Improved Transport Terminal Utilization: The Case of Jordan Wharf, Guimaras, Philippines

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Abstract

Public transport in the Philippines comes in different modes depending on the geography. For Guimaras island province, commuters depend on both land and water transport to carry out their daily trip activities. Despite the high number of public transport services, transport operators do not practice methods on improving its service reliability. The Jordan wharf is an intermodal passenger terminal which provides both land and water transport. Transport providers freely create their own schedule based on passenger demand estimated from past trends, or by simply waiting for passengers. Operators also employ a "go-when-full" scheme in dispatching their vehicles. The current scheme leads to an unreliable system of operations at the wharf as it leads to the oversupply of public transport available at the wharf and the increase in waiting time for passengers. This paper would focus on improving the efficiency of operations of the departing land transport by reducing the number of waiting vehicles at the wharf and the waiting time of passengers. The reduction was done by modeling passenger arrivals of pumpboats after a Gaussian distribution and by determining the design frequency to accommodate the passenger volume using the percentages of modal shares. A proposed fleet size was given to further improve the operations of the wharf. The service operating characteristics of the wharf and of the public transports were determined by a detailed survey plan.

Key Words: Public transport, Water transport, Public transport demand and supply

1. General Introduction

Public transportation plays a vital role in promoting the mobility of individuals to their respective destinations at a more affordable cost. It is for this reason that there has been a thrust in seeking to improve the service reliability of public transportation. Ceder (2007) noted several factors that are of concern to passengers when it comes to reliability. The factors are mostly related to the improvement of the level of service of public transportation in terms of travel time and comfort. Intermodal terminals are specific areas of concern in intermodal transportation as inefficient operations in these areas can lead to an unreliable public transport service.

Intermodal transportation has been defined by Jones *et al.* (2000) as the shipment of cargo and the movement of people that makes use of more than one mode of transport during a single journey. Intermodalityshould optimize the traveling conditions of passengers considering the advantages and disadvantages of each mode of transport. The transferring from one mode of transport to another mode, technically known as transfer, has been considered as the "weak" link in a combined transport system. For this reason, efficient operations of intermodal terminals are of utmost importance.

The Philippines have different modes of transport available to passengers but only a few studies relevant to the improvement of the public transportation system have been made. This paper seeks to improve the operations of an intermodal transportation terminal by reducing the number of operating vehicles to reduce the waiting time of passengers and to increase the utilization of the offered capacity of the public transport. This study is different in the sense that the passenger demand for land transport given is dependent to the passenger arrivals of marine transport.In orderto maintain the availability of public transport at the terminal, this study needs to determine service

supply available that would meet the seasonal fluctuations of transport demand.

The island of Guimaras lies southeast of Panay Island and northwest of Negros Island. It has five (5) municipalities and has an estimated population of 162,943. Being an island, Guimaras can be accessed primarily by water travel. Travelers, coming from Iloilo can ride pumpboats at Parola, Ortiz Port, and MuelleLoney port terminals. Travelers that are coming from Negros can also ride pumpboats at Pulupandan and arrive at M. Chavez wharf at Sibunag. There are different entry points in Guimaras.This paper would concentrate on Jordan wharf, an intermodal passenger terminal,where majority of pumpboat arrivals and departures occur.

There are different modes of public transport available in the study area: jeepneys, multicabs, vans, motorcycles, and tricycles which constitute the land transport and pumpboats for water transport. Table 1 shows that pumpboats outnumber other modes of marine transport which enables it to carry out more trips and transfer more passengers from one island to another. Each mode operates on different routes except for motorcycles and tricycles as their destination are determined by the destination of the passenger. Jeepneys, vans, and multicabs can be rented by touring visitors or can be used for cargo transport. Table 2 shows the statistics of registered vehicles in Guimaras. The values show that the main type of public land transport in the area is the jeepneys. There is also an emergence of the use of multicabs and vans in the area but is not shown in the table. Each mode of public transport is different when it comes to its vehicle and service operating characteristics. The differences can contribute to the modal preferences of each passenger. Table 3 shows the characteristics of each mode of transport.

Table 1 Registered marine transport

Type	Registered
Pumpboats	123
Ferry boats	5
RoRo Ship	1

Source: National Statistical Coordination Board, 2004

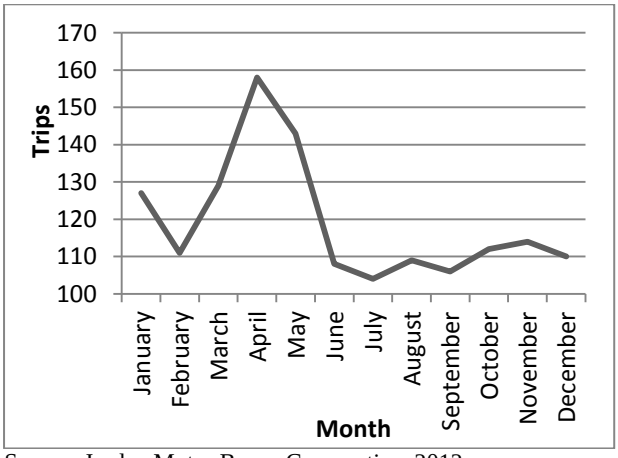
Table 2 Number of registered vehicles in Guimaras

