Development of Bus Rapid Transit (BRT) in Khon Kaen, Thailand

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Abstract: BRT is very successful in many cities, but not yet in small- and medium-size cities in developing countries. This paper is to share the practical experience of BRT planning in Khon Kaen, Thailand. The planning is (1) to study on a feasibility in developing a Bus Rapid Transit (BRT) Prototype in a regional city of Thailand, so as to alleviate transport related issues; (2) to collect necessary information and data required for undertaking the detailed design and construction of the Bus Rapid Transit (BRT) Prototype System in Khon Kaen; and (3) to assess benefits of the BRT system. The study also demonstrated the network and feeder effects, which could encourage significantly BRT demand. The propose of this paper is to share the practical experience of BRT planning, and lessons learnt which should be useful for other cities.

Keywords: Bus Rapid Transit (BRT), Khon Kaen

1. INTRODUCTION

Attractive public transport systems should be developed to be able to compete with private vehicles. However, high quality mass transit systems are extremely expensive for developing countries. In developing countries, particularly in small and medium-sized cities, public transport typically consists of low quality bus services and special forms of para-transit. They are unreliable, inconvenient and unsafe. This state of public transport services does not serve the need of travellers. Because of poor public transport, car users and motorcyclists are highly captive to their respective modes (Emberger, 2009). Developing cities in South East Asia have extremely high motorcycle dependence. This generates a series of direct and indirect effects, particularly noise pollution and accident. There is frequently a high proportion of motorcycle; i.e. in Hanoi and Ho Chi Minh City (in Vietnam) motorcycle share 81% and 90%, respectively, of all motorized trips (Schipper et al., 2005; JICA et al., 2004), and in Khon Kaen (in Thailand) motorcycle share 49% of all travel trips (SIRDC, 2008). Thus, it is very challenging to encourage modal shift from motorcycle to alternative modes.

Bus raid transit (BRT) can provide high quality, metro-like transit service, with affordable cost (Wright, 2005). BRT can be an extremely cost-effective way of providing high-quality, high-performance transit (Levinson et al., 2003). Some empirical data is also supportive of the case that BRT has generally similar performance to light rail in the perceptions of passengers (Currie, 2005).

BRT is very successful in the Latin American cities, e.g. Curitiba (Brazil) and Bogotá (Columbia). In South East Asia, Jakarta (Indonesia) has also been developing BRT. Many other developing countries, including many cities in Thailand, Hanoi (Vietnam) and Manila (Philippines) are highly interested in introducing BRT (CAI, 2006). This is mainly because of the affordable investment and operating costs.

In Thailand, apart from Bangkok where BRT has been operating since 2010, a few cities are interested and in the process of BRT planning; including Khon Kaen, Chiang Mai, Phuket and Korat. They all already have feasibility studies, but Khon Kaen has been in the process of detail design.

Since 2007, Khon Kaen Municipality and Khon Kaen Provincial Administrative Organization with closely supporting from Khon Kaen University have been working on BRT planning for the city (SIRDC, 2008). The planning is (1) to study on a feasibility in developing a Bus Rapid Transit (BRT) Prototype in a regional city of Thailand, so as to alleviate transport related issues, e.g. road accidents, traffic congestion, global warming and climate change, environmental issues, as well as to promote sustainable liveable city, in sustainable manner; (2) to collect necessary information and data required for undertaking the detailed design and construction of the Bus Rapid Transit (BRT) Prototype System in Khon Kaen Metropolitan Area; and (3) to assess benefits of the BRT system.

Therefore, the propose of this paper is to share the practical experience of BRT planning in Khon Kaen. The paper includes selection of system and network (Section 2), selection of bus technology (Section 3), transportation and traffic engineering surveys (Section 4), forecasting of the BRT demand (Section 5), lessons learnt (Section 6), and conclusions (Section 7).

2. SELECTION OF SYSTEM AND NETWORK

In the beginning, the study considered which public transport was suitable for the city. This study surveyed attitudes of both transport planners and decision makers, and travellers. (Jaensirisak and Klungboonkrong, 2009). For transport planners' and decision maker's survey, it was to investigate how transport planners and decision makers evaluate BRT, compared to rail-based systems. The study found that transport planners and decision makers prefer BRT to tram. Not only because BRT was a cheaper system, but all other aspects of BRT can compete with on-street rail-based system.

For the travellers' survey, it was to investigate how travellers examine BRT, compared to their current travel modes. The study found that all traveller groups perceived that BRT is slightly less convenient than car and motorcycle, but much more convenient than the current public transport. For other images: attractiveness, safety and the environment, BRT is at the same level with car, and much higher than motorcycle and the current public transport.

In summary, from the attitude survey all aspects of BRT can compete with on-street rail-based system. These finding confirms that BRT systems can be effective in attracting passengers much more than the current public transport.

The other aspect in selecting the system is system capacity and investment cost (Figure 1). As a medium-size of the city (with 250,000 population), public transport demand is less than 10,000 persons per hour per direction. As well as, Khon Kaen Municipality and Khon Kaen Provincial Administrative Organization has limited budget for the improvement of public transport. Thus, BRT is the most suitable system for Khon Kaen, and is likely for most small- and medium-sized cities.

