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Mending a Metropolis – Understanding Passenger Demand across Metro Manila to Improve Road Transit

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Abstract: Metro Manila's public transport supply has evolved over many decades with little centralised planning. Public utility jeepneys, buses and Asian utility vehicles provide the majority of road transit services, but with very little knowledge or evidence of existing passenger journeys. Do existing current services meet passenger demand? This paper presents the findings of the Metro Manila Road Transit Rationalisation Study which sought to answer this question.

By analysing existing passenger demand - understood through extensive origin-destination datasets developed for this study - within CUBE, it has been possible to demonstrate what an optimal road transit network would look like if it were to meet existing passenger demand. 16 mass transit routes and 58 secondary high quality public transport services were identified. These proposed corridors and services inter-connect with one another to create a network of transit routes that enable people to make complex journeys efficiently.

Keywords: Public Transport, Metro Manila, Road Transit, Rationalisation

1. INTRODUCTION

In 2013, the Department of Transport and Communications (DOTC), with grant support from the World Bank, embarked upon the Metro Manila Road Transit Rationalisation Study in an attempt to establish an evidence base for optimising the road transit network. The study was completed in June 2014 and concluded by establishing the framework of a mass transit network based solely on passenger demand. This paper presents the findings from that study and explores how the road transit network of Metro Manila could be optimised and rationalised to better meet passenger demand. This is the first step towards the development of a planned, inclusive and resilient transit system in Metro Manila.

2. BACKGROUND TO PUBLIC TRANSPORT IN METRO MANILA

Metro Manila is the capital region of the Philippines. The metropolis has a growing population - in 2010, the National Capital Region (NCR) had an official population of 11,855,975 having increased from 10,490,000 in 2000. Alongside this, the population density is also increasing, having been recorded at 18,650 per sq. km in 2010. With an increasing population and population density comes increasing pressure on the transport network to accommodate trips made by these residents. The current public transport supply is characterised below.

Metro Manila currently has four urban and commuter rail systems, LRT1, LRT 2, MRT 3 and the Philippines National Railway. In addition to the rail mass transit network, there is also a significant supply of road-based transit, mainly provided by public utility buses (PUB), public utility jeepneys (PUJ) and Asian utility vehicles (AUV). There are 82 PUB routes and 676 PUJ routes across Metro Manila. PUB services typically operate on the major arterial roads of Metro Manila including EDSA. The 82 PUB routes are operated by around 38 different operators, delivering 390 different franchises and operating more than 6,000 vehicles.

PUJs ply the primary and secondary roads of Metro Manila. Services are generally provided by small-scale operators with almost all operators owning one unit each. There are approximately 34,500 PUJ franchises issued by LTFRB within Metro Manila and around 44,000 vehicles delivering those franchises.

While buses and jeepneys ply fixed routes, AUV Express services (a relatively new road transit mode) offer point-to-point services using air conditioned vehicles. Their franchises specify the route termini and drivers have some liberty on which route to take. They are not allowed to load and unload passengers along the way so they do not directly compete with jeepney services. In practice however, the loading and unloading of passengers away from the specified end points can be observed.

In addition to the franchised vehicles, colorum (non-franchised, illegal) vehicles also ply PUJ, PUB and AUV routes, in addition to developing their own routes. It is not possible to quantify the number of colorum services.

3. OBJECTIVES AND METHODOLOGY

3.1 Objectives of the Study

There were five key objectives for this work. These were to develop the plan for an integrated road transit system that:

1. Enables the efficient movement of the travelling public across Metro Manila
   - Service-oriented to meet traveler demand, not profit oriented
2. Enables people to travel in an environmentally sustainable manner
3. Is cost effective for passengers & commercially viable for operators
4. Supports the developed and evolving mass transit network
   - Determination of the optimum public transport corridors
   - Determination of the most appropriate mode of transport driven by demand
   - Determination of most appropriate level of service, driven by demand
5. Highlight where demand is of a level of intensity that may warrant and justify further mass transit systems or routes

3.2 Methodology

Despite a vast array of transit studies having been carried out over a number of years, there was no single database that collated all available data to be used as a resource for transit planning in Metro Manila. Therefore, this study sought to collate all existing data and evidence and add to this to provide one database that could be used by DOTC and others in future. There were several recent studies that collected large datasets that could be utilised for this study:

- The Mega Manila Public Transport Planning Support System (MMPTPSS),
- Quezon Avenue and Ortigas Avenue BRT feasibility studies
- C5 high quality bus corridor study

- Metro Manila GTFS study

While extensive, these datasets could not provide a comprehensive database from which an examination of existing passenger demand could be analysed. There was therefore a need to supplement this data with an extensive data collection programme. Given the time and financial constraints of this study, it was necessary to adopt innovative and smarter ways of collecting transit oriented data. Technology played a significant role with two smartphone applications used within the data collection phase, one of which was developed specifically for this study.

Boarding and Alighting (B&A) Surveys

B&A surveys sought to capture the geographic locations of where road transit passengers board and alight vehicles to understand how passengers use existing services. These surveys were carried out using Transitwand, a dedicated open-source smart web and mobile application (app) used to collect transit data. Surveyors recorded each time a passenger boarded or alighted a vehicle, and the app then recorded the ongoing load factor of the vehicle, the GPS co-ordinates of each passenger movement, and the GPS co-ordinates of the entire length of the route. The data emanating from Transitwand therefore provided:

- The geographic locations of where passengers board and alight, including trip attractors and/or interchanges
- A mapped geographic representation of every road transit route
- The load factor of each surveyed vehicle along every route
- The turnover of seats along every route

Surveys were carried out on every PUJ and PUB service operating within Metro Manila, including routes that cross the boundary into non-metropolitan areas. If B&A surveys had been carried out on other routes using Transitwand as part of other studies, these routes were not surveyed again. Surveys were carried out for the whole length of each route in both directions. Surveys were carried out on weekdays only, during the day with surveys starting around 6am and finishing around 8pm. Surveys were carried out in September and October 2013.

Carrying out surveys on only PUJ and PUB services is a limitation of this study. Due to financial constraints it was not possible to carry out surveys on all public transport modes, most notably, LRT, MRT and UV Express services. In addition, car and taxi users were not surveyed, limiting our understanding of their movements across the metro. This was in part addressed by using data from other recent studies but remained a limitation.

