JICA SPECIAL ASSISTANCE FOR PROJECT IMPLEMENTATION (SAPI) FOR THE ASSISTANCE FOR THE INTRODUCTION OF ITS ON ROADNETWORK IN HYDERABAD METROPOLITAN AREA

Revised Draft ITS Master Plan for HMA

October, 2013

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
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EAST NIPPON EXPRESSWAY CO., LTD.
METROPOLITAN EXPRESSWAY CO., LTD.
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1 Background

Japan International Cooperation Agency (JICA) has been assisting for Intelligent Transportation System (ITS) implementation on Outer Ring Road (ORR) in Hyderabad, under Assistance for the Introduction of ITS Related to the Hyderabad Outer Ring Road Construction Project. Aiming at the synergy effect by applying the ITS in the city of Hyderabad, the project for preparation of ITS Master Plan for Hyderabad Metropolitan Area (HMA) has been formulated.

JICA dispatched a survey mission (JICA Mission) to Hyderabad Growth Corridor Limited (HGCL) and Hyderabad Metropolitan Development Authority (HMDA) during January – March in 2011 for the purpose of project formulation.

As a result, HGCL/HMDA and JICA Mission confirmed that both parties would sincerely cooperate with each other with a view to contributing toward the smooth introduction of ITS in HMA. A Memorandum of Understanding between HGCL and JICA was signed for preparation of Master Plan for introduction of ITS in Hyderabad Metropolitan Area and supporting for implementation of Pilot Project(s).

2 Objectives of the Study

ITS is one of the key technologies for achieving an ideal traffic society. The ultimate objectives of ITS are summarized as following:

- Safety
- Environmental / Energy
- Productivity
- Mobility
- Efficiency
- User Satisfaction

In order to achieve above objectives, a number of related issues in HMA such as road infrastructure, traffic discipline, vehicle growth, organisations, decision making processes and etc need to be addressed. To resolve these issues, both hardware measures such as road infrastructure improvement and software measures such as organisational improvement and utilisation of information technology for the road transport sector are required. The objective of the study is to assist the Andhra Pradesh government and Hyderabad city authority to formulate a master plan for ITS development and prioritizing ITS projects that could be developed in a phased manner and assist HGCL for procurement of contractors for the pilot project. The target area of the study covers the inside ORR with the prime focus on the core of the city where the traffic congestion has been significantly serious in recent years.
3 Expected Outcomes

The outputs of the study are as follows;

- Master Plan of ITS in Hyderabad
- Design for Implementation of Pilot Project(s)
- Preparation of Operation and Maintenance Specifications

(1) Master Plan Activities

- Review and Assessment of Current Condition
- Policy Framework for Introduction of ITS
- Formulation of ITS Master Plan
- Conceptual Design of ITS Projects
- Organisational Setup and Implementation Plan
- Financing Plan and Funding Scheme
- Capacity Building

(2) Pilot Project(s)

- Basic Design of Pilot Project
- Preparation of Tender Documents
- Preparation of Operation and Maintenance Specifications
4 Review and Assessment of Current Condition

4-1 Outline of Hyderabad Metropolitan Area

Hyderabad is listed as one of the 6 major cities in India. It is the capital of Andhra Pradesh state and a major city in South India located almost midway between Mumbai, Bangalore and Chennai. It has been the base of rapid development of international business (Information Technology Industry and Pharmacy Industry) in recent years. The population and number of vehicles have been rapidly growing in the Hyderabad Metropolitan Area.

The total area of HMA is nearly 7,200 sq km. The jurisdiction of HMDA contains 55 mandals and municipal towns located in five districts. It is the second largest urban development area in India after the Bangalore Metropolitan Region which is about 8,005 sq km.

The highways connecting to other cities cross in radial pattern in the centre of the city. Serious traffic congestion is commonly seen due to the increasing number of automobile vehicles that pass through the city and that travel within the city.

4-2 Socio-Economic Characteristics

(1) Hyderabad Population Growth

The population of HMA is rapidly growing. The most populated areas in HMA are Hyderabad Core Area and its surrounding Rangareddy District Area. According to the population census released by Directorate of Census Operations, the population in 2011 is reported approximately 9.4 million in HMA.

The population of HMA increased from 5.78 million in 1991 to 7.6 million in 2001 (32% increase) and to approximately 9.4 million in 2011 (23% increase).

<table>
<thead>
<tr>
<th>Year</th>
<th>Hyderabad</th>
<th>Rangareddy</th>
<th>Medak</th>
<th>Mahabubnagar</th>
<th>Nalgonda</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>31,42,214</td>
<td>17,70,965</td>
<td>5,29,117</td>
<td>89,412</td>
<td>2,51,441</td>
<td>57,83,149</td>
</tr>
<tr>
<td>2001</td>
<td>38,29,753</td>
<td>27,45,304</td>
<td>6,47,744</td>
<td>11,40,020</td>
<td>2,90,025</td>
<td>76,26,828</td>
</tr>
<tr>
<td>2011</td>
<td>39,00,238</td>
<td>43,51,939</td>
<td>7,78,624</td>
<td>1,22,250</td>
<td>3,02,650</td>
<td>94,55,701</td>
</tr>
</tbody>
</table>

(Source: Edited by JICA Study Team based on Census Data, Census of India, 2011)

(2) Climate Conditions in Hyderabad

The climate in Hyderabad is a combination of tropical and dry weather. The summer is between February and early July and the temperature is between 30 to 40 degrees during this period. The monsoon starts in the middle of July till early October. During the monsoon, the water-logged roads are observed in wide areas in Hyderabad due to old and insufficient drainage systems.

* The mandal is a lower level administrative body under a district. A mandal comprise several villages.
Figure 4-1 Climate Condition in Hyderabad: Average for 50 Years (1951-2000)

![Climate Condition in Hyderabad: Average for 50 Years (1951-2000)](image)

Source: IMD Monthly Mean Maximum & Minimum Temperature and Total Rainfall 1901-2000 Data

Figure 4-2 Water Logged Road in Monsoon Season - Near Necklace Road

![Water Logged Road in Monsoon Season - Near Necklace Road](image)

Source: JICA Study Team

(3) **Gross Domestic Product (GDP) Growth**

India is the next economic super power after China and has been one of the top nations in the world economy in the past few decades. But rapidly increasing inflation and other economic issues are the major hurdles of the countries development.

Hyderabad, the capital city of Andhra Pradesh state, is a centre of the economic growth of the state. According to the 2011 GDP statistics, Hyderabad is ranked at the 5th amongst the top 10 cities of India.
Table 4-2  Top 10 Cities of GDP in India in 2011

<table>
<thead>
<tr>
<th>Rank</th>
<th>City</th>
<th>2011 GDP (in Billion USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mumbai</td>
<td>209</td>
</tr>
<tr>
<td>2</td>
<td>Delhi</td>
<td>167</td>
</tr>
<tr>
<td>3</td>
<td>Kolkata</td>
<td>150</td>
</tr>
<tr>
<td>4</td>
<td>Bangalore</td>
<td>83</td>
</tr>
<tr>
<td>5</td>
<td>Hyderabad</td>
<td>74</td>
</tr>
<tr>
<td>6</td>
<td>Chennai</td>
<td>66</td>
</tr>
<tr>
<td>7</td>
<td>Ahmadabad</td>
<td>64</td>
</tr>
<tr>
<td>8</td>
<td>Pune</td>
<td>48</td>
</tr>
<tr>
<td>9</td>
<td>Surat</td>
<td>40</td>
</tr>
<tr>
<td>10</td>
<td>Visakhapatnam</td>
<td>26</td>
</tr>
</tbody>
</table>


4-3 Environment

(1) Ambient Air Quality

Air quality of HMA has been deteriorated for last few years. The Andhra Pradesh Pollution Control Board (APPCB) publishes the annual report on air quality and noise levels in HMA and entire Andhra Pradesh.

As per the 2012 statistics, the Respirable Suspended Particulate Matter (RSPM) and Total Suspended Particulate Matter (TSPM) are above their upper limit and Sulphur Dioxide ($SO_2$) and Nitrogen Dioxide ($NO_x$) are within their normal range as compared with the National Ambient Air Quality Standards (NAAQS). The yearly average and the NAAQ Standard of air quality measured at various locations in HMA are shown in below Figure.
Figure 4-3 Yearly Average of Air Quality Levels in Hyderabad against the NAAQ Standards

(2) Noise Levels

The annual report of the year 2012 indicates that the noise levels in HMA exceed their upper limit. The published average and peak noise levels indicate that inhabitants of the Hyderabad city are exposed to high noise levels.

- The noise levels are measured at around 73dB in the traffic and commercial areas.
- Higher noise levels of 52 and 54dB are also measured at the sensitive locations, namely Zoo Park and Kasu Brahmananda Reddy National Park (KBRN) respectively.
- The reported data is based on the monitoring carried out during the day and night time.
### Area Code | Category Area/Zone | Limits in dB (A) | Day Time | Night Time
--- | --- | --- | --- | ---
(RA) | Residential area | 55 | 45
(CA) | Commercial area | 65 | 55
(IA) | Industrial area | 75 | 70
(SA) | Sensitive area | 50 | 40

Source: Andhra Pradesh Pollution Control Board, 2012

Figure 4-4 Yearly Average Noise Levels in Hyderabad against the NAAQ Standards

(3) **Tourism**

Tourism is an important industry for Indian economy. The number of foreign tourists has been rapidly growing and it has doubled during the last decade. In 2012, the Foreign Tourist Arrivals (FTA) in India was 6.64 million with a growth rate of 5.4% from 2011. The Andhra Pradesh state is ranked at the 12th for FTA with 0.292 million visitors in 2012, which is 4.4% of total FTA in India. The number of tourists in Andhra Pradesh state increased in 2012 from 0.268 million in 2011. However it decreased in Hyderabad.

There are attractive tourist spots and historical places such as Golkonda Fort, Charminar, etc., in HMA as shown in the figure below. However essential information such as explanation of historical exhibit, guidance for tourists indicating the location of nearest parking, etc., is not sufficiently provided at these locations. There exists a potential for attracting more tourists if more appropriate information on tourism is provided to the visitors.

![Figure 4-5 Major Tourism Spots in HMA](source: Clickindia Website)
Figure 4-6  Number of Foreign Tourists to India 2001-2012

(4)  Hyderabad Metropolitan Area Jurisdiction Map

The map below shows the jurisdictional area of HMDA and GHMC.
The HMDA was constituted by the Andhra Pradesh government order in the year of 2008. The authorities such as Hyderabad Urban Development Authority, Hyderabad Airport Development Authority and Cyberabad Development Authority were dissolved and merged with the HMDA. The HMDA was formed by combining the entire suburbs with the GHMC. The jurisdiction of HMDA now consists of 55 mandals located in five districts. The five districts are, i) Hyderabad (all 16 mandals), ii) Medak (10 mandals), iii) Rangareddy (22 mandals), iv) Mahaboobnagar (2 mandals) and v) Nalgonda (5 mandals). The total area of HMDA is around 7,200 Sq.Kms.

The HMDA is responsible for planning, co-ordinating, supervising, promoting and securing the planned development of HMA. It coordinates the development activities of the municipal corporations, municipalities and other local authorities like the Hyderabad Metropolitan Water Supply, Sewerage Board (HMWS&SB), the Transmission Corporation of Andhra Pradesh Limited (APTRANSCO), the Andhra Pradesh Industrial Infrastructure Corporation (APIIC), the Andhra Pradesh State Road Transport Corporation (APSRTC), and other such bodies. The HMDA also maintains and manages the Hyderabad Management Development Fund, allocating finances based on the plans and programs of local bodies to undertake development of amenities and infrastructure facilities.

