

## Study on the Introduction of LRT System in the Asian Cities

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### ***Abstract:***

Light Rail Transit (LRT) system has attracted attention as a tool of urban development and urban revitalization and well-established their position in Europe and the United States; however, it has not become widespread into Asian region. Japan is one of the typical countries in Asia where an old-type tramway system is still well-working in several cities. Past researches related to LRT system strongly emphasizes on the impacts of its introduction in Japan, Europe (Germany, France and UK) and the United States as a study area, but not in Asian countries. This study, therefore, aims at organizing the Asian tramways and light rail transit system from the past to the future, and examining the regional features what the trend of Asian LRT is.

Asian region obviously do not have much of a presence in terms of total network length. Historically, lots of tramways existed in early 1900s, especially in South-Eastern Asia. This was affected by the imperial power (i.e. UK, France and the United States). Bangkok (Thailand) where Asian first tramway had operated was not a colony; however, largely influenced by its pressure to survive as an independent country. It is also found that Asian cities with Light Rail Transit system tend to have a population of over 1 million, relatively high population density with more than 5,000 person/km<sup>2</sup> compared to European cities, and mass rapid transit system such as Metro and MRT has been introduced.

### ***Keywords:***

Light Rail Transit, Tramways, Streetcar, Public Transportation, Urban Development

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## 1. Introduction

Old Tramways has been redeveloped with the state-of-the-art technology as Light Rail Transit System (LRTS). It is expected to play an important role as urban transport system as well as to lead the city to explosive diffusion of urban revitalization as one of the development tools.

Before the World War II, total length of LRTS in the world had a tendency to be increased; however, rapid economic growth after the War had promoted private vehicle usage in the developed countries. France has experienced such motorization and in turn erosion of urban public transport system<sup>1)</sup>. Due to the technological development of LRTS, several cities in France tend to return to LRTS from private transportation. On the other hand, there are fewer cities operating LRTS in Asia compared with European cities. In Asian mega cities such as Jakarta, Seoul, Bangkok and Istanbul, Bus Rapid Transit System has come to the forefront instead of LRTS<sup>2)</sup>. LRTS could be introduced for at-grade, underground and elevated structure based on existing road space; thus it looks suitable to apply for highly-populated Asian cities.

In order to find the past achievements in LRTS-related researches, the published literatures available in Japan have reviewed. Most of them are mainly classified into three aspects. First area is that how the introduction of LRTS and transit mall affects to local economy, travel behavior, environmental consciousness and CO<sub>2</sub> reduction<sup>3)-11)</sup>. Osada et al. (2006)<sup>12)</sup>, for instance, examines the impacts on road traffic by introducing LRTS in Utsunomiya City, and concludes that LRTS contributes to the reduction of traffic congestion partially; while, it is also concluded that the result indicates a dispersion of congestion within the city, not a radical solution. Second area is “Features of LRTS-operating Cities”<sup>13)-16)</sup>. Suzuki et al. (2008)<sup>17)</sup> compares Japanese cities with French cities from viewpoint of population and population density. It indicates that population of most French cities does not exceed 300,000 persons. Matsunaka et al. (2008)<sup>18)</sup> also analyzes the relation between population along the LRTS corridor and number of trips made by LRTS in Japan and France; then found that trips made by LRTS in France is larger than that in Japan at the same population level. In terms of “Introduced Country and City” as the last aspect, most researches are focused on Japan, the United States and European countries such as Germany, France and UK<sup>19)20)</sup>. It is greatly contributed to derive effective findings to introduce foreign practices into Japan. Sakai (2009)<sup>20)</sup> made a cross-sectional comparison study on LRTS among UK, the US, Germany, France and Japan. The main objective of the study was to identify the points to be considered from the experience of analyzed country when Japan’s city introduces LRTS. It analyzed the urban transportation policy, implementation mechanism for measures taken, and positive impacts on LRTS introduction. In this way, past researches on LRTS are mainly focused on Japan, Europe and the US. There is very few cases for Asian countries other than Japan in a systematic manner.

The objective of this study is to organize past, present and future Asian LRTS in a systematic manner and to examine the characteristics and causal factors on the introduction of LRTS in Asian. Through the literature review and statistical analysis, this paper discusses on 1) Present trend of LRTS and characteristics of LRTS existing cities, 2) Future movements on LRTS projects in Asia and case study of Taiwanese example, 3) Historical LRTS experiences in Asia, and 4) Influential factors for LRTS introduction in Asia as a conclusion. The information on existing and future LRTS is collected mainly from Jane’s Urban Transport<sup>21)</sup>, Light Rail Transit Association<sup>22)</sup> and magazines specialized in railway. Hattori (2011)<sup>37)</sup> summarizes the world tramway/LRT database. It is based on Jane’s Urban Transport, and includes tramway, LRT, streetcar, rubber-tired tram as well as light metro system. This paper studies the world and Asian LRTS based on its definition.

It is, however, limited to find historical records on LRTS in Asian countries due to the languages and data availability; thus such information is searched from a Japanese literatures and research papers searched at National Diet Library as well as a website namely “*Tram Views of Asia*”<sup>23)</sup> which contains a history of tramway in the cities of Middle East, Far East, Southeast Asia and Indian Subcontinent in the early 20 century. The statistical analysis basically refers to the data issued by international organizations (The International Monetary Fund<sup>24)</sup>, The United Nations<sup>25)</sup> and The World Bank<sup>26)</sup>).

## 2. Regional Characteristics on Socio-Economic Aspects in Asia

This paper elaborates on LRTS in the Asian region. Although several definitions for Asian Region exist, this paper employs the region defined by The United Nations<sup>25)</sup>. As for Asia, it is also classified into five sub-regions; Western Asia (WA), Central Asia (CA), Eastern Asia (EA), South-Eastern Asia (SEA) and Southern Asia (SA) as summarized in Table-1.

