ANALYSIS OF THE FACTORS ACCOUNTABLE FOR CATASTROPHE & HURDLING THE TRAFFIC SYSTEM

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ABSTRACT

The present paper studies, the records of road accidents that took place during the last 4-5 years and specifically focused in the year 2012- 2013 and impact of these accidents on the lives of the sufferer's family with reference to Indore City. It describes the main causes behind the incidents i.e. avoidance of traffic rules, physical use of roads, highway incidences, crossing of speed limit, wear and tear of vehicles, road space rationing, movements and crossing of animals in between the roads etc.

It also describes the failure of government authorities, their supervision and market disciplines to follow the traffic obligation and bringing awareness among the masses to follow the same.

Administrative segment of Indore city needs to learn the steps from developed countries to make the road infrastructure strong enough to control the whole process required to correct the traffic system.

Finally, changes in regulation, supervision & construction of roads with better quality of raw material would spread happiness across the population of Indore

The factor analysis a statistical tool is being used to determine factors which influence the traffic system & road development. Simultaneously the graphical representation on the basis of composition of demographic profile of the respondents is also depicted in the study.

The principle conclusion of the present study is that while these road mishaps represent a massive regulatory failure, such failures are inherent until corrective measures are taken. Apart from this, under- constructed roads which are not being completed in a particular time must be constructed. It also emphasizes more on regulating authorities, state government authorities, municipal corporations, road development authorities etc to increase the understanding among the people by taking necessary measures to remove and diminish the mishaps due to bad conditions of roads & avoidance of following the traffic rules and therefore must strengthen masses towards the cause. This in turn calls for some major actions such as: spreading awareness to follow traffic rules, revising the licensing policy for drivers and taking stringent action towards the person who disobeys rules.

Keywords: *- Traffic system, Roads, Infrastructural development, Traffic system.*

1. INTRODUCTION

1.1 Traffic Congestion

Traffic congestion is a condition on networks that occurs as use increases, and is characterized by slower speeds, longer trip times, and increased queuing. The most common example is the physical use of roads by vehicles. When the traffic demand is such that the interaction between vehicles slows the speed of the traffic stream, congestion is incurred. As demand approaches the capacity of a road (or of the intersections along the road), extreme traffic congestion sets in. When vehicles are halted for a considerable period of time, this is colloquially known as a **traffic jam**.

Traffic congestion occurs when a volume of traffic or modal split generates demand for space greater than the available road capacity. There are a number of specific circumstances which increase or aggravate congestion; most of them reduce the capacity of a road at a given point or over a certain length, or increase the number of vehicles required for a given throughput of people or goods. Traffic congestion has a number of negative effects:

- Wasting time of motorists and passengers ("opportunity cost"). As a non-productive activity for most people, congestion reduces regional economic health.
- Delays, which may result in late arrival for employment, meetings, and education, resulting in loss of business, disciplinary action or other personal losses.
- Inability to forecast travel time accurately, leading to drivers allocating more time to travel

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"just in case", and less time on productive activities.

- Wasted fuel increases air pollution and carbon dioxide emissions (which may contribute to global warming) owing to increased idling, acceleration and braking. Increased fuel use may also in theory cause a rise in fuel costs.
- Wear and tear on vehicles as a result of idling in traffic and frequent acceleration and braking, leading to more frequent repairs and replacements.
- Stressed and frustrated motorists, encouraging road rage and reduced health of motorists. Emergencies: blocked traffic may interfere with the passage of emergency vehicles travelling to their destinations where they are urgently needed.
- Spillover effect from congested main arteries to secondary roads and side streets as alternative routes are attempted ('rat running'), which may affect neighborhood amenity and real estate prices.

2. OBJECTIVE OF THE STUDY

2.1 To study the impact of road accident due to avoidance of traffic rules, speed measures, and creating awareness among the masses of Indore city.