The Unified Metropolitan Transport Authority, UMTA, is a high level coordinating and decision-making body for urban transport. The National Urban Transport Policy (NUTP) encourages setting up UMTA in the cities of million-plus population in India.

It was established in Hyderabad in 2008. The metropolitan commissioner of HMDA is a member convener of UMTA.

### 4-4 Road Transport

#### (1) Overall Condition

The major National Highways (NH) and State Highways (SH) are passing through Hyderabad city. The national highways include NH-44 (old NH-7), NH-65 (old NH-9) and NH-163 (old NH-202) and the state highways are SH-1 (to Karimnagar), SH-2 (to Nagarjunasagar), SH-4 (to Vikarabad), SH-5 (to Srirajalah) and SH-6 (to Medak). While the national highways and state highways are of 4 or 6 lanes, the other roads were basically developed as double lane.

The Inner Ring Road (IRR) passes around the centre of the city and connects all the major surrounding areas. The ORR is currently under construction and will pass through the suburban area of the city.
(2) **Major Road Network**

The state road network is developed to link the national highways to the major road network of the city. The IRR connects all the major junctions of the city and accommodates the inner city traffic. The ORR is being constructed to divert the concentrated traffic of the central areas of the city, together with the purpose of further development of the surrounding region.

The HMA road network plan comprises of 5,443 KM of road network and includes NHs, SHs, HMDA roads, IRR (50 KMs), and ORR (158 KMs).

![Major Road Network in HMA](image)

Source: JICA Study Team

(3) **Road Traffic Volume**

The major road traffic surveys that were conducted in HMDA area are listed in the table below.
Table 4-3 Available Studies for Road Traffic Volume Survey

<table>
<thead>
<tr>
<th>No</th>
<th>Report name</th>
<th>Contents as Traffic Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hyderabad Area Traffic Study (HATS) I (1983-1988), HATS II (2000)</td>
<td>Comprehensive traffic study was conducted</td>
</tr>
<tr>
<td>2</td>
<td>L&amp;T Ramboll, 2003</td>
<td>Development of Hyderabad Multi Modal Suburban Commuter Transportation System on Commercial Format</td>
</tr>
<tr>
<td>3</td>
<td>GHMC, City Development Plan (CDP), 2007</td>
<td>Traffic Volume Data</td>
</tr>
<tr>
<td>4</td>
<td>Assistance for the Introduction of ITS Related to the Hyderabad ORR Construction Project, 2010</td>
<td>Traffic survey on 22 cross-sections near outer ring road planned site Origin Destination (OD) survey at road side</td>
</tr>
<tr>
<td>5</td>
<td>Comprehensive Transportation Study (CTS), 2011</td>
<td>Traffic Survey (Field Survey Report)</td>
</tr>
</tbody>
</table>

It was identified by the CTS that the largest volume of traffic, in terms of average daily traffic volume, is approximately 2,03,966 PCU at Begumpet ROB. In particular the traffic congestion is severe in the areas around the Inner Ring Road.

Table 4-4 Average Daily Traffic on Various Locations

<table>
<thead>
<tr>
<th>No</th>
<th>Location</th>
<th>Total PCUs/Day</th>
<th>No</th>
<th>Location</th>
<th>Total PCUs/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kondapur-Hitech City Rd</td>
<td>68,800</td>
<td>12</td>
<td>Fateh Nagar ROB</td>
<td>64,681</td>
</tr>
<tr>
<td>2</td>
<td>Old Mumbai Rd at Raidurgam</td>
<td>60,206</td>
<td>13</td>
<td>Sanath Nagar ROB</td>
<td>1,12,662</td>
</tr>
<tr>
<td>3</td>
<td>Attapur Bridge</td>
<td>90,285</td>
<td>14</td>
<td>Hi-tech City MMTS Stn. RUB</td>
<td>71,067</td>
</tr>
<tr>
<td>4</td>
<td>Chaderghat Bridge</td>
<td>97,548</td>
<td>15</td>
<td>Old Bombay Rd, Lingampally</td>
<td>32,402</td>
</tr>
<tr>
<td>5</td>
<td>Moosarambagh</td>
<td>63,018</td>
<td>16</td>
<td>Alugadda Bhavi</td>
<td>1,19,644</td>
</tr>
<tr>
<td>6</td>
<td>Nagole Bridge</td>
<td>95,927</td>
<td>17</td>
<td>On NH-9 near Malakpet</td>
<td>1,77,937</td>
</tr>
<tr>
<td>7</td>
<td>Rail Nilayam RUB</td>
<td>1,01,212</td>
<td>18</td>
<td>On NH44 (old NH-7) near Thondapalli</td>
<td>41,633</td>
</tr>
<tr>
<td>8</td>
<td>Rashtrapathi Rd</td>
<td>72,688</td>
<td>19</td>
<td>Vidyanagar</td>
<td>42,504</td>
</tr>
<tr>
<td>9</td>
<td>Ranigunj</td>
<td>73,367</td>
<td>20</td>
<td>Alwal</td>
<td>36,801</td>
</tr>
<tr>
<td>10</td>
<td>Ministers Rd - Necklace Rd,</td>
<td>32,644</td>
<td>21</td>
<td>On NH44 (old NH-7), Medchal Road</td>
<td>62,614</td>
</tr>
<tr>
<td>11</td>
<td>Begumpet ROB</td>
<td>2,03,966</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: CTS Report, 2011
Overall Condition of Road Transport in Hyderabad City

The road network in Hyderabad is inadequate in terms of road transport because of lack of the basic transport infrastructure. The purpose of ITS is to enhance the capacity of transport infrastructure and it becomes possible only if the basic transport infrastructure facilities are properly developed and operated.

It is evident through the site surveys that there are a number of road infrastructure related issues in Hyderabad city such as,

- Insufficient lane marking and unclear indication of lane width.
- Unclear demarcation of border between private land and public land.
- Frequent delay of land allocation/acquisition due to religious and legal issues.
- Insufficient pedestrian passes and the routes for handicapped people.

Traffic Signals

Around 175 signals in total are currently installed in the city, 126 in Hyderabad and 49 in Cyberabad regions respectively.

<table>
<thead>
<tr>
<th>Description</th>
<th>Hyderabad</th>
<th>Cyberabad</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 way</td>
<td>56</td>
<td>31</td>
<td>87</td>
</tr>
<tr>
<td>4 way</td>
<td>63</td>
<td>18</td>
<td>81</td>
</tr>
<tr>
<td>5 way</td>
<td>7</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>49</td>
<td>175</td>
</tr>
</tbody>
</table>

Source: JICA Study Team

Source: RFP for HTRIMS
The current traffic signals are standalone type and are either the timer based or manually operated by the traffic constable. The traffic signals are not adequate in number. It has been observed that most of the traffic signals are not in operation because of various reasons such as power-failure and improper maintenance. The GHMC and the Traffic Police recently initiated Hyderabad Traffic Integrated Management System (HTRIMS) project by the state fund. The purpose of the HTRIMS project is to install 221 signals with vehicle actuated controllers, including replacement of the existing signals, in the GHMC area. These traffic signals are powered by solar energy and are controlled from the Traffic Command Centre (TCC). It is planned to prepare TCC equipped with a 25 ft X 5 ft video wall at the Hyderabad Police Commissioner Office.

(6) **Accidents**

The number of fatal accidents was 1,565 in 2009 and noticeable decreases have not been observed since then.

![Accident Statistics in HMA](Figure 4-10)

Source: Hyderabad and Cyberabad Traffic Police

(7) **Driving Manner**

The driving manner is a major issue in HMA. The distinctive manners that adversely affect the traffic were observed by the field survey.

A great majority of the drivers ignore the traffic lanes even in the section where the traffic lanes exist. In particular, it is frequently observed that the vehicles are running in parallel without lane discipline.
- The vehicle drivers take right turn at the intersections where it is prohibited.
- The traffic signals are normally ignored by the drivers.
- Three or four persons ride on the two-wheelers without helmet.
- The reverse running on the road is frequently observed.

Figure 4-11 Driving Manners in Hyderabad

(8) Inadequate Facilities for Non Motorised Transport

The Non-Motorised Transport (NMT) is a mode of transport that the trips are made on foot, by bicycle or tricycle (cycle rickshaw), hand-pulled rickshaw and wheelchairs.

The NMT share is decreased to 1% from around 11% over the last decade. The reason for the decrease is longer trip lengths, risk of accidents, increase in two-wheelers, etc.

The NMT is not major transport in the Hyderabad city yet. The existing major transport studies points out the inadequate facilities for NMT in the city. The attention has been recently paid to the NMT as environmentally sustainable transport. The planning agencies are considering the introduction of bicycle tracks in Hyderabad on a pilot basis.

(9) Growth of Intermediate Public Transport

The Intermediate Public Transport (IPT) is a mode of public transport that is used to reach bus stops or train stations. It generally means auto-rickshaws, cycle-rickshaws and human-pulled rickshaws. The last mile connections of the major public transport such as city bus, metro and railways have not been adequately prepared yet in India. Therefore, such intermediate public transport is a primary means of transport for general public.
The auto-rickshaw is a dominant mode of the IPT in Hyderabad. It constitutes approximately 12% of all modes of transport and increase of 30% in number during the last decade. The basic tariff which begins from INR 14 and increases based on distance, is affordable for the people. Thus it is widely used.

However, it adversely affects the traffic and environment. The examples of the adverse affect include lack of traffic manner, blocking the traffic by the rickshaws waiting on the roads, emitting black smoke and etc.

(10) Footpaths, Foot Over Bridges and Underpasses

A noticeable aspect of road infrastructure in Hyderabad is inadequate presence of footpaths, pedestrian walkways and underpasses in the city. The footpaths are generally obstructed by trees and poles in the middle, and occupied by street vendors. Thus, the pedestrians are forced to walk on the roads and obstruct the traffic.

A limited number of the foot over bridges and under passes exist in the city. However, they are not properly located nor designed. Many of them are left without proper maintenance.

Some NGOs have been recently striving for raising public awareness of improvement of road infrastructure for pedestrian. The GHMC began taking some measures in the city.

(11) Road Traffic Composition of Vehicle

The noticeable feature of the traffic in Hyderabad is ‘heterogeneous traffic’ and the dominant mode is 2-wheeler comprising 57% in 2012. The Composition of the traffic is mainly characterised by:

- Two wheelers (motor cycle)
- Three wheelers (auto-rickshaws)
- Buses (APSRTC and private bus)
- Private cars
- Taxi and cabs
- Commercial vehicles
- Trains (MMTS and long trip train: South Central Railway)

The public transport in the city is heavily dependent on road-based modes such as buses, auto-rickshaws (3 wheelers) and taxies. The rail-based mode is not a major public transport in Hyderabad city yet.
Figure 4-12 Comparison of Vehicular Composition

The below chart indicates the total number of vehicles registered over the years in Hyderabad area.

Source: CTS Report, 2011

Figure 4-13 Total Registered Vehicles

Source: MoRTH Report, 2011

4-5 Public Transport

(1) Bus Transport - APSRTC

The Andhra Pradesh State Road Transport Corporation (APSRTC) is a state bus service operator. They mainly provide inter-city and inter-state bus services in the state. They also offer the city bus services in Hyderabad city.
They operate 22,222 buses for 7,894 bus routes in total in the state including in Hyderabad city. Out of the total number of buses, they own 18,163 buses and hire 4,509 buses.

They operate approximately 3,800 buses for 865 routes as city-bus services in Hyderabad city. The daily passengers are approximately 3.6 million. There are 25 bus depots in the city.

There is a major bus terminal in Hyderabad city, called ‘Mahatma Gandhi Bus Terminal’. It is located in the south region of the city. It functions as a primary origin and destination hub for inter-city and inter-state buses handling approximately 2,800 buses and 80,000 passengers per day.

