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

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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. This paper focused on improving the efficiency of operations of land and water transport by reducing the number of waiting vehicles at the wharf. The reduction was done 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 efficiency of the wharf operations. The service operating characteristics of the wharf and of the public transports were determined by a detailed survey plan. The results show a significant decrease in number of waiting vehicles at the wharf and an increase in utilization coefficients.

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

1. INTRODUCTION

Public transportation plays a vital role in promoting the mobility of individuals to their respective destinations. It is for this reason that there has been a thrust in improving the service reliability of public transportation. From the perspective of the passengers, the reliability attributes that are of concern are: waiting time, boarding time, in-vehicle time, alighting time, total travel time, transfer time, pre-trip information time, pre-trip time required for changes in access path, and seat availability (Ceder, 2007).

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. Intermodality aims to optimize the traveling conditions considering the advantages and disadvantages of each mode of transport. The transferring from one mode of transport to another mode has been considered as the “weak” link. It is for this reason that efficient operations of intermodal stations are of utmost importance. In order to attain such the terminal should provide: (1) a reliable and adequate level of service in the operation of the terminal; (2) satisfactory facilities serving the transfer; (3) provision of low cost travel; (4) sufficient accessibility to the terminal across all users; (5) reduction in travel time compared to the travel time without transfer; and (6) direct access between platforms of different modes serving the (Pitsiava-Latinopoulou & Iordanopoulus, 2012). The number of modes and vehicles types, the operating time period with its desirable level of service, the expected level of activity in terms of passenger volume, frequencies, and waiting times, and the seasonal variations in demand are some elements that should be identified in the design or redesign of a terminal (Rivasplata, 2011). In cases that these are not taken into consideration, there would be negative impacts that would affect the efficiency of operations, safety of passengers, and travel reliability. Positive impacts as presented by Henry *et al.* (2008) include decrease in transportation costs, increase economic productivity and efficiency, reduce the stresses induced on the infrastructure components, and reduce in energy consumption.

This study would focus on the reduction of the number of operating vehicles in an intermodal transportation terminal in Western Visayas, Philippines. In the country, there are different modes of transport and there are only a few studies that focus on vehicle scheduling. 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. This study would be different in the case that the reduction would be based on the demand that is brought about another mode of transport. Passenger demand, therefore, was based on the arrivals of passengers at the intermodal terminal.

This paper would focus on implementing a schedule of operations by scheduling the number of operating vehicles for an intermodal transportation terminal at Jordan Wharf, Guimaras. The challenge that this paper would like to address is meeting passenger demand of water transport when it is dependent on the arrivals of land transport and vice-versa. Similarly, to maintain availability of public transport in the area, it would also need to determine the service supply available that would meet the fluctuations of transport demand.

2. STUDY AREA: THE PROVINCE OF GUIMARAS

The study would focus on the provincial island of Guimaras in Western Visayas. Guimaras can be primarily accessed by water travel. Coming from Iloilo, travelers can ride ferry boats or pump boats at Parola, Ortiz Port, and Muelle Loney port terminals. Travel time usually varies from 15 to 20 minutes. Pump boats are more preferred then their ferry boat counterparts because of its ability to make more trips (about 6 trips per day per pump boat). There are different entry points in Guimaras (for water transport) namely: Jordan Wharf; MacArthur Wharf; Tacay Wharf; M. Chavez Wharf; Suclaran Wharf; Tumanda – Cabano Wharf; Puyo Wharf; and Cabalagnan Wharf. This study would concentrate on Jordan wharf where majority of the arrivals and departures occur.

There are different modes of public transport available in the study area: jeepneys, multicabs, vans, motorcycles, and pedicabs which constitute the land transport and pump boats for water transport. Each mode operates on different routes except for motorcycles and pedicabs as their destinations are dictated by the destination of the passenger. Jeepneys, vans, and multicabs are also capable of performing special trips which can be rented by touring visitors and for transporting cargo.

2.1. Public Transport Operations

Pump boats operate on a “go-when-full” system wherein the vessel departs the wharf when it is already near its capacity or when it is at its capacity. The operating hours of pump boats is 5:30 AM to 9:00 PM.