2.2 To identify the factors creating hurdles in making the traffic system effective .

3. LITERATURE REVIEW

Several studies have been carried out related to optimization of regional traffic systems using multiple objectives concerning externalities taking traffic dynamics into account. In 1978, Gershwin et al. had already developed a system which could be used to optimize traffic systems by using traffic lights, ramp metering and reserved lanes taking route choice and mode choice into account.

The optimization could be travel time, fuel consumption or a combination of the two Gershwin, S.B. et.al. .More recently Lu, Z. L. (2006) applied a bi34 level multi-objective programming model and need a genetic algorithm as solution to determine the optimal solution for ramp metering control. Schmöcker, J.-D. et.al. (2008) used a multi-objective fuzzy logic approach similar to earlier studies. Anderson, J.M. et.al.(2007) used to optimize traffic lights, taking into account both emissions and traffic delays. They proved the feasibility of their approach.

Mathew, and Sharma (2006) the network design problem is formulated as a bi-level optimization problem in which emission costs and travel time costs are taken into account. They also showed the feasibility of their approach. A grid search algorithm was used by Zuurbier, et.al. (2007) to determine the optimal application of Variable Message Signs. They used an objective function consisting of a weighted sum of the effects of the air quality and accessibility, and showed that there are different optimal solutions for the individual as well as combined objectives. Ahn, K. and Rakha (2008) have done a research on the effects of route choice in terms of energy use and emissions of pollutants. This research shows that a user equilibrium or system optimum in terms of travel times does not necessarily result in minimizing energy use or emissions.

Delhomme et al. (2009) observed that it is not practical to conduct a rigorous outcome based evaluation of the effectiveness of mass media campaigns in road safety. They concluded that the best evidence comes from broad literature reviews or meta-analyses of mass media campaigns. From a synthesis of findings from descriptive studies and meta-analyses in the public health and road safety domains, they found that campaigns were enhanced by the following key elements:

- In combination with other activities such as enforcement, education and/or legislation
- Using a theoretical model
- The campaign is based on prior research
- Choosing a single theme rather than multiple themes
- Addressing a specific target audience
- The target audience is segmented (e.g. by demographics, attitudes, values etc.).

In link traffic flow analysis motorway simulation seems to be more common than simulation of ordinary two-lane or two-way traffic roads. One of the reasons here is that in two-lane

road the interactions between vehicles traveling in opposite directions have to be modeled. The platooning and overtaking are not only dependent on traffic situation but also on the road environment (sight distances, passing control). This way the problem is much more complicated than in the motorway environment. Probably the most well known programs in this area are the Swedish VTI-model (Algers et al. 1996) and the Australian TRARR (Hoban et al. 1991), both basically developed in the 1970's.

Traffic safety related questions have been quite a hard problem for simulation. In traditional simulation programs the drivers are programmed to avoid collisions. Thus, they do not exist. Some trials for analysis of conflict situations through simulation can be found (Karhu 1975; Sayed 1997), but a general approach to the problem and widely used safety simulation tools are still missing. Traffic safety simulation belongs to the field of human centered simulation where the perception-reaction systems of drivers with all its weak points have to be described. This kind of approach is sometimes called nano simulation in order distinguish it from the traditional microscopic simulation.

Rao and Grenoble (1991) proposed a model to study the effects of traffic congestion on JIT mode of material supply for a developed nation like USA. The framework suggests various alternatives for improving logistics performance. One of them is called pooled delivery, in which a carrier picks up shipments from various suppliers and makes a single delivery to the buyer's plant. However, no significant work has been reported from the developing nation.

3.1 Cameras emerge as an automated enforcement system:

Cameras were first used in order to try to deter people from running red lights. The cameras were installed at busy intersections to catch all the violators. As technology advanced the use of the system also advanced and they were applied to many more areas of traffic. Digital cameras and video cameras were thus developed.

