

# **Night-Time Operations in Transit Systems: Evaluating the Athens Metro Owl Services**

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## **Abstract**

Public transport operators make significant efforts toward improving the quality of operations by upgrading and maintaining infrastructure and rolling stock, training personnel, and offering better and more responsive services to passengers. Among these responsive services is the extension of service at night (night-time extension) whose goal is to serve night-time demand for passengers. This paper examines, analyzes, and evaluates the performance and quality of the Athens Metro night-time service extension for a two-month trial period. Based on ridership estimates and extensive passenger satisfaction surveys, results indicate that the night-time extension attracted a considerable number of passengers who previously used their private automobiles for the same trips and that users were highly satisfied with the service.

## **Introduction**

Public transportation systems have long been considered the best alternative to automobile transportation in large urban areas; their ability to carry large numbers of passengers while occupying limited urban space at a lower (unit) cost and with far fewer environmental impacts are advantages that make transit

suitable and desirable for urban transport operations (Sinha 2003; Vuchic 2004). Demand, however, is closely related to customer satisfaction by the services provided; improved quality of service, such as higher reliability and adequate service frequencies, is critical for shifting passengers to public transportation (Friman and Felleson 2009; Eboli and Mazzulla 2009).

In this context, public transport operators frequently make significant efforts towards improving the quality of operations by offering new and improved services to passengers. Among these new services is extended operating hours into night, with the goal of serving passengers who otherwise would not use transit (the so-called “transit owl services”) (Faria and Smith 1996; Gwiazdzinski 2006; Reinhold and Kearney 2008). Indeed, a number of European, Australian, and U.S. cities have established public transportation night-time operations: Paris, London, Melbourne, and Amsterdam, for example, have late-night bus lines, while the metro systems of Athens, Berlin, Barcelona, Copenhagen, New York, and Washington, D.C. are among those systems that have extended service hours past midnight. Examples of night-time metro operations for European cities appear in Table 1. (The interested reader is referred to ELTIS web portal [www.eltis.org](http://www.eltis.org) for further information on such services in Europe.) Anticipated gains related to transit owl services focus on the potential reduction of auto accidents by decreasing the use of private vehicles at night and averting the combination of drinking and driving. Moreover, such services have a distinct social role since they (a) allow low-cost transportation during night-time hours, (b) can facilitate transit’s captive passengers, and (c) may generate new jobs in the transit sector (TRB 1998a).

**Table 1. Night-Time Metro Operations for some European cities**

City	Weekday	Weekend	Notes on Weekend Timetable
<b>Barcelona</b>	05.00-24.00	05.00-02.00	Friday and Saturday night
<b>Berlin</b>	04.00-01.00	All night	Friday and Saturday night
<b>Hamburg</b>	04.00-24.00	All night	Friday and Saturday night
<b>Lisbon</b>	06.30-01.00	06.30-01.00	-
<b>Madrid</b>	06.00-02.00	06.00-02.00	-
<b>Munich</b>	04.10-01.30	04.10-02.30	Friday and Saturday night
<b>Paris</b>	05.30-01.15	05.30-02.15	Saturday night

Source: Metro systems web sites, ELTIS web portal <http://www.eltis.org>

While transit owl services are becoming popular in large urban areas, there has been only limited research and in-depth investigation on this topic; Miller (1984), for instance, evaluated and proposed a novel redesign for night-time transit service for Salt Lake City County in the early 1980s. Gwiazdzinski (2006) discussed elements of night-time mobility and transportation services and potentials. In a recent study, Currie and Loader (2009) analyzed night extension of bus services for the Melbourne bus transit system; the authors reported that the extension had a considerable positive effect on overall transit ridership.

In early 2008, the Athens Metro authority extended service for two hours (12:30-2:30 a.m.) on Fridays and Saturdays for a two-month trial period. Their effort aimed at (a) improving access to recreational/night entertainment areas in downtown Athens that suffer from inadequate road infrastructure and limited parking spaces and (b) providing alternative transportation to people not wanting to use their private automobiles (possibly because of alcohol consumption). It should be noted that while Athens has strong recreational and night-entertainment activities year-round, after-midnight transportation traditionally has been available only to private vehicle and taxi users (prior to the trial extension period).

This paper examines, analyzes, and evaluates the performance and quality of the Athens Metro night extension of service for its two-month trial period. More specifically, based on the results of extensive surveys, ridership estimates and passenger satisfaction are derived, analyzed, and discussed. The remainder of the paper is organized as follows: the next section presents details on the set of surveys undertaken throughout the two-month trial period of the night-time extension. Then, results for ridership, trip characteristics, and passenger satisfaction are presented, analyzed, and discussed. Finally, concluding remarks and a short discussion are offered.

## **Surveys and Data Collection**

The survey took place at all stations of the Athens Metro system (Figure 1) each Friday and Saturday night from 11:00 p.m. to 2:30 a.m. for a period of 45 days (February 15 - March 29, 2008). It included two parts, with the first part focusing on passenger boardings and transfers and the second on collecting passenger opinions regarding the extension by means of short personal interviews.



