Basic Concept of the Technical Study of the Automatic Traffic Congestion Control System in Delhi, NCR Region

By

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ABSTRACT

The Technical study analyses existing and expected situation, defines critical localities on the basis of this analysis, which is necessary to solve and defines a framework for solution and its technical characteristics, respectively different alternatives of solutions. The article describes the current state of the ITS in the Delhi, NCR, the scope of the Technical study of urban ITS and an ideological proposal of the Traffic Control System (TCS) in Delhi, NCR. The urban ITS with respect to main goal – capacity increasing of existing urban road network and traffic congestion reducing – has been designed.

Keywords: intelligent transport system, ITS, traffic control system, detection system, traffic control center.

1. INTRODUCTION

The mobility of inhabitants and degree of motorization was increased not only in other developed countries but also in Delhi, NCR. This has resulted in increased traffic loading and overloading of existing urban road networks. Problems are most evident in towns where there is a growth in traffic congestion, traffic accidents and negative impacts on the environment. Intelligent Transport Systems (ITS) implementation is one of the ways to effectively use the existing road network in the towns and increase its capacity and safety. ITS is inevitable within the state, thus in towns, to be built in coordination and consistently on basis of interoperable systems based on open and public standards.

The part of the proposed system environment TIS is implementation of ITS in 11 chosen towns in Delhi, NCR. For the purposes of the Technical study document for each town was elaborated in the first phase. The Technical study analyses existing and expected situation, defines critical localities on the basis of this analysis, which is necessary to solve and defines a framework for solution and its technical characteristics, respectively different alternatives of solutions. The article describes the current state of the ITS in the Delhi, NCR Region. The scope of the Technical study of urban ITS and an ideological proposal of the Traffic Control System (TCS) in Delhi NCR.

2. DESIGN OF URBAN ITS AS A PART OF THE DELHI, NCR REGION

Some advanced countries have already had for several years operational systems enabling reception and distribution of relevant information related to road transport not only on domestic roads, but also on interstate roads. Although Delhi, NCR is for a relatively long time in the field of creation and mainly exchange of traffic information with foreign countries it is significantly behind. The situation should be improved by creating a Traffic Information System, which should be a complex system environment for acquisition, processing, sharing and distribution of traffic data from information and communication systems and technologies on the road network in Delhi, NCR.

To ensure the basic functionality of TIS in Delhi NCR, four realization domains presented in the figure 1 were allocated. Moreover, they could be built separately and in future connected to each other: -

Implementation domain of NTIC – central system for securing the acquisition of traffic data from various agent based information and telemetric applications, processing, exchange, publication and distribution of traffic data.

Implementation domain of Production and acquisition of information – central evidence system of closed roads, system of planned road servicing, agenda system of oversize and dangerous cargo, etc.,

Implementation domain of ITS of main roads – extension of technological equipment and improvement of telemetric applications on main roads which secure the detection of traffic flow characteristics, automatic traffic counting, queue detection, acquisition of the meteorological data and state of road surface.

Implementation domain of ITS of agglomerations. From the viewpoint of ITS implementation in towns, the essential part of TIS project creates the 4-th realization domain which represents solution of integrated ITSs systems for 11 chosen agglomerations in the Delhi, NCR. The third biggest town Delhi, NCR has been chosen, too. Currently, in the Delhi, Ghaziabad, NCR no integrated urban ITS has been completed and made functional yet.
In ITS systems design the process shown on Figure 2 was generally accepted in accordance with the technical regulation TP 09/2008 [2], where the phased process of ITS systems creation (a necessary design documentation process) is described. These stages are closely related to each other and result in an integrated implementation of transport systems that are solving the transport service for a defined territory.