Origin and Destination (O&D) Surveys

O&D surveys provide information relating to where transit users travel from and too, without considering how they get between the two points. This data illustrates the existing transit demand without taking account of the constraints of the existing public transport supply.

Surveys were carried out using a software app designed specifically for this study. This consists of some basic questions to ask each passenger (such as journey purpose and the number of legs within that journey), plus a map for the surveyor to accurately record the origin and destination of each passenger journey. Each origin and destination record was geo-coded, while all responses were uploaded automatically to an external server at the end of each journey to ensure that no data was lost and that the data was accurate. Surveys were carried out using Nexus 7 tablets.

Surveys were carried out on 488 PUJ and 51 PUB routes and for the whole length of each

route in both directions. Surveys were carried out on weekdays only, during the day with surveys starting around 6am, culminating each day around 8pm, to ensure both peak periods were surveyed.

Public Transport Frequency and Vehicle Occupancy Surveys

The aim of these surveys is to record, for each road transit route that travels within the study area:

- The number of vehicles which serve each PUJ and PUB route per day – and hence frequency; and
- The occupancy levels of each PUJ and PUB service as it passes each survey location

Surveys were carried out at 32 different locations across Metro Manila. The locations were selected in order to capture frequency and vehicle occupancy data for all the routes for which there was no existing PT frequency or occupancy data.

Every PUJ and PUB passing each location, in both directions, was surveyed between the hours of 6am and 10pm. Effort was made to record the occupancy rates of every public transport vehicle that passed each survey location, with care taken to ensure that the occupancy rates were specific to services on each route that passed the survey location. The occupancy of vehicles was recorded as empty, ¼ full, ½ full, ¾ full, full, overfull, where full means that all seats are occupied, and overfull means all seats occupied with standing passengers. Surveys were carried out using traditional paper based forms and were carried out in September and October 2013.

Data Processing

In order to carry out this study it is necessary to have data that represents existing travel demand for a typical day. It is not possible to record every passenger and every vehicle movement, therefore the collected data requires processing and expanding.

Boarding and alighting surveys were expanded as follows:

- For every PUB and PUJ route, surveys were carried out in both travel directions for the whole length of the route. Frequency surveys then provided the number of vehicles operating along that route in both directions. Occupancy surveys also provided the occupancy levels on each vehicle.
- Multiplying the number of vehicles serving each route by the occupancy of each vehicle gave an indication of the number of passengers on each route in a day.
- Assuming that all B&A points for a given route are representative of the rest of the day, these are factored up in line with the number of passengers that travel on that route on that day.

O&D surveys were expanded in a very similar way to B&A data, and described below:

- For every PUB and PUJ route, passenger interview surveys were carried out in both directions for the whole length of each route. Frequency surveys then provided the number of vehicles operating along that route in both directions. Occupancy surveys also provided an indication of the number of passengers carried on each vehicle.
- Multiplying the number of vehicles serving each route by the occupancy of each vehicle gave an indication of the number of passengers on each route in a day.
- Assuming that all O&Ds of passengers on a given route are representative of the rest of the day, these are factored up in line with the number of passengers that travel on that

route on that day.

Option Development and Appraisal

To develop transit options two models were developed within Cube. The first was a highway assignment model which assigned O-D pairings to the highway network to understand the routes that passengers would take if they could make their journey in the most efficient way possible. The outputs from this model provided an illustration of the core corridors where demand for road transit is greatest.

By suggesting that mass transit services are required on each of those corridors, a network of integrated routes that complement one another was developed. For each core corridor select link analyses were carried out to understand where passengers travel to and from when using that corridor, and this process helped to define the termini. This process further informed the development of different road transit services within network of routes to ensure it best meets the needs of the greatest number of existing transit users.

The second model to be developed was a public transport model. Each identified route and service was entered into the model to understand which services are the most patronised and within the network context, which routes and services worked best together. This process required several iterations, with each iteration appraised based on the maximum number of passengers carried.

4. UNDERSTANDING EXISTING TRANSIT SUPPLY

There are 677 different PUJ routes across Metro Manila. The average length of PUJ routes is 10.9km, although this can vary from a route of around 1km between Ortigas Complex to Robinson's Galleria to over 47km between Jala Jala and Cainta. The sum length of all PUJ services (in one direction only) is 7,347km. PUJ routes collectively carry approximately 8,960,000 passengers per day. Around 65% (5,824,000) of passengers are carried on just 20% of PUJ routes, while the top 3% of PUJ services carry 20% of passengers. The top 3% of routes all carry at least 60,000 passengers each day. The busiest PUJ route is between Sangandaan and Divisoria with a total of 213,861 passengers travelling along that route each day, with almost 11,000pphpd during the AM peak hour on an inbound direction.

There are 82 PUB routes across Metro Manila with an average route length of 36.7km. The length of PUB services ranged from 4.18km between Ayala and Fort Bonifacio via Mckinley to 60.5km between Balibago and SM Fairview via EDSA. There are other services with similar route lengths, such as Dasmarinas-Navotas via EDSA (58.6km) and Angat-Leveriza via Ayala (58.5km) The sum length of all PUB routes (in one direction only) is 3013km.

In total, there are 759 different PUJ and PUB routes across the metropolitan area, covering a total of 10,360km. Across all PUB services (notably, not including any provincial bus services), approximately 1,865,000 passengers are carried on a daily basis. The most patronised PUB service operates between Fairview and Baclaran via Quezon Avenue, carrying approximately 94,000 passengers per day, and over 5,000 during the am peak hour.

Table 1 presents the average number of services per hour for every route throughout the day. The use of the terms inbound and outbound reflect the general direction of travel, with inbound services those that travel in the general direction of central areas of Manila, or other central business districts. Where this is unclear a reasonable assumption has been made for each route.

