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Travel Demand Analysis: Requirements for Transit Modeling for Metropolitan Manila

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ABSTRACT. Traffic congestion has been an everyday phenomenon in Metro Manila. With road-based and rail-based transport facilities operating at overcapacity, it can be construed that transport planning employed for the capital region of the Philippines has been inadequate. In-depth scrutiny of the transport planning carried out in the metro, however, would reveal that there had been plenty of transport plans completed since the late 1960s—with most of these plans' recommendations unimplemented. It is in this context that this research note seeks to bring to light these past transport plans. Using available state-of-the-art transport modeling software, the project's proponents aimed to overlay these railway plans on existing traffic and land use conditions in Metro Manila, and, in this research note, presented the requirements to simulate the counterfactual scenarios in relation to past transport plans. The model outcomes of the simulation would fill in the what-if scenarios being sought as the key to understanding what could have been the state of traffic in Metro Manila if past rail transport plans had been implemented.

KEYWORDS. travel demand forecasting · transport planning · modeling

Introduction

Metro Manila seems to be in a perpetual state of traffic congestion. Whether it be users of road-based or rail-based modes of transportation, everyone can be a witness to the dreadful days of traveling within the metro. Former Department of Transportation and Communications[1] secretary Joseph Emilio Abaya, for instance, reported in February 2014 that the Manila Metro Rail Transit System Line 3 (MRT-3) was designed to carry 360,000 to 380,000 passengers per day, but actual passenger ridership reached 560,000 (de Fiesta 2014). This means that MRT-3 has been operating at 1.47 percent to 1.56 percent of its actual capacity. Meanwhile, Waze (2016, 23), the company known for its mobile navigation application, listed Manila as having one of the worst traffic situations in the world based on the "driver satisfaction index,"[2] ranking 170th out of 186 of the 235 metros surveyed by the popular app. All of these unfavorable traffic conditions have been costing the economy PHP 2.4 billion, and this economic loss may escalate to as high as PHP 6 billion a day by 2030 if no intervention is done (JICA and NEDA 2014, 3–6).

Much has been said about the traffic woes copiously experienced in Metro Manila and its environs, but in-depth scrutiny of the transport planning carried out in the metro would reveal that there had been plenty of transport plans that were completed, beginning in the late 1960s. Most of these plans' recommendations, however, were not pursued. It is in this circumstance that this project reexamines past transport plans. Using state-of-the-art transport modeling software, it is the goal of the project's proponents to revive and lay out the rail plans upon the existing traffic and land use conditions of Metro Manila. In this research note, the requirements to simulate the counterfactual scenarios in relation to these past transport plans are discussed.

Context of Transport Simulation

Simulation of counterfactual traffic scenarios in metropolitan Manila is one of the deliverables of this project for the interdisciplinary research program "The Mass Transit System in Metro Manila: From Tranvia to MRT, 1879–2014." This can be done by laying out the past rail transport projects, namely, the Monorail Transit System for Metropolitan Manila (MTSMM, 1969), the Urban Transport Study in Manila Metropolitan Area (UTSMMA, 1973), the Metro Manila Transport, Land Use, and Development Planning Project (MMETROPLAN, 1977), and the Metro Manila Urban Transportation Integration Study (MMUTIS, 1999) and thereafter, analysing their impact on the desired parameters such as travel speed, travel time, and volume-to-capacity ratio. The model outcomes of the simulation fill in the what-if scenarios being sought as the key to understanding what could have been the state of traffic in Metro Manila if the past rail transport plans had been implemented. It is important to note, however, that certain assumptions need to be specified to be clear as to what degree of accuracy the simulation is targeting.

Objective

This research note aims to discuss the requirements for the simulation of counterfactual traffic scenarios for metropolitan Manila. Specifically, this research note intends to introduce the fundamental concepts on travel demand analysis, and to present the needed dataset such as transportation network (i.e., highway and transit), socioeconomic data, and software tools that would be used for the simulation of what-if scenarios.

TRAVEL DEMAND ANALYSIS

Transport planning is the process that outlines the necessary steps to conceptualize, evaluate, and implement a transport policy or program. Different characterizations of the process have been created depending on the political and economic agenda per geographical region. In the United States, for instance, urban transport planning process has been divided into three phases: a) pre-analysis phase, b) technical analysis phase, and c) post-analysis phase. Pre-analysis phase consists of problem identification, formulation of goals and objectives, data collection, and generation of alternatives. Mathematical models to represent the factors being studied such as land-use or activity system model, urban transportation model system, and impact prediction model are included in the technical analysis phase. Lastly, post-analysis phase is more involved with the evaluation of alternatives, decision-making, implementation, and monitoring of the transport project (Pas 1986, 54).