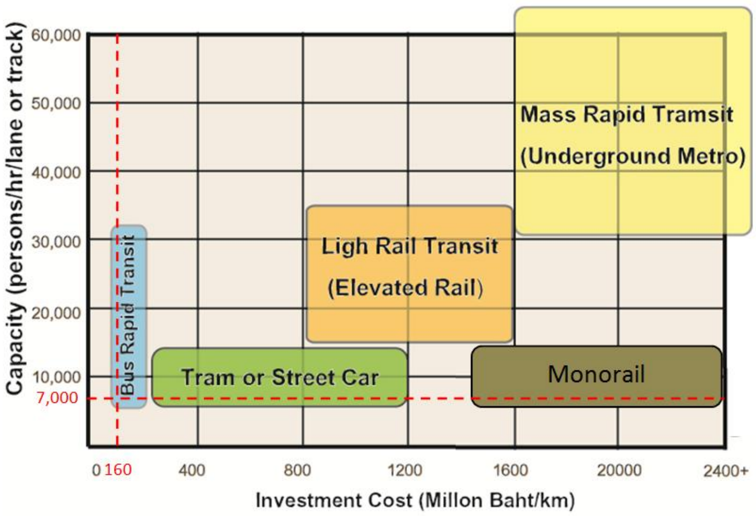
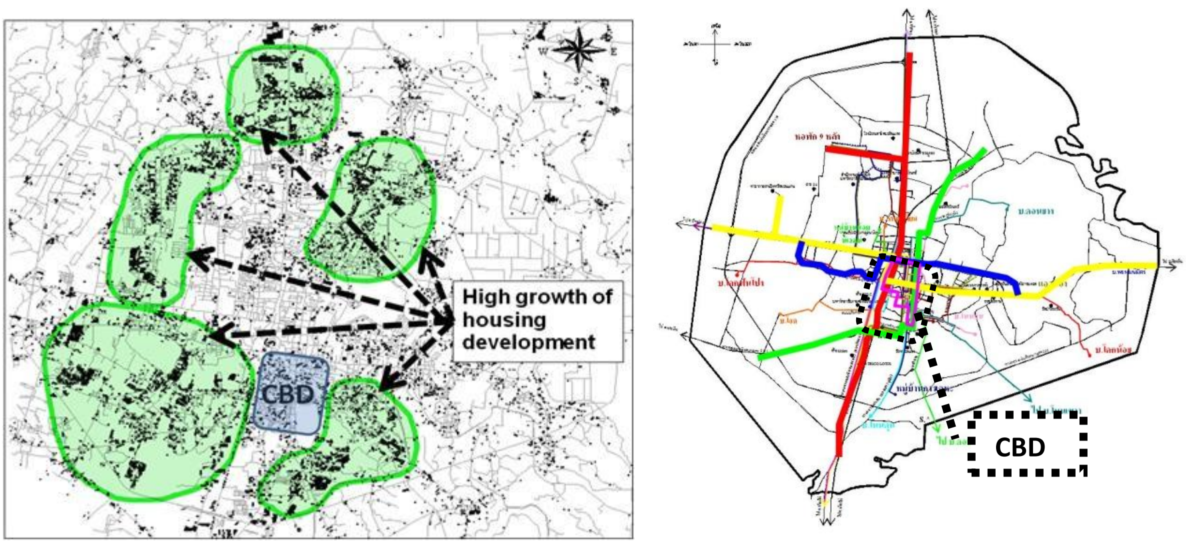


Figure 1. System capacity and investment cost of public transport systems (SIRDC, 2008)

BRT network design was based on land use development and travel demand between origin and destination (OD). Since in the Central Business District (CBD) has been fully developed. Growth of new housing development has been increasing on the fringe of the city, as shown in Figure 2(a), where public transport service is limited. Thus, the BRT route was designed to provide the residential areas with a good access to CBD by public transport. At the same time, these areas could be developed following the concept of Transit Oriented Development (TOD).



(a) Housing development areas

(b) BRT network

Figure 2. Housing development areas in Khon Kaen and BRT network

The designed network includes five BRT routes (see Figure 3(b)), in total 82 kilometres with 83 stations, as shown in Table 1.

Table 1. Khon Kaen BRT routes

Line No.	Line colour	Distance (km.)	No. of stations
1	Pink (Circle line)	7	12
2	Red	33	17
3	Blue	10	14
4	Green	18	21
5	Yellow	14	19
	Total	**82**	**83**

For the existing public transport, there are two options. One is that they can operate on the fix routes as currently. The other option is that it is re-designed to support the BRT as feeder lines.

After the BRT master study, the red-line BRT route (lining North-South) was selected to design in details. The system operation, compared to BRT systems in other counties, is presented in Table 2. (The transport and traffic engineering surveys and demand forecasting are presented in Sections 4 and 5, respectively.)