Table 2 presents the average occupancy of PUJ and PUB services at different times of day. What is evident from the two tables is that both PUJ and PUB services appear to have higher

occupancy levels during the PM peak than during the AM peak. In fact, outbound services in the PM peak for both vehicle types have greater occupancy rates than inbound services during the AM peak. Cross referencing this phenomenon with the evidence reported in Table 1 where the average frequency of services is lower in the PM peak than the AM peak, it appears that there are fewer services operating with higher occupancy rates during the PM peak compared to the AM peak where there are more services operating with lower occupancy rates.

It is speculated that there may be two reasons for this phenomenon. Firstly, by the PM peak, PUJ and PUB drivers may have achieved their 'boundary' and therefore earned their money for the day. Secondly, traffic conditions during the PM peak are notoriously congested, and therefore it was suggested that drivers and operators choose not to operate during the PM peak as increased fuel consumption leads to a reduced profit margin.

Table 1 Average hourly frequency of PUB and PUJ services throughout the day

	6am-9am	9am-12pm	12pm-3pm	3pm-5pm	5pm-7pm	7pm-10pm
PUJ Inbound	21.15	16.70	15.21	16.00	16.98	13.74
PUJ Outbound	20.45	16.81	15.05	16.44	17.69	13.98
PUB Inbound	9.93	9.15	8.37	8.02	8.29	7.32
PUB Outbound	9.49	9.60	8.64	9.07	8.82	7.71

Table 2 Average vehicle occupancy of PUJ and PUB services throughout the day

	6am-9am	9am-12pm	12pm-3pm	3pm-5pm	5pm-7pm	7pm-10pm
PUJ Inbound	12.17	10.29	9.55	9.16	10.24	8.78
PUJ Outbound	9.55	9.16	9.92	11.60	14.56	13.93
PUB Inbound	46.36	39.23	31.70	29.43	36.41	30.53
PUB Outbound	27.53	21.91	28.41	38.79	57.11	51.67

Figure 1 shows the sum of boarding and alighting movements across the metro. In this illustration, the larger the circle the greater the number of passenger boarding and alighting movements were seen in that location. Where there are concentrations of circles, this denotes a high number of boarding and alighting movements in adjacent or nearby areas. As an overview, these points illustrate popular transit routes and corridors, show key trip attractors and help to identify interchange points across the network.

From north to south, it is evident that there is a concentration of boarding and alighting movements in and around Fairview towards the north east of Quezon City, along Commonwealth Avenue towards Philcoa and Philcoa itself which has a particularly high concentration of movements which is likely to be a result of interchange and of its proximity to the University of the Philippines.

There are notable passenger movements along the northern stretch of EDSA around Balintawak, Roosevelt and SM North/Trinoma and along Quezon Avenue and Espana Boulevard, which are popular transit corridors with a high number of boarding and alighting movements to access the residential and commercial developments along it. Manila City has a very high number of road transit passenger movements and presents probably the greatest density of road transit passenger movements as any other single area within the metro.

The density of high frequency routes around Cubao and Araneta is supported by the large concentration of boarding and alighting movements in the area. Focusing on EDSA, it is evident that there are some key points along the route that have high passenger movements. The area around Ortigas Avenue and EDSA/Shaw Boulevard has a high level of boarding and alighting

movements which can be attributed to the significant commercial activities, such as shopping malls, banks, government agencies and other businesses. Furthermore, there are public transport interchange opportunities with MRT, PUB and PUJ services.

Makati has a large concentration of movements around it which is intuitive given its significant commercial, business and leisure activities which are key trip attractors for many people from across the metropolitan area. Towards the southern stretch of EDSA, there are many passenger movements around Baclaran and Pasay Rotonda. This can be explained by a large number of services terminating/originating from that area and interchange with provincial bus services from the south and also services heading north. The area is also close to a number of shopping malls and also a large market which are likely to be significant trip generators.

Overall, the sum of boarding and alighting movements demonstrate that there are many areas across the metropolitan area that attract a large number of passenger movements, highlighting the polycentric nature of Metro Manila. This polycentricism makes designing public transport particularly complex. The varied nature of all road transit passenger demand therefore needs to be comprehensively understood before a network of routes can be developed to meet the needs of existing passengers.

