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Decreasing of Traffic Delay With Intellegent Transportation System ITS

Subtitle as needed (*Relationship Between Speed Mangement and Traffic Delay Along Arterials*)

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Abstract: **This study investigated the effect of speed management and ramp metering on traffic delay along arterials in Istanbul-Turkey. Urban arterial congestion is a recurring problem that affects urban traffic flow. Data were collected along 5·7 km long westbound approach arterial from the Anatolian side of Istanbul to the bridge initiated a study to investigate methods to mitigate congestion through traffic management and improved traffic flow. A micro simulation model based on traffic data using *VISSIM* software package suggested the applicability of traffic speed management along the existing infrastructure to relieve congestion and provide flow stability. Simulation was conducted along five hour which is the period of recorded data from 6:30 to 11:30 Am. The results indicated that the speed management could decreased traffic delay by an approximate 8% of delay from the existing value of 242 s/vehicle at 36 km/h to 202 s/vehicle at 65 km/h speed limits. Also, there were about of 17% increase in the total number of served vehicles from 23 844 vehicles/5 h to 28 244 vehicle/5 h. On the other hand, the optimum cycle time for ramp metering signal was 18 second. Applying of ramp metering strategy for 18 second cycle time led to 13,3% reduction in delay and 6.3 % increasing in flow speed. Finally, if ramp metering and speed management are applied together, the average delay is reduced to 188 seconds / vehicle from 242 s/vehicle (reduction in average delay by 25%). Also, average speed was increased by a 13% increase (from 36 to 41 km / h and).**

Keywords: **Congestion, speed management, ramp metering, interchange, delay, micro simulation**

I. Introduction

Traffic congestion is a contemporary problem in urban areas. Increasing car ownership, increasing urban population, arterials with limited or no alternatives within the transportation infrastructure and insufficient infrastructure management all contribute to urban traffic congestion.

Istanbul is a metropolitan city established on the two sides of the Bosporus Strait connecting the Black Sea and the Marmara Sea. Across the strait, there are currently five links: three of these are suspension bridges currently serving roadway traffic, with the third bridge scheduled to serve railway transport in the future. the southernmost bridge, indicated with a 1 in Figure 1, provides a link between the southern districts of Istanbul, supporting three lanes for each direction. Distances between the bridges along the Bosporus Strait, measured by straight lines through their mid-spans, are approximately 5.7 km.

The figure below shows the investigated arterial route taken in the years 2016. The figure also shows and denotes the number of the interchanges along the route. The current centre-to-centre spacing of the interchanges within the investigated section of the highway between I-4 and I-3, I-3 and I-2, I-2 and I-1 are 1·6 km, 2·2 km and 1·9 km, respectively.

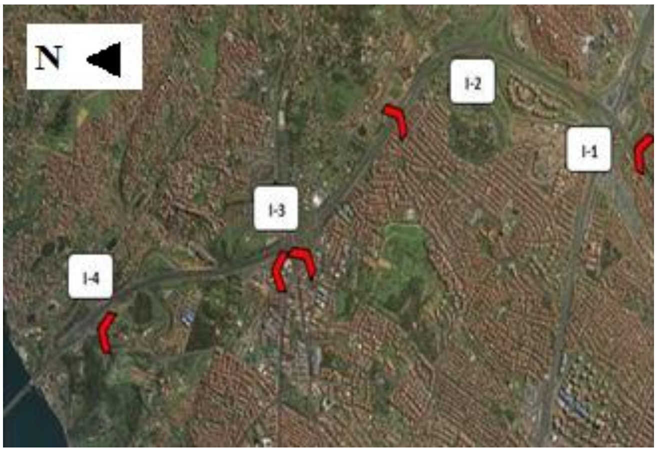

Figure 1. Urban development along the route in 2016

II. Literature review

The old concept of supplying the insatiable traffic demands of urban life through urban expansion and construction of new infrastructure contributed to urban sprawl and congestion in many metropolitan cities (Hanson, 1992). The wealth of problems associated with the urban sprawl and congestion provided an opportunity to seek better ways to deal with the increasing traffic demand. Speed management is a traffic management technique among many others, which developed with the new understanding of the concept of managing traffic demand rather than supplying the traffic demand through the addition of new infrastructure. Realized benefits of speed management in terms of providing acceptable levels of traffic flow, as early as the 1990s, led to its application as an effective means to maintain flow in urban settings (Jorgensen, 1992).

Several studies investigated the traffic congestions on freeways and studied the impact of speed management on traffic delay, proposing the implementation of variable speed limitations (VSL) that change based on road, traffic and weather conditions. (Rudjanakanoknad, 2002), (Zhang, H. M. et al. 2001) Studies confirmed that the variable speed

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limits reduced travel time by 25 % and increased safety in work zones (Park, B. B., and Yadlapati, S. S.t 2003), (Dilmore, J., 2005),(Lee, C., Hellinga, B., and Saccomanno, F., 2004.

