Challenges of implementation of intelligent transportation systems in developing countries: case study – Tehran

H. Behruz, A. P. Chavoshy, A. Lavasani rad & G. Mozaffari
Tehran Traffic Control Company, Iran

Abstract

The slope difference of development curves between developed countries and developing ones in IT applications in transportation (ITS) leads to a gap in studies conducted among those countries that will evolve over time. As a result, developing countries usually decide to take advantage of new technologies and the experiences of other countries as soon as possible in order to minimize the costs.

While the benefits of ITS applications make the imposed socio-economic costs bearable, and available experiences of similar countries are so helpful; uncoordinated development of infrastructure, cultural differences, lack of law and the inappropriate organizational structure of agencies has led to numerous problems of different nature in the operation of these systems.

For example, in some arterial streets of Tehran (which the offending vehicles license plate is recorded by cameras equipped with ANPR technology), many cases of covered license plates by the drivers (in order to become invisible to the cameras), and breaking surveillance cameras and telecommunication equipment of these systems have been reported and new types of offenses are generated.

This study illustrates the benefits achieved by the implementation of the ITS new technologies in Tehran as a developing city toward sustainable transportation, numerous prominent problems will be unveiled and several suggestions to improve the situation will be addressed in conclusion.

Keywords: intelligent transportation systems, developing countries, traffic congestion, sustainable development.

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1 Introduction

From the point of view of transportation, Iran has earmarked an inappropriate rank in the numbers of road deaths, and degrees of air and noise pollution (figure 1).

Figure 1: Polluted cities of the world according to the report of the World Bank [1] (the most polluted shown in red).

The capital of Iran, Tehran, has a disordered road network with a length of 2700km, 14% of which is highways and 27% is main (arterial) streets. Each day 15 million journeys have been recorded with an average (public or personal) vehicle speed of 21km/h in this network [2].

There are lots of reasons for traffic jams in this network and for air and noise pollution in Tehran. Nearly 4.2 million automobiles and more than 1 million motorcycles haunt Tehran [3]. More than 400,000 automobiles are over 25 years old and more than 1.5 million cars are over 7 years old. While an unsuitable program has been used for replacing them for many years, each year the number of time-worn automobiles increases extraordinarily. In this regard, some policies and explanations have apparently improved the transportation indexes. For example, according to new regulations the minimum age of automobiles needed to pass technical tests changed from 2 to 5, and therefore, on the basis of this new definition, from among 2.5 million automobiles which have not received technical test certificates, a large number will not be taken into account. However, even new automobiles in Tehran blow lots of pollutants into the air because of lack of attention to repair and systematic maintenance and also due to the outdated technology of Iranian made automobiles which include the main part of the troublesome automobiles in Tehran.

Automobile manufacturing and assembling technology used in Iran is out of date and for this reason the fuel consumption of Iranian made automobiles is up to three times more than that of the world standards. The low quality of the supplied fuel and lack of necessary controlling mechanisms have created serious discussions in the field of air pollution and fuel quality. A lack of appropriate development of public transportation has resulted in creating unimportant problems, and increased remarkably the share of personal vehicles from daily trips.

Geographically, Tehran is restricted by mountains from 3 directions which has led to inappropriate ventilation of urban air and immovability of pollutants. From the point of view of population, Tehran is one of the most crowded cities in the world, and resulting in lots of inner-city trips.

2 Sustainable development of Tehran transportation

There are lots of explanations for sustainable development but the natures of all of them are the same and are briefed in the efficient use of resources. A sustainable transportation system is one that [5]:

I. Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations
II. Is affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development
III. Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.

Some studies indicate efforts that suggest policies to push society along a path that is 'more sustainable' than present trajectories, as measured by a set of indicators [6]. Some studies refer to decoupling the expected growth in transportation from corresponding increases in greenhouse gas (GHG) emissions that present a clear challenge to the international community. New innovative technologies and policies, at scale, will be required [7].

In a report of the United Nations Economic Commission for Europe (UNEC) it is indicated that mobility policy is part of a complex pattern which needs coordinated vision, commitment and investments so as to have visible results, safer and reliable transport networks as well as safer and performing vehicles.

In this context, the deployment of an intelligent transport system must be considered as the sole tool able to maximize the chances of making the best use of investments, planning and resources, and creating a visible profitable outcome [8].