The current practice of public transit operation at the Jordan wharf is: (1) public transport (jeepneys, multicabs, vans, tricycles, and motorcycles) operators wait for arriving (disembarking) passengers; (2) there are different dispatchers for each transport association of each public transport; (3) each transport association have different vehicle schedules per day; (4) dispatchers arrange the fleet per mode on a “first-come-first-serve” basis, that is, whichever vehicle came in first would serve the arriving passenger first, and so on, and; (5) succeeding vehicles would line-up and wait in another area (also at the wharf) before they are called for service.

The current operation leads to an oversupply of public transport at the wharf. Waiting time would also increase as operators depart on a "go-when-full" scheme. The researcher quantified the current public transit operations at the wharf, the arrival and departure rates of public transport and the modal shares (actual count of passengers utilizing a certain mode of transport) were determined. This data was essential in analyzing the modal shares to determine the adequacy of vehicles waiting at the wharf. Counts of waiting public transport vehicles were made and the actual supply and demand deviations per mode of transport and per route were determined.

3. METHODOLOGY

3.1. Detailed Survey Plan

In determining the actual demand of passengers at the wharf, the survey periods covered the daily operations of the wharf. That is, the survey procedure was done during the daily operations: 6:00 AM – 6:00 PM. The nightly operations were disregarded as the operating vehicles and pumpboats were significantly less than that of the daily operations.

The current lay-out (as shown in Figure 1) shows where the positioning of surveyors with respect to the wharf. In total, there were 9 surveyors that gathered the actual data. A total of three (3) surveyors were designated to get the service operating characteristics of the pump boats arriving at the wharf and departing to Iloilo. Four (4) surveyors were used for the arriving and departing public transports while two (2) surveyors were designated to gather data about waiting public transport and marine transport at the wharf. Considering the differences of each mode of public transport, each surveyor was given separate survey sheets to accomplish.

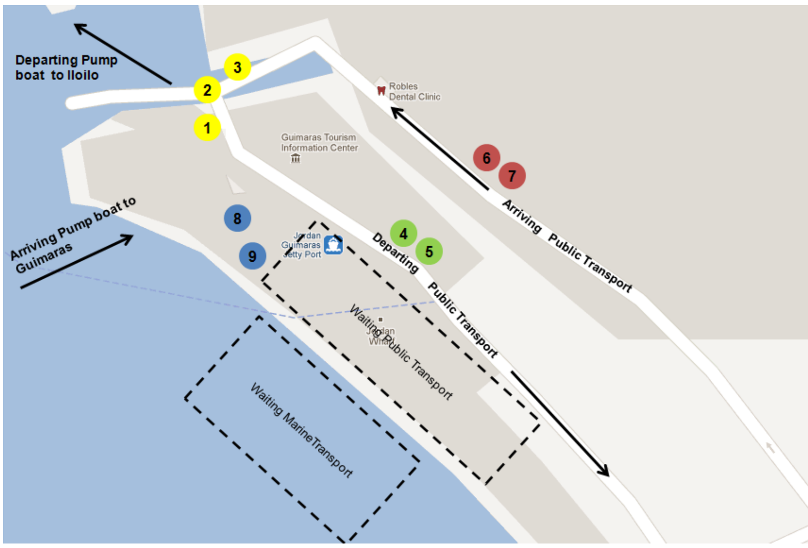

Figure 1. Current Jordan Wharf lay-out and the positioning of the surveyors

3.1.1 Arriving and Departing Marine Transport

In recording the arrivals and departures of marine transport, features of the vessel were noted such as its name or if it was used for rent or for transporting cargo. For arriving pumpboats, the arrival times of each vessel and the number of passengers that disembark the vessel were counted. To be uniform, the time of arrival that was considered was the time wherein the pumpboat was successfully moored into place and when the first passenger had successfully disembarked the vessel. Passenger counts were done for every fifteen (15) minutes to determine if there is a peak passenger count within the hour.

For departing pumpboats, the time of the first passenger, time of departure, and number of passengers were captured in an hourly basis. The time of departure that was considered is the time when the vessel had "pushed back" from the wharf.

3.1.2. Arrival and 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, whether arriving or departing, 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 to determine the adequacy of the transit units operating at the wharf. The route that the vehicle was serving was recorded to classify the supply available.