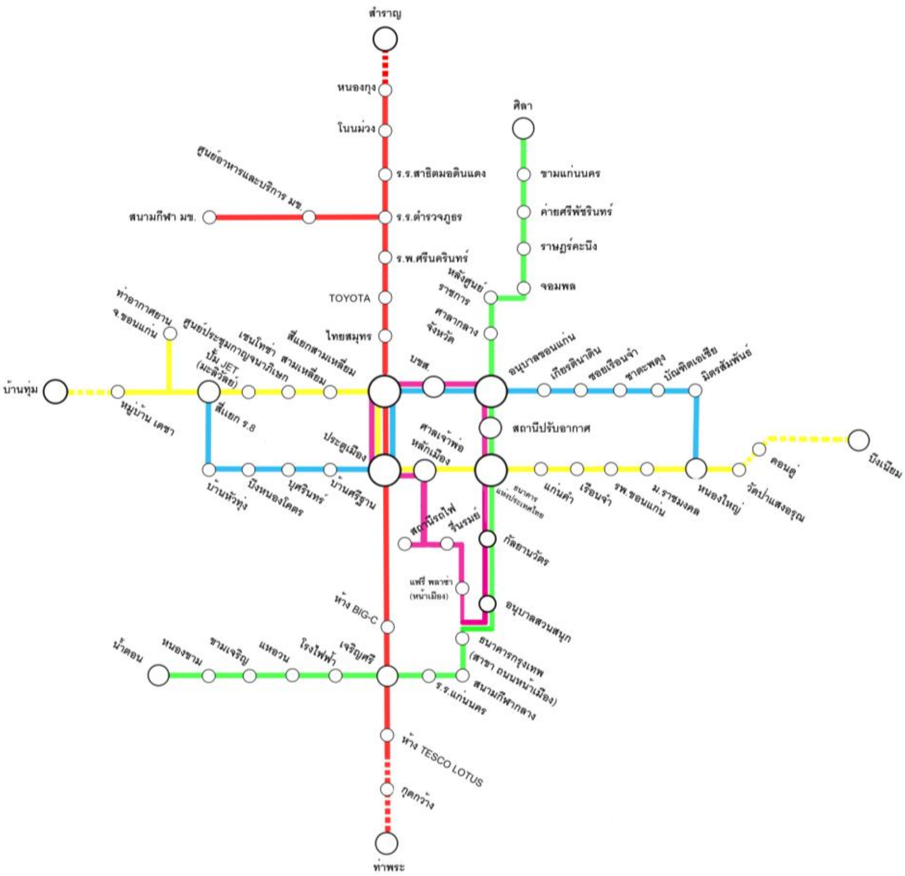


Figure 3. Khon Kaen BRT network

Table 2. Comparisons of the Khon Kaen red-line BRT route and BRT systems in other counties (Adapted from Wright (2005), SIRDC (2012))

BRT Features	Colombia	China	South Korea	Indonesia	Thailand	
	Bogota	Beijing	Seoul	Jakarta	Bangkok	Khon Kaen
Year system commenced	2000	2004	2002	2004	2010	N/A
Number of existing trunk corridors (km)	6	1	6	3	1	1
Total length of existing trunk corridors (km)	84 km	16 km (14 exclusive)	86 km	46.9 km	16 km	33 km
Location of busway lane	Centre lane	Centre lanes	Centre & curbside	Centre lanes	Centre lanes	Centre lanes
Location of doorways	Median side (left)	Median side (left)	Curbside (right)	Median side (right)	Median side (right)	Median side (right)
Number of stations	107	18	73	54	12	17
Average distance between stations (m)	500	940	750	860	1,333	1,940
Number of terminals	7	1	Not available	4	1	1
Number of depots	7	1	40	3	1	1
Number of total system passenger-trips per days	1,450,000	120,000	-	140,000	20,000	N/A
Average peak headway	3 minutes	1 minute	4-5 buses / min	1.5 minutes	5 minutes	5 minutes
Average dwell time at stations (seconds)	25	20	N/A	N/A	30	30
Number of trunk vehicles	1,013	87	N/A	N/A	25	29
Trunk vehicle type	Articulated	Articulated	Standard	Standard	Standard	Standard
Fuel type used in trunk vehicles	Diesel Euro II/III	Diesel Euro III ,CNG	CNG	I: Euro I diesel II&III: Euro III CNG	Diesel Euro III ,CNG	Diesel Euro III ,CNG
Trunk vehicle capacity	160	160	75	75	80	80
Trunk vehicle length (m)	18.5	18	10 & 12	12	12	12
Type of fare collection / verification technology	Smart card	Smart card	Smart card	Smart card	Smart card	Smart card
Fare (US$)	0.58	0.26	1.00	0.30	0.34	0.40
Total infrastructure cost (US$ million/km)	$5.3 (ph. I) $13.3 (ph. II)	US$4.68	US$1.2	US$1	US$4.31	US$1.36

Remark: N/A = not applicable

3. SELECTION OF BUS TECHNOLOGY

The appropriate bus technology for the Khon Kaen's BRT is expected to be 12 meters long vehicle with a maximum occupancy of 60-80 passengers per bus. The platform system should be Low-Floor Type. The seat arrangement should be a mixture pattern (sit and stand). The bus design should be modern and attractive, with its colour representing the red-line route and style representing local and cultural uniqueness of Khon Kaen, as an example of red-line shown in Figure 4.