Red light runners (RLR) as well as speeders could now be caught with a picture. Speeding cameras were primarily used in school zones and construction zones in the hope that they would slow down speeders. Proponents of the system claimed that they lessen the number of accidents associated with speeding and running red lights. With this system there is no contact between the violators and law enforcement.

The cameras capture a photo of the vehicle and possibly the driver and the ticket is sent through the mail to the owner of the vehicle. The photo records the date, time of day, time elapsed since the beginning of the red signal, and possibly the speed and a copy is sent along with the citation to the owner. The system is operated by the vendor of the camera system and not a law enforcement agency and it is up to their discretion as to who to issue the citations too. The company is usually paid by the state on a commission based on the number of tickets issued.

3.2 According to the U.S. Department of Transportation there are 10 requirements that the automated enforcement system should meet:

3.2.1 The ability to capture, transmit, process, store and recover captured images so that data may be managed in an efficient manner;

3.2.2 Sufficient resolution to satisfy court standards for the image-reading of vehicle license plates, clear detail of the vehicle, and identification of the vehicle operator (if necessary);

3.2.3 The capability to prevent the spreading of overexposed portions of an image (anti-blooming) that may result from vehicle headlights or sunlight from highly reflective surfaces.

The fines assessed, are based on photos or videos captured automatically when a vehicle enters the intersection after the signal has changed to red and range from $50 to $271 dollars. A portion of this fine went to the state while the private company received a percentage. The cameras used in the systems cost about $50,000 to $60,000, with installation, including detectors, equipment cabinet, and mounting pole, adding approximately an additional $25,000. Monthly operating costs are approximately $5,000 for a breakdown of the cost of tickets and the

commission made by the companies in certain states.

3.3 Technology behind the cameras:

3.3.1 35mm/Wet Film

There are currently three different types of camera systems that are in use at different intersection around the country. The first and most common type used is the wet film or 35mm. This automated enforcement system places a 35mm camera at intersections normally to catch red light runners. Sensors are placed in the ground, (either loop sensors or piezoe sensors) before the pavement marking that defines the intersection; this is usually the stop bar or a crosswalk. When the light turns into the red phase, the system is activated meaning that the camera is ready to take pictures of any vehicle that enters the intersection at this point.

In order to differentiate between the vehicles that are running the red light and vehicles that might be caught in the intersection when it turns red, the system is usually set up with a "grace period". The common period is 3/10 of a second although an international standard of 1/2 of a second exists. The camera will not snap pictures until 3/10 of a second after the red phase of the light starts. There is also the possibility of cars turning right on red or cars attempting to stop that might set off the cameras. Because of this a minimum necessary speed is usually required to activate the system. This usually ranges from 15 to 20 miles per hour. Also the placement of the sensor is very important. In one case where this system was in use in Pasadena California, 95 percent of the pictures taken were of non-violating vehicles that were trapped trying to make a left turn in the intersection when the light turned red. The sensors were placed in such a way that they tried to continue to make the left turn and get out of the intersection, the automated enforcement was triggered and a picture was taken.

3.4 Digital

The second type of cameras used is a result of the quickly changing face of video technology. Digital cameras have the ability to produce pictures with a higher resolution, more sharply detailed images of the vehicle, and are able to prevent reflections of headlights from smearing the image. Some manufactures claim that they are able to get a clear image of a car that is traveling over 200 miles per hour. The cameras can also take either black and white or colored pictures but the majority is colored. The setup for digital cameras is much like that for the wet film. They are stored in special boxes or the crossbars for the traffic signals and are connected to sensors found in the road. One slight difference in the setup between the two is that digital cameras require two sensors so that the presence of both the vehicles as well as speed can be detected. These cameras thus are not only limited to red light runners but can also be used to identify speeders. They are activated just like the wet film cameras. Thus usually you will not be caught for speeding unless you also run a red light because the system is only triggered while the light is red.