Selection of design speed for a roadway is a task that needs to consider many aspects of roadway service concerning safety and economy (Gargoum et al., 2016). Urban roadway hierarchy composes roadway networks that serve an array of traffic needs, including mobility and accessibility. Design speeds are lower for roads providing accessibility, whereas roads that provide mobility require higher design speeds. Whereas concerns for pedestrian safety and therefore lower speed limits are associated with roads for access, concerns for economy and therefore higher speed limits are associated with roads for mobility (GRSP, 2008). One other technique to maintain flow would be the management of the traffic content. Compared to passenger cars, the effects of heavy vehicles on traffic flow are more adverse with respect to safety and delay because of their larger size and low maneuverability. Their interaction with smaller vehicles and the resulting headways are also different from the mutual interaction of smaller vehicles (Aghabayk et al., 2014).

This study concentrates on evaluating the effect of speed management on the congestion that occurs along a principal arterial. Through a micro simulation model developed to represent the arterial, the first part of this study investigates the effects of variable speed limits on the flow conditions. The study then evaluates the effects of the ramp metering together with speed management on the flow.

III. Data and methods

The presented study investigates the traffic conditions along the 5·7 km principal arterial with four interchanges approaching the Martyrs Bridge from the Anatolian side of Istanbul. There are eight counts of merging or diverging lanes along the studied route. Figure 7 schematically shows the studied section of westbound flow from Anatolia to Europe along the principal arterial, showing the consecutive merging and diverging lanes.

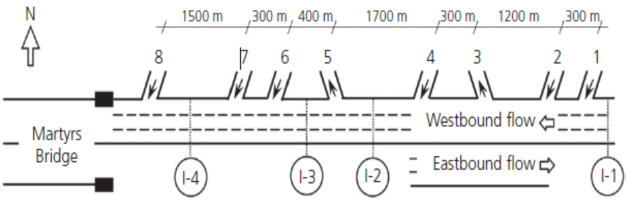

Figure 2. Plan of the studied corridor and the sections for data collection at the interchanges

Geometric lane characteristics of the route, along with the observed flow rates and flow speeds on-site, provided the data to develop and calibrate a 'Vissim' model of the route. Five cameras monitored the four interchanges on 10 and 11 February 2011 between 06:30 and 11:30. The aerial photo in Figure 3 presents the camera placements along the route. The recorded data for each location yielded vehicle counts and speeds for automobiles, taxi, vans, minibuses, buses, and heavy-trucks. The analysis time of the recorded data was 140 h.

Figure 3. Camera positions at the interchanges

Traffic volumes was grouped into 6 group as mentioned before. Volumes were extracted through manual counting. Four person were counted traffic volumes for every 15 minutes as period study. Volumes tables is showing at figure4.

Table 1. Traffic volume counts of interchange 1

Recording Hour		Car	Taxi	Van	Bus	Heavy	Total
6:30	6:45	1,340	18	109	7	10	1,484
6:45	7:00	1,101	25	250	5	30	1,411
7:00	7:15	946	20	349	4	60	1,379
7:15	7:30	921	11	337	6	71	1,346
7:30	7:45	1,113	21	311	4	50	1,499
7:45	8:00	1,059	7	300	9	81	1,456
8:00	8:15	1,271	19	235	14	44	1,583

IV. Model calibration

The eight sections for micro simulation analysis represent the four interchanges along the route with eight locations where there are merging and diverging lanes, as presented earlier in Figure 2. There are, in total, six entrance ramps and two exit ramps along the route. Data was collected on site by video cameras positioned at the overpasses at the interchanges, denoted by sections I-1, I-2, I-3 and I-4. Figure 5 shows snapshots of the Vissim model showing the interchanges I-1.

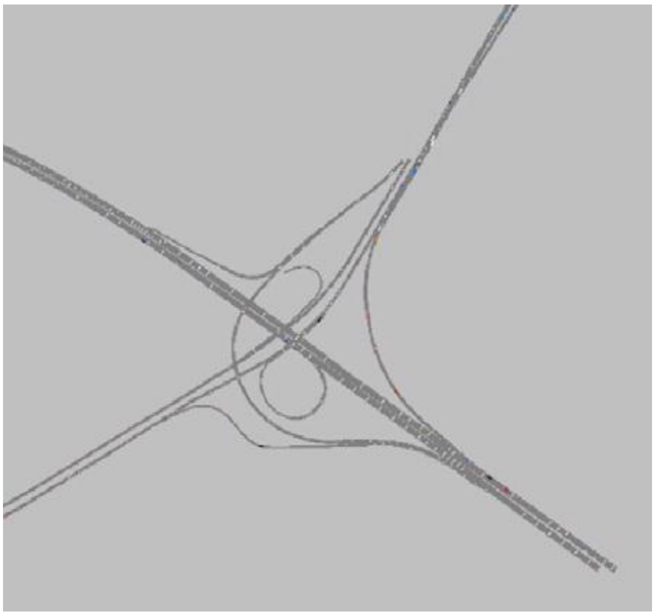

Figure 5. Model view of the interchanges I-1.

