The Use of Geographical Information System in the Assessment of Level of Service of Transit Systems in Kuala Lumpur

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Abstract

Due to heavy traffic and congested roads, it is crucial that public transport services are continuously monitored and improved to fulfill rider's needs and report updated information to transit agencies. This paper attempts to evaluate the level of service of public transportation provided by Rapid Kuala Lumpur using Geographical Information System (GIS). Using the customized GIS software, the transit supportive area is calculated with employment density at ten jobs per hectare or household density at 7.5 unit per hectare. The Level of Service is identified based on a percentage of the Transit Supportive Area covered by transit. This study shows that GIS can map the status of Transit-Supportive Area and identify the level of service provided by Rapid Kuala Lumpur.

Keywords: Geographical Information System (GIS); service coverage; transit supportive area; transit system

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1. Introduction

Transit services such as the Putra LRT, Star LRT, KTM Commuter, KL Monorail and rapid bus is one of the main public transport services in Kuala Lumpur. Riders in Kuala Lumpur rely on this public transport to travel from one destination to another destination within the city due to heavy traffic and congested road in Kuala Lumpur. Although the public transport in Kuala Lumpur has improved and developed, yet there are some tourist attraction places such as the Titiwangsa Lake and Lake Garden that has no availability of public transport. Therefore, the public transport should always be monitored and improved to fulfill the rider's requirement and be kept updated by the transit agencies.

Public transit should be encouraged because it can accommodate greater travel demand than cars. Increasing the share of public transit will reduce traffic congestion, improve air quality, reduce the number of accidents, reduce energy consumption, increase the number of viable transportation options and help improve the quality of life and create new economic opportunities. Transit agencies are always struggling with the attraction of riders in a highly competitive transportation market. One of the problems encountered by the transit agency is the presentation of the information and transit planning. Transit planning is defined as a purpose to plan, design, deliver, manage and review transit, balancing the needs of society, the economy and the environment.

Therefore, measuring the transit performance easily and accurately is very important for public transit agencies in transit planning. Transit performance measures have generated considerable components in a transit planning analysis. However, there is a need to investigate the underlying components of transit quality as this can reflect passengers' perceptions of transit performance while performance measures can reflect a wider range of perceptions, mainly on behalf of the transit agencies. Transit service coverage is one of the key components of quality of service.

The transit supportive area is the portion of the transit agency's service area that provides sufficient population or employment density to require service at least once per hour. Transit supportive area is areas determined to be having a good potential for significant transit ridership (O'Neill, W., D. Ramsey, and J. Chou., 1995). The transit level of service is based solely on the percentage of the transit-supportive area covered by transit (TCQSM 2nd Edition).

GIS-based transit system modeling is a computer-integrated tool for evaluating transit system model and performing various transit analysis methods for transit planning. The GIS applications for transit system modeling include transit service area analysis, data attribution and network representation, transit demand, transit distribution, linking transportation system and others. GIS can be employed to perform the transit supportive area analysis and calculate the level of service (LOS) based on the transit supportive area. The aim of this paper is to evaluate the level of service of public transportation provided by Rapid Kuala Lumpur using Geographical Information System (GIS).

2. Background of study

2.1. Quality of service measures and transit planning

Transit quality of service is the appraisal of transit service from the passenger's point-of-view. It takes a different approach to service evaluation than that historically used by the transit industry, which is to measure the business aspects of transit service – things such as ridership, cost-effectiveness, and productivity. Transit quality of service appraisal are not intended to replace these traditional measures but somewhat to supplement them. For an example, transit quality of service measures can help transit agencies better understand their ridership patterns and help them plan their service to supply the best quality of service possible to the greatest number of potential customers within the constraints of their budget.

There are two primary aspects of quality of service to consider. The first is the availability of service both geographically and by the time of day. If the service does not available between the locations where one wants to travel or does not provide at the time one wants to travel, then transit isn't an option for that trip. Besides that's, even if the service is available, but people need to know how to use it and utilized it. This is when the transit planning is very important for the transit agencies to make sure the transit service is available for the convenient of the riders.