The benefits of digital cameras over wet film besides resolution and quality of the images is the ease in collecting and sending the data. The image that is taken by the camera can be electronically transmitted directly to be reviewed. This speeds up the time in which tickets can be sent out to the owners of the vehicles. It also cuts down on cost like those associated with film, processing, and the manpower of going out and retrieving and changing the film.

There are a couple of problems with the use of digital cameras. One is the fact that unlike the wet film, digital images are very easy to tamper with. This topic will be covered more in the ethical issues but it is important to point it out here. Another problem with this type of enforcement system is the fact that the cameras become inactive while they are capturing an image. This means that if there are multiple violators, the second or third car through the red light will not be caught because the camera is busy capturing the image of the first car.

4. RESEARCH METHODOLOGY

The study is based mostly on restoring the primary data collected through the method of random sampling. The place of survey we have chosen is Indore. Close – ended questionnaire is being used for the primary data collection .We administered to 330 respondents .Our thrust , to determine the factors which affect the traffic system , as well as to determine the awareness level among

the masses, due to which there are a number of hurdles in the traffic system. A set of 24 statements reflecting various attributes of the problem. The respondents were requested to rank the statements on a 5-point likert scale basis (from strongly disagree to strongly agree).Factor analysis is used to identify the factors which helps in cramming the factors responsible for hurdling the traffic system .The Software package SPSS 18.0 version has been used for analysis, interpretation & results .

4.1 Demographic profile of the respondents:

Out of 330 respondents, 225 were males & 105 were females. Respondents belong to different age groups between 18-35 were 165, 26-35 were 36.4%, 36-45 were 8.2%, 46-55 were 1.8% & 56 & above were 3.6%. Apart from this, the category of respondents which we found are as follows:-

Table 1:- Characteristics of respondents:-

N=330	% Of Respondents
Gender	
Male	68.40%
Female	31.60%
Age:	
18-25	50%
26-35	36%
36-45	8%
46-55	2%
56 & above	3.60%
Occupation	
Professional	59.70%
Student	28.50%
Govt employees	8.20%
Business	1.80%
Others	1.80%
Type of vehicle	
2-Wheeler	37%
4-Wheeler	30%
3- Wheeler	16%
Others	17%

Analysis, Interpretation & Results

Reliability Measurement:-

Twenty eight variables were identified for use in the survey. Cronbach's Alpha is the most widely used measure of reliability, which asses the consistency of a scale. The generally agreed upon lower limit for Cronbach's Alpha is 0.7, although it may decrease to 0.60 in exploratory research. The variables used resulted in a Cronbach's Alpha value of 0.731 & hence establish the reliability of the scale developed by the authors.

Table 2:- KMO & Bartlett's Test.

Table 2 :Reliability Statistics

Cronbach's Alpha	N of Items
.731	28

Factor Analysis:
KMO measure of sampling adequacy & Bartlett's test of sphericity:-

KMO measure of sampling adequacy is an index used to test appropriateness, adequacy of the factor analysis .The minimum required KMO is 0.5.The table below shows that the index for this data is 0.631 & chi-square statistics is significant (0.000 < 0.05).This means the principal component analysis is appropriate for this data.

Table 3: KMO & Bartlett's Test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.631
Bartlett's Test of Sphericity	Approx. Chi-Square	3987.229
	df	276
	Sig.	.000

Bartlett's test of sphericity is used to ensure that the variables are uncorrelated in the population. High correlation is required among the variables for the application of factor analysis .Therefore, we test for the null hypothesis that the population correlation matrix is an identity matrix (I.e. each variable correlates perfectly with itself, but is uncorrelated with the other variables). The result of Bartlett's test (the chi-square value is 3987.229 at 0.000 significance level) clearly rejects the null hypothesis that the population correlation matrix is an identity matrix. Therefore we can proceed with factor analysis.

According to Kaiser Criterion, only the first seven factors should be used because subsequent Eigen values are less than one.