### 3. BASIC STEPS OF ITS AGGLOMERATIONS IMPLEMENTATION – TECHNICAL STUDY

<table>
<thead>
<tr>
<th>Technical Study</th>
<th>Functional Specification</th>
<th>Construction Project</th>
<th>Continuous realization project</th>
<th>realization project</th>
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<tr>
<td>Analysis of conditions &amp; frame determination of technological equipment scope</td>
<td>Detailed function system design</td>
<td>Constructional design of individual objects resulting from functional specification</td>
<td>Establishment of applicant’s ability to realize the system</td>
<td>Detailed specifications of system, devices and infrastructure</td>
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#### Figure 2. Phases of ITS implementation

For realization purposes of the TIS it is necessary in the first phase of implementation domain of ITS agglomerations to elaborate the Technical study (TS) for each town agglomeration, i.e. A document which: - analyses the existing and expected situation, - defines problems on the basis of this analysis, which is necessary to be solved, - defines a framework for solution and its technical characteristics, or different alternatives of solutions. The aim of TS is an analysis of external conditions in particular solving urban area of agglomeration (Table 1) and framework for determination of the extent of technological equipment (Table 2) in terms of the technical regulation TP 09/2008 [2].

The minimal range of external conditions analysis is as follows:
- classification of individual road sections, - constructional properties of roads, - identification of road sections in which capacity is reduced (according to TP 10/2010) because of objective or subjective reasons, - identification of critical locations from traffic point of view, - identification of critical locations from meteorological point of view, - determination of sections from which traffic has to be instantly excluded in case of need, - determination of network control need, - constructional properties analysis of tunnels (for each tunnel separately), - analysis of other important factors. The range of a basic framework design infrastructure is as follows: - power supply infrastructure, - communication infrastructure and - operator workplaces equipment. In an analysis of external conditions, the following primary inputs have been considered: analysis of construction conditions and traffic volume of the road network, capacity analysis of roads and intersections, possibilities of diversion routes, as well as analysis of traffic accidents, weather conditions and the existing state of technology systems.

#### Table 1. The minimal range of external conditions analysis

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#### Table 2. The range of a basic framework design infrastructure
4. THE TRAFFIC CONTROL SYSTEM IN DELHI, NCR REGION

In this part of the article the ideological design of Automatic Traffic Control System (TCS) in agglomeration Delhi, NCR Region is described in general terms. A Technical study of ITS for the Delhi,NCR Region agglomeration has been elaborated. There are described in more details the functions and links of each system, their localization within agglomeration town and connection with the TIC (Traffic Information Center) master system. The TCS Delhi, NCR itself is designed as an open system which enables integration of other systems, such as navigation system for local parking, urban mass transportation etc. The TCS Delhi, NCR has been designed on the basis of detailed analysis of external conditions. An urban road network of Delhi, NCR is presented on Figure 3, where examples of external analysis outputs – critical location from traffic point of view and critical location of traffic accidents are drawn. Urban road sections and intersections, not complying with terms of capacity are drawn in red. These are the fundamental functions of designed TCS acquisition of traffic information and data, - traffic control and navigation, - operator monitoring, - providing of information, - supervision and repression, - technological revision of operation.

4.1. Fundamental subsystems of the TCS in Delhi, NCR

The main goal of designed TCS Delhi, NCR has been to increase capacity of existing road network and to reduce traffic congestions by: - timely and accurate monitoring of the current traffic situation in a controlled area with optimizing of traffic management, - increasing the capacity of existing urban roads and intersections for more vehicles, - reducing the impact and duration of congestion in the controlled area. - improving of performance and timely problem solving of capacity in emergencies or other emergency states, increasing the average speed of vehicles on the roads and reducing the time passing through the city, - increasing operational efficiency and safety of the travelling public, - providing sufficient information for road users with a choice of routes, - cooperating with other transportation management systems (e.g., highway management systems). To achieve this goal, a complex traffic control system was designed within the frame of Technical Study of ITS Delhi, NCR which consists of three basic layers:

- technological layer, which consists of technological devices which monitor, inform and control the traffic situation.

Figure 3.
Urban road network of Delhi, NCR Region critical locations from traffic point of view and critical locations of traffic accidents
signal controllers, detectors, variable message signs, monitoring cameras etc.),

- **Transmission layer** formed by active transmission and network elements serves for data transmission mediation between the technological and control layer (communication system for data transmission and control from traffic control centre).

- **Superior control layer** consisting of the control and visualization system (components of these systems are concentrated in traffic control centre). The mentioned three layers – technological, transmission and superior – are for TCS Delhi; NCR analytically divided into the following subsystems:
  
  A. Local Traffic Control System – LTCS,
  B. Vehicle Detection System (on strategy level) – VDS,
  C. Monitoring camera system (Closed Circuit TV) – CCTV,
  D. Variable Message Sign System – VMSS,
  E. Data Communication Network – DCN,
  F. Traffic Control Centre – TCC.