The second aspect is the comfort and convenience of the service. This encompasses a number of factors for an example, the waiting environment at the bus stop, the ability to get a seat on the bus, the overall travel time, the
reliability of the service, passenger's perceptions of the safety and security of the trip and the cost of the trip relative to other choices. Assuming transit is an option for a trip, these factors help influence whether one would choose the transit or not to use it.

Six measures of quality of service for fixed route transit system has been identified in Transit Capacity and Quality of Service Manual, 2 Edition (TCQSM) which is to passengers and transit agencies. The six measures are listed in the Table 1 below.

Table 1. TCQSM fixed-route transit quality of service measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Transitt Stop</th>
<th>Route Segment</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability</td>
<td>Frequency</td>
<td>Hours of Service</td>
<td>Service Coverage</td>
</tr>
<tr>
<td>Comfort &amp; Convenience</td>
<td>Passenger Load</td>
<td>Reliability</td>
<td>Transit-Auto Travel Time</td>
</tr>
</tbody>
</table>

2.2. Transit availability

There are a number of conditions that affect transit availability, where all of which need to be met for transit to be an option for a particular trip:

- Transit must be provided near one's trip origin. If demand-responsive service is not provided to one's door, a transit stop must be located within walking distance and the pedestrian environment in the area should not discourage walking (e.g., due to a lack of sidewalks, steep grades, or wide or busy streets). Persons with disabilities require a continuous ADA-accessible path to the transit stop. One may also be able to ride a bicycle to a transit stop if bicycle storage facilities are available at the stop or if bicycles can be carried on transit vehicles. Similarly, one may be able to drive to a park-and-ride lot if such a lot is provided along the way and space is available in the lot.
- Transit must be provided near one's destination. The same kinds of factors discussed for the trip origin apply to the trip destination as well, except that bicycles or automobiles left behind at the boarding transit stop will not be available to passengers at their destination.
- Transit must be provided at or near the times required. In most cases, service must be available for both halves of a round trip—from one's origin to one's destination, as well as for the return trip. If passengers perceive a risk of missing the final return trip of the day, or if transit is available for only one of the two halves of passengers' round trips, transit is less likely to be an option for those passengers.
- Passengers must be able to find information on when and where transit service is provided and how to use transit. If passengers are unable to find out where to go to board transit, where they need to transfer, how much the fare will be, and so forth, transit will not be an option.
- Sufficient capacity must be provided. If a transit vehicle must pass up passengers waiting at a stop because the vehicle is already full, transit service was not available at that time to the passengers waiting at the stop. If all of these conditions are met, transit is an option for a particular trip. Then, the passenger will decide to use transit will depend on the comfort and convenience of the service relative to competing modes.

2.3. Transit comfort and convenience

The kinds of questions weighed by potential passengers when assessing the comfort and convenience of transit service are often not all-or-nothing. Each person assesses particular comfort and convenience factors differently, depending on his or her own needs and situation. A passenger's decision to use transit rather than a competing mode (when transit is an option) will depend on how well transit service quality compares with that of competing modes. Some of the most important factors that affect transit comfort and convenience are the following:

- Passenger loads aboard transit vehicles. It is more uncomfortable to stand for long periods of time and the time spent standing may not be able to be used for more productive or relaxing purposes, such as reading.
- The kinds of passenger amenities provided at transit stops.
- The reliability of transit service.
• Door-to-door travel times, by themselves, and in relation to other modes.
• The out-of-pocket cost of using transit, relative to other modes.
• Passengers' perceptions of safety and security at the transit stop, onboard vehicles, and walking to and from transit stops.
• Whether transfers are required to complete a trip.
• The appearance and comfort of transit facilities.

2.4. Modern transit system in Kuala Lumpur

Mass transit systems are becoming popular in metropolitan cities. Light Rail Transit (LRT) systems that are the modern version of street cars are one of the more popular transit systems in Kuala Lumpur. LRT is an important part of modern transit system due to its ability to transport high numbers of passengers comfortably, efficiently and quickly. Monorail is also an important mode of public transportation in Kuala Lumpur. Since the tracks of the monorail system require minimal space horizontally and vertically, therefore this system is usually located in the middle of busy and congested areas.

