New Concept of the Urban and Inter-Urban Traffic

A. Kardashyan, A. Kardashyan

***Abstract*— conceptually the article describes the new method of the traffic management according to the database of the traffic users and dedicated traffic roles. The developed system can establish traffic management due to the special algorithm. The system reduces the cost of the traffic control cameras meanwhile it allows full traffic control individually of all roadworthy traffic users.**

***Keywords:* GPRS transmitter, GPS receiver, traffic management, speed camera, urban and inter-urban traffic**

I. Introduction

THE road traffic collisions are an important cause of death and disability worldwide. Every year around the world 1.2 million people are killed and up to 50 million are injured or disabled as a result of road traffic collisions [1]. Morbidity from road traffic collisions is expected to increase in future years, and it is estimated that road traffic collisions will move from ninth to third place in the global burden of disease ranking, as measured in disability adjusted life years [2].

Measures to reduce traffic speed are considered essential to reducing casualties on the road. Speed cameras are increasingly used to help to reduce traffic speeds in the belief that this will reduce road traffic collisions and casualties, and an expansion in the use of speed cameras is under way in many countries, most notably the United Kingdom [3]. However, the effect of using speed cameras is controversial, vociferous opponents, including some motoring associated organizations, oppose their use, and cameras are often criticized in the media [4-6].

Nowadays along with the increasing electronics methods to detect and avoid the safety cameras, as well as the lack of safety cameras on the road assures the development of the essentials on the new traffic management concept.

The main disadvantage of the speed cameras is no continuality, which means that the safety cameras are installed in a defined places and road users can expand extremely high speed in an area between cameras without any speed limit detection. Moreover the most traffic users are sure that they have avoided safety cameras and they are not under control until next camera.

Manuscript received June 07, 2011; revised June 23, 2011.

Ara. G. Kardashyan, PhD, Member of IAENG, Oxford Nanopore Technologies, 75 Gainsborough Green, Oxfordshire, OX14 5JL, Abingdon, UK:+44 78 464 299 03(e-mail ara.kardashyan@gmail.com).

Artashes. G. Kardashyan, PhD, State Engineering University of Armenia, 00025, Heratci 22, apt 21 Yerevan, Armenia: +37494 242-244 (k_artash@mail.ru).

One of the solutions is to increase the number of safety cameras, but however, it's quite expensive solution and practically impossible to keep all traffic under the camera control. Thus, the traffic management needs conceptually new solutions, because the effect of safety cameras and other existing methods of the traffic management are limited [7].

The idea of the new concept of the traffic management is quite simple: the car itself, periodically, and especially in case of the traffic low violation, should send the essential information to the central traffic management office (CTMO). In this case all legal road users, (who passed the inspection and has special integrated module in a car), are controllable continuously at any time and in any situation. The main traffic control office is periodically receiving the information about the road user, and correspondingly can control their actions and detect any law violation. For example if CTMO receives the speed which is over the limit in the defined road then the vehicle with the correspondent registration number will be fined.

The simple algorithmic solutions can easily solve the other traffic management problems, like a traffic jam predication, accident detection etc.

II. Existing Methods of Traffic Management

The traffic management issue becomes very critical as with increasing demand for travel, more and more road networks are experiencing Traffic Congestion. In many cases this could be reduced if more real-time information was available to traffic engineers and drivers. But today UK spends £30 billion per year to support the current traffic management system. However it doesn't fully resolve the problem as still it's not obvious how to spear the essential real-time information to the all traffic users in the certain area. This problem becomes more difficult for the less popular areas especially in bad weather conditions.

