, a State Council decision declared that urban public transport development should be a national priority. Subsequently, particularly after the responsibility for urban public transport was given to the newly formed Ministry of Transport in 2007, the national government has been actively looking to define its role in this sector. The current focuses are define a national policy toward public transport and review issues related to subsidies and institutions.

According to World Bank, these developments are timely and will work well to support urban transport and low-carbon developments.

*Chapter 11 of Sustainable Low Carbon City book*⁵ summarizes the range of measures a Chinese city can take to improve the quality and competitiveness of its public transport system. While solutions are often context-specific and every city will need to find ways to improve public transport based on local needs and conditions, there are broad similarities in the strategies that almost all cities will benefit from. The following “three-integrations” present the key focus areas and challenges Chinese cities are facing to develop public transport systems that would support a low-carbon economy:

⁵ <http://www.worldbank.org/>

- *Developing customer-oriented services:* Modern customer-oriented public transport enterprises can attract users of choice. This will require greater attention to the details of bus and rail transfer facilities, as well as the creation of premium services and a customer-oriented mentality.
- *Integrating schedules and fares across modes and services:* Although the use of multi-modal smartcards is common, bus interchange facilities that help passengers change modes or services are systematically underused. In addition, fare policies are rarely designed to facilitate intermodal fare transfers. Integrated bus and rail services, schedules, and fares will contribute greatly to improved services for passengers.
- *Integrating land use with transport planning:* It is increasingly evident that even the most effective systems of public transport cannot be competitive if they are not carefully integrated with land use planning and design.

5.2. Policy and R&D trends

In order to outline policy and R&D trends in Chinese cities, two experts have been identified and interviewed: Mr. Ximing LU (Shanghai City Comprehensive Transportation Planning Institute) and Mr. Haode LIU (China Urban Sustainable Transport Research Center and China Academy of Transportation Sciences).

5.2.1. Interview to Mr. Ximing LU

Mr. Ximing LU has been director of Shanghai City Comprehensive Transportation Planning Institute (SCCTPI). Senior engineer at professor level as well as deputy chairman of China Academic Commission of Urban Transport Planning. He is also appointed as the consultant of Ministry of Housing and Urban-Rural Development of the People's Republic of China, Shanghai Academic Commission of Urban Transport Planning, Shanghai Municipal Government, traffic expert of the Ministry of Construction, expert of China International Investment Consulting Co., Ltd as well as the freelance professor and doctoral supervisor of Tongji University, Shanghai Maritime University and Beijing University of Technology.

He has been engaged in transportation-related activities for 30 years. He presided over resident trip investigations in the entire city of Shanghai, comprehensive transportation planning and Transport White Paper and the latest strategy for comprehensive transport, as well as the technical work regarding model of Shanghai comprehensive transport.

The main outcome of the interview addressed to Mr. Ximing LU are summarized in the following.

National and local PT priorities

In China the main priority dealing with public transport is the share of collective modes among all modal options available. Not only the states but also local governments today pay close attention to it. The document *Opinions on the Priority*

Development of Urban Public Transport (2004) suggests “ public transportation should account respectively for 30% of all means of travel in megalopolis and 20% of all means of travel in large and medium size cities (including walking and bicycling). *The target of The States Council’s Guidance on Urban Priority Development of Public Transport (2012)* are even higher: “public transportation should account for 60% of all means of travel in large size cities (walking and bicycling not included)”. The governments pay close attention on the scale and frequency of the passenger travelling of public transportation. The 4 times *Shanghai Comprehensive Transportation Planning* and 2 times *Shanghai Transportation Development White Paper* set the *share ratio of public transportation* as the main target of the planning year. But the effect of implementation is not ideal.

Main PT policies

Three main policies are currently encouraged in China to foster public transportation, namely: planning, facility supplying and management policy.

Planning: the land use planning should encourage citizens to travel by public transport rather than the private cars. The mixed land use and the distance between the inhabiting places to work places shouldn’t be too long. A Transit Oriented Development (TODs) planning has been already encouraged in many cities in China.

Facility supplying: constructing urban railway systems, rapid transit systems, and other massive transportation systems to improve the capacity and the service quality of public transport.

Management policy: implementing policies to restrict residents travelling by private car, such as the quota action policy for car license plates (Shanghai) or the license plate lottery (Beijing). More than 600 cities in China, including Shanghai, apply policies which embrace the three aspects above to foster PT.