In this connection, the management of the Tehran transportation system has made an extensive attempt in promoting efficiency and urban transportation indexes in the framework of making transportation systems intelligent, so that which is used today shall be usable by future intelligent systems with vast and more efficient controlling of the traffic flow therefore greatly helping to decrease traffic congestion and improving urban transportation indexes which will finally decrease air and noise pollution, the time wasting of citizens, fossil fuel consumption, etc.

Many of these efforts have been made using the experiences of other countries; however many differences cause new challenges. In many cases, as the operation of different parts of the urban transportation network are interdependent, changing and upgrading one part (such as cameras for recording plates of offending vehicles) without upgrading the other sections (such as the organizational structure of issuing fines) may cause many inconsistencies, and therefore the improper operation of the system. As a result, some offenders may not receive notification of their fines and, as a result, the public trust in the accurate operation of the system will be decreased and then new social problems will occur. (Offending charges will reduce.)

On the other hand, parallel work and the lack of enough specialized knowledge may result in the use of different equipment (such as different brands of video surveillance cameras) for the same task in different parts of the city. Such heterogeneity will lead to the problem of non-conformity of systems. Thirdly, there is the problem of cultural differences of the users (drivers) as to the way of use of modern systems. For example, many cases of non-acceptance of offending plate recording cameras (ANPR) by drivers have been reported; which cause behavior such as the breaking of cameras or the covering of the number plates of their automobiles. The fourth problem is related to non-calibration of equipment which has been basically developed to be used in another country with a different situation.

For example, many cases of stealing speed violation recording cameras in Tehran have been reported which shall lead us to design a special cabinet in order to solve this problem.

In the next sections, different activities of city commuting intelligent transportation in recent years, the challenges for each of them, and probable solutions will be discussed.

3 Challenges of transportation management of Tehran in the use of intelligent transportation systems

The actions taken in this regard will be categorized in 4 main parts: using cameras equipped with plate recording technology of ANPR; equipping the transportation system with GPS; the use of an intelligent routing system by public transportation passengers; and a modern informative system for offenders.

3.1 Use of cameras equipped with automatic number plate recognition (ANPR)

The use of ANPR cameras started three years ago and has gradually increased in Tehran, so that today the restricted passages are controlled by more than 400 cameras. More than 100 cameras are assembled for recording high-speed violations, and nearly 120 intersections are equipped with a red-light crossing violations recording system. Almost 1000 video surveillance cameras are monitoring traffic flow used by operators in order to manage the traffic.

3.1.1 The cameras for controlling entrances of traffic restricted area in Tehran

In the center of Tehran city a closed restricted area has been defined, where entering and exiting during office hours is only possible in special cases and with previously obtained permissions. All 103 entrances to this restricted area, and also all its exits are equipped with ANPR cameras.

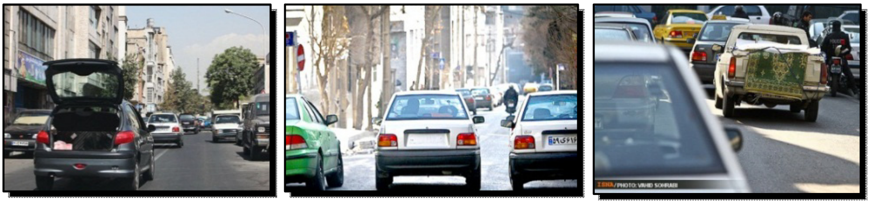
3.1.1.1 Advantages Through a simple comparison of the recent system's operation with that in the past (when police officers identified the offending drivers and issued fine bills for them), we will find the distinct advantages of using these cameras. As an example, the cameras are capable of fining any number of offending vehicles simultaneously (compared to officers). Moreover, fine bargaining by the offending drivers resulting in blockage of the traffic flow is not possible as was the case before. Expenses are decreased and the police officers use their abilities in other needed fields. By this method, the number of identified offenders has increased from 20% of all offenders to more than 75%. As the central part of the city is faced with heavy noise and air pollution, a decrease of offenders will have a noticeable effect.