Type	Registered
Jeepneys (PUJs)	960
Tricycles / Motorcycles	4496
Trucks	314
Private Vehicles	5757
Cars	157

Source: Land Transportation Office, 2003

1.1 Public Transit Operations

Pumpboats operate on a "go-when-full" scheme. This means that the vessel departs the wharf when it is already near its capacity or when it is at its capacity. The operating hours of pumpboats is from 5:30 AM to 9:00 PM. The peak and off-peak seasons of marine transport operations were observed at the onset of the summer months at March and at the start of classes at June, respectively. Figure 1 shows the pumpboat trips from Iloilo to Guimaras in the year 2012. The data is from the Jordan MotorBanca Cooperative which handles the operations of the pumpboats.



Source: Jordan Motor Banca Cooperative, 2012

Fig. 1 Pumpboat trips to Guimaras

Public transport operations at the wharf is handled by different dispatchers of each transport association of each mode of transport. There are three (3) transport associations for multicabs, two (2) associations for jeepneys, and one (1) association for vans. Each transport association employ vehicle schedules per day. The schedule is normally done on an alternate basis (i.e. vehicle A operates onMondays, Wednesdays, and so on while vehicle B operates on Tuesdays, Thursdays, and so on).Public transportation that arrives at the wharf would be arranged by their dispatchers on a "first-

come-first-serve" basis.These vehicles would wait for passengers at the wharf until it reaches its capacity before it departs.Succeeding vehicles would be queued and asked to wait in another area before they are called for service.This type of operation leads to an oversupply at the wharf. Oversupply, in this study, would refer to the idea that public transport offers a high number of seats available but is not utilized by passengers.

Table 3 Comparison of Public Transport

Mode	Jeepney (J)	Multicab (MC)	Van (V)	Tricycle (T)	Motorcycle (M)
Fare	Php 8.00 for 1st 4 km, Php 1.25 per succeeding km		Php 1.50/km	Destination dependent	
Capacity	24	16	18	6	2
Select routes	Nueva Valencia, Lucmayan, and Pandaraonan	San Miguel, Santa Tersa, Ravina	Igdarapdap and Cabalagnan	Passenger dependent	
Average route length	27.45 km	13.0 km	36.4 km		

The "go-when-full-scheme" also increases the waiting time of passengers. The oversupply and the implemented scheme make the operation at the wharf inefficient.This justifies the need for improvement by determining the appropriate passenger demand and by reducing the operating vehicles at the wharf.

2. Literature Review

In order to ensure the efficiency of operations of intermodal stations, Pitsiava-Latinopoulou and Iordanopoulos (2012) noted factors that a terminal should provide. Terminal operations should have a fair level of service and have satisfactory facilities in serving the transfer of passengers. The terminal should ensure low cost travel and sufficient accessibility across all users. Finally, they noted that it should reduce travel time even compared to the travel time when there is no transfer involved. This can be done when there is direct access between platforms of different modes serving the terminal. If a terminal were not designed properly, it would hinder the efficiency of operations, endanger the safety of passengers, and affect the reliability of travel. Henry (2008) noted the positive impacts of an efficient terminal. Some of which involves the decrease in costs and energy consumption, which, in return, increases economic productivity.

The researchers pursue the idea that fleet size reduction and frequency setting of public transport would improve the efficiency of the terminal by reducing the waiting time of passengers. The purpose of frequency setting is to determine the appropriate number of frequencies for each line of the network at a specific time period. The common definition of a time period is in accordance to the hour of the day, day of the week (Guihaire&Hao, 2008). The frequency setting should be able to satisfy the demand of the users in order to reduce the required fleet size for operation and lessen the cost of operations.

Furth and Wilson (1982) presented four mathematical approaches in the determination of headways of transit routes: (1) policy headways, which is not derived from passenger demand, (2) headways which are derived from maximum passenger load and the capacity of the vehicle, (3) headways such that the ratio of the revenue and the cost will not exceed a preset value, and (4) headways that are designed to achieve a desired of passenger-miles to vehicle miles in an hour.

A heuristic method was proposed by Han and Wilson (1982). In this method, the frequencies at a certain line and the capacities are given for each route. Their problem is the allocation of vehicles to a route network. In solving this problem, they proposed a two staged heuristic. In the first stage, the frequencies were set to a minimum so that the demand would be satisfied. The second stage involved uniformly increasing the frequencies among lines so that all vehicles can be utilized. The second stage made use of an iterative procedure so that frequencies are increased.