Source: APSRTC Website

Figure 4-14 Hyderabad City APSRTC Bus Route Map
The bus schedules are shown by static sign boards at the bus stops. The dynamic information such as expected bus arrival time is not provided yet.

It is planned by APSRTC to introduce bus tracking and passenger information provision system. The project is funded by JnNURM and it comprises the following major components.

- Real Time Bus Tracking System,
- Passenger Information System with LCD/LED Display Boards at Bus Stops (To dynamically provide expected arrival time together with bus routes and operation status),
- Central Control Rooms and Data Centre, and
- Other Associated Applications.

It employs, as core technology, Global Positioning System (GPS) installed in bus and General Packet Radio Service (GPRS) for data transmission.

(2) **Local/Suburban Rail System - Multi-Modal Transport System**

The Multi-Modal Transport System (MMTS) is a suburban railway in Hyderabad. It is operated by a joint partnership of state government of Andhra Pradesh and South Central Railway (SCR). The operation in the first phase started in August in 2003. It covers 27 stations and carries approximately 1,50,000 passengers per day. There are first class, general class and special ladies compartment.

There are platform tickets, reserved tickets for first and second class and non-reserved tickets for express and ordinary trains.

The smart card is issued by the SCR. This smart card is used to purchase these tickets by vending machine at MMTS stations.

A combined ticket is also issued jointly by APSRTC and MMTS. It can be used for both bus and train.
In May 2010, Indian railways decided to implement the 107-km Phase-II project of the MMTS at the estimated cost of Rs. 641 crore. The railway board has cleared the Phase-II after the state government agreed to fund two-third cost. It would carry a 0.3 million passengers a day. The Second phase is comprised of six segments as follows:

- Lingampally-Tellapur-Patancheru (9 km)
- Secunderabad - Bollarum - Medchal (28 km)
- Falaknuma - Umdanagar - Shamshabad Airport (20 km)
- Secunderabad - Moulali - Ghatkesar (19 km)
- Moulali - Sanathnagar chord line (21 km)
- Sitaphalmandi - Moulali - Malkajigiri chord line (10 km)

(3) Mass Rapid Transit System - Hyderabad Metro Rail (HMR)

The Hyderabad metro rail is a mass rapid transit and it is now under construction for the city of Hyderabad. The Phase I of the project includes 3 corridors, of which total length is approximately 72 Km. The stations will be located roughly at every one kilometre. The trains will run every three to five minute during peak hours. The three corridors are as follows:

Corridor 1: Miyapur – L.B.Nagar (29Km)
Corridor 2: Jubliee Bus Stand - Falaknuma (15Km)
Corridor 3: Nagole – Shilparamam (28 Km)
The project cost is estimated at INR 141.32 billion. It is expected that there will be 1.5 million passengers per day in 2015. The project is executed on Design, Build, Finance, Operate, Maintain and Transfer basis in Public Private Partnership (PPP) model. The implementing agency is Hyderabad Metro Rail Limited and concessionaire is Larsen & Tourbo Metro Rail Hyderabad Limited (L&TMRHL). The concession period is 35 years and it includes 5 years of construction. The project began in July 2012 and the construction is scheduled to complete in July 2017.

The table below shows the sub-contractors by package, under the prime contractor of L&TMRHL.

Table 4-6 HMR Sub-Contractor Details

<table>
<thead>
<tr>
<th>No.</th>
<th>Package</th>
<th>Sub-Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Rolling stock</td>
<td>Hyundai Rotem, Korea</td>
</tr>
<tr>
<td>2</td>
<td>Signalling and Communication</td>
<td>Thales Canada / India (French Company)</td>
</tr>
<tr>
<td>3a</td>
<td>Track construction</td>
<td>L&amp;T Construction</td>
</tr>
<tr>
<td>3b</td>
<td>Rails</td>
<td>Tata Corus, France</td>
</tr>
<tr>
<td>3c</td>
<td>Fasteners</td>
<td>Vossloh Germany</td>
</tr>
<tr>
<td>3d</td>
<td>Turnouts</td>
<td>Voestalpane, Austria</td>
</tr>
<tr>
<td>4</td>
<td>Automatic Fare Collection System</td>
<td>Samsung Data Systems India Pvt. Ltd</td>
</tr>
</tbody>
</table>

Source: HMR Website
Transport Related Studies and Plans in Hyderabad

(1) Major Transport Related Studies

A number of the traffic and transport related studies were conducted earlier in Hyderabad for planning purposes. The major studies are:

- Traffic Studies by the REC (currently NIT) Warangal in 1983-88
- HATS – II in 2000
- DMRC Study for Metrorail in 2003
- L&T Ramboll Study for MMTS Phase- II in 2003
- Comprehensive Transportation Study (CTS), 2011
- HMDA Master Plan 2031
(2) **Comprehensive Transportation Study, 2011**

The Comprehensive Transportation Study (CTS) is being carried out by the HMDA with the approval of UMTA. It covers the HMA and is funded partly by the Ministry of Urban Development (MoUD). The LEA Group is the study consultant. The objectives of the study are:

- To assess the long-term (up to 2041), medium-term (up to 2031) and short-term (up to 2016 and 2021) transport infrastructure requirement in HMA,
- To propose institutional framework,
- To propose optimum mobilisation of required resources for the transport infrastructure development,
- To develop scenarios of transport and land use for the target year in 2041,
- To assess the above scenario and alternatives.

The long-term transportation strategies are proposed by the study as follows:

- Integrated land use transport plan and transport driven development,
- Transportation corridor - right of way protection,
- Promotion of transit oriented development,
- Implementation of Non-Motorised Transport (NMT) policy and improve road safety,
- Implementation of parking policy,
- Institutional reforms and capacity building, and
- Efforts on alternative funding sources with focussed approach on development charges.

The improvement and development of public transport for the short, medium and long terms for 2021, 2031 and 2041 are proposed as follows:

<table>
<thead>
<tr>
<th>No.</th>
<th>System</th>
<th>2021</th>
<th>2031</th>
<th>2041</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Metro network in kms</td>
<td>98</td>
<td>175</td>
<td>48</td>
<td>321</td>
</tr>
<tr>
<td>2</td>
<td>MMTS network in kms</td>
<td>147</td>
<td>116</td>
<td>165</td>
<td>428</td>
</tr>
<tr>
<td>3</td>
<td>BRTS network in kms</td>
<td>67</td>
<td>53</td>
<td>273</td>
<td>393</td>
</tr>
</tbody>
</table>

It is also proposed for the improvement and development of highway network in 16,900 km and partially/fully access controlled highway network in 790 km by 2041.

The required costs to cater for the transport network requirement in HMA for the period up to the target year in 2041 are preliminarily estimated at approximately INR 1.25 trillion.
(3) **HMDA Master Plan 2031**

The Master Plan for HMA 2031 was prepared by the HMDA. It was officially approved in January 2013 by the Municipal Administration and Urban Development Department (MA & UD), Government of Andhra Pradesh. The primary considerations were made to transit oriented development, multi nuclei concept developing alternative centres, public transport and road development for urban development of the HMA.

a) **Transit Oriented Development (TOD):**

The major developments in recent years such as Rajiv Gandhi international airport, Nehru outer ring road, radial roads, PVNR expressway which connects the centre area of the city and the airport, MMTS, metro rail, software development park (HITEC city), hardware development park, will affect people travel pattern in the city.

Several economic hubs, called ‘multiple nuclei centres’ are planned to disperse the economic activities under such situation, a transit oriented development which facilitates better connectivity in the city incorporating all above aspects is planned in the master plan.

b) **Multiple Nuclei Development:**

It is projected that the urban population in the Hyderabad metropolitan region will grow at 15 million in 2031. It is critical to properly disperse the growing economic and commercial activities in the urban area. The multiple nuclei centres/sub centres which are distributed economic/commercial hubs are planned as shown in the figure below.
c) **Proposed Road Network Improvement and Development:**

The figure below shows the major road network plan proposed by the master plan. It includes the development and improvement of radial roads, regional ring road, peripheral urban road, regional roads and etc.
d) Proposed Public Transport Development:

The figure below shows the major public transport development proposed by the master plan. It is planned that the BRTS with the dedicated lane along the national highway which passes through the locations of growing economic activities around the city will be developed. The local bus routes which cover these areas are planned as well.
4-7 Current Conditions of ITS in India and Hyderabad

4-7-1 Initiatives at National Level in India and Other Cities

(1) National Level

The Government of India has been taking various initiatives for ITS along with the high level national policies for socio-economic strategies and urban transport development. The major initiatives are as follows:

(a) 12th Five Year Plan (FY2012-FY2016)

The five year plan is the highest socio-economic strategy and it is formulated every five years. The 12th Five Year Plan gives importance on ITS in transport sector as listed below.

- Utilising real-time traffic information for traffic demand management,
- Introducing quantitative traffic data collection and utilisation to support proper decision making for traffic management and transport planning,
- Introducing congestion based road pricing and toll collections by ITS, and
- Integrating multi-modal transport assisted by ITS.
(b) National Urban Transport Policy (NUTP)

It is a national level policy for planning and development of urban transport and it has been launched since April in 2006. It spells out the principles of urban transport development in the cities. The examples include urban transport planning consolidated with urban development, urban mass transport planning which targets the next 30 years and strengthening public transport together with consideration of preparation of parking facilities and non-motorised transport.

Amongst above, the NUTP emphasises the utilisation of ITS for strengthening the public transport.

(c) Jawaharlal Nehru National Urban Renewal Mission (JnNURM) – Second Phase

The JnNURM second phase is under consideration by the MoUD. According to the news reports in June 2012, the government will launch USD 40 billion budget for the second phase of JnNURM. It is expected that the JnNURM in the second phase will more focus on the sector of road and transport development.

The high level national policies and strategies encourage the ITS in the transport sector as described above. It is expected that the implementation of ITS in the cities in India will be progressed. However further measures for ITS at national level would be required. These include formulation of national ITS master plan, preparation of national ITS architectures, establishment of inter-ministerial organisation and cross-sectoral framework collaborated by government, academia and industry for ITS promotion in India.

(2) Regional Level

ITS is a software measure to support resolving traffic issues. ITS effect can be maximised in a situation where the road and transport infrastructure are properly and adequately prepared with traffic discipline. Thus, immediate maximum effect would be still challenging in India where the road and transport infrastructure are still in progress of improvement in heterogeneous traffic.

Nevertheless, some major cities have been initiating ITS facilities. The existing ITS facilities have certain similarities and the major components are generally as follows:

- Traffic control centre monitoring by CCTV and controlling signals,
- Enforcement systems for traffic signal violation and over speed, called ‘e-challan’,
- Operation and monitoring system of BRT,
- Operation and monitoring system of Metro, and
- Operation and monitoring system of taxi generally by private companies.
The major examples of ITS in the cities are;

a) Delhi:

Delhi Integrated Multi-Modal Transit System (DIMTS) has been set up for provision of better services of public transport and expert services in the field of urban transport in Delhi.

DIMTS operates Bus Rapid Transit System (BRTS). The corridor is equipped with Closed-Circuit Television (CCTV) and signalling system. The other bus operators in Delhi such as Delhi Transport Corporation (DTC) and cluster buses are utilising the DIMTS automatic vehicle location service for providing information through passenger information system to the commuters.

b) Ahmadabad:

The Ahmadabad Janmarg Limited (AJL) has been set up to operate the BRTS. The BRTS initially started with 35 buses on the 12.5 Km dedicated corridor. It was then expanded to the 45 KM dedicated route with 112 buses. The control centre of AJL tracks the buses using GPS and GPRS for bus scheduling and information provision on LED boards at BRT bus centres.

c) Bangalore:

The traffic police in Bangalore operate the traffic control system. It is called ‘B-TRAC’ and was developed in 2006. The traffic control centre monitors the traffic by CCTV at major junctions and provides the road traffic information by variable message sign board (VMS), short message service (SMS) and websites. Other associated subsystems include the enforcement system for traffic signal jumping, black-berry based on-line ticketing and registering system for traffic violation, signal controlling and etc.

