A Framework for the Assessment and Policy Development of Water Transit Services in Dubai, UAE

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Abstract

The Marine Agency-Roads and Transport Authority (MA-RTA) of Dubai-UAE recently undertook a study to develop a new transport policy for service delivery. The goal of the new policy is to increase rider share and use of MA-RTA services. The existing service policy guidelines of the water transit services were barely supported by the loading patterns, existing market coverage, adequate intermodal planning tools, economic feasibility, and capital return of services. Based on user and operators surveys of the water transit services, aiming at assessing the baseline conditions, methodologies are suggested to estimate important service attributes, including service coverage, intermodal connectivity, and market demand estimation. The estimated service attributes were used as measures to develop the service policy standards to increase water transit ridership and enhance service efficiency. It is recommended to incorporate some of the service standard/guideline measures under a framework discussed in this study for developing service plans, monitoring performance, and providing short or long term alteration to the services.

Introduction

Urban development and prosperity, as well as the quality of life of city dwellers in Dubai, depend on the accessibility and smooth operation of public transit. Public transit that provides people with outstanding service is a real alternative to the automobile, thus contributing directly to sustainable development. Investing in public transit is also a lever for economic development because of the transportation industry's role in our production chain and daily activities. Improvement in marine transport would relieve some of the pressure on the congested roads in the city.

Waterbus service has been introduced recently in Dubai-UAE as a mode of marine transport under the authority of the Marine Agency-Roads and Transport Authority (MA-RTA). As such, it was necessary to develop a service policy and operational guidelines for the Waterbus in particular and for marine transport modes in general. This service policy and guidelines are important for the monitoring, assessment, and improvement of marine transport services and particularly to support MA-RTA's vision of increasing ridership of marine modes to reduce demand on land transport modes, and subsequently to reduce congestion in the Emirate of Dubai. Therefore, MA-RTA undertook a study aimed at developing a transport policy for service delivery. Policy development would initially depend on the assessment of existing baseline services by RTA through user and operators surveys (Hassan et al. 2010). The assessment of transport system performance through targets is becoming increasingly widespread worldwide (FHWA,2004; NCHRP 2004; Zografos et al. 2004; Hidas and Black 2002; Turner et al. 1999; Gates 2001). The study was conducted by the Roadway, Transportation and Traffic Safety Research Center (RTTSRC) at UAE University (RTTSRC 2008a,b). The overall goal of the new policy is to increase the ridership or use of MA-RTA services. To attain this goal, MA-RTA adopted a five-year service policy for the establishment of modern, cost-effective, and efficient services to attract higher ridership.

In general, the literature on issues of marine transport operation and planning of services is scarce, with little of relevance to marine agency policy development. No literature of relevance was found related to policy development, such as how policies are developed, whether they are developed subjectively or using a quantitative approach, how guidelines are developed, the difference between policies and short term planning of service enhancements, and data needed for policy development and planning. Presented herein is previous work of relevance to marine operation in general but not necessarily policy development.

Previous work in the area of marine operation and services tackled issues of planning for services (Cedar 2006), evaluation of services (Odek and Barthen 2009), forecasting demand (Laube and Dyer 2007; Outwater et al. 2003), best practices for public outreach (Camay et al. 2008), marine network design (Wang and Lo 2008), and intermodal modeling (East and Armstrong 1999).

Ceder (2006) presented a planning approach with an evaluation procedure for making the best use of existing water and pier resources to improve public ferry transit through the provision of commercially-viable services in Hong Kong. Odek and Brathen (2009) developed the so-called data envelopment analysis model to demonstrate ferry performance evaluation and service improvements in Norway. Laube and Dyer (2007) presented a model for demand forecasting of the ferry service system to serve the National Park of New York Harbor. Outwater et al. (2003) tackled the expansion of mode choice models to account for traveler attitudes and different market segments. The causal relationships between traveler socio-economic profile and travel attitudes towards ferry services of San Fransisco Bay Area were integrated into the mode choice models. Camay et al. (2008) described some best-practice methodologies for public outreach, focusing on socio-economic and community assessment of ferry services. Wang and Lo (2008) developed a heuristic model for the network design of Hong Kong ferry services. East and Armstrong (1999) dealt with planning intermodal transfers of passengers from transit to ferries for six ferry terminals of the Washington State ferry systems.

The RTTSRC (2008a) identified some specific objectives that should be included in the mission of the RTA marine transport. Policy goals, objectives, and associated performance measures and targets are to be established through policy formulation and, ideally, integrated within the agency's planning process. To evaluate the progress towards achieving the mission of MA-RTA, the study identified the service policy objectives that represent the most important characteristics of a "world-class" transit system: (1) accessibility, where services are made geographically available throughout the community and are operated at convenient times and frequencies (MBTA 2006); (2) reliability, where services are operated as scheduled; (3) safety, where services are provided at a safe manner; (4) comfort, where services offer a pleasant and comfortable riding environment; and (5) cost effectiveness, where services are tailored to target markets in a financially-sound and cost-effective manner (MBTA 2006).

The main objectives of this paper are (a) to propose a service policy development framework based on field survey data and (b) to illustrate how the guidelines (in the service policy) were developed on the basis of user demand perspectives, with the goal to increase marine transport ridership. Therefore, this paper highlights the methods to estimate some important service parameters that are needed for assessment of existing services. The parameters were estimated based on a field user survey (Hassan et al. 2010) in the absence of relevant direct data. The inferred service parameters (obtained from a field user survey) were used in developing the standards of MA-RTA service policy. The service attributes under consideration include mobility rate as an indication of existing service coverage, level of perceived service difficulty as an indication of intermodal connectivity, and demand-fare prediction as an indication of the responsiveness of the demand market to changes in fare policies.

Existing Marine Transport Services

MA-RTA operates a comprehensive set of transit services. This paper addresses two particular modes of the existing RTA marine services: Abra includes small vessels with 20-passenger capacity that link two points in the two districts of Deira and Bur Dubai across the opposite sides of Dubai Creek, and Waterbus includes 36-passenger vessels that make multiple stops, are air-conditioned, and offer luxury seats and high-tech features such as panoramic windows, LCD screens, and access for special needs passengers. Figure 1 shows the route maps of both Abra and Waterbus in Dubai, and Table 1 summarizes the features of the various routes of service for these two public marine transport modes.