Meanwhile, in Japan, urban transport planning is commonly referred to as urban transport strategy. Formulation of an urban transport strategy is divided into two components: a) collection of data necessary for strategy formulation; and b) urban transport strategy proposal. The former covers data collection using urban data sheet, checklist to diagnose urban transport condition, and interview sheet, while the latter signifies the output which would be the diagnoses of and prescriptions for urban transport problems, and the selection of the most suitable transit mode from available investment alternatives (JICA 2011, 23). There may be different labels for each process but, generally, all these follow a single template.

The Four-Step Process

The transport planning process tends to differ in label according to geographical region, but the fundamental part of the process has remained unchanged and lies on the technical component, which aims to estimate the future travel demand on the transportation system. This quantification of travel demand can be done using the conventional

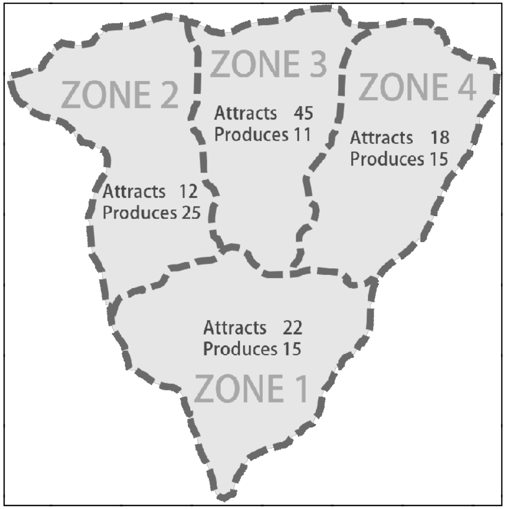

Figure 1. Representation of trip generation (production and attraction).

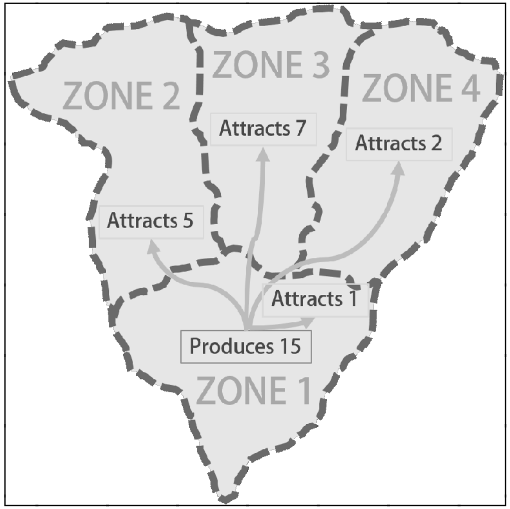

Figure 2. Representation of trip distribution.

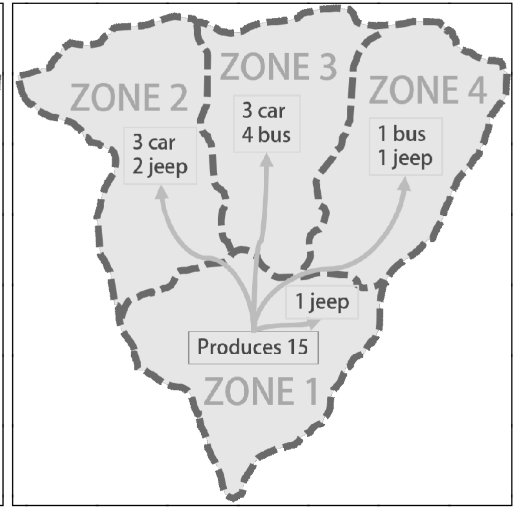

Figure 3. Representation of modal split.

four-step travel demand analysis or forecasting—trip generation, trip distribution, modal split, and traffic assignment.

Before travel demand forecasting is employed, traffic surveys that aim to collect the needed data have to be carried out. Household interview survey, cordon line survey, and screen line survey are some of the necessary traffic surveys conducted by transport planners. Household interview survey aims to acquire information about the socioeconomic conditions and travel characteristics of households within the study area. Cordon line survey is used to gather data about the non-residents of the study area, and the result of this survey would give information on the external trip data. Lastly, screen line survey is used mainly for the calibration of data. The resulting origin-destination matrix[3] from household interview survey would be compared to the actual result done in the screen lines (JICA and DOTC 2015a). Of all the surveys mentioned, household interview survey is the most important since it provides baseline information on the sample population such as zone, occupation, industry, gender, age, vehicle ownership, household income, volume of trip generation and distribution, modal shares, among others (JICA and DOTC 2015a; 2015c, 6).

While the traffic surveys are being conducted, the transportation database should be designed and built. The transportation database should include the highway network, transit network, and socioeconomic data encompassing the study area. The highway network is composed of nodes (i.e., intersection and interchanges) and links (i.e., highways, roads and streets) that make up the roadway facilities of the study area (Martin and McGuckin 1998, 10). Each link must have attributes that would represent the level of service that link is capable of servicing. Link distance, link speed, and link capacity are some of the attributes that can be associated for a given link (12). After the highway network, the transit network is then mapped out. Transit network is also made up of nodes and links but is established with a given route. Attributes such as headway and route name are added to the transit network (13).