In addition to these systems an Electrical Power Infrastructure (EPI) of all technological devices and meteorological stations were designed in the study.

**ITS AGGLOMERATIONS implementation domain**

- **Traffic Control Center**
- **TCS Traffic Control System**
- **Central Control Computer**
- **Central Data Storage**
- **Information Al Web Server**
- **Digital Video Recorder**
- **Backup Control Computer**
- **Warm stand-by**
- **EPI Electrical Power Infrastructure**
- **DCN Data Communication Network**
- **VDS Vehicle Detection System**
- **CCTV Closed Circuit TV**
- **LTCS Local Traffic Control System**
- **VMSS Variable Message Sign System**

The TCS Delhi, NCR is schematically shown on Figure 4. Individual components of TCS will be interconnected into a fully functional unit. The TCS Delhi, NCR will work on two levels:

- The operated level – controlling of traffic flows on local level of traffic node (intersections), eventually several intersections in coordination. The controlling will be optimized on the basis traffic requirements determined by a detection system of intersection traffic controller (Local Traffic Control System – LTCS),

- The strategic level – the TCS system will automatically evaluate the current traffic situation on-line detected on detection zones of designed controlled area (Vehicle Detection System on strategy level – VDS). If necessary, a superior system will realize a proper action based on new traffic conditions to optimize control of traffic flows in area. Detection of traffic conditions on this level is realized by a standalone vehicle detection system (independent from the detection system of a traffic light controller) and traffic flows are controlled by traffic light controllers or using variable message signs to redirect traffic flows to alternative routes of urban road network. Intersections that will be implemented by local traffic control system (LTCS) and also positions where the strategic detectors of traffic detection system (VDS) will be placed within Delhi, NCR area are shown on Figure 10.

**4.2. Local Traffic Control System – LTCS**

The main component of the Local Traffic Control System (LTCS) is a traffic signal controller with its own detection system. Detection system in many cases consists of loop detectors. Detectors are separated from VDS and traffic data are collected in controller for efficiently control signals. LTCS operates traffic signals by optimizing signal display and signal time according to the traffic data in each direction on the road – dynamic (on-line) traffic controlling on the basis traffic demands in real time. Fundamental function LTCS will be to control traffic flow on the road and mitigate traffic congestion by properly controlling signals. There are traffic signal controllers designed on 17 intersections in Delhi, NCR – 2 existing traffic lights, 8 reconstructed traffic lights and 7 new traffic lights. All local traffic signal controllers installed in town will be checked and operated from Traffic Control Centre automatically.

**4.3. Vehicle Detection System – VDS**

A necessary foundation for traffic control is traffic data acquired from traffic detectors which mediates an image of traffic behaviour in a location requiring traffic-flow control. Primarily the input data for evaluation are the traffic volume, speed and traffic-flow composition. Detected data are evaluated in such a way that they do not only provide information about the actual traffic volume but also predict formation of impulse waves of vehicles or identify traffic accidents. VDS (Vehicle Detection System) Delhi; NCR is a system to collect traffic data on strategy level and consists of traffic survey detectors. These devices are divided according to function: - Traffic Flow Analyzer (TFA) – traffic survey detector, which function is detecting of immediate characteristics of traffic flow to monitoring and traffic controlling in real time (such as traffic volume, speed, share, time gap, etc.), - Traffic Incident Detection Device (TIDD) – traffic survey detector, which function is in real time to identify of specified incidents in traffic flow. The traffic data collected via VDS from traffic detectors TFA or TIDD are provided to the Traffic Control Centre for the purpose of traffic strategy management. There are video detectors designed on 32 locations in Delhi, NCR (Figure 10) and this type of detectors cover both functions – traffic flow analysis and traffic incident detection, too. In addition to TFA and TIDD traffic detectors a Railway Crossing Occupancy Detection (RCOD) has also been proposed within VDS system in Delhi, NCR on strategic level.

**4.4. Monitoring camera system – CCTV**
Monitoring camera system is created by Closed Circuit TV (CCTV). CCTV is a system for monitoring traffic situation of selected roads and intersections, for visually and simultaneously checking it at traffic information centres when incident or emergency happens, for helping road-users and for performing a road safety function. Considering this, CCTV is designed on 17 locations and there are rotary DOME cameras designed (Figure 10).

