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Progress Report
Group #2

"Implementation of a Methodology for Determining Quality of Service in Bus Routes"

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Abstract

Puerto Rico is a small island in the Caribbean, consisting of only 160 km of length and 56 km of width. It has a population of approximately 3.8 habitants with a high vehicular density of 247 vehicles/km^2. Transportation problems in the SJMA include concentrated population and employment, limited capacity of the highway system, inadequate public transport service, lack of intermodal connections and the constrained mobility for low income families. The SJMA has many parking and general congestion problems, contributing to excessive delays at almost every hour of the day. The Tren Urbano (TU) offers the Metropolitan Area an alternative to the traffic congestion problem that affects it, which is highly due to the high dependency of the population to its private vehicle. The TU and the buses need to be integrated, forming an intermodal transit system.

However, limitations and disadvantages exist. Within these is the necessity for an adequate coordination. The Autoridad Metropolitana de Autobuses (AMA) has a fleet of approximately 244 buses. However, its current schedule is not compatible with that of the TU. Lack of coordination affects the current and potential users' reliability in the system. Choice riders will probably reconsider other trip options due to the unreliability of the bus system operation.

If information of the service frequency and quality were to be given to the bus users, the reliability of the system might increase, leading to a potential increase in ridership of the system. A good way to increase ridership and provide information about the quality of service to the users would be to get real and up-to-date data from the bus routes and evaluate their operation to develop a communicable quality of service level for the public. Using the proper methodology, this may be realized.

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I. Implementation of a Methodology for Determining Quality of Service in Bus Routes

Puerto Rico is a small island in the Caribbean, consisting of only 160 km of length and 56 km of width. However, it has a population of approximately 3.8 habitants with a high vehicular density of 247 vehicles/km^2. A high vehicle to person ratio of 1.69 puts it in the largest density of this type in the world, three times larger than any city in the USA. The San Juan Metropolitan Area consists of 13 municipalities, summing up to around 1036 km^2 (1, 2).

It has a population density of 1352 habitants per square kilometer. The SJMA generated 3.2 million trips per day in 1990, and by the year 2010 the number of trips is expected to increase by 45% (2).

Transportation problems in the SJMA include concentrated population and employment, limited capacity of the highway system, inadequate public transport service, lack of intermodal connections and the constrained mobility for low income families. It has a vehicular density of 56 vehicles per km (90 vehicles per mile) of paved street, higher than in any other city of the world. The SJMA has many parking and general congestion problems, contributing to excessive delays at almost every hour of the day. Commuters are willing to wait up to15 minutes or less between transfers (8). Above all, commuters want to feel secure and want to arrive on time at their destinations.

Statistics show that the mass transit usage has declined 40.7% from 438,000 in 1964 to 259,524 in 1990 (5). The available means of transportation in SJMA include the private vehicles, taxis, buses (AMA, Metrobus 1, and Metrobus 2), “Carros Publicos”, ferryboats, and the Tren Urbano (TU). The TU consists of a 16.9 km rail system of 16 stations and serves the municipalities of San Juan, Bayamon and Guaynabo. Figure #1 shows a map of SJMA and the TU's transit service route.

Figure 1. San Juan Metropolitan Area and the TU.

The Tren Urbano (TU) offers the Metropolitan Area an alternative to the traffic congestion problem that affects it, which is highly due to the high dependency of the population to its private vehicle. The TU and the buses need to be integrated, forming an intermodal transit system. Advantages of this integration will be:

- It permits the use of various modes of transport, therefore expanding the service area and the time of service.
- An increase in the number of transported passengers.
- A decrease in fuel consumption, good for the environment.
- Money saving in the cost of gasoline for the vehicle, parking, maintenance and vehicle depreciation.

However, limitations and disadvantages exist. Within these is the necessity for an adequate coordination.

The Autoridad Metropolitana de Autobuses (AMA) has a fleet of approximately 244 buses. It operates 32 routes of which 21 were modified to serve in junction with the TU. However, its current schedule is not compatible with that of the TU, adding to the disadvantages of the integration which is not proving to work well because of coordination problems. The lack of coordination affects the current and potential users' reliability in the system. Choice riders will probably reconsider other trip options due to the unreliability of the bus system operation. Therefore, ridership growth is limited and diminished.

If information of the service frequency and quality were to be given to the bus users, the reliability of the system might increase, leading to a potential increase in ridership of the system. A good way to increase ridership and provide information about the quality of service to the users would be to get real and up-to-date data from the bus routes and evaluate their operation to develop a communicable quality of service level for the public. Automated Vehicle Location (AVL) data is needed to make such an analysis.

