Level of Service Analysis for Urban Public Transportation of Dumlupinar University Evliya Celebi Campus in Kutahya, Turkey

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Abstract

In this study, the public transport system problems between Kutahya city center and Dumlupinar University Evliya Celebi Campus were firstly mentioned. Then, the transit quality of service was evaluated from various aspects such as transit availability, comfort and convenience. For this purpose, at first, transit availability was examined in terms of service frequency and hours of service. Secondly, the comfort and convenience provided by the transit system in Kutahya Dumlupinar University Evliya Celebi Campus was studied. For this reason, the overall crowding levels within the vehicles, headway adherence, and transit-automobile travel time were considered. In order to carry out most of these analyses, the procedures in Transit Cooperative Research Program (TCRP) Report 100 were followed. Finally, the results compared to 2011 results and several recommendations for increasing public transport usage were given.

Keywords: The City of Kutahya, Dumlupinar University, Public Transport, Level of Service, Quality of Service

1. Introduction

People expect from a transportation system to have several major characteristics. At first, safety factor should be large while people are using the transportation system. Secondly, the transportation system should carry people, materials and products at minimum time and cost. Finally, it should provide the greatest possible comfort (Vuchic, 2007).

Transportation investments should be compared from various aspects such as congestion, air pollution, noise, land use, costs, energy consumption and security. Similarly, many different factors such as number of passengers carried, capacities, frequencies and volumes are taken into consideration in determining public transport system to be used. Even though these factors generally vary from place to place, the system used for transportation should be safe, fast, affordable, punctual and frequent (Uludag, 2005). Hence, as the system is determined for a city or a region, many factors such as topography, geology, climate and socioeconomic structure should be considered (Sallis and others, 2004). In this study, the transit quality of service for Kutahya Dumlupinar University Evliya Celebi Campus was evaluated from various aspects such as transit availability, comfort and convenience. In order to carry out most of these analyses, the procedures in Transit Cooperative Research Program (TCRP) Report 100 were followed.

2. Existing Public Transport System for Kutahya Dumlupinar University Evliya Celebi Campus and Its Current Problems

Kutahya is a developing city that lies in the west of Turkey. The city has one university with nearly 50,000 students. The city of Kutahya has a population of approximately 260,000 inhabitants within the limits of the Municipality Region. Because of the growing impact of increasing passenger demand, the car ownership and congestion levels in Kutahya have begun to rise considerably. Private public buses are used as a means of public transport for Dumlupinar University Evliya Celebi Campus. The buses used in the public transport system are small ones, and have a seating capacity of 22 passengers. These buses can also accommodate 20 standees. These private public buses have been running on 4 different lines (Kutahya Mun., 2016). There is no fast and efficient public transportation network in the city of Kutahya. Some bus routes are longer than necessary. Besides, due to lack of coordination among the lines, lengthy waiting times occur at transfer points. This situation decreases the efficiency of public transportation (Yaliniz and others, 2011).

3. TCRP Transit Capacity and Quality of Service Methodology

The headways and hours of service were considered in order to evaluate the transit availability. To calculate hours of service, the departure time of the last run was subtracted from the departure time of the first run, and 1 hour was added to this subtraction. This additional hour accounts for the last hour when service is provided. Then, any fractional hours were rounded down. When service was not operated throughout the day, the number of hours of service for each portion of the day when service was provided was calculated, and then the total was used in determining the.

Table 1 Fixed-Route Hours of Service LOS

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

Table 2 Fixed-Route Service Frequency LOS

LOS	Average Headway (min)	vec/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

LOS, based on Table 1 (TCRP, 2003). Service frequency determines how many times an hour a user has access to the transit mode. Service frequency also measures the convenience of transit service to choice riders, and is one component of overall transit trip time. However, the service measure used is usually average headway, which is the inverse of the average frequency. Therefore, Table 2, which is taken from TCRP Report 100, lists service frequency LOS by both headway and frequencyThe overall crowding levels within the vehicles, headway adherence, and transit-automobile travel time were considered for evaluating the comfort and convenience provided by the public transport system. To this end, the overall crowding levels within the vehicles are firstly observed during peak and non-peak hours, and passenger load LOS was roughly determined by taking into account the values from Table 3. Afterwards, headway adherence LOS was determined for the lines operating at headways of 10 minutes or less in order to evaluate the comfort and convenience provided by the public transport system. As it is known, for transit service operating at headways of 10 minutes or less, headway adherence is used to determine reliability. For this purpose, the procedure described in TCRP Report 100 was used again. In this procedure, the measure is based on the coefficient of variation of headways of transit vehicles serving a particular route arriving at a stop, and is calculated as follows:

$$c_{vh} = \frac{\text{standart deviations of headway deviations}}{\text{mean scheduled headway}}$$

where:

