# V2X Technology in Metro trains using Internet of Things (IOT) and Automatic Train Supervision (ATS) for smart cities.

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***Abstract- The concept of intelligent transportation system (ITS) will be built on the foundation of vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) technology. The system will ensure communication between vehicles and the infrastructure. This technology introduces radio-based systems that can see "beyond the sensors" range to augment the information provided by the vehicles advanced driver assist systems (ADAS). This collection of technology marks a new era in vehicle communication.***

***The metro trains operate through Automatic Train Supervision (ATS). The system has the capability to supervise and organize the train movements continuously in an optimum manner. The main function of ATS system is automatic management of train movement with due interfacing with the Automatic Train Protection (ATP)/Automatic Train Operation (ATO)/ Computer Based Interlocking (CBI) systems for automatic route setting and train regulation. The whole idea of interfacing V2X technology with the centralized ATS using IOT is to create opportunities to mine the accumulated data to provide new services by applying intelligent analytics.***

**Keyword- Intelligent Transportation System, Vehicle-to-Vehicle, Vehicle-to-Infrastructure, Automatic Train Supervision, ATP, ATO, Computer Based Interlocking, UTO, MMI, OCC, RSU.**

## INTRODUCTION

The ATS subsystems monitors the status of the system continuously and helps in providing the required control so as to direct the operation of trains and maintains the scheduled arrival and departure, traffic patterns and minimize the problem of train delays on the existing operating schedule and service reliability. This in turn helps to avoid or reduce the damage resulting from system abnormalities and equipment malfunctions by performing the following tasks: supervision of train status, automatic routing selection, on the fly adjustment of train operations, automatic schedule creation, automatic operations logging, statistics and report generation, automatic system status monitoring and coordination of personnel scheduling for train management. The operation of ATS is controlled in Operation Control Center (OCC). There are three levels of operation on the basis of connection system: Central system (line), Local system (station), Depot system (depot).

ATS is executed through Man machine interface (MMI) software. The MMI offers a graphical interface to the whole set of ATS function through dedicated objects, menu and button. It consists of display system unit, keyboard, mouse and a

processing unit. On the other hand, the Unattended Train Operation (UTO) works on the concept of Internet of things (IOT). The train operation, scheduling, alarming and display system are controlled and operated with IOT.

The concept of V2X will be an integral part of smart-city deployment as it employs IOT. This can be used for roadway sensing road hazards and freight handling. The usage of this technology has potential use cases for connecting transportation systems together. The trains will send real-time information about departure time and platform numbers through the ATS and IOT interfacing. Personal ITS stations can process information to guide the passenger on the fastest route to the platform. Parked vehicles can process this information using smart devices like smart phones which enables bluetooth technology to autonomously drive to the arrival exit just in time to pick up the passenger to avoid road congestion and traffic mismanagement. V2X technology can also be used for traffic density patterns on road. The real time information can be obtained by road side units and onboard units using sensors.

## 1. REAL LIFE APPLICATION OF V2X

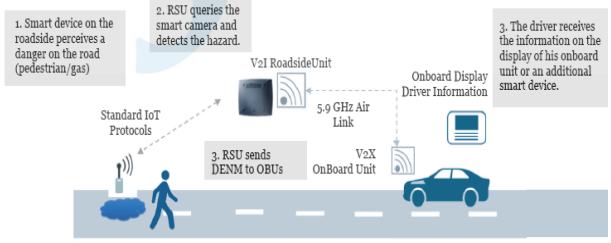


Fig1. IOT sensors and smart devices will allow a seamless integration of V2X technologies with smart cities that will increase road safety. For instance, vehicle and roadside sensors will be able to detect road hazards and pedestrians in the road and the onboard unit will alert the driver to take evasive action.

The driver can sense hazard or a danger using this technology and thus avoid accident. The smart device preinstalled on the road will sense or perceive the danger. Then the Road side unit (RSU) detects it and sends to Onboard unit (OBU). The driver of the vehicle can receive the danger in the form of information displayed on his onboard unit or the smart device using bluetooth.

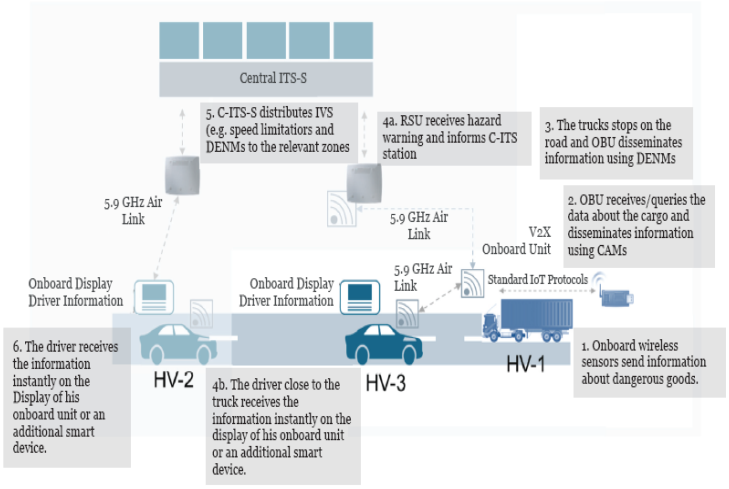


Fig2. V2X integration with smart city systems will improve freight management. For example, a truck's cargo can inform its environment about potentially dangerous goods, either by direct communication, or optionally via a central ITS station.

