STUDY OF AUTOMATED HIGHWAY SYSTEM

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Abstract - *Automated highway system (AHS), which promises an increase in traffic capacity. The core of this protocol to achieve a fully automated highway system is four-layer hierarchical control architecture. Automated Highway System, abbreviated as AHS is newly developed idea which uses different sensors and microprocessors for automatic design process. The management and control of traffic system using roadside controllers and intelligent vehicles is innovative technique for the design of highway system. The Automated Highway System is the design concept introduced to enhance safety, efficiency and many other vehicular as well as user characteristics of highways. This concept has introduced for the improved architectural layout of highway design and also helped in reducing the environmental effects of the vehicles running on the highways*

***Key Words*: AHS Functional Evolution, Incremental Deployment, Reducing Accident Rate, Smart Highway.**

1. INTRODUCTION

The problems associated with the annual growth of automobile transport start spreading from large metropolitan cities to small towns. [1] For many years, scientists and engineers have envisioned building an automated highway system (AHS) to increase both the safety and efficiency of the nation's highways. In such a system, the vehicles become driving robots, capable of sensing and reacting to the surrounding environment while the driver is free to do other tasks. Automating the vehicle has significant potential it can reduce accidents caused by driver error and can potentially increase traffic-carrying capacity and fuel economy by eliminating human driver inefficiencies. [2]

1.1 Need and Necessity

- Improvement safety by significantly reducing fatalities, personal injuries, pain and suffering, anxiety and stress of driving.
- Improvement in accessibility and mobility for reducing delays, smooth flow of traffic, making driving more accessible to less able to drivers.
- Ensuring exchange of road and route data as well as other information between the respective transport information centers and the traffic control in different regions and different states.
- Taking measures required for automated highway systems associated with safety into vehicles and traffic infrastructure as well as ensuring the elaboration of interaction as to safety in person-machine terms.
- Development of alert systems for passengers and road users, development of traffic demand control systems in urban and rural region.
- Fuel consumption and polluting emissions might be reduced by smoothing traffic flow and running vehicles close enough to each other to benefit from aerodynamic drafting.

1.2 Objectives

- Introduce new tools for managing urban transport. Automated highway system will develop tools that can help cities to cross the thresholds that are preventing them from introducing innovative systems.
- Studies will be carried out to show that an automated transport system is not only feasible, but will also contribute to a sustainable solution for the city's mobility problems, now and in the future.
- To study the effect of Traffic volume, Capacity, Road feature, Surface properties on accident rate on highway road.
- To study the defects on highway and annual, monthly accidents rates on the selected highway road.
- To survey and document automated highway system with driver and passenger safety systems on roads.
- The reliable intelligent driver assistance systems and safety warning systems is still a long way to go.
- To study eliminate the more than ninety percent of traffic crashes that are caused by human errors such as misjudgments and in-attention.

2. Automated Highway System (AHS)

It is driverless technique which uses an automatic control system for operation of vehicles. Different techniques related with computing ideas, microelectronics, various sensors and advanced civil engineering techniques are used for design of an automated highway system. The major components of any mechanically operated vehicles i.e. throttle, steering and braking are automatically operated in automated highway system. The major requirement of any traffic facilities such as coordinated movement of vehicles, removal of obstacles, improvised traffic system and safety are easily provided by an automated highway system.

The increment in capacity of vehicles running on the road with fully controlled traffic system is basic concept used for design of automated highway system. With comparison to behavior of human drivers, the innovative concept of automated highway system has played crucial role in management of transportation network in developed cities.

2.1 Component and function of automated highway system

The component and function presents the evolution of vehicle automation capabilities in terms of lateral motion handling, longitudinal motion handling, and obstacle handling.

2.1.1 Lateral Motion Handling

The lateral (side-to-side) motion of the vehicle has a number of different functions, from vehicle-centric maneuvers such as lane keeping to those involving merging in heavy traffic. First, if the vehicle is to stay within the lane, it needs to know where the lane boundaries are lane detection is currently achieved through a number of different technologies, including a vision system, magnetic nails buried in the roadway which are then sensed by the vehicle, or a radar-reflective stripe.