The ‘B-TRAC’ is widely known as one of the best practices of ITS in India. The upgrade of B-TRAC, constructing new centre is underway.

d) Mysore:

Mysore is the one of the major tourist destinations in India. The city bus operator (KSRTC) introduced the ITS project to be implemented at Mysore to encourage the usage of bus services. It is called Mysore Intelligent Transport System (MITRA). The major sub-systems such as vehicle tracking system, real-time passenger information system and central control station, and etc., are implemented as part of this project. The project is aimed to improve operational and managerial efficiency in the bus transport system. This ITS project is also a demonstration project under NUTP sustainable urban transport project which is initiated by Government of India with the support of the Global Environment Facility (GEF), World Bank and United Nations Development Program (UNDP).
e) Mumbai:
As a financial centre of India, the road infrastructure is relatively moderately developed in Mumbai city. The traffic police in Mumbai operate the traffic control centre and monitor the traffic by CCTV in the city. They operate other associated subsystems similar to the ones in Bangalore such as VMS, signal controlling, enforcement systems for traffic signal violation and etc. The Greater Mumbai Municipal Corporation (MCGM) operates the facility monitoring centre which monitors the above road side equipment of the traffic police. Both systems are well prepared. The traffic police and MCGM are closely coordinated.

f) Pune:
The Pune Municipal Corporation operates the control centre. They are city government and city road administrator. But interestingly, their centre monitors the traffic in the city by CCTV and BRTS operation equipped with signal control along the BRTS corridor.

As exemplified above, some initiatives have been taken for ITS in the cities. The major cities such as Delhi, Mumbai and Bangalore have prepared and operate well developed ITS facilities and control centres. However under the situation where the ITS is increasingly introduced by the individual different agencies, comprehensive and integrated planning of ITS such as regional ITS master plan is needed for the cities. The ITS planning and introduction shall also be coupled with the development of road and public transport. The agency responsible for planning, development, operation and expansion of ITS is needed to establish as well. The ITS shall be gradually expanded under such above framework.

### 4-7-2 Current Condition and Existing Plans of ITS-Related Facilities in Hyderabad

The ITS facilities have not been substantially in place yet in Hyderabad. However some related projects are underway, as listed below.

(1) **ITS Facilities on ORR**

The ITS facilities will be prepared on the entire stretch of the ORR. It includes Toll Management System (TMS) for automatic toll collection, and Highway Traffic Management System (HTMS) for monitoring traffic conditions and operation of the ITS equipment.

a) **Highway Traffic Management System:**

The components of the HTMS include 1) Traffic Control Centre, 2) Automatic Traffic Counting and Classification, 3) Closed Circuit Television, 4) Emergency Call Box, 5) Meteorological Stations, and 6) Variable Message Signboards.
The major facilities of HTMS are as follows:

- Traffic monitoring and control by the centre and road side equipment,
- Road and traffic information provision by VMS and Internet,
- Voice communication with patrol team and road users by wireless terminal, emergency call box, mobile phone and land line,
- Roadside equipment monitoring by the centre, and
- System management, database management and fault management.

b) **Toll Management System:**

A total of 157 manual and touch & go lanes and 23 ETC lanes are planned at 19 interchanges on Hyderabad ORR. The main traffic control centre is proposed at Nanakramguda interchange and sub traffic control centre as data backup centre at Ghatkesar interchange.

The TMS will comprise the following components:

- Manual and Touch & Go lane equipment,
- ETC lane equipment,
- POS system at toll plaza office for issuance and re-charge of smart card,
- Plaza server system,
- Toll management centre.

(2) **Hyderabad Traffic Integrated Management System**

The Hyderabad traffic police together with the GHMC introduced the HTRIMS for the purpose of improvement of traffic management and enforcement. The major features are as follows:

- To prepare the Traffic Command Centre (TCC) at the location of the existing headquarter of the Hyderabad police commissioner office and back-up centre at the Cyberabad police commissioner office.
- To equip the TCC with large display board called ‘video wall’, which is 25 ft X 5 ft to monitor the traffic in the city by CCTV.
- To prepare the signals at 221 Junctions (180 existing + 41 new) including 15 Secunderabad cantonment board junctions. The traffic signals are powered by solar energy.
- To equip all traffic signals with virtual loop to control the traffic flow at the junctions.
- To remotely operate the signals from the TCC / or at site based on the traffic condition.
- To monitor the health of the signal facilities from the TCC.
- To provide traffic information to the road users by VMS at 17 locations in the city.
- To prepare management information system to support decision making for traffic emergency such as heavy rain fall, accidents, terrorist attack, VIP movements etc.
The HTRIMS project is executed by Bharat Electronics Ltd., (BEL), which is a central government agency. The contractor is responsible for supply, installation, operation and maintenance of equipment. The contract period is for five years.

(3) **Bus Information System by APSRTC**

The Andhra Pradesh State Road Transport Corporation (APSRTC), a road transport corporation owns 22,222 buses in total and operates around 3,800 buses within Hyderabad as city service.
The APSRTC is planning to introduce GPS/GPRS based bus location system for the fleet of 12,000 buses in phase I and extend it to the remaining buses in the next phases. The major purpose of the proposed system is to track the location of their buses from the Central Control Room and also provide information to the passengers at the bus stop about the scheduled timing and expected arrival time of the buses.

The figure below shows the configuration of GPS/GPRS enabled system planned by APSRTC. The in-bus GPS device transmits GPS location of bus and route data to back office. In-bus and bus stop display devices receive messages from the back office through GPRS connection. The bus equipped with LED boards located at front and back side and display route information. The LED board at bus stop will display messages such as the expected arrival/departure time, bus scheduling, and etc., to the passengers.

Figure 4-22 Bus Location System as Planned APSRTC

The contractor for implementation of Vehicle Tracking and Passenger Information System (VT&PIS) in APSRTC was finalised and a letter of intent was issued to M/S CMC Ltd. As a part of the project, GPS vehicle tracking equipment will be installed in about 1,350 JnNURM and conventional metro buses operating in Greater Hyderabad area.
4-8 Identified Issues

4-8-1 Summary of the Identified Issues

Based on the review of the current conditions and existing plans, the major issues are identified as summarized below;

Table 4-8 Summary of Identified Issues

<table>
<thead>
<tr>
<th>Category</th>
<th>Identified Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Socio-Economic Characteristics</td>
<td>Rapid growth of urban population (up to 2.5 times from 1991) due to continuous migration into the city of Hyderabad. Sprawl growth of urban area.</td>
</tr>
<tr>
<td>Regional Traffic Characteristics</td>
<td>Rapid growth of vehicles, high proportion of motorcycle and auto rickshaw, heterogeneous traffic composition, heavy traffic volume inside IRR, chronic traffic congestion inside IRR and major roads. Low average travel speed, traffic mixed with low speed vehicles e.g. auto rickshaw.</td>
</tr>
<tr>
<td>Regional Transportation Characteristics</td>
<td>Insufficient connectivity between different transport mode, limited number of railway crossing, insufficient information of the public transport, improper location of bus stops, insufficient maintenance of the public transport, large proportion of road transport mode usage, insufficient ticketing system, declining quality of bus services, increasing number of fatal road traffic accidents.</td>
</tr>
<tr>
<td>Road Infrastructure</td>
<td>Insufficient road infrastructure to accommodate the traffic demand in the city, absence of hierarchical road classification, insufficient facilities including sidewalks encroachment, inadequate parking spaces, improperly designed junctions/intersections, not properly working signals etc.</td>
</tr>
<tr>
<td>Traffic Manner</td>
<td>Lack of traffic discipline including lane hogging, no helmet wearing, signal jumping, railway crossing pedestrians, wrong way driving, phone usage while driving, excessive number of people on vehicles/motorcycles, forcible overtaking. Insufficient awareness of importance of traffic discipline.</td>
</tr>
<tr>
<td>Existing Facilities</td>
<td>Not sufficient maintenance, absence of systems which support for planning/traffic and road management, absence of data base such as traffic data, road inventory, absence of cash less system, absence of travel information/traffic information, signals installed on the intersections which are not properly designed, insufficient facility for public transport information provision.</td>
</tr>
</tbody>
</table>
### Identified Issues

<table>
<thead>
<tr>
<th>Category</th>
<th>Identified Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility Management</td>
<td>Complex structure of facility management through procurement, installation, operation and management. (e.g. traffic signal procured, installed and maintained by GHMC, managed by Traffic Police and outsourced to the private company for operation by BOT) The responsibility becomes unclear and results in lack of consistency for proper operation and management.</td>
</tr>
</tbody>
</table>

| Administrative Structure  | Insufficient coordination for infrastructure planning, traffic management, road management. Different agency involvement for road and facility management including procurement, construction/implementation, operation and maintenance, complicated jurisdiction demarcation of road network, lack of human resources, lack of finance, lack of engineering experience/knowledge. |

### 4-8-2 Most Critical Issues from a View Point of ITS

In addition to the above, the most critical issues in Hyderabad from a view point of ITS are as follows;

**Table 4-9 Most Critical Issues in Hyderabad**

<table>
<thead>
<tr>
<th>Most Critical Issues in Hyderabad</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Absence of Quantitative Traffic Data</td>
</tr>
<tr>
<td>2. Absence of Centrally Coordinated Administrative Structure</td>
</tr>
<tr>
<td>3. Lack of Basic Infrastructure</td>
</tr>
<tr>
<td>4. Insufficient Proper Facility Maintenance</td>
</tr>
<tr>
<td>5. Absence of National Framework</td>
</tr>
</tbody>
</table>

The details are explained below.

**1) Absence of Quantitative Traffic Data**

The road infrastructure and traffic management need to be properly planned, implemented and evaluated for the effects. This is realised by utilizing the accumulated quantitative traffic data. However there does not exist any basic facilities which enable to collect, accumulate and evaluate the measures taken. There are no major initiatives taken place for this matter by the implementing and planning agencies either.

The traffic monitoring is solely dependent on CCTV in Hyderabad. It is planned to install more number of the CCTV. However the CCTV is to be used to visually confirm the condition at site to assist the operation. It cannot be used for quantitative measurement of the traffic.
Thus, the traffic/transportation measures such as road construction in the city, lane marking are taken on ad-hoc bases, not achieving the fundamental solution.

(2) **Absence of Centrally Coordinated Administrative Structure**

The different agencies are planning ITS related facilities in Hyderabad. However these plans are not sufficiently coordinated among the involved agencies and it results in the lack of integration and proper maintenance. The planning, implementation and evaluation of the traffic management, road/transport infrastructure and urban development need to be carried out in well coordinated manner among the related agencies. It is assumed that the absence of such coordination is one of the prime causes of the issues in Hyderabad.

(3) **Lack of Basic Infrastructure**

The prime component of ITS is data collection of the traffic condition, which is measured by the equipment. The road infrastructure and traffic discipline need to be in place to properly collect the data on traffic. The examples include i) properly designed junctions/intersections, straight-shaped road, well-prepared footpath, and etc for road infrastructure and ii) lane keeping, vehicle queues in order on the roads, following the signals and etc for traffic discipline.

(4) **Insufficient Proper Facility Maintenance**

Some preliminary facilities are in place in Hyderabad. They include CCTV at junctions, traffic signals, signal jumping violation equipment and etc. However many of them are not properly working due to insufficient proper maintenance. The reasons for this derive from the related issues including lack of human resources, finances, infrastructure, know-how, coordination among the agencies and etc. Assurance of the proper maintenance needs to be addressed for sustainable ITS operation.