4.5. Variable Message Sign System – VMSS

Variable Message Sign System (VMSS) is a system to inform road users about road and traffic states, car accidents, closed roads or road construction information in real time. Variable message signs are applied for reroute traffic flow to alternative routes from overloaded roads, too. VMSS is designed for three purposes in Delhi, NCR - to regulate traffic flow - reroute traffic to alternative routes, - to control traffic flow and - to inform road users. The informing drivers, the warning about existing congestions and diverting traffic on alternative routes is possible by change of certain symbols or messages on VMSS. There are VMSS (prismatic or LED) designed at 5 locations in Delhi, NCR (Figure 10).

4.6. Data Communication Network – DCN

The created communication network infrastructure formed by optical network (Figure 9) will serve for network transmission of data between traffic (operator) centre and technological devices (TD) combined into technological nodes [4, 5]. The technological node is according to configuration able to support several TDs like vehicle detector, variable traffic sign, traffic controller, surveillance CCTV camera, etc.

Figure 9. Private backbone network (L1 type) TCS Delhi, NCR

4.7. Traffic Control Centre – TCC

The Traffic Control Centre is a place concentrating the initial care of traffic controlled area. It is intended for application domains for traffic data processing, traffic control and monitoring of the entire traffic control system. It operates all technological devices and ensures archiving of all events by a record system. In this location the momentary technical conditions of all devices in traffic controlled area are monitored and where necessary an intervention is decided. The central control system inputs within its competitions actively into traffic control in the controlled area in full-automatic mode.

The competent dispatching worker – operator can perform, based on supporting systems results, an adequate intervention to traffic control by either inputting the necessary data (for example about a traffic accident) into the automatic control system, or by a direct manual action. From practical perspective within traffic control in a town a main function is examined – optimisation of traffic flows in controlled area together with control of critical or emergency states. For on-line control it is necessary to ensure that the Traffic Control Centre in Delhi, NCR has actual information not only from TCS subsystems (LTCS, VDS, eventually CCTV), but also from the superior Traffic Information Centre. Traffic data and information from TCS subsystems will directly from the picture of traffic situation in town or send information about critical or emergency state (occurrence of congestions, traffic accident or other emergency situation). The superior NTIC will provide to TCS information primarily about traffic situation on main roads entering town and also on the adjacent superior road network (D1 highway and R4 motor way), on which the town communication system is connected. This way the TCS Delhi, NCR will be able to react on time on traffic problems on these roads and optimize the traffic control in town with respect on traffic situation or traffic problems outside town. It also holds in the opposite case when based on traffic data from TCS Delhi, NCR enables the superior TIS to effectively control and regulate traffic on adjacent and superior road network outside town with respect to current traffic situation in town. Besides traffic control and regulation itself it is necessary to ensure informing of drivers either from position of TCS Delhi, NCR or TIS by the available ways (VMSS, RDS-TMS, radio, cell-phone, and internet).

4.8. Localization of Technological Devices with in Delhi, NCR Agglomeration

Based on TCS Delhi, NCR proposal on the controlled road network of town Delhi, NCR it is possible to generate a final location plan of designed technological devices (Figure 10). This way deployed technological devices after completion by another ITS devices (like meteorological-stations of RWIS system, etc.) complexly cover the controlled area and accomplish the goals summarized in the conclusion of this paper.

5. CONCLUSIONS

The proposal of Automatic TCS Delhi, NCR significantly contributes to reduction of congestions formation and high traffic volumes on by overloaded urban roads within the Delhi, NCR. At the same time it creates a background for a significant operational effectiveness increase of authorities, organizations and institutions in the area of administration and maintenance of roads, their components and accessories, in the area of economy of pavements and other property, in the area of traffic supervision on roads. The real output of the Automatic TCS in Delhi,NCR is implementation of procedures within the area of traffic control and optimization and within the area of analytical operation targeting towards permanent removal of traffic problems which impair safety or traffic continuity within the Delhi,NCR.
Figure 10. The proposed deployment of technological devices in Delhi, NCR

6. REFERENCES