On the other hand, the household and economic data extracted from household interview surveys can be used for the socioeconomic part of the transportation database. It is desired that traffic analysis zones[4] have to be well-established before the encoding of household and employment data (Martin and McGuckin 1998, 13). Once the transportation database has been finalized and the traffic surveys have been employed, the future travel demand can now be quantified using the four-step travel demand forecasting.

Trip generation refers to the number of trips per analysis area. It basically addresses the question,"How many trips will begin or end in each traffic analysis zone?" (Fricker and Whitford 2004, 198) (see figure 1). Trip generation has two aspects: a) trip-production and b) trip-attraction. Trip ends[5] associated with the outbound direction (e.g., from a traveler's home) are said to be trip productions, while trip attractions are the trip ends associated with the inbound direction (e.g., non-home ends of the trip) like workplaces and schools (Martin and McGuckin 1998, 20).

Certain considerations have to be studied in trip generation before it is employed, such as the amount and the character of the urban activity. The amount of urban activity is related to measuring the number of employees and households per zone. On the other hand, the character of urban activity is described through socioeconomic variables such as family size, family income, and car availability (i.e., for residential land uses) (FHWA and UMTA 1977, 3–3).

The second step is trip distribution, which provides the linkage between trips produced and trips attracted for each zonal pair (Martin and McGuckin 1998, 36) (see figure 2). Trip distribution answers the question, "How many trips that begin at a given origin will end at a given destination?" (Fricker and Whitford 2004, 206). Trip productions and attractions by trip purpose for each zone, which are outputs of trip generation, and the travel impedance obtained from the transportation network, are the inputs to trip distribution (National Academies 2012, 43). The output of this step is mainly an origin-destination matrix that tallies the number of trips between each pair of zones. Generally, zones that are located within the area being studied are called internal zones while external zones are the ones located outside of the study area. There are four characterizations of trips: a) a trip that begins and ends within the model region is called internal-internal; b) a trip that begins in an internal zone and ends in an external zone is called internal-external; c) a trip that begins in an external zone and ends in an internal zone is called external-internal; d) a trip that begins and ends outside of the model region but is able to pass through inside the model region is called external-external (National Academies 2012, 49).

The Gravity Model has been the most widely used model for trip distribution, which is derived from the gravitational theory of Newtonian physics. Using this theory, it was concluded that:

> the relative number of trips made between two geographical areas or TAZs [traffic analysis zones], is directly proportional to the number of trip ends (productions or attractions) in each TAZ and inversely proportional to a function of the spatial separation (or travel time) between those two areas. (Martin and McGuckin 1998, 37)

Results of trip distribution are assigned to the transportation facility to determine the travel demand, which would then relate to the carrying capacity of that facility (Martin and McGuckin 1998, 36).

The third step is modal split. This refers to the determination of the mode of transport to be used by travelers (see figure 3). It is in this step where the trips are split according to what mode of transportation the travelers use. Modal split gives the answer to the question, "How many travelers will choose each mode of transportation?" (Fricker and Whitford 2004, 217). Before analyzing the differences in mode choice, it is important to understand the factors that affect how people make choices when travelling. These factors are: the characteristics of the trip maker, characteristics of the trip and the characteristic of the transportation system (Federal Highway Administration and Urban Mass Transportation Administration 1977, 5-3). Logit model is the basis for most of the modal split formulations. This formulation describes the mathematical model to estimate the probability of a traveler choosing a specific mode depending on the attractiveness or utility of that mode (Martin and McGuckin 1998, 62). Utility is a function related to the in-vehicle and out-of-vehicle travel times, and the cost of that mode (63).

Traffic assignment is the last step in travel demand forecasting. This process determines the routes or paths that will be taken by tripmakers to travel from an origin to a destination. "What route or path will be taken by each tripmaker?" is the query that can be answered through traffic assignment (Fricker and Whitford 2004, 228). The assignment of trips to the highway and transit network is the output of this step (Martin and McGuckin 1998, 93).

REVIEW OF RAIL TRANSPORT PLANS IN METROPOLITAN MANILA

It is within the scope of the project to deal with the railway lines that have been identified from past transport plans, beginning in the late 1960s. In this section, these railway lines from past transport plans are briefly discussed, and the available transit network data per transport plan essential for the simulation of counterfactual scenarios are presented.