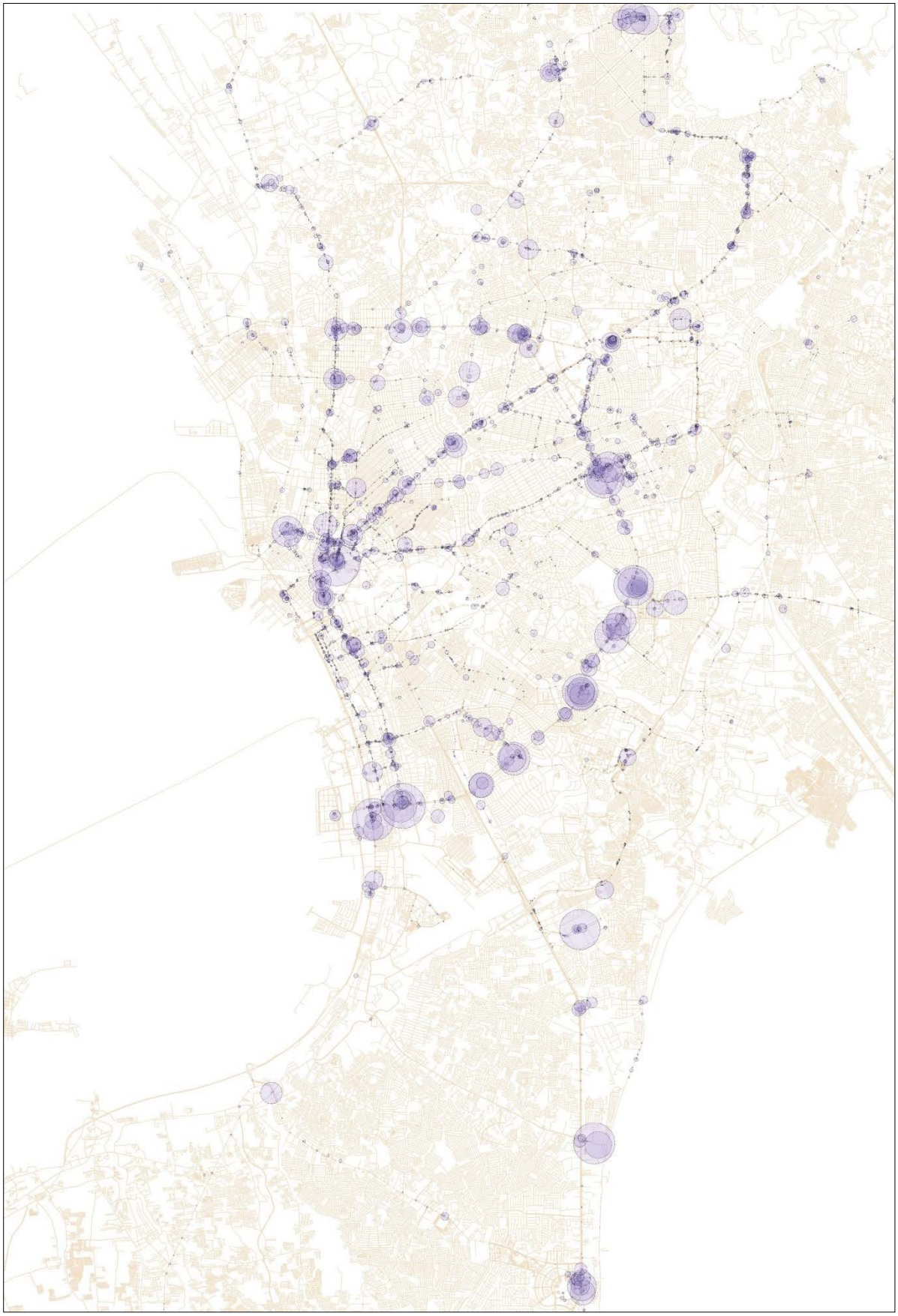

Figure 1 Sum of boarding and alighting movements

5. UNDERSTANDING EXISTING PASSENGER DEMAND

Understanding passenger demand for transit is essential for planning a transit network. In Metro Manila, there are no existing data sources, such as from the purchase or use of transit tickets (as might be expected in other cities such as Singapore and Hong Kong) that can be used to understand passenger demand. Therefore, OD surveys were undertaken to understand where road transit users travel from and to.

Approximately 35,000 OD pairs were obtained for the study. These OD pairs were expanded to provide a dataset of passenger movements on an average day in Metro Manila. The expanded OD dataset was then assigned to Cube using two different zonal models. The first used a 479x479 zonal matrix which illustrates the micro movements of road transit users, while the second used a 50 x 50 zonal matrix to record macro movements. Figure 2 presents the 479x479 matrix with lines denoting the movement of people between each zone. The thicker the line, the more people travel between those two zones.

Figure 2 OD Pairs between 479 zones – AM peak hour

Fairview in Quezon City stands out as a key origin and destination with several larger thicker lines illustrating key movements throughout the metro. There appear to be several thick lines between Fairview and zones to the north of the metro around Novaliches amongst others. In addition, there is a large movement of people between Fairview and a zone around Ortigas, with between 600 and 1000 people making that journey during the AM peak.

Other key movements between two individual zones include areas around Tandang Sora to the southern areas around Commonwealth Avenue, northern areas around Rizal Avenue to areas around Balintawak and from areas around Paco to Santa Mesa in Manila City.

It is, however, necessary to be cautious when considering these singular movements from just one individual zone to another. As there are 479 zones, it is likely that movements between two particular zones will be relatively small and insignificant. However, where there are dense concentrations of O-D pairing lines, it shows that there are large numbers of journeys being made in those areas, which is most evident in Manila City.

Manila City and areas around Quiapo and the coastal industrial areas experience large numbers of movements to a wide variety of zones, however what is evident is the relatively short movements made by passengers between zones, suggesting that there are large numbers of road transit users making short journeys around Manila City. This corroborates the findings from the Boarding and Alighting data used for the supply-based analysis in the previous section where there are large numbers of road transit users boarding and alighting in Manila City. As the two survey types were carried out at different times but show very similar patterns, there is a high degree of confidence that these outcomes are accurate and that Manila City does experience a high number of road transit users making journeys to and from the inner city areas.

Figure 4 illustrates the same data as Figure 3, except it is presented using the 50x50 matrix to illustrate the movement of people during the AM peak at a macro level. The main observation is the very high number of relatively short distance movements in and around Manila City. There are several O-D pairs between the larger zones within Manila where large numbers of public transport users want to travel, which is less clear in Figure 3 because of the large number of individual zones within Manila. This clearly shows the high level of demand for public transport, and in particular road transit, in and around Manila City and again corroborates the findings from the road transit supply based analysis that highlighted many road transit passenger movements around the city.

A second observation from comparing Figures 3 and 4 is that while there are large movements of people to and from the areas around Fairview to the north, these movements are less dominant in comparison to Manila City. It is apparent that there are significant movements of people around Fairview from North Caloocan City and Novaliches. However there is less emphasis of movement from Fairview to central areas of the metropolitan area, suggesting that there are fewer passenger movements between Fairview and central areas when compared to passenger movements between other areas.

Other notable observations from Figure 4 include passenger movements between Malabon and Valenzuela City and South Caloocan City, large passenger movements between South Caloocan City and Manila City, significant movements between Manila City and Pasay City and movements within Makati and between Makati and Manila City