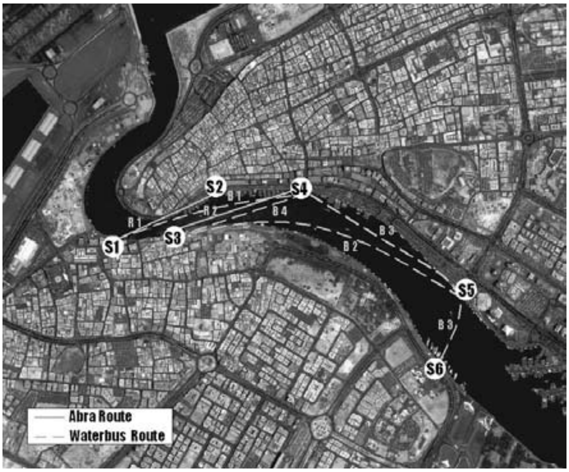


Figure 1. Location of Dubai Marine Service Stations and Routes

Table 1. Basic Information of MA-RTA Services*

Route	Route Stations	Working Hrs	Vessel Capacity	Number of Vessels	Number of Operators	Route Length (km)	Average Daily Person Trips
R1	S1- S2	5am - 12 midnight	20	40	80	0.55	10,839
R2	S3 - S4	24 hrs	20	110	220	0.8	28,186
B1	S1 - S4	6am - 11pm	36	1	24	1.058	109
B2	S3 – S5	6am - 11pm	36	2		1.286	335
B3	S4 - S5 - S6	6am - 11pm	36	2		1.966	393
B4	S3 - S4	12 midnight - 6am	36	1		0.907	107

**R and B refer to Abra and Waterbus routes, respectively. S1 Bur Dubai station, S2 Diera Old Souk station, S3 Dubai Old Souk station, S4 Al Sabkha station, S5 Baniyas station, and S6 Al Seef station.*

Service Policy Development Framework

The framework for the assessment and development of the service policy guidelines of the MA-RTA is presented briefly in Figure 2. This framework is based on the survey conducted by Hassan et al. (2010) that collected opinions of existing marine transport users. The system-wide survey was meant to assess the existing service efficiencies at a broader scale and to specify directions on how the service can be improved in the form of a policy or general guidelines. It is essential to note that a policy is not meant to get into a detailed level of the route specifics, and it is usually developed with coarse system data. The survey questionnaire was designed to capture the necessary field data to estimate the direct and, hence, inferred parameters of the major service perspectives such as service coverage, availability of intermodal connectivity, and trip fare and demand relationships. The collected data were particularly limited to user characteristics and service utilization.

It is essential to consider collecting more thorough data on demand characteristics as well as prospective users. This will be required for purposes of planning the marine services, including route reconfigurations (if needed), particular route frequencies, etc. It is important to differentiate here between data needed for policy and for planning for service operation. While planning for services mandates extensive data on demand characteristics and prospective users, policy development

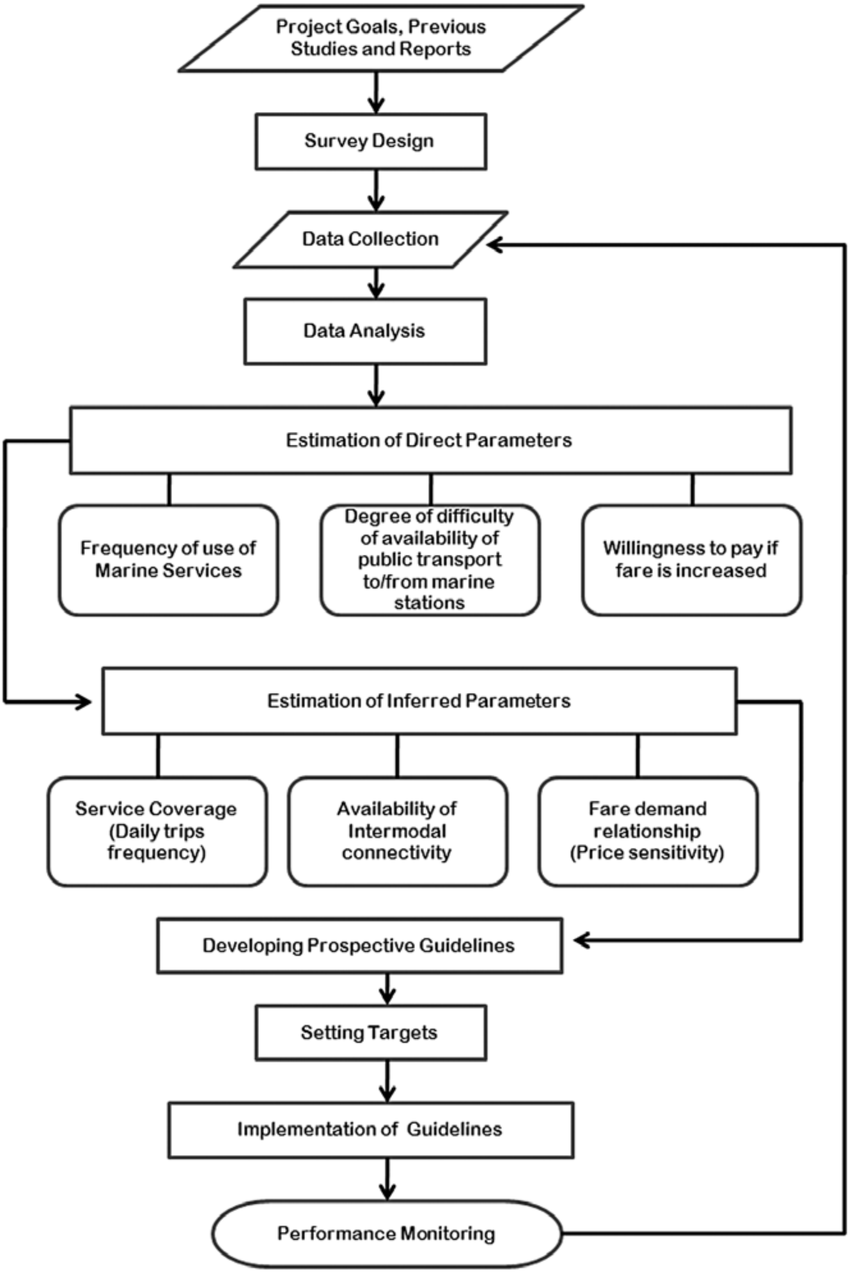


Figure 2. Service Policy Development Framework

and assessment can be accomplished using only broader observations of existing user characteristics and service utilizations or efficiencies. The study recommends extensive and systematic collection of data on demand characteristics and prospective users (for planning purposes) to reconfigure the service characteristics and consequently optimize the services. Such data can also be useful, to some extent, in reviewing the developed policy or guidelines.