Table 1. Description of each route in MTSMM

Type	Route	Description
Radial	North	From Plaza Lawton to Bonifacio Monument Circle at the North end of Epifanio de los Santos Circumferential Avenue in Caloocan City.
	Northeast	From Plaza Lawton to the Quezon Boulevard-Epifanio de los Santos Circumferential Avenue intersection at the Diliman quadrangle in Quezon City.
	East	From Plaza Lawton to the Aurora Boulevard-Epifanio de los Santos Circumferential Avenue intersection in Cubao, Quezon City.
	Southeast	From Plaza Lawton to the Shaw Boulevard-Epifanio de los Santos Avenue Circumferential avenue intersection in Mandaluyong.
	South	From Plaza Lawton to the Taft Avenue Extension-Epifanio de los Santos Circumferential Avenue intersection in Baclaran, Parañaque.
Circumferential	Inner Circumferential	From San Andres Rotonda at Taft Avenue to the Claro M. Recto Boulevard-Jose Abad Santos Avenue intersection, linking the innermost stations of the first five routes.
	Outer Circumferential	From Baclaran, Parañaque to the Bonifacio Monument Circle in Caloocan City along Epifanio de los Santos Circumferential Avenue, linking all of the outer terminals of the first five routes.

Note: Reproduced from Project Technologists Inc (1969, 3).

Monorail Transit System for Metropolitan Manila (1969)

This transport plan has been deemed by the proponents as the pioneering study on rail transport development for metropolitan Manila. Completed in 1969, the study was made in accordance with the terms of a franchise granted to Philippine Monorail Transit System Inc. by Republic Act 4652. This transport development study (Project Technologists, Inc. 1969) proposed a monorail network spreading along seven routes. Five of these were radial in type while two routes

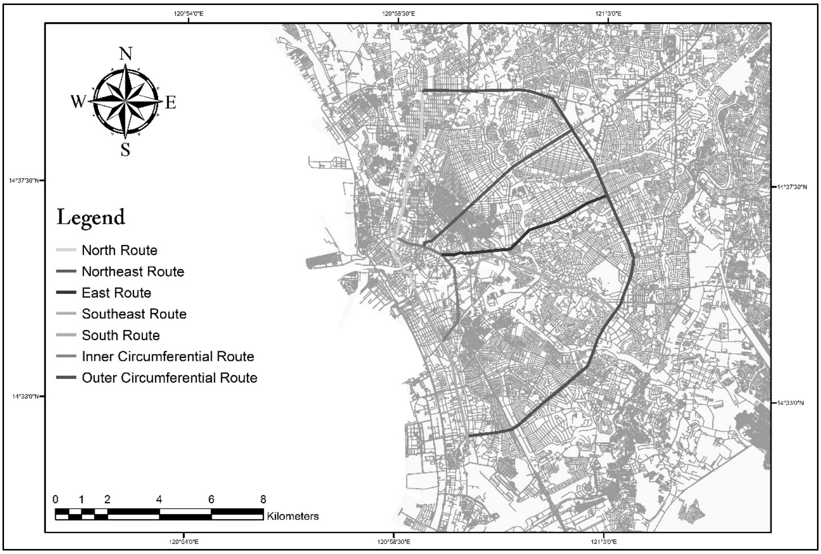

Figure 4. The monorail network proposed in MTSMM.

were circumferential. Table 1 shows the description of each route proposed in MTSMM; see figure 4 for the map of the lines.

Urban Transport Study in Manila Metropolitan Area (1973)

Unlike in MTSMM, this transport plan recommended a heavy rail transit system rolling out in five different routes (OTCA 1973). The plan was completed in 1973 by the Overseas Technical Cooperation Agency of the Japanese government (the precursor of Japan International Cooperation Agency). Table 2 shows the description of each line proposed in UTSMMA; see figure 5 for the map of the lines.

Metro Manila Transport, Land Use, and Development Planning Project (1977)

This study (DPWTC and FFA 1977) suggested a light rail transit network composed of a central area network located at the central business district of Manila at the time and lines extending to four major thoroughfares: Rizal Avenue, Taft Avenue, Shaw Boulevard, and Quezon Avenue. The study was carried out by the London-based consultancy firm, Freeman Fox and Associates. It was completed in 1977. Table 3 shows the description of each route proposed in MMETROPLAN; see figure 6 for the map of the lines.

Table 2. Description of each heavy rail line in UTSMMA

Line	Length (km)	Description
No. 1	27.1	From Constitution Hill to Talon via central Quezon Boulevard, Manila downtown and the International Airport.
No. 2	36.0	From Novaliches to Cainta via Manila downtown and Pasig.
No. 3	24.3	Along Highway 54 (C-4): half a circle route about 12 km from Manila downtown.
No. 4	30.1	From Marikina to Zapote via Cubao, Manila downtown and the Manila Bay area.
No. 5	17.6	From Meycauayan to Manila downtown running between Line No. 2 and PNR.

Note: Reproduced from OTCA (1973, 13).

