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DRIVERLESS PERSONAL MOBILITY – REMOTE CONTROLLING SOLUTIONS

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***ABSTRACT*:** Driverless Personal Mobility problems are mostly associated with Human Interface, Weather Conditions, Legal Framework, Security and Safety of Passengers. These problems can be addressed by a Driverless remote controlled automated personal mobility vehicle, the benefits being Safe and fearless driving environment, fatigueless travel, Higher efficiency in transportation. This paper addresses the problems by providing a centralised Controlling infrastructure like fully functional Control Rooms, usage of high speed communication networks, Real time remote manual monitoring in Control Rooms. This paper addresses certain upgradation and new infrastructure to enable seamless driverless personal mobility. Most of the above infrastructure is already used in smart cities. Law enforcement agencies and municipal corporations already have basic infrastructure. They need to be upgraded. A dedicated corridor will be provided with requisite automated control systems such as clearly demarcated laning systems, high speed communication, signalling, sensors, cameras etc. The dedicated bus Corridor for public transportation buses in Jaipur is an example. Metro Rail systems are an example for driverless systems. Driverless vehicles to be fitted with Real time Video and Audio based controllers on board to interact with remote control room on the real time traffic situation, condition of carriageway and a fully functional Control Room with Real time Video and Audio Link to every Vehicle for real time control. A survey was conducted to check the public awareness on Driverless Personal Mobility systems and related problems.

Keywords *:* Driverless Personal Mobility systems, Fully Functional Control Rooms, Security and Safety of Passengers, Major Concerns about riding / using autonomous vehicles, Driver / User / Owner general interest to own a autonomous Vehicle.

I. INTRODUCTION

Advances in Artificial Intelligence have led to applications in personal mobility solutions such as self-driving vehicles which have resulted in widespread interest and discussions in the public. This is also covered widely in media and a number of surveys have been conducted to ascertain the public perceptions for Self-Driving Vehicles. The first understanding of general public as a mention of Self-driving vehicles is a driverless car plying on city streets 24/7. One is reminded of automatic remote controlled Metro Rail System or even a Google autonomous controlled car.

Several Countries such as USA, Japan, UK, Germany, Australia, China & India are working on technologies for Self-Driving Vehicles. Companies developing and/or testing driverless cars include Audi, BMW, Ford, Google, Apple, General Motors, Volkswagen and Volvo and are a popular Topic on Media. Several Surveys etc. have been conducted to gauge perception of Governments and Public at large. Policies to support self-driving vehicles in the United Kingdom in 2013 led to a city named Milton Keynes to develop plans for self-driving vehicles in the city as a new form of public transportation for implementation by end of 2017. In Europe, an amendment was recently proposed to the United Nations Convention on Road Traffic to allow self-driving vehicles on public roads in countries governed by the treaty 2014 by United Nations.

In the U.S., California recently enacted legislation to permit testing of self-driving vehicles on public roads subsequent to permission for Autonomous Vehicles testing in 2011/Nevada, 2012/Florida and 2013/Michigan. The U.S. Department of Transportation has published an initial policy outlining strategies and recommendations for supporting the widespread introduction of self-driving vehicles on public roads across the country.

A driverless car or a *self-driving car or* an *automated car* or an *autonomous vehicle or a connected car* is an on-board computer controlled vehicle that is designed to travel from source to destination without a driver. A vehicle must be able to move from source to destination without human intervention over roads that have not been adapted for its use.

Google's test involved a fleet of self-driving cars -- six Toyota Prius and an Audi TT -- navigating over 140,000 miles of California streets and highways. A single accident occurred during one of the infrequent occasions when a human was driving. Another test of over 1000 miles was completed successfully with no human intervention.

- *Driverless Cars India scenario:*

Tata and Mahindra Groups have been working on IOT Driven Driverless cars. Tata has been working at a testing track outside Bangalore. Efforts are being made to develop an autonomous driving system by recreating the jumble of Indian roads. Some start-ups and engineering schools are also working on Autonomous Vehicles. Intel projects with the giants of the Industry actively pursuing application of technological advances will spur an over $7 trillion of spending by 2050. India which is forecasted soon to be the world's third-largest auto market, will not be left behind despite of its chaotic roads and regulations, which create unique hurdles. Indian Companies are also working on providing Autonomous Systems based on AI software backbone for global Autonomous Car manufacturers.