During the model calibration process, alteration of driving behavior parameters continued until a quantitative balance was reached between the simulation and the observation.

The GEH index, symbolized by the initials of its developer Geoffrey E. Havers, assisted in the calibration process evaluating the relative differences between the observed link volumes, C, and the link volumes simulated through the model, M. Equation 1 shows the GEH index and its relation to collected and simulated traffic volumes (Villa et al., 2014). The simulation model is acceptable if the GEH scores are smaller than 5 in 85% of the links.

$$GEH = \sqrt{2(M - C)^2/(M + C)} \qquad (1)$$

The GEH scores through the interchanges are 0·26, 2·13, 1·10 and 1·57, respectively, for I-1, I-2, I-3 and I-4. The quality of agreement of the model estimations with the actual flow values varies along the route through the interchanges; however, each one of them is lower than 5. The lowest agreement between the counted and simulated values occurs at I-2.

V. Results

Following the generation and calibration of the Vissim model based on the traffic counts and route geometry, an in-depth evaluation considered the effects of some parameters on flow characteristics. The parametric study included the effects of speed management and ramp metering. The following sections investigate the effects of each parameter through the results of the traffic simulation model of the investigated route.

V.a Speed management

Figures 6 show the traffic volume counts through the interchanges for 5 h and the corresponding simulation results through the calibrated models. The best agreement occurs at I-1, which is the first interchange of the studied route.

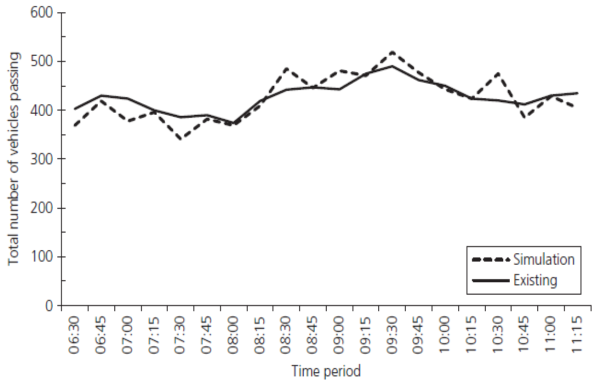

Figure 6. Comparison of the simulation estimates with the collected values for I-1

The speed limit of the principal arterial leading to the Martyrs Bridge is 80 km/h. However, the average running speeds based on the real-time traffic conditions seldom reach this limit due to the congestion that occurs. In the absence of real-time data providing a real-time running speed limit that would maintain flow, drivers tend to attain their individual highest possible speeds with disregard to the downstream congestion their random vehicular speed values may cause. The analysis evaluated the collected data to determine the influence of a variable speed limit (VSL) on the traffic delay observed along the arterial.

The analysis investigated the response of the totality of the network at constant speed limits followed by the application of variable speed limits. In the first step, the model evaluated the network performance for each speed limit value to obtain the optimum speed limit that would lead to minimum traffic delay. Figure 7 shows that the actual condition at a speed of 36 km/h has an average delay equal to 242 s/vehicle and the total number of vehicles served in 5 h shown in Figure 8 is approximately 23 844. There is an approximate 8% reduction of delay from the existing value of 242 s/vehicle at 36 km/h to 202 s/vehicle at 65 km/h speed limits. Figure 8 shows a corresponding 17% increase in the total number of served vehicles from 23 844 vehicles/5 h to 28 244 vehicle/5 h. With the implementation of VSL, drivers are obliged to reduce their speed according to the specified speed with respect to the traffic conditions, thereby improving the stability of traffic flow by preventing the development of shock waves in the traffic.

At flow levels approaching capacity, increasing speeds diminish the remaining capacity rapidly and cause congestion and delay. Figure 7 shows that delays increase at speeds beyond 65 km/h due to saturation of the traffic downstream of the interchanges.