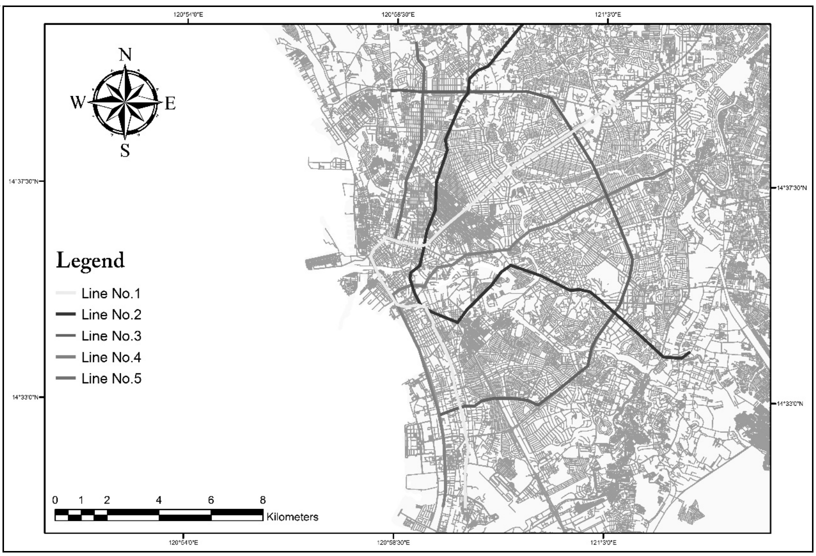

Figure 5. The heavy rail transit system proposed in UTSMMA.

Metro Manila Urban Transportation Integration Study (1999)

This study was completed in 1999 by the Japan International Cooperation Agency. Several lines and extension of existing railway lines at the time were proposed in this transport plan (JICA 1999). Table 4 shows the description of the lines proposed in MMUTIS; see figure 7 for the map of the lines.

Table 3. Description of each light rail route in MMETROPLAN

Route	Description	Distance (km)	Direction
A	Rizal–Taft	13.84	one-way
B	Quezon (Ellipse)–Central–Quezon (Ellipse)	23.5	round trip
C	Quezon (Roosevelt)–Central–Quezon (Roosevelt)	14.4	round trip
D	Shaw–Taft	11.6	one-way
E	Shaw–Rizal	15.0	one-way

Note: Reproduced from Freeman Fox and Associates (1977, 2 T24/5).

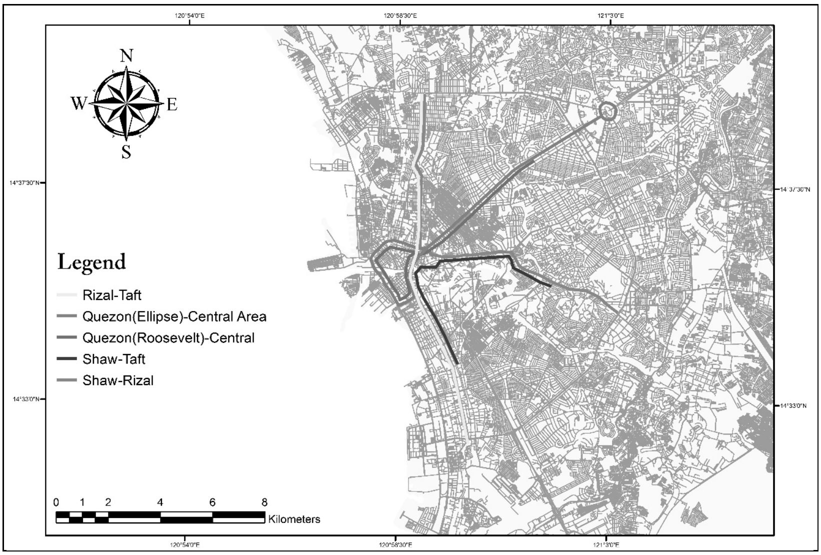

Figure 6. The light rail transit system proposed in MMETROPLAN.

Requirements for Modeling

It has been mentioned that the development of a transportation database is necessary before undertaking the estimation of travel demand. This database would include highway network, transit network, and socioeconomic data encompassing the study area. With regard to this development, it is important to note that the project will be utilizing the capacity development report of Japan International Cooperation Agency entitled MMUTIS Update and Enhancement Project (MUCEP) that was completed in 2015. This report has been completed upon the need to update the data collected from MMUTIS.

Table 4. Description of each railway line in MMUTIS

Proposed	Description
Line 1 Extension	The line will extend to Dasmariñas, Cavite in the south (30 km elevated).
Line 2 Extension	The line will extend to Antipolo in the east (12 km elevated) and to the west across Line 1 to the Port Area from where the line passes along Roxas Boulevard and Buendia to link Makati and Fort Bonifacio (17 km underground). Then the line will further lead to Binangonan in the east (20 km elevated/at-grade).
Line 3 Extension	The line will extend to Navotas and Obando (16 km elevated) in the north across Line 1 and PNR. The line in the south will extend to the reclamation area across Line 1 and further extend to Kawit (15 km elevated/at-grade) in the south.
Line 4	The line will extend to San Mateo in the north via a branch line. In the city center, instead of terminating at Recto Avenue, it can take over the extension portion of Line 2.
North Rail and Extension	A suburban commuter service will be provided between Malolos and Caloocan (30 km at-grade). From there, the line links Fort Bonifacio (20 km underground) and extends to General Trias in the south (25 km underground/elevated/at-grade).
MCX and Extension	A suburban commuter service will link Calamba with Alabang (28 km at-grade) from where the line will be elevated up to Paco (42 km). The line will then proceed toward the north across EDSA (11 km underground) and further extend northward to San Jose del Monte (18 km elevated).