Modern transit systems in Kuala Lumpur consist of six transit systems. They are the Ampang Line, Sri Petaling Line, Kelana Jaya Line, KTM Commuter, Express Rail Link (ERL) and Rapid KL bus system. Ampang Line, Sri Petaling Line, and Kelana Jaya Line are the LRT systems operating under one main operator that is the Rangkaian Pengangkutan Integrasi Deras Sdn Bhd (RAPID KL). The routes of these three systems cover most areas of Kuala Lumpur and some areas of Selangor. KL Monorail is operated by KL Monorail System Sdn Bhd, which runs through the central areas of commercial buildings, hotels, and shopping arenas in the Kuala Lumpur district. KTM Commuter is Malaysia's first electrified rail system operated by KTMB Berhad. This commuter rail system serves certain areas in Kuala Lumpur and Selangor. ERL is a high-speed air-rail system between Kuala Lumpur City Air Terminal at KL Central Station and Kuala Lumpur International Airport (KLIA).

3. Methodology

Fig. 1. Research methodology flow chart
The overall research process is outlined in Figure 1. It illustrates the series of sitting process which starts from objectives of the study, identifying the related parameters and data, data acquisition, preparing and organizing the data into GIS, analysis process and finally presenting the application by creating the program for the application for public usage.

The data that were collected is converted into GIS format (shape files). The data that were collected in hardcopy, manual digitizing were performed to convert them into the GIS format. The data that were collected are:

- Transit routes and stations (Putra LRT, Star LRT, Monorail, and KTM) – using GPS
- Rapid KL bus stops – using GPS
- Street maps – JUPEM, Lake, and Building Maps
- Census data i.e. population, household data, socioeconomic data, employment and industry from Department of Statistics. (This data were determined using the zone boundary in Kuala Lumpur with a total of 881 zones.)

4. Analysis and results

4.1. Application of the parameters

There are twelve (12) parameters that have been collected to develop the transit information system using GIS. The parameters namely Rapid KL bus stops, Putra LRT lines and stations, Star LRT lines and stations, Monorail lines and stations, KTM lines and stations, streets, building such as commercial and residential and lastly lake. All these parameters were chosen because these parameters facilitate a lot in the development of transit information system in the city. Figure 2 shows the transit systems that have been chosen for developing the transit information systems. The lake parameters affect the transit system because riders could not assess the transit systems.

![Fig. 2. Transit systems chosen for developing transit information systems](image-url)
4.2. Service coverage area

The second step that has to be taken for the development of transit information system is to determine the service coverage area for each transit systems. The service coverage area measure identifies which area in a city or region is capable of supporting at least hourly transit service, and measures the proportion of those areas served by transit. It is a useful tool for identifying potential unattended transit markets. When supplemented with demographic information, this kind of analysis can also be used to identify potentially underserved neighbourhoods that are areas that currently receive some transit service but are not capable of supporting additional service.

4.3. Application of service coverage area

An application for generating service coverage area for every transit system has been created using the visual basic programming language. This application can produce the service area layer (buffering) with the desired radius distance. Figure 3 is the interface of the service coverage application that was programmed using the visual basic programming language. Figure 4 indicates the buffering zones for Putra LRT Rails, Stations, and Rapid KL Bus Stops. All three parameters were combined into one layer and intersect with the census data to represent the layers of zones data. Figure 5 reveals the total area covered these transit systems. As can be seen, the total area covered is 9571.513494 hectares, and the minimum and maximum area covered is 0.087555 and 668.705352 hectare.
Fig. 5. Frequency distribution of total area covered

Fig. 6. Buffering zones Monorail Rails, stations and Rapid KL bus stops

Fig. 7 Frequency distribution of total area covered for buffering zones Monorail Rails, stations and Rapid KL bus stops
Fig. 8. Buffering zones KTM Rails, stations and Rapid KL bus stops

Fig. 9. Frequency distribution of total area covered for buffering zones KTM Rails, stations and Rapid KL bus stops

Fig. 10. Transport supportive area served for Monorail and Rapid KL Bus
Figure 6 indicates the buffering zones for Monorail Rails, Stations, and Rapid KL Bus Stops. All three parameters were combined into one layer and intersect with the census data to represent the layers of zones data. Figure 7 reveals the total area covered these transit systems. As can be seen, the total area covered is 8489.914249 ha and the minimum and maximum area covered is 0.087555 and 668.705352 ha.