After analyzing the relevant service parameters with regard to strategic goals, prospective service guidelines with service policy targets are recommended for implementation. Finally, performance monitoring is carried out to re-evaluate MA-RTA service enhancement in light of the recommended service policy guidelines.

Survey Design Process

The survey design adopted was the "stated preference survey" (Hassan et al. 2010). In this type of survey, people are placed in hypothetical choice situations and asked what they would do if they were faced with this particular choice (Espino et al. 2007; Ahern and Tapley 2008). The user survey form provides the stated preference of the responses in terms of service characteristics, accessibility, and marine transport station facilities. The questions were designed to capture the (1) socioeconomic characteristics in terms of gender, age, level of education, and personal (family) income and (2) factors affecting the choice of modes for connecting trips, the purpose of the trips, the possibility of switching to an alternative mode, willingness to pay an increased trip fare, the origin and destinations of their regular travel patterns, general satisfaction level regarding the service and problems, and suggestions for using the infrastructure facilities.

Substantial efforts were invested in ensuring that the relevant information on preferences was elucidated with fewer questions. The on-site survey method was used as it allowed the interviewer to elaborate on the marine transport characteristics as well as personally interview the respondents. This enabled respondents to make more informed "stated preference" decisions on the marine transport and increased the reliability of the responses. The population of the survey represented actual MA-RTA services users; it did not include non-users (or prospective users). The key data from the user survey include purpose of trip, route, fare, economic ability of the user, accessibility of modes to other land transport systems, trip travel time, frequency, comfort, safety, and user preference of services.

Sample Size

A simple random sampling procedure was considered. Each response, either quantitative or qualitative, of a question was considered of equal importance and had equal likelihood of selection. For distribution of responses with normal distribution, the minimum number of surveys required for a 90% confidence level was calculated using the following formula (Miller et al., 1990):

$$n = \frac{3.24v^2}{d^2} \tag{1}$$

where, n is the minimum sample size (number of users), v is the coefficient of variation (assumed as 0.5), and d is the tolerance level (assumed as 5%). Therefore, the minimum sample size of the survey to obtain the specified statistical significance was determined to be 324.

This sample size was determined to provide a statistically significant sample to assess the overall system or to estimate the overall service characteristics and efficiencies. As such, route-specific performance data or daily loadings were not particularly addressed. As indicated earlier, this may be essential only for "planning" purposes. Hence, detailed Abra and Waterbus route performance surveys entailed a larger sample size and were, in fact, recommended for the second phase of the project to address planning issues.

It should be noted that the proportions of Abra and Waterbus riders in the overall population of marine transport riders are about 98 percent and 2 percent, respectively. Applying these proportions to the sample size, very few surveys would have been collected from the Waterbus riders (only 7 surveys would be needed for Waterbus). A total of 500 samples were targeted to have more representation of Waterbus responses. A larger sample size was sought to collect more information on Waterbus riders, while maintaining the necessary minimum of Abra riders to obtain statistical significance. This explains why the "targeted" sample size was larger than the minimum needed. The number of approached Abra and Waterbus riders to fill the survey was about 675. The number of successfully conducted surveys was 506 (about 75% response rate), comprising 384 (76.4%) for Abra and 119 (23.6%) for Waterbus. More emphasis on Waterbus users was made intentionally to have better representation, keeping in mind that one of the policy objectives is to increase the ridership of Waterbus in particular or to have a fair balance between the two modes.

The two modes were combined to report the overall marine transport system efficiencies. In other instances, the two modes were analyzed independently to assess the mode-specific characteristics and efficiencies. It should be noted that the two modes are mostly complementary (i.e., they serve different routes), with only one route being served competitively by the two modes. The two modes serve essentially two groups of riders with different socio-economic characteristics. Hassan et al. (2010) reported that 53 percent of Abra users earn AED 2000 or less monthly, while 70.3 percent of Waterbus users earn AED 5000 or more monthly. Nonetheless, the two rider groups equally ranked trip fare followed by safety as the most important criteria of service effectiveness. Therefore, both rider groups are driven by same service characteristics, despite differences in their socio-economic characteristics.

Survey Management Process

The survey team consisted of transport engineers, transport planners, and survey specialists. Team members were of different nationalities and spoke Arabic, English, Hindi, Urdu, Bengali, and Filipino fluently in order to communicate more comfortably with users.

A preliminary (pilot) survey questionnaire was tested to check if the questions were understandable, answerable, well-motivated, and useful. The pilot survey also was used to check timing and response behavior. Moreover, the pilot survey was intended to examine whether or not the survey questions contained technical jargon or were long-winded, biased, redundant, or made the respondent uncomfortable. The questionnaire was slightly modified after the pilot survey to incorporate the shortcomings.

The survey was conducted on both weekdays and weekends to cover the potential variability of the service on different days and to capture the various trip purposes. The survey schedule also considered hourly variations (i.e., morning and evening working hours).

As the survey management process was critical to the successful execution of the survey, the aspects of survey quality control and response rate were monitored carefully. Survey quality control includes recruitment and training of interviewers, supervision of survey staff, procedures for data capturing and cleaning, and communications with the public. Users at the stations were either given the survey form to fill out or interviewed by a survey team member, whichever was more convenient to the user. In many instances, the survey team member boarded along with the Abra or Waterbus passengers to increase the convenience level for the users. Respondents of little education were interviewed by a survey team member.