Figure 4. Bus Design Concepts for Khon Kaen BRT

The appropriate engine technology is CNG/NGV while bus controlling system is Intelligent Transport System (ITS), which Bus Priority System at all signalized intersections. Transit fare should be progressive according to the distance travelled. The ticketing system should be an automatic ticketing system. There will be ticket collectors stationed on the buses. Passengers can buy tickets at the station or from the ticket collectors on board. The BRT fare structure is designed for 5 Baht (fixed) plus 1 Baht per kilometre with the maximum fare of 20 Baht (1 USD ≈ 29 Baht in 2013). This is based on the affordability of the travellers (the current public transport fare is 10 Baht flat rate) and systematic demand modelling.

There are park-and-ride stations and the facilities at both ends of each route. The control centre should be located in the centre or close proximity of the 5 BRT routes. The maintenance centre should be consisted of other facilities such as fuel station, cleaning facility, repairing and maintenance station, and be located in the same area as the control centre. Figures 5 and 6 show a park and ride station and a control center.

Figure 5. Park and ride station

Figure 6. Control center

4. TRANSPORT AND TRAFFIC ENGINEERING SURVEYS

Recently the detailed design has been working on the Red-line BRT route (lining North-South), as shown in Figures 3 and 7. All transport and traffic engineering data and information along the Khon Kaen's Red-Line BRT route were collected. Some interesting findings are presented as follows.

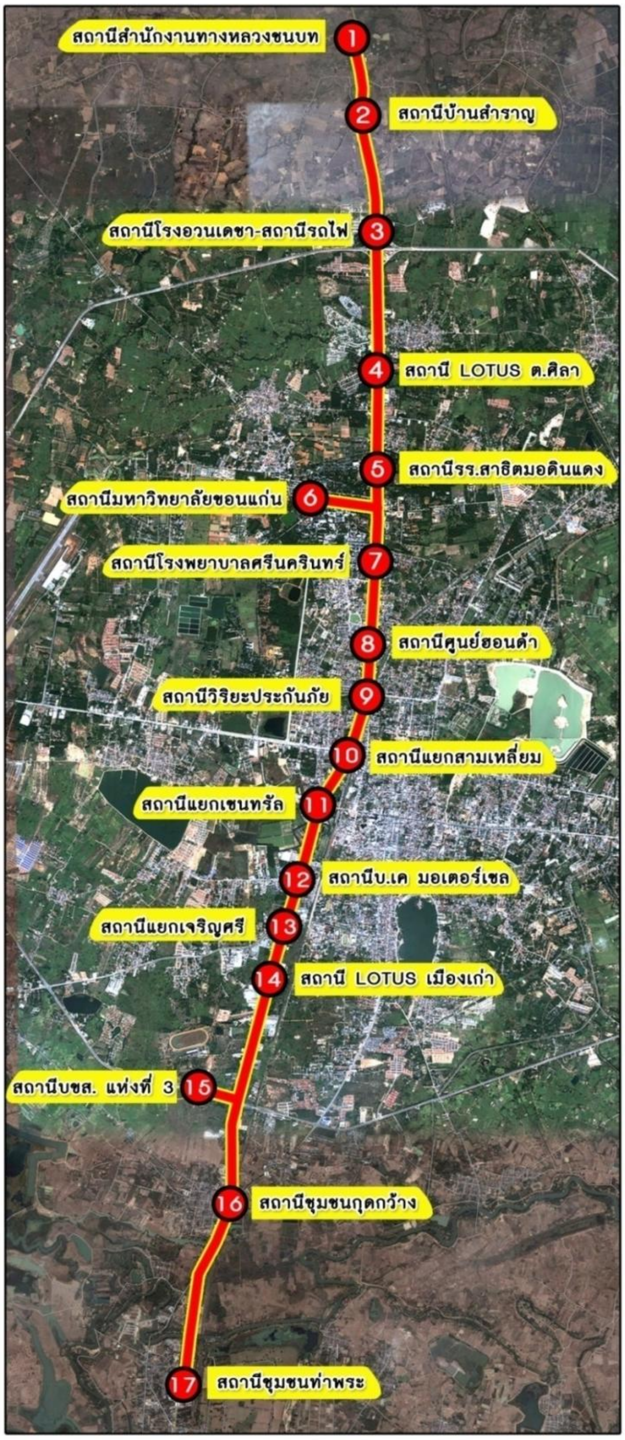


Figure 7. The Red-line BRT (33 km.) route and 17 Stations

4.1 Mid-Block Traffic Count

Mid-block traffic count survey results as illustrated in Figure 8 showed that the majority of vehicles are sedans/pickups/vans 69.3%, motorcycles 17.0%, and two-row seat buses (existing buses called "Song-Thaew") 3.0%. The rest are other types of vehicles. Therefore, it shall be concluded that most of the vehicles are sedans/pickups/vans.

Moreover, it was found that a checkpoint location had the highest block count for all three time slots (morning peak, mid-day and evening peak): 4,437, 2,224, and 3,345 vehicles per hour. The highest V/C in the morning rush hour was 0.82, while that of the evening rush hour was 0.73.