Table-1. Definition of Region and Sub-region by The United Nations<sup>25)</sup>

Region/Sub-region	Countries /Regions	Names of Country/Region in Asia
Africa	51	-
<b>Asia</b>	<b>51</b>	-
<i>Western Asia(WA)</i>	18	<i>Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Israel, Jordan, Kuwait, Lebanon, Occupied Palestinian Territory, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Turkey, United Arab Emirates, Yemen</i>
<i>Central Asia(CA)</i>	5	<i>Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan</i>
<i>Eastern Asia(EA)</i>	8	<i>China, China (Hong Kong), China (Macao), Dem. People's Republic of Korea, Japan, Mongolia, Republic of Korea, Taiwan</i>
<i>South-Eastern Asia(SEA)</i>	11	<i>Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, Viet Nam</i>
<i>Southern Asia(SA)</i>	9	<i>Afghanistan, Bangladesh, Bhutan, India, Iran (Islamic Republic of), Maldives, Nepal, Pakistan, Sri Lanka</i>
Europe	48	-
Latin America & Caribbean	46	-
Northern America	5	-
Oceania	23	-
Total	224	-

Table-2. Regional Comparison in Socio-Economic Aspects

Region	Economic Growth		Demography		Motorization	Environment
	GDP Growth Rate	GDP per capita	Population	Pop Density	Car Ownership	CO <sub>2</sub> Emission
	(% p.a.) 2010 IMF <sup>24)</sup>	(US\$) 2010 IMF <sup>24)</sup>	(1,000) 2010 UN <sup>25)</sup>	(per/km <sup>2</sup> ) 2012 WB <sup>26)</sup>	(per 1,000 person) 2011 WB <sup>26)</sup>	from Transport 2011 WB <sup>26)</sup>
Africa	5.28	4,247	1,022,234	94	39%	41.5%
<b>Asia</b>	6.48	15,866	4,164,252	908	44%	21.7%
<i>Western Asia</i>	<i>n/a</i>	<i>21,734</i>	<i>231,995</i>	<i>226.6</i>	<i>67%</i>	<i>n/a</i>
<i>Central Asia</i>	<i>n/a</i>	<i>5,159</i>	<i>60,726</i>	<i>34.6</i>	<i>41%</i>	<i>n/a</i>
<i>Eastern Asia</i>	<i>n/a</i>	<i>26,192</i>	<i>1,573,970</i>	<i>3,995.6</i>	<i>54%</i>	<i>n/a</i>
<i>South-Eastern Asia</i>	<i>n/a</i>	<i>15,254</i>	<i>593,415</i>	<i>809.5</i>	<i>44%</i>	<i>n/a</i>
<i>Southern Asia</i>	<i>n/a</i>	<i>4,592</i>	<i>1,704,146</i>	<i>399.1</i>	<i>32%</i>	<i>n/a</i>
Europe	1.75	25,761	738,199	585	73%	27.3%
Latin America & Caribbean	2.86	11,459	590,082	155	79%	39.3%
Northern America	2.94	44,204	344,529	445	82%	31.2%
Oceania	2.80	10,647	36,593	114	71%	33.1%

Note: Numbers are calculated and summarized by the author.

As a basic information, Table-2 summarizes the key socio-economic indicators for each region and sub-region. Approximately 60% of world population concentrates in Asian region and it is still growing along with economic growth of more than 6% p.a. Huge amount of person in Asia would move from suburban area into urbanized area as the economy grows, though level of urbanization currently stays lower position. According to World Motor Vehicle Statistics<sup>27)28)</sup>, passenger car ownership in Asia is growing at a rate of 5% p.a. between 2005 and 2012, though world average is estimated at 2.6% p.a. growth. It grows at a rate for above population growth (1.2% p.a. between 2005 and 2010) in SEA.

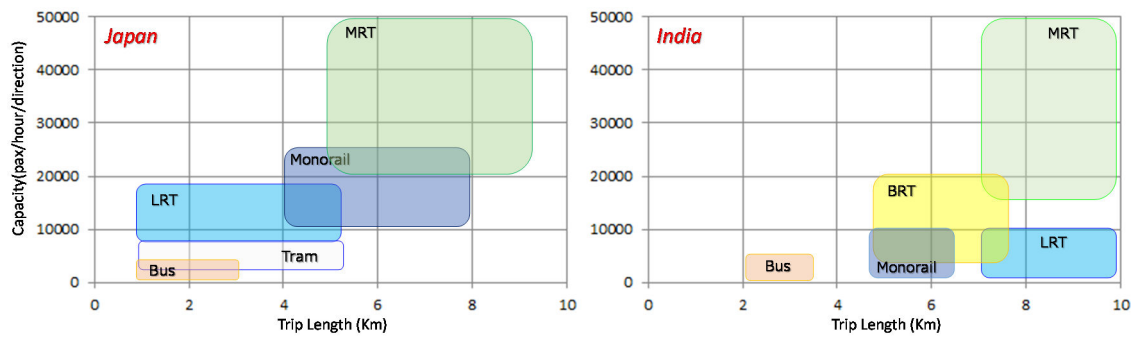
### 3. Features of LRT System

There are several discussions on the definition of LRTS in the world. Depending on the country, it is sometimes called as “LRT”, “Streetcar”, “Tramways”, “Tram”, “Light Rail” and “Light Rapid Transit”. As far as researching, there is no concrete definition for LRTS. International Association of Public Transport (UITP)<sup>29)</sup> defines Light Rail Transit System as “*Light Rail Transit (LRT) is an electric rail-borne form of transport which can be developed in stages from a tramway to a rapid transit system operated partially on its own right-of-way.*” It is clear that even international society does not clearly define LRTS.

Ministry of Land, Infrastructure, Transport and Tourism, Japan also defines LRTS as “*LRT is a highly advanced and sophisticated tramway system. It employs a low-floor vehicle with universal design and sophisticated exterior, and it runs at-grade, underground and elevated sections. It also enables to be inter-operability between LRT and urban railway. LRT, therefore, can well-utilize existing urban space and provide high quality public transport service*”<sup>30)</sup>. Japan focuses on low-floor and universal design, not on right-of-way. Summarizing the definition of LRTS by several organizations<sup>31)-34)</sup>, the followings are commonly pointed out; “Running partially or fully segregated right-of-way”, “Running underground, at-grade or elevated”, “Single or connected vehicles”, “Intermediate role between conventional Bus and MRT (Metro)”.

Moreover, it examines the definition of LRTS from its feature. Figure-1 shows the definition of urban public transport system in Japan and India. Both are drawn by system capacity and trip length. Although this kind of information was searched through available sources (official websites) officially published by the Government or the related Ministry, only India has issued the basic selection criteria of urban transport system with transport capacity and trip length on the same basis as Japan. In Japan, each system is clearly defined and sharing a role, and LRT as a mid-size transport system is expected to play an intermediate role between Monorail and Tram/Bus, that is the system to serve as feeder or supplement service as trip length of LRT is shorter than MRT’s<sup>35)</sup>.