A Test Car, a White TATA NANO Hatchback fitted with SECONDARY AUTONOMOUS CONTROLS built by Roshy John, (a 17 year veteran of Robotics in TCS) was permitted to test drive on Bangalore Roads, it weaved its way through thin Sunday morning traffic in Bangalore at just 25 miles per hour, making frequent, jerky stops. As the car pulled up the required four meters short of the vehicle in front, irate drivers honked incessantly and yelled out abuse. A cow moving on the road into its path triggered a halt, as did the flinging of a massive banana stem out onto the road by a shop owner, the car's engine stopped abruptly.

II. WHAT IS AUTONOMOUS / DRIVERLESS PERSONAL MOBILITY? HOW DOES IT WORK?

Autonomous / Driverless cars works as follows:

- The user/passenger sets a destination (place) he/she wants to go. The car's GPS / software calculates, plans and prescribes a route depending upon traffic, distance and road conditions.
- A Radar working on Light Detection and Ranging Technology Sensor mounted on the roof of the vehicle is used for driving the car. The LIDAR sensor monitors a 60-meter range around the car and creates a dynamic 3-D map of the car's current environment.
- To detect the car's relative position to the GPS Map, a sensor on the left rear wheel is used to monitor sideways movement
- To calculate distances from the vehicle to obstacles, a Radar systems in the front and rear bumpers is used.
- An Input from GPS and video Cameras inside the car are connected to AI Software.
- The inputs given by GPS and in-vehicle Cameras are linked to a Data Base for decision making and acts like a driver controlled vehicle.
- The Controls of vehicle systems are applied through an AI simulated human perception and decision-making.
- An alternative option is provided to override function and to allow a human to take control of the vehicle whenever required.

Google's self-driving cars, which have collectively logged more than 24 Lakh Kms (4.84 Lakh Kms without an accident), are completely autonomous—no human input needed.

METHOD

A Survey was conducted in three cities covering wide vehicle and road users. A Questionnaire was developed mainly addressing the following:

- A General Opinion and User familiarity about autonomous and self-driving vehicles
- Awareness and knowledge of the current autonomous-vehicle technology.
- Understanding of benefits expected of self-driving vehicles
- User / passenger concerns in using self-driving vehicles
- External concerns in general on a macro environment in implementation of self-driving vehicles
- Driver / User / Owner general interest to own a autonomous Vehicle.
- Owner willingness to pay extra for the self-driving technology.
- Whether the users / passengers / owners are familiar about autonomous and self-driving vehicles
- Whether the users / owners / passengers are aware about autonomous-vehicle technology in the vehicle they use.
- Awareness and knowledge of benefits of self-driving vehicles
- Major Concerns about riding / using autonomous vehicles
- Major Concerns about implementation of Autonomous vehicles
- Interest to pay extra and cost of technology of self-driving-vehicle

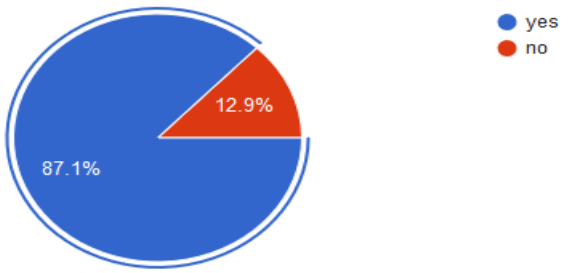
A set of same questions was asked in each city. The responses were related to each respondent's current vehicle type, including the level of autonomous technology on each respondent's vehicle, and additional demographic information was collected to include in this analysis. This survey was conducted in July 2017.
Efforts at the survey resulted in 173 respondents. 84 respondents were from Hyderabad, 62 were from Bangalore and 27 were from Mumbai.
The demographic break down of the respondents are as follows:

Demographic Aspect		PERCENTAGE		
		HYDERABAD	BANGALORE	MUMBAI
Age Group	18 to 29	76.20	75.30	77.10
	30 to 39	10.70	10.80	10.15
	40 to 49	6.00	6.80	7.17
	50 to 59	6.00	6.70	5.58
	60 to 69	1.10	0.40	0.00
	>70 old	0.00	0.00	0.00
Gender	Male	61.90	65.30	70.65
	Female	38.10	34.70	29.35
Education	Less than Graduation	40.50	47.20	40.80
	Graduate	32.10	28.60	31.80
	PostGraduate	21.40	18.65	21.10
	Professional	2.40	4.20	3.60
	Doctorates	3.60	1.35	2.70
Employment	Full Time	25.60	27.30	40.62
	Part Time	18.30	30.60	30.18
	Not Employed	5.30	4.70	1.20
	Retired	1.20	1.80	1.40
	Student Full time	45.10	30.00	14.20