The bus routes selected for this study are the A-3 and B-21. Both routes serve places of importance and are integrated to the TU. Also, these routes serve train stations with much ridership.

II. Objectives

The main two objectives of this research are to evaluate the quality of service and analyze the delays of bus routes that serve the TU system.

Evaluation of Quality of Service

- To analyze quality of service of buses from the user's point of view.
- Identify and analyze different existing methodologies for the determination of a LOS for buses to be applied in Puerto Rico. (accomplished)
- To apply the methods to particular routes.
- To design an effective method to provide reliability information to the users.
- Identify the routes to be analyzed. (accomplished)
- Analyze the quality of service offered to users by taking in consideration delays, headways and travel speed.
- Identify critical segments of delay in routes.
    - Identify what is a critical delay according to the user.
- Suggest possible changes in routes.

III. Justification

Transportation investments are influenced by the level of service ratings of the current and expected system performance (6). The Highway Capacity Manual (7) defines Level of Service (LOS) as a “quality measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed and travel time, freedom to maneuver, traffic interruptions and comfort and convenience.” Frequency of service is the primary evaluation measure for assessing transit LOS. The level of service LOS for transit is based on a number of factors. Common measures of LOS are local route headways, commuter route headways, service span, average interval between stops, and service span.

Up to now, no recent studies with a scientific nationally approved methodology have been done regarding the quality of service of the integrated AMA- TU bus routes.

IV. Evaluating Transit Quality of Service Literature Review

Progress in this research includes the determined methodology to assess quality of service. The methodology chosen to realize this study is that of the Transit Capacity and Quality of Service Manual. Due to the extreme similarities between the Highway Capacity Manual and the Transit Capacity and Quality of Service Manual, both methodologies may be interchanged for fixed-route buses. In this section a review of the chosen methodology for assessing quality of service for bus systems is provided.

Transit Capacity and Quality of Service Manual

This methodology is to be used for the evaluation of transit service quality of service. It consists in a quantitative measure of performance that best describes a particular aspect of the transit service from the passenger's point of view.

It is important to have in mind the following terms: quality of service, transit service measure, transit performance measure, and level of service.

- Transit service measure is a quantitative performance measure that best describes a particular aspect of transit service and represents the passenger's point of view.
- Quality of service is an overall measured or perceived performance of transit service from the passenger's point of view.
- Transit performance measure is a quantitative or qualitative factor used to evaluate a particular aspect of a transit service.
- Level of Service (LOS)—Six designated ranges of values for a particular service measure, graded forma A (best) to F (worst) based on a transit passenger's perception of a particular aspect of transit service.

In this study, transit service measures will be taken into account, not transit performance measures.

The Highway Capacity Manual and the Transit Capacity and Service Manual coincide on several important distinctions. Some of these are:

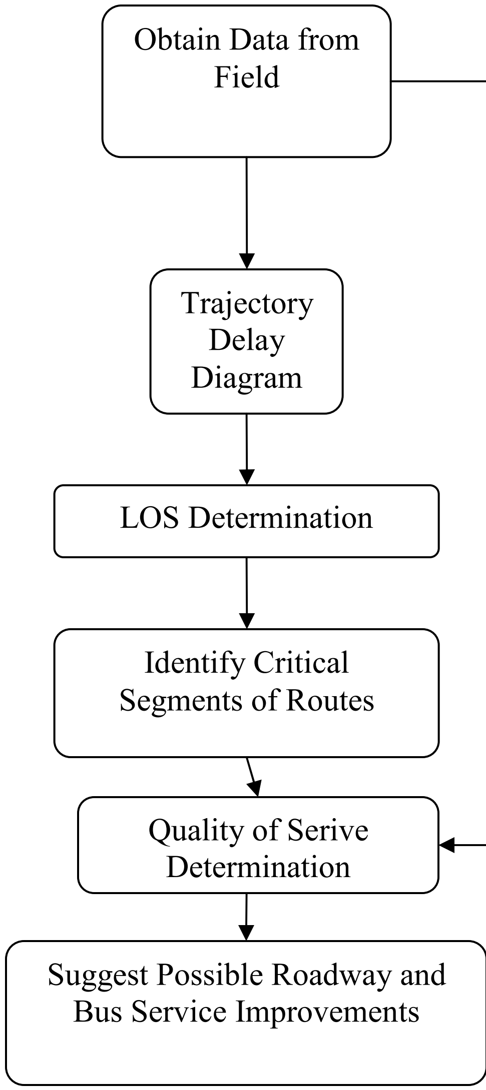
- Service measures represent the passenger's point of view, whereas performance measures can reflect any point of view.
- Service measures should be relatively easy to measure and interpret.
- Level of Service (LOS) is only for service measures.