There are many projects working on the traffic management issue. In the below review we have analyzed the most popular projects in UK and discussed their achievements:

• **Traffic data collection**: method based on the measurement of flow, speed, occupancy, travel times, origin-destination matrices, etc. New traffic data collection systems are being developed giving enhanced measurement of conventional traffic parameters or the capability of measuring new parameters. Sensors based on video image processing, for example, have the potential of being as accurate as loops, being more easily maintainable and giving a picture of the traffic. On heavily trafficked or sensitive sections, if integrated with video AID (congestion)

ISBN: 978-988-19251-7-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

functions and with existing TV monitoring facilities, they can potentially compete on cost-benefit ground with loop-based systems. The market introduction of GSM/GPS based systems (like SOCRATES) for bi-directional traffic information exchange makes it possible to collect floating car data (flow data as well as incident data) at all of the relevant road sections without any infrastructure costs being involved. The widespread implementation of toll systems will give new opportunities for traffic data collection. Conventional closed toll collection systems can already be used for monitoring traffic conditions: the magnetic toll ticket, which is read at the exit, contains the name of the entry and the time when the vehicle entered the network, so that it is possible to know Origin-Destinations and travel times along the motorway. The development of Automatic Toll Collection systems will make it possible to extend this possibility to open toll collection systems (using beacons reading tags at entry points), to get even more information (travel times on each stretch between junctions using intermediate beacons) and to integrate more easily this new data into the general motorway data collection system. More largely, the floating car concept (vehicles as probes in the general traffic delivering individual parameters through beacons or GSM), provided a sufficient number of vehicles are equipped, could potentially provide an alternative to conventional data collection.

• **Automatic Incident Detection (AID)**: is an essential part of monitoring and surveillance. It is highly desirable that Automatic Incident Detection (AID) is developed and generalised because it has a far greater efficiency compared to conventional means such as patrols, emergency call boxes and direct human viewing of CCTV monitors.
Automatic Incident Detection requires great effort in the experimentation of suitable algorithms able to detect the changes in normal traffic flows. An intensive experimental phase was necessary to test the algorithm in the highest number of traffic situations in order to measure its effective level of performance. Within the ATT Programme there were

• **Emergency call systems**: (generally call boxes along the road linked to traffic control centres) is part of the Incident Detection system, and is still the most important source of information about incidents on inter-urban motorway links. However, an increasing use of mobile telephones is being made by drivers who either ask directly for assistance or phone spontaneously when they have witnessed an incident. The use of portable telephones raises several problems including identification of the incident location and phone call jams. The development of the pan-European GSM system may contribute to solve these. It also has the potential to enhance the effectiveness of incident detection and of incident rescue and management. For example, the use of the Automatic Emergency Call systems triggered by on-board crash sensors that transmit a distress call, using the mobile telephone network, sending a data log containing relevant information on the vehicle involved in the accident and its location to the emergency services. If the incident involves a truck carrying hazardous materials, the data log provides essential information about the nature of the load so that appropriate precautions can be taken. Knowledge of the precise location of an incident allows effective routing of rescue teams and automatic despatching of calls to the relevant control centre;

• **Weather and weather related road condition monitoring** -prevents accidents in many countries in Europe. Most inter-urban highway owners make use of weather information and forecasts, either from their own weather measurement facilities or from various other sources such as airports and national meteorological offices. As well as for safety purposes, weather data is applied to winter maintenance scheduling and, for some authorities, for driver information.

• **Short term traffic forecasting**: Short-term traffic forecasting (with a time horizon of a few minutes to a few hours) is an essential element of advanced traffic monitoring and surveillance. Although, because of the limits of modelling and the random character of traffic, unlimited accuracy of forecasting cannot be expected, there is a definite need for the development of such tools for the purposes of driver information (either en-route or for trip planning) and traffic control. There is particular potential benefit from identifying current and future OD's and routes in motorway networks and corridors to allow the application of diversion strategies (using VMS or in-vehicle systems) during unpredictable conditions (accidents, road works, etc.).

• **Traffic modelling**: Modelling of traffic flow patterns (volumes, speeds, travel times, queue lengths etc) is a core issue for inter-urban (as well as for urban) traffic management. It may take the form of short-term forecasting of traffic patterns but may also address a range of other issues of relevance to the operation of ATT systems, such as traffic pattern reconstruction, traffic assignment and driver behaviour models.