Figure 8 indicates the buffering zones KTM Rails, Stations and Rapid KL Bus Stops. All three parameters were combined into one layer and intersect with the census data to represent the layers of zones data. Figure 9 reveals the total area covered these transit systems. As can be seen, the total area covered is 11019.096467 ha and the minimum and maximum area covered is 0.087555 and 668.705352 ha.

Figure 10 indicates the buffering zones for Putra LRT, Monorail, KTM, Star LRT Rails Stations and Rapid KL Bus Stops. All three parameters were combined into one layer and intersect with the census data to represent the layers of zones data. As can be seen, the total area covered is 17012.233504 ha and the minimum and maximum area covered is 0.087555 and 668.705352 ha.

Figure 11 shows the transport supportive area served for Monorail and Rapid KL Bus and figure 12 shows the transit supportive area served for KTM and Rapid KL Bus. The transit supportive area analysis were calculated with
the employment density of at least ten jobs per hectare (4 jobs / acre) or household density 7.5 unit / hectare (3 unit / acre). The range shows that most zones have the employment density range that falls within 0.000000 to 27.907581 per hectare followed by the range from 27.907582 to 56.700569 per hectare. The range 1458.207383 to 5013.997954 per hectare has the lowest number of zones of employment density covered. This shows that almost all people in the area in Kuala Lumpur city have a job.

4.4. Level of service application

Findings show that the level of service for the Putra LRT and Rapid KL Bus is less than half of higher-density areas served and the percentage transit supportive area served by transit is 42.51%. The level of service for Monorail and Rapid KL Bus is also less than half of higher-density areas served and the percentage transit supportive area served by transit is 37.71%. On the other hand, the level of service for KTM and Rapid KL Bus is about half of higher-density areas served and the percentage transit supportive area served by transit is 55.71%.

5. Conclusion and recommendation

The research investigated how application of Geographical Information System (GIS) software can be used in transportation planning for public transit agencies. It also developed a GIS-based Kuala Lumpur Transit Information System (KLTIS) database system which is an information system that will be designed to serve as a one-stop data depository for transit planning in Kuala Lumpur. Five transit systems, namely Light Rail Transit (LRT), Monorail Transit, Keretapi Tanah Melayu (KTM) and Sri-Petaling Transit Line (STAR) and Rapid KL bus transit were chosen as case studies. Transit supportive area shows the significance of transit ridership for this particular area. Areas that are covered with sufficient population and employment density are having potential for good transit ridership. The level of service (LOS) for the transit services can be calculated with the percentage of transit supportive area covered by transit. The following recommendations were suggested for future research:

- For future studies, it would be useful to incorporate more data into the GIS-based analysis. For example, the Florida Transit Information Systems considered more than 13 map layers during their development of transit information system, increasing the relevancy of the final output.
- In a real case study, a broad knowledge of parameters must be employed for the analysis. The incorporation of the parameters from each of the environmental, socio-political, engineering and economic aspects is necessary for a precise conclusion to be made.
- Perform an analysis in 3D view can give a greater impact of visualization in presenting outcome of the system. It can give a clearer view of the site location and its surrounding areas as well.
- The service coverage is one of the qualities of service measures that have been applied in this study of transit planning, thus for future research it is recommended to employ the other quality of service measures such as transit auto-travel time, hours of service, frequency, passenger load and reliability for better performances and output towards transit planning.
- Develop a web application using the ArcGIS server for ease the related parties to view and analyze work scopes.

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