India has considered the Five Year Plan for Urban Transportation<sup>36)</sup> by Ministry of Urban Development, and this defines urban transportation system with system capacity and trip length. MRT plays a role of trunk mass transport system for longer trips and high demand; BRT is feeder service as mid-capacity system; Monorail seems small-scale system and smaller capacity than BRT; LRT is the same capacity as Monorail and transports a passenger with longer trip. Therefore, LRT could be adopted to the cities where do not have high demand but plays a role as trunk system. It should be noted that LRTS has a flexibility of its application range city by city, and country by country. It is also noted that each country has different types of transport system; Japan has a tram, but India has BRT system on the figure. Urban transport systems are diversified depending on the country.



Note: Figures are drawn by the author based on reference data.

Figure-1. Definition of Urban Public Transport Systems in Japan and India<sup>35)36)</sup>

#### 4. LRT in the World and Asia

##### (1) LRT in the World

The world first electrified tramway started its operation in 1881 in Germany, and it was expanded to the US and European countries as well as the rest of the world. Road development, however, had preceded after the war, and then trend of transportation means was rapidly shifted from public to private transportation; that is motorization. In this manner, the electrified tramways had gradually decreased and disappeared from the city. In 1978, the first Light Rail Transit (LRT) system was developed in Edmonton, Canada. It gradually hails around Europe and the US.

Table-3 shows the summary of LRTS in the world<sup>37)38)</sup>. It is clear that approximately 80% of LRTS is located in European region. Adding Northern America, the share of LRTS could reach nearly 90%. Asian region looks relatively lower presence at 7%. From 2000 to 2010, LRTS is mainly introduced in Europe (698.8km), followed by Northern America (244.9km) and Asia (135.9km). Although European region had 80% share in the market by 1999, its presence seems to be declined in terms of share of network length since 2000. On the other hand, Northern America and Asian region further intensify the introduction of LRTS. In Asia, Eastern Asia has the longest length about 470km and occupies 40% of Asian LRTS, followed by Central Asia (22%) and Western Asia (18%). It is obvious that Western Asia records rapid growth after 2000.

Table-3. LRT System in the World<sup>37)38)</sup>

Region	Up to 1999			From 2000 to 2010		
	Cities	Length (km)	Share (%)	Cities	Length (km)	Share (%)
Europe	241	11,473.0	80.3%	43	698.8	64.4%
North America	31	1,368.4	9.6%	11	244.9	22.6%
Latin America	3	94.5	0.7%	1	6.2	0.6%
<b>Asia</b>	<b>34</b>	<b>939.5</b>	<b>6.6%</b>	<b>10</b>	<b>135.9</b>	<b>12.5%</b>
<i>Western Asia</i>	4	90	10%	6	92.5	68%
<i>Central Asia</i>	5	244	26%	0	0.0	0%
<i>Eastern Asia</i>	22	449	48%	3	24.4	18%
<i>South-Eastern Asia</i>	2	90	10%	0	0.0	0%
<i>Southern Asia</i>	1	66	7%	1	19.0	14%
Africa	1	146.0	1.0%	0	0	0.0%
Oceania	3	267.2	1.9%	0	0	0.0%
Total	313	14,288.6	100.0%	65	1,085.8	100.0%

Note: Numbers are summarized by the author based on reference data.

Table-4 summarizes the average and maximum length of LRTS by city. In terms of average network length, it is characterized that average length after 2000 is dramatically decreased by less than half of length introduced before 1999. Latin America and Asia has clearly shorter average length than Europe and Northern America. They would establish a single line as a feeder service rather than multi lines as LRTS network.

The cities introduced before 1999 has a tendency to form more than 100km-length network such as Melbourne (245km, Open in 1885), Wien (220km, Open in 1865), and Katowice (205km, Open in 1894)<sup>37)</sup>. In 1800s, it can be said that tramway was significant transport mean for the city where no other mass transport systems exist. Karlsruhe and Stuttgart, Germany has more than 100km-network despite construction in 1990s, although they are unusual case. On the whole, the recent LRTS could be characterized as feeder model rather than network model as trunk transport system.

Table-4. Average & Maximum Length of LRTS by City<sup>37)38)</sup>

Region	Average Length per City (km)		Maximum Length per City (km)	
	-1999	2000-2010	-1999	2000-2010
Europe	47.6	16.3	220.0	59.6
Northern America	44.1	22.3	88.4	54.4
Latin America & Caribbean	31.5	6.2	47.0	6.2
<b>Asia</b>	27.6	13.6	133.8	22.0
<i>Western Asia</i>	44.9	15.4	35.2	22.0
<i>Central Asia</i>	48.8	-	133.8	-
<i>Eastern Asia</i>	18.7	8.1	52.5	9.2
<i>South-Eastern Asia</i>	45.1	-	56.0	-
<i>Southern Asia</i>	66.0	19.0	66.0	19.0
Africa	118.7	N/A	54.0	N/A
Oceania	89.1	N/A	245.0	N/A
World Total	45.6	16.5		

Note: Numbers are calculated by the author based on reference data.

## (2) LRTS in Asian Countries

Figure-2 illustrates LRTS network length in Asian countries. In Asia, 45 cities in 9 countries operate LRTS, and Japan has the longest network in Asia about 280km, followed by Turkey (206km) and Uzbekistan (134km). Top 4 countries has approximately 70% of all Asian LRTS. Regional imbalance might exist, since SA and SEA obtains small portion.

