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Measuring the Performance of a Public Minibus Transit System: Case Study of Sweileh District, Amman, Jordan

Moawiah Alnsour(1), Sora Omari(2)
[1]*Assistant Professor of Civil Engineering, Civil Engineering Department, Isra University, Amman 11622, Jordan.*
[2] *Lecturer of Civil Engineering, Civil Engineering Department, Isra University, Amman 11622, Jordan.*
Corresponding Author: Moawiah Alnsour

ABSTRACT
A public transit system is essential for any community in order to develop socioeconomic growth. Performance measures are the navigation tools that can help public transit authorities and city governments determine where they want to go and how to improve the services provided for people. They have many practical applications including trend analysis, comparisons, target setting, system improvement, and incentives for managers and employees. Performance measures help in identifying potential problems and optimal solutions. Therefore, the investigation of a set of performance measures that play a significant role in public transit planning and management is needed for developing cities to start adopting performance evaluation. In this regard, this paper investigates the performance measures for a successful public minibus transit performance evaluation system in Sweileh district, Amman, Jordan. These performance measures are accessibility, mobility, productivity and comfortability. The results show that the overall performance measures are significant, but the most important performance measure is the productivity represented by recovery cost with respect to the operation. Indeed, the current system suffers from high waiting times and in-vehicle times; thus, the mobility of the whole system is reduced. However, on the other hand, in respect to the end users, the most significant measure is to ensure the accessibility is the most proper one to achieve the end users' needs and then to effectively manage the performance of the public transit system for minibuses in Sweileh district, Amman, Jordan. Therefore, the findings of this paper would be useful for policymakers, analysts and practitioners involved particularly in Sweileh district and for public transit planning.
Keywords – Amman, Jordan, minibuses, performance measures, public transit system.

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I. INTRODUCTION AND LITERATURE REVIEW

Transport is a vital sector for the economy, and it is an important element of daily life for Jordanians. In the past decade, the country has heavily invested in expanding the sector, which constitutes the backbone of the national transport system, improving urban transport, and enhancing the logistics industry and the international connections (MoT, 2017). In fact, transport demand is growing rapidly, due to a growing population and the economic development within the country and in the region. Jordan is having to bear a huge share of the global responsibility for hosting more than 1.3 million Syrians, with 630,000 of them being registered refugees (Jordan Times, 2017). This stress has grown over the years, as the influx of refugees escaping violence in their country has rapidly increased, which places significant pressure on Jordan's economy, communities and public services (Awad, 2016). Moreover, with 55% of Amman's population under the age of 25, there will also be a very substantial natural growth in population independent of future inward migration and factors linked to economic growth, and, more importantly, there will be unprecedented demand for mobility as this population enters the work force (GAM, 2017).

Recently, due to the population growth, the public transit system in Jordan is considered to not be meeting users' (or the Jordanian community's) requirements. Indeed, there is an increased demand on the social and economic public infrastructure in terms of electricity, water and wastewater network, schools, roads, hospitals and public transit (MPWH, 2017). Thus, an efficient and effective transport system including both passenger and goods transport is crucial to meet the increased demand on the public transit system (MoT, 2017). This dramatic increase is concentrated on parts of the transport networks near the main urban areas and along the key roadways. Consequently, parts of the network are under pressure, and performances are below what is required. Without intervention, things

will worsen and, at the end of the next decade, the system will not be able to perform as needed to support the Jordanian economy and daily life of the country's citizens (MoT, 2017).

However, a network of mainly unscheduled bus services of different types provides public transit services in Jordan (MoT, 2017). The overall public passenger transit system includes buses, minibuses and jitneys, which have a 14% mode share (GAM, 2017). Historically, a weakened public transit system is due to infrastructure investments which have focused on roads and bridges, rather than public transit. As a result, passenger transit in Amman is underdeveloped, unreliable and lacks a well-structured hierarchy of transportation modes and services. Bus services are quite poorly developed for the size of the city, with a large proportion of public transit trips being made by smaller vehicles (GAM, 2017). Therefore, most cities in Jordan experience insufferable congestion levels. This congestion is caused by the lack of acceptable passenger transit services; consequently, many private vehicle owners use their cars instead of public transport (Al-Masaeid and Shtayat, 2016). This situation creates large pressure on the existing infrastructure, which requires huge investments to ease this problem and improve the services provided for public transit users. Therefore, improving the public transit system in Jordan may cause an increase in demand from people using it instead of using their private cars.