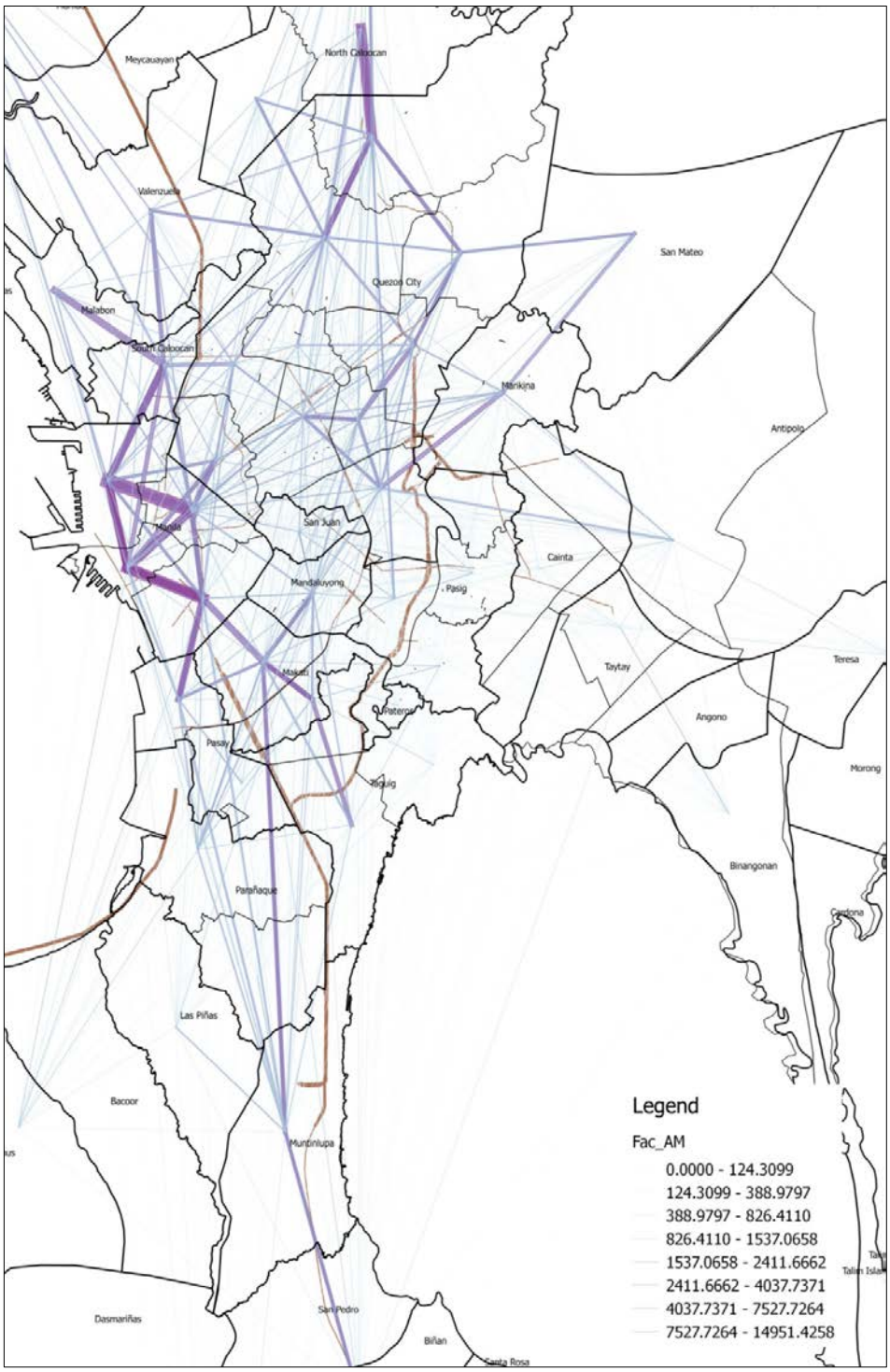

Figure 4 OD Pairs between 50 zones - AM

Overall, the presentation of OD pairings highlights the complex movement of people and the polycentric nature of Metro Manila. This demonstrates the complex nature of planning a public transport system to accommodate all of these movements in an efficient way.

6. SWOT ANALYSIS OF ROAD TRANSIT PROVISION IN METRO MANILA

A helpful way to understand what changes might be required to a public transport network is to examine the strengths and weaknesses of the existing system to ensure that strengths are built upon and weaknesses are overcome within a new network. In addition, overcoming any threats (or at least managing them) and exploiting potential opportunities would also help to ensure the outputs of this study lead to a much improved public transport network for Metro Manila. This section will therefore carry out a SWOT analysis of existing public transport provision to inform the development of an optimised road transit network, although will not focus solely on the public transport network, but also wider elements of the transport network that impact upon public transport supply. Figure 5 presents an illustration of the SWOT analysis.

Strengths

- High existing PT usage amongst population
- Existing mass transit provides spine to road transit network
- PUJ and PUB Services operate at high frequencies
- Some good interchange facilities at shopping malls
- Network of tricycles enable passengers to complete end-end journey by PT
- Strong desire by DOTC to improve PT provision

Weaknesses

- Collection of routes rather than planned network
- Lack of network update as land use changes
- Need for operators to make profit leads to some areas poorly served by PT
- Reduced road capacity due to PT vehicles breaking down, slow to accelerate at junctions and from stops, poor driver behaviour due to on-street competition
- Poor walking and cycling infrastructure
- Poor interchange between LRT and MRT at Cubao, Retro, Taft etc
- Poor quality PUJ and PUB vehicles
    - Poor air quality
    - Poor access
    - No dignity of travel
- Highly fragmented and individualized operations. Each driver is armed only with what he knows - very limited information

Opportunities

- Desire for large corporations to invest in/support PT network development
- Trunk road network has high capacity for on-road mas transit
- Several under-served PT corridors e.g. C5, C3, Roxas Bvd
- Potential to increase capacity on MRT and LRT
- Large numbers of different bus companies, so opportunities for them to be involved in optimised, organised PT network
- 3 proposed provincial bus terminals enable opportunities to introduce high quality interchange facilities
- Developers constantly looking to develop new land, which enables properly planned PT services to be implemented at the outset

Threats

- Increasing car ownership levels
- Lack of a link between development and PT planning
- Lack of planning regulations
- Polycentric nature of MM makes it difficult to cater for passenger demand
- Urban sprawl encouraging car ownership
- High number of people employed by PUJ and PUB industries, therefore reliant upon the income generated by the industry
- Staff at DOTC lowly paid. Threat to long term delivery and management of service based contracts and ongoing PUV network development

Figure 5 SWOT analysis of road transit provision in Metro Manila

This paper will not comment on these elements as many are self-explanatory, but does supplement the SWOT analysis with conclusions of other relevant reports. There are a variety of studies that have highlighted the issues and problems of the existing public transport supply within Metro Manila, including the DOTC Medium Term Land Transport Action Plan 2005-2010. This highlighted a variety of issues with public transport provision, including:

- Inefficient public transport services
- Poor enforcement of traffic rules
- Inadequate intermodal connections among road based and rail-based public transport services

The issues highlighted in 2005 remain in 2013 and the outputs of this study will play a role in rectifying the issues that have existed for many years. It is however important to consider in more detail the deficiencies of public transport provision in Metro Manila to ensure that this

study can fulfil its objectives.