$c_{vh} = \text{coefficien t of variation of headways}$

Headway deviations are calculated by subtracting the scheduled headway from the actual headway. As shown in Table 4 which is taken from TCRP Report 100, the coefficient of variation of headways can be related to the probability P that a given transit vehicle's headway h_i will be off-headway by more than one-half the scheduled headway h. This probability is measured by the area to the right of *Z* on one tail of a normal distribution curve, where *Z* is 0.5 divided by c_{vh} in this case. Because headway adherence is applied to routes with headways of 10 minutes or less, calculations have been made for the Lines of 1 and 7. One of the most important factors in a potential transit user's decision to use transit on a regular basis is how much longer the trip will take as compared to the automobile. In order to analyze this, the level of service measure used is transit-auto travel time; that is, the door-to-door difference between automobile and transit travel times, including walking, waiting, and transfer times (if applicable) for both modes. In other words, it is a measure of how much longer or shorter a trip will take by transit. Travel time for transit includes walking time from one's origin to transit, waiting time, travel time on transit vehicle, walking time from transit to one's destination, and any transfer time required. On the other hand, travel time for cars includes travel time in the car and time required to park one's car and walk to one's destination. Walking time is based on a maximum of 400-m walk to transit stop at a speed of 5 km/h, which will take about 5 minutes. Since all transit users do not walk the maximum distance, it is generally assumed to be an average of 3 minutes.

Table 3 Fixed-Route Passenger Load LOS

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

*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.

Table 4 Fixed-Route Headway Adherence LOS

LOS	c_{vh}	$P(h_i > 0.5\ h)$	Comments
A	0.00 - 0.21	≤ 1 %	Service provided like clockwork
B	0.22 - 0.30	≤ 10 %	Vehicles slightly off headway
C	0.31 - 0.39	≤ 20 %	Vehicles often off headway
D	0.40 - 0.52	≤ 33 %	Irregular headways, with some bunching
E	0.53 - 0.74	≤ 50 %	Frequent bunching
F	≥ 0.75	> 50 %	Most vehicles bunched

Note: Applies to routes with headways of 10 minutes or less.

It is harder for small cities to achieve high levels of service for this measure as compared to large cities. For example, in large cities, it can be travelled faster between downtown and a suburban area by public transport system with high quality such as rail rapid transit. On the other hand, for a small city with a population less than 50,000, the walk and wait time for transit by itself is nearly as much as the total of automobile travel time. Therefore, the calculated LOS will be very low. For small cities or for short trips, the total transit travel time will be, in general, significantly larger than the automobile travel time. Because transit-auto travel time is a system measure, its data requirements are greater than those for transit stop and route segment measures. It can be calculated by using a transportation planning model or by hand. As with many of the other service measures, transit-auto travel time can be measured at peak and off-peak times. Because peak hour traffic congestion tends to lengthen automobile trip times, the calculated LOS will be usually better during peak hours than during the rest of the day. Table 5 gives the transit-auto travel time LOS thresholds. The manual method is useful in areas which do not have a transportation model or when a faster assessment of travel time LOS is desired. Therefore, in this study, the manual method preferred for carrying out the analysis.

4. Level of Service Analysis for Urban Public Transportation of Dumlupinar University Evliya Celebi Campus

As mentioned previously, the public transport quality of service in the city of Kutahya was evaluated from various aspects such as transit availability, comfort and convenience. For this purpose, at first, transit availability was examined in terms of hours of service and service frequency. Secondly, the comfort and convenience provided by the public transport system in the city of Kutahya was studied. For this reason, the overall crowding levels within the vehicles, headway adherence, and transit-automobile travel time (the door-to-door difference between automobile and transit travel times, including walking, waiting, and transfer times for both modes) were considered. In order to carry out most of these analyses, the procedures in Transit Cooperative Research Program (TCRP) Report 100 were followed (TCRP, 2003).

4.1. Evaluation of the Transit Availability for Kutahya Dumlupinar University Evliya Celebi Campus

The headways and hours of service of four bus lines were considered in order to evaluate the transit availability for Campus. As for the results obtained from this analysis, they are given in Table 6. Also 2011 results are given in same table (Yaliniz and others, 2011). Secondly, service frequency LOS was determined for all lines in order to evaluate the transit availability. The results obtained from the analysis and 2011 results are also summarized in Table 6 (Yaliniz and others, 2011).