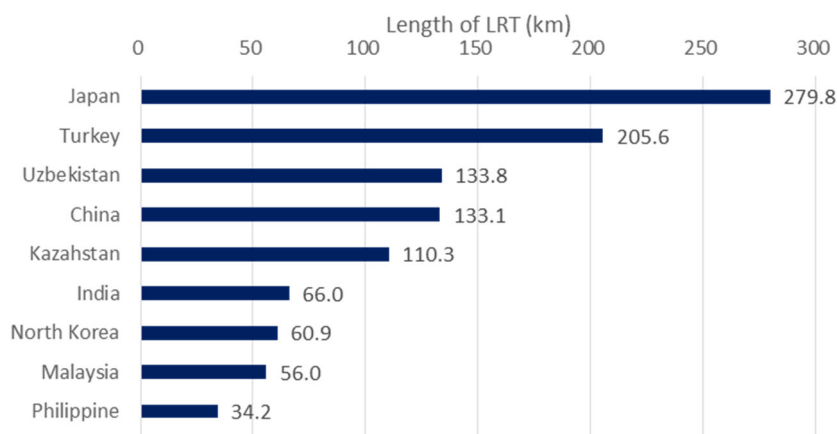


Figure-2. Existing LRTS in Asian Countries (as of 2010)<sup>37)</sup>

Table-5. LRTS Cities in the Asia (as of 2010)<sup>37)</sup>

Region	Country/Region	Cities	Length(km)	Region	Country/Region	Cities	Length(km)
EA	Japan	Sapporo	8.5	EA	China	Hong Kong	16.3
		Hakodate	10.9			Tuen Mun	36.2
		Tokyo	12.2		DPR Korea	Pyongyang	47.9
		Kamakura	10.0			Chongjin	13.0
		Toyama	14.0			SEA	Malaysia
		Takaoka	12.8	Philippine	Manila		30.8
		Fukui	21.4	SA	India	Kolkata	66.0
		Toyohashi	5.4	WA	Turkey	Ankara	8.5
		Kyoto	11.0			Antalya	5.0
		Ootsu	21.6		Istanbul	19.6	
		Osaka	18.7		Izmir	11.5	
		Okayama	4.7		Bursa	22.0	
		Hiroshima	35.1		Konya	18.5	
		Matsuyama	9.6		Eskişehir	16.2	
		Kochi	25.3		Kayseri	17.8	
	Kitakyusyu	16.0	Adana		8.0		
	Kumamoto	12.1	Samsun		17.0		
	China	Nagasaki	11.5	CA	Uzbekistan	Tashkent	133.8
		Kagoshima	13.1			Kazakhstan	Almaty
		Changchun	22.2		Ust-Kamenogorsk	16.5	
Dalian		24.3	Pavlodar		43.3		
Shanghai		9.2	Temirtau		27.5		
Tianjin		7.6	Total		45 Cities	1,075.4	

 Table-6. Population Size of LRTS Cities in Asia by Region<sup>37)38)39)</sup>

Region	Population Size (City or Metropolitan Area) <sup>(2)</sup>					Total	Total Cities
	Fewer than 500 000	500 000 to 1 million	1 to 5 million	5 to 10 million	10 million or more		
EA	20%	25%	30%	10%	15%	100%	20
WA	0%	33%	56%	0%	11%	100%	9
SEA	0%	0%	0%	50%	50%	100%	2
SA	0%	0%	0%	0%	100%	100%	1
CA	33%	0%	67%	0%	0%	100%	3
Total	14%	23%	37%	9%	17%	100%	35

 Table-7. Population Size of LRTS Cities in France and Germany<sup>37)38)39)</sup>

Country	Population Size (City or Metropolitan Area) <sup>(2)</sup>					Total	Total Cities
	Fewer than 500,000	500,000 to 1 million	1 to 5 million	5 to 10 million	More than 10 million		
France	54%	23%	15%	0%	8%	100%	13
Germany	39%	39%	17%	6%	0%	100%	18
Total	45%	32%	16%	3%	3%	100%	31

Table-6 analyses the characteristics of LRTS cities in Asia from viewpoint of city population. In Asia, 45 cities introduce LRTS, of which 35 cities are analyzed due to the data availability in the single source. It was unavailable for other 10 cities to collect the data on the same basis. As a result of analysis, 63% of LRTS in Asia has been introduced to the cities with a population of more than 1 million. On the other hand, Germany and France are selected as a competitive target in order to investigate the Asian unique characteristics. The reason why they are selected is that Germany has the world longest LRTS, and France has been rapidly introducing LRTS since 2000 (13 cities in 10 years). In total, 31 cities were selected in consideration of city-level data availability. Consequently, more than 75% of cities has introduced to the cities with less than 1

million population in both countries. Specifically, the cities in France does not exceed a population of half million. This tendency is completely different from Asian cities.

The relation between population density and LRTS network length is depicted in Figure-3. The most Asian cities do not exceed a length with a range of 50km per city, and they has a population density more than 5,000 person/km<sup>2</sup>. LRTS in Asia, therefore, has introduced to the relative high dense cities. In German cities, the variation in LRTS length exist ranging from 25km up to 250km. However, they does not exceed a population density of 5,000 person/km<sup>2</sup>, it seems that LRTS has operated in lower dense cities. It does not exceed the level of 50km in length and 5,000 person/km<sup>2</sup> in population density in French cities. LRTS could be adopted to small- to mid-sized cities as a trunk public transport system. Asian cities with less than 5,000 person/km<sup>2</sup> contain 13 cities, of which 9 cities are Japanese cities.

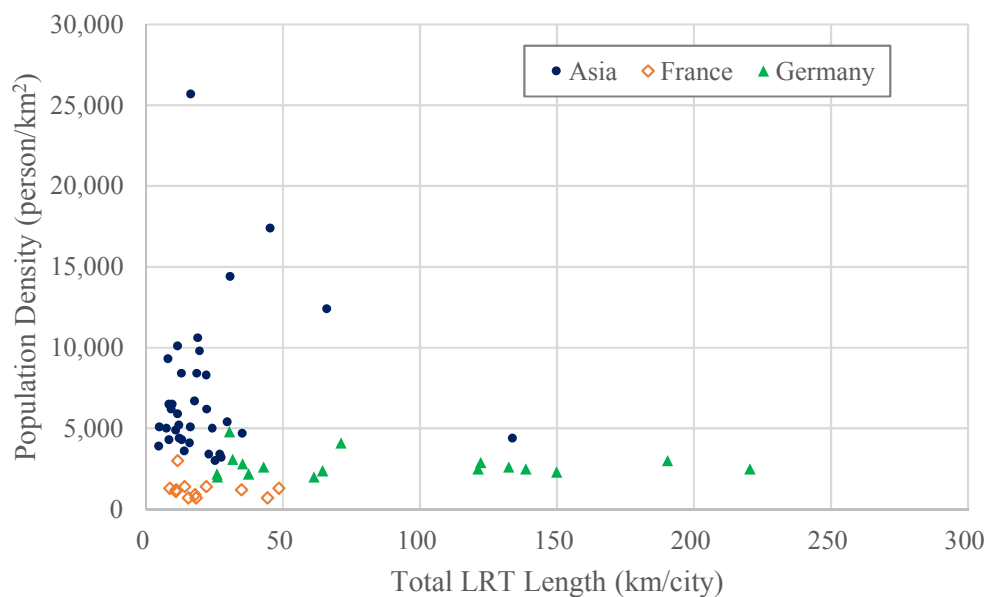


Figure-3. Population Density vs. LRTS Length<sup>39)</sup>

In addition, the existence of other mass transit systems such as Metro or Mass Rapid Transit (MRT) is surveyed for 35 cities in Asia. It excludes the inter-city railway operated by national railway, for instance Japan Railway in Japan. As a result, 17 of 35 cities have introduced Metro or MRT. They has Metro and LRTS in the same city. Moreover, all 17 cities has a population with more than 1 million. In case of Germany and France, only 10 cities has Metro and LRTS among 31 cities, and of which 7 cities are over a million population.