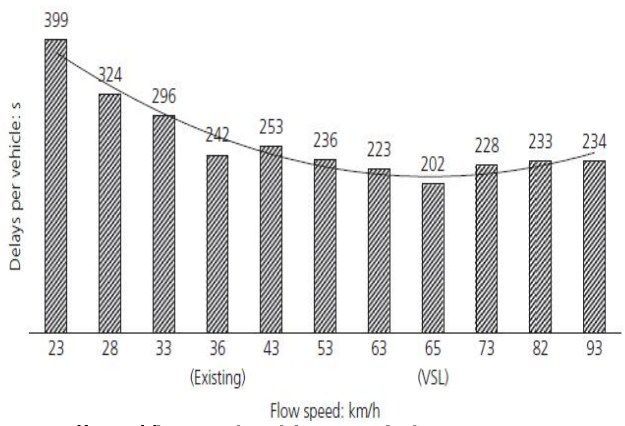

Figure 7. Effects of flow speed on delays per vehicle

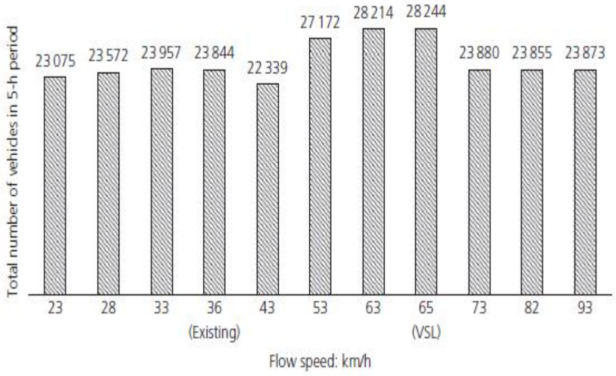

Figure 8. Effects of flow speed on traffic volume

Table 2 shows a summary of the results through the application of constant speed limits and VMS.

Parameter	Actual	Constant speed limits		Variable speed limits	
		No.	%	No.	%
Average delay (second/vehicle)	242	223	-8	202	-16
No. of served vehicles (vehicle/5 hour)	23,844	28,214	+18	28,244	+18

V.b Ramp metering

To investigate the impact of ramp metering (RM) on network performance, several networks with changing cycle time were tested to get the optimum cycle time. This optimum cycle time was equal to 18 seconds as showing in the figure below which led to minimum delay, higher flow rate and increasing of average speed. Then by using this optimum cycle time, both of Speed Management (SM) and Ramp Metering (RM) for 18 seconds cycle time were tested together. The results is showed in figure below. Best results came from applying both of (RM) + (SM), the average delay could decreased by 25 %. Also, average speed and volume was increased by 13 and 2 % respectively.

Status	Delay Sec/veh.	Speed km/hr	No of pass veh (veh)	Delay Decrease %	Speed Increase %	Volume Increase %
Present	249,2	36,3	42145	0,0%	0,00%	0,00%
20 Sec.	222,4	38,0	43276	10,7%	4,61%	2,68%
18 Sec.	216,0	38,6	44335	13,3%	6,18%	5,20%
15 Sec.	242,2	36,3	42845	2,8%	0,00%	1,66%
14 Sec.	244,1	36,2	42142	2,0%	-0,40%	-0,01%
SM + RM	188,2	41,0	43000	24,5%	12,92%	2,03%

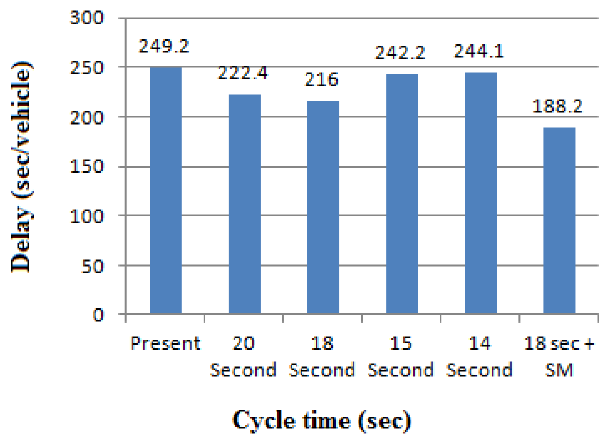

Figure 9. Effects of cycle time length on average traffic delay.

VI. Conclusions and Recommendations:

The study conducted along the 5.1 km stretch of the artery leading to the Bosphorus Bridge from the Anatolian Side of Istanbul yielded the following:

1. Management of arteries leading to primary transportation infrastructures such as suspension bridges is a necessity to prevent the formation or manage the degree of congestions.

2. Along congested routes, the drivers can seldom reach the posted constant speed limit and a traffic management plan that gives the drivers their own initiative to select their maximum possible speed based on traffic conditions typically results in speed levels that saturate and congest the traffic.

3. Variable speed limitations through ITS network reduce delays and the optimum speed for the investigated roadway yielded 63 km/hour.

4. Applying of ramp metering can improves of network performance by decreasing average delay by 13 %. On the other hand, both of speed and volume can be increased by 6.1 % and 5.2 % respectively.

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