What if Metro Manila Developed a Comprehensive Rail Transit Network?

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Abstract: Metro Manila is currently lagging in the development of mass transit systems that could have alleviated traffic congestion in the metropolis. Several studies have proposed rail transit lines in the past including a heavy rail network in 1973 and a light rail transit network in 1977. The former was not realized and only parts of the latter have been implemented. Meanwhile, in 1999 a new master plan was drawn up that also made recommendations for future rail transport development. This paper presents on these rail transit lines and discusses the counterfactual scenarios for Metro Manila concerning rail-based transportation network development according to the recommendations of past projects. It attempts to answer the question of whether transportation and traffic in Metro Manila could have been better if a more extensive rail transit network was realized.

Keywords: Rail Transport, Counterfactual Scenarios, Transport Modelling

1. INTRODUCTION

1.1 Background and Context

There is an ongoing research program documenting mass transit development in Metro Manila and its adjoining areas from 1879 to the present. Among the studies being undertaken is a counterfactual assessment of transport and traffic in Metro Manila if various railway lines proposed in past studies have been built and operational now. It is generally perceived that a comprehensive rail transit system for a metropolitan area like Metro Manila could have prevented the severe road traffic congestion currently experienced by many daily. However, there has been very few if no studies that have been undertaken to prove this concept of counterfactual transport situation.

This study focuses on the rail transit lines proposed by three major studies completed in the 1973, 1977 and 1999. There are the Urban Transport Study for Manila Metropolitan Area (UTSMMA, 1973), the Metro Manila Urban Transport and Land Use Plan Study (MMETROPLAN, 1977) and the Metro Manila Urban Transportation Integration Study (MMUTIS, 1999). The paper basically attempts to answer the question of what could have been transport and traffic in Metro Manila at present if the plans in 1973, 1977 or 1999 were implemented according to their recommendations. Could it have been better, the same or worst if a more extensive rail transportation network was realized?

1.2 Objectives

This study has the following objectives:

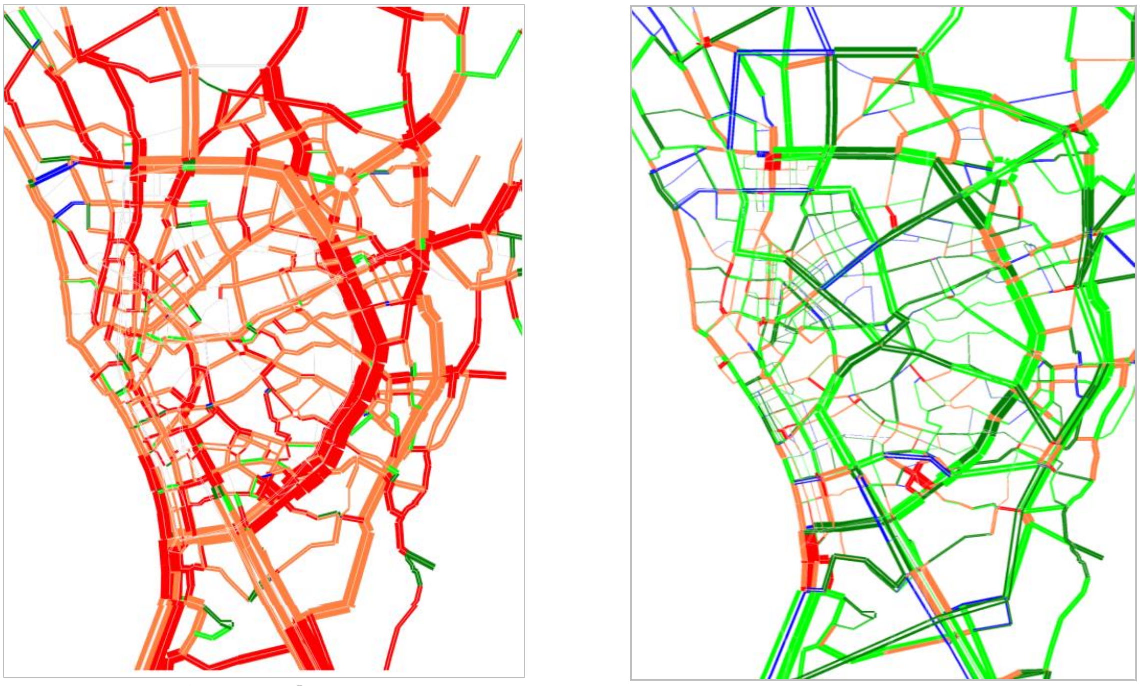
a. Present rail transit plans for metropolitan Manila from past to present;
b. Develop transport models using popular commercial software (i.e., EMME) to analyze counterfactual rail transit development impacts; and
c. Assess model outcomes in the context of current transport issues in metropolitan Manila.

1.3 Methodology

The methodology for this study basically follows the typical process for undertaking impact assessment of projects. That is, two basic scenarios are developed – "without project(s)" and "with project(s)".

Impact analysis of projects is a common method for assessing the benefits of implemented projects on transport and traffic. Regidor and Felias (2003), for example, examined the traffic impacts of infrastructure projects funded by overseas development assistance. Micro-simulation software was used as a tool to determine benefits in terms of parameters such as travel speed. Meanwhile, Tiglao, et al (2005) assessed the vehicle restraint policies in Metro Manila to determine their impacts on a larger scale (i.e., metro-wide) using the JICA STRADA transportation planning software as a tool. More recently, Fillone (2015) presented the modelling approach that is also used in this paper, which included network development, scenario development, calibration and model runs.

Recent studies for Metro Manila and its adjoining regions (JICA, 2014) conducted to support a framework for Mega Manila transport development also employed modeling tools. Figure 1 shows the model outcomes for scenarios on "do-nothing" and "do all projects" for the year 2030.



a) Do-nothing　　　b) Do all projects

Figure 1. Example evaluations for future traffic (JICA Dream Plan, 2014)

2. RAIL TRANSIT PLANS FOR METRO MANILA

2.1 Pre-War

Prior to the Second World War, metropolitan Manila had a very extensive electric streetcar network. The tranvia, as it was known, was the main public transportation in Manila and neighboring areas (Iwata, 1993). These streetcars were owned and operated by the Manila Electric Rail and Light Company (Meralco) and by 1925 operated a total of twelve lines. Another rail system was operated by the Manila Railways Company (MRC) but mostly fro long distance travel. Interestingly, there was a line with two branches that connected Manila to the east (i.e., Antipolo and Montalban in what is now the province of Rizal).