In fact, the transit infrastructure needs to be invested in based on the requirements of public transit users. Therefore, efficient transit services can generate employment, create effective wealth and drive economic development (UNDP, 2015). Public transit infrastructure should be accessible for all genders and ages (Shen et al., 2010), and ensure the requirements of elderly and disabled people are considered (Valdes-Vasquez et al., 2012). Therefore, in order to improve and manage public transit services, there is a need to measure the performance of the public transit system.

Indeed, measuring the performance of public services which are provided to public transit users is a difficult task. Public transit users have different attitudes and interests, so policymakers need to work in cooperation with different parties in the country to achieve the required results. Therefore, in this paper an investigation has been conducted to measure the performance of the public transit system provided to focusing on how to improve these services to meet customers' expectations regarding accessibility, mobility, productivity and comfortability. Hence, in order to do so and make public transit attractive, public transport needs to be planned, operated and marketed well and then monitored on a continual basis (GIZ, 2011). As a result, the congestion would be decreased, which will result, in turn, in comfortable, accessible and friendly journeys (Edama, 2016).

In Jordan, passenger transit means include buses, minibuses and shared service taxis, which are working on fixed routes (Al-Masaeid and Shtayat, 2016). The use of more efficient modes such as bus rapid transit (BRT) and light rail systems is necessary, especially for large cities such as Amman, which has a population of more than four million (GAM, 2017). Therefore, if the transit infrastructure is being planned for decades ahead, the outcomes which can be obtained at different national and local levels will have positive impacts upon the community (UNDP, 2015). In fact, performance measures are extensively used in transport planning worldwide (GIZ, 2011). Therefore, the importance of this paper is in the need to measure the performance of the public minibus transit system, which is the most attractive service provided for people in Jordan, in which the extent of this service achieves the country's objectives in the line of sustainable development. The research probed into these measures that can evaluate the services provided to public transit users to provide a happier journey, friendly community, reduce the number of road accidents, reduce the travelling time on the network and improve the operational cost recovery.

Several studies have been carried out to determine the relevant performance measures for a public transit system. Generally, measuring the performance of the public minibus transit system is an essential practice for effective planning and management of the public transport system (GIZ, 2011).

As a result, a study was conducted by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ, 2011) in measuring the performance of the public transit system for developing cities. The study summarized different performance indicators from developing cities' experiences and lessons learnt from different countries. The study indicated that more than 400 indicators can measure the performance, while the major themes can be categorized into availability, service delivery, community impact, travel time, safety and security, maintenance and construction, and economic and financial viability. The study concluded that each of these measures are essential to improve the public services delivery for people and to track the organization's achievement of its intended objectives.

Furthermore, Al-Masaeid and Shtayat (2016) conducted a research study to investigate the performance of urban transit in Jordan. Their study employed field surveys to investigate several

performance measures of the country's urban transit system. Their findings indicated that several measures would be needed to meet the intended performance of the urban transit system in Jordan, namely, accessibility, mobility, productivity, punctuality, waiting time and comfortability.

Most recently, Tashman et al. (2019) investigated the accessibility of public transit routes in Amman, Jordan, through evaluating the performance of the service and its convenience for the public. However, the study employed only one performance measure, the accessibility of public transit routes.

However, despite these above studies, Sweileh district in Amman, Jordan, still needs to be investigated to measure the performance of the public minibus transit system. The current research study, therefore, employed triangulation of research collection methods by collecting data from archival documents, self-observations and field surveys. The research's significant contribution comes from its employment, firstly, of triangulation of data collection methods for performance measures of the public minibus transit system. Secondly, it is the first piece of research that has been conducted in Sweileh district in Amman.

II. METHODOLOGY AND DATA COLLECTION

Research methodology is a process for how to collect data from respondents. Data collection is a communication process that involves the transferring process from the provider (respondents) to the collector (researcher) (Fellows and Liu, 2008; p150). Data collection can be classified as being primary or secondary. In collecting data for this study, a triangulation technique was employed using both primary and secondary data through employing several common research methods to complement each other. These research methods for collecting data, according to Bryman (2003), are namely: Interviews, Questionnaires, Observation and Analysis of documents. As a result, different data collection methods might be employed to reduce and eliminate the limitations and the disadvantages in each of them while gaining the advantages from each (Fellows and Liu, 2008; Utomo, 2011). It improves the accuracy and increases confidence in the research data and findings (Mlybari, 2012).