Table-8. Cities with LRT and Metro in Asia by Population Size<sup>21)39)</sup>

Region	Population Size (City or Metropolitan Area) <sup>(3)</sup>					Total Cities
	Fewer than 500 000	500 000 to 1 million	1 to 5 million	5 to 10 million	10 million or more	
CA			2 (100%)			2 (100%)
EA			4 (44%)	2 (22%)	3 (33%)	9 (100%)
SA					1 (100%)	1 (100%)
SEA				1 (50%)	1 (50%)	2 (100%)
WA			2 (67%)		1 (33%)	3 (100%)
Total			8 (47%)	3 (18%)	6 (35%)	17 (100%)



### (3) Recent Movement of LRT Systems in Asia

As shown in the last section, the presence of LRTS in Asia is quite low level over the world. Therefore, recent movements was searched through the literature review. Jane's Urban Transport System summarizes the LRTS information on the status of under construction, planned and proposed projects in Asia as shown in table below.

Table-9. Recent Movements in Asia from Jane's 2012-2013<sup>21)</sup>

Status	Region	Country/Region	City
Under Construction	Eastern Asia	China	Chengdu
			Shenyang
			Xiamen
		Taiwan	Kaohsiung
			Taipei
Planned	Central Asia	Kazakhstan	Astana
	Western Asia	Qatar	Doha
		United Arab Emirates	Dubai
		Israel	Tel Aviv
		United Arab Emirates	Abu Dhabi
Proposed	South-Eastern Asia	Viet Nam	Ho Chi Minh City

Table-10. Recent Movements in Asia from LRTA<sup>22)</sup>

Status	Region	Country/Region	City
Under construction	Eastern Asia	China	Suzhou
		Republic of Korea	Busan
			Seoul
			Yong-In
	Western Asia	United Arab Emirates	Dubai
Planned	Southern Asia	Israel	Tel Aviv
		Iran	Mashhad
	South-Eastern Asia	Viet Nam	Hanoi
	Eastern Asia	China	Macau
	Western Asia	Jordan	Amman
		Saudi Arabia	Jeddah
			Riyadh

Other movements can be found from another information source. Light Rail Transit Association (LRTA) publishes the database of World Systems List on their website. By using its database, additional project information in Asia were searched. It sets search keywords at [Asia] and [Light Rail], [Rubber Tired Tram], [Tram] or [Tram Train] as well as project status [Planned], [Proposed] or [Under Construction]. The search result was summarized in Table-10. Extracted 12 cities were not completely correspondent with the result from Jane's Urban Transport. Most projects are founded in Eastern and Western Asia. After converting Jane's information with LRTA information, 19 cities are nominated as the cities for further analysis. Table-11 shows the population size for 19 cities, of which 15 cities has a population with over 1 million. Furthermore, 8 cities have already introduced a Metro or MRT system.

In order to study the planned city in detail, only one city will be taken up as a case study. Among them, the countries where has a historical experience to introduce LRTS in any cities and currently operating LRTS were excluded from a candidate. And then, 5 countries and 1 region were nominated; Israel, Jordan, United Arab Emirates, Saudi Arabia, Qatar (Western Asia) and Taiwan (Eastern Asia). Among the candidates, this study chose Taiwan as a case study. The detail

project information is collected through their official website.

Table-11. Population Size of LRTS Planned, Proposed, Construction Cities by Region<sup>21)22)39)</sup>

Region	Population Size (City or Metropolitan Area)					Total
	Fewer than 500 000	500 000 to 1 million	1 to 5 million	5 to 10 million	10 million or more	
EA		1	4	3	1	9
WA		2	4	1		7
SEA			1	1		2
SA						0
CA		1				1
Total		4 (21%)	9 (47%)	5 (26%)	1 (5%)	19 (100%)

#### (4) Recent Movement of Asian LRTS: Project Analysis on Kaohsiung LRTS (Taiwan)

Kaohsiung has a population of 2.3 million (population density: 7,700 person/km<sup>2</sup>)<sup>39)</sup> and the second largest city in Taiwan. In 2010, Kaohsiung City Government announced “*The Greater Kaohsiung Transport Policy White Paper*”<sup>40)</sup>, and it declared to create “30-minutes living circle” in the metropolitan area. White paper includes the following seven action items:

- a) *Establishing a transportation system that connects the Port of Kaohsiung and downtown city;*
- b) *Taking care of disadvantaged groups by expanding the fleets of barrier-free low-floor buses and Fu-Kang buses;*
- c) *Promoting three low-carbon transportation vehicles;*
- d) *Implementing four intelligent transport corridors;*
- e) *Seamlessly integrating five public transportation systems;*
- f) *Setting up six major transit hubs; and*
- g) *Establishing seven major transportation systems for tourists*

In order to achieve the creation of high quality transport environment, the City Government has set the integration seamlessly among five public transportation systems, MRT, LRT, BRT, Shuttle Bus and DRT (Demand Responsive Transit). It seems that the integration with five systems could be a rare case and a big challenge. On the other hand, Taiwan is one of highly motorized societies, especially with motorcycle. Figure-4 illustrates vehicle registration in Taiwan from 2002 to 2011. Registered motorcycle reaches approximately 15 million, while passenger car 7 million. Motorcycle is twice as large as number of passenger car. Population of Taiwan is about 23 million in 2010<sup>25)</sup>. It means that motorcycle ownership is 652 vehicle per 1,000 person and passenger car 304 vehicle per 1,000 person.