Only the Philippine National Railways (PNR), formerly the MRC, remained and was rehabilitated after the war. The tranvia never recovered as road transport and infrastructure developed rapidly and took over land transportation in the National Capital Region.

2.2 Manila Monorail

A monorail system was proposed for metropolitan Manila in 1966 and was the subject of a feasibility study (Project Technologists, Inc. 1969). Figure 3 shows the proposed monorail network superimposed on the current road network map of Metro Manila. The proposed network included five radial lines and two circumferential lines. These are shown in Figure 3 against the backdrop of the current road network of Metro Manila.

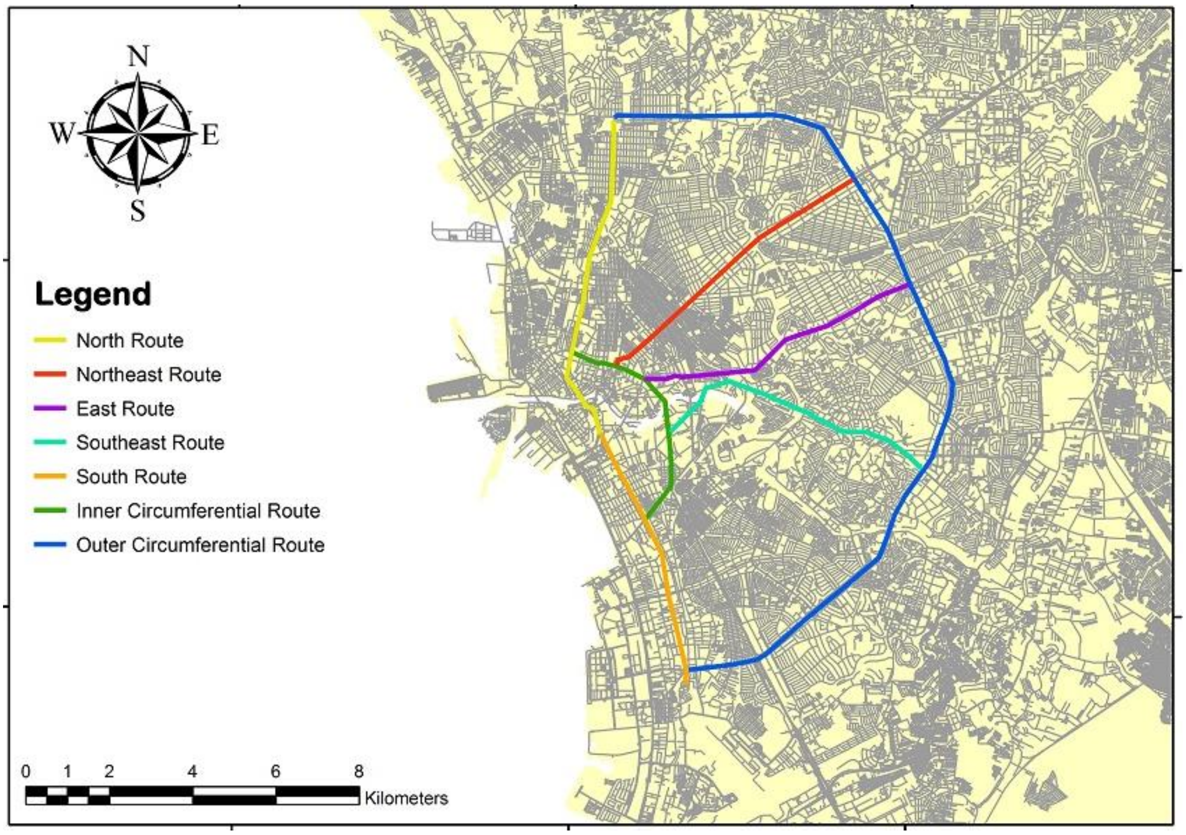


Figure 3. Proposed monorail network (1969)

Despite being granted a franchise by congress in 1966 and having established the Philippine

Monorail Transit System, Inc. for the implementation and operation of the system, none of the lines were actually built. It was only in the early 1970s when another plan was drawn up for a mass transport system in the Philippines' capital region.

2.3 Urban Transport Study for Manila Metropolitan Area

The Urban Transport Study for Manila Metropolitan Area (UTSMMA) was completed in 1973 and recommended five (5) rail rapid transit (RRT) lines for a then rapidly urbanizing metropolis. These lines were all proposed to be heavy rail systems with characteristics similar to Japanese metros including subways within the metropolitan Manila and at-grade or elevated rail sections towards the periphery of the metropolis. Such was not unexpected given that the study was conducted through the Overseas Technical Cooperation Agency (OTCA) of Japan, which was the precursor of the present Japan International Cooperation Agency (JICA). Figure 4 shows the five RRT lines superimposed on a current road network map of Metro Manila.