Service Coverage

Service Coverage Assessment Measures

Mobility is one of the important efficiency measures of any transport system. This system efficiency measure could be assessed from the end-user side in the absence of other system efficiency parameters data. The mobility indicator in terms of "trips per user per day" of the relevant system used in this study could be defined as the extent of service coverage among the existing daily regular commuter who could make at least two trips/user/day, assuming that all passengers make return trips at least daily. If 100 percent of daily users make at least one trip daily, then the value of the mobility indicator would be one trip/user/day, and if 100 percent of daily users make a return trip daily, then the value of the mobility indicator rate would be two trips/user/day. This mobility indicator could take a maximum value of 2.15 trips/user/day for the marine system, assuming 90 percent of the daily passengers return (i.e., making two trips/user/day) and 10 percent of the passengers make several trips a day (assumed here as 3.5 trips/user/day).

One question on the user field survey questionnaire was intended to capture the daily frequency of the marine transport usage (Abra or Waterbus). The daily usage was mathematically manipulated to estimate the mobility indicator of the service coverage among the regular commuter. As shown in Figure 3, the daily users (i.e., at least one trip daily) for the Abra and Waterbus were 38 percent and 41.2 percent, respectively.

The frequency of the combined marine transport of both Abra and Waterbus was obtained from the weighted average based on the number of users of the two modes as collected from the field data. For the frequency of the combined marine transport service usage, the following results were found:

- 31.41 percent of the respondents indicated two or more trips daily; 90 percent of this group used the marine transport system twice (for roundtrip) and 10 percent used it several times, with an average of about 2.15 trips daily.
- 7.36 percent of the respondents indicated only one trip daily.

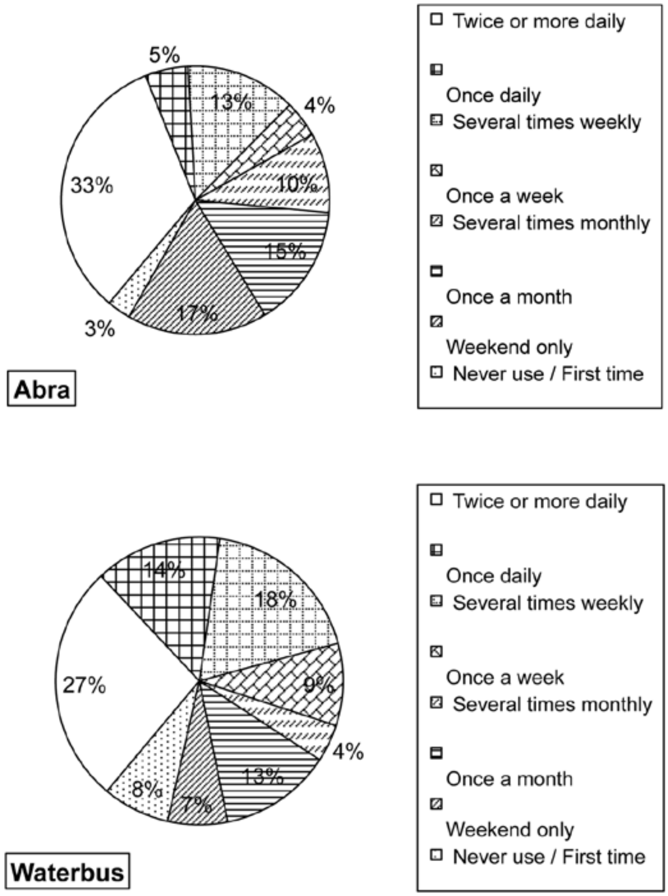


Figure 3. Frequency of Use of Marine Service

- 14.51 percent of the respondents indicated several trips weekly, or approximately 0.5 trips daily.
- 5.57 percent of the respondents indicated one trip per week, or approximately 0.143 trips daily.
- 8.35 percent of the respondents indicated several trips per month, or approximately 0.117 trips daily.
- 14.31 percent of the respondents indicated one trip per month, or approximately 0.033 trips daily.

- 14.51 percent of the respondents indicated use on weekends only; two-thirds of this group took a round trip, and the remainder took a single trip. This group accounts for 0.238 trips daily.
- 3.98 percent of the respondents indicated that they were using the mode for the first time and had never used it earlier. This group accounts for approximately 0.003 trips daily.

The service coverage of the marine transport in terms of the mobility rate (M) indicator can be calculated as:

$$M = \sum \left(\frac{Daily\ trips \cdot Frequency\ of\ the\ group(\%)}{100} \right) \qquad (2)$$

The overall mobility rate (denoting the average number of trips per user per day) for the marine transport system of the combined Abra and Waterbus is 0.88 trips/user/day. In another way, it can be explained that the equivalent of 88 percent of existing daily regular users use the marine transport for making at least one trip daily. For the Abra system, the mobility rate is 0.89 trips/user/day, and for the Waterbus it is 0.85 trips/user/day. These mobility indicator rates imply that not all the existing daily users make at least one trip daily with the existing marine transport modes. It should be noted that the mobility measure can be applied to either the Abra or Waterbus systems separately or for each route separately to determine the characteristics of daily users and their daily mobility pattern.

Service Coverage Policy Targets

The overall mobility rate measure found for the combined systems indicates that the existing daily users are commuting with less than one trip daily. This means that opportunity remains for MA-RTA to enhance its services, which can be directly measured by the mobility rate. A higher mobility rate is a true reflection of more utilization of the marine service and implicitly indicates an improvement in the service. That is, the MA-RTA could adopt this system efficiency performance standard with some annual incremental increase to attract more users to use the marine services on a daily basis.

Setting annual incremental targets is, of course, constrained by the flexibility of changing services as well as budget constraints. It was found that reasonable but sustainable progress with limited funding requirements can be attained by setting the target mobility rate at 1.10 trips/user/day (in two years) and at 1.30 trips/user/

day (in five years). These set targets could be achieved if the RTA marine transport system service is enhanced to attract more existing users to become regular single- or return-trip makers rather than making trips several times weekly or monthly. Therefore, these two targets were included in the system efficiency guidelines within the service policy standards of MA-RTA.