Note: Reproduced from JICA (1999, II 7-13).

The traffic surveys conducted for MUCEP covered the entire Metro Manila and its adjoining municipalities in the provinces of Bulacan, Rizal, Cavite, and Laguna (JICA and DOTC 2015a).

The update on the highway or road network suggested that there exists a total of 2,810 links pertaining to all roads, streets or highways including the newly constructed roadways (JICA and DOTC 2015b, 5–5). The capacity and speed attributes for these links depend on the location, road category and the carriageway type. Table 5 summarizes the values of capacity and speed that have been used.

For the transit network, table 6 summarizes the parameters that have been used. However, it must be noted that the railway lines proposed by MTSMM, UTSMMA, MMETROPLAN, and MMUTIS will be used, and the lines of Manila Light Rail Transit System (LRT-1 and LRT-2) and MRT-3 will not be considered for the modeling.

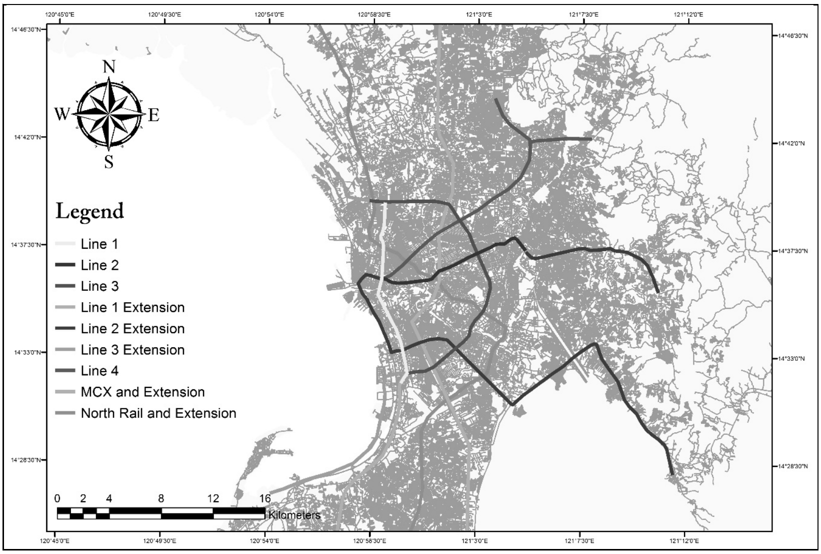

Figure 7. The rail transit lines proposed in MMUTIS.

The socioeconomic data follow the zoning presented in figure 8. This zoning system has 272, 82, and 67 traffic analysis zones designating the zones from the National Capital Region, zones from nearby provinces (i.e., Bulacan, Rizal, Cavite, and Laguna), and zones from outside the study area, respectively (JICA and DOTC 2015d, 1–10). Population and occupation according to night time and day time, car-ownership household rate, and average household income are the socioeconomic factors considered per zone.

Travel Demand Models

MUCEP has already developed models for each step of travel demand forecasting. This enables the project to lessen the burden in developing its own travel demand models. However, certain assumptions need to be specified to alter some parts of the models produced by MUCEP. For trip generation, trip production and attraction models were classified by trip purpose (i.e., to work, to school, to business, to private, and to home), and regression models were used. Fratar Method was adopted for trip distribution, which assumes that trip making pattern will be the same for the base year and the future year. Meanwhile, truck trips, walk trips, and the split between public and

Table 5. Capacity and speed attributes for the links

Area	Road category	Carriageway type	Capacity one-way (pcu/day/lane)	Maximum speed (kph)
Inside EDSA	Local Road	Single	2,000	30
	Secondary	Single	4,400	40
	Primary	Single	6,600	45
Outside EDSA, inside Metro Manila (including EDSA)	Secondary	Single	7,700	50
	Primary	Single	8,250	60
	Secondary	Divided	14,000	70
	Primary	Divided	16,500	80
Outside Metro Manila	Local Road	Single	8,000	30
	Secondary	Single	11,000	55
	Primary	Single	15,400	60
Urban/ intercity	Access/egress	Single	15,000	80
	Expressway	Single	17,000	80
	Expressway	Divided	20,000	100

Source: JICA (2015b, 5-6)

Table 6. Parameters for the transit network

Parameter	LRT-1	LRT-2	MRT-3	PNR	Jeepney	Bus
Average Speed (kph)	30.0	30.0	26.0	26.0	—	—
Boarding Fare (PHP/boarding)	7.5	7.5	6.5	5.0	—	—
Additional Fare (PHP/km)	0.8	0.8	0.9	0.4	1.4	1.8
Access Walk Speed (kph)	4.0	4.0	4.0	4.0	—	—

Source: JICA (2015b, 5-6)

private modes of transport were used for modal split. Lastly, the speed-volume functions that have been generated in road and rail links were carried out to facilitate traffic assignment (JICA and DOTC 2015b, 5–11—5–13).