Cooperation with foreign countries

The cooperation with foreign countries is mainly achieved through academic exchange and technology importing. UITP is very active in China with two offices in the mainland and Hong Kong and facilitate knowledge sharing with several worldwide PT stakeholders. At university level, there are many foreign exchanges students in the transportation policy education (e.g. at the Tongji University). These students are always the public officer of the transportation department in their country.

Since several years, China has been importing the foreign technologies and facilities in the construction of metro, electric tram, etc. For example, Shanghai imported the vehicles and the signal system of metro from Siemens, Alstom during the construction the metro system. Similarly, the technology of the construction of metro system also export to other country such as Vietnam. Shanghai City Comprehensive Transportation Planning Institute (SCCTPI) also participate the passenger forecasting of metro system for Vietnam.

Key innovation domains

As a low carbon emission and low cost mode of transportation, PT is to be conceived as a mobile “public space”. It should be operated more efficiently and effectively. Other forms of collective transport like carpooling can be very efficient in specific

travel distance patterns and operating cycle. In some cities of China, the route selection of metro system is not reasonable, the volume of the passengers cannot meet the goal set during the planning phase. For the purpose of low carbon emission, the metro system must be planned more efficiency and effectively.

If carpooling vehicles can be equipped with electric energy system or other low pollution energy, this kind of mode of transportation should be promoted together with public transportation system as combined mobility. In some cities of China, carpooling vehicles are allowed to run on the bus lane during peak-time hours. These actions can be considered innovative solutions to complement PT which cannot supply the door to door service. Indeed, the passengers' volume of car sharing systems is not even comparable to traditional public transportation systems, therefore land use planning is key for built environment contexts that are more PT oriented.

Innovation

Overall, innovations should apply mainly on the operating and legislative framework to convert the idea of traditional public transportation to the sharing public transportation system. A good example is the electric car sharing system developed by SAIC Motor (Shanghai Automotive Industry Corporation). According to the national energy car policy of China, some costs of construction and operation of the service are covered by subsidies, so the final cost for the traveler is between private transportation system and public transportation system.

5.2.2. Interview to Mr. Haode LIU

Dr. Haode LIU is professor at China Urban Sustainable Transport Research Center (CUSTReC) and China Academy of Transportation Sciences (CATS) with field of expertise in public transport system policy and intelligent transport.

The main outcome of the interview addressed to Mr. Haode LIU are summarized in the following.

National and local PT priorities

Urban public transport priorities in China focus on policy, finance, land use and road space. The state has adopted the national strategy of developing urban public transportation as a priority in 2004 and has issued the national guidance of the urban public transportation priority in 2006 and 2012. Moreover in 2008 the function of guiding the development of urban public transportation was transferred from the Ministry of Construction to the Ministry of Transport to unify the national urban and rural passenger transport system administrative system.

China's legislature, the National People's Congress, endorsed the country's *12th Five-Year Plan* on 14 March 2011. This far-reaching plan sets the nation's course for the next five years: the social and economic measures contained in the plan will have a deep impact on the business landscape, both within China and in countries that do business with China.

Three of the main priorities in this plan are sustainable growth, industrial upgrading and the promotion of domestic consumption. These priorities explain why certain sectors, including energy, automotive, IT infrastructure and biotechnology also receive a high degree of focus.

The first planning “*The Development Outline of the Urban Public Transportation in 13th Five-Year*” drafted by the Ministry of Transport will be issued soon. For example, the 8th document of Harbin transportation bureau rules that the large residential area with more than 50,000 m² should be accompanied the complementary bus station. The planning, designing and constructing of bus stations should be implemented as a unitary and systematic process. The document guarantees the development of the urban public transportation system from policy level to land use.

Main PT policies

Several local policies have been adopted to guarantee the funds for the development of public transportation system. Furthermore, with the aggravation of the city traffic congestion, the policy adopted by TDM (Transport Demand Management) is to reduce the use of private car and foster a land-use development which is public transport oriented.

TDM can restrict motor vehicle use through effective guidance of transport demand, and is an important way for developed countries to realise green transportation. In recent years, China has tried some measures and accumulated certain experience in TDM adopting License plate quota auction system, Parking charges, Travel restriction measures for cars, Other economic instruments like Consumption tax adjustments and Fuel tax.

Shenzhen has proposed the practical action to push the development of the urban public transportation through funding, road usage restriction for cars, finance and taxation support, infrastructure construction.