It is important to note that the supply of public transport services and the development of new or amended routes are not linked to customer demand. One of the key functions of the LTFRB is "to prescribe and regulate routes of service, economically viable capacities and zones or areas of operation of public land transportation services provided by motorized vehicles in accordance with the public land transportation development plans and programs approved by the Department of Transportation and Communications." However, as was reported within the 2007 Mega Manila Public Transport Study (MMPTS), "in practice, the agency rarely prescribes the routes that are opened to applications. In fact, the public transport network of Mega Manila has developed through route additions and withdrawals at the instigation of the operators". This has led to a public transport supply that, on the whole, exists to meet the needs of operators and not necessarily the needs of the passengers it carries.

A key contributory factor to the inefficient operation of the public transport network in Metro Manila has been the historical lack of co-ordination and monitoring of services by LTFRB. This has been partly rectified through the GTFS study in 2012; however the legacy of a lack of co-ordination and monitoring of franchises remains. The DOTC is aware of illegal practices whereby operators who have more licences than they require "lease out" their spare licences to other operators. The lack of robust and coordinated enforcement to prevent this from happening allowed such practices to occur.

PUJ and PUB drivers are paid on a commission basis whereby the more passengers they carry, the more money they will make. There is therefore a highly competitive market and this competition is often "fought" on the streets of Metro Manila and can lead to erratic behaviour that flaunts road traffic rules. With a history of poor enforcement of road traffic violations, this has led to a situation where the behaviour of public transport vehicles affects and inhibits other road users. This leads to an inefficient use of road space as significant amounts of space is given to PUJ and PUB vehicles where they pull over to pick up and drop off passengers.

PUJ and PUB services often wait until they are full before the service departs a terminal which can result in various issues:

- Long wait times for passengers who board when a vehicle is empty
- Irregular headways so passengers wishing to board a service part way along the corridor do not know when a service may arrive
- Full vehicles mean that a passenger has to alight before others can board, resulting in longer waiting times for those wishing to board a service part way along a corridor

While there are some interchanges within the metropolitan area that enable passengers to switch between modes, there is greater scope to integrate PUB and PUJ services with LRT and MRT services. A more coordinated approach to public transport provision with a clear hierarchy and a structured network with strong levels of integration between modes at key interchanges is required.

Other public transport related issues highlighted by the DOTC include:

- Lack of road safety enhancement measures
- Lack of road safety enhancement measures
- Inadequate standards and procedures on driver and vehicle safety
- Poor coordination among land transport agencies

7. MASS TRANSIT NETWORK DEVELOPMENT

To develop a network best suited to passenger demand, this study has employed two types of transport model, a highway assignment model and a public transit model. The first model involves assigning the Origin-Destination (OD) matrix to the road network using a simple highway assignment model. The second model assigns the OD matrix to defined transit routes within the metropolitan area.

The highway assignment model was initially used to understand where passenger demand exists and where they would actually travel if all supply side restrictions associated with transit routes were removed. These include the alignment of each route as well as frequency, capacity and fares. This model assigns the OD matrix as if each person were in their own car. The model is still sensitive to the capacity and speed of each road, so not all supply side restrictions are removed and congestion still builds up on each road. This ensures that the roads can accommodate the projected flows of demand and the situation does not arise whereby significant numbers of passengers travel along a minor road because it offers the shortest path.

The highway assignment model was used to explore how passengers would best choose to travel throughout the metropolitan area and this analysis was used produce a first draft of corridors and routes where passenger demand warrants mass transit services. Each of these mass transit routes was then tested using the more complex public transit assignment model which assigns each passenger to specific transit routes. For each proposed route, consideration was given to serving key trip attractors and those areas where demand is greatest. The development of a network of routes was also essential, with different alignments tested to examine which network best meets passenger demand. An iterative process was then followed by which different route arrangements were tested to arrive at a final recommended mass transit network. Ultimately, the final recommended mass transit network was based on carrying the greatest number of passengers.

The initial outputs from the initial highway assignment model showed the most popular corridors and which would warrant mass transit services i.e. services with a passenger per hour per direction of 4,000 or more. The following were identified as possible mass transit corridors:

- McArthur Highway
- NLEX
- Rizal Avenue
- Quirino Avenue
- A Bonifacio
- Mindanao Avenue
- Quezon Avenue
- Commonwealth Avenue
- EDSA
- C5
- Aurora Boulevard
- Ortigas Avenue
- SLEX
- Taft Avenue
- Roxas Boulevard & Coastal Road

Select link analyses were performed along each of these corridors to understand where the passenger demand that uses each corridor comes from. These analyses led to the development of nine mass transit routes that were then tested within the public transport model.

A second iteration of the public transport model was carried out with modified and additional routes included. These are presented in Table 3. This shows a healthy demand on each corridor and justifies implementing mass transit services along each of them.

Table 3 Forecast daily passengers on each modelled mass transit route – final iteration

Main Corridor	**Service**	**Forecast daily passengers**
Aurora Boulevard	Marikina to Pier 4	677,422
Quirino Highway, A Bonifacio, Rizal Ave, McArthur Bridge	SM Fairview-Lawton (via Quirino Highway)	477,518
Roxas Boulevard and Cavite Expressway	Zapote to Lawton	190,044
Quezon Avenue	SM Fairview to Baclaran, with unsegregated running along Commonwealth	563,257
McArthur Highway, Rizal Avenue	Marilao-Lawton	483,332
SLEX, C2, Nagtahan Bridge	Alabang to Rizal Avenue (Blumentritt)	430,590
Taft	Lawton to Baclaran (this could form an extension of the Quezon Avenue route)	412,171
Ortigas Avenue	Antipolo to Gilmore LRT 2 station (for continuity, this route could extend down Aurora to Divisoria)	394,053
C5, Commonwealth, Global City, Makati, Buendia	SM Fairview to Roxas Boulevard via Global City and Makati (unsegregated running on Commonwealth)	400,216
C5, Commonwealth, SLEX	SM Fairview to Alabang via C5 (unsegregated running on Commonwealth)	326,435
Global City, Makati, SLEX, C2	Global City to Rizal Ave (Blumentritt) via Makati	278,553
Quirino Highway, Mindanao Avenue	SM Fairview-SM North via Mindanao Ave	254,008
SLEX	Sta Rosa to Alabang	180,022
Juan Luna St, Recto, McArthur Bridge	Sangandaan to Lawton via Divisoria	134,934
Quirino Highway	San Jose Del Monte to SM Fairview	103,987
Alabang - Zapote	Alabang - Zapote	77,293