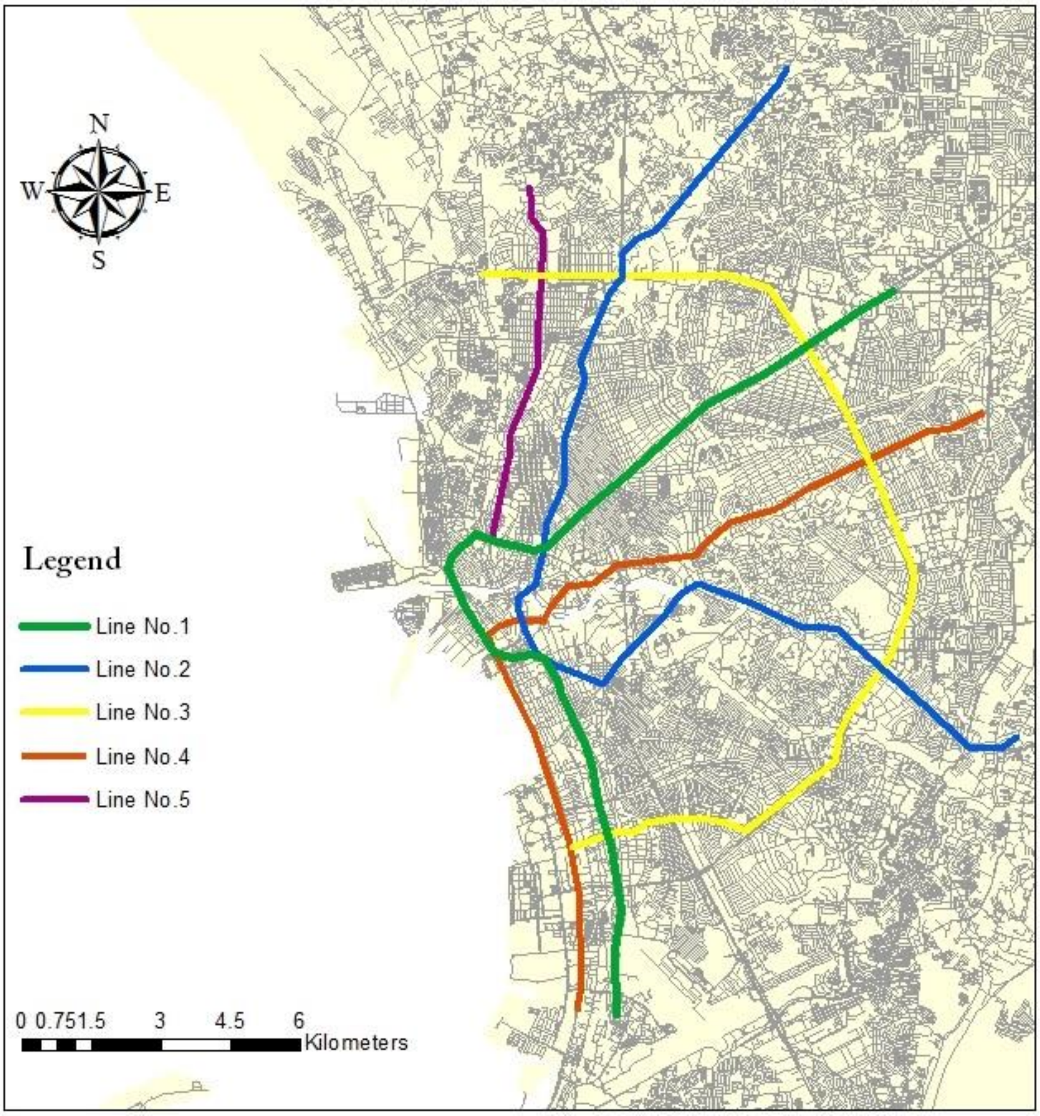


Figure 4. Rapid Rail Transit (RRT) lines proposed in UTSMMA (1973)

2.4 Metro Manila Transport and Land Use Plan Study

The Metro Manila Transport and Land Use Plan (MMETROPLAN) was a comprehensive master plan study completed in 1977 with support from the World Bank. Among other outcomes of the study, it disagreed with UTSMMA and recommended for a network of Light Rail Transit (LRT) lines. These lines are shown in Figure 5; again, superimposed on the current road network of Metro Manila.

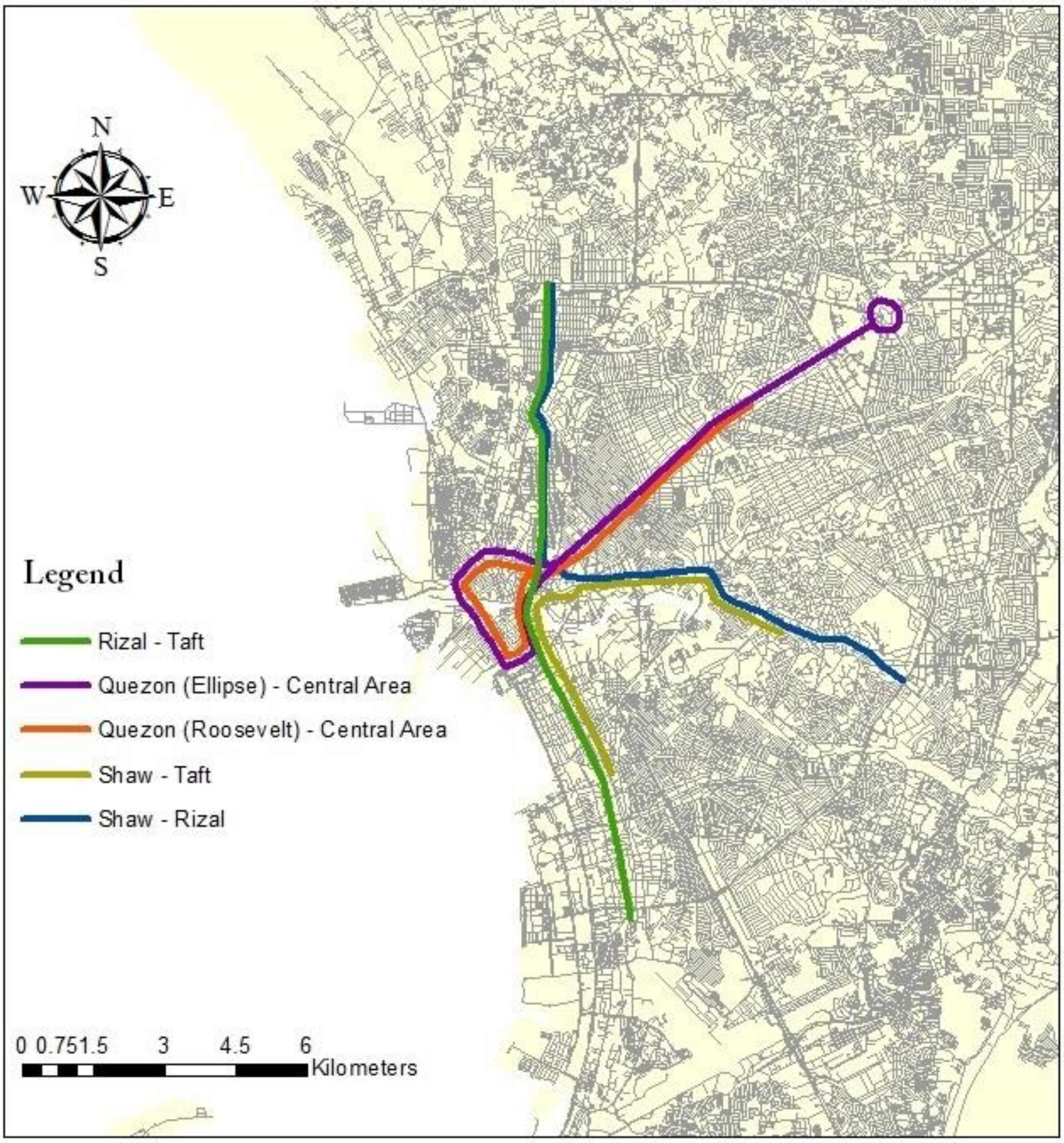


Figure 5. Light Rail Transit (LRT) lines proposed in MMETROPLAN (1977)