Cooperation with foreign countries

There are no national strategic cooperation with foreign countries in China. In the framework of Sino-American cooperation, the Sino-American transportation forum is held every year. The experience on public transportation is part of the knowledge and experience exchanges which take place at the forum. Furthermore, there are some academic and technology exchange on the sustainable transportation, with a focus on zero carbon emission PT.

Key innovation domains

From the 12th five of national economic plan, Ministry of Transport dominated the construction of the “Transit Metropolis” demonstration project. Today 37 cities are involved in this project. Funds from the state are available on the following development areas: public transportation hubs, intelligent infrastructure construction, energy saving and emission-reduction as well as rapid transit system to encourage the

local government to set the priority for the development of efficient and more attractive urban public transport systems.

Zhengzhou was one of the first cities to join the project. They addressed several initiatives about multimodal transportation, traffic flows, hub construction, service promotion, intelligent infrastructure construction, low carbon transport, traffic management etc. The city is committed to develop a medium and long term plan for the urban public transportation, implement a priority scheme for PT services and increase the investment to PT. An increase in PT modal share as well as in the user satisfaction is expected after 3 years since the demonstration project will be put in operation.

Innovation

The States Council's Guidance on Urban Priority Development of Public Transport was purposed in 2012. The Ministry of Transport which is responsible for the management of the public transportation announced disseminated this guide and, as a result, many cities published a document of local policy to foster the development of public transport. Since the *12th five year of economic planning*, investment of the public transportation, the guaranteeing of land use, the amount of vehicle and equipment was increased substantially. The development of urban public transportation got a rapid growth period of opportunity. There are many great changes in the service and the development of urban public transportation.

5.3.R&D advances

5.3.1. Urban Transport Improvement Project of Tianjin

The Urban Transport Improvement Project will finance civil works for 111 metro stations, along existing Tianjin Metro Line 1, 2, 3, 9, and Line 5 and 6 (under construction), to provide these station with facilities to promote intermodality (i.e. bike parking, bus connection/terminal, taxi connection, landscaping and park and ride). This project will increase the catchment area of these metro stations and optimize large past investments in the mass transit system.

The establishment of a Public Bicycle Sharing (PBS) System Pilot in the core urban area of Tianjin will be financed as well as in areas along metro lines to support last mile accessibility. It will include about 12,370 bicycles and 446 stations. The civil works include the pavement of the PBS stations. The project also will finance the PBS management system, including hardware and software, the provision of bicycles, docking poles, CCTV and other required devices.

The Project include also a Bus Terminal Development. Civil works will include pavement of the terminals, as well as bus stops, bus parking, car parking, bicycle parking and service buildings. The project also will finance equipment within the bus terminals for bus operation. Overall, five terminals are part of this initiative on bus terminal development and they are located primarily at the end of metro lines, acting as feeder services for the population living in the area. Joint commercial development will be carried out above one of the bus terminal (Beichen Liuyuan).

5.3.2. Zhengzhou Urban Rail Project

The objective of the Zhengzhou Urban Rail Project for China is to improve urban mobility for the population of Zhengzhou along the catchment area of Line 3 from Xin Liu Lu Station to Hang Hai Dong Lu Station. The project consists of the following four components:

- Construction of the Zhengzhou Urban Rail Line 3 (about 25.2 km) which starts at Xin Liu Lu station and ends at Hang Hai Dong Lu station. Line 3 will connect the city center of Zhengzhou with its northwest and southeast development areas. Line 3 will include 21 stations, located underground and connected by tunnels. Six interchange stations to be built will provide convenient interchange with other urban rail lines. The Bank loan will support the construction of five stations and five tunnels located at the southeast end of the line.
- Equipment of Line 3. This component includes equipment necessary to the operation of Line 3, such as rolling stock, power supply, control system, signalling system, communication system, monitoring system, fare collection system, safety and security system, ventilation and air conditioning system, water supply, sewerage and fire protection system, station auxiliary equipment. This component will be financed entirely by local counterpart financing.
- Design, Construction Management and Technical Assistance. This component includes: (i) activities for design and preparation of the project; (ii) activities for construction management and quality assurance; and (iii) technical assistance (TA) and capacity building of relevant staff and the Urban Rail Company (URC). The Bank loan will support the TA and capacity building activities.
- Safeguards and Other Construction Costs.