Ceder (1984) developed four methods in determining the bus frequencies in a certain line. These four methods were carried from two forms of data – ride check and point check data. For each set of data, two sets of methods were proposed. The point check data considered two methods for

setting frequencies based on: (1) maximum daily load and (2) maximum hourly load. The succeeding methods for the ride check data considers the (3) load-profile in terms of passenger-kilometers and (4) level of service by reducing crowding to a certain percentage along the route. Chi-square tests were used to determine which set of data-gathering method is the most appropriate based from previous data that were gathered.

The study of Kang *et al*. (2010) provided a heuristic procedure to determine the optimal frequency of jeepney operations in Metro Manila based on maximum load, load factor, and vehicle capacity and route length.

The study of Hsu (2010) explored the different effects of variation of headways, capacity, and coefficients of variation to waiting time at multi-modal connecting stations. The author used the traditional passenger waiting time designed by Osuna and Newell (1972) and Welding (1957). The study of Knoppers and Muller (1995) was used to model the arrivals of feeder vehicles after a normal distribution. Through simulation, it was noted that when connecting service headways increase, waiting times also increase.

From these studies, the determination of frequencies is primarily based on the works of Ceder and Kang, et al. The passenger demand of the studies of Ceder and Kang is based on passenger volume along the route. This study would be different, for the passenger volume would be based on the arrivals of another mode of transport at an intermodal passenger terminal and simultaneously considering seasonal and operating peak and off-peak periods.

3. Methodology

The design of an intermodal passenger terminal, according to Rivasplata (2001), should focus on the effective and functional use of available space to maintain a high level of service for which it is designed. It is for this reason that the author specified some elements that should be taken into consideration in the design and redesign of the terminal. The number of modes and the types of vehicles should be determined in order to properly allocate the space for each mode. Passenger volume, frequencies of arrival, and waiting times should also be noted to identify passenger activity at the terminal. Finally, season variations should be taken into consideration so that demand fluctuations would be addressed and public transport supply would not be compromised.

The factors that Rivasplata (2001) presented were taken into consideration in the design of the detailed survey plan.

3.1. Detailed Survey Plan

The survey period covered the daily operations of the wharf from 6:00 AM – 6:00 PM. Night operations were disregarded as the operating vehicles and pumpboats were significantly less than that during the daily operations.

Nine (9) surveyors were strategically positioned at the wharf, as shown in Figure 2, to cover the actual transport operations, which include the arrival and departure rates of public transports and number of vehicles that are parked at the wharf. A total of six (6) surveys that covers the peak and normal operations at the wharf were accomplished.

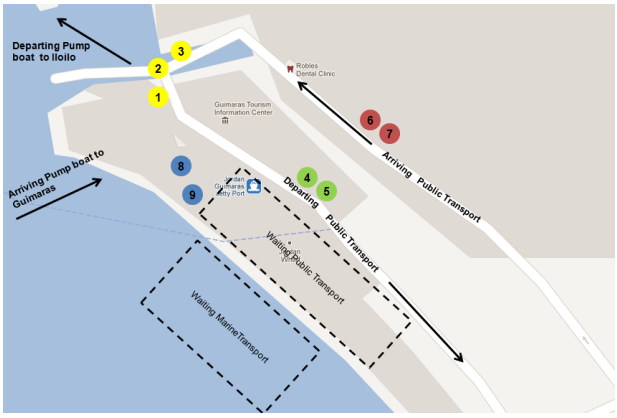


Image Source: Google Maps

Fig. 2 Surveyor positioning and current lay-out of Jordan Wharf

3.1.1 Marine Transport Arrivals

In recording the arrivals of marine transport, the features of the vessel such as its name or if it was rented or not were noted. The arrival times of each pumpboat and the number of passengers that disembark the vessel were counted. The considered time of arrival is when the first passenger successfully disembarked the vessel.

3.1.2. Departing Public Transport

The point check method was employed by determining the mode of transport, the number of passengers aboard the vehicle, and the route that the vehicle traverses. For public transport, the passengers on-board were assumed to be the maximum for the whole route length. The passenger volume was taken as the cumulative in an hourly basis.

3.1.3. Waiting Land Transport

Recording the waiting land and water transport at the wharf is necessary in determining the available supply provided by the transit units operating at the wharf. Operating characteristics of the vehicle such as the route and the vehicle capacity were also noted.

4. Data Analysis

4.1 Public Transport Modal Shares

Figures 3 and 4 show the average modal shares of public transport during peak and off peak seasons. The figure suggests that of the modes of transport, jeepneys have transported the most number of passengers out and in to Jordan Wharf. Jeepneys, along with tricycles and multicabs, are the more preferred modes of transport throughout the daily operations. Vans, motorcycles, and private vehicles constituted only to a small percentage of the modal shares. The trend of modal shares for jeepneys, multicabs, and tricycles are consistent to the increase in passenger demand such that when passenger arrivals increase, the modal shares for these three also increase while others decrease or remain the same. This suggests that these three modes are the more preferred modes of transport out of the wharf.