4. DATA ANALYSIS

4.1 Public Transport Modal Shares

Figure 2 shows the modal shares of arriving and departing public transport. The figure suggests that of the modes of transport, the jeepney has transported the most number of passengers out and in to Jordan Wharf. The jeepney, along with tricycle and multicab, were 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.

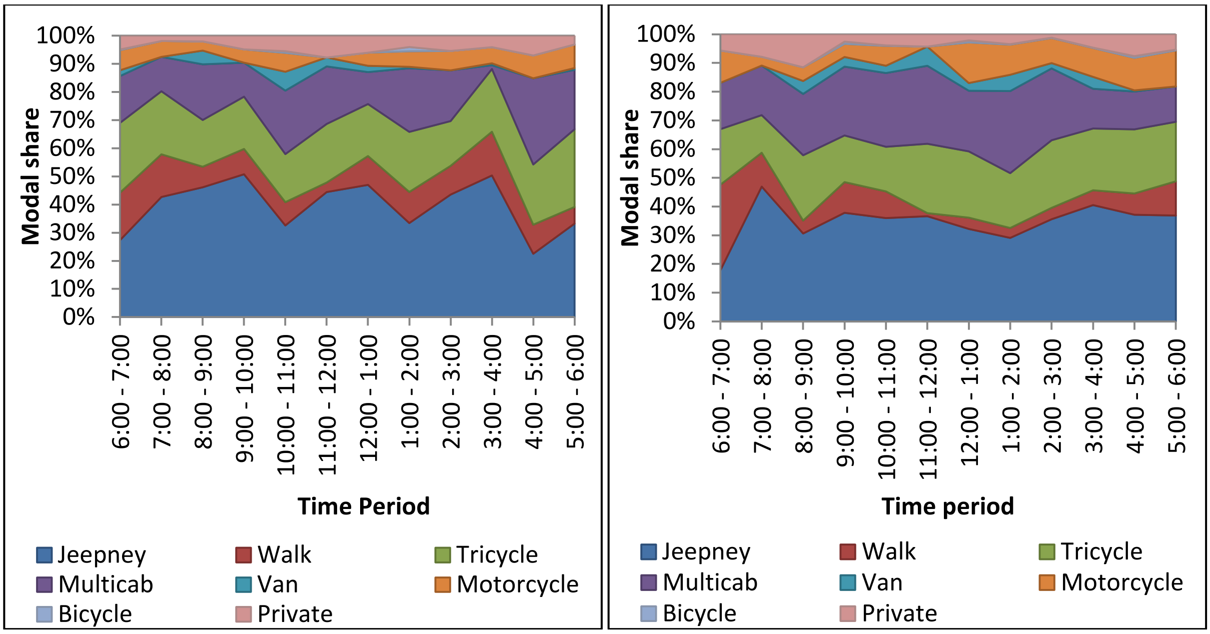

Figure 2. Modal shares across operating period for arriving (left) and departing (right) public transport

The results indicate the peak hours of operation of the wharf as 8:00 to 9:00 AM and 5:00 – 6:00 PM for departures and arrivals, respectively.

Table 1. Vehicles waiting at the wharf per mode (not including actual departing vehicle)

	Multicab	Jeepney	Van	Total
6:00 - 7:00	11	10	0	**21**
7:00 - 8:00	22	18	2	**42**
8:00 - 9:00	26	18	7	**51**
9:00 - 10:00	21	19	6	**46**
10:00 - 11:00	23	28	7	**58**
11:00 - 12:00	19	24	8	**51**
12:00 - 1:00	19	22	6	**47**
1:00 - 2:00	19	30	5	**54**
2:00 - 3:00	16	27	4	**47**
3:00 - 4:00	19	24	1	**44**
4:00 - 5:00	21	21	0	**42**
5:00 - 6:00	18	18	0	**36**

4.2. Determination of Offered Capacity and Total Utilized Capacity

The offered capacity is defined as the total capacity being offered for a specific time period. It is the sum of the waiting capacity and the line capacity. Waiting capacity is the total capacity of waiting vehicles at the wharf. Line capacity is the actual capacity offered to passengers that are transported past a point in the time period. Each offered capacity would be denoted for each mode. Mathematically,

$$C = C_w + C_l \quad (1)$$

$$C_w = n \cdot C_v \quad (2)$$

$$C_l = f \cdot C_v \qquad (3)$$

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,
- f : frequency

Total utilized capacity, also known as passenger demand, is the sum of number of passengers aboard a vehicle arriving or departing the wharf at a specific time period. Mathematically,

$$P = \sum_i p_i \qquad (4)$$

where,

- p_i : number of passengers aboard the i^{th} vehicle arriving or departing the wharf