5.3.3. Chongqing Public Transit Network Optimization

Chongqing Municipal Commission of Transport, Chongqing City Transportation Development & Investment Group and Chongqing Bus Group together introduced a one-hour free transfer policy, allowing passengers using free electronic tickets on busses and subways for transfers between travel modes within one hour. The policy covers downtown Chongqing (9 districts) and benefits about 5 million passengers. The scheme applies to standard electronic ticketing users, but not those with already reduced fares or passengers paying with cash. The policy is a major step toward the goal of a fully integrated public transportation system.

In addition to the one-hour free transfer policy, China Sustainable Transportation Center is committed to help the city of Chongqing in undertaking a comprehensive PT optimization initiatives. Together with the local planning bureau CSTS planners helped improve the efficiency of the city's bus system, eliminating repetitive routes, increasing bus capacity and promoting bus stop accessibility. The project has paid close attention to the availability of alternative transportation modes, ensuring the viability of biking and walking alongside bus and subway systems. As a result of this analysis, the city plans to adjust 51 bus routes where operate more than 1700 buses.

The project is expected to eliminate the need for 420 bus trips per day while increasing the bus transfer volume by 0.8 million. The re-organisation of the bus routes will reduce on average the travel time by 3 minutes accounting for a total of 110,000 hours per day, increase the capacity of the whole public transport network by 20.3% and reduce CO2 emissions by 68000 tons per year.

5.3.4. Zaozhuang City BRT System (Shandong Province)

Zaozhuang is one of the first cities in China for planning and implementing BRT systems; Line B1 from Downtown Zaozhuang to Xuecheng was initially implemented in August 2010. Today, the BRT lines in Zaozhuang have the longest distance in China and have formed a network: 65km of dedicated BRT lanes with traffic signal prioritisation (133km in total) allow a greater connectivity throughout the city. Besides, other lines are still under construction. The construction of the first line (Line B1) was totally funded by the city government. From the second line, the city government has invested in designing the lines and purchase the buses while the district governments has invested in the construction of the roads, station and supporting equipment.

The system has contributed to the development of the whole city through greater accessibility for citizens and a more enjoyable and easy PT services for tourists. However, insufficient investments in the planning stages of the project have led to many BRT stations not equipped with bicycle/car parking facilities.



Figure 11. Zaozhuang City BRT System (source: web)

5.3.5. Combined Rail and Property Investment in Shenzhen

In June 2008, Shenzhen Metro Group Co., Ltd. obtained the overhead land use rights for property development over QianHai Bay Depot, Metro Line 1, which launched Shenzhen's practice of "rail transit + property" development model. The goal of such a model is to integrate the construction of PT systems with underground and aboveground land use development, maximising the social and economic benefits in metro construction and operation and making full use of the along-metro and over-

metro regenerated land space. Moreover, the introducing of social capital to participate in metro construction and property development is of utmost importance in order to enhance the financing ability, establish the safe fund chain and guarantee a beneficial cycle of investment enterprise's sustainable development. The main key drivers for the implementation can be summarised as follow:

- Previously, the financing model used by the government was burdensome to the government itself while also limiting the development of Shenzhen Metro.
- The great success of MTR in Hong Kong made beneficial enlightenment to financing model innovation by Shenzhen Metro Group Co., Ltd.
- The Shenzhen's high prices of land and n housing made it suitable the implementation of Shenzhen Metro "rail transit + property" investment and financing model.

Shenzhen Metro financed the new metro project through bank loans, corporate bonds, medium-term notes and financial leasing. They designed the underground and aboveground space by combining metro and overhead property projects. Income from property development surrounding the metro systems is used to repay the loan and its interest for the metro construction. The scheme required collaboration between the Development & Reform Commission, the Urban Planning, Land & Resources Commission, the State-owned Assets Supervision & Administration Commission, the other relevant departments of the Shenzhen Municipal Government.

This "rail transit + property" development model has greatly reduced the pressure on the government's financial demand while intensively developing rail transit in Shenzhen City. It has also alleviated the shortage of land resources, expanded the space of urban development and stimulated economic growth along the new metro lines.

6. Conclusions with a European perspective

Research and innovation are increasingly interlinked worldwide in a fast-changing landscape. The relevance of an international cooperation strategy focused on research and innovation, in areas of common interest and mutual benefit, has been already highlighted by the European Commission, in particular with a view to implementing Horizon 2020. On 14 September 2012, the Commission adopted a Communication entitled "Enhancing and focusing EU international cooperation in research and innovation: a strategic approach". The strategy is based on the following 3 objectives:

- Extend the frontiers of scientific knowledge
- Tackle global challenges
- Invest in competitive industries.