This second and final iteration of the public transport model established 15 individual routes that warrant mass transit services i.e. all routes carry more than 4,000 passengers per peak hour per direction. This network of mass transit routes is presented in Figure 8 below. Note that existing and approved mass transit routes (MRT7, LRT 1 and 2 extensions) are included as they were assumed to have be constructed within the model.

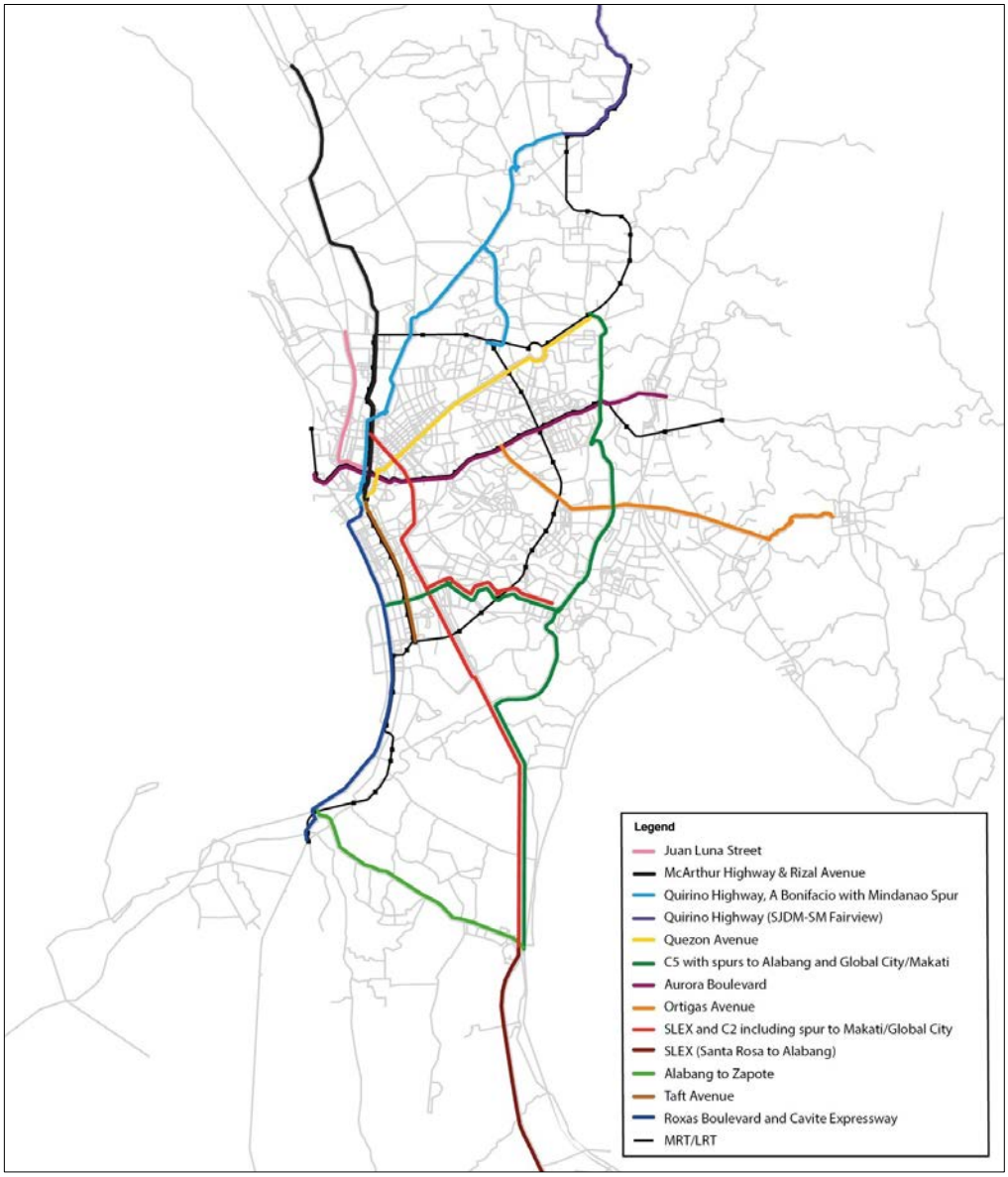

Figure 6 Proposed mass transit network

8. APPRAISAL OF PROPOSED TRANSIT NETWORK AGAINST OBJECTIVES

One of the primary tests of the proposed transit network developed through this study is to appraise how it performs against the objectives set out as part of this study. This section will look back at the objectives and consider how the proposed network meets these objectives. These will be considered in turn.

1. Enables the efficient movement of the travelling public across MM - service oriented to meet traveler demand, not profit oriented

The proposed mass transit network does enable the efficient movement of people across Metro Manila. The routes and services that have been designed have been done so to meet passenger demand regardless of the ability of an operator to make a profit.

2. Enables people to travel in an environmentally sustainable manner

It is proposed that mass transit services will have a minimum requirement of a Euro 4 engine (assuming BRT is the optimal mass transit mode), although the precise specification may be dictated by developing government policy. This study has carried out an assessment of the likely benefits of the proposed network in terms of CO2 emissions and has shown that there will be more than 500,000 fewer tonnes of CO2 emitted into the environment by road transit services each year than at present. A reduction in CO2 emissions of approximately 23% compared to today.

3. Is cost effective for passengers & commercially viable for operators

This study has not considered how cost effective the proposed mass transit network might be as this is dependent upon the outcomes of the integrated ticketing project in terms of fare policies, and the DOTC Reform Programme with regards to how service based contracts might work.