The utilization coefficient, denoted as α, is the ratio of the utilized capacity to the offered capacity. The coefficient shall be a value from 0 to 1. Mathematically,

$$\alpha = \frac{P}{C} \;;\; 0 \le \alpha \le 1 \qquad (5)$$

where,

- α : utilization coefficient

The results of the survey also showed the trend of the waiting public transport in the wharf. Table 1 shows this trend on a 15-minute interval. The data was presented on such interval to determine how long the vehicle actually waits at the wharf. The data suggests that the peak number of waiting vehicles occur at the time interval 9:01 – 9:15 AM with thirty-seven (37) vehicles. The data compliments the peak arrivals of public transport at the wharf in the sense that the arriving vehicles would have to wait for their turn to serve the arriving passengers from Iloilo.

Disregarding the different routes that the public transport traverses, the differences between the supply (in terms of seats available) and the demand (in terms of passengers utilizing the mode) is shown from Figures 3 to 5.

In Figure 3, the differences between the demand and supply for jeepneys were almost consistent for the whole day of operations. The time period wherein there was the largest deviation between supply and demand was from 1:31 – 1:45 PM with 407 seats available. It can be said that for the whole day of operation, there is an oversupply of jeepneys at the wharf.

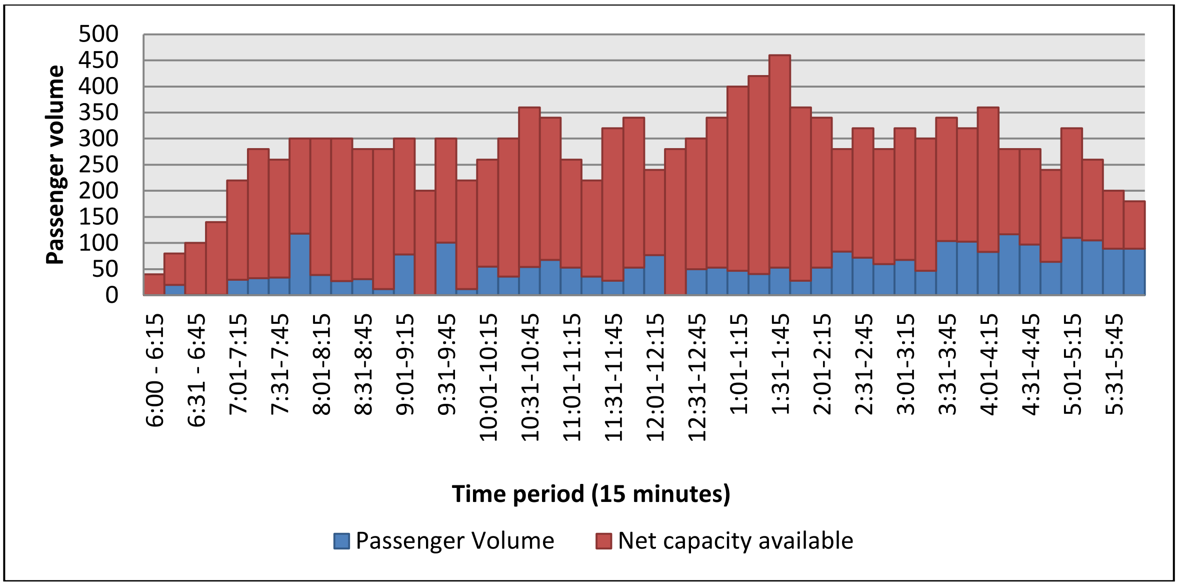

Figure 3. The demand and supply difference in Jeepneys

The findings for the demand and supply difference in multicabs yielded similar results. The largest deviation occurred from 9:01 – 9:15 AM with 278 excess seats available. It is significant to note that there are different time periods where there were a small number of passengers departing. These time periods are 6:00 – 6:15 AM, 6:31 – 6:45 AM, 7:01 – 7:15 AM, 8:16 – 8:30 AM, 12:31 – 12:45 PM, 3:31 – 3:45 PM, and 4:31 – 4:45 PM. These empty time periods should be addressed by distributing the passenger volume within the hour by varying the headway in the hour.