2.5 MMUTIS

The Metro Manila Urban Transportation Integration Study (MMUTIS) was conducted from 1996 to 1999 with support from the Japan International Cooperation Agency (JICA). The implementing agency from the Government of the Philippines was the Department of Transportation and Communications (DOTC) and the beneficiary agency was the Metropolitan Manila Development Authority (MMDA). Data for the study were derived from

Household Interview Surveys (HIS) conducted throughout Metro Manila and its adjoining provinces as well as from supplementary transport and traffic surveys that measured, among others, traffic volume, travel speeds and vehicle occupancies. The proposed rail transit lines in MMUTIS are shown in Figure 6.

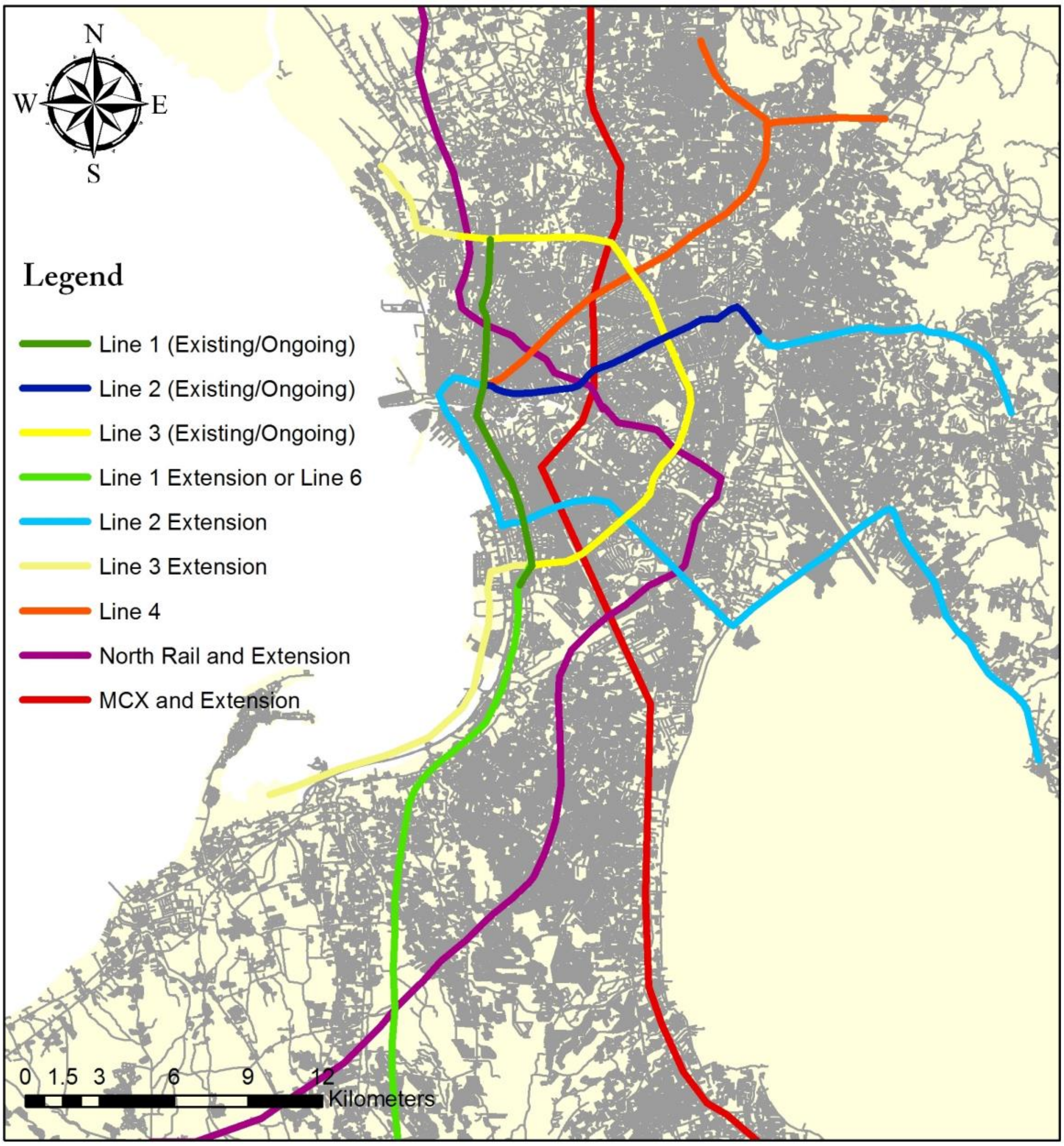


Figure 6. Rail transit lines proposed in MMUTIS (1999)

2.6 Summary

To summarize, comparing the estimated lengths of the rail systems. UTSMMA rail plan has the longest at an estimated length of 141.87 km, both directions followed by that of the present rail system at 74.53 km. It should be noted that the Philippine National Rail (PNR) system is included in the present rail system. The MMETROPLAN rail plan is last at 36.76 km. UTSMMA also has the highest number of stations at 136, followed by the present rail system with 61 stations and MMETROPLAN at 50 stations. Table 1 shows a comparison of the lengths and numbers of stations of rail systems proposed in UTSMMA, MMETROPLAN and MMUTIS with the present railways in Metro Manila.