Figure 1. The Athens Metro System

### ***Ridership Survey***

The Athens Metro fare collection system can provide only partial data on ridership, since (a) a considerable percentage of riders (over 50% for regular, daytime operations) use monthly and annual fare cards that do not need to be validated when entering the Metro system (and therefore could not be estimated without a survey), and (b) single-ride tickets are validated when only entering a station (implying that transfers had to be counted as well). A direct passenger count process was carried out at each Metro station platform by trained personnel located at pre-specified positions of platform entrances. The number of passengers arriving at the platforms was recorded during fixed time intervals (every 15 minutes); in addition, transfers were counted between all three Metro lines on the transfer corridors between platforms. It should be noted that the task of counting transfers required a detailed inspection of the topology of the transfer stations. It also should be noted that the ridership measurement process needed to be thorough, given the requirement for collecting accurate data regarding boardings and transfers at each platform and station.

### ***Passenger Survey***

The second part of the survey included short face-to-face interviews, through which information on passenger and trip characteristics and passenger satisfaction were collected. In particular, collection and analysis of passenger satisfaction using marketing techniques and surveys (TRB 1998b; TRB 1999) has been implemented widely in the last decade for evaluating new transit services; some relevant studies are presented in Iseki and Taylor (2008), Kim and Ulfarsson (2008), Eriksson et al. (2007), McDonnell et al. (2006), Pepper et al. (2003), and Pepper and Ray (1998). Two separate surveys were designed for this purpose, with the first focusing on various trip characteristics (such as travel times, modes used to approach the Metro line, origins and destinations, trip purpose, and so on). The second survey aimed at capturing passenger satisfaction; this was achieved through the part of the interview in which passengers were requested to grade aspects of the night extension on a scale of 1 to 5. The respondents were selected randomly among passengers waiting to board, and the interviews lasted approximately two minutes. A stratified sampling process (Tryfos 1996) was followed, considering gender and age, and a minimum number of 500 interviews was assumed to be adequate for the purpose of both interview-based surveys (3-5% of estimated ridership for that time period; this assessment was based on ridership information collected during the first weekend of the passenger ridership survey). However, the willingness of passengers to participate in the surveys led to over 2,000 completed pas-

senger satisfaction questionnaires and over 2,700 completed trip characteristic interviews. In Table 2, the data collected for each survey are discussed.

**Table 2. Collected Data**

# Survey Type	Collected Data
1. Ridership Survey	<ul style="list-style-type: none"> <li>• Boardings per station and platform /15min (23:00-02:30)</li> <li>• Transfers per station and platform /15 min (23:00-02:30)</li> </ul>
2. Trip Characteristics	<ul style="list-style-type: none"> <li>• Origin and destination stations</li> <li>• Fare type used</li> <li>• Trip purpose</li> <li>• Mode used for night-time transportation <b>before</b> the Metro service extension</li> <li>• Frequency of transit usage</li> <li>• Reasons for using the Metro system during the night-time extension period</li> <li>• Desire to establish a similar extension of service for the Athens bus lines</li> <li>• Gender, age</li> </ul>
3. Passenger Satisfaction	<ul style="list-style-type: none"> <li>• Trip purpose</li> <li>• Mode used for night-time transportation previously to the Metro service extension</li> <li>• Frequency of transit usage in general</li> <li>• Mode for accessing the Metro system</li> <li>• <b>Satisfaction</b> with respect to (1: dissatisfied – 5: satisfied for               <ul style="list-style-type: none"> <li>Security</li> <li>Frequency</li> <li>Duration of the extension</li> <li>Speed</li> <li>Cleanliness</li> <li>Fare validation</li> <li>Connection with other transport means</li> <li>Overall</li> </ul> </li> <li>• <b>Importance</b> of the above attributes</li> <li>• Gender, Age</li> </ul>

## **Ridership**

Figure 2 summarizes ridership for the extended hours; the relatively low ridership for March 7 and 8 (compared to the remainder of the period) is expected since this was a long weekend and inhabitants traditionally take long weekends. As can be seen from Figure 2, ridership increased during the trial period. It can be observed that ridership reached 22,000 passengers on Saturdays. Considering that four trains per hour and direction were scheduled and operated during the extension, the total Metro system capacity was  $4 \times 4 \times 1,000 = 16,000$  passengers/hour or 32,000 passengers during the (two-hour) extension period. This implies that Metro occupancy for the extension period was almost 70 percent, which was considered very good, given that under normal operations, a 15-minute service for a metro system is rather unattractive to passengers.

Figure 3 indicates that ridership during the extension period is comparable to that of Saturday mornings (8:00-10:00 a.m.). Moreover, ridership for the time period before the extension has increased, consistent with the findings of Currie and Loader (2009). Passengers “attracted” by the service extension use the Metro system for both approaching their destination and returning home, while before the extension they were discouraged from doing so and relied on other transportation modes (private vehicles, taxis). As far as ridership is concerned for specific stations, as can be seen in Figure 4, the largest number of boarding passengers is observed in downtown stations next to recreational areas (stations of Monastiraki, Syntagma, and Kerameikos). Other suburban stations (such as Halandri, for example) exhibit low ridership. It is apparent that during the night-time extension, passengers used the Metro system for departing and returning home; these passenger moved from the Athens downtown to the suburbs but usually not vice versa.