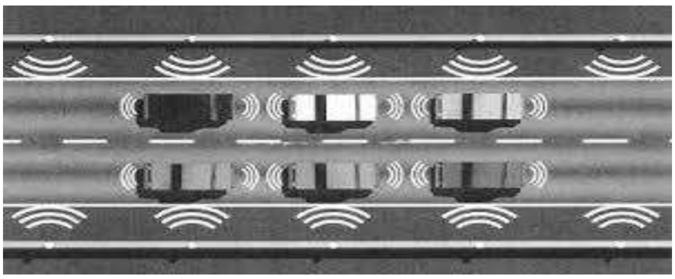

Fig -1: Sensor for lateral motion

Simple lane changing is the ability of the vehicle to move smoothly out of one lane and into another in light traffic conditions. The technical requirements for such a system include side-looking sensors that detect a gap, and the ability to cross between adjacent lanes and begin lane keeping in the new lane. Such a system could be considered "simple" if it changes lanes only in the absence of nearby vehicles, thus being assured of no risk of collision during the lane changing operation. Simple lane changing requires elementary, side looking vehicle detection

2.1.2 Longitudinal Motion Handling

The longitudinal (front-to-back) motion of the vehicle also has a variety of functions which range from simplistic in-vehicle handling to tactical driving within a congested traffic scene. Speed keeping is the most elementary function within this category, involving the maintenance of a constant travel speed. It is widely deployed in the form of "cruise control." Headway keeping, also known as adaptive cruise control is a function which adapts the speed of the vehicle to match that of a lead vehicle while maintaining a safe distance. Headway keeping is currently being deployed on a limited scale in foreign markets. Headway keeping, like all of the advanced functions in this category, depends upon reliable vehicle detection & vehicle motion detection. This is the ability to ascertain fundamental information about surrounding vehicles and their behavior. This capability will likely evolve from simple look-ahead functions to include look-behind and look-to-the-side as well. The term "look" is used loosely in this context, and refers to an ability to obtain information about surrounding areas in a particular direction. It does not mean to imply that vision-based systems must necessarily be used; indeed radar, ladder, and sonar systems may prove far more useful than vision systems, especially in reduced visibility situations such as rain and fog. Given the ability to detect vehicle and vehicle motion, longitudinal collision warning becomes possible.

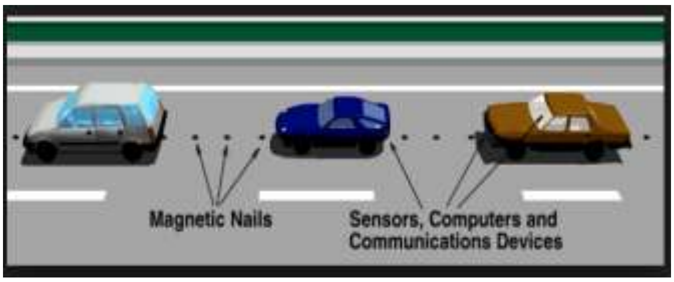

Fig -2: Sensor for longitudinal motion

2.1.3 Obstacle Handling

Obstacle avoidance capabilities reduce or eliminate safety hazards caused by obstacles on the automated highway system. This includes rocks, vegetation, dropped vehicle parts, disabled vehicles and animals. Obstacle detection and threat determination is a much more difficult task than vehicle detection due to the technical difficulties of sensing obstacles and identifying whether those obstacles present a threat. For determine the obstacle radar and sonar systems may be used. One way to reduce the need for obstacle avoidance is to implement obstacle exclusion. To a limited degree this is already deployed with fencing and highway department maintenance of the interstate highway system. Obstacle exclusion can significantly reduce the frequency of obstacles on the roadway, but it seems implausible that any exclusion method can be effective.

Fig -3: Sensor for obstacle motion

Obstacle motion detection & prediction may be a particularly difficult capability to develop. Unlike vehicles, which are physically constrained in realizable maneuvers, obstacles may not behave in readily predictable ways. Animals may run into the road and stop abruptly. Loose tires can bounce randomly, depending on road surface, tire wear, and angle of incidence. That obstacle motion prediction can be achieved; the vehicle can achieve avoidance via lane change. This becomes a unique capability that depends heavily on good prediction, not only of the motion of the obstacle, but also of how other vehicles will react to that obstacle.