It should be noted that in setting the improvement increments, or the targets, the values were specified subjectively and reasonably in order not to add any considerable financial or human burden on MA-RTA. Guidelines were provided on how to increase ridership, utilizing more or less the same financial and human resources. In prioritizing the measures to achieve the targets, the most effective measures with little added financial/ human resources were ranked higher. Therefore, the devised policy and guidelines not only provide incremental targets on effectiveness indicators (such as mobility rate), but also specify the most appropriate measures to achieve these targets. For instance, policy and guidelines specify how mobility rates can be increased by reducing trip fares, applying promotion periods, etc.

Intermodal Connectivity

Intermodal Connectivity Assessment Measures

Intermodal connectivity is another important efficiency measure of any transport system. This system efficiency measure can be assessed from the operator's supply side and/or from the end-user's demand side. The final outcome should come from the perceptions of the end-users, as it affects their mode choice patterns. Therefore, the end-user's perception on the level of difficulty was included in the field survey. The intermodal connectivity difficulties were evaluated in terms of availability and frequency of getting either taxis and/or public buses at the marine transport stations. Figure 4 illustrates the perceived levels of difficulties at the various water transit stations (S1 through S6).

Two observations can be made from the survey results: (1) for all marine stations, around 40 percent of the users confirmed difficulty of using land transportation modes, and (2) at least 60 percent or more of the users indicated some degree of difficulty at different stations. This reveals the importance of intermodal connectivity of the marine transport services and other surface public transport modes from the users' side. Therefore, the perceived level of difficulty by the users could be an important efficiency measure as it indicates the absence of a smooth intermodal connectivity. This level of difficulty of intermodal connectivity might be a factor that discourages non-users from using marine transport services at the current conditions.

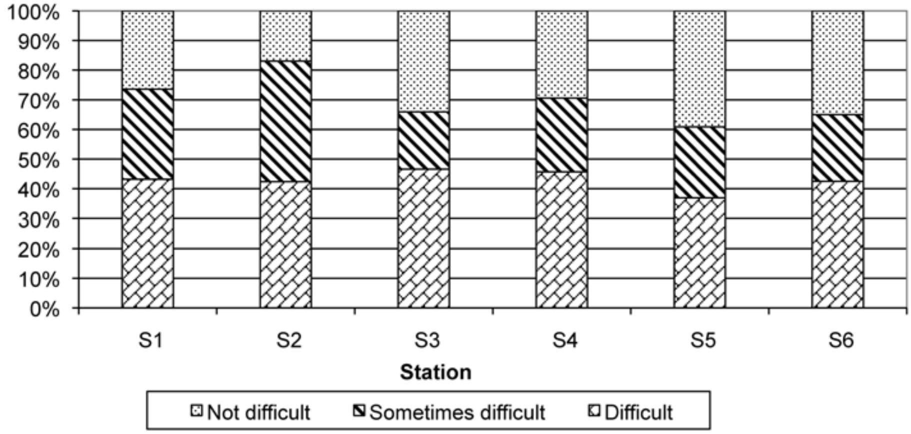


Figure 4. Availability of Public Transport (Bus and Taxi) to/from Marine Stations

Intermodal Connectivity Policy Targets

With the introductions of the new metro services by the end of year 2009, with various metro stations in the vicinity of the water transit stations, and with a plan of extensive bus coverage to facilitate connectivity to the metro stations, the MA-RTA could gain considerable benefits by working closely with the land public transport systems to improve intermodal connectivity.

A policy would indicate, for instance, that the overall system difficulty should not be more than 20 percent. The general guidelines would specify how to achieve this objective (again, at a broader level). Examples of general guidelines would be more frequent land transport, provision of parking areas for private cars or taxis, etc. These guidelines are extracted from the opinions (via system-wide surveys) of the current service users. Having this in mind, a target was set to reduce the perceived level of intermodal connectivity difficulty from its current value of 60 percent to 40 percent in two years and to 10 percent in five years. These two targets were included in the service policy standards of MA-RTA.

The detailed planning of the service adjustments (which is usually done at a lower level with more frequent updates or revisions) will then require detailed data collection (route specific, particular route surveys, opinions of prospective users of the route, etc). Specific actions to address such intermodal difficulties at a route level usually are addressed at the planning level of service adjustments, which is beyond the scope of this paper. Indeed, for planning purposes of service adjustments, detailed route information, particularly intermodal difficulties,the inclusion of prospective users is essential.

Market Demand Estimation

Market Demand Assessment Measures

Having access to detailed service parameters such as waiting times, frequency, and travel times is the basis for developing utility-based route choice or mode choice (logit or probit) mathematical models to accurately capture the demand levels in response to service changes. Nonetheless, from the system-wide survey results, it was evident, as clearly stated by the majority of users, that fare is their primary decision making factor in the selection of the mode. Given that this study was mainly intended to develop policy (not the planning of service adjustments), it may be adequate to depend on the fare parameter to capture the expected demand market in response to fare policy changes. In detailed planning of service adjustments, it will be essential to gather detailed route-specific parameters including user waiting times, travel times, transfer times, etc. These data should be used to calibrate utility-based demand models.

Existing market demand is obtained from counts of both the Abra and Waterbus riders; this information is readily available through the rider counting gates and service revenues. The market demand may change as a result of any newly-applied fare policy. To estimate what will be the new market demand with such newly-introduced fares, users were asked how much of a fare increase they would be willing to accept and still consider using the same mode. This survey question was used in developing the fare-dependent demand curves, as will be explained later.

The Abra and Waterbus demand curves in a perfectly competitive market were estimated based on several assumptions. First, the demand (i.e., willingness to use) of the marine transport system primarily changes with the trip far' attribute. This is justifiable since the survey revealed that trip fare is the highest-ranked attribute by the users. Second, when, theoretically, there is no trip fare (i.e., free ride), the demand of the transport system reaches its maximum capacity.

Third, the number of total daily users who would be willing to use the system even after a trip fare increase is assumed to be proportional to the response rate found in the survey. Here, the real-world response of marine users to fare adjustments is assumed to be similar (equal) to the responses obtained from the system-wide surveys. For instance, if the users in the survey indicated full acceptance of a 25 percent increase in fares, we assume that, in reality, a 25 percent fare increase will have little impact on market demand. If, in the survey, all users indicate no acceptance of 100 percent fare increase, we assume that, in reality, a fare increase of 100 percent will have a significant impact on ridership (considerable loss of ridership).