Table 1. Comparison of rail systems length and number of stations

	Estimated Rail System Length (km)	No. of Stations
Present Rail System (LRT1, LRT2, MRT3, PNR)	74.53	61
UTSMMA Rail Plan (1973)	141.87	136
MMETROPLAN Rail Plan (1977)	36.76	50
MMUTIS (1999)	279.24	142

3. MODEL DEVELOPMENT

3.1 Network Maps

The research programs under which this project is being conducted produced digital maps that traced and detailed, among others, the state of railway transportation in Metro Manila from the late 1800s to the present. Some of these maps were shown in the preceding Figures 4, 5 and 6. These were utilized in the development of the models, particularly in the building of the link and node network for private and public (road and rail) transportation.

3.2 Assumptions

The following assumptions were made for the development of the models:

- A mode shift of 12% based on PUBFIX outcomes was assumed for the most likely mode shift from private to public transport (rail) for the UTSMMA, MMETROPLAN and MMUTIS scenarios. It was also agreed to run an optimistic/aggressive scenario of 20% shift and a pessimistic scenario of only 5% shift for UTSMMA, MMETROPLAN and MMUTIS.
- Stations were assumed to be near major intersections with station spacing of between 800 to 1,200 meters. Only UTSMMA's first line, which has a Feasibility Study has specific stations named. This can already be used for the modeling.
- For UTSMMA rail lines, the capacity and specifications of the proposed RTR Line 1 trains were assumed. These are heavy rail lines and would have higher passenger capacities than the current Line 1 and Line 3 trains in operation.
- Fares will be the same as current rates for LRT/MRT, and these are assumed to be reasonable based on the riding public's acceptance/willingness to pay. However, since the deciding factor on how people choose their public transport mode is travel time and with the rail transit fares heavily subsidized, the latter was neglected in the modeling process.
- No adjustment was made in the layout or alignment of other public transport (city bus, jeepney, and AUV) service routes.

Parameters for the assessment to be performed using the model outcomes are the following:

- Travel speed per major corridor;

- Overall/average travel speed;
- Travel times between zones or cities (e.g., commute from QC to Makati, Taguig to Manila, etc.); and
- Volume to capacity ratio (VCR).

These parameters are easily understood by possible beneficiaries of our research including DOTR and MMDA, as well as by the general public.

3.3 Calibration

The following data were used in the modeling:

a. MUCEP Origin-Destination trip matrix for 2014. The study used the MUCEP OD trip matrix obtained from the home interview survey (HIS) in 2014. The graphical presentation of the OD trip matrix is shown in Figure 7 below.

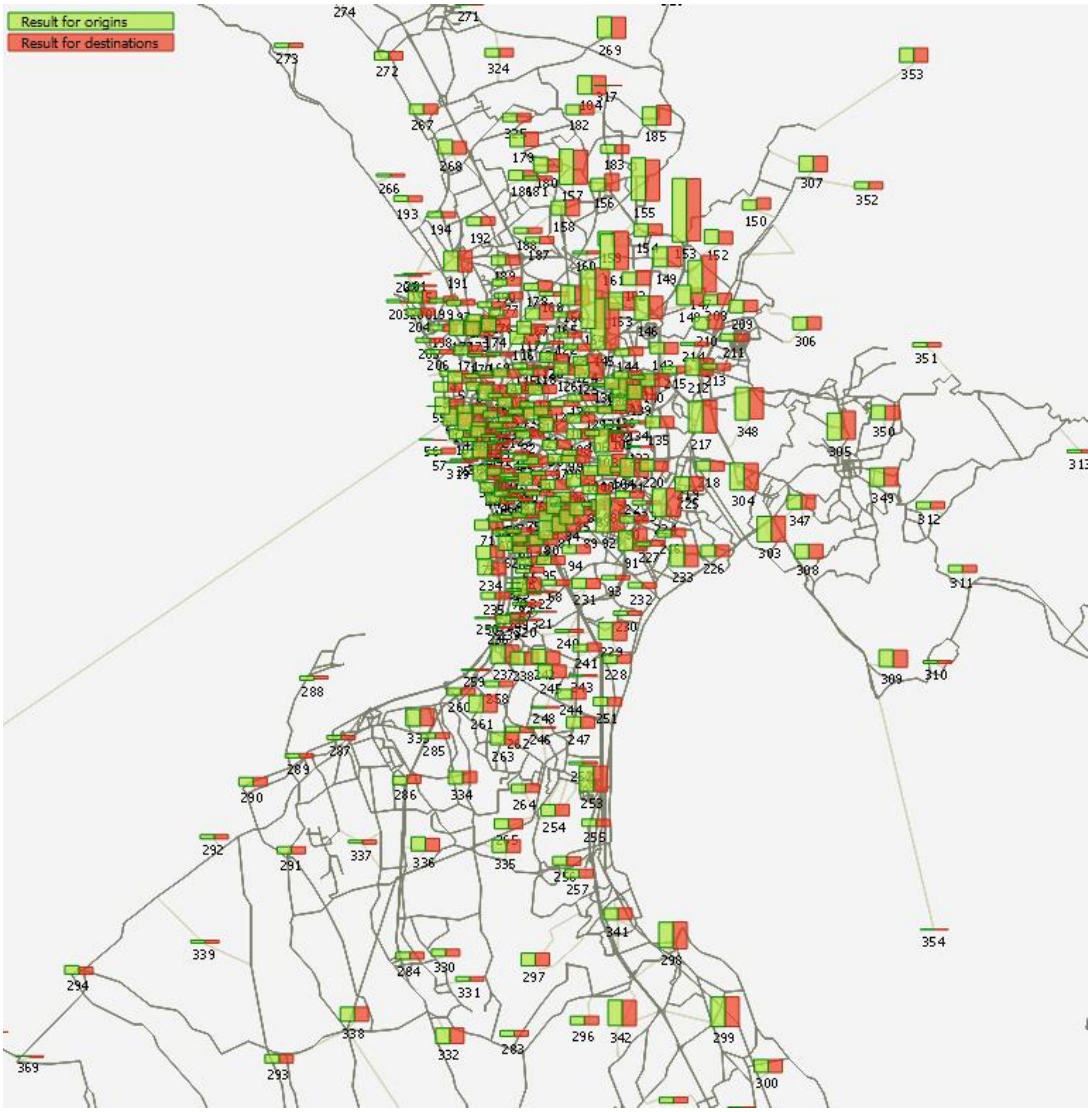


Figure 7. Origin-destination trips generated in Metro Manila (Source: MUCEP, 2014)

b. Volume delay functions (VDF). There were four delay functions used per type of road, expressways, national roads, city roads, and local roads as shown in Table 2. The plot of these delay functions, say, with demand per lane and the time consumed per kilometer of road, is shown in Figure 8.