2.2 ETC (Electronic Toll Collection)

The Electronic Toll Collection (ETC) System is a new toll system designed to enhance convenience for drivers by enabling cashless toll collection and thus reducing congestion at High-way tollgates.

ETC toll collection is a technology enabling the electronic collection of toll payment. It has been studied by researchers and applied in various highways, bridges, and tunnel requiring such a process. This system can determine if the car is registered or not, and then informing the authorities of toll payment violation, debits and participating accounts. The most advantage of this technology is the opportunity to eliminate congestion in toll booths, especially during festive seasons when traffic trends to be heavier than normal. Other general advantages for the motorists include fuel savings and reduced mobile emissions by reducing or eliminating deceleration, waiting time, and acceleration.

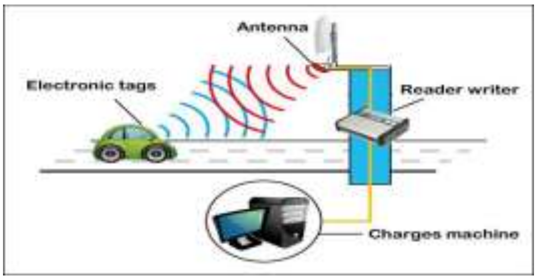

Fig -4: ETC mechanism

3.0 Methodology and Data

3.1 Information of study area Amravati to Talegaon National Highway.

The **Amravati to Talegaon** is India's national highway number 6 (NH 6 has been renumbered NH 53 after renumbering of all national highways by National Highway Authority of India in 2010 year.) high-speed, access controlled tolled highway. It spans a distance of 55.1 km connecting Amravati to Talegaon.

The highway is part of major East - West national highway NH-6 commonly referred to as NH-6 or the G.E. Road (Great Eastern Road). NH-6 is a busy National Highway that runs through Gujarat, Maharashtra, Chhattisgarh, Orissa, Jharkhand and West Bengal state in India. The highway passes through the cities of Surat, Dhule, Amravati, Nagpur, Raipur, Sambalpur & Kolkata. NH 6 runs over 1,949 km from Hazira to Kolkata forming important east-west connectivity across region.

This study section of NH-6 caters to various types of traffic such as urban, suburban and regional traffic. The development alongside the highway indicates mixed land use on both sides of the highway consisting of agricultural and barren lands, residential, commercial, small & medium scale industrial establishments such as textiles, woolen blankets, ropes, watches etc. The corridor in general has significant potential for future development along the highway and in the influence area, discussed further in this Report. Dominant land use of both side of project corridor is rural agriculture land. Since this stretch is part of Great Eastern Highway which connect two major ports of country namely Kolkata and Hazira, it carries good amount of commercial bulk transportation traffic.

Fig -5: Satellite view study area

The project highway corridor is in the state of Maharashtra and passes through Amravati district. En-route, it passes few major/minor urban centers, viz. Nandgaon Peth, Mozri, Tivsa, and Ramdara etc. along its length before reaching end of project stretch at Talegaon.

Corridor is also known as Amravati – Nagpur Highway. The highway has two carriageways each with two lanes, having a central divider, paved shoulders; side drains on both side and flyovers at major intersections.

The silent features of the study area are as given below;
Four Laning of Carriageway = 55.1 Km.
Major Bridges = 1 No.
Minor Bridges = 25 Nos.
Flyovers = 2 Nos.
Railway Over Bridge= 1 No.
Culverts = 86 Nos.
Pedestrian Under passes = 11 Nos.
Vehicular Under passes = 11 Nos.
Major intersection = 36 Nos.
Service Road = 26.50 Km.
Bus Bays = 15 Nos.
Toll Plaza Complex = 1 Nos.