The passenger point of view or quality of service, directly measures passengers' perception of the availability, comfort, and convenience of transit. Quality of service measures of transit service are divided into two main categories: availability, and comfort and convenience. According to the measure addressing spatial and temporal availability, if transit is located too far away or if it does not run at the times it is needed, a potential user would not consider the transit service available, and therefore the quality of service would be poor. If transit service is available, the quality measures to evaluate user perceptions of comfort and convenience can be applied. Such measures should be addressed at transit stops, route segments, and systems.

The type of route service that will be taken in consideration in this study is the fixed-route service. Paratransit service is not within the scope of this study.

V. Methodology

Fig. 2



VI. The Transit Capacity and Quality of Service Manual Methodology

The quality of service framework for fixed-route transit measures can be divided in 2 main categories:

1- availability

2- comfort and convenience

Availability Measures

Quality of service may be measured used to measure at the stop, route segments, and the system. Since route segments are composed of a series of stops, stop-level measures are also applicable at the segment level.

Service Frequency

From the passenger's point of view, transit service frequency determines the number of times an hour a user has access to the transit mode. This is assuming that the transit service is within acceptable walking distance. Service frequency LOS is determined by destination. Service frequency is also a measure of the convenience of transit service to choice riders and is component of overall transit trip time. Urban scheduled transit service includes all scheduled service within a city as well as service between cities within a larger metropolitan area. The service frequency LOS measure for urban scheduled transit service is headway. The SJMA's transit service falls in this category. Passengers, however, find it easier to understand schedules when clock headways are used. A clock headway is one that is evenly divisible into 60.

Buses on separate routes serving the same destination that arrive at a stop within 3 min of each other should be counted as one bus for the purposes of determining service frequency LOS.

Fig. 3 Exhibit 3-12 Fixed-Route Service LOS

LOS	Avg. Headway (min)	veh/h	Comments
A	<10	>6	Passengers do not need schedules
B	10-14	5-6	Frequent service, passengers consult schedules
C	15-20	3-4	Maximum desirable time to wait if bus/train missed
D	21-30	2	Service unattractive to choice riders
E	31-60	1	Service available during the hour
F	>60	<1	Service unattractive to all riders

Accessibility at Transit Stops:

This includes Pedestrian bicycle, automobile and ADA accessibility of transit stops. An evaluation of pedestrian accessibility should consider whether sidewalks are provided, the condition of the sidewalks, terrain, traffic volumes on streets that pedestrians must cross to access a transit stop and the kind of traffic control provided on streets. Accessibility considerations that apply to transit stops also apply to route segments.

Route Segment Hours of Service

Service span, or hours of serve, is the number of hours during the day when transit service is provided along a route, route segment, or between two locations. It plays an important role in determining availability of transit potential users. For fixed-route service, LOS is based on the number of hours per day when transit service is provided at least once an hour. One hour must be added to the span for the LOS determination. The hours of service LOS is intended only for transit service provided within cities. It does not apply to intercity transit.

The following table illustrates the corresponding LOS according to the hours of service.

Fig. 4 Exhibit 3-13

LOS	Hours of Service	Comments
A	19-24	Night or "owl" service provided
B	17-18	Late evening service provided
C	14-16	Early evening service provided
D	12-13	Daytime service provided
E	4-11	Peak hour service only or limited midday service
F	0-3	Very limited or no service

Comfort and Convenience Measures

Passenger loads reflect the comfort level of the onboard vehicle portion of transit trip both in terms of being able to find a seat and in terms of overall crowding levels within the vehicle. Passenger load LOS for bus uses square meters per passengers. This LOS can be measured by time of day or by the amount of time a certain condition occurs.

Passengers may wear or carry objects that increase the space they occupy. Because of this, One may wish to use the concept of equivalent passengers, based on the projected area values given in the following table.

Fig. 5 Exhibit 3-25

Situation	Projected Area (ft^2)	Projected Area (m^2)
Standing	1.6-2.2	0.15-0.20
... with briefcase	2.7-3.2	0.25-0.30
... with daypack	3.2-3.8	0.30-0.35
... with suitcases	3.8-5.9	0.35-0.55
... with stroller	10.2-12.4	0.95-1.15
... with bicycle (horizontal)	17.2-20.4	1.60-1.90
Holding on to stanchion	2.7	0.25
Minimum seated space	2.7-3.2	0.25-0.30
Tight double seat	3.8 per person	0.35 per person
Comfortable seating	5.9 per person	0.55 per person
Wheelchair space (ADA)	10.0 (30 in x 48 in)	0.93 (0.76 m x 1.22 m)

NOTE: Stroller and bicycle dimensions are based on a review of manufacturer specifications.