• **Inter-urban traffic control**: Traffic control on motorways (as well as inter-urban motorways) and networks includes established techniques such as access and exit control, speed control and route control or advice and extends to a wide range of novel techniques including in-vehicle systems. In many instances, it encompasses the adjacent network which can be used by diverted motorway traffic.

• **In-vehicle information**: It is vital to be able to communicate with the driver when implementing unscheduled control strategies. These can be for re-routeing purposes, or to provide important information concerning the safety of the driver. VMS are, and will probably remain for some time, one of the essential means for delivering information and indications to drivers on inter-urban motorways passing a particular location. They can be used for control purposes (speed control, entrance or exit closure, guidance by means of variable directional signs or route advice) as well as for information delivery (comfort and safety). Until now there has been no common agreement on:
• The effectiveness of VMS use;
• VMS messages and strategies;
• VMS impact on driver behaviour;

• **Traffic and travel data exchange and communication**: Given the interconnection of road networks and the mutual

ISBN: 978-988-19251-7-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

interdependence of traffic systems across borders as well as within a single country, it is clear that compatibility of message contents and formats is needed to allow for easy information exchange and information dissemination. Various coding systems (GSM, RDS, GDF) and data dictionary formats (STRADA) have been established and have to be verified and validated.

• **Urban/inter-urban interface**: In the vicinity of conurbations, urban and inter-urban road and traffic systems interface strongly with one another. This results generally in extended congestion during peak periods and underlines the necessity of data exchange between urban and inter-urban traffic centres for the purpose of co-ordinated driver information (including park-and-ride and P.T. information) and traffic control strategies.

• **Systems architecture**: In the context of the variety of road traffic environment components and of the complexity of their relationships and interactions, a conceptual structure of the whole IRTE, i.e. a global architecture, is clearly needed. This architecture could cover sub-systems whose own architectures would have been made compatible with one another. It needs to consider the following components: urban traffic management, inter-urban traffic management, travel and traffic information, automatic debiting systems, public transport and freight and fleet management.

The above revue as well as our research shows that the all existing traffic control systems are based on collecting the information from external sensors (like CCTV cameras, or aquatic sensors), providing information about the traffic and road condition. The main problem of all existing systems is the lack of the sensors and absence of the synchronised feedback between the driver and traffic control office. That means that CCTV or aquatic sensors can not catch all areas, especially less popular areas like a small towns or mountainside roads. Also revue shows that the existing traffic control systems are not effective for the current traffic and needs conceptually new approach for high effective and continue traffic control.

III. REAL TIME TRAFFIC MANAGEMENT

The new developed traffic management system allows acting on all mentioned issues without using expensive road cameras and video analyzing systems. Also the new system allows establishing synchronized automated communication between the traffic users and traffic control office, which will improve the effectiveness of the control system.

The basic of the new concept of the traffic management is a duplex system, which can receive a position from the GPS navigation system and, itself, send important information to the CTMO. Hierarchically system consists of the Central Traffic Management offices, Local GPRS/GSM repeater amplifiers, and vehicles with the integrated special device (traffic users), as shown on figure1 a).

Another very important application of the current system is traffic flow control. The traffic flow algorithm is designed to predict the traffic jam in critical areas, make announcements and if possible adjust the traffic flow by applying for example variable speed limits or any other techniques to adjust the traffic flow.

The conceptual model of the traffic management data collection is shown on figure 1 b).

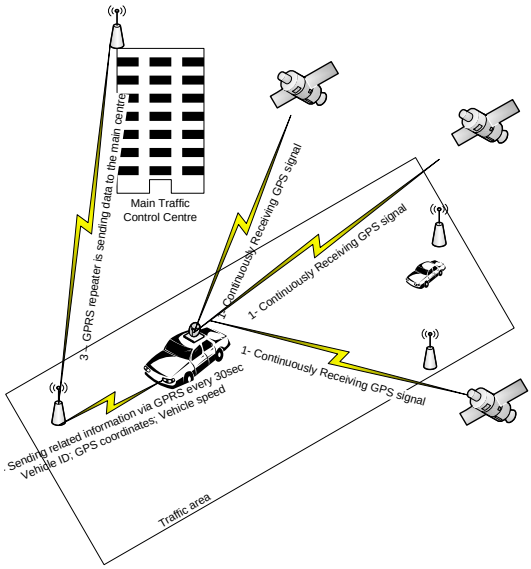
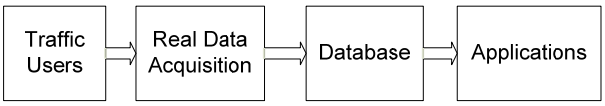