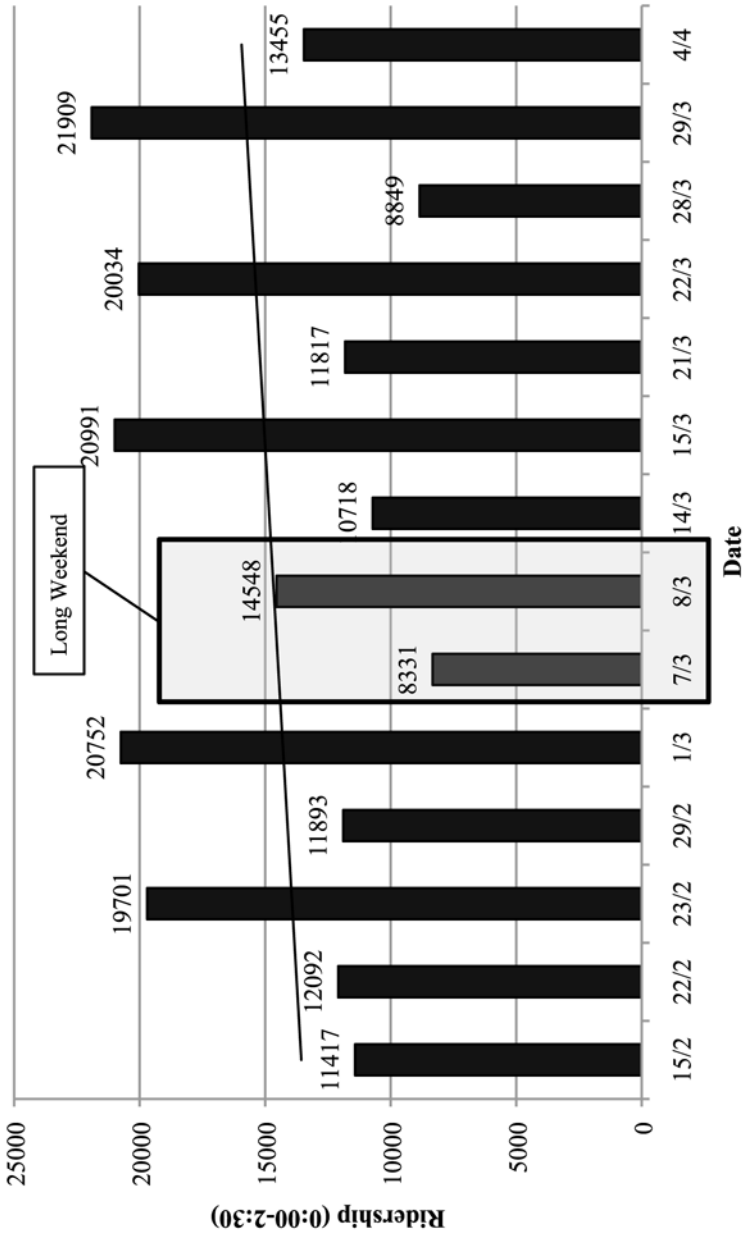
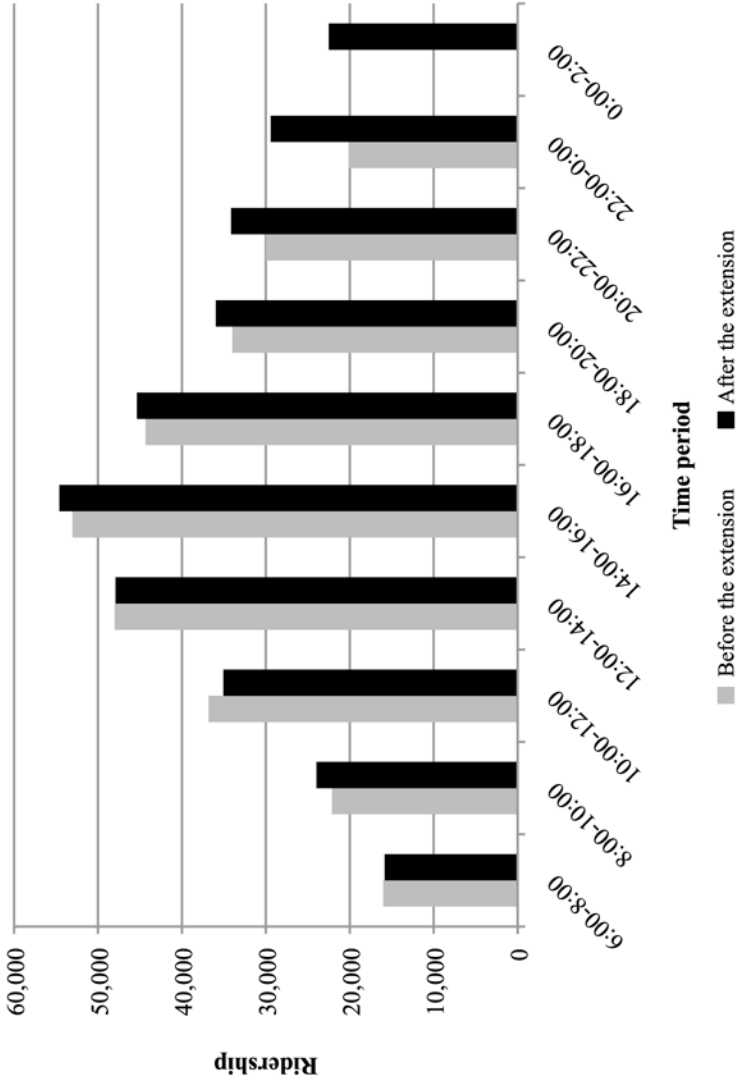