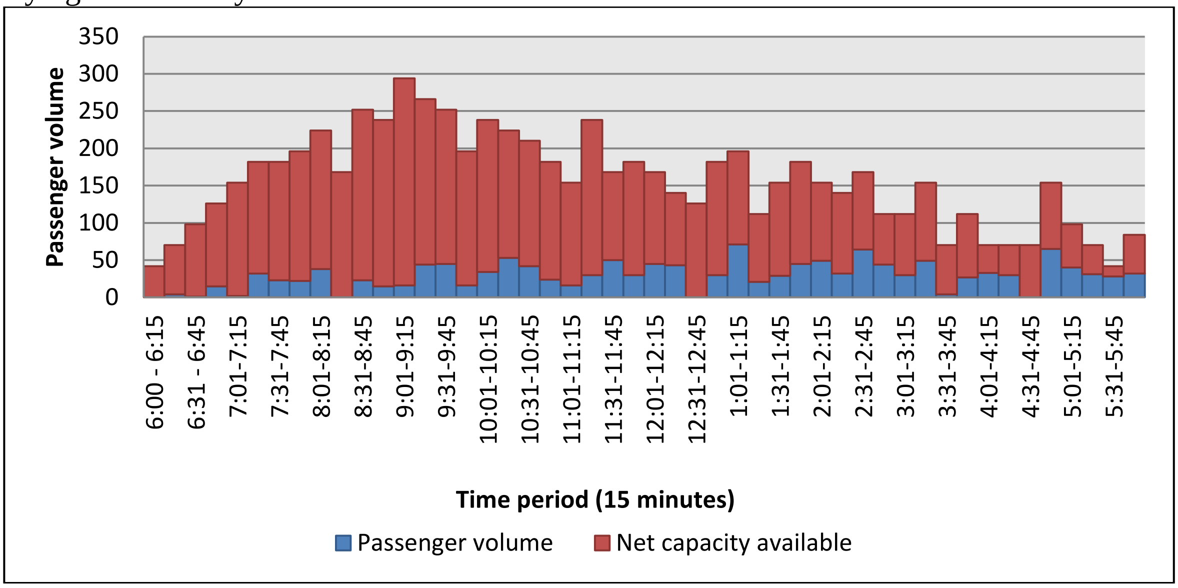

Figure 4. The demand and supply difference in Multicabs

The difference between the supply and demand for vans is more significant. It can be clearly seen in the succeeding figure (Figure 5) that vans only operate on a less frequent rate compared to their jeepney and multicab counterparts. It also confirms that the preference for vans as a mode of transport is miniscule as shown in Figure 2. With the small demand for vans, there is an oversupply for vans waiting at the wharf and there is a need to reduce this supply to make their operations more efficient.