Table 2. Delay functions used in the modeling

Volume delay functions		Equations	el1(design speed, kph)	el2(Lane capacity, veh/hr)
FD1	National Roads	(length*60/el1)*(0.5+1.5*((volau+volad)/lanes)/el2)^4	60	1,000
FD2	Expressways	(length*60/el1)*(0.5+1.75*((volau+volad)/lanes)/el2)^4	80	1,200
FD5	City Roads	(length*60/el1)*(0.5+2.715*((volau+volad)/lanes)/el2)^4	50	900
FD6	Local Roads	(length*60/el1)*(1+0.85*((volau+volad)/lanes)/el2)^4	30	750

Note: volau is the volume of private vehicles using the road while volad is the volume of public modes using the road.

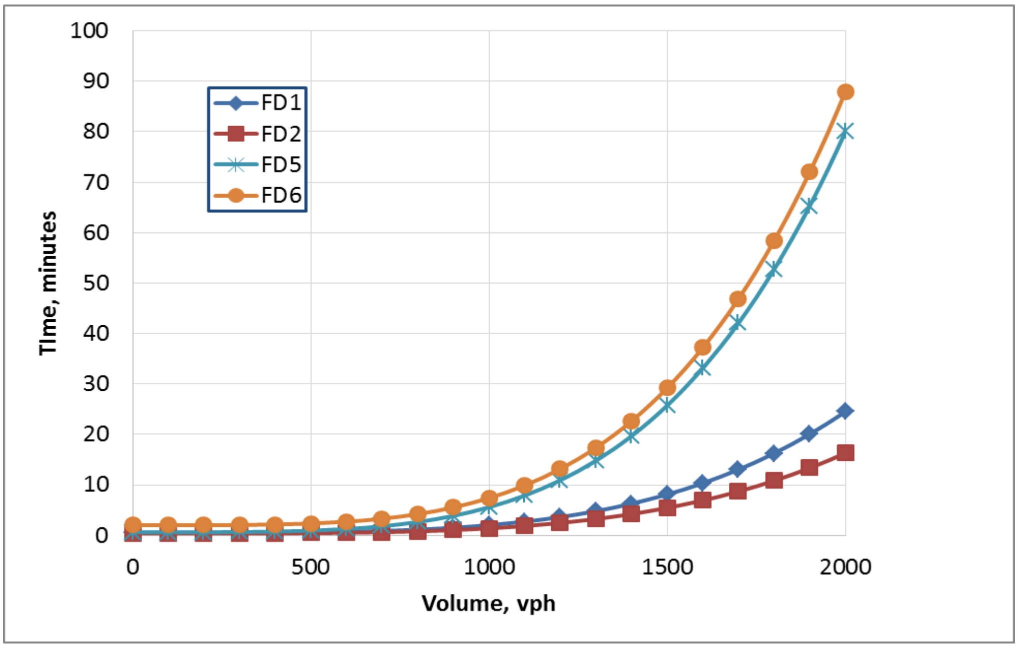


Figure 8. Plot of volume delay functions used in the study.

In EMME, calibration of the baseline scenario was done by pegging the calibrated passenger demand of the rail systems and other public transport to the OD demand estimates for 2014 during the peak hour period. The calibrated passenger trips are higher since sometimes several public transport modes are used when traveling from one's origin to one's destination. Table 3 shows the calibrated passenger demand and the current estimated passengers are within ±10% of each other. The calibrated base year result is then modeled with a pessimistic 5% shift, and an optimistic 20% shift from private to public transport.

Table 3. Calibrated passenger demand during the peak hour (2014)

Mode	Actual OD (Data)	(%)	Baseline Calibrated Results		% Difference
			Passenger Trip Segments	(%)	
AUV	290,100	11.23	636,800	17.38	6.15
Jeep	1,003,647	38.85	1,747,834	47.70	8.84
AC Bus	848,520	32.85	1,013,947	27.67	-5.18
Rail	440,829	17.07	265,820	7.25	-9.81
Sum	2,583,096		3,664,401		

4. MODEL OUTCOMES

The result of the baseline modeling and calibration for the peak hour period is shown in the second column of Table 4 for Year 2014. The estimated total private vehicle trip is estimated to be 1,077,680 while that of the total public transit trips is 2,700,570. The average travel speed in the network during the peak hour is estimated to be 13.97kph. The volume to capacity ratio (VCR) is known to be 1.365, the Vehicle-hour-travel (VHT) is 4,667,566 veh-hr while the Vehicle-distance-traveled (VDT) is known to be 11,084,477 veh-km. The passenger-kilometer traveled by all transit trips is known to be 33,222,324.2.

Table 4. Modeling results of EMME4 (2014), Peak Hour Trips

Parameters	Baseline	UTSMMA		MMETROPLAN		MMUTIS	
		Pessimistic 5% shift	Optimistic 20% shift	Pessimistic 5% shift	Optimistic 20% shift	Pessimistic 5% shift	Optimistic 20% shift
Private Trips (OD)	1,077,680	1,022,900	861,562	1,022,900	861,562	1,022,900	861,562
Public Transit Trips (OD)	2,700,570	2,755,340	2,916,680	2,755,340	2,916,680	2,755,340	2,916,680
Average travel speed, kph	13.97	15.67	18.58	15.59	18.59	15.92	18.85
VCR	1.365	0.793	0.666	1.021	0.665	0.758	0.637
VHT (veh-hr)	4,667,566	2,893,236	1,275,911	2,841,470	1,254,075	2,502,129	1,111,829
VDT (veh-km)	11,084,477	10,586,890	8,623,877	10,586,740	8,617,979	10,281,763	8,406,410
Passenger-km (All Transit)	33,222,324.2	35,016,608	37,836,692	30,583,217.5	37,384,306.3	34,229,653	36,094,176

After calibrating the baseline situation, the UTSMMA, MMETROPLAN, and MMUTIS rail plans were run under two scenarios, (1) pessimistic (5% shift) and (2) optimistic (20%). Hence, similar private and public transit (OD) trips were used for the three rail plans. Under a pessimistic scenario with only 5% shift from private to public transport. For the UTSMMA rail plan results, an improvement in average travel speed from 13.97kph (baseline) to 15.67kph (pessimistic) and 18.58kph (optimistic) were realized in the whole network as well as improvement in VCR to less than 1.0 at 0.793(pessimistic) and 0.666(optimistic).