Figure 2. Metro Ridership for the Night-Time Extension Trial Period





**Figure 3. Ridership Distribution for a typical Saturday before and a typical Saturday after the Extension Period**

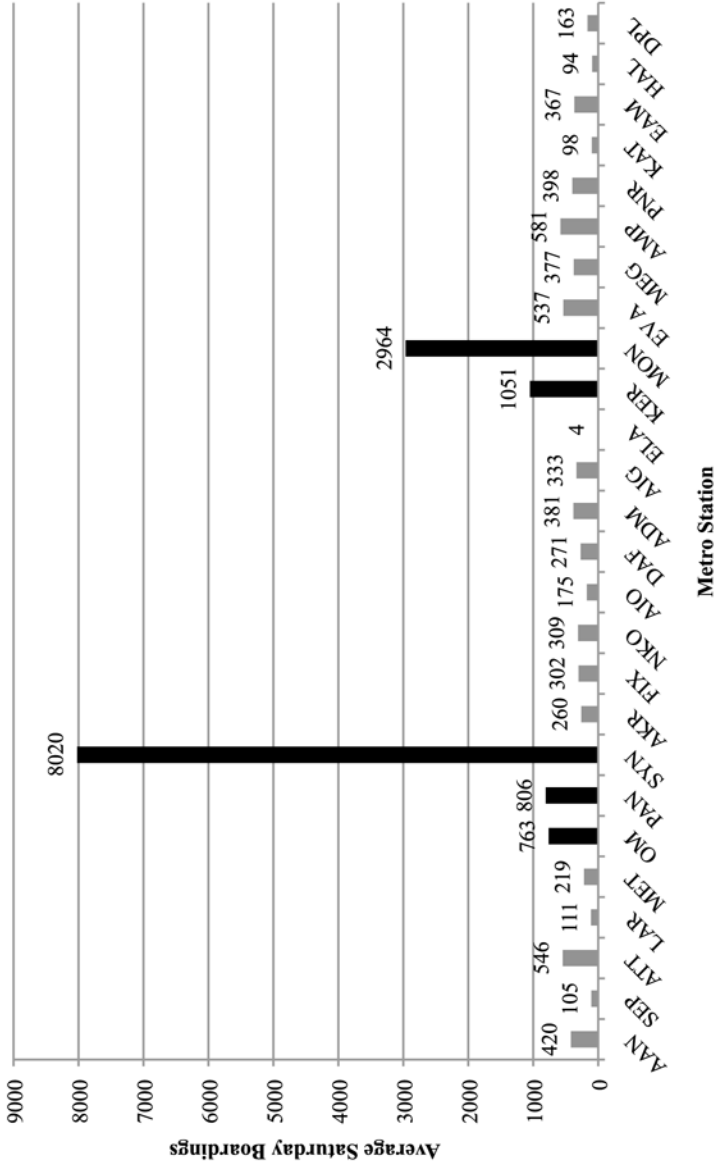
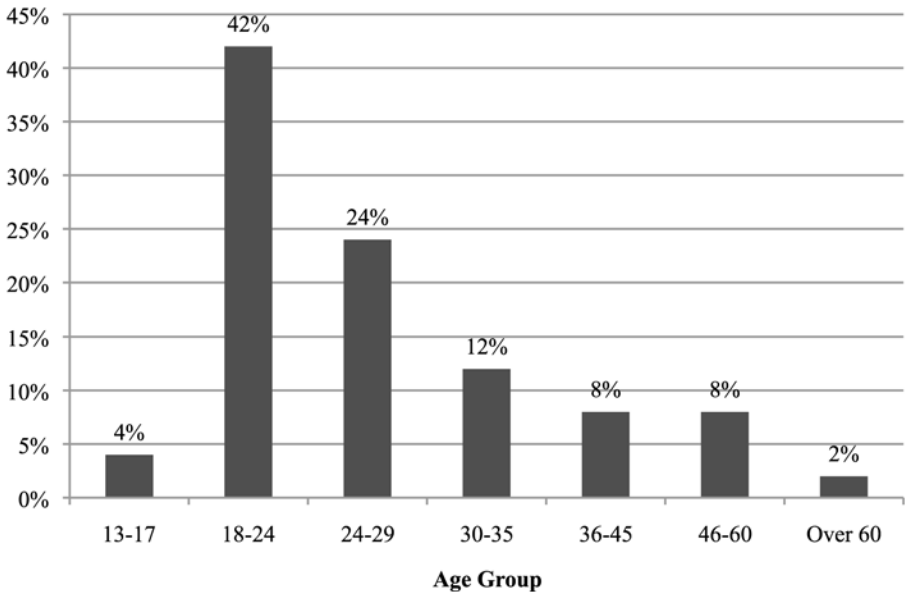