Assumptions

The following assumptions can be considered for the development of the models:

a) Mode shift values for the most likely mode shift from private to public transport (rail) for the UTSMMA, MMETROPLAN and MMUTIS scenarios. Optimistic or aggressive scenarios such as 20 percent shift from private and road-based public transport to rail transport can also be considered. A pessimistic scenario such as

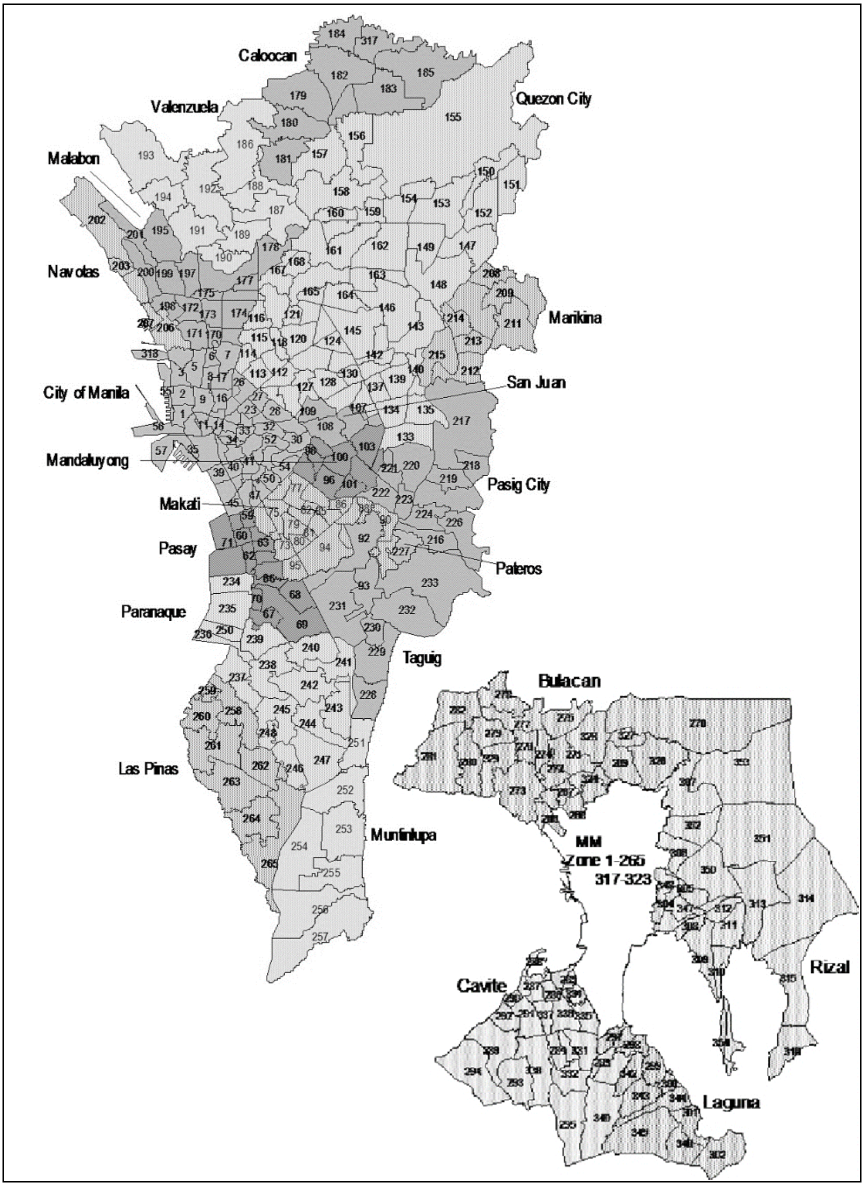

Figure 8. Traffic analysis zones adapted by MUCEP. *Note:* Map reproduced from JICA (2015d, 1–10).

only 5 percent shift can also be considered in order to establish a range of values for the likelihood of outcomes.

b) Transit stations can be 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.

c) For UTSMMA rail lines, the capacity and specifications of the proposed Rapid Transit Railways Line-1 trains were assumed. These are heavy rail lines and would have higher passenger capacities than the current LRT-1 and MRT-3 trains in operation.

d) Fares can be assumed as the same as current rates for LRT-1, LRT-2 and MRT-3, and these can be further assumed to be reasonable based on the riding public's acceptance or willingness to pay.

e) Routes of road-based public transportation can be assumed as the same. That is, current jeepney, bus, and utility vehicle or UV express routes will be the same as current ones in operation.