The VHT and VDT also decreased which would mean faster travel and less distance travel under similar total demand. Although the MMETROPLAN rail system plan is less in length even than the current rail system, its radial network plan that cut across most of the CBD in Metro Manila may be better than the current lay out. Furthermore, in the current rail system the PNR is included which has a lower demand compared to the rest of the rail system.

Among the three, the best rail network plan is that of the MMUTIS which is almost double in length compared to that of the UTSMMA rail network plan.

Under the MMUTIS rail network plan all the travel parameters improved compared to the other rail network plans. Under the optimistic scenario, the average travel speed improved to 18.85 kph, VCR at only 0.637, VHT at only 1,111.829 veh-hr, and VDT at 8,406,410 veh-km. The typical rail transit demand outputs for the Baseline, UTSMMA, MMETROPLAN and MMUTIS are shown in Figure 9.

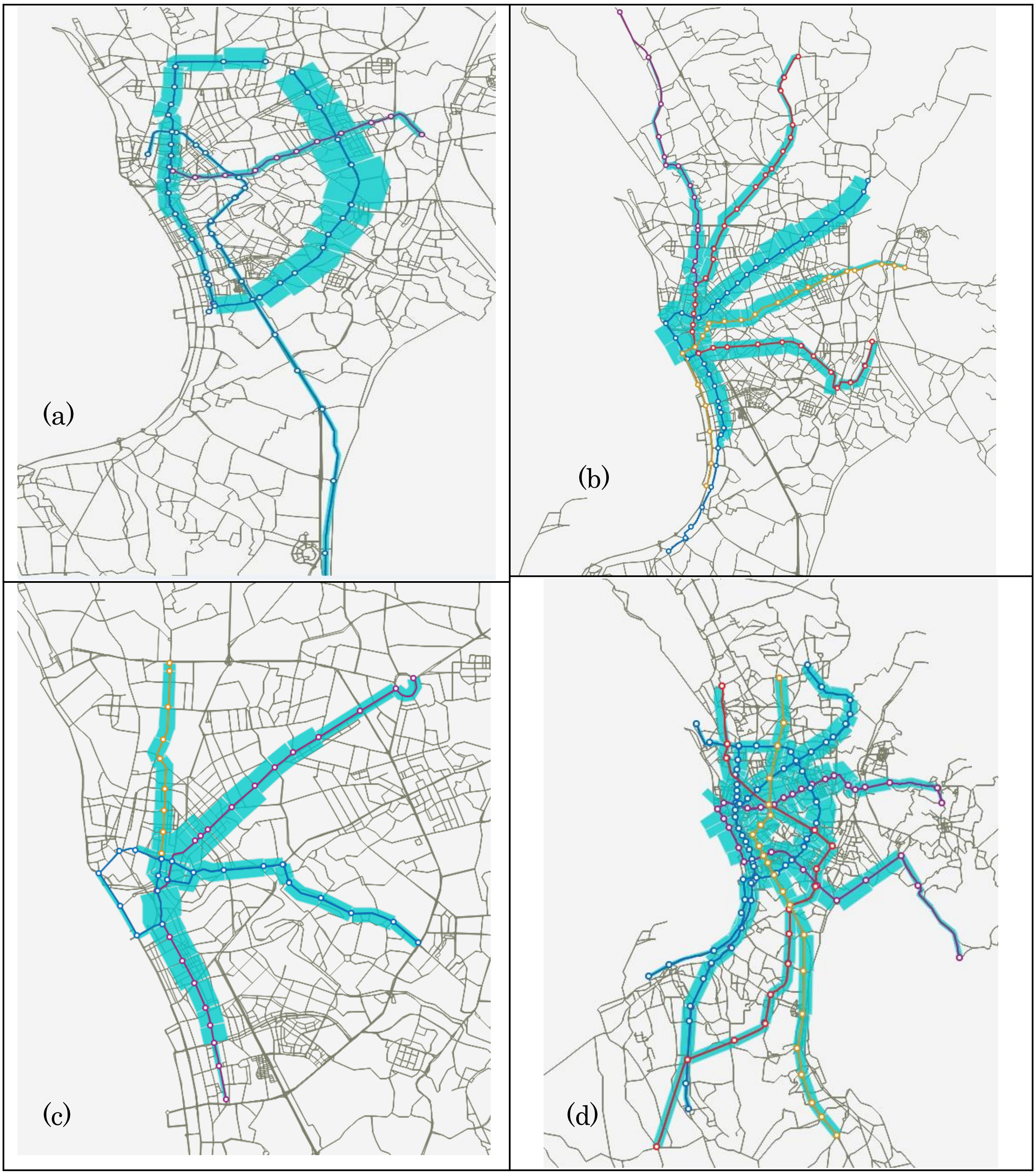
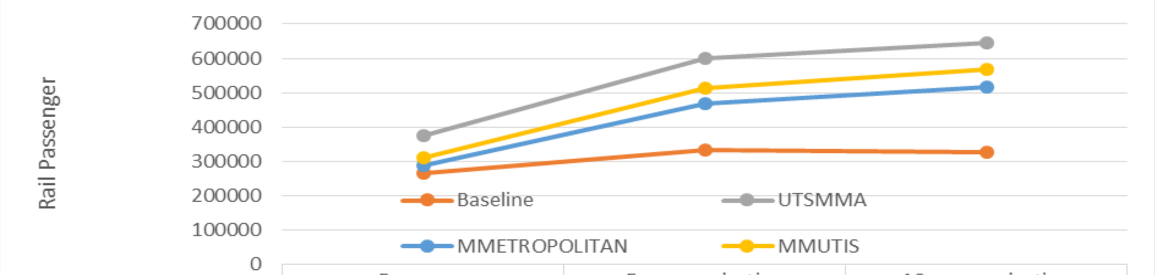