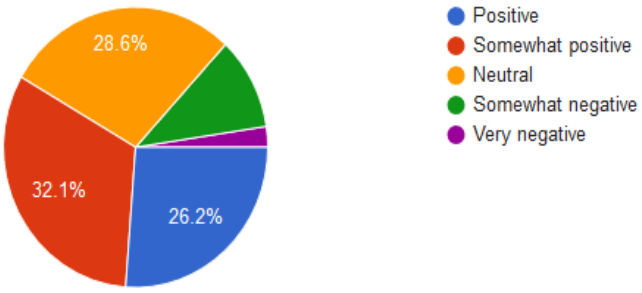
	Part Time Student	4.50	5.60	12.40
Vehicle Type Driven	Car	17.90	22.20	19.80
	Minivan	Included in SUV	Included in SUV	Includedin SUV
	Pickup Truck	1.20	0.25	0.55
	SUV	4.80	10.20	6.70
	TwoWheeler	56.00	49.50	49.75
	Do notdrive	11.90	8.75	13.10
	Others - like to pillion or passenger rides	8.20	9.10	10.10
Autonomous Vehicle Used on vehicles	Do not Have a Vehicle	35.43	43.75	38.60
	Level 0	37.00	40.10	42.35
	Level 1	9.90	10.70	11.80
	Level 2	1.20	0.75	1.35
	I do not know of a vehicle with such technology	16.47	4.70	5.90

III. RESULTS OF SURVEY CONDUCTED BY US:

- **Awareness, Knowledge and familiarity with Autonomous / Self-Driving Vehicles:**



A majority of respondents had heard and were aware of



autonomous / self-driving vehicles before this survey. 87.1% of the respondents were aware and knowledged of self-driving vehicles. Of the respondents who were aware of Self Driving Vehicles, females constituted 32% and Males constituted 55.10%. It also was observed that young aged (18-29 Years group) of male and female respondents were more familiar with Autonomous Vehicles.

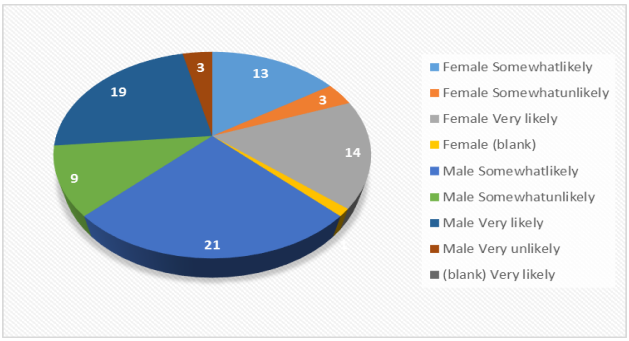
- **Opinion on Autonomous / Self-Driving Vehicles:**

It was found that 26.60% of the respondents were neutral and only about 13.10% were found to have a negative opinion of Autonomous / Self-driving vehicles.

- **Benefits of Autonomous / Self-Driving Vehicles by Respondents:**

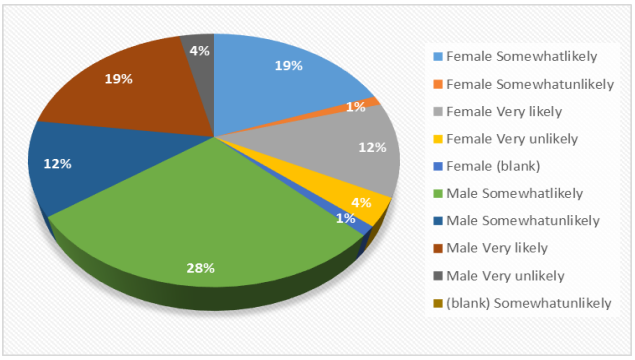
The respondents were asked "How likely do you think it is, that the following benefits will occur when using completely self-driving vehicles?" They were asked to select "very likely," "somewhat likely," "somewhat unlikely," or "very unlikely" for each item in a list of expected benefits for completely self-driving vehicles (Level 4). The table below and accompanying Pie charts give a representation of the responses received.