Further analysis of the passenger count data shows that there are different peak and off-peak operating hours within the peak and off-peak seasons. The peak operating hours for the peak season and non-peak seasons and the non-peak operating hours for the peak and non-peak seasons are shown in Table 4.

The peak periods for the peak season is believed to be at the morning because passengers arriving at peak seasons are mostly tourists and visit the area during the morning and leave during the afternoon. During off-peak seasons, the peak period is at the afternoon because students and employees come back from Iloilo during this time period.

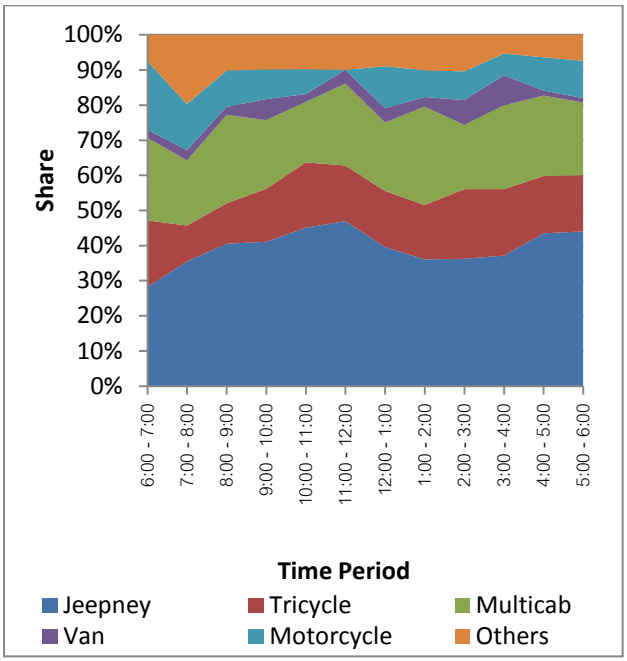


Fig. 3 Public transport modal shares during the peak season

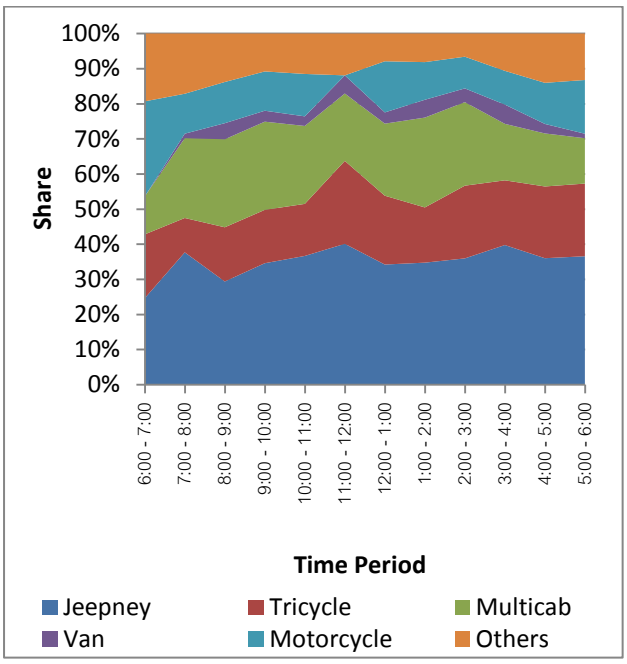


Fig. 4 Public transport modal shares during the off-peak season

Table 4 Peak and off-peak seasons' peak and non-peak operating periods

Season/Period	Peak Season	Non-peak season
Peak period	7:00 AM – 12:00 NN	2:00 PM – 6:00 PM
Non-peak period	6:00 AM – 7:00 AM and 12:00 NN to 6:00 PM	6:00 AM – 2:00 PM

4.2. Passenger Waiting Time

As stated in the previous sections, the waiting time formulation that was adopted in this study is that of Welding (1957). The waiting time formulation is shown below:

$$w = \frac{E(h)}{2}\left[1 + (C.V.)^2\right] \quad (1)$$

where, E(h) -mean headway of public transport
C.V. is the coefficient of variation

The data were collected from the departure rates of public transportation. Similar to the previous analysis, the data were grouped into seasons and periods. The waiting times of jeepneys, multicabs, and vans are shown in Table 5. Note that the succeeding table does not contain the waiting time of passengers who use motorcycles and tricycles.This is because their service does not require reaching its capacity before departing the wharf.