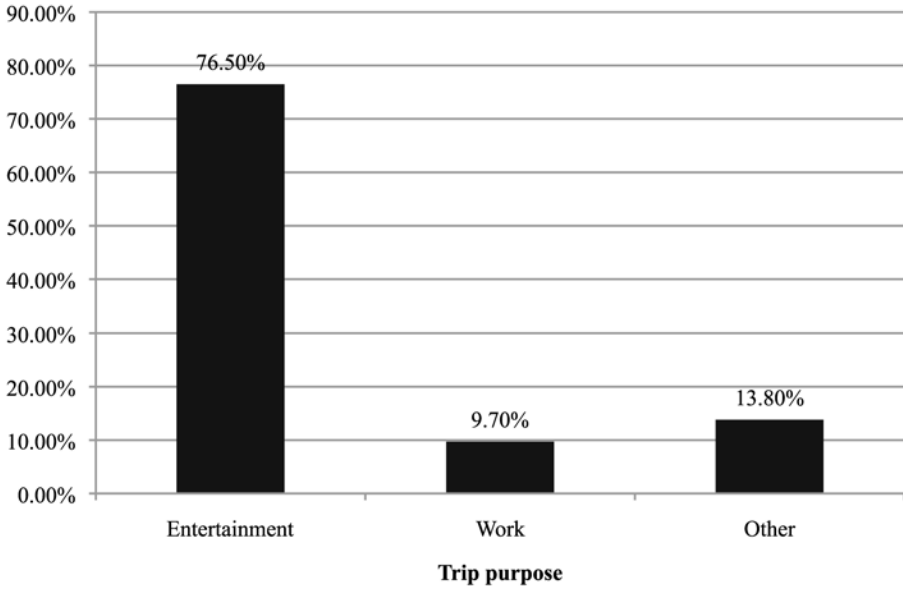
Figure 4. Average Saturday boardings for selected Athens Metro Stations

## Trip Characteristics and Passenger Preferences

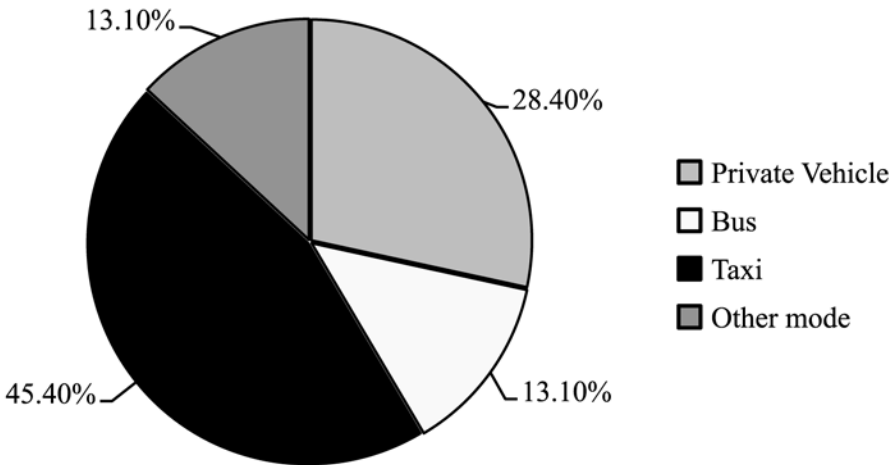
Obtaining information on trip characteristics and passenger preferences was among the main objectives of the study. It was considered important to study the manner in which passengers used the Metro system during the extension period (combination with other modes, origin, destination, trip purpose and so on), since this could help in improving services and studying mode choice behavior in the pre- and post-extension periods. Results indicate that the majority of passengers were 18 to 30 years old (about 67%), and over 75 percent of them had entertainment as their trip objective (they either approached or returned from a night entertainment site; see Figures 5 and 6). What also is interesting is that most of the passengers (almost 90%) are regular public transportation users; they are either captive passengers or passengers preferring transit as a convenient alternative to private vehicles. Figure 7 presents passenger mode choice for the same (or similar) trips in the pre-extension period (note that prior to the extension, a very limited number of night-time bus lines existed).