In this research paper, for each performance measure different methods of data collection were used to investigate the current services provided to people. In-depth investigation was employed by conducting face-to-face interviews to reach a deep understanding about the current situation regarding the public minibus services and rich primary data were collected from respondents. Archival documents were used as one of the techniques for collecting data. Therefore, in this study, documents from related sources were collected. Data were obtained on transit routes and route length, and maps were obtained from the Greater Amman Municipality (GAM)/Department of Geographic Information's system. Information on fleet size on each route and fare level was gathered from bus operators and users of the public transit system. Table 1 illustrates the number of public transit vehicles and number of routes in Sweileh district, Amman, Jordan.

Observation is another technique used to collect data. It is a systematic description of events, behaviours and artefacts in the social setting chosen for study (Marshal, 1989) cited in (Kawulich, 2005). Observations enable the researcher to describe existing situations using the five senses, providing a "written photograph" of the situation under study (Mlybari, 2012).

It includes different types of observation, such as listening and watching. The quality of the research will then be based on the level of the accurate data provided from observers who interact or participate in the research (Mlybari, 2012). Regarding the current research, this technique has been used for data collection. A direct observation technique was used in investigating the waiting time and travelling time, for example.

Lastly, a closed multiple choice questionnaire survey was also distributed to obtain users' responses about the public minibus transit system in Sweileh district, Amman, Jordan, which gave a wide picture of the performance provided by the public minibus transit services.

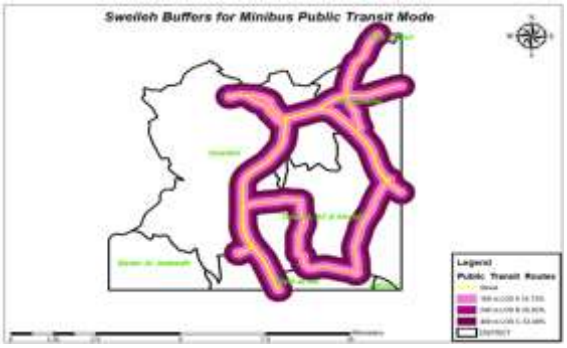

Figure 1: Coverage areas for public minibus transit routes in Sweileh district in Amman.

III. DATA ANALYSIS AND RESULTS

3.1 Accessibility

To find out about accessibility, direct interviews with public transit users at bus stations in Sweileh were performed. The sample size is calculated based on a confidence level of 95%. The population of Sweileh district was found to be about 90,000, 400 questionnaires were distributed, and the

returned valid questionnaires were collected 383 with a high returned rate of about 96%.

The interviewees were asked to determine the time needed to reach the nearest bus stop and given four walking time options:

- X_1: 2 minutes or less,
- X_2: 2 to 3 minutes,
- X_3: 3 to 5 minutes and
- X_4: More than 5 minutes.

The survey was conducted during March 2019 and respondents were chosen randomly. About 63% of the sample size were females, due to the fact automobile ownership is higher among males than females.

The highest age grouping proportion in the sample was 18-23 years.

Figure 1 shows a map drawn using ArcGIS software to estimate the percentage of service coverage area and the percentage of served population within each buffer area. The procedure was implemented by creating buffer areas around each route. Buffers were created based on time and distance that people are willing to walk to access the transit service.

Based on a walking speed of 1.4 m/s, the buffer zones were set for a walking time of 2 minutes or less for a walking distance of approximately 160 m, and for 2 to 3 minutes and 3 to 5 minutes, the walking distances are respectively 240 m and 400 m.

Accessibility analyses were made for Sweileh district, Amman, Jordan. Accessibility is defined as the percentage of population served by public transit (Al-Masaeid and Shtayat, 2016). Accessibility was measured by conducting a questionnaire survey public minibus transit user at stations, and the average walking time to access the bus stop has been worked out based on the interviews. For each route, access was measured depending on time or distance to public transit route, terminals or stops (El-Geneidy et al., 2013). Several buffers were identified and three buffer zones have been set: 160 m, 240 m and 400 m from the transit route at each side, starting from the lightest pink buffer, which represents a distance of 160 m to the bus stop with a percentage of 16.73% of the total coverage area, the fuchsia buffer, which represents 240 m with a percentage of 26.82%, and the purple buffer, which indicates 400 m with a coverage percentage of 33.48%.