Research and Innovation on public transport can significantly help achieving these objectives, as the analysis carried out within Viajeo Plus has confirmed. Climate change, industrial leadership, advancement in technological development are beyond this.

Today, urban public transport is able to give relevant contribution to key issues faced worldwide beyond the demographic, geographic and social peculiarities, among them:

increasing traffic demand, pressure on urban land and infrastructure capacity, vehicular conflict, energy demand, environmental pollution and the need for more homogeneous living standards,

Similarly to European cities, in China, Singapore and Latin America public transport is seen as the solution to cope with these challenges, even though approaches and research priority seem to differ across the regions. Domains for cross fertilization and cooperation are identified accordingly.

China

In China, public transport is conceived as a mobile “public space” that should be operated more efficiently and effectively. Complementary forms of collective transport, already well-known in Europe, like carpooling or car sharing seem to be promising to meet users’ mobility demand in specific travel distance patterns and operating cycle. A good example is the electric car sharing system developed by SAIC Motor (Shanghai Automotive Industry Corporation). According to the national energy car policy of China, since some costs of construction and operation of the service are covered by subsidies, the final cost for the traveler is between private and public transportation system.

In some cities of China, the route selection of metro system is not reasonable, the volume of the passengers cannot meet the goal set during the planning phase. For the purpose of low carbon emission, the metro system must be planned more efficiency and effectively, also in terms of multimodality.

Priorities therefore rely on innovative operating and legislative frameworks to move from the idea of traditional public transport to the sharing public transportation system. This priority links to the new paradigms of the shared mobility and mobility as a service raising in Europe, also explored within Viajeo Plus as a potential topic for future cooperation between Europe and China.

Singapore

To make public transport more attractive, Singapore is focusing on improving the capacity and reliability of train and bus services. The objective is to spread travel beyond the peak hours and encourage off-peak travel for citizens who are able to do so. Several actions are planned for the next years.

Key broad strategies and focal areas are identified to provide the leadership, guidance and support to help Singapore achieve this vision, among them: implementation of cost-effective smart mobility solutions for diverse transport users and broader application of big data analytics for better travel planning and management; establishing partnerships and collaborations between public and private sectors; enhancing integration between public Transport and road operation; reducing reliance on private vehicles; facilitating walking and cycling as another way to encourage the use of public transport and as alternative modes of transport.

Likewise Europe, automated driving is seen in Singapore as one of the key technological advancements influencing and shaping our future mobility and quality of life. It is well-known that the main drivers for higher levels of automated driving are: reducing accidents caused by human errors, increasing transport system efficiency and reduce time in congested traffic, enabling user's freedom for other activities when automated systems are active; ensure mobility for all, including elderly and impaired users and facilitate access to city centres⁶.

The process towards autonomous driving has already started with the development of ABS, ESP and Advanced Driver Assistant Systems (ADAS) and will progressively apply to more functions and environments. In parallel, driverless automated systems can be deployed to provide transport solutions in restricted areas with dedicated infrastructure or at specific locations e.g. airports. Nevertheless, the European community is facing important challenges to enable higher levels of Automated Driving in all environments. To name just a few of them, legislation and regulatory framework must be adapted according to the technological advancement. Further, industrialisation is key for implementation of automated driving and to realise the positive economic impact.

In Singapore several R&D initiatives and collaboration between LTA (the Land Transport Authority of Singapore) and Universities, industries and other organisations in the sector aim at investigating the opportunities and challenges of autonomous vehicles and seamless mobility, aiming at trips that can be made in self-driving buses or pods, as and when citizens need it. A five-year Memorandum of Understanding has been signed between LTA and the Agency for Science, Technology and Research (A*STAR) for starting a joint partnership "The Singapore Autonomous Vehicle Initiative" (SAVI). SAVI will provide a technology platform for managing R&D (autonomous vehicles, autonomous mobility system and automated road system) and diverse trials for automated driving for public and industrial stakeholders. Besides SAVI, there are already several ongoing trials for automated driving on Singapore's roads, for instance between MIT and the National University of Singapore (NUS). Within this project, a fleet of autonomous golf buggies is currently tested for car-sharing concepts

The European Union has a long history of funding collaborative research projects contributing to the development of automated driving. International cooperation on this topic would be of utmost important to address challenges and existing gaps (technology, legislation, regulatory, policy, etc.). Cooperation between European industries and Singaporean stakeholders for the development of projects in automated collective transport are already a reality.