If standing passenger area is not known, the following steps can be used to estimate it.

1. Calculate the gross interior floor area.
2. Calculate the area occupied by seats and other objects.
3. Calculate the standing passenger area.

Once this is obtained, the following table is used to obtain the level of service.

Fig. 6 Exhibit 3-26

LOS	Load Factor (p/seat)	Standing Passenger Area (ft^2/p)	(m^2/p)	Comments
A	0.00-0.50	>10.8†	>1.00†	No passenger need sit next to another
B	0.51-0.75	8.2-10.8†	0.76-1.00†	Passengers can choose where to sit
C	0.76-1.00	5.5-8.1†	0.51-0.75†	All passengers can sit
D	*1.01-1.25**	3.9-5.4	0.36-0.50	Comfortable standee load for design
E	*1.26-1.50**	2.2-3.8	0.20-0.35	Maximum schedule load
F	*>1.50**	<2.2	<0.20	Crush load

*Approximate value for comparison, for vehicles designed to have most passengers seated. LOS is based on area.
†Used for vehicles designed to have most passengers standing.

On time performance should be measured at locations of interest to passengers. On time is defined for this methodology as 0 to 5 minutes late, and can be applied to either arrivals or departures. Early departures are not considered on-time at stops where passengers board. Early departures are considered on-time only in locations where no passengers would board, such as end of route.

On-time performance would typically be measured for a route over a series of days. It takes a minimum of 20 observations to achieve the 5% resolution between LOS grades.

Fig. 7 Exhibit 3-29

LOS	On-Time Percentage	Comments*
A	95.0-100.0%	1 late transit vehicle every 2 weeks (no transfer)
B	90.0-94.9%	1 late transit vehicle every week (no transfer)
C	85.0-89.9%	3 late transit vehicles every 2 weeks (no transfer)
D	80.0-84.9%	2 late transit vehicles every week (no transfer)
E	75.0-79.9%	1 late transit vehicle every day (with a transfer)
F	<75.0%	1 late transit vehicle at least daily (with a transfer)

NOTE: Applies to routes with a published timetable, particularly to those with headways longer than 10 minutes.

VII. Acquired Data

Technological devices may be used in order to develop frequency, headway, dwell times, and boarding and alighting data. Such devices include Automated Passenger Counters (APC) and Automatic Vehicle Location (AVL) technologies. Presently, these devices have not yet started to work efficiently on the AMA busses. For purposes of this research, such data must be acquired by visiting the field and measuring it. In the future, the methodology presented by this study may be used to obtain a quality of service measure. Following is some of the data obtained from the APC unit. However this data is still not trustworthy.

Table 1. APC Output

Date	Day	Unit		Boarding	Alighting	Difference	> de 10 %	< de 10%
		APC	AMA				DIF.	DIF.
Nov 14,2005	Monday	62	2002-07	16	419	(403)	-96.2%	
		66	20001	3436	2947	489	14.2%	
		68	20003	4231	2442	1789	42.3%	
		73	20008	2024	1487	537	26.5%	
		83	20018	0	0	0		
		87	20022	3246	1790	1456	44.9%	
		112	20047	0	0	0		
		125	20060	17	366	(349)	-95.4%	
		128	20063	2624	2095	529	20.2%	

Table 2. Boarding and Alighting Measured On-Site

Stop	Boarding	Alighting	Accumulated Boarding	Accumulated Alighting	Occupancy
1	36	0	36	0	36
2	1	1	37	1	36
3	0	10	37	11	26
4	1	2	38	13	25
5	0	3	38	16	22
6	2	1	40	17	23
7	0	9	40	26	14
8	0	3	40	29	11
9	1	0	41	29	12
Terminal Parada 18	0	12	41	41	0

VIII. Schedule

	2005																2006															
ACTIVITY	October				November				December				January				February				March				April				May			
Literature Review																																
Interviews : AMA/ATI																																
Hand In Proposal			26																													
Proposal Presentation			29																													
Progress Report									3																							
Data Collection- On Site							23																									
Survey Preparation																																
Survey																																
Analysis of Survey																																
Analysis of Results																																
Poster Preparation																																
Poster																													6			
Preparations Final Report																																
Final Final Report																														16		

Yellow- Proposed Green- Done

IX. References

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