Figure 1 a), Concept of the traffic management system



b)

Figure 1 b) Conceptual model for the data path

The model consists of four main subsystems:

Traffic users: these are all the traffic users (with integrated GPS/GPRS device) registered in the global database. This category is divided in two subcategories which are passive traffic users and active traffic users. The passive traffic users are vehicles which are registered in the data base but they are not in move, while active traffic users are moving and their speed is different from zero. There are separate algorithms (functions) to deal with passive and active traffic users.

Real time data acquisition: this is a special function and telecommunication solution to collect the real time GPS data (geographical information described by longitude and latitude) from every single traffic user. These are the main data which allows the central traffic management system to analyze and establish proper traffic management.

Database: It is one of the most complicated parts of the system and it needs continuous development and improvement. In the simplest scenario the database is the detailed map for the selected area. In more developed versions the map will include all the traffic roles, parking permitted areas, road works, accidents, average vehicle flow capability etc.

Automated applications and feedback: Gathering all real time traffic data into the central management office database will ensure the analysis and automated decision making results. For example if the system feels the traffic development on the particular area, the automatic application can enable variable speed limits slowing down the approaching traffic enabling to clear the problematic area.

The informative feedback to the traffic users is very important in all types of traffic management systems as

ISBN: 978-988-19251-7-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

shown in our review. This allows users to be informed about the situation on the road and how it affects to them.

So the CTMO always knows the speed, direction, condition of all traffic users individually.

Central Traffic Management Office is an analogue of the Central office in a general telephony. All traffic management algorithms and final decisions are on the CTMO responsibility. The intellectual algorithms and software solutions are also established in the CTMO. CTMO receives plenty of information from different local translators, analyzes them with the integrated algorithms, makes decision, prints and sends report. Simultaneously CTMO monitors the traffic flow, checks average traffic speed, estimates and predict traffic jams. The CTMO also can find the vehicle with the defined registration number, which can be useful for the security reasons thus preventing illegal vehicle movement (for instance, stolen vehicles, vehicles without MOT or without road Tax disc and so on). The simplest algorithm of the main functionality is shown on the figure 2. Current programming level allows making a quite modern and suitable algorithm for entire traffic management system.

The essential information which is the source of the data analysis is defined in the flowing word format:

- vehicle registration number;
- vehicle's current location (GPS coordinates)
- vehicle speed received from the speed sensors of the vehicle
- emergency bit which can be on when the SRS system is in operation.

Integrated Special Traffic Management Device (TMD). As clear from the context the main data source of the system is vehicle, which has an integrated special device and this device periodically is sending essential information to the CTMO. In other words, the device continuously receives GPS coordinates, analyses them adding own vehicle registration number and other vehicle information, and periodically sends it by the GPRS or other wireless communication network (e.g. WiLink) to the CTMO. As the result the CTMO knows all useful information about the vehicle at almost any time and any situation.

The Device consists of the main processing unit, GPS receiver unit, GPRS transmitter unit, vehicle additional sensor interface (like a speed sensor, SRS sensor etc), program and data memories.

The simplified block diagram of the system is shown on the figure 2.