Table 4:Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.211	21.712	21.712	5.211	21.712	21.712	3.388	14.115	14.115
2	3.798	15.824	37.536	3.798	15.824	37.536	3.387	14.114	28.229
3	1.915	7.980	45.516	1.915	7.980	45.516	2.195	9.146	37.375
4	1.503	6.262	51.778	1.503	6.262	51.778	2.097	8.736	46.111
5	1.403	5.847	57.625	1.403	5.847	57.625	1.712	7.134	53.245
6	1.199	4.995	62.620	1.199	4.995	62.620	1.706	7.108	60.354
7	1.084	4.516	67.136	1.084	4.516	67.136	1.628	6.783	67.136
Extraction Method: Principal Component Analysis.									

This output gives the variance explained by the initial solution .This table gives the total variance contributed by each component. We may note that the percentage of total variance contributed by the first component is 21.712, by second component is 15.824 & by the third component is 7.980.It may be noted that the percentage of total variances is the highest for the first factor & it decreases thereafter. It is also clear from this table that there are total three distinct factors for the given set of variables.

Rotated Component Matrix:

The Table 4 below is the most important table for interpretation. The maximum of each row (ignoring sign) indicates that the respective variable belongs to the respective component. The variables 'Following Traffic Rules, increase in construction of more number of zebra crossings & speed trackers are highly correlated & contribute to a single component. '**Increase the number of Zebra crossing**', '**Parking area' , 'Requirement more number of footbridges /Footpaths /Flyovers etc ,' 'Awareness ,' 'Alternative roots' , 'Forecast travel time' etc** contribute to the second component. 'Natural calamity, stress, frustration, Peak hours, Wear & tear of roads and vehicles etc, contribute to the rest of the components respectively.

Table 4 :- Rotated Component Matrix[a]

Components	Component						
	1	2	3	4	5	6	7
Noise Pollution	.779						
Speed trackers	.695						
Stop use of mobile phones/drink etc	.689						
Peak Hour entry				.397			
Road infrastructure				.263			
Screening before allotting License	.523						
Increase the number of Zebra crossing		.786					
Parking area		.733					
Required more number of footbridges /Footpaths /Flyovers etc		.652					
One way /Two way traffic restricted area		.611					
Awareness		.591					
Alternative roots		.575					
Forecast travel time		.492					
Stress			.800				
Natural Calamity			.695				
Wear – Tear value of vehicles			.644				
Motivates				.771			
More number of reversible lanes.				.611			
Follow speed limit				.436			
Traffic police behavior							
Effective traffic signals					.825		
Follows traffic rules						.753	
Contribution							.670
Physical use of road should be banned							.604

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 11 iterations.

5. INTERPRETATION OF RESULTS

Table 5.1: Interpretation of the Results:

Factor No.	Labels	Factor Name	Statement	Factor Loadings
F1	**S20**	**Smooth Running**	Increase in the number of vehicles in cities have contributed in air /noise pollution /global warming	**0.779**
	S13		Use of speed tracker (speedometer/camera) in public transport can minimize the risk of road-mishaps.	**0.695**
	S6		Alternative roots can reduce traffic load in peak hours.	**0.689**
	S8		Natural Calamity causes problem in smooth running of traffic	**0.523**
F2	**S17**	**Physical movement**	Use of zebra crossing is must for the pedestrians to being on the safer side from heavy traffic.	**0.566**
	S19		Parking of public/private vehicles on road hinders the traffic .	**0.635**
	S16		Construction of footpaths/Foot-over bridges /Fly overs etc on the roads can reduces the traffic .	**0.585**
	S18		Restrictions on movement of four wheelers /heavy vehicles/Buses/ Lorries etc should be stop , so that it may reduce accidents & traffic jams.	**0.446**
	S2		Education and awareness of drivers towards traffic rules and public safety standards can help in smoothening of traffic.	**0.591**
	S3		Physical use (Shaadi, Baarat, Welcome gate, animal walking, etc.) of road should be banned	**0.575**
	S7		Inability to forecast travel time doesn't cause hurry to the traveler.	**0.492**
F3	**S11**	**Maintenance of Vehicle and roads.**	One should not drive, when he/she is in any kind of Stress and frustration which leads to severe accidents.	**0.800**
	S10		Wear and Tear in vehicle condition results in frequent accidents	**0.695**
	S12		Improved road infrastructure is not necessary to reduce accidents/traffic load.	**0.644**
F4	**S23**	**Responsibility & Authority**	Police authority should also follows the traffic rules , to motivate general public to do the same	**0.771**
	S15		Implementation of reversible lanes with different time schedule system can reduce the traffic congestion.	**0.611**
	S4		Mentioned speed limit should be followed.	**0.436**
F5	**S22**	**Penalized**	Traffic Police should charge the penalty strictly on the person whoever breaks the rules and create violence.	**0.865**
	S21		Effectively working signals are necessary to control the traffic.	**0.825**
F6	**S1**	**Awareness**	As an aware citizen I always follow traffic rules.	**0.753**
F7	**S24**	**Cooperation**	Contributions & support of citizens in creating traffic awareness can control the traffic to the greater extent	**0.670**
	S5	**Vendors**	Vendors should not be allowed to roam among the sides of the traffic signals.	**0.604**

5.1 Naming Of The Factors:-

A factor loading represents above is self - explanatory, where its states the correlation between an original variable & its factor. The signs are interpretive just like any other correlation coefficient. On each factor 'like signs' of factor loading means factors & factors are positively correlated & 'opposite signs' of factor loadings means that factor loadings & factors are negatively correlated. The names of the factors, statement labels & factor loading are summarized in the above Table **5 which** has been formulated from SPSS data output.

6. CONCLUSION & FINDINGS

In the present study, as per the Complexity of traffic control on a network grows it becomes more difficult to coordinate the actions of the large number of heterogeneous traffic management instruments that are available in the network. One way of handling this complexity is to divide the main problem of coordination into smaller coherent sub problems that can be solved with a minimum of interaction. In the literature no consensus exists about the best configuration of the traffic managing multi-agent system and how the activities of the agents that comprise the multi-agent system should be coordinated. The decomposition of a problem into various sub problems is an active field of research in the world of distributed artificial intelligence.

In the paper an attempt has been made to highlight some of the design based issues of road accident concepts. This concept can be applied to the existing and proposed corridor. It should be viewed along with the other safety policies applied to India and not individually. The other design concepts having bearing on safety, such as stopping sight distance, shoulder rollover etc is not highlighted in view of space constraints.

Traffic research still cannot fully predict under which conditions a "traffic jam" (as opposed to heavy, but smoothly flowing traffic) may suddenly occur. It has been found that individual incidents (such as accidents or even a single car braking heavily in a previously smooth flow) may cause ripple effects (a cascading failure) which then spread out and create a sustained traffic jam when, otherwise, normal flow might have continued for some time longer.Work – in – Progress & under –construction roads are also responsible for the growing number of accidents in the city.

7. SUGGESTIONS

7.1.1 To change the attitude and behavior of the drivers and riders by creating awareness for public safety:

7.1.2 Promote a positive attitude towards enforcement laws and infuse sense of courtesy and concern among road users.

7.1.3 Regularly monitoring relevant local and international road statistics and developments in order to ensure improvements.

7.1.4 Ensure protection of the environment and take appropriate steps for prevention of noise and air pollution.

7.1.5 Inculcate a sense of discipline amongst road users and educate the public including school children on road safety.

7.1.6 To reach out to Government, Media, Corporate and Community to solicit their support to prevent colossal waste of human life on Indian roads as India holds the dubious distinction of highest road crash fatalities in the Indore city.