Fourth, the demand curve was assumed a typical "exponentially decreasing" shaped cost-demand curve, commonly used in transport economics analysis. Using the aforementioned assumption, the demand curve was calibrated using the survey data to obtain the best fit curve by regression analysis.

Waterbus Demand Curves

The maximum daily capacity of the Waterbus system is calculated in Table 2. The daily capacity of each route is calculated by multiplying Waterbus vessel capacity by the number of scheduled daily trips along the route.

Table 2. Maximum Daily Capacity of Waterbus System

Route	Description (from Station – to Station)	Daily Capacity (Vessel Capacity Multiplied by Scheduled Daily Trips)
B1	Sabkha – Bur Dubai	2,448
B2	Baniyas – Old Souk	4,896
B3	Al Seef- Baniyas- Sabkha	4,896
B4	Dubai Old Souk – Sabkha	432
Total capacity		**12,672**

The responses of Waterbus users to the question on the willingness to use the service in case of an increasing trip fare are summarized in Table 3. The first row represents reaching the theoretical capacity in the case of a zero fare. The second row represents the existing condition with a fare of 4 AED per trip. The last column of the second row indicates the current daily trips (944). In response to the question of willingness to still use the Waterbus in the case of a 25 percent increase in fare, 67.3 percent of the respondents indicated that they would not use it, while 32.7 percent indicated that they still would. Similarly, in case of 50 percent increase in fare, only 14.4 percent of the respondents indicated that they would use it. A total of 9.6 percent of the respondents indicated that they would still use Waterbus in the case of a fare increase of 75 percent. With a fare increase of 100 percent, all respondents indicated they would not use Waterbus. The demand (in column 5) was estimated by multiplying the existing demand (944) by the cumulative percentage of users who would be willing to use the Waterbus system.

Table 3. Willingness-to-Pay Responses for Waterbus System

Trip Price (AED)	Trip-Fare Increase (%)	Cumulative Unwillingness to Use Waterbus (%)	Willingness to Use Waterbus (%)	Demand (daily User Trips)
0	-	-	-	12,670
4	0	-	-	944
5	25	67.3	32.7	311
6	50	85.6	14.4	137
7	75	90.4	9.6	91
8	100	100.0	0.0	0

Regression analysis was conducted on the results shown in Table 3 using SPSS. The following formula found the best fit trip-fare demand relationship, with a coefficient of determination (r^2) of 0.828:

$$Q = 28.7 \cdot 0.366^{P} \qquad (3)$$

where, Q is the daily user trips (in 1000 trips) (column 5 of Table 3), and P is the trip fare in AED (column 1 of Table 3).

No restrictions (constraints) were made on meeting the maximum capacity at a zero trip fare. To account for the maximum capacity at a zero fare, while minimizing the standard errors, the regression was constrained by enforcing the zero fare data point. The calibrated equation of the Waterbus trip-fare demand curve is:

$$Q = 12.6 \cdot 0.51^{P} \qquad (4)$$

It should be noted that Eqs. (3) and (4) are based on using the same data (shown in Table 3). Equation (3) was derived using the first and last columns of Table 3. Equation (4) was calibrated from the same data set, but with the regression "constrained,"forcing the regression curve to pass through the "zero fare" data point following the typical shape of the demand curve. At the zero-fare point, the expected demand is assumed to be equal to the maximum capacity of the marine service vessels.

The monopoly market demand curve was estimated by simply assuming no change in the daily user trips in case of an increase in the trip fare. This assumption is justified, given that there is no other suitable, feasible, or cheaper alternative mode for passengers to shift from the existing Waterbus system.

Figure 5 illustrates the three curves of the Waterbus: the demand curve from survey opinions (without restrictions on the theoretical capacity), the demand curve with the theoretical capacity enforced, and the monopoly demand curve.

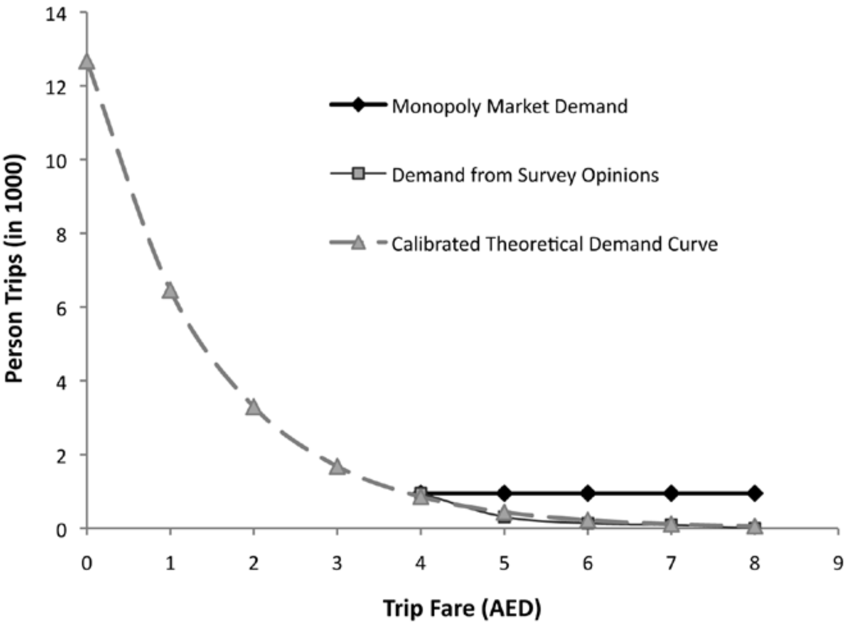


Figure 5. Waterbus Demand Curves

Waterbus Price Elasticity

The price (fare) elasticity of the Waterbus (*E*) can be calculated as (Papacostas and Prevedouros 2001):

$$E = \frac{\frac{dQ}{Q}}{\frac{dP}{P}} = \frac{dQ}{dP} \cdot \frac{P}{Q} \qquad (5)$$

where, *Q* and *P* are as defined before.