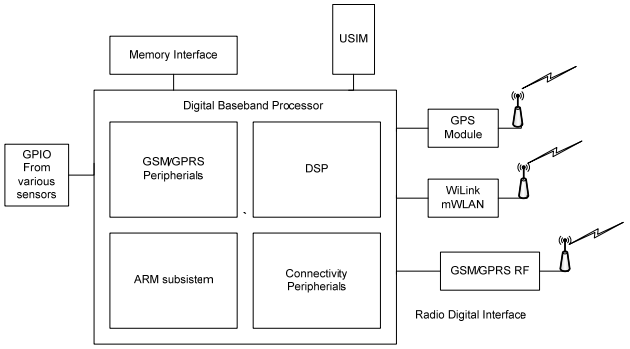


Fig. 2. Simplified block diagram of the traffic management system

Local GPRS/GSM repeater. Currently the most traffic engaged areas in the world are covered by the mobile connectivity. The one of the important blocks of the mobile network is local amplifiers/repeaters which are receiving information from the users and sending them to the central office. The operational principle of the new traffic management system is based on the same idea.

Particularly, the TMD can send information to the CTMU via well known GPRS network. In that case the existing local GPRS/GSM repeaters can be used for the traffic management purpose as well.

The basics and practical implementation of the GSM repeaters/amplifiers nowadays are well investigated by the various authors [10, 11].

IV. THE SYSTEM PROTOTYPING

The current designed system has been prototyped and validated in a small area of the city. The map of the area has been created and edited to add the basic traffic roles like speed limit, street direction etc.

Like the GPS/GPRS device the prototype design has been used. The device is mounted on the vehicle under the bonnet in a special heat resistant package. The database server and WEB application has been developed as an example of the central traffic management system. The SQL database is designed to store the data, and Net application to control the device and receive data figure 3.

Fig. 3 Web application of the traffic control server

The special algorithms have been developed to calculate the average speed and traffic flow.

The figure 4 a) shows the speed chart captured from the vehicle which moves in a high speed traffic flow. As we can see from the chart the vehicle between 'A' and 'B' developed average speed is more than 60km/h which indicates good traffic flow for that road.

ISBN: 978-988-19251-7-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)

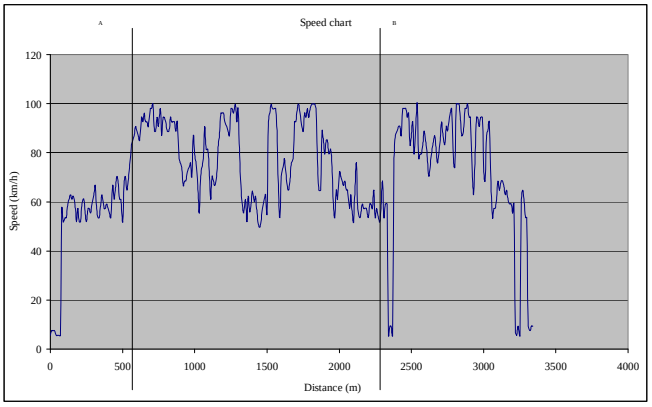


Figure 4 a), Captured Speed chart

The figure 4 b) shows another capture, this time indicating the slow traffic flow. As we can see the vehicle is moving with the speed lower than 20km/h.

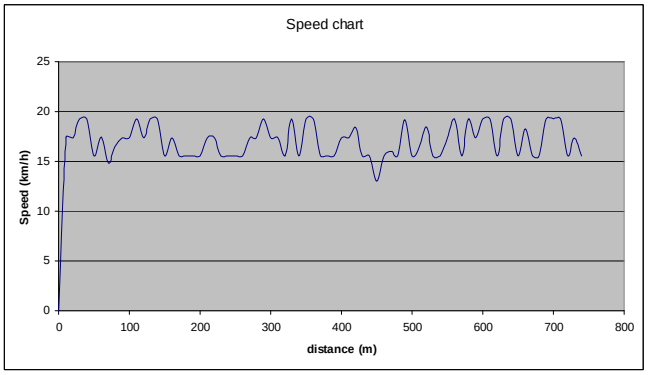


Figure 4 b), Captured Speed chart

Having this information from many different vehicles, the server or central traffic control unit can predict the traffic flow. As shown on the figure 5 a real time, precise traffic flow map can produced.