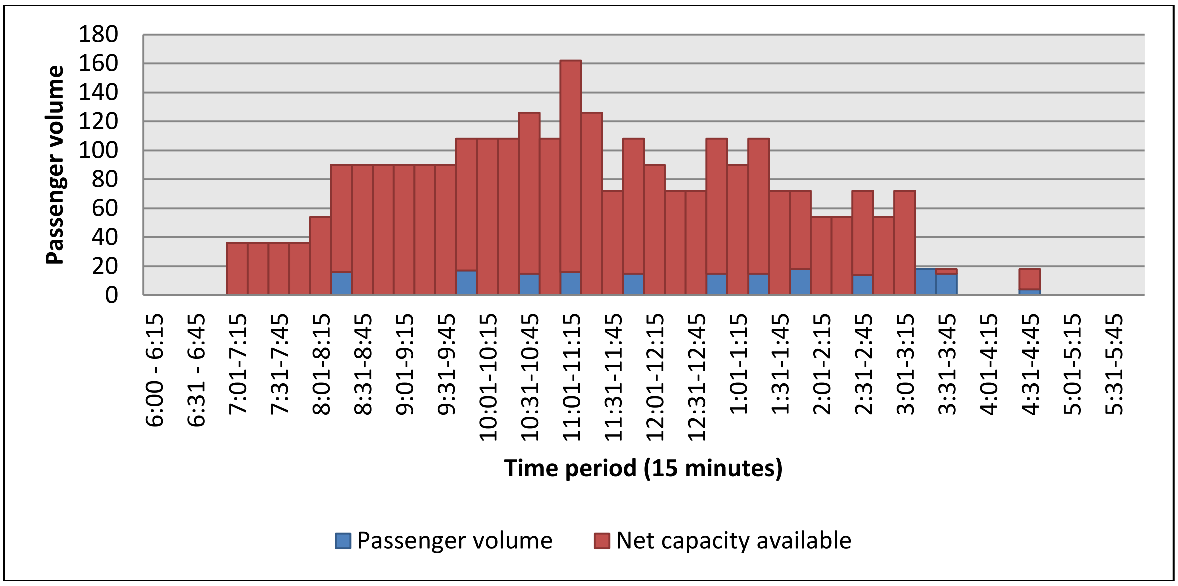

Figure 5. The demand and supply difference in Vans

Analysis of the utilization coefficients for arriving public transport at the wharf indicates that for jeepneys and multicabs, the supply is utilized by at least 50% for the time periods of 6:30 – 11:30 AM and 7:30 – 11:30 AM. The trend in decrease and increase in utilization was analogous to the trend of arrivals and departures of passengers at the wharf. For departing public transport, majority of the utilization coefficient is below 0.5 which means that almost twice of the offered supply were not utilized. In order to increase the utilization without altering the passenger volume, the number of transit units or vehicles that were waiting at the wharf was decreased by setting the appropriate number of vehicles needed to accommodate the demand of pumpboat passengers arriving to the area.

Table 2. Utilization coefficients (α) for arriving land transport

	Jeepney	**Multicab**	**Van**
6:00 - 7:00	0.50	0.37	0.44
7:00 - 8:00	0.83	0.52	0.00
8:00 - 9:00	0.73	0.58	0.51
9:00 - 10:00	0.89	0.80	-
10:00 - 11:00	0.93	0.89	1.02
11:00 - 12:00	0.62	0.59	0.44
12:00 - 1:00	0.37	0.46	0.56
1:00 - 2:00	0.55	0.47	0.11
2:00 - 3:00	0.40	0.42	-
3:00 - 4:00	0.31	0.25	0.11
4:00 - 5:00	0.36	0.32	-
5:00 - 6:00	0.34	0.61	0.11

Table 3. Utilization coefficients (α) for departing land transport

	Jeepney	Multicab	Van
6:00 - 7:00	0.10	0.10	-
7:00 - 8:00	0.43	0.26	-
8:00 - 9:00	0.21	0.22	-
9:00 - 10:00	0.44	0.34	0.16
10:00 - 11:00	0.36	0.37	0.12
11:00 - 12:00	0.31	0.39	0.22
12:00 - 1:00	0.34	0.39	0.14
1:00 - 2:00	0.26	0.47	0.37
2:00 - 3:00	0.49	0.59	0.19
3:00 - 4:00	0.52	0.40	0.92
4:00 - 5:00	0.57	0.50	0.22
5:00 - 6:00	0.78	0.55	-

4.3 Determination of Departing Land Transport Fleet Size

The determination of the appropriate fleet size was based on the appropriate passenger design volume. The passenger design volume is the product of the actual passenger volume and the peak hour coefficient. The ratio of the highest volume multiplied by four and the total hourly volume is the peak hour coefficient. From the modal shares, the design volume per mode can be determined. The frequency of operations can be determined by dividing the design volume of the hour to the appropriate modal capacity. It is assumed that the cycle time of each vehicle is greater than the time period. This assumption is to avoid the same vehicle serving the same time period. The design frequency would be the transport fleet size that is needed and the number of vehicles that would be set as the limit for waiting transit units. Mathematically,

$$P_d = P \cdot PHC \qquad (6)$$

$$PHC = \frac{4p_{15}}{P}; \; 0 \le \text{PHC} \le 4 \qquad (7)$$

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

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

where,

Pd	: design volume,
PHC	: peak hour coefficient,
p15	: highest 15-minute volume,
$P_{dJ,MC,V}$	: design volume for each mode
	J - jeepney (cap. 24), MC – multicab (cap. 16) , V – van (cap. 18)
n, fd	: number of vehicles needed or design frequency
$C_{J,MC,V}$	: capacity for each mode of transport

It should be noted that *n* or the designed frequency assures that all vehicles will depart the wharf for the specific time period.