Papacostas and Prevedouros (2001) describe that the negative sign of the elasticity value reflects the fact that a percentage increase in *P* will cause a percentage decrease in *Q* and, depending on the demand function, the price elasticity of demand is not constant for all points on the curve. In addition, the value of the price elasticity of demand reflects the implication of a price change on the total revenue ($P \cdot Q$) of the supplier. For example, when $E < -1$, the percent decrease in Q is larger than the percent increase in P. In this case, the demand is said to be elastic, and the total revenue, after an increase in price, decreases because the loss of sales volume outweighs the extra revenue obtained per unit sold. When $E > -1$, the demand is said to be inelastic, and the total revenue increases after raising the price. When $E = -1$, the demand is unitarily elastic, and the revenue derived from selling less units at a higher price is equal to the total revenue prior to raising the price. When $E = 0$, the market is a perfect monopoly and, hence, the price change does not cause a change in demand.

Differentiating Eq. (4) and substituting in Eq. (5), the price elasticity for a perfectly competitive market can be stated as:

$$E = -8.48 \cdot 0.51^{P} \cdot \frac{P}{Q} \tag{6}$$

Using the current trip-fare (P = 4 AED) and an estimated demand from Eq. (5) of 0.852 thousand trips/user/day, the E value would be -2.69. This price elasticity value indicates that for an increase in trip fare (from the current 4 AED per trip), the demand for Waterbus would fall at a significant response rate (in case other suitable alternatives were available in a perfectly competitive market). Alternatively, the demand would significantly increase when the trip-fare is reduced. A proposal was made to reduce the existing trip fare to 2 AED (instead of 4). The expected demand and difference in revenue is shown in Table 4. The expected number of daily person trips under the proposed scenario was calculated using Eq. (4).

Table 4. Expected Revenue Scenario with Reduced Trip Fare for Waterbus

Scenario	Trip-Fare (AED)	Daily Person-Trips	Daily Revenue (AED/day)	Increase in Daily Revenue from Current (AED/day)	Increased Revenue from Current (%)
Existing	4	945	3,780	-	-
Proposed	2	3,277	6,554	2,774	73

Abra Demand Curves

Using a similar procedure to the Waterbus demand curve estimation method, the regression analysis of the Abra fare demand relationship is as follows:

$$Q = 9.7P^2 - 62.1P + 84.8 \; ; \; r^2 = 0.98 \tag{7}$$

Figure 6 illustrates the three demand curves of the Abra: the demand curve from survey opinions (without restrictions on the theoretical capacity), the demand curve with the theoretical capacity enforced, and the monopoly demand curve.

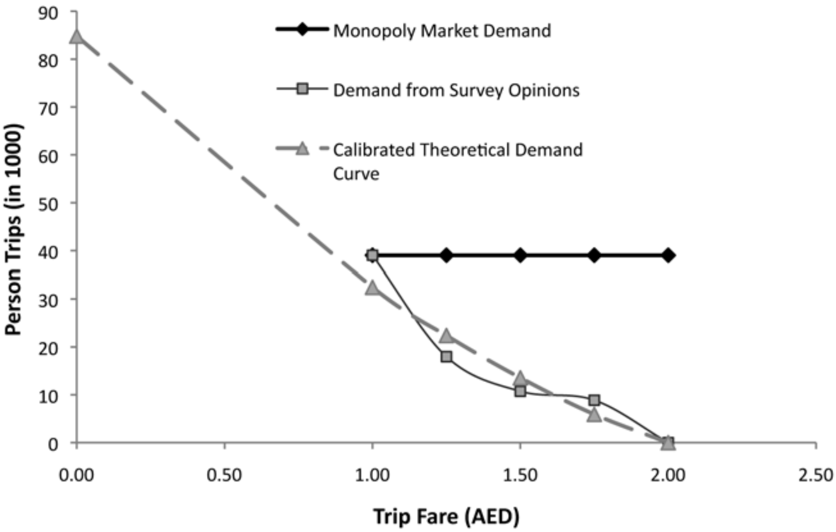


Figure 6. Abra Demand Curves

Abra Price Elasticity

The used formula of the price (fare) elasticity is as follows:

$$E = (19.41P - 62.06) \cdot \frac{P}{Q} \tag{8}$$

Using the current trip-fare (P = 1 AED) and an estimated demand from Eq. (7) of 32.4 thousand trips/user/day, the *E* value would be -1.31.

Market Demand Policy Targets

The higher Waterbus price elasticity value implies that the demand for Waterbus would fall with a significant response rate (in case other suitable alternatives were available in a perfectly competitive market). Alternatively, the demand would significantly increase when the trip-fare is reduced.

This monopoly market scenario illustrates the inelastic situation that more or less represents the existing Waterbus market. Nonetheless, even with a prevailing monopoly market, policymakers should consider this significant response rate that actually quantifies the unwillingness of users to pay higher prices for the trip fare. This explains the small daily loading percentages of Waterbus, indicating non-popularity among commuters even though Waterbus is known to be more comfortable and safer than Abra. In the survey, some Abra users suggested that they might shift to Waterbus if the current price level were reduced to 2 AED.

As a solution to increase Waterbus ridership, the single trip fare was suggested to be reduced to 2 AED for single trip (i.e., 4 AED for round trips) to increase the number of passengers by attracting non-users in the coverage area or some of Abra users.