Table 5 Waiting time (in minutes) of passengers for jeepneys (J), multicabs (MC), and vans (V)

Mode of transport		J	MC	V
Season	**Period**			
Peak	Peak	5.11	7.63	20.73
Peak	Off-peak	6.23	9.00	16.47
Off-peak	Peak	3.95	4.64	17.66
Off-peak	Off-peak	5.39	5.97	17.44

Table 5 shows the average waiting time for each passenger considering the seasonal and daily operational variations. All three modes have lower waiting times during the off peak seasons and almost all of the lowest waiting times occurred during off-peak seasons and peak periods. It can be observed that peak periods have lower waiting times for jeepneys and multicabs. However, peak seasons tend to increase the waiting time of passengers. This could be attributed to the idea that since there are many vehicles waiting at the wharf, operators would want to maximize their revenue by serving passengers exceeding their vehicle capacity.

4.3. Determination of Offered Capacity and Total Utilized Capacity

The offered capacity is defined as the total capacity available during a specific time period. It is the sum of the waiting and line capacities. Waiting capacity is the total capacity being supplied by waiting vehicles. Line capacity is the total actual capacity offered to passengers that are transported past a point in the time period. Mathematically,

$$C = C_w + C_l \quad (2)$$
$$C_w = n \cdot C_v \quad (3)$$
$$C_l = f \cdot C_v \quad (4)$$

where C: offered capacity,
C_w: waiting capacity,
n: number of waiting vehicles,
C_v: capacity of each mode of transport,
C_l: line capacity, and
f: frequency

Total utilized capacity, is the sum of number of passengers boarded on a vehicle departing the wharf at a specific time period. It is expressed mathematically as,

$$P = \sum_i P_i \quad (5)$$

where p_i: number of passengers aboard the ith vehicle arriving or departing the wharf

The utilization coefficient, denoted as α, is the ratio of the utilized capacity to the offered capacity. This coefficient normally has values between 0 and 1. Coefficients that are above 1 signify that the passengers aboard a vehicle are greater than the capacity being supplied by the vehicle. High utilization coefficients affect passengers in terms of comfort. The utilization coefficient is denoted mathematically as,

$$\alpha = \frac{P}{C}; 0 \le \alpha \le 1 \quad (6)$$

where α: utilization coefficient

Table 6 Public Transport Fleet Size (including waiting vehicles) during the (a) Peak Season and (b) Off-Peak Season

Time period	Peak				
	J	MC	V	T	M
6:00-7:00 AM	19	19	1	80	87
7:00-8:00 AM	29	25	3	113	128
8:00-9:00 AM	27	27	2	134	156
9:00-10:00 AM	29	20	5	123	167
10:00-11:00 AM	25	15	2	132	184
11:00–12:00 NN	25	18	2	76	146
12:00-1:00 PM	25	18	3	71	140
1:00-2:00 PM	21	24	2	79	119
2:00-3:00 PM	21	18	4	62	124
3:00-4:00 PM	22	25	5	63	116
4:00-5:00 PM	21	19	1	56	150
5:00-6:00 PM	19	11	1	51	101

Time period	Off - Peak				
	J	MC	V	T	M
6:00-7:00 AM	9	12	1	35	71
7:00-8:00 AM	23	22	3	63	99
8:00-9:00 AM	21	25	6	78	125
9:00-10:00 AM	23	22	2	91	158
10:00-11:00 AM	27	18	6	77	157
11:00–12:00 NN	28	18	6	90	152
12:00-1:00 PM	26	17	3	82	175
1:00-2:00 PM	26	18	4	72	148
2:00-3:00 PM	25	17	4	93	157
3:00-4:00 PM	29	17	3	91	166
4:00-5:00 PM	26	18	1	105	164
5:00-6:00 PM	19	13	1	117	182

Legend: J – Jeepneys, MC – Multicabs, V – Vans, T – Tricycles, and M – Motorcycles

Table 6(a) and 6(b) shows the current public transport fleet size (including the waiting vehicles) at Jordan Wharf. The values shown here were used in determining the offered capacity. It can be clearly observed that the fleet size during off-peak seasons is less compared to the fleet size during peak seasons.

The utilization coefficient quantifies the deviation between passenger demand and the service supply. Figures 3a and 3b shows the graphs of utilization coefficients for the departing land transport. It should be noted that there is no utilization coefficient for tricycles and motorcycles as these are specialized modes of transport wherein passengers choose a specified destination.

If Figure 5a would be analyzed, it would be seen that the majority of the utilization coefficients were below 0.6 across all time periods. This implies that only 60% of the seats offered by the different modes of transport were utilized by passengers. During off peak seasons, almost only 50% of the service supply has been utilized. Both figures show that the service supply is not fully utilized during the daily operations. The low utilization could be attributed to the high number of vehicles waiting at the wharf. This stresses the need to determine the required fleet size at the wharf to improve the utilization of public transport available at the wharf.