IV. Fewer Accidents and Crashes:



Majority of the respondents both Males and Females felt self-driving / Autonomous vehicles will lead to FEWER ACCIDENTS and Crashes.

❖ **Reduced severity of crashes:**



A Majority of respondents felt that in the eventuality of Crash / Accident, the severity would be reduced.

❖ **Improved Emergency Response to Crashes:**

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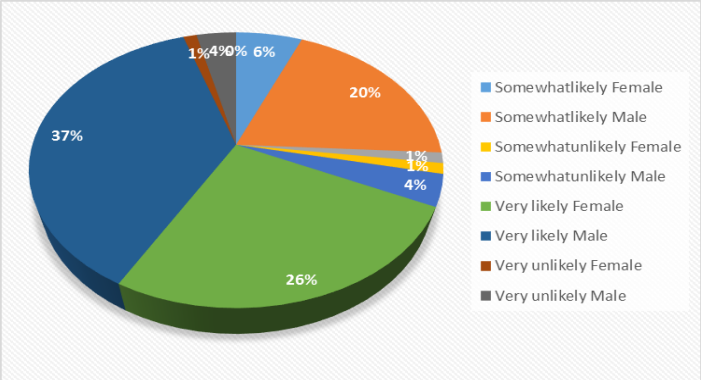
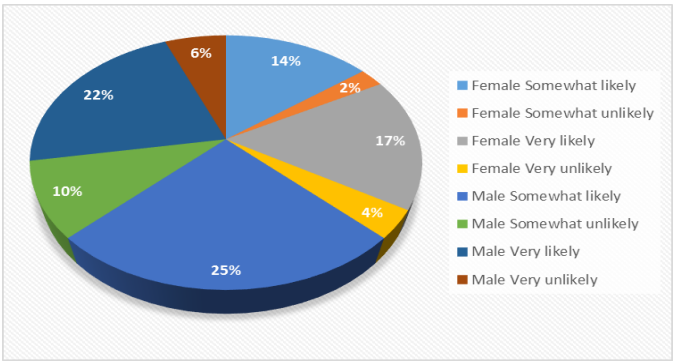


Majority of respondents felt that there will be a marked improvement in Emergency response to Crashes.

- **Responses to concerns on issued related to Self-Driving Vehicles:**

The respondents were asked a question "How concerned are you about the following issues related to completely self-Driving Vehicles (level 4). Responses were sought via Options "Very Likely", "Somewhat Likely" "Somewhat Unlikely" and "very Unlikely".

❖ Safety Consequences of failure of Equipment



Majority of the respondents were concerned about consequences of Equipment Failure on the Autonomous / Self-Driving vehicles.

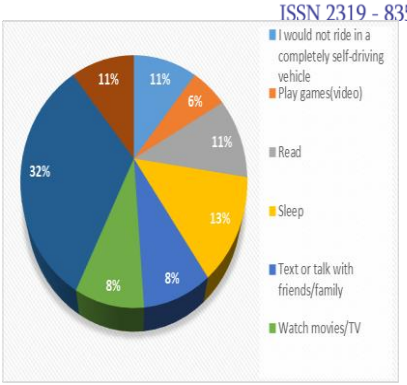
❖ **Legal Liability for Drivers / Owners**

Majority of respondents felt most likely the legal liability in case of crashes would be on that of Owners or Drivers of other vehicles that are involved in the crashes / accidents.

❖ **System Performance in Bad weather**

Some of the respondents felt that they would be concerned about the system performance in bad weather. However, most of them were somewhat unlikely to be concerned about the reliability of systems. A majority of the respondents were very unlikely to be concerned while travelling in a self-Driving Taxi. There were somewhat likely to be concerned about other passenger vehicles, trucks and buses moving on the roads.

❖ Respondents were asked a Question as to what they would do when riding in a self-Driving Vehicle:



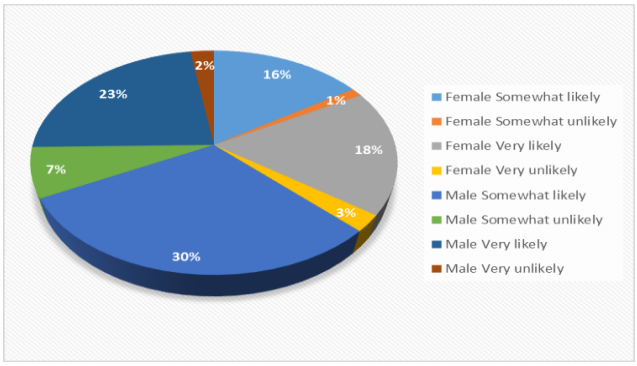
Respondents to this question preferred to do their work or read or sleep or play or talk or watch movies. However, 32% of the respondents said they would still watch the road even not in charge of driving. This exhibits a certain level of concern in a self-Driving / Autonomous Vehicles.