Latin America

In Latin America, the major cities are adopting buses that have embedded intelligent systems, as a fundamental basis for improving the management of the operation and increase user satisfaction. Innovation initiatives focus on BRT, integrated ticketing systems and ITS leading to integrated models of city management, where

⁶ ERTRAC, 2015. Automated Driving Roadmap v.5.0.

transportation is a key element. Particularly important is the adoption of BRT as the main element to fulfill the demands of big events like the World Cup and Olympics games, denoted an important strategic decision, creating structural means to improve the quality of public transport through dedicated infrastructure with the possibility of incorporation intelligent transportation systems that provide new ways to deal with public transport.

In Latin America buses used to be a weak element of the Public Transport system. Large investment programmes traditionally dealt mainly with rail and metro systems. Recently, , investments have been dedicated to buses thanks to the development of BRTs which have strongly improved the quality of life of people by raising the LoS (Level of Service) and QoS (Quality of Service); in some cases in Rio, BRTs have reduced the travel times from 3 hours to 50 minutes. Nevertheless what is still missing is an efficient network of “common” bus lines. The main issues here are in the basics: less crowding at peak hours due to higher speeds and better regulation of bus flow, safety and accessibility.

A metropolitan or regional vision for Public Transport network is also needed to enhance the interoperability between operators both in terms of infrastructure and fare policies.

The successful public transport solutions gained in Viajeo Plus suggest to explore the potential of BRT systems in Europe, by investigating the requirements for BRT specifically designed for European cities based on the latest development worldwide. Infrastructure, rolling stock, operations and socio-economic issues are equally important for the deployment of effective solutions. Pilot projects of BRT in European cities should be on the roadmap of the European Commission in future R&D funding programmes.

Annex 1 - Questions for experts

Target Region	
Name of the expert	
Biography and field of expertise	
<u>What are the priorities on Public Transport in your Country? Please, after a general overview of the priorities in the Country, focus on urban public transportation of a City.</u>	
<u>What is the policy adopted at local level to foster PT and the transport initiatives? Please refer to specific examples of one of more Cities.</u>	
<u>Is there any strategic cooperation with foreign countries?</u>	
<u>What are the innovation topics your country is focusing on? Please make examples referring to specific cities.</u>	
<u>Please name one single innovation that in your opinion has helped transforming public transport in your region.</u>	

Annex 2 - List of experts interviewed and reference documents by region

Experts:

Latin America	Mr. Juan Carlos Gonzalez (Transurbano Foundation, Chile),
	Mr. Claudio Luzi Marte (University of São Paulo)
	Mr. Alessandro Santiago dos Santos (Institute for Technological Research of Sao Paulo State).
China	Mr. Ximing LU (Shanghai City Comprehensive Transportation Planning Institute)
	Mr. Haode LIU (China Urban Sustainable Transport Research Center (CUSTReC) and China Academy of Transportation Sciences).
Singapore	Mr. Khaw Boon Wan (Transport Minister). The report is based on an interview addressed to the Minister by Channel News Asia in April 2016.
	Mr. Chew Men Leong (Chief Executive, Land Transport Authority Singapore from October 2014). The report is based on statements reported on the LTA web site.

Reference Documents:

Latin America	http://portal2.tcu.gov.br/portal/pls/portal/docs/2062408.PDF
	http://www.transportes.gov.br/component/k2/itemlist/category/4.html?Itemid=148
	http://www.transportes.unb.br/downloads/eventos/politica_nacional_de_mobilidade_urbana.pdf
China	World Bank, 2012. http://www.worldbank.org/en/news/feature/2012/08/14/building-sustainable-transport-systems-in-chinese-cities
	Sustainable Low Carbon City book, Axel Baeumler, Ede Ijjasz-Vasquez, Shomik Mehndiratta, 2012.
	Improving Public Transport in Chinese Cities: Elements of an Action Plan, Shomik Mehndiratta and Andrew Salzberg
	China 2015: Transportation and Logistics Strategies, A.T. Karney, 2015
	Sustainable Low-Carbon City Development in China, KPMG Advisory, 2011

	China 12 th Five-Year Plan, KPMG China, 2011.
	http://sustainabletransport.org/urban-transport/
Singapore	Land Transport Master Plan 2013
	ITS strategic plan for Singapore - Smart Mobility 2030