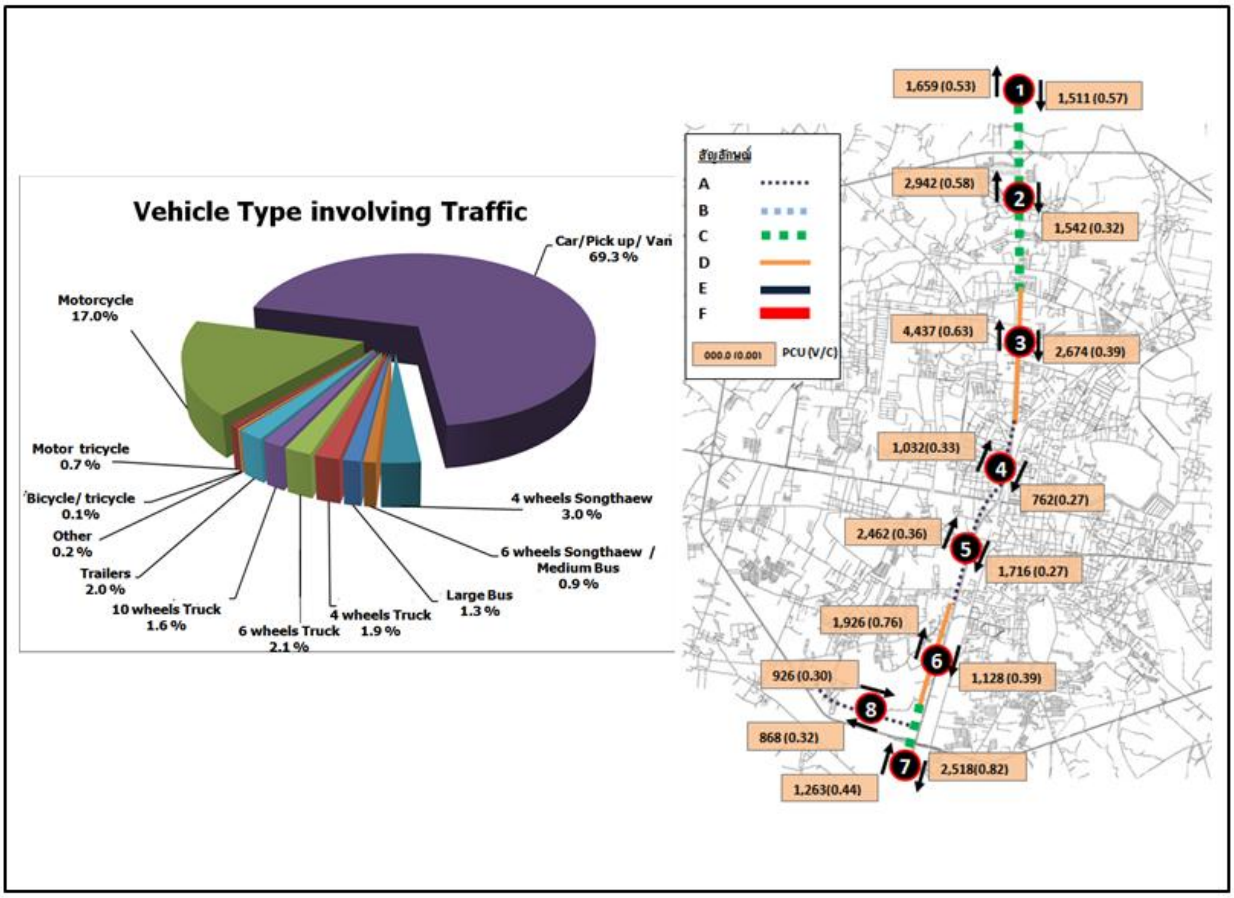


Figure 8. Mid-block traffic count survey

4.2 U - Turn Traffic Count

There are a total of 12 U-turns along the BRT prototype route, of which 4 are U-turns at intersection and 8 are U-turns at Mid-block locations. The prototype will be designed by taking these data into consideration. The U-turn with the highest U-turning rate for traffic heading north is Triangle Intersection (Sarm-Liam Intersection) with 618 vehicles per hour during evening rush hour. For traffic heading south, the highest U-turning rate is at km.6+100 with 1,085 vehicles per hour.

4.3 Intersections, Delays, and Queues

4.3.1 Intersection Turning Movement Count

Along the BRT route, the intersection with the highest turning count is the City Gate Intersection (near Station 11) with 24,310 vehicles per day, followed by the Triangle Intersection (near Station 10) and North Eastern University Intersection (near Station 12) with 19,274 and 18,769 vehicles per day, respectively. The intersection with lowest turning movement count is Ta Pra Intersection (near Station 17) with only 7,590 vehicles per day.

4.3.2 Average Delays at Intersections

The average delays at intersection can be used to identify the Level of Service (LOS) at each intersection. At each approach of an intersection, compared to the LOS standard with traffic signals, it was found that during morning peak hour period (07:30 – 8:30 hr) the LOS at intersection was C to D. This indicated that there is moderate traffic volume without congestion. The intersections with LOS of F, indicating that there were critical traffic congestion because of congestions and inappropriate traffic signals are Triangle Intersection (near Station 10) heading south and City Gate Intersection (near Station 11) heading east. These intersections have been suffered from unacceptable long delay and queue.