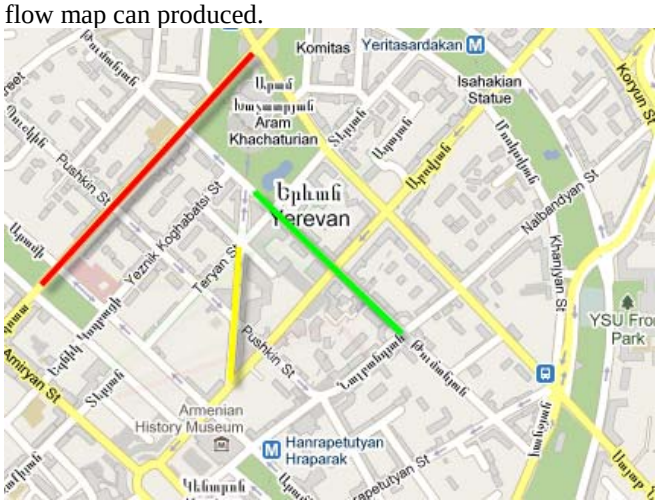


Fig. 5. Traffic flow map

Legend
1. Red= speed < 20km/hr.
2. Yellow=speed 20-30km/hr
3. Green=speed>30km/hr

V. Conclusion

Nowadays, due to the complicated traffic networks, traffic speed and the huge number of the traffic participants, the safety cameras and other existing traffic management methods are not good enough for controlling and managing traffic in any situation and in any location. The described method conceptually suggests new traffic management solution based on the automatically individual control to any traffic user anywhere and anytime. The principal of the method is as follows: any registered vehicle periodically sends information about itself, which is being decoded and analyzed by the central traffic management unit. As a result the central traffic management unit knows the location, speed and condition for every single registered vehicle. According to the information, the system can establish traffic management due to the traffic management algorithm.

The advantages of the new concept are as follows:

- Automatically detects of the speed of any registered vehicle.
- Automatically fines the vehicle parked in the restricted area.
- Automatically measures average speed of the traffic flow, predicts and reports on traffic jams.
- Finds precise location of any vehicle.

This paper describes conceptually new traffic management duplex method; it enables both the control of the traffic in the selected area and the monitoring of the traffic users individually if required.

Taking into consideration the existing mobile network and the GPS availability almost in all areas of the world the new concept seems economically profitable against the existing ‘speed cameras’ or human inspection methods.

References

[1] Roberts I. War on the roads. BMJ 2002;324: 1107-9.[Free Full Text]
[2] R press release. Life-saving cameras to be made more visible—Spellar, August, 2001. www.press.dtlr.gov.uk/pns/DisplayPN.cgi?pn_id=2001_0359 (accessed 5 Jan 2005).
[3] Association of British Drivers. www.abd.org.uk/ (accessed 29 April 2004).
[4] Barker P. Speed cameras: costing us millions, and costing us lives. Autocar Magazine 2003 Nov 11: 18-23.
[5] Elvik E. Effects of accidents of automatic speed enforcement in Norway. Transportation Research Record 1997; 1597: 1-19.
[6] Ali SY, Al-Saleh O, Koushki PA.. Effectiveness of automated speed-monitoring cameras in Kuwait. Transportation Research Record 1997;1595: 20-6.
[7] Traffic: speed cameras prove to be lifesavers. Law and Order 1996;44: 75-6.
[8] Keall MD, Povey LJ, Frith WJ. The relative effectiveness of a hidden versus a visible speed camera programme. Accid Anal Prev 2001;33: 277-84.[Medline]
[9] Swali L. The effect of speed cameras in West London. In: Traffic management and road safety: proceedings of a PTRC seminar at Manchester University, September 1993. PTRC Education and Research Services Ltd, 1993.
[10] Design of Class-E Radio Frequency Power Amplifier –Al-Shahrani, Saad Mohammed
[11] Applications Note AN-1222: A Low Noise High Intercept Point Amplifier for 1930 to 1990 MHz using the ATF-54143 PHEMT – A.J. Ward

ISBN: 978-988-19251-7-6
ISSN: 2078-0958 (Print); ISSN: 2078-0966 (Online)