The Highway Capacity Manual (HCM, 2010) reported that the 400 metres distance is the limit of the areas served by public transit. Thus, only 33.48% of Sweileh district area is served by public transit. Figure 1 shows the accessibility of public transit for users in Sweileh district in Amman, Jordan. It reveals that the Sweileh district in Amman is not well served, thus it will be necessary to extend the radial routes and circumferential routes to improve accessibility.

Comparing the results with some international values, the obtained accessibility of 33.48% for Sweileh district in Amman was quite low in contrast to, for example, Los Angeles, Berlin, and Ontario – the corresponding values were 88%, 68% and 77%, respectively (Brooking Institute, 2010). Considering that the number of public minibus transit users in Jordan is high, this accessibility should be enhanced. To improve this situation, three actions are recommended. First, routes should be extended to serve new developments in the periphery of cities. Second, public transit routes should be restructured to improve internal coverage. And, third, circumferential routes are recommended to enhance passenger transfer and distribution and provide feeder routes to the main routes.

3.2 Mobility

Mobility was measured using the average travel speed of public minibus transit for each route. Fleet size and fare have been obtained from interviews with bus operators at different stations (note that the values are much greater than the data from the Land Transport Regulatory Commission (LTRC)). The average route length was obtained from Greater Amman Municipality (GAM) data.

For each route, five different bus operators were interviewed, so there were 80 such interviews in total. The average route length was adapted from GAM data.

The average speed on peak and off peak and the average number of stops were found from the researcher's observation: 4 trips were made on each route, 2 on peak and 2 off peak hour, thus 32 trips for each period. The field observations were carried out during March and April 2019. The number of stops were counted for each trip, while the average speed values were calculated from the overall trip time and the route length. The trip times were measured by a stopwatch starting from the moment the bus left the bus station until it arrived at the destination station.

The waiting time was found from interviews with bus users (the same as accessibility). The sample size was 383 respondents. The average waiting time for each route was calculated for on peak and off peak, and then these values were checked from the field observations.

The average waiting time was observed through the previous trips and checked by interviewing each minibus user. In fact, the fleet size can reduce the passenger waiting times (Al-Masaeid and Shtayat, 2016). The waiting time was measured during peak and off-peak hours. The results revealed that the average waiting times for

passengers for public minibus transit in Sweileh district were found to vary from 16 to 32 min during peak hours and from 13 to 20 min during off-peak hours. The World Bank (2008) reported that the acceptable waiting time for passenger for public transit vehicles varied from about 10 to 20 min. It is well known that public transport passengers arriving randomly at stations are served best when the time intervals between vehicles – also known as the headway – are equal. Therefore, the average waiting times for public minibus transit users for the investigated Sweileh district in Amman, Jordan, were found to be marginally high. However, field observations revealed that both departure and arrival times are not scheduled. Therefore, in order to overcome this issue and attract more users, operating minibuses need to be rescheduled.

In fact, average speeds of public minibuses may be affected by vehicle type, traffic level, type and length of route, and the number of stops during the trip. As such, travel speed was measured during peak and off-peak hours. Minibus speeds on peak and off peak and the average number of stops have been observed through trips on the minibuses; 4 trips for each route have been taken, 2 on peak and 2 off peak.

Table 1 shows the obtained results for the average speed of public minibus transit in Sweileh, district in Amman. The results revealed that the average speeds of minibuses in peak and off-peak periods were 20 and 26 km/hr, respectively. Thus, the average speed is considered low compared with cited values in the United States or Canada (Nakanishi, 1997). Also, the results revealed that the average speeds of minibuses for longer routes were higher compared with those for shorter ones. In general, the number of stops during the trips was very high. In fact, traffic congestion, topography, lack of traffic management and lack of exclusive lanes for public transportation may have a great influence on public minibus transit speed. Clearly, it is necessary to improve mobility, by introducing new public transit system models, such as the BRT system, especially in Amman city.