Chen et al. (2013)<sup>43)</sup> indicates that approximately 58% of total trips in Taipei was made by motorcycle and passenger car. It causes critical traffic accidents and parking problem. In this way, Taiwan is characterized as one of highly motorized country in the world. As shown in Figure-5, Kaohsiung has the highest motorcycle ownership in Taiwan at 788 vehicles per 1,000 person. Under such circumstances, LRTS project in Kaohsiung must be huge challenge. It could cause the negative responses from road users, since LRTS must prevent traffic flows of private vehicle on the road.

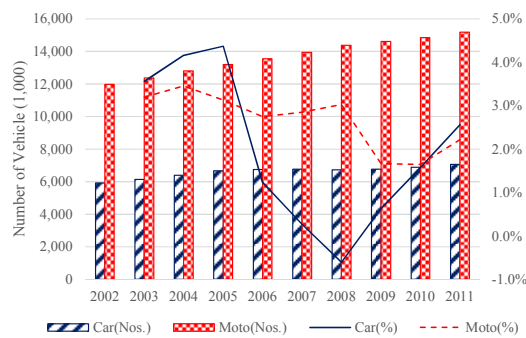


Figure-4. Vehicle Registration in Taiwan<sup>41)42)</sup>

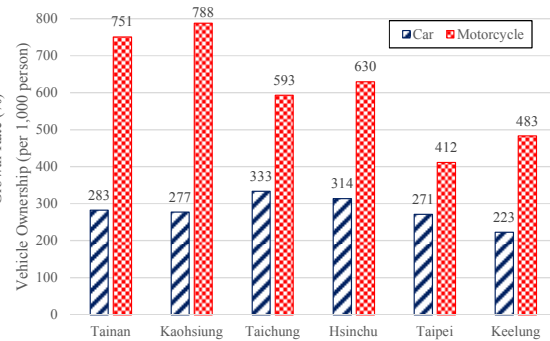


Figure-5. Vehicle Registration in Major Cities in Taiwan (2009)<sup>43)</sup>

In 2008, Kaohsiung City has started MRT operation; Orange Line (East-West) and Red Line (North-South). However, MRT did not work well by themselves. They decided to construct Light Rail Transit system to re-develop existing public transportation network. Kaohsiung City mentions the objectives of LRTS<sup>44)</sup> as follows:

- To increase the quality and coverage ratio of public transportation in Kaohsiung, while decreasing overall traffic congestion throughout.
- To integrate different modes of public transportation, thereby minimizing transfer times between modes.
- To increase land use by promoting industrial development in the urban area.
- To minimize noise and air pollution in operational areas.
- To enable the City of Kaohsiung to continue development as a thriving metropolis, as the new LRT system will become the city's moving land mark, that represent the globalization and modernization image.
- To restructure Kaohsiung's main traffic model, by implementing joint operation between loop line LRT, Red-Orange line of MRT, and the next coming MRT-type TRA.

Summarizing the objectives of LRTS project, LRTS is expected to solve traffic congestion, to promote intermodal transport, to promote land use in CBD, to minimize environmental burden, to establish city's land mark and to restructure transport networks. One of the LRTS features is symbolic value in terms of interior and exterior design. It implies that the city strongly expects such symbolic role as Kaohsiung's land mark.

Consequently, Kaohsiung City clearly defines the seamless integration among public transport modes including LRTS as well as the role of LRTS in the city. This could be one of the driving factors to move forward the project. Kaohsiung, in addition, has a million population, higher population dense, and already introduced MRT system. It is clear that these demographic data completely satisfies with the conditions of Asian LRTS. Kaohsiung LRT does not establish LRTS network itself, but serves as supplemental system to metro orange and red lines. From another viewpoint, only one city of 45 LRTS cities in Asia has MRT and BRT other than LRTS; where is Istanbul City, Turkey. Kaohsiung would be the second city in Asia.

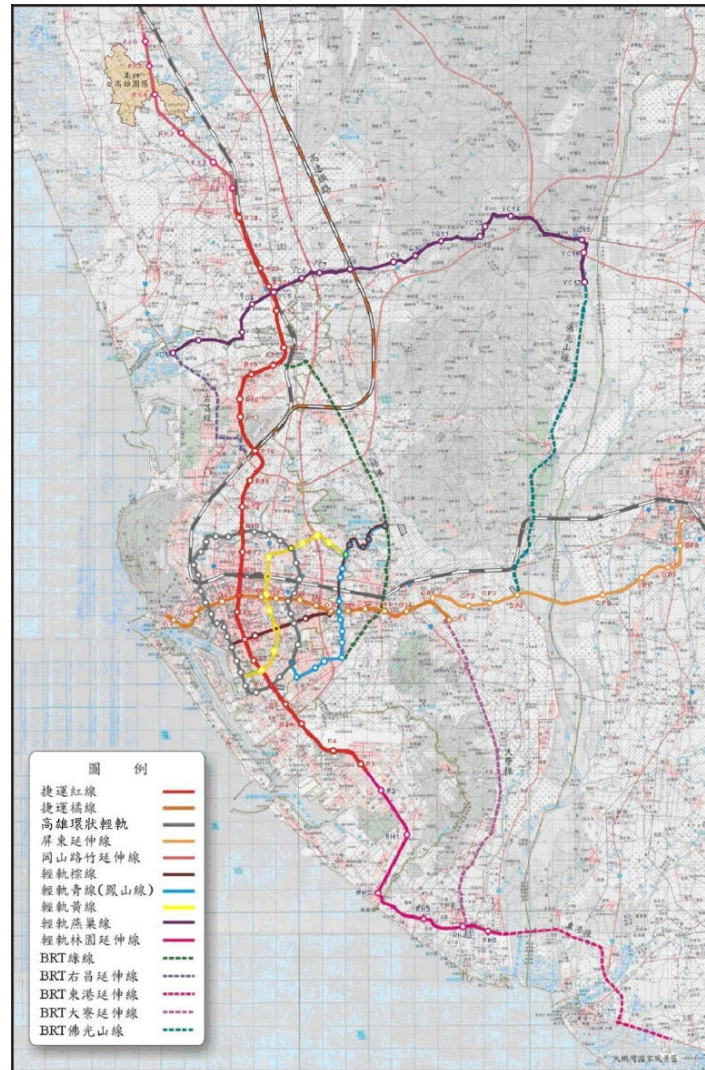


Figure-6. Kaohsiung Long Term Transport Development Plan<sup>44)</sup>

### (5) LRTS History in Asian Region

It is limited to find out the literatures written on the history of tramways in Asia, but obvious that tramway existed in several Asian countries in the late 1800s such as Bangkok (Thailand), Mandalay (Myanmar), Hanoi (Viet Nam), and Ho Chi Minh City (Viet Nam) <sup>45)</sup>. These cities had introduced tramway before the war. In this section, the historical experience in Asian countries was summarized with available sources.