It was also observed that the concerns were more related to other drivers, vehicles, obstructions, and road condition etc., factors which are external to the autonomous vehicles.

Respondents were also asked if they would feel safer in a Driverless Self-Driving Vehicle. 68% of the respondents were working females were very likely to ride in such a vehicle. 22% Respondents were males who would like to drive a vehicle on their own and were very unlikely to ride in a driver less vehicle.

DISCUSSION

Given the high levels of exposures, the younger respondents (18 to 40 years) were more likely to be aware and knowledged of self-driving vehicles. They are more likely to possess a "very positive" to "Positive" view of such technology. However, the respondents were more likely to say "very concerned" to "Concerned" about legal liability, data privacy, tracking, Vehicle interaction with other vehicles, system performance in poor weather etc., the most frequent and major concern about riding in Level 4 vehicles was more about external to the vehicle in general. Few people said they were



"moderately concerned" about system security, vehicle security and interaction with pedestrians and bicyclists.

Level 3 and Level 4 self-driving vehicles

Respondents expressed high concern about riding in Autonomous Vehicle (Level 3 or Level 4) though they felt

there was a potential safety issue, the respondents preferred to take back the control of the vehicle (Level 3) compared to fully autonomous vehicle (Level 4).

Human drivers versus self-driving vehicles

A high level of respondents said they had concerns that, self-driving vehicles would not drive as well as human drivers. However, when pointed out that in a trial of 240,000 Mile drive of Autonomous vehicle, there was only 1 instance of an accident and that too due to human intervention. There was a general low level concern on the reliability of the autonomous systems. The high level of concern was expressed by unruly and undisciplined human drivers rather than the autonomous vehicle.

Opinions regarding self-driving vehicles versus connected vehicles

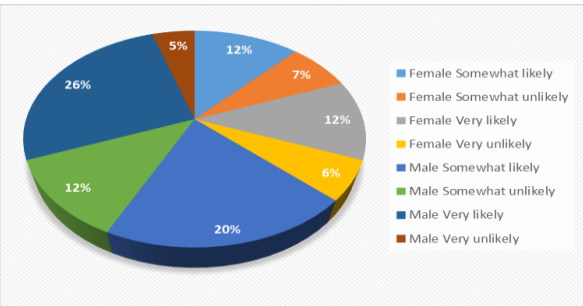
Have you ever heard of connected or self-driving vehicles: Majority of respondents had heard of the self-driving vehicle.

Expected benefits. Expected trends were found w.r.t respondent expectations. A majority felt that the expected benefits were likely to occur in level 3 and Level 4 vehicle types. Most respondents felt there would not be any benefits owing to less traffic congestion and shorter travel time with self-driving vehicles.

Concerns. While there were concerns with self-driving vehicles, more concern was about the operating environment of the vehicle rather than the vehicle itself.

Interest in owning. While there was interest in owing and using Self-Driving Vehicles, there was more Interest in owing a connected-vehicle technology. There was a high level of respondents opting for some level of monitor and control from a control center.

Willingness to pay. A Majority of the respondents were willing to pay extra for the technology on their vehicle. However those who were willing to pay were not willing to pay high to very high amounts. The respondents also cited preference for connected vehicles monitored / controlled. Majority were willing to pay extra.