Table 4. Proposed number of waiting vehicles at the wharf

	Jeepney	Multicab	Van	Total
6:00 - 7:00	2	2	0	4
7:00 - 8:00	14	8	0	22
8:00 - 9:00	6	7	2	15
9:00 - 10:00	9	8	1	18
10:00 - 11:00	11	11	1	23
11:00 - 12:00	11	12	3	26
12:00 - 1:00	10	10	2	22
1:00 - 2:00	10	14	3	27
2:00 - 3:00	12	12	1	25
3:00 - 4:00	16	9	3	28
4:00 - 5:00	18	10	1	29
5:00 - 6:00	11	6	0	17

The previous table shows the proposed number of waiting vehicles at the wharf. Unlike the results in Table 1, the number of waiting vehicles proposed in this period is assured of departure within the time period.

In correspondence to the proposed number of waiting vehicles, the effect of the proposal to the utilization coefficient was made and shown in Table 5. It can be noted that majority of the coefficients were twice of the current utilization coefficient. Likewise, across all time periods, most of the utilization coefficients were above 0.5 which implies that the utilized capacity is about 50% of the total offered capacity which makes the operations more efficient. The last time period, 5:00 – 6:00 PM showed a significantly high utilization coefficient above 1. With this high utilization coefficient, transit operators can increase the number of frequency or increase the number of waiting vehicles. As much as possible, utilization coefficients should not exceed the value of 1 to avoid crowding inside the vehicle. Increasing the frequency in this case would not constitute an immediate effect to the operations of the wharf but, it would give passengers more comfort inside the vehicle.

Table 5. Utilization coefficients (α) of proposed condition

	Jeepney	Multicab	Van
6:00 - 7:00	0.46	0.63	0.00
7:00 - 8:00	0.64	0.62	0.00
8:00 - 9:00	0.76	0.68	0.44
9:00 - 10:00	0.88	0.95	0.94
10:00 - 11:00	0.81	0.86	0.83
11:00 - 12:00	0.64	0.66	0.57
12:00 - 1:00	0.75	0.74	0.42
1:00 - 2:00	0.70	0.74	0.61
2:00 - 3:00	0.93	0.98	0.78
3:00 - 4:00	0.84	0.76	0.61
4:00 - 5:00	0.84	0.80	0.22
5:00 - 6:00	1.49	1.36	0.00

4.4. Data Validation

To validate if there was a significant difference to the current and the proposed conditions, a t-test was performed on the number of waiting vehicles. The t-test performed assumes that there is an unequal variance between the two samples. The null hypothesis is that there is no difference between the two means while the alternative hypothesis is that the two means are not equal. The statistical results are shown in the next table (Table 6).

Table 6. EXCEL t-test output

	Current	*Proposed*
Mean	44.8333	21.3333
Variance	91.2424	49.5152
Observations	12	12
Hypothesized Mean Difference	0	
df	20	
t Stat	6.86156	
P(T<=t) two-tail	1.1E-06	
t Critical two-tail	2.08596	

With the p-value less than 0.05 the results are significant at a 5% level of significance. The t-stat is also greater than the critical t-value for two-tailed test which shows that there is a significant difference between the current and the proposed conditions.

5. CONCLUSIONS

The result of this paper showed that there is an oversupply of public transportation at the Jordan wharf. The oversupply of public transport leads to a very small utilization coefficients for departing public transport as there are a lot of vehicles that are waiting at the wharf. The waiting vehicles have no effect on the arriving public transport at the wharf. The utilization coefficients actually showed that vehicles entering the wharf have almost half of its offered capacity being utilized. The results show that there is still a need for improvement in increasing the coefficient for arriving public transport. The methodology presented, using the trend of pumpboat passenger counts, would not be sufficient in making an analysis. Hence, a more in-depth methodology of vehicle scheduling considering the actual routes of each mode of transport is suggested to further increase utilization of public transport modes.

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