#### a) Thailand<sup>46)51)</sup>

Horse tramway began operation in 1889 in Bangkok, and then electrified in 1893. It was the first electric tramway in Asia, even Japan's first electric tramways opened in 1895 in Kyoto. During golden age, it extended tramway network to 7 routes, 49km. It, however, induced road disruption and congestion since it was operated on road surface. Most routes were abolished in 1962, and all tramways were disappeared from Bangkok in 1968 due to the road traffic issue.

#### b) India<sup>47)</sup>

In 1873, horse tramway opened in Kolkata, India. Between 1900 and 1905, it had been upgraded to electrified tramways. In golden age in 1943, total network length reached approximately 68km. Although it is gradually shrinking, continuously operating now.

c) Singapore<sup>48)</sup>

Singapore established tramways in 1905 with 23km-routes. After 20 years, all networks stopped operation in 1927 due to high fare level and competition with cheap rickshaw and trolley bus.

d) Democratic People's Republic of Korea<sup>49)50)</sup>

In 1907, human-powered tramway started operation from Pyongyang Station. Only 3 km-section was electrified in 1923, and it extended their network to 13km as of 1932. During the peak period, it reached 42 million passengers a year. Due to the war, tramway was destroyed and eventually abolished. Again, it was re-opened in Pyongyang City in 1991.

e) Republic of Korea<sup>49)</sup>

In Seoul, electric tramway started construction in 1898 and begin its operation in 1899 on 26km section. Total network expanded to 40km in 1959 and annual passenger recorded at 200 million. After the war, it was impossible to operate with only fare box revenue; traffic congestion was worsening. For that reasons, tramway completely disappeared from Seoul in 1968.

f) China<sup>51)</sup>

Shanghai opened electric tramway on 6km-section in 1908. Though the network had been expanding, tramway was finally disappeared because trolley bus took over its role in 1975. In 2010, a rubber-tired tram has constructed and operated in High-tech Park in Shanghai. Hong Kong introduced tramway in 1904, but it was under the British Administration.

g) Indonesia<sup>52)</sup>

Jakarta, the capital city of Indonesia, introduced horse tramway in 1869, steam tramway in 1881 and then electrified tramway in 1899. It is discussed that electrification was achieved due to geographical issues. Indonesia is located in the tropical zone; therefore it makes a horse vulnerable and lots of horse died. It was a trigger to step up to steam and electrified tramway. After few decades, level crossing with Indonesian railway became a bottleneck and caused user's inconvenience. In 1962, all networks were abolished and converted to bus transportation.

i) Philippine<sup>53)</sup>

Electric tramway had opened in 1905 in Manila, but abolished due to the World War II. Up to 1966, there was no rail-based urban transport system in Manila. Instead, public bus and Jeepney which is converted from a vehicle of US Army took the lead of Manila's urban transport.

j) Myanmar<sup>54)</sup>

Steam tramway was introduced in Rangoon (Yangon) in 1884 by British engineer. In 1906, electrified tramway started its operation.

In this way, the region has a lot of historical experiences specifically in the countries where do not currently have LRTS such as Thailand, Myanmar, Indonesia and Singapore. It was fact that tramway had played a significant role in Asian countries as urban transport system. Tramway was sucked under a wave of urbanization and motorization, and then disturbed road traffic. History of tramway's disappearance seems to be the same as European and Japanese experiences, which is rapid LRTS decrease due to motorization. From global perspective, horse tramway created a boom in Europe and the United States in 1870s, and electrified tramway appeared in Berlin, Germany in 1881. The first horse tramway opened in Jakarta in 1869 and first electric tramway in Bangkok in 1893. This means that Asian region was not left behind Europe in terms of tramway introduction. It starts quite early stage of technology. This could be affected by colonial domination. Nomura (1995)<sup>55)</sup> mentions the reason why Bangkok could achieve the first

electric tramway in Asia. It is likely that tramways in Bangkok was developed by foreign entrepreneurs (Denmark and Belgium) by licensing the concession in operating its tramway. It is also implicated that Thailand had struggled to survive from invasion by the big power (the UK, France and the US); thus, they chose rather smaller power (Denmark and Belgium) as a safety net in order to avoid the invasion and keep the country independent. Thailand has never experienced the colonial domination; however, the power and threat of imperial country in neighboring countries seems to affect significant effects to Thailand.

Table-12. Chronological Table on Asian LRTS<sup>(23)(45)-56)</sup>

Open Year	Region	Country /Region	City	Colony <sup>(4)</sup>	Note
1881	-	Germany	Lichterfelde	-	Start operation, World First Electric Tram
1893	SEA	Thailand	Bangkok	no	Start operation, Asian First Electric Tram
1894	SA	India	Madras	yes	Start operation, Japanese First Electric Tram
1895	EA	Japan	Kyoto	no	
1898	SA	Sri Lanka	Colombo	yes	
1899	SEA	Indonesia	Jakarta	yes	
	EA	Korea	Seoul	yes	
	EA	China	Beijing	no	
1900	SA	India	Kolkata	yes	
1901	SEA	Viet Nam	Hanoi	yes	
1904	EA	China	Hong Kong	yes	
	SEA	Myanmar	Mandalay	yes	
1905	SEA	Singapore	Singapore	yes	
	SEA	Philippine	Manila	yes	
1906	SEA	Myanmar	Yangon	yes	
	SEA	Malaysia	Penang	yes	
1907	WA	Syria	Damascus	no	
1908	EA	China	Shanghai	no	
	WA	Lebanon	Beirut	no	
1913	WA	Turkey	Istanbul	no	
1923	EA	DPR Korea	Pyongyang	yes	
1923	SEA	Indonesia	Surabaya	yes	
	SEA	Viet Nam	Saigon (HCMC)	yes	
1928	WA	Turkey	Izmir	no	
1929	WA	Syria	Aleppo	no	

Note: This table was made by author based on available information. It may not cover all historical track record.