3.2 Classified Traffic Volume Count

The objective of conducting a Classified Traffic Volume Count is to understand the traffic flow pattern including modal split on a roadway. The Classified Traffic Volume Count survey has been provided by concessionaire of project highway from actual traffic data gathered at toll plaza locations based on monthly data. The vehicles can broadly be classified into fast moving / motorized and slow moving / non-motorized vehicles, which can be further classified into specific categories of vehicles. The groupings of vehicles are further segregated to capture the toll able vehicle categories specifically and toll exempted vehicles are counted separately. The detailed vehicle classification system as per IRC: 64-1990 is given in Table

Table -1: Vehicle Classification System

Vehicle Type	
Auto Rickshaw	
Passenger Car	Car, Jeep, Taxi & Van (Old / new technology)
Bus	Mini Bus
	Standard Bus
Truck	Light Goods Vehicle (LCV)
	2 – Axle Truck
	3 Axle Truck (HCV)
	Multi Axle Truck (4-6 Axle)
	Oversized Vehicles (7 or more axles)
Other Vehicles	Agriculture Tractor, Tractor & Trailer

3.3 Traffic Characteristics

Toll revenue of the highway does not solely depend on traffic volume. There are certain characteristics of traffic which have significant potential to affect toll revenue. Component of local traffic, component of passenger and commercial traffic, portion of return journey traffic, portion of monthly pass traffic are some such characteristics of traffic.

Fig -5: Toll Plaza Location as TP1

3.4 Traffic Data

The highway is currently under toll operation, the data collected is corresponding to category of toll able vehicles.

Table -2: Traffic Data

Sr. no.	Type of Vehicle	Annual Average Daily Traffic For 2015-16	Annual Average Daily Traffic For 2016-17	Annual Average Daily Traffic For 2017-18
1	Car	5105	5770	5918
2	Mini Bus / LCV	1253	1333	1421
3	Truck / Bus	1238	1244	1426
4	Multi Axel	1742	1808	2031
5	Oversized Vehicles	2	1	2
	Total	9337	10156	10798

3.5 Analysis of traffic count

Understanding the character of existing traffic forms the basis of traffic forecast. The various vehicle types having different sizes and characteristics can be converted into a single unit called Passenger Car Unit (PCU). Passenger Car equivalents for various vehicles are adopted based on recommendations of Indian Road Congress prescribed in "IRC-64-1990: Guidelines for Capacity of Roads in Rural areas". The adopted passenger car unit values (PCU) are presented in following table.

Table -3: PCU Factor Adopting For Study

Vehicle type	PCUs
Car/Van	1.0
Mini Bus	1.5
Standard Bus	3.0
LCV	1.5
2-Axel Truck	3.0
3-6 Axel Truck	4.5
Multi Axel Vehicle	4.5
Auto Rickshaw	1.0
Agriculture Tractor with Trailer	4.5
Agriculture Tractor without Trailer	1.5

Table -4: Traffic in PCU

Period	Traffic No	PCU	PCU Index
For year 2015-16	9337	18543.5	1.99
For year 2016-17	10156	19642	1.93
For year 2017-18	10798	21476	1.99

It can be observed from above that project traffic has PCU index close to 2.0 which indicates good mix of commercial, goods traffic and passenger traffic.

3.6 Analysis of accident data

Road transport is essential for development as it provides mobility to people and goods. However, it also exposes people to the risk of road accidents, injuries and fatalities. Exposure to adverse traffic environment is high in India because of the unprecedented rate of motorization and growing urbanization fueled by high rate of economic growth. As a result, incidents of road accidents, traffic injuries and fatalities have remained unacceptably high in the India.
Previous year data of accidents on study highway as following

Accident Data for the Month of April-2015 to April-2018

Table -5: Accident Data Amravati to Talegaon

Sr. No.	Year	Fatal	Grievous	Minor	Total
1	Apr-2015 to Dec-2015	7	39	47	93
2	Jan-2016 to Dec-2016	20	34	52	106
3	Jan-2017 to Dec-2017	17	22	25	64
4	Jan-2018 to Apr -2018	4	11	20	35
	Total	48	106	144	298

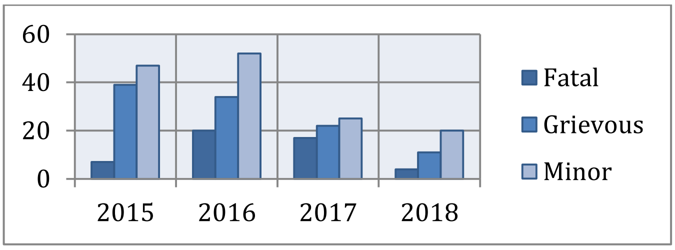

Chart -1: Accident data of April 2015- April2018

Accident Data of Dead Animals

Table -6: Accident Data of Animals Amravati to Talegaon

		Animals								
Months	Cat	Goat		Dog	Pig	Cow	Ox	Donkey	Buffalo	Total
1	Jun-15	2	1	58	0	0	0	3	1	65
2	Jan-17	1	0	17	2	1	2	0	0	23
3	Mar-18	9	1	34	4	2	1	1	0	52
4	Apr-18	12	0	32	3	0	3	2	0	52
	Total	24	2	141	9	3	6	6	1	192