7.1.7 To work as a pressure group to create political will and help improve road safety situation.

7.1.8 Sensitize masses by raising awareness about road traffic injuries, their grave consequences and thus build community involvement around the issue of Road Safety.

7.1.9 Develop cost effective road safety programs to increase knowledge, awareness and skills amongst the Indian road users.

8. REFERENCES

8.1 Bibliography

Ahn, K. and Rakha, H. (2008), The effects of route choice decisions on vehicle energy consumption and emissions. Transportation research Part D, Vol. 13, pp. 151-167.

Algers, S., Bernauer, E., Boero, M., Breheret, L., di Taranto, C., Dougherty, M., Fox, K., and Gabard, J. (1997) Review of micro-simulation models. Smartest Project deliverable D3. Leeds.

Anderson, J.M., Sayers, T.M. and Bell, M.G.H. (1998), Optimization of a fuzzy logic traffic signal controller by a multi objective genetic algorithm. Proceedings 9th International Conference Road Transport Information and Control. pp. 186-190.

Delhomme, P., De Dobbeleer, W., Forward, S., & Simoes, A. (2009). Manual for designing, implementing and evaluating road safety communication campaigns. Brussels: Belgian Road Safety Institute.

Gershwin, S.B., Ross, P., Garner, N. and Little, J.D.C. Optimization of large traffic systems. Transportation Research Record No. 682, 1978, pp. 8-15.

Hoban, C., Shepherd, R., Fawcett, G., and Robinson, G. (1991) A model for simulating traffic on two-lane roads: User guide and manual for *TRARR version 3.2*. Australian Road Research Board, Technical Manual ATM 10 B, Vermont STH.

Karhu, M. (1975) A simulation model for intersection traffic conflict analysis (in Finnish). Master's thesis, Helsinki University of Technology, Computer Science. Espoo.

Lu, Z. L., Fan, B.Q., Liu, J.J. and Zhou, Y.H. (2006), Bi-level multi-objective programming model for the ramp control and pollution control on urban expressway networks. Kongzhi yu Juece/Control and Decision Vol. 21(1).

Mathew, T. V. and Sharma, S.(2006), Continuous network design with emission pricing as a bi-level optimization problem. Applications of Advanced Technology in Transportation - Proceedings of the Ninth International Conference on Applications of Advanced Technology in Transportation, Chicago, IL.

Murat, Y. S. and Kikuchi S. (2007), Fuzzy optimization approach: Comparison with the classical optimization method using the problem of timing a traffic signal. Transportation Research Record: Journal of the Transportation Research Board, No.2024, pp. 82-91.

Rao, K. R. and Grenoble, W. L. (1991), "Modeling the effects of traffic congestion on JIT", International Journal of Physical Distribution and Logistics Management, 21(2), 3 -9.

Sayed, D. (1997). Estimating the safety of unsignalized intersections using traffic conflicts. Proceedings of the third international conference on intersections without traffic signals, Kyte, M., ed., pp. 230-235. Portland.

Schmöcker, J.-D., Ahuja S. and Bell, M.G.H.(2008) Multi-objective signal control of urban junctions - Framework and a London case study. Transportation Research Part C: Emerging Technologies, Vol.16 (4) pp. 454-470.

Zuurbier, F.S., Hoogendoorn, S.P. and Van Lint, H. van. (2007), Evaluating non trivial objective functions for traffic management by means of optimal prescriptive route guidance. 14th world congress on ITS, Beijing Exhibition Center, China.

8.2 Webliography

www.arivesafe.org.
www.indorepolice.org
www.indorecitybus.com
www.mobilidades.org/arquivo/escape_final_report.pdf
www.wikipedia.org/wiki/Intelligent_transportation_system
www.wikipedia, the free encyclopedia- traffic congestion.
www.dot.ca.gov/newtech/researchreports/.../ucb_its_prr_2011_04.pd..