(5) **Absence of National Framework**

ITS is a broad concept, which is not only limited to particular facilities such as traffic signals. It involves a wide range of different subsystems and needs to be properly integrated / harmonized to function as a whole. It is ideal to prepare the ITS in the individual cities under the framework of the National Policies. However the introduction of ITS has just started in recent years in India and thus any established National policies have yet been in place.
5 Policy Framework for Introduction of ITS

5-1 Methodology for ITS Master Plan in Hyderabad

There exist a number of different subsystems of ITS including the advanced ones that are implemented in various countries in the world. It would not be appropriate to simply apply those that are in place in different countries to Hyderabad Metropolitan Area. The particular local condition needs to be well considered for applying ITS. But, it is also true that there are many good examples which can be used as reference for consideration of ITS in Hyderabad. Thus, the following methodology, as shown in the figure below, is applied for preparation of ITS Master Plan which can be best suited for the Hyderabad Metropolitan Area.

![Methodology for Formulation of ITS Master Plan for Hyderabad](image)

Figure 5-1 Methodology for Formulation of ITS Master Plan for Hyderabad

5-2 What is ITS?

The goals of ITS are to enhance safety, improve road environment, comfort in road usage and leading to the economic growth of the region. In order to realise these, the important area to be addressed is improvement of traffic condition. In the adverse traffic congestion, the safety, environment and users’ conveniences are sacrificed and consequently economy growth is stagnant. The ITS enhances the efficiency of traffic control and road management by applying the information technology to the transport sector, leading to the ultimate objective.

The hardware measures e.g. road network development, fly over construction, road widening, etc, are important for stable economic development. But the software measures such as proper traffic control and road management are also critical as along with the hardware measures. The ITS addresses the software measures and consequently enables the proper implementation of the hardware measures.
5-3 Best Practice of ITS in the World

The best practice of ITS in the world are as described below.

(1) Traffic Control Centre

The traffic control centre collects the road and traffic related data such as CCTV image, traffic volume, travel time, weather condition on the road and etc. Such data is monitored at the traffic control centre for 24 hours and 365 days by the road and traffic operators. The traffic congestion data is automatically generated. The incidents are identified by monitoring CCTV images at the traffic control centre and also based on the information reported by the traffic police at site and other agencies.

The road and traffic operators dynamically control the city traffic and provide the traffic regulation information to the road users through VMS, Website, SMS and etc.

Figure 5-2 below shows an example of the traffic control centre in Japan and Figure 5-3 below shows a congestion map on the website provided by the road operator in Japan. The red lines in Figure 5-3 indicate the heavily congested road sections. It is automatically and periodically updated based on the results of traffic analysis. The road users can obtain the road and traffic data through such media as car navigation and internet on the computer and mobile-phone.

![Figure 5-2 Traffic Control Centre](image)

![Figure 5-3 Congestion Information](image)

(Identified congested section and level of congestion on road network)

(2) Variable Message Signboard

The Variable Message Signboard (VMS) is installed with the supporting structures on the road. There are two types of the supporting structures. They are cantilever and gantry types. The size of VMS is designed to be sufficient for the drivers to be able to recognise the displayed information on the VMS. There are different types of VMS such as character display, graphic display, black & orange colour, full colour, and etc.

The LED is usually used as a light source because of efficient energy consumption and long life cycle time. The VMS devices are controlled from the traffic control centre.
Figures shown below are the examples of VMS in Japan. Figure 5-4 is the graphic type VMS to show the real time simplified road image showing the traffic status such as road closure and congestion. Figure 5-5 is multi colour and character type VMS. This type of VMS is often used on the expressway in Japan. Figure 5-6 is a simplified road image type. It shows the traffic information such as road closure, congestion and travel time to the several major destinations ahead. This type of VMS display helps the road user know the road network, alternative routes and select the optimum routes to reach the destination. It is often used on the expressway in Japan.

![Figure 5-4 Graphic Variable Message Sign Board](image)
(Showing road disaster and road closure ahead/ and providing alternative route guidance)

![Figure 5-5 Variable Message Signboard](image)

![Figure 5-6 Variable Message Signboard](image)
(Showing congested section and level of congestion on road network)

Figures shown below are the examples of VMS in Europe.

The left picture in Figure 5-7 shows the combined type of graphic and character. The right picture in Figure 5-7 shows two types of VMS. The one is a standard single colour type. The other displays variable speed limit on each lane. The speed limit is dynamically changed according to the traffic condition.
The CCTV system is composed of CCTV camera, hi-speed communication line such as dedicated fibre optic line and TCP/IP based network, and remote monitoring and controlling system in the traffic control centre. The CCTV camera is installed on the road side at critical locations, flood prone locations and congestion points.

Figure 5-8 shows the CCTV camera attached to structure pol. The camera is covered by special case to protect it against rain. Figure 5-9 is a large screen in the traffic control centre and the real time traffic images at different locations are monitored. The road operator can monitor these pictures and recognize the road status such as congestion, vehicle accident, road weather and special events in real time to take appropriate actions according to the road condition.

Figure 5-10 and 5-11 show the examples of image processing analysis. Thin green or white lines drawn on the pictures are the results of dynamic image processing analysis. It can be seen that these thin lines are overlapped on the vehicle because the image processor recognizes the vehicle in real time.
The number plate recognition systems (NPRS) based on CCTV camera is utilised for traffic planning of OD survey.

(4) Probe Car (Floating Car)

The probe car, also known as a floating car, is a system to collect vehicle tracking information dynamically. A probe unit installed in a vehicle is composed of GPS unit, processor unit, communication unit and power supply unit. The probe unit sends the traffic data such as vehicle position, speed, direction and recorded time dynamically to the centre system. The Probe data collected at the centre from various vehicles is corrected for data discrepancies and analysed to dynamically generate travel time and travel speed on the road network. The analysed data is stored in database for future usage as the statistical and historical data by the road planning agencies for traffic and the urban development plans.

Human probe system is nowadays developed as the advanced probe system and is increasingly utilised by several agencies. The smart phones such as iPhone and android phones are used as human probe systems. The location is identified by GPS embedded in the smartphone or Wi-Fi positioning system, and travel time and travel direction are dynamically calculated. Such data is collected by communication carriers or mobile application companies like Google. The collected data is analysed in terms of traffic mode such as waking speed, vehicle travel speed on the city roads, on the expressway and travel speed on the train. The traffic data is categorised into each traffic mode. Based on such data, the traffic congestion is identified, travel time is calculated, and traffic reports are rapidly generated.

The images below shows bird-eye-views of road network by the satellite picture of the city in Japan. The light blue line means smooth traffic, yellow line slightly congested and red line highly congested. Figure 5-12 shows the damaged road after the massive earthquake in Tohoku-area in Japan in 2011. These maps are generated by utilising the probe car data.
Figure 5-12 Probe System
(Identified congested section and level of congestion)

Figure 5-13 Probe System
(Identified damaged road section after massive earthquake in Japan)

(5) **Bus Location System**

The bus location system employs the same technology as the probe car system. It uses the probe unit in the bus, and utilised it for bus tracking on the road. The central computer system collects all probe data installed in the buses and analysis the location and speed of the buses, and estimate travel time to the next bus stops. The bus location system helps the bus users know the arrival time. The below images are examples of the bus location system operated by bus agency in Japan. Figure 5-14 shows the bus locations and their travelling status on the city roads shown on the website. Figure 5-15 shows the information provided at bus stop. It helps the bus users know the expected arrival time and the bus routes to reach their destinations.

Figure 5-14 Bus Location Information Provided on Website

Figure 5-15 Bus Location Information Provided at Bus Stop

(6) **Vehicle Information and Communication System**

The Vehicle Information and Communication System (VICS) is a leading road traffic information system which is available in entire area of Japan. It provides the dynamic road and traffic information to the road users. The road and traffic data is collected by the road and traffic administrators and processed at VICS Centre. The processed information is provided to the drivers and shown in the car navigation as shown in Figure 5-16.
The information provided by VICS is shown by the car navigation unit. It includes congested section, congestion level, road closure notification and etc.

Figure 5-17 Traffic Condition Shown on Car Navigation through VICS

(7) Smart Card System

The smart card system is an integrated system that can be used across different transportation and multi-purpose usage including buses, railways, shopping etc. It is an electronic money rechargeable card and can be recharged at a shop or by internet. The auto rechargeable system linked with credit card company is also available for some smart card systems.

The figure below shows a smart card system in Japan.
Figure 5-18 Multipurpose Smart Card

(8) Electronic Road Pricing

The Electronic Road Pricing (ERP) system is an electronic toll collection for traffic demand management by way of road pricing and as a usage-based taxation scheme. The ERP system consists of ERP gantries located at all roads which connect central business area such as downtown. They are also located along the expressways and arterial roads to discourage the heavy traffic during peak hours.

Figure 5-19 Electronic Road Pricing in Singapore

The vehicle detectors and cameras are attached to the gantries. In-vehicle unit is used to identify the vehicle and the smart card is inserted for payment of the road usage charges.
Figure 5-19 above shows the ERP in Singapore. Singapore was the first city in the world to have implemented the electronic road toll collection system for the purpose of congestion pricing. The system uses open road tolling where the vehicles do not stop nor slow down to pay the tolls.

(9) Lane Control System

There are various types of the lane control system such as reversible lane, lane parking and variable speed controlled lane.

The reversible lane is a lane in which traffic may travel in either direction, depending on traffic conditions. It improves traffic flow during rush hours, by using overhead traffic lights and VMS notifies drivers as to which lanes are open or closed. The reversible lanes are also used for the tunnels, bridges and surrounding roadways. Some recent reversible lanes use a movable barrier to physically separate between allowed and not-allowed lanes of travel. In some systems, a concrete barrier shifted during low-traffic hours to switch a central lane from one side of the road to another.

The lane control system is a system that uses as parking as a part of the lane during the time of low traffic.

The variable speed controlled lane is a system that controls lane speed by showing variable speed limit according to time and traffic conditions. Figure 5-20 shows the variable speed controlled lane system in USA.

![Figure 5-20 Lane Control by Showing Variable Speed Limit According to Time and Traffic Conditions in USA]
5-4 Important Differences of ITS between Developed Country and Developing Country

In all countries, an information strategy, which is an example of the software measure, is essential for the traffic network as well as the hardware measure.

In the developed countries where the road network is almost completed, ITS is more likely to be provided as value-added services to the road users and administrators. In the developing countries as well, the ITS may be introduced as advanced tools.

However, the implication of ITS would be different in the developing countries where the hardware measures such as the preparation of road infrastructure are yet sufficient. In such a situation, the software measure is not limited to the domain of the information strategy but implies more fundamental ways by which it shall be reinforced on the ground of the hardware measure for realizing better traffic. Under such scenario, ITS is regarded as an inclusive traffic strategy which equally encompasses the hardware and software measures in the developing country. The word of ITS can be expressed as ‘Integrated Transportation System’ in this sense, whereas it is generally called ‘Intelligent Transportation System’.

5-5 Differences between National Level ITS and Regional Level ITS

The National level ITS addresses the benefits of the entire country and the regional level ITS addresses the particular local conditions. In case that the regional level ITS develops independently, the information exchange beyond the state border becomes difficult and the manufacturers are required to provide different products for each region.

In order to avoid such situation, it is necessary that the national level policies and strategy across the regions such as the standard shall be established and the regional level ITS is prepared under the framework of the national level policies. The national level ITS strategy with clear vision allows the industry to produce and supply their products which are compatible across the regions. It also realises the information exchange by the regional ITS beyond the borders.