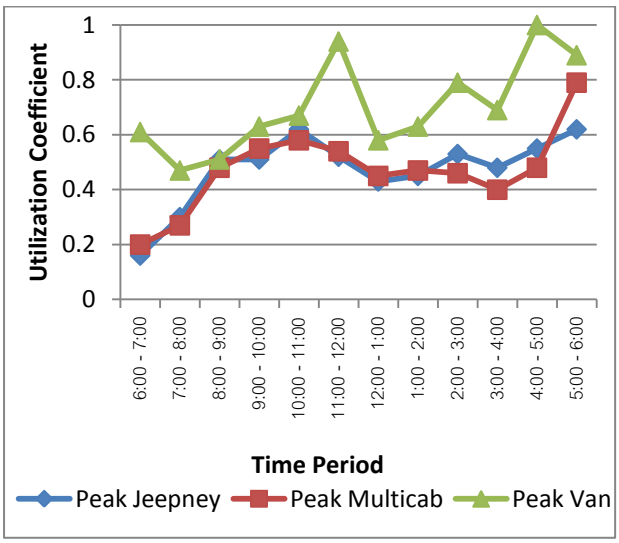


Fig. 5a Utilization coefficients during peak seasons

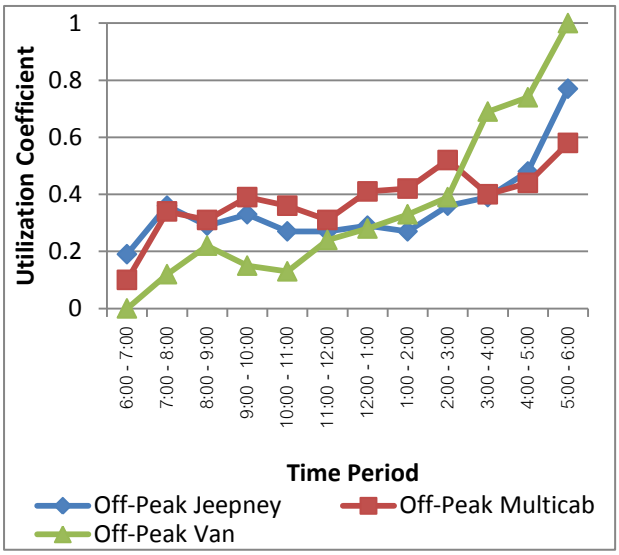


Fig. 5b Utilization coefficientsduring off-peak seasons

4.4 Determination of Departing Land Transport Fleet Size

The determination of the appropriate fleet size was based on the appropriate passenger design volume. The passenger volume is derived from the passenger counts of arriving pumpboats modeled after a Gaussian distribution. The pumpboat operations are also divided into peak and off-peak operating hours. Using SPSS, passenger counts were tested to fit to a normal distribution at a 95% level of confidence. The data were validated using the Kolmogorov-Smirnov test and the results were shown in Figure 6.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of P_P is normal with mean 858.60 and standard deviation 321.78.	One-Sample Kolmogorov-Smirnov Test	.791	Retain the null hypothesis.
2	The distribution of P_NP is normal with mean 513.52 and standard deviation 297.77.	One-Sample Kolmogorov-Smirnov Test	.471	Retain the null hypothesis.
3	The distribution of NP_P is normal with mean 764.17 and standard deviation 149.67.	One-Sample Kolmogorov-Smirnov Test	.995	Retain the null hypothesis.
4	The distribution of NP_NP is normal with mean 434.88 and standard deviation 169.01.	One-Sample Kolmogorov-Smirnov Test	.995	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Fig. 6 Goodness-of-fit test results using SPSS

The Normal distribution has a probability distribution function of

$$f_X(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \quad (7)$$

whereμ and $\sigma$are the mean and standard deviation of passenger arrivals respectively

With the cumulative distribution function of each season already, the 95% probability of no more than X passengers at the wharf were determined. This value enable the researchers to have a confidence that at 95% of the time, there would be no greater passenger arrivals than the determined value. The estimates of the maximum value of passenger arrivals for the different seasons were derived from the cumulative distribution functions (CDFs). The values are shown in table 7.

Table 7 Estimated number of passengers arriving at the wharf from normal distribution at 95% confidence

Season	Period	Passengers
Peak	Peak	1388
Peak	Off-peak	1003
Off-peak	Peak	1010
Off-peak	Off-peak	713

The passenger demand is multiplied to the modal share, β, to determine the design volume. In case the design volume for the design hour is less than the vehicle capacity, the design volume is added onto the next hour. Carrying over the passenger demand to the next time period ensures that each vehicle would be highly utilized by passengers. The fleet size *n*, or design frequency is the quotient of the design volume and the individual capacities of each mode of transport. Since tricycles and motorcycles are specialized modes of transport, the average passenger volume of these modes would be used as the capacity.

$$P_{d_{M,MC,V,T,J}} = P_d \cdot \beta \quad (8)$$

$$n = f_d = \frac{P_{d_{M,MC,V,T,J}}}{C_{M,MC,V,T,J}} \quad (9)$$

where, P_d: design volume,
β: modal share
$P_{dJ,MC,V,T,M}$: design volume for each mode
J - jeepney (cap. 24), MC – multicab (cap. 16) , V – van (cap. 18); T – tricycle (ave.vol. 2.8), M – motorcycle (ave.vol. 1.3)
n, f_d: fleet size or design frequency
$C_{J,MC,V,T,M}$: capacity for each mode of transport

It should be noted that the designed frequency assures that all vehicles will depart the wharf for the specific time period. Unlike the values in Table 6, the fleet size proposed in Table 7 assures vehicles of departure within the operating day.