The freight movement can be managed through this technology. The onboard vehicle sensor senses the danger and transmits it to OBU about the cargo and information disseminates according to the standard IOT protocols. The truck stops. The RSU receives a warning and the information is passed to the central ITS and at the same time the driver of the vehicle close to the truck receives information on his display unit, later then the information is passed on to the central ITS through the air link. The communication can be a two way process.

### 1.1 THE OBJECT CONTROL AND CBI FOR TRAINS USING IOT.

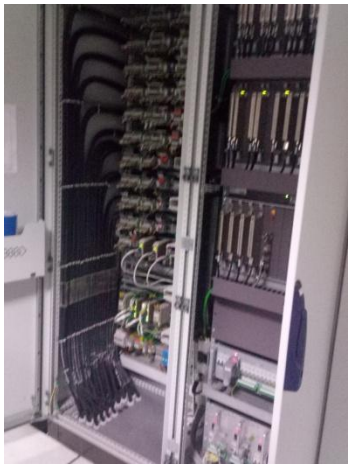

Fig3. Object control unit depicting the termination of fibres

Fig4. Computer based interlocking unit (CBI)

The optical fibres from the field terminate at the object control, and then the data is passed through the CBI where digital processing takes place. The control and operation is maintained by Central Operations Control Center. All this is done with computer based networking and programming. Each of the card storage is responsible for two signals, one for transmission and other for receiving. In UTO mode the operation takes place through IOT. The interface can be done with the V2X technology for efficient communication, train dispatch, train derailing problems, signal detection, changing environmental factors, master clock operation and passenger display systems.

Fig5. Axial counter on track with transmitter and receiver connected via fibre optical cables.

**1.2 AXIAL COUNTER**

The axial counter is preinstalled on the track field. Its preliminary function is to count the number of wheels crossing the track and indicate in the OCC whether the train has surpassed the platform or not. The axial counter does not get affected by the environmental parameters.

Fig6. Norming point installer on the track field.

**1.3 NORMING POINT**

The Norming point is installed at certain predetermined distance on the track to locate the location of the train using fibre optic cables connected underground to the Local automatic train supervision (LATS).

The track contains track circuits which are fixed and determine the occupancy of the train at the station. This also includes the concept of dynamic block which determine the actual area occupied rather than depicting the whole area under the train at the platform. This gives an added advantage of accommodating more than one train for efficient passenger commutation.


Fig7. WNRA of the field connected to system equipment room

### 1.4 TRACK CIRCUIT

A track circuit is a circuit which typically consists of relay coil connected to the rail through wires where low power is applied across each rail. When there is an absence of a train on the track, the relay is energized and is in operation through the current which is flowing from the power source to the rails. On the other hand, when a train is present on the track, its axels short (shunt) the rails together; the current to the track relay coil drops, and it is de-energized and it is not in operation. This clearly indicates that train is present or not. This concept is diminished which is now replaced with dynamic block on the track. Circuits through the relay contacts therefore report whether or not the track is occupied. A series resistor limits the current when the track circuit is short-circuited.

The software simulation and interfacing is done with the help of SIMTRAF and SIMMOD software. ATS is distributed in the form of CATS, LATS, and DATS.

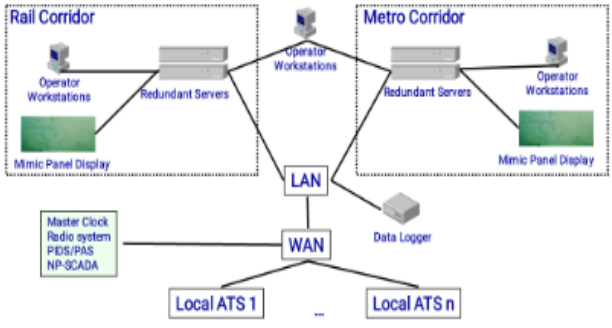


Fig8. Networking system of trains with the local ATS and redundant servers.

### 2. DESIGN PARAMETERS

The system is designed in such a manner that if at all any server fails to operate due to power failure, the trains can operate with the same efficiency. All this is possible due to the presence of redundant system. The workstation and the panel display are connected to the redundant servers and all are connected to local area network through cables.