Implementation and Performance Monitoring

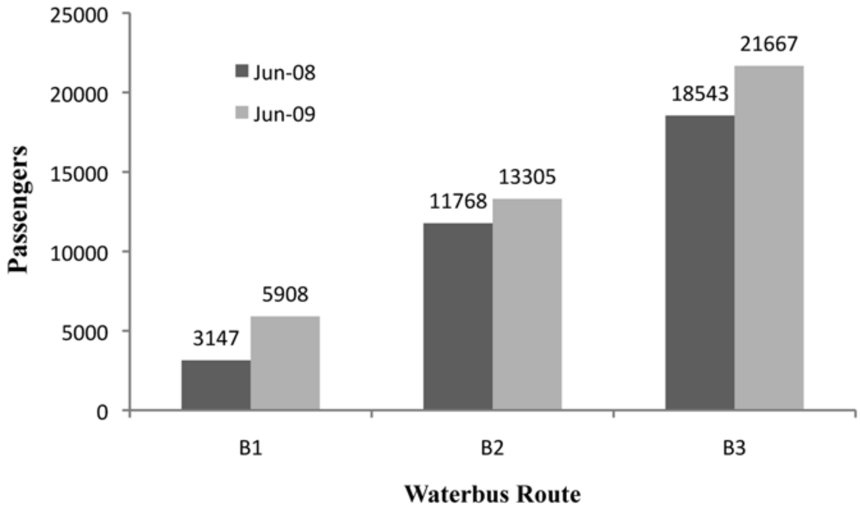
Trips Fare Reduction Guideline for Waterbus

Following the recommendations of the study, the RTA Board of Directors approved in March 2009 a fare of 4 AED per round trip during a single day (khaleejtimes.com). The recommendation was expected to attract various non-users as well as divert a portion of the Abra users, as explained earlier. It also was expected that the overall revenue of MA-RTA services would increase in light of a Waterbus fare reduction.

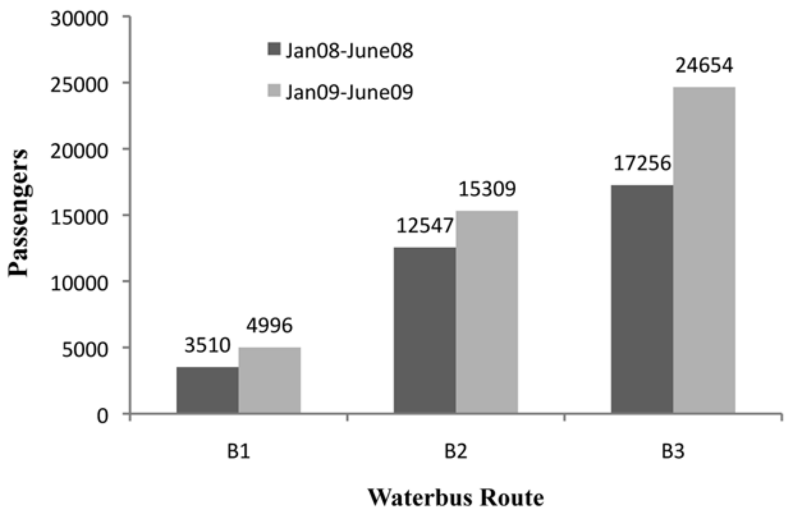
Monitoring of Waterbus Ridership

An essential element of policy development is performance monitoring in light of the suggested recommendations. Although early at this stage to make an overall system performance assessment, early indicators suggested considerable gains due to the implementation of the new service policy.

Over 43,351 passengers were ferried in 11,100 trips by Waterbus in June 2009, according to recently-released counts by MA-RTA. These counts show an increase of 12,052 passengers for Waterbus compared to June 2008 statistics (khaleejtimes.com). The ridership increase on Waterbus B1, B2 and B3 routes in certain months in 2009 as compared to counterpart periods in 2008 is shown in Figure 7.



(A) Passengers in June 2009 compared to June 2008



(B) Average monthly passengers during January-June of 2008 compared to the same period of 2009

Figure 7. Waterbus Ridership Increase

The application of fare reduction was implemented in March 2009, and the increase in Waterbus ridership was reported in June 2009. During this short period, there was no major land-use change within or nearby the study area. Also, the study area consists primarily of offices, traditional markets, shopping areas, and residential areas. There are no industrial activities near the marine transport stations. Therefore, it can be concluded that the effects are not related to other land-use or exogenous factors.

The increase in Waterbus ridership was reported immediately following the fare reduction. More time is needed for the demand to stabilize and then be re-measured. Also, the demand on transport modes in general is less during summer as compared to winter. The expected demand levels in response to the fare change (as shown in Figures 5 and 6) represent the upper bound of the demand increase in the case of a fare reduction/increase. An important point to note is that the demand levels on all transport modes in 2009 were considerably affected by the global economic crisis on one hand and the economic status of Dubai in particular on the other. Dubai has witnessed considerable losses in demand levels on all transportation modes in general. Therefore, the reported 30 percent increase in a few months is a good indicator of a successful fare reduction policy.

It should be noted that throughout the survey, many Abra users indicated their willingness to shift to Waterbus if its fare were reduced to a compatible level with that of Abra. The suggestion to reduce the Waterbus fare was particularly supported by evidence from surveys as well as the developed fare-ridership demand curves. The increase in Waterbus ridership following application of the fare reduction can be attributed to several possibilities: 1) shifting of Abra users to the more convenient Waterbus mode, 2) an increase in the number of trips of Waterbus riders, and 3) newly-generated trips by prospective users. Suggestions for continuous monitoring and post-implementation surveys were made to MA-RTA to follow up on causes of ridership increases/changes and generally on the post-effects of policy and guideline implementations.

Conclusions

The existing service policy guidelines of MA-RTA are supported little by existing market coverage, loading patterns, adequate intermodal planning tools, economic feasibility, and capital return of services. The service policy planning models currently used for strategic planning of the various modes by RTA need to be critically validated. Moreover, major initiatives of service changes are not driven by policies, outcome measures, or performance indicators. For these reasons, it is imperative that the policy guidelines for MA-RTA are introduced in a precise and well-documented way, creating a formal and systematic method for service assessment and planning, operation monitoring, and evaluation. Therefore, MA-RTA should incorporate some of the service standard/guideline measures under the adopted framework discussed above for developing service plans, monitoring performance, and providing short or long term alteration to services. The indicators of system performance under the new service fare policy are quite encouraging.

It would have been useful to have more post-policy data for verification and fine-tuning of the guidelines. However, this was not possible since few of the suggested policies and guidelines were implemented. As such, we focused only on the implemented policies within a reasonable time frame. The fare policy was the first to be implemented; thus, we included some findings of the Waterbus fare reduction policy. Full incorporation of the service policy guideline would require more time to reach system stability. Future work would entail reporting detailed service performance in light of the adopted guidelines, together with the fine-tuning of service target values. Therefore, collecting more post-policy data should be considered in future research.

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