3.1.1.2 Challenges

I. More than 3500 drivers cover the number plate of their cars daily in order to not to be fined. Considering the nature of this new kind of violation, more manpower will be needed for controlling this in comparison with the main violation of entering the restricted area, which is simply not possible for police officers. Sometimes, instead of covering number plates, drivers use magnetic numbers to change one or some of the digits of their number plates which may cause fines to be issued to other vehicles. In some crowded passages, some people start to walk along the back of the car hiding number plates, getting some money from drivers.

II. Some drivers who repeatedly pass specific passages try to destroy or damage the cameras and their equipment. So, while imposing heavy costs of repair, all of the route will lose its capability of identifying offending drivers during the time of repair.

III. The process of the intelligent control of restricted area includes: identifying the offending vehicle, filming, image processing, the issuing of fines by the police, and sending to the address of the offender. In this process, three different government sectors and two private contractors are cooperating with each other. Considering the load of other entrusted duties, making coordination between these sectors is a very hard task, and may cause some problems such as the non-issuance of notification of fine for all offenders and/or the non-receiving of the fine notification by some offenders.



(a) (b) (c)

Figure 2: Making the number plate unreadable: (a) opening the trunk door; (b) using different temporary foam sprays; (c) using cloths.

In the long term, drivers will find out that the offenders will not always be fined, and the reduced trust in the system may cause new violations.

3.1.2 Speed violation recording cameras in Tehran's highways

Today, more than 100 fixed cameras equipped with radar technology are assembled to identify and record speed violations on Tehran's highways.

3.1.2.1 Advantages Six months after using the above-mentioned system and within a period of six months, a comparison study of statistics of speeding violations shows a decrease of 72% of these violations. Assured of getting fined through being caught on camera, drivers rarely attempt to drive over the speed limit. During the same period, crash statistics has shown a decrease of 40%. Driving within a specified speed will lead to far lower fuel consumption, and therefore less air pollution. By the first six months of the start up of the system, a decrease of 1 million liters in fuel consumption has been recorded.

3.1.2.2 Challenges

I. In the long term, after identifying the locations where the cameras are installed, drivers may attempt to increase their speed in the distances between cameras, and this may cause many disturbances in traffic flow.

II. Considering the local conditions, technologies used in this system may cause some problems. For example, in Iran drivers of heavy vehicles in addition to having a normal number plate are obliged to have a larger plate fixed on the back of their vehicles, too. Sometimes, both plates are recorded for one offending vehicle simultaneously, and different speeds are announced and two different fine notifications are submitted to the driver (Figure 3).

III. There is a challenge in determining the regulations of using the system. For example, how much should the distances or intervals between the fines be. If there are 4 cameras in a tunnel, should the offending vehicle fined 4 times or only once.

IV. Due to the weakness of technology, identifying motorcycles is not possible in this system (considering that half of the vehicles commuting in Tehran are motorcycles).

Figure 3: Recording two different speeds for a truck.

3.1.3 Cameras for recording violations of passing through red-lights at intersections

Today, 120 cameras are assembled at intersections of Tehran city in order to record the red light running violations.

3.1.3.1 Advantages A decrease in this kind of violation will have a direct effect in reducing car crashes and capital loss.

3.1.3.2 Challenges

I. In many intersections, due to the low quality of crosswalks and zebra crossings in Tehran, it is really hard to determine a threshold running from which enables the driver to be known as an offender (Figure 4).

II. As in many intersections, turning left or right is not legally forbidden, it is really a hard job to distinguish the vehicles doing so from the violators.

III. There are some challenges in determining the violation. For example, there is a need to explain new kinds of violations besides complete passing through intersections in the red phase. Recently, the experts have been studying the

Figure 4: Determining a threshold for passing through red light violation.

amount of fines for a kind of violation in which the driver does not completely pass through the intersection in the red phase, but stops at a zebra crossing.

3.1.4 Cameras for the controlling of entrances and exits of taxis' terminals

There are 85,000 taxis in Tehran driving in different taxi lanes and, due to the scattering of exploitation companies many violations as to changing the ordinary route of a taxi may occur. Equipping the terminals with plate recording cameras has helped urban management by putting the taxis' transiting in order (Figure 5).

3.1.4.1 Advantages By using this system, taxis are presented in their own lanes at determined times, so, from the point of view of the passengers, trust for the system has been widely increased, and as a result, the use of personal automobiles has decreased. On the other hand, violations due to taxis exiting their designated routes as well as the transporting of passengers by personal automobiles have been outstandingly decreased. In addition, 80 inspecting automobiles are getting equipped with GPS, and the possibility of their violation has also decreased.