## (6) Classification of Asian LRTS and Countries

The previous sections examined the past, present and future of Asian LRTS with available information and sources. The results are summarized in Table-13. It is preferable to organize it based on city level; however, this table is established by country due to the limitation of city-level data. It is classified the Asian countries into five types as below.

*Type 1 Country (City): LRTS Existing (as of 2010)*

*Type 2 Country (City): LRTS in Construction Stage*

*Type 3 Country (City): LRTS in Planning or Proposal Stage*

*Type 4 Country (City): Rapid LRTS Growth (since 2000)*

*Type 5 Country (City): Historically Existing (Currently Absence)*

As shown in the table, countries in South-Eastern Asia have some proposals and plans, but there is no practical achievements after Manila and Kuala Lumpur LRTSs.

Table-13. Summary Table on Asian LRT System<sup>21)-23)37)38)45)-55)57)-61)</sup>

Region	Country/Region	LRT/Tram					
		In Operation (Cities)	LRT Length (km)	Under Const. (Cities)	Planned (Cities)	Rapid Growth	Historical Experience
		Type 1	--	Type 2	Type 3	Type 4	Type 5
<i>Eastern Asia</i>	China	5	133.1	4		x	
	China (Hong Kong)	1					
	China (Macao)				1		
	Taiwan			2			
	Dem. People's Republic of Korea	2	60.9				
	Japan	19	279.8				
	Mongolia				1		
	Republic of Korea			3			x
<i>Central Asia</i>	Total (Eastern Asia)	27	473.8	9	2	1	1
	Kazakhstan	4	110.3	1			
	Kyrgyzstan						
	Tajikistan						
	Turkmenistan						
	Uzbekistan	1	133.8				
<i>Southern Asia</i>	Total (Central Asia)	5	244.1	1	0	0	0
	Afghanistan						
	Bangladesh						
	Bhutan						
	India	1	66		1		
	Iran (Islamic Republic of)			1			
	Maldives						
	Nepal						
	Pakistan						x
	Sri Lanka						x
<i>South-Eastern Asia</i>	Total (Southern Asia)	1	66	1	1	0	2
	Brunei Darussalam						
	Cambodia				1		
	Indonesia				1		x
	Lao People's Democratic Republic				1		
	Malaysia	1	56				
	Myanmar				1		x
	Philippines	1	34.2				
	Singapore						x
	Thailand						x
	Timor-Leste						
	Viet Nam			1			x
	Total (South-Eastern Asia)	2	90.2	1	4	0	5
<i>Western Asia</i>	Armenia						
	Azerbaijan						
	Bahrain						
	Cyprus						
	Georgia						
	Iraq						x
	Israel			1	1		
	Jordan				1		
	Kuwait						
	Lebanon						x
	Occupied Palestinian Territory						
	Oman						
	Qatar			1			
	Saudi Arabia				2		
	Syrian Arab Republic						x
	Turkey	10	205.6			x	
	United Arab Emirates			1	1		
	Yemen						
	Total (Western Asia)	10	205.6	3	5	1	3
<b>Grand Total</b>		<b>45 cities</b>	<b>1079.7km</b>	<b>15 cities</b>	<b>12 cities</b>	<b>2 countries</b>	<b>11 countries</b>

Note: The countries where LRTS project is planned or proposed are additionally extracted from the reports of Japan International Cooperation Agency and Ministry of Economic, Trade and Industry.

## 5. Conclusion

The aims of this study are to systematically organize the Asian LRTS and to find the regional characteristics on LRTS in Asia. Since LRTS is not clearly defined internationally, each country has different definition of LRTS; therefore, it is fact that there is no uniform and common LRTS records over the world.

In Asia, a tramway has been introduced since 1800s; that timing is not left behind Europe and the United States just 10 years behind since the world first electric tramway begin commercial service in Berlin in 1881. It indicates a fact and proof which Asian countries incorporated advanced technology “Tramway” into the city at an early age. It is likely that this movement was affected by colonial domination from late 1800s to early 1900s. The imperial countries might exported or transfer its technologies to their colonies. That is why many Asian countries (i.e. Indonesia, Myanmar and Viet Nam) had operated tramways in early age. Thailand was not dominated by any countries, but it had been affected by the pressure of colonial power. It can be said that it was a trigger to encourage Thailand to introduce new technology from minor powers. LRTS has innovated on Tramway system since 1978; however, such re-innovated technology has not been widely used in Asia as compare with Europe and the United States. After the colonial domination, LRTS cities in Asia also experienced or is still experiencing rapid motorization in urban area, and it causes heavy traffic congestion. This could be one of the factors why LRTS becomes widespread over Asia. This point must be studied further.

On the other hand, it is identified that most cities in Asia where currently owns and operates LRTS have a population of over 1 million. Only 20% of cities exceeds 1 million person for French and German cities. From different viewpoint, it is observed that high population density with more than 5,000 person/km<sup>2</sup> and existence of Metro or MRT system could be basic conditions on the introduction of LRTS in Asia. A case study for Kaohsiung LRT project also falls under the category of city population (2.5 million), population density (7,700 person/km<sup>2</sup>) and Metro system (MRT Orange & Red Line). This tendency, therefore, can be assumed that LRTS in Asia is mostly positioned as feeder or supplementary system to mass rapid transit system rather than trunk public transport system by LRTS. In fact, Kaohsiung LRT forming a circle line will play effective role within central part of the city as feeder system to metro system.

Asian countries and cities are growing and experience further urbanization in near future. In 2010, over a million population cities reach 21 cities in Asia; while, 37 cities in 2025. The region has huge potential to adopt LRTS to the city under the identified basic conditions on LRTS development. Since a track record on LRTS seems few in South-Eastern Asia though several plans and proposals exist, the background and reasons why LRTS do not become reality will be studied in this region.



**Notes:**

- (1) “Level of Urbanization” is defined by share of Urban Population against Total Population.
- (2) Population size are extracted from “Reference 39) Demographia”. If LRTS cities are listed in this document, they are selected as a city to be analyzed. LRTS cities in France are the cities developed after 2000.
- (3) LRTS cities where population data exists are further studied with Jane’s Urban Transport. If Metro exists in a city, it is extracted as a city to be analyzed. However, it does not include a city where Metro is under construction or planned.
- (4) “Colony” means that the country was a colonial domination by the imperial country at the time of start LRTS operation.

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