4.3.3 Queues

The results from queue length survey at key intersections along the route showed that, during the morning peak hour period (07.30 - 08.30 hr), the longest queue was at Triangle Intersection (39 vehicles), followed by Modindaeng Intersection (near Station 5) (29 vehicles). During the afternoon peak hour period (16:30 – 17:30 hr), the longest queue was at Triangle Intersection (49 vehicles) and City Gate Intersection (31 vehicles), respectively. In conclusion, along the BRT route, there were several traffic congested areas, especially around the Triangle Intersection which had long queues all day long. This is due to the fact that it is the main highway. Consequently, appropriate traffic signal installation, cycle times and signal phasing setting is essentially important.

4.4 Average Travelling Speed

The average travelling speed during morning peak hour period, off-peak hour period, and afternoon peak hour period showed that, on Mittraphap Road, the average travelling speed was 30-60 kilometres per hour. This means that the road section had LOS between A and C, except at intersections which the average speed decreased slightly to 30 – 39 km/hr.

4.5 Street Network Physical Characteristics & Traffic Management of the Route and Surrounding Area

The physical characteristics of road networks as well as the existing traffic management schemes along the route and its surrounding area were surveyed to determine traffic lanes, lane width, median width, pedestrian walkway width, traffic signal control, traffic management, parking control, other physical characteristics of intersections, U-turn points, and utilities for pedestrians, etc.

4.6 Existing public transport Information

The existing public (para-transit) transport is called “Song-Thaew” as illustrated in Figure 9. There are a total of 13 service routes. In the study, a survey was conducted on Song-Thaew servicing within Khon Kaen Municipality. The survey was conducted on the sample size of 230 drivers which accounts for 39% of the average bus serviced of 618 vehicles (Khon Kaen Provincial Land Transport Office, 2007). The interview results (as shown in Table 3) can be summarized as follows: the average number of hours of work is 12 hours; the average fare is 5-10 Baht; bus dispatch frequency is every 10 minutes; the average net income per day is 320 Baht; most of the fuel used is diesel, CNG, and LPG, respectively; the average highest expense on fuel is 400-500 Baht per day; and the most frequent drop-off spot is Khon Kaen Bus Station, etc.

Table 3 Basic information from “Song Thew” driver survey

Route Number	Distance (km)	Fare* (baht)	Average daily working hours (hrs.)	Number of Service Round (Trip)	Net revenues (bath/day)	Routing Costs (baht/day)	Fuel Costs (baht/day)	Maintenance Costs (baht/year)
2	20	5 / 6 / 9 / 10	13	5	300	300	400	9,600
3	23	5 / 6 / 9	12	5	400	400	400	8,400
4	21	5 / 6 / 9	12	8	400	500	500	9,600
5	15	5 / 7 / 9	13	7	400	500	400	9,600
6	27	5 / 6 / 9 / > 10	10	5	250	300	400	8,400
8	12	5 / 6 / 9	13	7	400	500	500	9,600
9	13	5 / 6 / 9	13	8	300	500	400	9,600
10	15	5 / 9 / 9	12	7	300	450	300	5,000
12	16	5 / 6 / 9 / 10	12	5	300	250	400	8,400
13	22	5 / 6 / 9 /10	12	3	200	150	300	8,400
16	12	5 / 6 / 9	12	5	300	250	300	8,400
20	18	5 / 6 / 9	12	7	400	400	400	8,400
23	15	5 / 6 / 9 / > 10	12	5	300	200	400	8,400

Remark: *Dependent on user groups

Figure 9. The existing public transport called “Song-Thaew”

5. FORECASTING OF THE BRT DEMAND

The collected data on traffic and transportation have been used to develop an urban traffic and transportation model as well as to determine the accessibility rate into the network and BRT performance. The model was developed by applying sequential the 4-step urban transport planning model. There were two phases for the study. The first one was in 2008 to develop a mass rapid transit (MRT) master plan (the results are presented in Section 5.1). The other one was in 2011 to design the red-line in detail as a pilot case (the results are presented in Section 5.2). These two cases demonstrate the network effect which could encourage significantly BRT demand (compared to a single route implemented). The significant effect of feeders is also demonstrated.

5.1 With the complete BRT network in Khon Kaen

With the complete five lines of BRT in service (as mentioned in Section 2), as suggested in the 2008 Mass Rapid Transit Master Plan in Khon Kaen, the BRT would be increasingly selected by 25.6% of travellers, of which 9.6% would be switching from motorcycles and 2% from passenger cars. This indicated that the BRT system would increase the efficiency of mass transit service in Khon Kaen. The BRT passengers would be those who currently use Song-Thaew buses. In order to eliminate the service duplication, the Song-Thaew service should be improved by using the Feeder System to bring the passengers to BRT stations. Moreover, the transfer point should also be developed to transfer passengers to the BRT system as well as to the park-and-ride stations.