The whole idea of interfacing V2X technology with the ATS is to improve the effective inter-communication and to avoid the unwanted accidents on the path. The interfacing can be done via wifi.

### 3. V2X FUNCTIONING

V2X technology can benefit the present working system in various ways. Gathering data related to the most visited sites improvising and managing the most congested and populated areas. This information can help the concerned authorities for deciding future actions regarding safety concerns, improving the efficiency of trains and reducing costs. This is a key issue in the country as transportation highly affects the growth and development of economy.

Message delivery schemes can get affected greatly by blind broadcasting of messages, provoking congestion and reduces the communication performance. To mitigate the effects, information about the traffic density patterns helps on determining the number of vehicles (trains) competing for the same channel, thus allowing for correcting measures like limiting non-critical information transmission.

The information collected by the road side units provide us with the global real time information about the traffic density. Hence this information can give us idea about the density and reduce jams on the way ahead.

### CONCLUSION

We conclude that approach that is able to fulfill the desired capabilities according to the standards by ITS and keeping in mind, the cost factor; V2X technology can be effectively put to practice according to the architectural structure and sensor arrangements. One of the greatest problems of getting affected by environmental factors is overcome by this technology. Adverse climatic conditions greatly affect the present built infrastructure, thus acting as a hindrance in efficient operation.

Combining Vehicle-to-Vehicle and Vehicle-to-Infrastructure communication will allow the uncertainty of the information which is gathered and makes it possible for human beings to get accurate

data, thereby improving the overall system in terms of fault tolerant capabilities.
This technology provides opportunities for the communication providers and application developers to go beyond the existing technical know-how ranging from road-hazard warnings and collision warnings. Integration of this technology with the internet of things will be an integral part of the upcoming and desired smart city concept serving beyond traditional means.

**FUTURE SCOPE**

This technology well applied in metro systems can also be applied and implemented in Indian Railways where a lot of problems like train delay; signaling issues and stopping destination can be resolved to a very large extent. The technology Rail2X, Ship2X, Airplane2X can be incorporated with the V2X ecosystem. Rail2X can be implemented using activation message to the road side units situated across the railway crossings to alert the corresponding system on the roads of approaching vehicles with the messages that a train is on the way.
Similarly Ship2X technology can guide vessels to their way towards the harbor and can help in efficient handling of freight handling.

**REFERENCES**

[1]. Sensing Traffic Density Combining V2V and V2I Wireless Communications
Julio A. Sanguesa 1, Javier Barrachina 1, Manuel Fogue 1, Piedad Garrido 1,
Francisco J. Martinez 1,*, Juan-Carlos Cano 2, Carlos T. Calafate 2 and Pietro Manzoni 2

[2]. Baiocchi, A.; Cuomo, F.; de Felice, M.; Fusco, G. Vehicular ad-hoc networks sampling protocols for traffic monitoring and incident detection in Intelligent Transportation Systems. Transp. Res. Part C Emerg. Technol.
**2015**, 56, 177–194.

[3]. Tyagi, V.; Kalyanaraman, S.; Krishnapuram, R. Vehicular Traffic Density State Estimation Based on Cumulative Road Acoustics. IEEE Trans. Intell. Transp. Syst. **2012**, 13, 1156–1166.

[4]. Mousannif, H.; Khalil, I.; Olariu, S. Cooperation as a service in VANET: Implementation and simulation results. Mob. Inf. Syst. **2012**, 8, 153–172.

[5]. Santa, J.; Pereñiguez, F.; Moragon, A.; Gomez-Skarmeta, A.F. Experimental evaluation of CAM and DENM messaging services in vehicular communications. Transp. Res. Part C Emerg. Technol. **2014**, 46, 98–120.

[6]. Soares, V.N.; Farahmand, F.; Rodrigues, J.J. Traffic differentiation support in vehicular delay-tolerant networks. Telecommun. Syst. **2011**, 48, 151–162.

[7]. Santa, J.; Tsukada, M.; Ernst, T.; Mehani, O.; Gomez-Skarmeta, A.F. Assessment of VANET multi-hop routing over an experimental platform. Int. J. Internet Protoc. Technol. **2009**, 4, 158–172.

[8]. Suwannasa, A.; Puangpronpitag, S.; Phongsiri, W. A novel authentication scheme for V2I communication based on WAVE unicast services. Int. J. Distrib. Sens. Netw. **2013**, 2013, doi:10.1155/2013/827084.

[9]. Du, S.; Tian, P.; Ota, K.; Zhu, H. A secure and efficient data aggregation framework in vehicular sensing networks. Int. J. Distrib. Sens. Netw. **2013**, 2013, doi:10.1155/2013/298059.

[10]. Qadri, N.; Altaf, M.; Fleury, M.; Ghanbari, M. Robust video communication over an urban VANET. Mob. Inf. Syst. **2010**, 6, 259–280.

[11].Bombardier Cityflow 650 ATC System Description