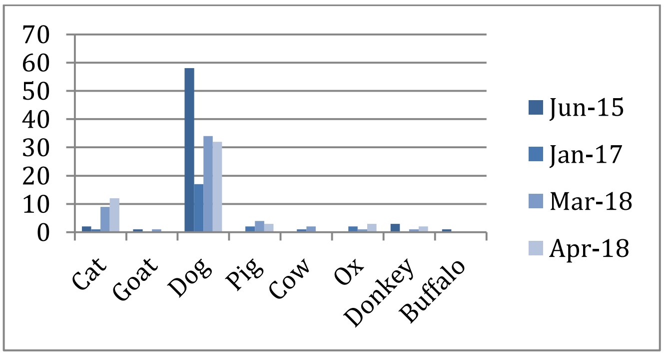

Chart -2: Accident data of Animals

3.7 Case Study of Japan Automated Highway

Japan, with a population density almost 12 times greater than the United States, has an abiding interest in developing intelligent transportation systems (ITS) to resolve its traffic congestion and other transportation problems. Indeed, the Japanese Comprehensive Automobile Traffic Control System (CACS) program.

But recently, Japanese officials have started looking at ITS from a much greater perspective. ITS is an essential element in creating a global advanced information and telecommunications society. This advanced society will realize the free generation, circulation, and sharing of information and knowledge that are the products of all human intellectually creative activities, thus leading to a new socioeconomic system that can forge a balance between living/culture, industry/business, and nature/environment. As a result, it is expected that there will be an expansion of economic frontiers, balanced national land development, and the creation of a standard of living for the people such that they can realize a truly comfortable and affluent lifestyle.

Accident rate before & After Automation in Japan in a year

Table -7: Accident Data of Japan before Automation

Sr. No.	Vehicle Type	Accident
1	Bus	545
2	Heavy / Truck	85
3	Passenger Vehicle	654
4	Two Wheeler	850
5	Car	541
6	Other	658

Table -8: Accident Data of Japan after

Sr. No.	Vehicle Type	Accident
1	Bus	246
2	Heavy / Truck	32
3	Passenger Vehicle	342
4	Two Wheeler	352
5	Car	152
6	Other	354

From the table 7 & 8 the use of ITS automation System the accident rate are nearly 50% reduces.

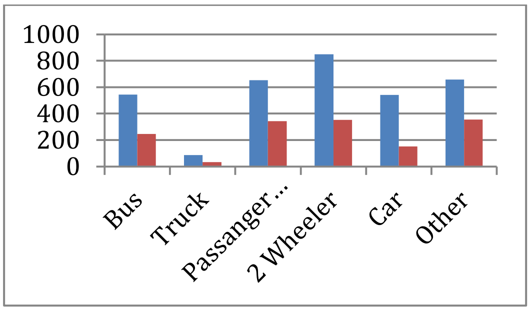

Chart -3: Before and After Automation of highway Accident

4.0 Result

4.1 Accident rate

On this basis the total accident hazard is expressed as the number of accidents of all types per km of each highway and street classification.

R=A/L

Where,
R = total accident rate per km for one year,
A = total number of accident occurring in one year,
L = length of control section in km.

Accident rate April 2015 to April 2018 including all accidents (Fatal, Grievous, Minor)

Table -9: Total Accident Rate Amravati to Talegaon

Years	Length (km)	Total No. of accident	Accident rate per km
Apr-2015 to Dec-2015	55	93	1.70
Jan-2016 to Dec-2016	55	106	1.93
Jan-2017 to Dec-2017	55	64	1.16
Jan-2018 to Apr-2018	55	35	0.64