It shall be considered that in a huge country such as India, the major transport mode is not limited to the vehicles but includes various transports such as air planes, railways and vessels. In such a situation, it is necessary that the information strategy corresponding to the multi-modal transport environment is established as early as possible, and the regions and manufacturers cooperate and make advances towards the same objectives under the national visions.
The required national level ITS policies include:
- Traffic Network Strategy Across the Nation
- Categorisation of ITS and Clarification of Division of Roles among Industry-Government-Academia
- Strategic Investment for Research for the Systems
- Implementation of Pilot Projects
- Fibre Optic Cable Network Development
- Standardisation of Digital Road Map
- Establishment of Regional and National ITS Centre
- Intercommunication Network Method

The features of the regional ITS include:
- Individual Systems Best Suited for Their Particular Needs
- Developed and Deployed In Line With Their Road Network
- Customized to Incorporate Above Under the Framework of the National ITS Strategy

5-6 Review of ITS Architectures in Major Countries

The architecture is a term used in the field of information technology. It is a framework which summarizes the policy and roles of the elements. In the field of ITS, the developed countries prepared their individual ITS Architecture.

For this study, the ITS Architectures prepared in the U.S.A, Canada, Europe, Japan and ISO were reviewed because these countries are leading in research, development and deployment of ITS technologies. The brief descriptions of the ITS Architectures in these countries are provided as follows;

(1) United States of America

The United States of America (USA) ITS architecture is the first country to have developed the national ITS Architecture. It was developed in 1996 by the US Department of Transport (US DoT).

The USA ITS architecture adopts a process-oriented methodology. It is the method which defines functions and processes to realise the user requirements, which are expressed as specific user services in the field of ITS. It is a combination of the defined functions/processes, physical subsystems which contains field equipment and vehicles, communication interfaces required for information flow amongst the subsystems.
The benefits of the process-oriented methodology are:

- **Integration**: The architecture is designed by open standard. Thus the integration of subsystems becomes easy.
- **Compatibility**: The compatibility of equipment across boundary is needed.

Some disadvantages are:

- The architecture is required to regularly maintain.
- The maintaining and revising tasks are complex processes and require large amount of budget.

(2) **Canada**

The Canadian ITS architecture incorporates all aspects of the USA national ITS architecture. The additional four services were identified which had not been included in the USA architecture e.g. safety of vulnerable road users, international border transportation management, etc. It was initiated by the guidance of the steering committee consisted by the representative from public and private transportation sectors. The Border Information Flow Architecture (BIFA) is undertaken in partnership with USA Federal Highway Administration.

(3) **Europe**

The ITS architecture prepared in the Europe is called FRAME architecture. It was prepared for building the common components across the different countries in consideration of the individual regional conditions under the framework of European Union.

(4) **Japan**

The Japanese national ITS architecture was completed in 1999. It was prepared in collaboration among the related five (5) cabinet level ministries and agencies, National Police Agency, Ministry of Trade and Industry, Ministry of Transport, Ministry of Construction and Ministry of Posts and Telecommunication. The ITS architecture is prepared in nine (9) development areas and has 21 user services with 172 sub-services.

The Japanese architecture adopts an object-oriented methodology. It is the method which develops system by building self-contained modules or objects that can be replaced, reused, and individually modified. In this method, every entity is treated and regarded as an independent individual object. The entity includes user services, subsystems, modules and communication interfaces. Each object is self completed and responsible by itself.
The ITS architecture prepared by object-oriented methodology is aimed to achieve the following objectives:

- Assuring that the architecture flexibly meets changing social needs and evolving technology
- Assuring that the architecture realises ITS which is inter-operable and inter-connectible with surrounding advanced technologies and telecommunication environment.

(5) ISO 14813-1 (ISO TC204)

The ISO 14813-1 2006 was prepared by the ISO technical committees as a reference model architecture for the ITS sector. There are varying levels of details related to definitions of different services. These details differ from nation to nation, depending on whether the specific national architecture building blocks are based directly upon services or on groups of functions. Thus, it is intended to address the groups of services and the respective domains within which they fit. The Australian national ITS architecture was prepared based on the ISO 14813.

(6) Comparison Analysis of ITS Architecture of Major Counties

The following table compares the ITS architectures in the above countries. For example, Japanese architecture is featured as object-oriented method and defines the services in detail which is comparatively easy to maintain. ISO reference model architecture is prepared as standard for reference by the regions/countries for preparation of ITS architecture. It is considered that the ISO reference model architecture is appropriate base for the master plan study.
## Table 5-1 Comparison Analysis of ITS Architecture of Major Countries

<table>
<thead>
<tr>
<th>Country</th>
<th>U.S.A</th>
<th>Canada</th>
<th>Japan</th>
<th>Europe</th>
<th>ISO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agencies Owned by or Developed</td>
<td>The United States Department of Transportation (USDOT) established national ITS architecture in 1996. Since then, the US National ITS architecture has been updated several times, with Version 6 released in 2009.</td>
<td>Under the guidance of a steering committee of public and private sector representatives from the Canadian transport industries, the development of the ITS Architecture for Canada was initiated in 1999. Transport Canada is undertaking the development of the Border Information Flow Architecture (BIFA) in partnership with U.S. Federal Highway Administration.</td>
<td>Jointly developed by five (5) government agencies as follows; • National Police Agency • Ministry of International Trade and Industry • Ministry of Transport • Ministry of Posts and Telecommunications • Ministry of Construction</td>
<td>The FRAME Architecture (originally called the European ITS Framework Architecture) was developed as a result of recommendations from the High Level Group on transport telematics, which were supported by a resolution of the Council of Ministers. It was established and first published by the EC funded project KAREN in 2000. ※Karen : Keystone Architecture Required for European Networks</td>
<td>ISO technical committees prepared ISO 14813-1 as a reference model Architecture for the ITS sector.</td>
</tr>
<tr>
<td>The No. of User Services</td>
<td>It is comprised of 33 user services and they bundled into 8 groups.</td>
<td>It is comprised of 37 user services and bundled into 9 groups.</td>
<td>It is composed 21 user services (56 specific user services) and bundled into 9 groups of development areas.</td>
<td>It is comprised of 677 user needs and bundled into 9 groups.</td>
<td>ISO 14813-1 identifies 11 service domains and 43 service groups.</td>
</tr>
<tr>
<td>Analysis Result</td>
<td>This defines the functions that must be performed to implement a given vehicle oriented user service. Therefore, services for pedestrians are not included. In contrast, Special feature of this architecture is to present specific goals for deployment services depending on either Urban, Inter-urban or Rural and time frame either 5years, 10 years and 20years.</td>
<td>This subsumes all of the U.S. National ITS Architecture work and extends and modified it to provide new services. This excluded “Traffic Management” as an independent category compare with The US’S. 4 services were specified also which are missing the US Architecture such as safety of vulnerable road users, international border transportation management, etc.</td>
<td>This Architecture is adopted the object-oriented method. This method makes it easier for future alteration and expansion. Because, there is no one-to-one correspondence between other countries and Japanese. Second advantage is each sub-services defined in detail so that particular services provided will be explicit.</td>
<td>This is defined by the user needs and functional view point. The “User Needs” of each group was described all aspects of task-wise such as objective, planning, activation and so on. JICA study team assumes the reason of so many “users need” is that any nation within E.U. enables to adopt in accordance with specific situation of each. In addition, description of functionality for vehicle control system is limited.</td>
<td>This is designed to assist the integration of services into cohesive architecture, assist interoperability and with common data definition. The definition of different services varying levels of detail. Because services and the respective domains should be useful for the nation preparing ITS architecture. Overall, this is function base like U.S.A. but it elaborates more detail and many descriptions for vulnerable users, disaster and facilities for across the border.</td>
</tr>
</tbody>
</table>
(7) Summary of ITS Architectures in the World

In view of above, the ITS Architectures in the world are summarized on the bases of the ISO reference model architecture. The most upper level user services in all architectures are summed up by the category of user service bundles defined by ISO as shown in the table below.

Table 5-2 Summary of ITS Architecture in the World

<table>
<thead>
<tr>
<th>No.</th>
<th>User Service Bundles</th>
<th>U.S.A</th>
<th>Japan</th>
<th>Europe</th>
<th>France</th>
<th>Canada</th>
<th>ISO</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Traffic Management and Operations(^{(ISO)})</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td>Traveller Information(^{(ISO)})</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td>Vehicle Systems(^{(ISO)})</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>4</td>
<td>Freight Transport(^{(ISO)})</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>5</td>
<td>Public Transport(^{(ISO)})</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>6</td>
<td>Emergency(^{(ISO)})</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>7</td>
<td>Transport-Related Electronic Payment(^{(ISO)})</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>8</td>
<td>Road Transport-Related Personal Safety(^{(ISO)})</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>9</td>
<td>Weather and Environmental Conditions Monitoring(^{(ISO)})</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Disaster Response Management and Coordination(^{(ISO)})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>National Security(^{(ISO)})</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>ITS Data Management(^{(ISO)})</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>13</td>
<td>Maintenance and Construction Management</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>14</td>
<td>Law Enforcement</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Financial Transactions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Advances in Navigation Systems</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: The ITS architecture in each country employs different categorisation. The items (No1 - No12) in the table are summarized in accordance with ISO categorisation. The items (No13 - No16) are consolidated by the similar services/functions in the referred architectures.
It can be construed that the above shown services are basically the important ones as these are commonly in place across the major countries. The ITS service menus for Hyderabad are considered based on the above listed services.

(8) Goals and Objectives of ITS

The ultimate goals of ITS are 1) Safety, 2) Environment and Energy, 3) Productivity, 4) Mobility, 5) Efficiency and 6) User Satisfaction. The objective to be achieved by ITS in line with the goals can be summarised as follows:

Table 5-3 Goals and Objectives of ITS

<table>
<thead>
<tr>
<th>No.</th>
<th>Goal</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Safety</td>
<td>• To reduce risk in transportation&lt;br&gt;• To reduce traffic accidents&lt;br&gt;• To enhance communication and response in emergency&lt;br&gt;• To reduce damage in disaster</td>
</tr>
<tr>
<td>2</td>
<td>Environment / Energy</td>
<td>• To reduce air pollution&lt;br&gt;• To reduce CO₂ emissions&lt;br&gt;• To reduce energy consumption</td>
</tr>
<tr>
<td>3</td>
<td>Productivity</td>
<td>• To increase national or regional economic output through efficient utilisation of transport facilities</td>
</tr>
<tr>
<td>4</td>
<td>Mobility</td>
<td>• To increase efficiency in reaching destination&lt;br&gt;• To reduce travel time&lt;br&gt;• To reduce travel costs&lt;br&gt;• To give care to disabled people</td>
</tr>
<tr>
<td>5</td>
<td>Efficiency</td>
<td>• To invest efficiently in traffic related infrastructure&lt;br&gt;• To increase efficiency in road use&lt;br&gt;• To reduce cost of road management&lt;br&gt;• To enhance appropriate management of ITS data</td>
</tr>
<tr>
<td>6</td>
<td>User Satisfaction</td>
<td>• To increase satisfaction with safety, environment and mobility&lt;br&gt;• To increase satisfaction with convenient life</td>
</tr>
</tbody>
</table>

(9) General Measures and Examples of Required ITS Services

The table below describes the goals, objectives, general measures to achieve the objectives and examples of required ITS services.
### Table 5-4  General Measures and Examples of Required ITS Services