It would be observed that the proposed fleet size for jeepneys, multicabs, and vans is less than the current conditions. This addresses one objective of the paper – reducing the current fleet size at the wharf to improve efficiency of transport operations. Tricycles and motorcycles, however, contradict this information, for at some periods, the

proposed fleet size increased. The increase in fleet size could be caused by the use of the average passenger volume of tricycles and motorcycles. The average passenger volume does not consider the trends of passenger loads for these types of specialized modes of transport. In total, the fleet size in this study ensures that it would meet passenger demand considering the seasonal and hourly operational variations.

Table 8 ProposedPublic Transport Fleet Size (transit units)during the (a) Peak Season and (b) Off-Peak Season

Time period	Peak				
	J	MC	V	T	M
6:00-7:00 AM	12	15	2	96	99
7:00-8:00 AM	21	17	3	71	91
8:00-9:00 AM	24	22	2	80	72
9:00-10:00 AM	24	17	5	105	59
10:00-11:00 AM	27	15	2	129	50
11:00–12:00 NN	28	21	4	110	0
12:00-1:00 PM	17	13	3	81	61
1:00-2:00 PM	16	18	2	78	39
2:00-3:00 PM	16	12	4	100	41
3:00-4:00 PM	16	15	5	95	32
4:00-5:00 PM	19	15	0	82	48
5:00-6:00 PM	19	13	2	81	54

Time period	Off - Peak				
	J	MC	V	T	M
6:00-7:00 AM	9	11	0	46	69
7:00-8:00 AM	11	9	3	32	38
8:00-9:00 AM	13	12	0	34	26
9:00-10:00 AM	13	9	4	34	25
10:00-11:00 AM	14	8	0	32	26
11:00–12:00 NN	14	11	3	58	0
12:00-1:00 PM	12	9	2	58	43
1:00-2:00 PM	11	13	2	43	29
2:00-3:00 PM	16	12	4	91	40
3:00-4:00 PM	16	16	5	98	51
4:00-5:00 PM	19	15	0	138	79
5:00-6:00 PM	19	14	2	153	113

Legend: J – Jeepneys, MC – Multicabs, V – Vans, T – Tricycles, and M – Motorcycles

Table 9 Passengerwaiting time (in minutes) for jeepneys (J), multicabs (MC), and vans (V)

Mode of transport		**J**	**MC**	**V**
Season	**Period**			
Peak	Peak	1.24	1.71	12.33
Peak	Off-peak	1.92	2.15	12.91
Off-peak	Peak	1.74	2.16	11.95
Off-peak	Off-peak	2.59	3.09	12.48

The results in table 9 show a decrease in waiting time compared to the current condition. It can be said that the reduction of fleet size at the wharf for jeepneys, multicabs, and vans, led to the decrease in waiting time. It should be noted, however, that the headway estimation of the new condition assumes that the vehicles would be operating at even headways for each time period. A reduced waiting time increases the efficiency of the public transport service for it gives passengers a higher level of comfort while utilizing public transport.

The effect of the proposed conditions to the utilization coefficients was examined. The results are shown in Figure 5. It can be noted that all coefficients improved from the current condition and all are above 0.5. The results imply that across all time periods, at least 50% of the seats being provided by public transportation would be utilized by passengers. The results hold true for both peak and off-peak seasons. In order to increase the level of comfort being experienced by passengers, operators have the option of increasing the frequency. Increasing the frequency of departures would not constitute to an immediate effect to the operations of the wharf. It should be noted that transit operators should properly regulate the increase of frequency of operations to avoid the oversupply at the wharf.

In correspondence to the proposed number of waiting vehicles, the effect of the proposal to the utilization coefficient was made and shown in the succeeding figures. It can be noted that all of the coefficients improved from the current condition and are above 0.5. Increasing the frequency in this case would not constitute an immediate effect to the operations of the wharf but, it would increase the level of service experienced by passengers as it gives them more space inside the vehicle.