Tables 4 and 5 present number of BRT passengers for the case of BRT without and with the feeder system respectively on the five routes in the year 2022 and 2032. With the feeder system, passenger demand on the BRT increases significantly. The BRT with feeder system could increase the mode share of public transport from 13% (in 2007, base year) to 28% (in 2032), as shown in Figure 10.

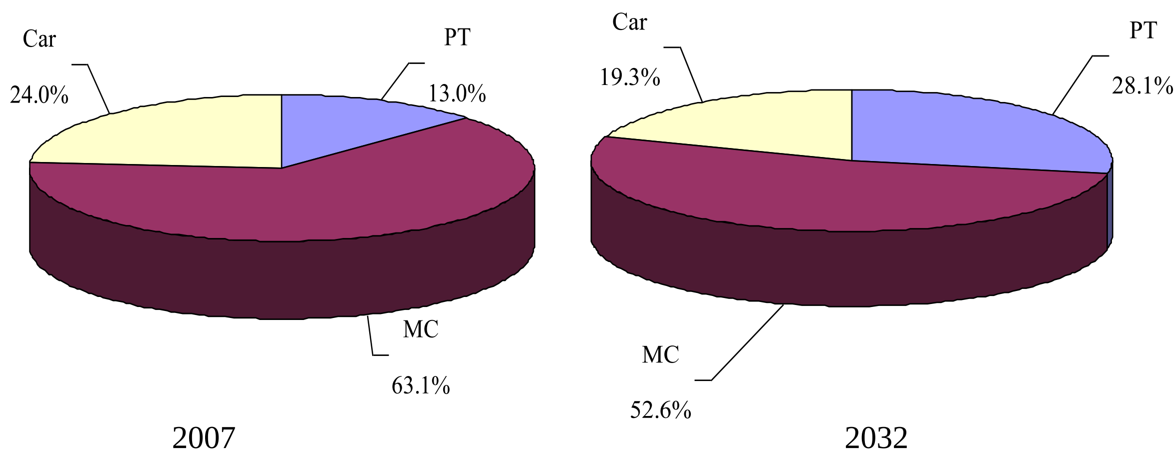


Figure 10. Modal split in the year 2007 (without BRT) and 2032 (with BRT and feeders)

Table 4. Number of BRT passengers for the case of BRT without feeders

Route	Year	
	2022	2032
Red	18,000	21,000
Yellow	23,000	27,000
Green	16,000	18,000
Blue	11,000	13,000
Pink (Circle line)	14,000	16,000
Total	**82,000**	**95,000**

Table 5. Number of BRT passengers for the case of BRT with Feeders

Route	Year	
	2022	2032
Red	46,000	53,000
Yellow	30,000	35,000
Green	24,000	28,000
Blue	16,000	19,000
Pink (Circle line)	24,000	30,000
Total	**124,000**	**140,000**

The model was used to assess traffic situation after having BRT with feeder system. The results are presented in Table 6. In 2032, total travel distance in the city would reduce 20%, total travel time would reduce 42%, V/C would reduce 20%, and average speed would increase 37%.

Table 6. Assessment traffic results of BRT with feeder system

	2007	2022		2032	
		Without Project	With Project	Without Project	With Project
1. Travel Demand (trips/day)	533,737	688,808		784,099	
2. Travel Distance (Veh-Kms)	311,038	376,493	316,328	431,082	345,051
			(-16.0%)		(-20.0%)
3. Travel Time (Veh-hrs)	10,459	18,404	12,580	25,113	14,627
			(-31.6%)		(-41.8%)
4. Average Speed (km/h)	29.7	20.5	25.1	17.2	23.6
			(22.9%)		(37.4%)
5. V/C Ratio	0.36	0.44	0.37	0.50	0.40
			(-16.0%)		(-20.0%)

The results show that the development of the Khon Kaen's BRT System has the potential to induce the change in travel patterns and modes significantly. This suggests that the BRT system is a system that potentially improves the efficiency of public transport services of the city of Khon Kaen, as well as reduces the use of private vehicles, particularly in reducing the use of motorcycles, a vehicle that is dangerous and has the highest accident rate significantly. The BRT can also reduce traffic jams, air and noise pollution, greenhouse gas emissions (that causing climate change) and consumption of fossil fuel. This is in turn increase the quality of life for the people of Khon Kaen City.

5.2 With the existence of red-line BRT alone

If there is only the red-line route, as shown in Table 7, the analysis results from the model indicated that the study area has the average traffic volume per capacity (V/C) of 0.37 with average travelling speed of approximately 26 kilometres per hour. With no projects implemented in the study area by 2017, 2022, 2027, it is predicted that the traffic volume would increase and cause traffic congestion or V/C up to 0.41, 0.43, and 0.49, respectively, while the current average travelling speed would decrease to only 21.7, 20.3, and 17.0 kilometres per hour, respectively. On the other hand, with project (the existence of red-line BRT) in 2017, 2022, 2027, traffic congestion or V/C would reduce 3.3%, 5.6%, and 7.3%, respectively. The average travelling speed in the area would increase and reduce the travelling time. The travelling speed would increase 1.5%, 2.4%, and 4.2%, respectively, while reducing the travelling time by 4.1%, 4.3%, and 8.5%, respectively.

