GIS-BASED VISUALIZATION FOR ESTIMATING LEVEL OF SERVICE

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Key Words; Level of Service (LOS), Geographic Information Systems (GIS), Congestion, Safety

ABSTRACT

Traffic congestion is the biggest problem in Turkey, especially in Istanbul. People have a hard time because of the traffic problems, which causes accident and deaths in Istanbul. In this regard, in order to minimise those kind of problems, the concept of safety level of service (LOS) at a section existing on the Trans European Motorway (TEM) and D-100 state roadway having huge traffic congestion especially in peak hours is determined with the help of using Geographic Information Systems (GIS), which is the objective of this study. According to Highway Capacity Manual (HCM), volume-to-capacity (V/C) ratios and average travel speeds are used for the estimation of LOS for selected motorway segments requires. In this paper, types of LOS will be assigned for the concerned road sections and some suggestion will be given in order to solve some traffic congestion related problems about the road.

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1. INTRODUCTION

The estimation of the level of service within an urban road network should be one of the regular tasks of traffic management in order to either maintain a stable traffic flow or to identify and cure traffic congestion. The term ―Level of Service‖ (L.O.S.) has been introduced by the Highway Capacity Manual (HCM) which represents the level of facility an user can derive from a road under various operating characteristics and traffic volumes.

Marwah and Singh (2000) have classified level of service into four groups (LOS I-IV). In another study for heterogeneous traffic condition on urban roads Maitra et al. (1999) redefined the LOS boundaries by quantifying congestion as measure of effectiveness. Kikuchi and Chakroborty (2006) have examined the definitions of LOS categories that have been followed traditionally. The authors have examined the uncertainty associated with the measuring and mapping of existing six LOS categories. Romana and Perez (2006) have used a threshold speed to assess LOS. The definition of threshold speed used "the minimum speed users consider acceptable in traveling on a uniform road section under heavy flows and platooning traffic".

A large number of studies on measuring Level of Service which having definition of "a qualitative 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, comfort and convenience."

The conceptual basis for cartographic representation has been the subject of extensive academic analysis (MacEachren 1995, Fairbairn et al 2001). In urban planning, cartography, and for navigation purposes, the visualization of roads on digital terrain models plays an important role (Döllner. J., 2005). Maps can be characterised by the degree of abstraction possible in the representation of geographic data (MacEachren and Ganter, 1990). From a cartographic perspective, at the lowest degree of abstraction, equivalent to the 'realistic' end of a continuum, are terrain renderings such as those of Imhof (1982).

The objective of this study is to estimate different types of Level of Service by using Highway Capacity Manuel Table (HCM, 2010) and visualize those with the help of applying cartographic representation methods. One of the main contribution of this research is that it provides an understanding the estimation and visualization of LOS on case study of Istanbul.

2. BACKGROUND

Level of service (LOS) is a term used to qualitatively describe the operating conditions of a roadway based on factors such as speed, travel time, maneuverability, delay, and safety. The level of service of a facility is designated with a letter, A to F, with A representing the best operating conditions and F the worst.

According to the latest version of the *Highway Capacity Manual* (2010 HCM), the LOS of freeway segments is based on the density of vehicles, expressed in passenger cars per mile per lane. The LOS can also be evaluated with volume-to-capacity (V/C) ratios that the ratio larger than 1.0 is assigned to LOS F for the road segments. The criterion of LOS for assigned motorway is determined from the density thresholds indicated in Table 1.

Table 1. Level of Service Criteria for Motorway (HCM, 2010)

Density(pc/mi/In)	**LOS by Volume-to-Capacity Ratio**	
	≤ 1	**> 1**
≤ 11	A	F
> 11-18	B	F
> 18-26	C	F
> 26-35	D	F
> 35-45	E	F
> 45	F	F

Density gives the proximity of other vehicles in the stream. Since it affects the ability of drivers to maneuver in the traffic stream, it is also used to describe LOS. The density calculation is shown in Equation 1: Freeway and Multilane Highway Segment Density.

$$\text{Density} = \text{Min}\,(v_p, c) / S \qquad (1)$$

where v_p = flow rate (pc/h/ln), c = capacity(pc/hr), S= Operational Speed (km/hr). In HCM 2010, speed-flow relationship is depicted in the figure below. The speed-flow curve depicted is used to determine the appropriate values of operation speed. Upon obtaining the flow rate and the operation speed of the vehicles on the segment, the LOS can be derived.