4.2. Evaluation of the Comfort and Convenience Offered by the Transit System for Kutahya Dumlupinar University Evliya Celebi Campus

The overall crowding levels within the vehicles, headway adherence and transit-automobile travel time were considered for evaluating the comfort and convenience provided by the public transport system for Campus. From observations and analyses, it was found that a wide range of passenger load LOS was experienced by passengers depending on time of day, line and section. During peak hours, it is not uncommon to encounter LOS “E” or even “F” in terms of passenger load on some sections of lines carrying a large number of passengers. The results are given in Table 7. Afterwards, headway adherence LOS was determined for the lines operating at headways of 10 minutes or less in order to evaluate the comfort and convenience provided by the public transport system. Because headway adherence is applied to routes with headways of 10 minutes or less, calculations have been made for the Lines of 1 and 7. These calculations are summarized in Table 8. The results obtained from this analysis are also given in this table. In this study, the manual method which has been explained in TCRP Report 100 was also preferred for carrying out the Transit-Auto Travel Time LOS analysis. The results obtained from this analysis are given in Table 9. In order to accomplish this aim, the feature of “driving directions” in Google Maps was used in terms of being a reference to automobile usage. So, the travel times on all the bus transit lines for Kutahya Dumlupinar University Evliya Celebi Campus were compared with private car travel times determined by Google Maps for the same routes. By founding the difference between the public transport and car travel times, the public transport service level in terms of transit-automobile travel time was evaluated. From Table 9, LOS “B”, meaning that the service offered by transit is about as fast as the service provided by automobile. In order to explain this result, several reasons can be given. At first, public transport vehicles and automobiles use the same routes for most O-D pairs. Secondly, the roads on these routes are not so congested.

Table 5 Fixed-Route the Transit-Auto Travel Time LOS

LOS	Travel Time Difference (minutes)	Comments
A	≤ 0	Faster by transit than by automobile
B	1 - 15	About as fast by transit as by automobile
C	16 - 30	Tolerable for choice riders
D	31 - 45	Round-trip at least an hour longer by transit
E	46 - 60	Tedious for all riders; may be best possible in small cities
F	> 60	Unacceptable to most riders

Table 6 Fixed-Route Hours of Service LOS and Service Frequency LOS of bus lines

Line Number	Daily Operation Hours of Line	Hours of Service of Line	LOS of Line in Terms of Hours of Service (2011)	LOS of Line in Terms of Hours of Service (2016)	Average Headway of Line (minutes)	LOS of Line in Terms of Average Headway (2011)	LOS of Line in Terms of Average Headway (2016)
1	6:50 -23:30	18	B	B	4	A	A
7	7:00-23:00	17	B	B	5	A	A
7A	7:00-23:00	17	-	B	15	-	C
7B	7:00-21:30	16	-	C	30	-	D

Table 7 Fixed-Route Passenger Load LOS for Campus

Line Number	LOS for Load Factor (2011)	Load Factor (p/seat) (2016)	LOS for Load Factor (2016)
1	F	1,95	F
7	F	1,91	F
7A	-	1,36	E
7B	-	1,18	D

Table 8 Fixed-Route Headway Adherence LOS of 2 Bus Lines with Headways of 10 Minutes or Less

Line Number	c_{vh} (2011)	P (h_i >0.5 h)	LOS of Line in Terms of Headway Adherence (2011)	c_{vh} (2016)	LOS of Line in Terms of Headway Adherence (2016)
1	0.41	≤ 33%	D	0.49	D
7	0.51	≤ 33%	D	0.45	D

Table 9 Transit-Auto Travel Time LOS of Bus Lines

Line Number	LOS of Line in Terms of Transit-Automobile Travel Time (2011)	Difference between Transit and Automobile Travel Times (minutes) (2016)	LOS of Line in Terms of Transit-Automobile Travel Time (2016)
1	B	24	C
7	B	12	B
7A	-	14	B
7B	-	28	C

5. Conclusions

In this study, the public transport quality of service for Kutahya Dumlupinar University Evliya Celebi Campus was evaluated from various aspects. For this purpose, the transit availability was firstly studied in terms of service frequency and hours of service. The comfort and convenience provided by the public transport system in the city of Kutahya was then examined. To this end, the overall crowding levels within the vehicles, headway adherence, and transit-automobile travel time were considered. For each line, different service levels in terms of public transport parameters considered were obtained. These service levels have provided important information for efficiency and sustainability of the public transport system. The time elapsed in public transport is slightly higher than the time spent during automobile travel for campus trips. Car drivers should be directed to public transport in order to ensure sustainable transportation. Making the inner city bus trips in shorter times can direct private car drivers to public transport. Shortening the time periods of public transport and providing more comfortable transportation service will divert car drivers to public transport. In order to accomplish this, new bus lines established for Campus in last 5 years. However, comfort is very low for Campus lines. So, new buses should be added to current lines. A fast and comfortable public transport system will both improve the quality of life and solve the major traffic problems that may occur in the future.

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