**Figure 5. Age Distribution of Respondents**



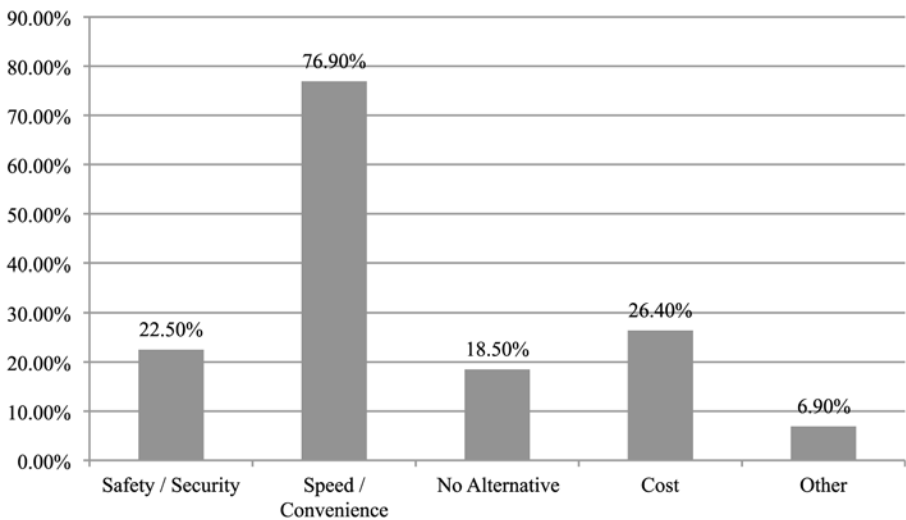
**Figure 6. Trip Purpose during Night-Time Service Extension**



**Figure 7. Mode choice prior to Metro System Service Hours Extension**

According to the findings depicted in Figure 5, most passengers in the pre-extension period used either their private vehicle (almost 30%) or taxis (45%) for night-time transportation. The Metro service extension resulted in an important reduction in private vehicle and taxi usage. For instance, for a Saturday ridership of approximately 22,000 passengers, about 28 percent of them previously used private vehicles. Assuming an average vehicle occupancy rate of 2 (for night-time transportation), this implies that about 3,000 private vehicles do not enter the Athens downtown areas at night, and higher-risk drivers (young and/or intoxicated) prefer the Metro over their automobile. This also leads to savings in fuel consumption; for example, considering a typical EU passenger car consuming around 9 lt of gasoline per 100 km in the city limits, an average trip length of 8 km and a cost of 1€/lt, more than 25,000 € are saved during each two-hour service extension period from private vehicles alone.

Furthermore, most respondents (70%) seem to use the Metro as the exclusive mode for their night-time journey; a significant number of the respondents (30%) use the buses to reach a Metro station and, subsequently, almost 80 percent of the respondents are attracted to the idea of a similar service extension for the bus system. Figure 8 depicts the reasons for preferring the night-time Metro services.



**Figure 8. Reasons for preferring the Metro Night-Time Extension**

The results indicate that the primary reasons for using the extension of the Metro services were *convenience* and (low) *cost*. Indeed, night-time traffic congestion in the Athens downtown entertainment areas is a common phenomenon, and parking spaces are limited and very costly. Further, the cost of a Metro ride during the extension period was 0.8 €, while the estimated travel cost with a private vehicle in a Greek urban area is about 0.3 €/km (not including parking cost) (Poriotis 2000) for a trip of 4-5 km on average (a total of 1.2-1.5 € for a trip), plus a minimum of €10 for parking. Finally, taxis during late night operations charge a minimum of 2.7 €.

## Passenger Satisfaction

### *Overview and Methodology*

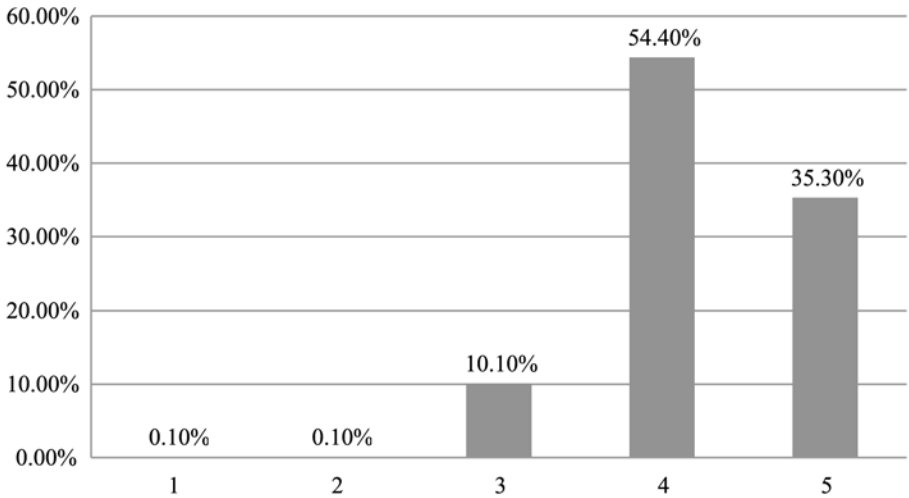
This section focuses on the passenger point of view regarding the quality of Metro night-time services (perceived service quality). Passenger opinions on quality attributes such as security, frequency, extension duration, speed, cleanliness, fare validation checks, and connectivity with other modes, as well as their overall satisfaction, were collected on a scale of 1 (not satisfied) to 5 (very satisfied).