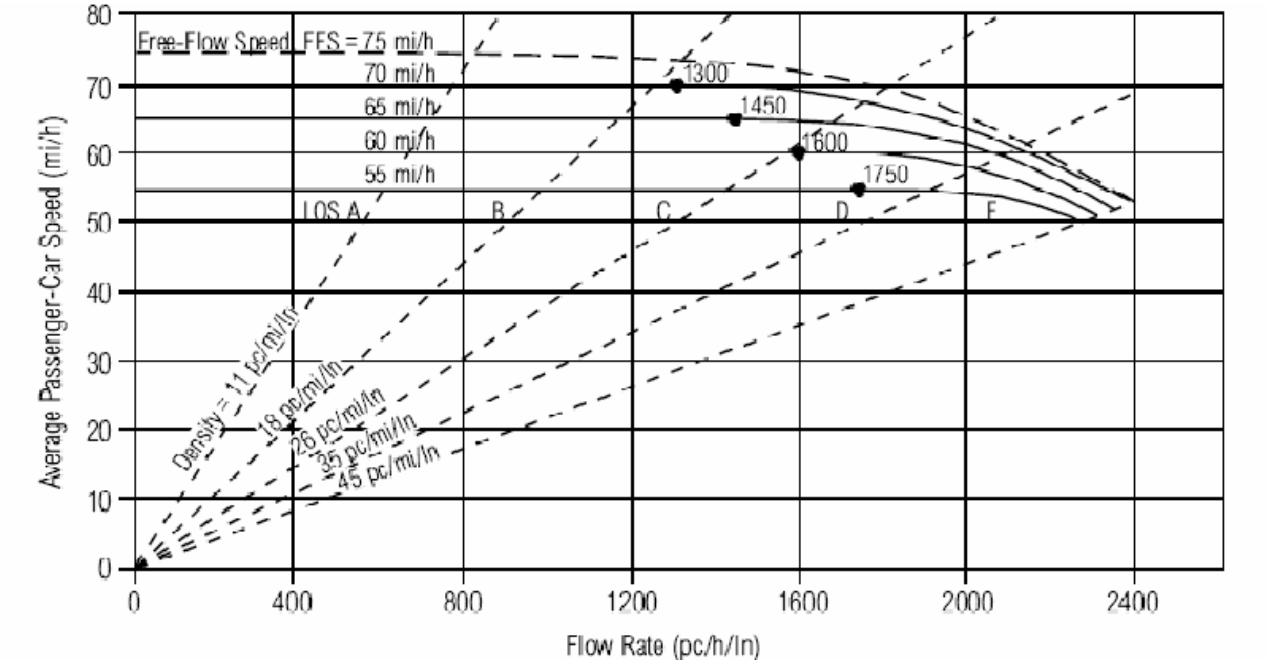

Figure 1. Speed-Flow Curves for Basic Freeway Segments

The HCM speed-flow models for both basic freeway segments and multilane highways indicate some features that do not appear to be consistent with expected traffic flow characteristics related to in-stream vehicle interaction and queuing considerations. As stated in HCM, "the higher the free-flow speed, the greater the drop in speed as flow rates move towards capacity". Thus, the HCM speed-flow models suggest that the rate of reduction in speed with increased flow is greater, and therefore traffic delays increase at a faster rate, and in fact the traffic delays are larger, for higher-quality facilities. (Akçelik,1988)

3. STUDY AREA

Istanbul is the most intensely populated city in Turkey, located in coastal area and seperated into two parts by three bridges. The case study was developed in at a section existing on the Trans European Motorway (TEM) and D-100 State Highway having huge traffic congestion especially in peak hours.

As occuring numbers of traffic accident, it is important to assess its accessibility at those sections by determiming the level of service (LOS). The TEM highway network in Turkey starts from Edirne at the Bulgarian border and passes through Istanbul via the Fatih Sultan Mehmet Bridge, having a total length of 10.000 km. Furthermore, D-100 State Highway having a paralel route to the TEM. D-100 State Highway starts from Edirne at the Bulgarian border and passes through Istanbul via the Bosphorous Bridge. Figure 2 indicates part of Google Earth image demonstrating the study area.