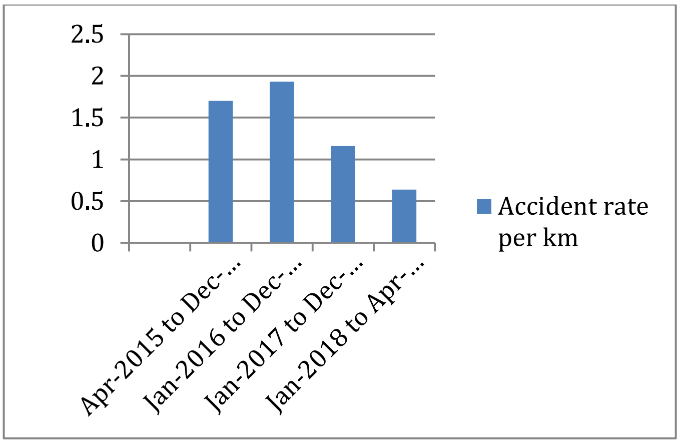

Chart -4: Total Accident Rate per km

Accident rate April 2015 to April 2018 for Fatal

Table -10: Accident Rate of Fatal Amravati to Talegaon

Years	Length (km)	No. of accident	Accident rate per km	%Accident rate per km
Apr-2015 to Dec-2015	55	7	0.13	**13%**
Jan-2016 to Dec-2016	55	20	0.36	**36%**
Jan-2017 to Dec-2017	55	17	0.31	**31%**
Jan-2018 to Apr-2018	55	4	0.07	**7%**

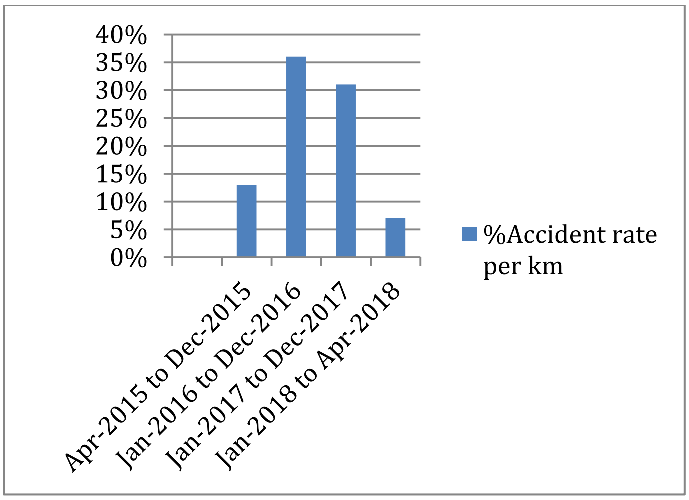

Chart -5: Percentage of accident rate of fatal

4.2 Accident rate for animal

On this basis the total accident hazard is expressed as the number of accidents of all types per km of each highway and street classification.

R=A/L

Where,

R = total accident rate per km for one year,

A = total number of accident occurring in one year,

L = length of control section in km.

Table -11: Accident Rate of Animals Amravati to Talegaon

Months	Length (km)	No. of accident	Accident rate per km
Jun-15	55	65	1.81
Jan-17	55	23	0.42
Mar-18	55	52	0.95
Apr-18	55	52	0.95

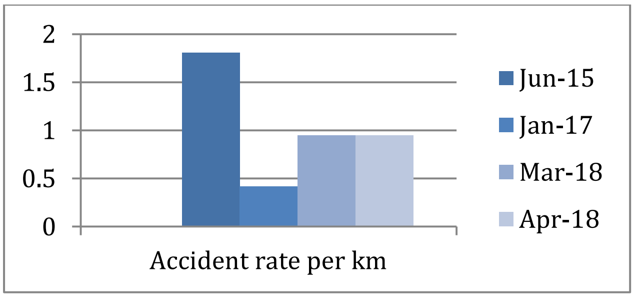

Chart -6: Accident Rate of Animals

5. CONCLUSION

In this paper, we study Traffic volume, Capacity, Road feature, Surface properties on accident rate on highway road. The defects on highway and annual, monthly accidents rates on the selected highway road. Survey and document automated highway system with driver and passenger safety systems on roads. The reliable intelligent driver assistance systems and safety warning systems is still a long way to go. We study eliminate the more than ninety percent of traffic crashes that are caused by human errors such as misjudgments and in-attention. Studies will be carried out to show that an automated transport system is not only feasible, but will also contribute to a sustainable solution for the city's mobility problems, now and in the future.

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