A bi-variate correlation approach was used for assessing the importance of the aforementioned quality attributes against overall satisfaction (TRB 1999; Weinstein 2000; Morfoulaki and Papaioannou 2006). A set of random variables  $y = \{y_i\}$ , obtaining discreet values of 1-5 is assumed; these variables represent satisfaction for corresponding quality attributes. Also, a random variable  $y_n$  represents total satisfaction for the night-time extension. Bivariate correlation examines the degree of correlation between variable  $y_n$  and variables  $y_i$ . Since the underlying distribution of random variables is unknown, the non-parametric Kendall's Tau-b test is used, and a significance level of 5% is used (Washington et al. 2003). The degree of correlation expresses the strength of the effect of each individual element to the overall satisfaction. Knowing the importance and satisfaction for each element, a quadrant analysis is performed (QUATTRO 1998), aiming at indicating any elements in need of improvement during the night-time service extension (QUATTRO 1998). Quadrant analysis is a widely-used tool that graphically represents the importance of a certain attribute to the overall service in terms of respondent satisfaction with this attribute. Importance rates are normalized, and the mean satisfaction rate for each attribute is estimated and again normalized. A scatter plot is then constructed with the importance versus mean satisfaction pairs (for

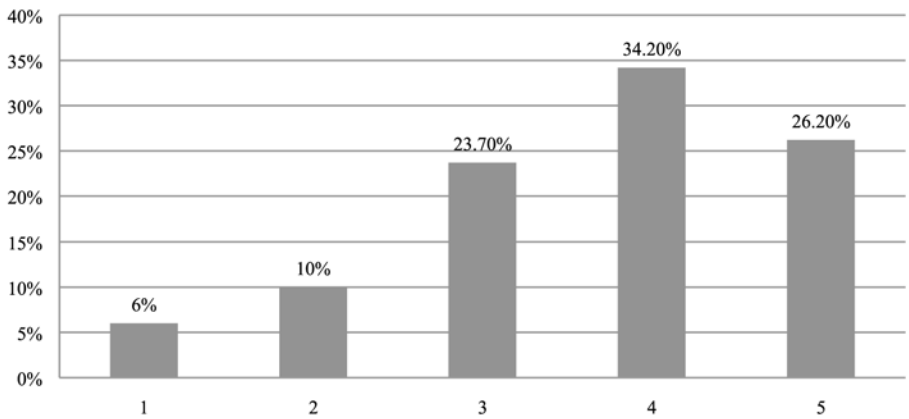
each attribute) and divided into four quadrants, where each quadrant indicates whether an attribute is important and/or satisfactory or not.

**Preliminary Results**

Figures 9 and 10 present passenger satisfaction results for overall satisfaction and satisfaction with connectivity to other modes.



**Figure 9. Overall Satisfaction**



**Figure 10. Satisfaction with connectivity to other modes**

As can be seen, overall satisfaction was high, while in the case of connectivity with other modes, a good portion of passengers (about 60%) were satisfied, despite the lack of bus lines feeding the Metro system at night. Additionally, the preliminary statistical analysis of results indicated, among other results, the following:

1. Passengers were satisfied (score of 4) or very satisfied (score of 5) with security (90%), speed (96%), and cleanliness (92%).
2. Satisfaction with the duration of the extension and the connectivity with other modes was acceptable (67% and 60%, respectively, of the passengers were satisfied or very satisfied).
3. Satisfaction with service frequency was relatively low (54%).

Overall satisfaction was very high, reaching almost 90 percent of satisfied and very satisfied passengers. It should be noted that the Athens Metro system has a history of providing high quality services; for instance, in 2006, the system was awarded the “Committed to Excellence in Europe” distinction by the European Foundation on Quality Management (EFQM). Frequency-related satisfaction was low; daily service frequency is 2 to 3 minutes during peak and 5 to 7 minutes during off-peak and, as such, a 15-minute frequency for the night-time extension was perceived as inadequate by passengers. However, ridership expectations and the need to balance costs (which were expected to be increased due to higher night-shift wage rates) and revenues (of relatively low fares) led to a compromise in the frequency of service.

**Importance of Individual Quality Elements**

Results from implementing Kendal’s Tau-b for each quality element are shown in Table 3.