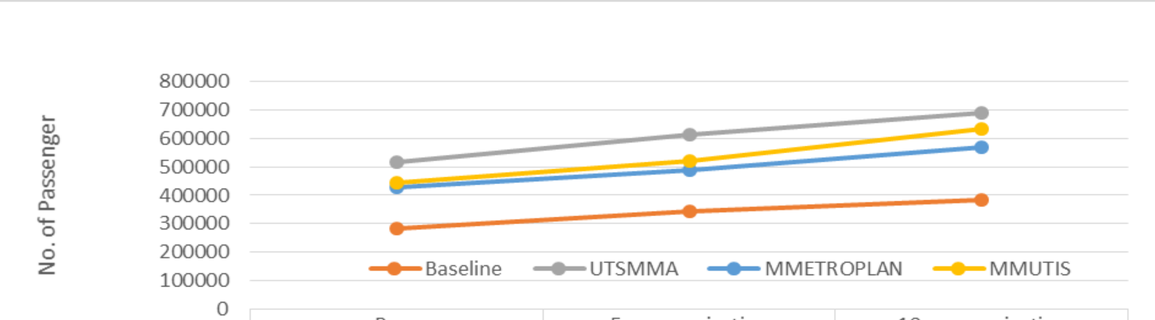
Figure 9. Rail transit demand outputs for (a) Baseline, (b) UTSMMA, (c) MMETROPLAN, and (d) MMUTIS

Considering the 5-year and 10-year projections of the number of passengers under a no shift, 5% shift and 20% shift from private to public, the UTSMMA rail plan will benefit the most with more shifting from private to public, followed by the MMUTIS rail plan, and lastly by the MMETROPLAN. Although the MMUTIS plan is more expensive than the UTSMMA, more may be willing to shift from private to public to the latter because of its better rail network layout. It should be noted that the shift from other public modes to the rail is not considered in Figures 10, 11 and 12. The MMUTIS network is still the between rail network plan if we consider also the shifting from other public modes to the rail system.



	Base year	5 year projection	10 year projection
Baseline	265820	332209	325747
UTSMMA	375236	600523	644291
MMETROPOLITAN	289273	469750	517452
MMUTIS	309445	512667	568898

Figure 10. Comparison of estimated passengers with no shift



	Base	5 year projection	10 year projection
Baseline	281903	342874	384168
UTSMMA	516319	615156	688873
MMETROPLAN	426480	487881	569889
MMUTIS	444574	521369	632548

Figure 11. Comparison of estimated passengers with 5% shift from private to public

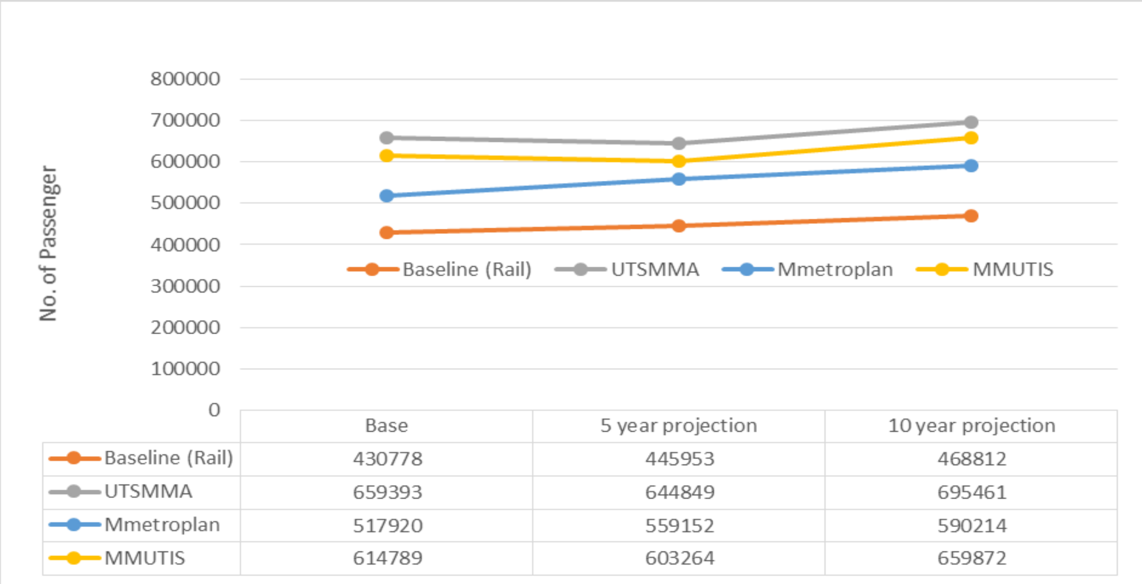


Figure 12. Comparison of estimated passengers with 20% shift from private to public

5. CONCLUSION

This paper presented on the rail transport development in Metro Manila including three major studies in the 1970s and 1990s. These studies (i.e., UTSMMA, MMETROPLAN and MMUTIS) recommended rail transport network for the metropolis that could have alleviated severe transport problems currently experienced in Metro Manila and its adjoining areas. The development of models to determine the counterfactual scenarios in relation to the rail networks proposed by the said studies was also discussed.

Based on the outcomes of the modeling, the following main findings can be derived from the study:

a. Because of having the most extensive rail network plan, the MMUTIS plan would have provided the greatest improvement in terms of improved travel time, lower VCR ratio, less distance travel (VDT) and less number of hours on the road (VHT) would show.
b. More significant shift from private to public modes of transport, particularly due to a more extensive rail transport network led to a general improvement in the travel parameters in terms of improved travel time, VDT, and VHT under similar demand characteristics.
c. The rail network plan layout is also important in capturing the demand or the shift from private cars to the use of the rail system. When the layout of the rail favors the car users to shift to rail, more car-using commuters will use the rail system.

In conclusion, the study was able to show a significant improvement in the general transportation and traffic based on the parameters measured (i.e., VCR, VDT, VHT and passenger-km) in the models evaluated. The model outcomes demonstrate and even reinforce if not validate the perception that transport and traffic in Metro Manila could be better in terms of mobility and accessibility if the metropolis and its adjoining areas were served by an extensive rail transit network along the lines of those proposed in previous studies in the 1970s and 1990s.

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