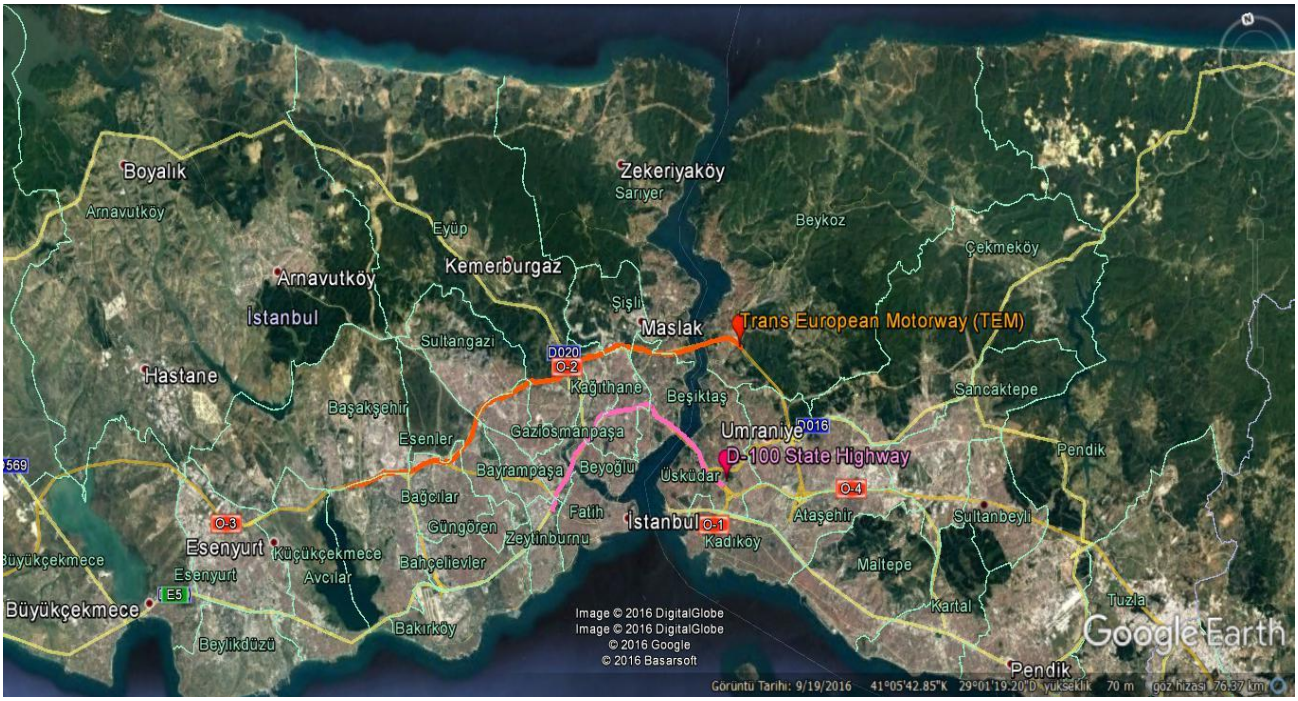

Figure 2. Section of Trans European Motorway (TEM) and D-100 State Highway

4. DATA COLLECTION

Data were collected at morning and evening peak hours which is a part of the day during which traffic congestion on roads and crowding on public transport is at its highest, namely, the times during when the most people commute. L.O.S. for urban and suburban arterials can be related to peak-hour factor, flow condition, average speed, and service volume capacity ratio. Traffic engineers face the dilemma of providing adequate road space for peak hour capacities with the underutilization of capacity for the rest of the hours in the day. The decision for a compromise might be easier to rationalize if that did not necessarily mean standstill congestion during peak periods. The peak hours that used in this study are indicated in Table 2.

Table 2. Morning and Evening Peak Hours

	Time
Morning Peak Hours	7:00 - 9:00 a.m.
Evening Peak Hours	5:00 - 7:00 p.m.

Density, capacity and volume were recorded per 30 minutes for each link at assigned section of TEM and D-100 State Highway. In order to specify Level of Service for each link, average

density were calculated at morning and evening peak hours and to be found the corresponding level grades using HCM 2010 Table.

The geographic coordinate system is GCS_GRS_1980 and the original projection system of dataset acquired from Istanbul Metropolitan Municipality is assigned as ITRF96_UTM_ZONE_35 with the given datum parameters of data.

5. CARTOGRAPHIC REPRESENTATION OF LOS

Data visualization is a method to convert data into a visual representation. The main goal of data visualization is to communicate information clearly and effectively (Friedman, 2008). Visualization is one of the most important parts in cartography, as a map is also one of visualized products. Cartographic visualization is mainly concerned with visual representation of spatial data. Cartography discipline also developed guidelines to help to improve the design of maps to produce maps which offers insight in spatial patterns and realtion in particular contexts.

Within GIS, a map can be considered as a visualisation and interactive tool generally oriented to the representation of a spatial configuration at a specific instant in time, or a spatial configuration valid for an interval of time. Cartography has a long tradition of representing spatial information in time. (Kraak et.al. 1997).