<table>
<thead>
<tr>
<th>Goal</th>
<th>Objectives</th>
<th>General Measures</th>
<th>Examples of Required ITS Services</th>
</tr>
</thead>
</table>
| Safety                      | • To reduce risk in transportation  
• To reduce traffic accidents                                                                 | o Enhancing public transport  
o Promoting public transport use                                | ▪ Information provision system of operation status of public transport  
▪ Public transport assistance  
▪ Multimodal transit information system  
▪ Kiosk terminal  
▪ Electronic money                                                                 |
|                             |                                                                                                      | o Improving road infrastructure such as preparation of pedestrian facilities and separation of road use by traffic mode | ▪ Traffic signal and pedestrian signal                                                                 |
|                             |                                                                                                      | o Introducing and implementing appropriate regulation, enforcement and education  
o Improving traffic manners                                                   | ▪ Automatic enforcement system                                                                                     |
|                             |                                                                                                      | o Improving safety of motor vehicles                                               | ▪ Safety measures taken by automobile manufacturers                                                                 |
| • To enhance communication and response in emergency |                                                                                  |                                                                                   |                                                                                                                   |
| • To reduce damage in disaster |                                                                                                      | o Implementing disaster prevention measures                                        | ▪ Rainfall and road flooding observation system  
▪ Disaster detection system  
▪ Disaster information collection and provision system                                                                 |

<PygmentsTranslator:'en'>
<table>
<thead>
<tr>
<th>Goal</th>
<th>Objectives</th>
<th>General Measures</th>
<th>Examples of Required ITS Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environment / Energy</td>
<td>• To reduce air pollution</td>
<td>o Reduce vehicular emission gas together with promoting public transport use</td>
<td>▪ Remote sensing for air pollution</td>
</tr>
<tr>
<td></td>
<td>• To reduce CO₂ emissions</td>
<td>o Enhancing public transport</td>
<td>(Same as the description of safety)</td>
</tr>
<tr>
<td></td>
<td>• To reduce energy consumption</td>
<td>o Promoting electric vehicle usage</td>
<td>▪ Electric vehicle/hybrid car</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Improving fuel efficiency of vehicle</td>
<td>▪ Power charge facilities for electric vehicles</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Productivity</td>
<td>• To increase national or regional economic output through efficient usage</td>
<td>o Enhancing smooth traffic</td>
<td>▪ Traffic signals and appropriate control</td>
</tr>
<tr>
<td></td>
<td>(productivity: efficiency, productivity: economic output)</td>
<td>o Reducing congestion</td>
<td>▪ Congestion information provision by VMS and Internet</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>▪ Optimum route guidance and selection by car navigation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>▪ Congestion prediction and provision of information</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>▪ Electronic road pricing for controlling traffic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>demand and restricting vehicle passage</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Using ITS for commercial purpose</td>
<td>▪ Vehicle tracking</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>▪ Vehicle dispatch control</td>
</tr>
<tr>
<td>Mobility</td>
<td>• To increase efficiency in reaching destination</td>
<td>o Enhancing public transport</td>
<td>(Same as the description of safety)</td>
</tr>
<tr>
<td></td>
<td>• To reduce travel time</td>
<td>o Promoting public transport usage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• To reduce travel costs</td>
<td>o Enhancing convenience of public transport</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Preparing parking</td>
<td>▪ Parking location guidance system</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>▪ Parking status information system</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Enhancing smooth traffic</td>
<td>(Same as the description of productivity)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>o Reducing congestion</td>
<td></td>
</tr>
<tr>
<td>Goal</td>
<td>Objectives</td>
<td>General Measures</td>
<td>Examples of Required ITS Services</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Efficiency</td>
<td>To give care to disabled people</td>
<td>Enhancing barrier-free measures</td>
<td>ITS services for disabled people</td>
</tr>
<tr>
<td></td>
<td>To invest efficiently in traffic related infrastructure</td>
<td>Preparing appropriate urban plan, Preparing appropriate transport plan</td>
<td>Traffic census data collection and analysis, Planning of lane parking system, Planning of variable lane system, Planning of electronic toll collection, Planning if electronic road pricing</td>
</tr>
<tr>
<td></td>
<td>To increase efficiency in road use</td>
<td>Enhancing smooth traffic, Reducing congestion</td>
<td>(Same as the description of productivity)</td>
</tr>
<tr>
<td></td>
<td>To reduce cost of road management</td>
<td>Integrating road management and organisation in terms of structure, budget, and authority, Saving labour by introducing ITS</td>
<td>ITS control centre, ITS for road management e.g. CCTV, vehicle probe, vehicle detector, meteorology monitoring, disaster detection and etc.</td>
</tr>
<tr>
<td></td>
<td>To enhance appropriate management of ITS data</td>
<td>Managing road and traffic data e.g. probe data, traffic volume data, and etc.</td>
<td>ITS Data Centre (ITS control centre)</td>
</tr>
<tr>
<td>User Satisfaction</td>
<td>To increase satisfaction with safety, productivity, environment, and mobility</td>
<td>Realising all above measures and achieving the goals</td>
<td>Questionnaire survey and user interviews</td>
</tr>
<tr>
<td></td>
<td>To increase satisfaction with convenience life</td>
<td>Replacing properly public and commercial facilities and improving road environment</td>
<td>Information provision of public and commercial facilities, Questionnaire survey and user interviews</td>
</tr>
</tbody>
</table>
Consideration of ITS for Hyderabad

Review of the Issues in Hyderabad

As identified in the previous section, the critical issues in Hyderabad in terms of ITS are as follows;

<table>
<thead>
<tr>
<th>The Issues in Hyderabad</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Absence of Quantitative Traffic Data</td>
</tr>
<tr>
<td>• Absence of Centrally Coordinated Administrative Structure</td>
</tr>
<tr>
<td>• Lack of Basic Infrastructure</td>
</tr>
<tr>
<td>• Insufficient Proper Facility Management</td>
</tr>
<tr>
<td>• Absence of National Framework</td>
</tr>
</tbody>
</table>

Required Measures by ITS for Hyderabad

Under the above condition, the required measures which shall be realised by the ITS in Hyderabad are;

<table>
<thead>
<tr>
<th>Required Measures by ITS for Hyderabad</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Basic Data Collection and Proper Monitoring</td>
</tr>
<tr>
<td>2. Proper Road and Traffic Strategy Scheme</td>
</tr>
<tr>
<td>3. Proper Road Management Scheme</td>
</tr>
<tr>
<td>4. Proper Traffic Control Scheme</td>
</tr>
<tr>
<td>5. Proper Decision Making Scheme</td>
</tr>
<tr>
<td>6. ITS Promotion on Commercial Base</td>
</tr>
<tr>
<td>7. Coordination with Central Government for National Level ITS Policy</td>
</tr>
<tr>
<td>8. Establishment of Central Organisation</td>
</tr>
</tbody>
</table>

The issues are tackled by the above measures as illustrated in the Figure below.
It shall be strongly stressed that it is important to start taking steps toward preparation and development of ITS in Hyderabad, as a software measure for road and traffic management.

The measures which shall be taken are explained in detail as follows;

(1) **Basic Data Collection and Proper Monitoring**

The basic scheme which enables to collect basic traffic data and proper monitoring on traffic shall be in place. The basic traffic data includes the real time traffic conditions such as traffic volume, travel time, occupancy etc by section and on-road/road-side condition data collection.

(2) **Proper Road and Traffic Strategy Scheme**

The scheme which realises proper road and traffic strategy such as preparation of road infrastructure with lane marking, junction improvement, foot path/road crossing, traffic demand control need to be in place.

(3) **Proper Road Management Scheme**

The basic scheme which enables proper road management shall be in place. For example, the major bottle neck on the road network needs to be quantitatively identified by the traffic volume by vehicle size and the road condition damaged by the flood to be properly monitored. These data shall be utilized for road infrastructure improvement in such ways as i) proper current condition comprehension, ii) bottle neck identification, iii) new road network/existing road improvement planning, iv) construction, v) evaluation of the project.
(4)  **Proper Traffic Control Scheme**

The basic scheme which enables proper traffic control shall be in place. For example, the road traffic shall be properly controlled in accordance with the traffic condition which continuously changes. In order to realise this, dynamic real time traffic monitoring and control is required.

(5)  **Proper Decision Making Scheme**

The basic scheme which enables proper decision making in timely manner by the involved agencies shall be prepared. For example, quantitative analysis for proper decision for planning becomes realised by storing real time data, aggregating, analyzing and visualizing. The monitored data and analysed results shall be shared among the related agencies and provided to general public in timely manner. Once proper decision making environment is prepared, further required policies such as introduction of electronic road pricing for traffic demand management can be properly planned. (Short term or long term)

(6)  **ITS Promotion on Commercial Base**

Financial mechanism needs to be in place for continuous operation of ITS. The possible scheme includes incorporation of toll charge on the major road in the future, IC-Card usage such as common mobility card, selling out the value added traffic information to the private sector. The scheme which generates the revenue on the commercial base needs to be prepared.

(7)  **Coordination with National Government for National ITS Policy**

As discussed above, a National ITS policy needs to be in place so as to derive Regional and Local ITS policies. But at present, ITS is prepared at Regional levels in India. It is critical that the regional ITS is implemented under the framework of the National ITS Policy which is set out by the Government of India.

(8)  **Establishment of Central Organisation**

The entity that enables all items described above needs to be prepared. It shall play the roles for initiating the ITS development, coordinating among the involved agencies/upper level ministries, taking care of standardisation, taking charges for planning, management and promotion of ITS.

The improvement of the road and transport infrastructure such as road network expansion, fly-over construction and etc, enforcement and education for improvement of traffic discipline need to be accelerated in parallel with/in accordance with the improvement of ITS as well. In such circumstances, an independent single agency is favourable.
ITS menus for Hyderabad were identified as detailed below based on the ITS Architectures studied so far.

(1) **Criteria for Selection of ITS Menus**

In view of above, the ITS menus for Hyderabad shall be identified. The following criteria is applied for identifying the ITS menus.

<table>
<thead>
<tr>
<th>The Criteria for Selection of ITS Menus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. To introduce critical components as basic ITS infrastructure as the first priority</td>
</tr>
<tr>
<td>2. To introduce the components that are critically necessary and practical for the current conditions and issues in Hyderabad</td>
</tr>
<tr>
<td>3. To introduce the components which shall be initiated by the public sector/governmental agencies</td>
</tr>
<tr>
<td>4. To introduce ITS in phased manner suitably in line with budget and policies</td>
</tr>
<tr>
<td>5. To introduce the components which do not immediately require large scale hardware/infrastructure improvements at the beginning of implementation</td>
</tr>
<tr>
<td>6. To introduce the components which do not require immediate drastic policy changes at the beginning of implementation</td>
</tr>
</tbody>
</table>

The following components are excluded from the menus selected, due to the nature of ITS in terms of private sector industry

1. Components which will be prepared by car manufacturers
2. Components which will be prepared by private companies
3. Components which will be prepared on the commercial base in general

(2) **ITS Menus to be Introduced in Hyderabad**

The ITS menus which need to be introduced in Hyderabad are identified as shown in the Table below. They were selected by referring the practices included in the user services in the ITS Architecture in the world which is shown in the previous section and the required measures in Hyderabad based on the current conditions by applying the above selection criteria. They are mapped to the user service bundles defined in the World ITS Architecture which are shown in the Table 5-2 in the previous section.
<table>
<thead>
<tr>
<th>No.</th>
<th>User Service Bundle of World ITS Architecture</th>
<th>ITS Menus for Hyderabad</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Traffic Management and Operations (ISO)</td>
<td>Data Collection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Information Provision</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traffic Control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optimum Route Guidance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Parking Management</td>
</tr>
<tr>
<td>2</td>
<td>Public Transport (ISO)</td>
<td>Bus Operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rail Transportation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Taxi / Auto Rickshaw Operation</td>
</tr>
<tr>
<td>3</td>
<td>Emergency (ISO)</td>
<td>Emergency Alert and Response</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Emergency Optimum Route Guidance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Emergency Signal Control</td>
</tr>
<tr>
<td>4</td>
<td>Transport-Related Electronic Payment</td>
<td>Transport-Related Electronic Financial Transactions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Integration of Transport-Related Electronic Payment Services</td>
</tr>
<tr>
<td>5</td>
<td>Road Transport-Related Personal Safety (ISO)</td>
<td>Driving Support</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Signal Dedicated for Pedestrian</td>
</tr>
<tr>
<td>6</td>
<td>Weather and Environmental Conditions Monitoring (ISO)</td>
<td>Collection of Weather Information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collection of Air Pollution Information</td>
</tr>
<tr>
<td>7</td>
<td>Disaster Response Management and Coordination (ISO)</td>
<td>Disaster Alert and Response</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disaster Operation Assistance</td>
</tr>
<tr>
<td>8</td>
<td>ITS Data Management</td>
<td>Collection, Store and Aggregation of Data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traffic Data Analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traffic Accident Analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Emergency and Disaster Information Analysis</td>
</tr>
<tr>
<td>9</td>
<td>Maintenance and Construction Management</td>
<td>Road Management</td>
</tr>
<tr>
<td>10</td>
<td>Law Enforcement</td>
<td>Assistance of Police Activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automated Speed Enforcement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automated Signal Jumping Enforcement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automated Wrong way Driving Enforcement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automated Illegal Parking Enforcement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Automated Overloaded Vehicle Enforcement</td>
</tr>
</tbody>
</table>

**Note:** The ITS menus along with examples, detailed description, technologies, benefits to stakeholders and flow diagrams are provided under the Appendix –I.
The items below which are defined by the ITS Architecture in the World are excluded because i) the items (1 – 4) are the service which are prepared by the private sector in general, ii) item (5) is the service which shall be prepared at the national level.