4. Supports the developed and evolving mass transit network

- Determination of the optimum public transport corridors
- Determination of the most appropriate mode of transport driven by demand
- Determination of most appropriate level of service, driven by demand

This study has determined the optimum public transport corridors and the routes that should operate along those corridors. This study has also determined the most appropriate mode for the remaining mass transit services.

It is recommended that the DOTC take on the findings from this study and carry out mass transit feasibility studies on the most dominant routes and corridors to develop a network of mass transit services across the metro. It is through these feasibility studies that the most appropriate level of service will be determined, although this study has illustrated approximate passenger demand, from which service levels can be estimated with relative ease.

5. Highlight where demand is of a level of intensity that may warrant and justify further mass transit systems or routes

As discussed above, this study has demonstrated where the level of demand is such a level of intensity that mass transit systems are required. Once MRT7 has been constructed, this study has shown that based on current demand, further metro lines are not necessarily required, instead, a network of alternative mass transit services can accommodate high levels of demand adequately. However, this study has made clear that the findings are based on existing demand, and there are a variety of factors that could influence travel demand in the short to medium term1. It could be the case that upon implementing mass transit services that demand is greater than forecast and would therefore warrant a higher level of service, such as metro. This emphasises the point again that constant monitoring of passenger demand with as high quality data as can be obtained is of paramount importance as the mass transit network of Metro Manila is developed over coming years.

Overall this study has, as far as it is able, met the original objectives and set out a clear plan for a network of mass transit routes to be implemented in the near future. The study has

[1] Demand can alter with growth, changes in car ownership and also the presence of mass transit might generate additional demand that is currently suppressed by lack of travel opportunity

advanced the understanding of the road transit network of Metro Manila to such an extent that there now exists a sound evidence base to develop a public transport network befitting of the National Capital Region.

9. CONCLUSIONS

This study has collated, collected, analysed and presented data that shows how the current road transit network operates. It is understood that this is the first time that data has been collected on this scale to provide such an in-depth examination of road transit services. It is evident that for the DOTC or any other organisation to advance transport policy making, comprehensive data is required in order to provide a robust evidence base to make sound policy decisions. Smart card data from all transit services, once smart cards are in use in Metro Manila, would provide a robust dataset from which transit services can be planned, monitored and amended. In addition, in the short term MUCEP data would also provide a valuable insight into existing transit demand which could be used to enhance the datasets developed through this study. However, in the long term smart card data would be the most valuable and accessible dataset, hence, it is recommended that the DOTC looks to roll out smart card technologies as soon as possible to better plan policies and transit services.

This study has demonstrated that existing PUJ and PUB services operate in an inefficient manner due to that fact that there are fewer services operating during the PM peak compared to the AM peak yet a very similar level of passenger demand, resulting in higher vehicle occupancy levels. This suggests that either operators do not understand the full extent of the road transit market or choose not to operate during the pm peak. As operators operate largely on a vehicle by vehicle or route by route basis, and because they do not have any record of passengers carried other than the revenue taken each day, they have little or no formal data to help them make informed decisions about their services. This highlights the role of this study in collecting such a wealth of data, and the importance to look at cross-metro travel patterns in order to understand these intricate details. This reiterates the need to collect robust datasets in future to support decision making.

While there are many weaknesses and threats to public transport delivery in Metro Manila, one fundamental strength that should not be overlooked is the fact that public transport usage is very high, despite the weaknesses in current services. This offers genuine potential for the DOTC to invest in a higher quality and efficient public transport system that meets the needs of passengers and allows the whole metropolitan area to function more efficiently.

Another strength identified within current road transit provision is that PUJ and PUB routes currently operate at very high frequencies. Highly frequent services are a fundamental part of an efficient transit network and one of the reasons why, despite the lack of a planned network, passengers can use existing services to make the journeys they want to make. It is important that in a newly developed transit network, the high frequent nature of services is maintained.

The SWOT analysis identified a lack of integration between land use planning and transport planning. For a metropolitan area with the population that Metro Manila currently has and the proposed increase in this population in the short-medium term, it is imperative that trips made by existing and new residents are accommodated within the transport system. A formal link between the planning process and the development of transport links would be highly beneficial, and active encouragement of transit oriented development is essential if Metro Manila is to cope with the pressures placed upon it now and in future.

Passenger travel demand patterns are extremely complex within Metro Manila. The polycentric nature of the metropolitan area leads to diverse travel patterns which the transit

network must accommodate, and which the transit network proposed in this study would accommodate. Despite the emergence in recent decades of modern business districts such as Makati, Ortigas and Fort Bonifacio, it is evident that Manila City still attracts a high proportion of public transport journeys alongside the more illustrious districts. It is therefore necessary to plan a network of routes and services that ensure that all of the business districts are well connected to ensure maximum accessibility. In addition, an efficient means of transporting people around the metro would not be on direct services from everywhere to everywhere else, but to have a coherent and complimentary network of services working together with planned interchange and passenger transfer locations to make the whole metro accessible from everywhere within the metro.

This paper has proposed 16 mass transit routes operating a long a series of different corridors with specific services that have been developed through an in-depth analysis of travel patterns. Several of the corridors have been well documented in past studies to understand whether mass transit services are required to accommodate passenger demand. However this study has gone an extra step to not only definitively set out where the greatest levels of demand currently are and where the greatest focus for mass transit services should be in coming years, but also the routes that services should take to best meet passenger demand. This study has demonstrated that designing a public transport network is not about single routes or corridors, but using those specific routes (which might operate down one or more corridors) to meet the majority of the demand, and then ensure there are strong connections and interchanges with other corridors and routes to provides seamless journeys across the metropolitan area.

When considering demand on a given proposed mass transit corridor, it is vitally important to be aware of the need to consider corridors as part of a network and not on an individual basis. This analysis has considered transit demand across the whole of the metropolitan area and therefore developed a network of services that complement one another, that connect with one another and enable large movements of people across the metro. By carrying out feasibility studies on an individual corridor basis the level of demand determined through such a study may not be evidenced. The appreciation and consideration of a network context is should be borne in mind when considering carrying out additional feasibility studies in the future.

10. ACKNOWLEDGMENT

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