The Level of Service can differ in terms of road conditions, thus a visualization of LOS on road network is the most suitable representation. By using this visualization the spatial distribution and level of service patterns for each road segment could be observed directly on the map. Visualization of LOS in road network will give an actual representation of road and traffic condition in real world as different level of service happened in the road network. The spatial distribution of LOS could also be easily depicted by using different color in terms of density thresholds for level of service on the road network. With this visualization, identify which road segments having whether high or low level of service would be easier. In this paper, density data will be visualised due to determining LOS as a map so that trends and patterns inside the data could be detected with the help of using GIS.

The level of service classes could be represented by using different colors and varied size marker symbols with respect to density thresholds given in HCM 2010 Table. The changes for each segment could also be observed by the changes of color and size for different density. The change of LOS could be determined by observing the sections of road network.

Level of Service for each segments of road at morning peak hours can easily be distinguished by using different colors as indicated Figure 3**.**

Figure 6. Level of Service for Morning Peak Hours

Level of Service for each segments of road at Evening peak Hours can easily be understood by using different size marker symbols as indicated Figure 4**.**

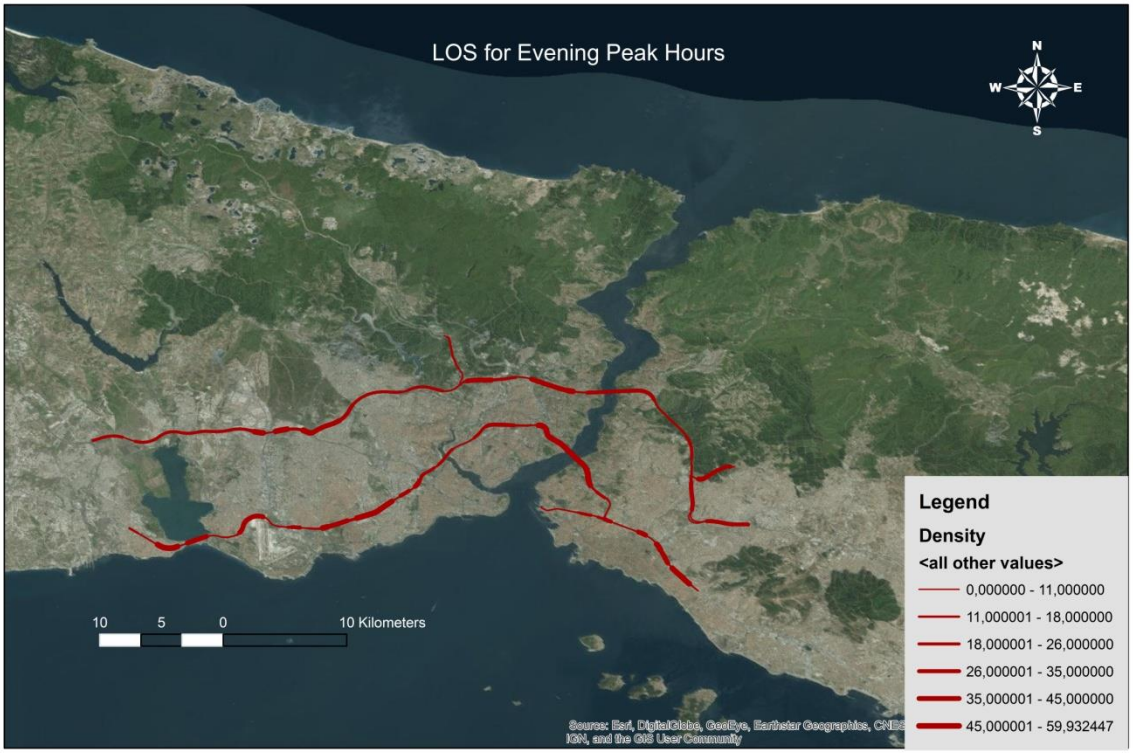

Figure 7. Level of Service for Evening Peak Hours

CONCLUSION

In this study, Level of Service for each segments of road were assigned and visualized through using cartographic techniques. Data were collected at morning and evening peak hours and recorded per 30 minutes for each linked at assigned section of TEM and D-100 State Highway and to be found the corresponding level of service grades using HCM 2010 Table. Each LOS acquired from table were visualized by using cartographic representation and to be undertood that both bridges have the worst Level of Service grades. The outcomes of this study could be beneficial for policy makers so as to detect the road section having worse LOS and suggest some alternatives such as developing transportation networks and promoting people to use public transportation and increasing its number.

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