Route	Fleet size	Avg. Route Length (m)	Route Length (Km)	Avg. speed on peak (km/h)	Avg. speed off peak	Avg. no. of stops	Fare (JD)	Avg. waiting time on peak (min)	Avg. waiting time off peak (min)
1	21	13475	13.475	22	27	10	0.4	20	15
2	35	14800	14.8	23	26	10	0.45	22	14
3	18	22000	22	28	31	16	0.38	20	16
4	36	16100	16.1	21	26	8	0.35	19	14
5	5	11540	11.54	20	24	5	0.33	16	13
6	14	8500	8.5	26	29	5	0.35	26	18
7	29	12630	12.63	28	33	9	0.35	20	13
8	30	6350	6.35	19	24	4	0.3	18	14
9	6	15000	15	22	29	11	0.35	31	24
10	32	22000	22	25	35	16	0.4	24	20
11	8	28100	29.1	30	36	18	0.45	32	26
12	10	16100	16.1	19	22	7	0.35	21	16
13	7	25850	25.85	25	34	15	0.5	22	18
14	4	9000	9	23	26	6	0.35	24	20
15	25	22000	22	28	21	13	0.4	27	23
16	10	22400	22.4	31	36	17	0.4	26	21

Table 1: Minibuses Public Transit Routes Description

3.3 Productivity

Eighteen bus operators were interviewed, five operators for each route, and they were very cooperative in sharing all the information required to estimate the operating ratio.

The operating ratio of the public minibus transit system and daily passengers carried by each minibus transit were used for estimating the productivity of the public minibus transit. In reality, the productivity is considered as a combined measure of the efficiency and effectiveness of transit performance. The operating ratio was computed for each route as the ratio of yearly revenue to the yearly operating cost. Fuel, oil, maintenance, salaries and overheads, licensing, tyres, depreciation, taxes and insurance costs were included in estimating the yearly operating costs. These cost elements were obtained from transit operators and drivers, among other sources. The LTRC regulations stipulate that operational life of a minibus is 15 years. Thus, this value was considered in estimating depreciation rates. Furthermore, number of passengers carried by each minibus transit and number of daily trips were observed.

Also, bus operators were interviewed, and the findings were used in the analysis. Analyses indicated that the operating ratio of minibuses in Sweileh district in Amman was 3.8.

Compared with world statistics, values obtained in this study are significantly high and can be explained by stating that only direct costs have been monitored. Table 2 shows a list of operating ratios for minibuses from different countries. The table was compiled using a detailed calculation of the operating cost including direct and indirect costs. Fuel consumption rates, maintenance, insurance, wages, road toll payments, tire wear, depreciation and all administrative costs are included for each bus in the route.

Hence, operating ratios which are less than 1 indicate that the route is not self-supporting and government subsidies are required to cover the cost; even in a transportation-friendly region like Europe some routes have low operating ratios. However, operating ratios can be recovered by reallocating the revenues of other profitable routes. The operating ratios in Asia tend to be high due to the higher population/public transportation ratios. For example, the Hong Kong MTR Corporation is one of the few self-supporting transit systems in the world.

The large value for the operating ratio in Sweileh including the districts' cities may be explained by the fact that most public transit vehicles leave the terminals only when they are full, since the public transportation system in Jordan is unscheduled and operates under individual bus operators. The flat fare level is determined based on occupancy level of 90%. This explains the high

waiting times in terminals, especially during off-peak hours. Also, analyses revealed that the average daily number of passengers carried by a minibus on each route was about 5531. For each minibus transit, differences may be due to route length and configuration, number of stops, and density of passengers at each route. Based on these results, it is recommended that minibuses be replaced by buses as they have higher operating ratios and vehicle utilization. Based on the above utilization figures and fleet size in Table 1, public transit in Sweileh district in Amman carried nearly 88,000 passenger trips per day in 2019. This figure is relatively low for a population of four million. Amman has a high automobile dependency ratio because the public transportation system is poor. Also, if the transit fleet in Amman is converted into an equivalent number of buses, based on the number of seats, then the result would be about 1000 minibuses. Hence, the ratio of buses to 1000 inhabitants in Amman would be 0.25. This ratio is also very low compared with most statistics, which report that the ratio ranges from 0.5 to 1.2 minibuses per 1000 inhabitants (Brooking Institute, 2010). Thus, an increase of the fleet size is recommended for Sweileh district in Amman, Jordan.