V. SOLUTIONS TO THE VARIOUS ISSUES: *limited to Indian Context:*

- Over the past 3 decades it is observed that automation has opened up several employment opportunities in newer and other sectors. Computerization and automation in Banking has led to a quantum growth in Internet, IT Enabled and ITES Service Sectors. Telecom Industry which is an example of remote services and control has witnessed growth and thereby resulting in employment creation. Hence the perception of Authorities that Autonomous Vehicles will lead to unemployment is misplaced.
- Automation in Public Utilities such a Metro Rail (which are primarily DRIVERLESS PUBLIC MOBILITY SYSTEMS WITH COMPLETE AUTOMATED REMOTE MONITORING) is creating several technical and supporting jobs. An entirely new sectoral opening of advertising in Metro stations, with employment in new super markets etc is resulting in benefits of new vistas of economic development and employment generation. The same can be applied to Autonomous Self-Driving Vehicle.
- To address issues of security and safety certain measures such as SHE CABS initiatives are implemented, reliability of such services is a big question mark. A dedicated Driverless remote controlled automated personal mobility vehicle is Safe and secure SOLUTION for present day demands of round the clock working environment.
- To address the issues posed by Present day, unregulated chaotic traffic environment to self-driving vehicles, a dedicated corridor such as completely dedicated lane system for different classes of vehicles(Two Wheeler, Three Wheelers, Cars, Trucks and Public Transport buses) should be implemented to enable smooth operation of Driverless vehicles. One way Systems (in case of Land deficiency to implement wide carriageways) for enhanced efficiency in usage of infrastructure will ensure smooth implementation of driverless vehicles. Such corridors are already in place such as OUTER RING ROADS, METRO RAIL SYSTEMS, LANING IN NATIONAL HIGHWAYS ETC. Fully fenced, (No U Turn and Interchanges) Planned Speed ways are in usage which are ideal for Driverless autonomous self-driving vehicles.
- An enjoyable driving environment, fatigueless travel, higher efficiency in transportation are RESULTANTS of a dedicated road network and efficient transportation system. An example of dedicated corridors which can be emulated are:

1. The dedicated bus Corridor for public transportation buses in Jaipur is replicable model for dedicated corridor. A bus ride from Northern part of Jaipur to southern part takes about 20 Minutes, while a drive by car through the chaotic traffic takes about 90 minutes. A Drive on popular Outer Ring Road in Hyderabad saves time, fuel (even though longer in distance) and is stress free. .
2. Metro Rail systems is an example for remote controlled driverless autonomous public transport systems.

VI. TECHNICAL SOLUTIONS & SUGGESTIONS BY THE AUTHORS:

- **DRIVERLESS VEHICLES TO BE FITTED WITH REAL TIME VIDEO AND AUDIO BASED CONTROLLERS ON BOARD TO INTERACT WITH REMOTE CONTROL ROOM ON THE REAL TIME TRAFFIC SITUATION, CONDITION OF CARRIAGEWAY AND A FULLY FUNCTIONAL CONTROL ROOM WITH REAL**

TIME VIDEO AND AUDIO LINK TO EVERY VEHICLE FOR REAL TIME CONTROL.

- **A CENTRALIZED, CONNECTED CONTROL ROOM MONITORING DRIVERLESS / AUTONOMOUS VEHICLES SHOULD BE SET UP. THE CONTROL ROOM SHOULD HAVE ACCESS TO VEHICLE SYSTEMS TO MONITOR AND CONTROL THE VEHICLE REMOTELY. A REAL TIME CONNECT, CONTROL AND MONITORING WILL ENSURE TROUBLE FREE PERFORMANCE OF THE VEHICLE AND ITS RELATED INFRASTRUCTURE. THE CONTROL ROOM WILL BE STAFFED ROUND THE CLOCK AND EXTENSIVE DATA LOGGING ON EACH AND EVERY VEHICLE CAN BE MAINTAINED. A HOT LINK WITH EVERY VEHICLE CAN BE MADE THROUGH HIGH SPEED DATA CONNECTING HARDWARE. THE RANGE AND JURISDICTION OF EVERY CONTROL ROOM CAN BE FIXED LIKE IN CASE OF MOBILE TELECOM.**
- **A CERTAIN UPGRADATION AND NEW INFRASTRUCTURE TO ENABLE SEAMLESS DRIVERLESS PERSONAL MOBILITY. MOST OF THE ABOVE INFRASTRUCTURE IS ALREADY USED IN SMART CITIES. LAW ENFORCEMENT AGENCIES AND MUNICIPAL CORPORATIONS ALREADY HAVE BASIC INFRASTRUCTURE. THEY NEED TO BE UPGRADED.**
- **A DEDICATED ROAD NETWORK CORRIDOR HAVE TO BE PROVIDED WITH REQUISITE AUTOMATED CONTROL SYSTEMS SUCH AS CLEARLY DEMARCATED LANING SYSTEMS, HIGH SPEED COMMUNICATION, SIGNALLING, SENSORS, CAMERAS ETC.**

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