**Table 3. Results of implementing Kendal’s Tau-b for each quality element ( $\alpha=5\%$ )**

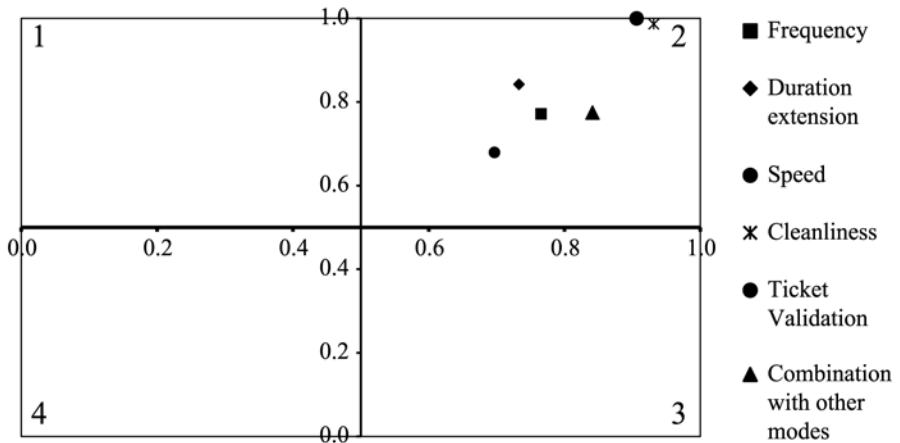
Attribute	Degree of correlation with overall satisfaction
Security	0.277
Frequency	0.212
Extension duration	0.203
Speed	0.251
Cleanliness	0.258
Fare validation	0.193
Connection with other modes	0.233



Of particular interest is that factors deemed as important (such as frequency) do not appear to strongly affect overall satisfaction. This is probably due to passengers rating overall satisfaction based on those elements that they find positive; as can be intuitively derived from preliminary data, security, frequency and speed exhibit a very strong satisfaction and tend to drive overall satisfaction to a positive level.

### Quadrant Analysis

The scatter plot developed for the quadrant analysis is shown in Figure 11. The quadrant analysis plot presents the relationship between importance and satisfaction of each quality attribute. The vertical axis indicates the normalized value of average satisfaction for each attribute while the horizontal axis its normalized importance.



**Figure 11. Quadrant Analysis Plot for Metro Extended Service Hours**

The plot is divided into four quadrants: Satisfaction—importance pairs in

- ...quadrant 1 imply low importance and high satisfaction
- ...quadrant 2 imply low importance and satisfaction
- ...quadrant 3 imply high importance and low satisfaction
- ...quadrant 4 imply high importance and satisfaction

Obviously, it is desirable to have as many pairs as possible in quadrants 4 and 1, while pairs in quadrant 2 may be tolerable. Any attribute whose pair is in quadrant 3 needs immediate remedial measures. As can be inferred from Figure 11, all

attribute pairs are located in the 4th quadrant. This means that while passengers consider all of them important to the overall quality of the service extension, they are also adequately satisfied by them. Among all attributes, frequency and combination with other modes seem to exhibit the worst performance, by achieving a lower level of satisfaction while being more important compared to attributes such as the duration of the extension and ticket validation.

## **Conclusions**

The objective of this paper is to present an assessment of the Athens Metro night-time service extension during weekends. Ridership data, trip characteristics, and passenger opinions were collected through extended surveys in an effort to estimate night-time passenger profiles and overall satisfaction with the new service. Ridership counts indicated that attracted passengers accounted for around 70 percent of provided capacity, while there was a marked ridership increase in the period before the night-time extension. Most passengers were young and had entertainment as their main trip purpose. Convenience and cost were the main reasons for preferring Metro instead of other modes; the extension of service led to a decrease in passenger car and taxi usage, since 28 percent and 45 percent of the passengers used these two modes, respectively. Passenger satisfaction was very high with the exception of service frequency. However, the strong positive effects of security and convenience were critical for obtaining an excellent overall perceived quality for the system. Furthermore, it should be noted that the Athens Metro system exhibits very high passenger satisfaction (an 81.7% Customer Satisfaction Index according to the European Extended Performance *Satisfaction* Index [EPSI] method) for its regular (day services), as reported by the managing authority (AMEL 2009) and independent studies (Karlaftis et al. 2005).

The issue of the actual trip purpose (entertainment) affecting the mood and, hence, satisfaction of passengers was not raised in this paper. While this possibly could be a fact, passengers still exhibit lower satisfaction for service frequencies and the duration of the extension, compared to daily services (where for instance, frequency satisfaction exceeds 70%, according to AMEL [2009]). This is an indication that while passengers do have a positive view of Metro (day and night-time) services and possibly a good mood, they still are not satisfied with elements of night-time operations and, therefore, their opinions are not influenced by their trip purpose. Trip purpose effect on customer satisfaction for night-time operations is a topic to be investigated by future research.

Overall, during the trial period, the night-time extension attracted a considerable number of passengers, and users were satisfied by the provided services. However, additional measures could prove useful for the extension to be successful in the long run. These could include the initiation of night-time bus feeder service to Metro stations, the improvement of parking facilities around Metro stations, and further discouraging private vehicles from entering the Athens downtown area. In particular, older passengers, currently accustomed to using private vehicles for entertainment-related trips, could be attracted to the Metro system by further improving convenience when accessing Metro stations. Moreover, promotional measures such as advertisement of the night-time Metro service extension and a combination of Metro tickets with other entertainment activities (theater tickets and so on) could attract more passengers to the service.

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