3.1.4.2 Challenges Most terminals have more than one entrance and exit, and therefore equipping them with this system will need many cameras.

Figure 5: Plate recording cameras at taxi terminals.

3.2 Equipping the transportation system with GPS

Despite many applications of GPS, most of the vehicles transiting in Tehran are not still equipped with routing (positioning) systems, and routing is done traditionally and relying on the personal knowledge of the driver. Recently, all buses have been equipped with this technology which makes their position more identifiable.

3.2.1 Advantages

By being informed of the position of the buses and using algorithms of calculating length of time of the journey, the approximate arrival time of buses to stations can be calculated and announced to the passengers. In addition, those who are speeding or using unauthorized routes can be identified. Using this system has resulted in a considerable reduction of dangerous high speed of buses, a decreasing of delay time of journey for the passengers, and also more accurate planning for optimum use of the transportation system.

3.2.2 Challenges

I. Some drivers try to deactivate the GPS before attempting violation. At best, they cover the GPS with aluminum foil to make it disconnected from the center.
II. Due to the need for a GPRS platform for sending the information to the center, using this system in Tehran is very expensive.
III. Due to the low average educational level of drivers and users of public transportation services, the relevant systematic training for using this system will be needed.

3.3 Use of intelligent routing systems for public transportation passengers

More than 800 bus stations are equipped with display screens to inform the passengers of the arrival time of the buses. Nearly 20 web kiosks are also assembled at stations which make the transfer information available through touch screens. An SMS system is also commissioned to get exact information about routing to the desired destination for passengers. In these systems, the passenger can receive information about the journey duration and the best manner of navigation after determining the origin and destination and also specifying the desired transportation mode such as metro, taxi, bus or walking.

3.3.1 Advantages

Advantages are summarized as a noticeable decrease in delay of journeys and an increase in productivity.

3.3.2 Challenges

Due to cultural problems, many cases of incurred damages to informative equipment such as LCDs have been reported. In order to persuade the people to use these routing systems, widespread training will be needed.

3.4 Modern informative systems for offenders

In the past, all violations were controlled by police officers, fine were issued to drivers by the police officer or put on their automobiles. In other cases, the offender would not get informed of his penalty until the settlement time. In the first years of making transportation and traffic system intelligent in Tehran, fine notifications were mailed to the violators' addresses, but due to the large number of violations this system encounters numerous problems. Today, developing the use of cell phones, all fine notifications and notices for a technical test will be informed to the offenders via SMS.

3.4.1 Advantages

Advantages are summarized as omitting many unimportant journeys to deliver the fine notifications to the offenders, omitting the process of printing and stuffing envelopes with fine notifications (noticeable savings), improving the safety coefficient of the system by almost 100%, informing all offenders of their violations in an online manner, and creating a cohesive database of the offenders.

3.4.2 Challenges

I. As the telecommunications system and necessary infrastructure have not been completely developed, some problems in sending the SMS to offenders have been occasionally observed.
II. Informative limitations such as length of words in SMS.

4 Conclusion and suggestions

I. Experience of using intelligent transportation systems in Tehran showed that upon using this systems, the amount of driving offences, crashes, and also traffic congestion has been remarkably reduced which finally led to a decrease in direct expenses (such as fatal accidents or fuel consumption) and indirect expenses (such as time wasted in traffic). Besides all gained advantages, reducing fuel consumption will cause reduction of air pollutants, and all these advantages will result in more efficiency of the urban transportation system and its sustainable development.
II. According to the experiences gained, it is revealed that cultural differences in behaviors of drivers of those countries who export technology of intelligent systems with that of the user country may become the origin of many problems in using these systems. Therefore, before deciding to use these systems, comprehensive social studies should be performed in order to determine the adaptability degree of society for using these systems and the manner of covering the present gap (through training via mass media), and also the most appropriate systems for the user country should be identified and chosen.
III. Intelligent transportation systems enjoy different technologies. Studying and choosing these technologies is a very important process for which special care is needed. Making some changes in software and hardware of these systems is often required, and the chosen system should have the said capability.

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