Calibration and Validation

Model calibration and validation are two different processes that are sometimes used interchangeably by transport modelers. Calibration is defined as the adjusting of parameter values until the predicted matches the observed travel demand levels (Barton-Aschman Associates, Inc. and Cambridge Systematics, Inc. 1997, 2). On the other hand, validation is the checking of model results against observed data, and thereafter adjusting parameters until the results fall within an acceptable range of error (3). Figure 9 shows where the calibration and validation fall into the modeling process. Although seemingly distinct processes, calibration and validation are related and should be done contiguously. Various tests[6] have been developed to employ calibration and validation. For instance, trip generation is calibrated and validated by checking the trip rates versus other zones (National Academies 2012, 25).

Calibration and validation requires real-world transport and traffic data such as traffic counts and travel speeds for simulation results to be

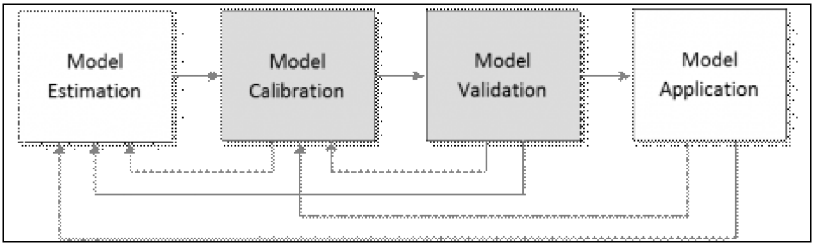

Figure 9. Calibration and Validation in the Modeling Process. *Source:* Travel Forecasting Resource (2016).

compared. Typical traffic counts data are collected at strategic locations such as those identified as part of a cordon or screen line. Examples of these locations are the major bridges along the rivers (e.g., Pasig, Marikina, Navotas, Malabon) and radial roads (e.g., Southern Luzon Expressway, Roxas Boulevard, Commonwealth, Marcos Highway, Ortigas Avenue). Basically, if it can be shown that the outcomes of simulation are statistically similar to actual counts and speeds then it can be assumed that the model is calibrated and can replicate real-world conditions.

Simulation Tools

There are many available software tools to perform transport modeling and simulation of scenarios. Among the most popular commercial software are Cube and Emme.

Cube is a transportation planning system software developed by Citilabs.[7] The Cube Transportation Modeling Suite provides advanced methods and techniques for the design and development of transport models. Moreover, it provides an application environment for quick and easy application of the models to build, test, and evaluate scenarios. On the other hand, Emme is a travel demand modeling software developed by INRO. Common applications of Emme include travel demand forecasting, transit planning, traffic planning, economic, emissions and environmental analyses, and transportation data science. Both of these software tools can analyze data in the geographic information system format, such that the links and nodes to be digitized can be referenced according to a certain projection system. Geocoding of socioeconomic data would be easier with the help of the advanced feature of these software tools. MMUTIS did not use any of these software tools. Instead, it used a precursor of Cube called STRADA. It is a transport modeling software developed and promoted by the Japan International Cooperation Agency and TranPlan.

Further Work

The project will pursue the modeling and simulation of proposed railway transit lines since the late 1960s to see if these could have improved current traffic conditions (i.e., alleviate traffic congestion) if they were implemented as planned. These what-if scenarios would be implemented using current available tools and data including state-of-the-art transport modeling software such as Cube and Emme, and an updated database (i.e., based on MUCEP) for Metro Manila.

In the proposal stage, it was stated that this project will employ analysis involving the co-benefits approach in assessing the impact of transport systems to air quality, fuel consumption, safety, traffic congestion, noise, and others. The co-benefits approach makes use of these other elements that are often easier to be understood and appreciated. Further, the assessment of transport and traffic conditions as related to rail transport development will employ conventional level of service concepts and criteria to determine the necessity and timeliness of railways in alleviating transport and traffic congestion in Metro Manila. The outcomes of simulated scenarios will be inputs toward the evaluation in the context of transport co-benefits and environmentally sustainable transport.❁

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Notes

1. This is now the Department of Transportation by virtue of Republic Act 10844 (Department of Information and Communications Technology Act of 2015) signed on 23 May 2016. A new government agency, the Department of Information and Communications Technology, was created, splitting the Department of Transportation and Communications into two departments.
2. Waze (2016) defined driver satisfaction index as a traffic index that measures six quantitative and qualitative attributes, namely, traffic rating, road safety rating, driver services rating, quality rating, socioeconomic rating, and wazey rating.

3. Origin refers to the starting point while destination refers to the ending point. The origin-destination matrix is the table that tallies the number of trips starting from a given zone and ending to a given zone.
4. Divisions of the area being studied. This is used as the geographic unit in travel demand forecasting.
5. It is defined as the beginning or ending of a trip; thus, a trip has two trip ends.
6. See Travel Demand Forecasting: Parameters and Techniques (National Academies 2012, 25–26) for the complete list of tests.
7. Citilabs website, http://www.citilabs.com.

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