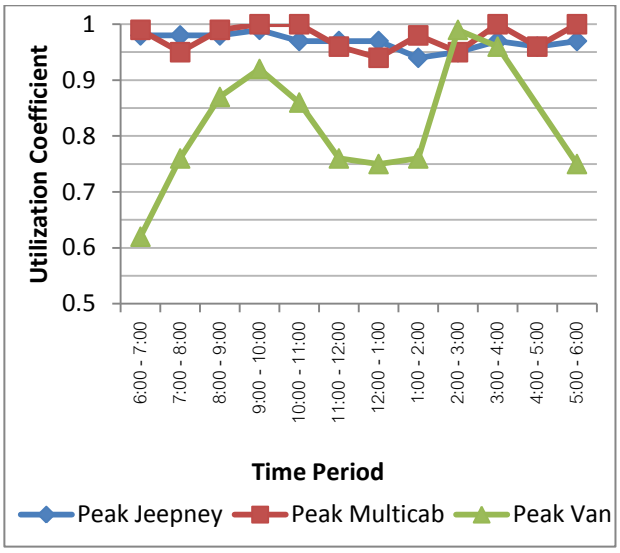


Fig. 7a Proposed conditionutilization coefficients during peak season

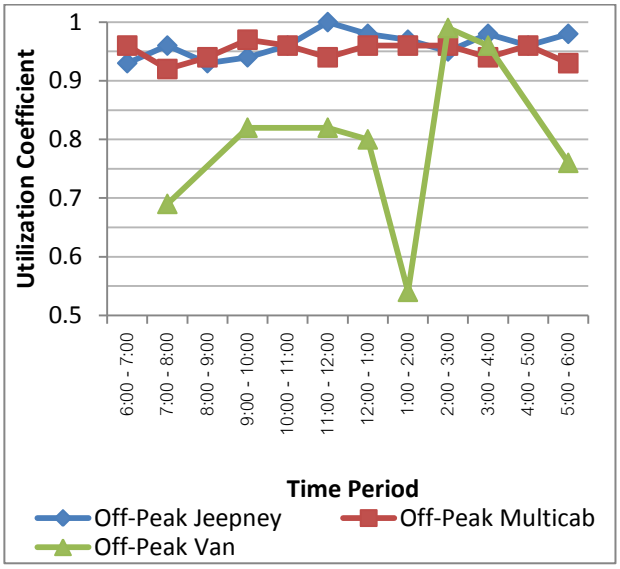


Fig. 7b Proposed condition utilization coefficients during off-peak season

4.5. Data Validation

To validate if there was a significant difference to the current and the proposed conditions, a t-test was performed on the fleet size. A paired t-test was performed with the null hypothesis of no difference between the two means (H_0 - H_1 = 0) and the alternative hypothesis of having a significant difference between the means. The resulting p-values of the hypothesis testing results are shown in table 10.

Table 10 P-values of the proposed conditions considering peak and off-peak seasons

Mode of Transport	Peak Seasons	Off-Peak Seasons
Jeepneys	0.0058	0.0000
Multicabs	0.0055	0.0009
Vans	0.2750	0.1328
Tricycles	0.0338	0.0002
Motorcycles	0.0049	0.0002

With the p-values less than 0.05, the results are considered significant. This shows that there is a significant difference between the existing and the proposed conditions. Some results were otherwise but it suggests that the existing conditions can sufficiently meet the passenger demand with minimal supply deviations. The hypothesis testing only takes into consideration the results of the reduction in fleet size. Other factors should be taken into account as well such as the utilization coefficients. The proposed conditions yielded higher utilization coefficients and give operators the opportunity to increase the fleet size without compromising demand-supply deviations. High utilization is beneficial to transport operators and drivers as it would translate to relatively high revenues. High revenues are expected since vehicles would operate at near capacity. Another factor that should also be taken into consideration is the effect of the proposed conditions to the passenger waiting time. The proposed conditions showed a drop in waiting time by almost half of the existing conditions. As previously explained, waiting time is one factor taken into consideration, from the perspective of the passengers, in public transport reliability. Therefore, with this result in waiting time, the proposed condition increases the reliability of public transport at the wharf.

5. Conclusions

The result of the study shows that there is an oversupply of public transportation at the Jordan wharf. The oversupply of public transport leads to very small utilization coefficients for departing public transport because there is a large amount of vehicles waiting at the wharf. The results show that there is still a need for improvement in increasing the utilization of departing public transport. The methodology presented, using the passenger counts of arriving pumpboats modeled after a Gaussian

distribution, is an effective tool, for it considers the seasonal and hourly variations of the passenger demand. However, a more in-depth methodology of vehicle scheduling that takes into consideration the actual routes of each mode of transport is suggested to further increase utilization of public transport modes. The resulting proposed utilization coefficients are almost equal to 1.0. The values imply that there is a need to increase the fleet size to avoid overcrowding. The resulting expected waiting time for passengers under the proposed condition also decreased. Hence, the proposed fleet size considered is the minimum fleet size that would address the arriving passengers and would minimize the passengers waiting time at the wharf.

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