The impact of BRT operation was tested to determine number of passengers and transport mode selection by analyzing year 2021. The results showed that, if by the year 2021 there are only Song-Thaew buses without BRT, the proportion of passengers using mass transit would be 15%, with 72,000 person-trip/day taking Song-Thaew bus. On the other hand, with the existence of the red-line BRT, the proportion of passengers using mass transit would be up to 18%.

Table 7. Assessment traffic results of BRT

	2011	**2016**		**2021**		**2031**	
		Without Project	**With Project**	**Without Project**	**With Project**	**Without Project**	**With Project**
1. Travel Demand (trips/day)	567,606	632,618		678,294		772,131	
2. Travel Distance (Veh-Kms)	320,901	351,972	342,463	368,963	356,083	422,460	402,634
			(-2.7%)		(-2.7%)		(-3.0%)
3. Travel Time (Veh-hrs)	12,450	16,189	15,526	18,218	17,167	24,859	22,734
			(-4.1%)		(-4.3%)		(-8.5%)
4. Average Speed (km/h)	25.8	21.7	22.1	20.3	20.7	17.0	17.7
			(1.5%)		(2.4%)		(4.2%)
5. V/C Ratio	0.37	0.41	0.395	0.43	0.404	0.49	0.454
			(-3.3%)		(-5.6%)		(-7.3%)

6. LESSONS LEARNT

In the planning, detailed design and implementation process, there are some barriers and key issues that could be lessons learnt by other cities. These are mainly related to physical, institutional, social, and political barriers. They can be summarised as follows.

6.1 Planning and implementation process

Physical barrier. In the CBD, right of way is limited. It is not straightforward to design two-direction BRT route passing the CBD. Planning with simulation for traffic management in detail is needed. The new traffic management would affect all groups of travellers and modes, as well as residents along the routes. This planning process has to involve all stakeholders in the beginning.

Public participation process is one of the most important issues. This is because some groups may feel that they will be worse off, e.g. existing public transport operators and current public transport users.

The existing public transport operators understand that BRT will compete with their current system and cause decreasing passengers on their buses. Thus, BRT organisation structure has to concern and involve all existing public transport and para-transit in the city. (Otherwise it will lead to a political problem.) This can be done by integrating both BRT and the current ones together, in terms of both network and organisation, as well as considering subsidy on some particular routes which overlap with BRT routes.

Those who currently use the existing public transport or para-transit may affect from the new BRT with re-routing of the current system. For example, they may have to increase the number of transfer to reach their destinations, increase total travel cost, and increase inconvenience and un-safety of access to BRT stations.

Institutional barriers. It is the main and full responsibility of the local authority for the BRT planning and implementation, even though BRT needs strong and continuous support from the central government, particularly funding and legislation.

Public acceptability and understanding. BRT is rather new in Thailand. Only one route is operated in Bangkok and not considered by the public as a successful case. Thus in Khon Kaen, one BRT route is selected to be a pilot route, in order to demonstrate to the public how the BRT works. However, the first implemented route needs to be considered and designed carefully to make sure that it will be successful (otherwise the whole BRT network plan would fail and cannot continue).

6.2 Detailed design for the case of red-line in Khon Kaen

Ticketing technology. Selection of ticketing technology has an effect on investment and operating costs, as well as on management of BRT stations, ticket sale machine, and bus control system, and BRT management and marketing strategy. This is in turn affect on the financial return of the system.

BRT station. Design of BRT stations in Khon Kaen is very much concern on: local and cultural uniqueness of the city, convenience and safety of accessibility, and integration with feeders and other modes.

BRT vehicle. Many BRT vehicles and types of energy used are offered widely, e.g. diesel, natural gas, hybrid engine and electric engine. For BRT in Khon Kaen, the vehicle selected is 12 meters long with CNG/NGV engine. This selection is not only based on vehicle cost, but also concerned on technology and fuel availability in the city, and vehicle maintenance.

Traffic control system. Traffic control system, particularly traffic signal at junctions and U-turns, is very important and not easy to design. Traffic micro-simulation model is a useful tool (that was applied in the red-line detailed design in Khon Kaen), in order to test alternative traffic control and analyse traffic impacts.

7. CONCLUSIONS

Overall, this study clearly showed that the development of BRT system in Khon Kaen City can contribute to solving multi-dimensional transport related problems, such as traffic congestions, road accidents, pollution and noise and air, global warming and climate change, as well as to alleviate the problems of social inequality, in a concrete and sustainable manner. The study also demonstrated the network and feeder effects, which could encourage significantly BRT demand.

In the planning, detailed design and implementation process, there are some barriers and key issues that could be lessons learnt by other cities. These are mainly related to physical, institutional, social, and political barriers.

Moreover, further research is needed to study in details on attitude and behaviour of each traveller group, in order to design and promote the system to fit with the need of each group. Also it should focus on how to make the shift from motorcycles. This would help to increase passengers on BRT, as well as to reduce traffic accidents because most of traffic accidents in developing countries involve motorcycles.

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