Normally, the number of passengers on each minibus is 23. A 90% occupancy assumption has been made since it has been observed that buses do not leave the station until they are totally occupied. As a result, bus operators have been interviewed and the following data have been found, as shown in Table 3:

- The average number of passengers per vehicle per day
- The average fuel expenses per vehicle per day
- The average wages per vehicle per day
- The average monthly maintenance and oil
- The licensing and insurance and other yearly expenses (tickets and fines)

In this study, in order calculate the operation costs (the revenues) from each minibus transit system there is a need to compute the farebox recovery ratio. It is the ratio of fare revenue to total transit expenses for a given system. The farebox recovery calculations are given in the following equations.

- Net daily income for the route = (route fare * route no. passengers/veh/day) – (route fuel cost + route wages)
- Net monthly income = net daily income *26 – (monthly route maintenance + route oil)
- Net yearly income = net monthly income *12 – (route licensing and insurance + other expenses)
- Fare box recovery = (net yearly income / net yearly expenses) *100%

Or

- Operating ratio = (net yearly income / net yearly expenses)

In this research study, the average fare box recovery was found to be about 218, which is considered high comparably with worldwide fare box recovery values due to the high occupancy rates for public transportation in Jordan since the whole system is unscheduled. However, the wages in Jordan are low, which reflects on the waiting time. As a result, minibus drivers tend to only leave the stations once their minibuses are full.

4.3. Comfortability

In order to measure the comfortability of the minibus transit system, the interviews with minibus users were conducted to obtain data about the comfort of transit.

For each trip made, 15 questionnaires were distributed among bus passengers, which resulted in 960 survey respondents, composed of 62.9% females and 37.1% males, and 79.3% of the participants were Jordanians. The highest represented age grouping was 18-23 years); 89.6% of respondents were willing to change from public transit to a private car if one was available. Passengers were asked to rate the comfortability level of the bus on which they were travelling. The comfortability was rated according to several criteria such as: seat comfortability, cleanness, air conditioning and level of crowding on the vehicle. The mean and standard deviation for each is given in Table 2.

Table 2: Statistical analysis of the comfortability measurement key

Comfortability criterion	**Mean**	**Standard deviation**
Bus crowdedness	3.23	1.13
Seat comfortability	2.08	0.62
Air conditioning	1.95	1.09
Bus Cleanness	1.48	0.57

Each criterion was rated separately by using a scale from 1 to 5 starting from 1, which indicated extremely uncomfortable, to 5, which meant very comfortable, and then was given a weighted average based on the importance from the passenger's perspective. Passengers ranked the crowdedness of the bus as the most significant criterion of vehicle comfortability.

Only 35% of minibus users stated that the level of comfortability on the bus was acceptable; most of the others rated it as poor, indicating that most users are not satisfied with the provided services.

According to Eboli and Mazzulla (2011), comfort can include cleanliness of windows, floors

and seats, as well as availability of air conditioning. The interviews were conducted for each transit route. It is worth mentioning that data were obtained for 10 vehicles on each route served by more than 10 vehicles.

IV. CONCLUSION

This study investigated the performance of the public minibus transit system in Sweileh district in Amman, Jordan. Results of analyses indicated that accessibility of public minibus transit, within walking distance of 400 m, was relatively low. The mobility of buses (how often they run) was low, which was found to be acceptable. Compared with the operating ratio for developed countries, the operating ratio for minibuses in the investigated district was considerably large. The district suffers from a lack of service coverage on the outskirts of the district and a high percentage of routes overlap, within 400 metres. Also, the results indicated that the number of buses per 1000 inhabitants was very low. Field surveys showed that bus operation was not scheduled and that the average passenger waiting time for buses was marginally high, specifically during peak hours. Lastly, approximately 25% of users rated the comfort inside transit vehicles as poor. Thus, suggestions to improve transit services are made in this study

To improve the accessibility, several actions can be taken, such as: increasing the number of routes on the outskirts of the district, improving route distribution by serving currently unserved areas and reducing overlapping. In addition, a possible and efficient solution that may increase the level of service and enhance the service provided for public transit users is as minibus has a higher ability to manoeuvre within congestion compared with buses. They can also carry around 23 passengers per trip compared with taxis, which can only carry about four passengers. The government should opt for efficient scheduling for departing and arriving at the terminals, and changing the routes depending on the demand and the congestion levels, as this will help to increase the coverage to meet the demand.

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