The standardisation such as traffic data format, exchange method needs to be prepared for the ITS services prepared by the private sector to be applicable across entire India. The standardisation shall be initiated by the Indian government at national level. The services related to the national security needs to be initiated and implemented at the national level.

Table 5-9 ITS Menus Excluded from Above

<table>
<thead>
<tr>
<th>No.</th>
<th>User Service Bundle of World ITS Architecture</th>
<th>Sub-System in Hyderabad</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Traveller InformationISO</td>
<td>To be Implemented by Private Sector</td>
</tr>
<tr>
<td>2</td>
<td>Vehicle SystemsISO</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Freight TransportISO</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Advances in Navigation Systems</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>National SecurityISO</td>
<td>National Level Implementation</td>
</tr>
</tbody>
</table>

5-9 Road Map for ITS in Hyderabad

5-9-1 Phased-Wise Implementation Policy

In consideration of the current condition in Hyderabad and required measures, the ITS shall be prepared in phased-wise manner. The first priority shall be the preparation of the basic ITS component and more advanced menus are gradually expanded. The road infrastructure needs to be improved along with expansion of ITS. The advanced ITS components are gradually introduced in accordance with the road infrastructure improvement and maturity of ITS industry.

On the basis of this approach, the following phased-wise expansion policies are set out;

Table 5-10 Phased-Wise Implementation Policy

<table>
<thead>
<tr>
<th>Phases</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase-1 (1-5 years)</td>
<td>Establishment of ITS Centre (ITSC)</td>
</tr>
<tr>
<td></td>
<td>Preparation of Basic ITS Component</td>
</tr>
<tr>
<td>Phase-2 (6-10 years)</td>
<td>Expansion of Basic ITS Component</td>
</tr>
<tr>
<td></td>
<td>Introduction of Advanced ITS Component</td>
</tr>
<tr>
<td>Phase-3 (After 10 years)</td>
<td>Expansion of More Advanced ITS Component</td>
</tr>
</tbody>
</table>
Notes:

i. **Number of Years Set Out:** The information technology advancement is very rapid in nature. Hence, it is appropriate to set out for 5 years for Phase-1 and 10 years for Phase-2. The systems to be introduced in the phase-3 will have to be re-considered because the surrounding environment will become significantly different such as emergence of new technology in future, due to the same reason of the rapid technological advancement.

ii. **System Review:** During the following phases after the phase-1, the systems prepared in the previous phases will be reviewed / evaluated and the systems to be further upgraded or newly introduced will be identified.

iii. **Equipment Replacement:** It shall be noted that the equipment needs to be replaced at certain intervals as indicated below;

<table>
<thead>
<tr>
<th>Items</th>
<th>Replacement Term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Processing Unit</td>
<td>5 years</td>
</tr>
<tr>
<td>Road Side Equipment</td>
<td>10 – 15 years</td>
</tr>
<tr>
<td>Communication</td>
<td>10 – 15 years</td>
</tr>
<tr>
<td>Electric Equipment</td>
<td>20 years</td>
</tr>
<tr>
<td>Civil Work</td>
<td>30 years</td>
</tr>
</tbody>
</table>

5-9-2 **Establishment of ITS Centre (ITSC)**

The ITS is indispensable social infrastructure which shall be prepared together with the road infrastructure development. In the absence of a central single agency, it is obvious that the different planning without proper and sufficient coordination will be independently carried out by the individual agencies such as GHMC, Traffic Police, APSRTC, HMDA etc. The integrated ITS development, traffic control and road management will become difficult in such condition, and more importantly, it will result in huge loss of human-power, cost and time.

It is also necessary for ITS planning to have consistency with the national ITS framework in India and to coordinate with the central governments and regional public agencies in neighbouring regions. The traffic information generated by the ITS will be provided to the private sectors with/without charge. The coordination and collaboration with the private sectors will become necessary as well, in this view point. Moreover, the engine for continuous promotion of ITS in Hyderabad is strongly required under the condition where the ITS implementation has not fledged at full scale yet in India.

So full benefits of ITS implementations at the city level will only be realised by establishing a framework and organisational structure. It must be possessed with the governmental authority to coordinate with various stakeholders and take appropriate policy decisions.
The ITSC must be established within the framework of the above mentioned organisation. The ITSC must be responsible for the planning, procuring, installing, operating and maintaining the ITS equipment in the city.

The image of ITSC to be established in phase-1 is shown in Figure 5-4.

The purpose and the functions which shall be equipped with are as follows:

(1) **Purpose of ITSC**

The purpose of ITSC is as follows.

- It plays as a central engine for continuous ITS initiative to expand in Hyderabad,
- It assures the coordination with the National ITS Policy for ITS expansion in Hyderabad,
- It carries out the business with the private sector by selling out the generated traffic information for assuring the revenue for the operation of ITSC,
- It functions as a central single agency responsible for planning, implementing, evaluating the ITS systems and development/expansion, and
- It collects all the road/traffic data and provides to the users and relevant agencies.

(2) **Functions of ITSC**

The following functions shall be handled by ITSC.

- Collection of traffic data from the road-side/probe based sensors and human based information through the related agencies (like probe data of APSRTC etc.,),
- Traffic information provision to the public through internet, SMS, call centre,
- Traffic information provision for traffic flow control through VMS on road-side,
- Automatic traffic signal control and related facilities for traffic flow control,
- Analysis of real-time dynamic data and off-line based accumulated data for identifying bottle neck of traffic, before and after evaluation of the project,
- Planning and evaluation of traffic management and road infrastructure,
- Owning the right of traffic data generated by ITSC,
- Sales of the generated traffic information to private sector,
- Management of standardisation of ITS technologies and related data such as digital road map,
- Management of road inventory,
- Management of ITS equipment, and
- Operation and management of clearing house of common mobility card.
Figure 5-22 ITSC to be Established in Phase-1
(3) Important Issues in Establishment of ITSC

The following issues need to be taken into consideration in establishing the ITSC.

(a) Establishment Scheme

The mostly recommended scheme is that the ITSC is established as Special Purpose Vehicle (SPV) invested by the related agencies such as HMDA, GHMC, Traffic Police and etc in consideration of its functions. However the financial reliability needs to be assured to form the SPV and it may take some time until the revenue becomes stabilised after commencement of operation. Hence, it would be practical that the ITSC will start as one of the department of HMDA in cooperation with GHMC and Traffic Police in the initial period. Then it will be shifted into the SPV as the revenues become assured after certain period.

(b) Authority for Traffic Control Vested with ITSC

Currently the Hyderabad traffic police are responsible for the Traffic management in the Hyderabad city. The HTRIMS project is carried out by the Hyderabad traffic police for the purpose of managing the city traffic from their TCC. But it is proposed the ITSC shall function as a central body for traffic management in the Hyderabad as a long term measure. The one of the major important roles is controlling the traffic such as controlling the traffic signals, diverting the traffic by providing the traffic information through VMS or SMS, implementing ERP in the future. Hence, the authority for traffic control shall be vested with the ITSC.

(c) Property Right of Traffic Data/Information

Various kinds of traffic related data will be collected through a number of different equipment such as traffic counter, flood monitoring sensors, bus probe systems and etc. Then the collected data will be processed and the traffic information will be generated at the ITSC. Such generated traffic information will have added value and can be used as a major source of revenue generation for the operation of the Centre by selling out to the interested parties including the public and private sectors. In order to assure this, the property right of the collected data and generated information shall be assured to the ITSC.

The detail diagram and the image of ITSC in the phase-1 are shown in the following figures respectively.
ITS Master Plan for HMA
Hyderabad ITS
JICA SAPI Team

Dynamic Measuring of Information
1) Probe unit on vehicles
2) Traffic counter on roads
3) Water depth gauge on roads
4) Meteorology sensor on roads
5) CCTV Camera on roads
6) Human–base information by telephone, fax, SMS and E-Mail
7) Signal Status (HTRIMS) / Optional
8) Road Inventory
   (Detail road map & road movie)
9) Digital road map

Dynamic Processing
(Congestion, Travel Time & Traffic Volume)
Dynamic Monitoring
(Shared Traffic Status by Large Display & Console)

Utilize The Data
(Record, Aggregate and Analyze)

Dynamic Provision of Traffic Information to Road User
(VMS, Web, SMS, E-Mail & Call Center)
Dynamic Control of Traffic Flow
(by VMS & Signal)
(Signal: Local Optimum -> Area Optimum)

Road Planning
(1) Improve Intersection,
(2) Widen & Expand roads,
(3) Improve Facilities for Pedestrian, etc.

Evaluate the Data
(Record, Aggregate and Analyze)

Improve and Construction of Road & Intersection, etc.

Utilize Traffic Data for Multi-Purpose such as Traffic Congestion Provision by Internet Provider, Marketing Research, BOT Investor, etc.

Others: Manage and Evaluate ITS Plan, Make Standard of Traffic Information and DRM.

Figure 5-23 Detail Diagram of Functions of ITSC
### (d) Stakeholder Responsibilities in terms of ITSC

#### Table 5-12: Role of Stakeholders to ITSC

<table>
<thead>
<tr>
<th>Major Stakeholder</th>
<th>Major Role in regard of ITSC</th>
<th>Required Data from Stakeholder to ITSC</th>
<th>Information Provision by ITSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Police (Hyderabad &amp; Cyberabad)</td>
<td>• City traffic management such as - Regulation - Enforcement - Education</td>
<td>• CCTV data</td>
<td>• Generated traffic information including congestion data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Traffic volume data collected from vehicle actuated cameras</td>
<td>• Road closure information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Traffic violation data</td>
<td>• Major accidents information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Road accidents data</td>
<td>• Event and Incident information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Traffic restrictions data</td>
<td>• Traffic Enforcement Management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Road closure data in events</td>
<td>• Traffic Monitoring and Control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Other public information</td>
<td></td>
</tr>
<tr>
<td>Hyderabad Metropolitan Development Authority (HMDA)</td>
<td>• Planning agency for HMA</td>
<td>• Data on proposed road planning</td>
<td>• Generated reports on road usage, traffic volume and road congestion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Data on urban development</td>
<td>• Analyzed road congestion and peak traffic information</td>
</tr>
<tr>
<td>Greater Hyderabad Municipal Corporation (GHMC)</td>
<td>• City road management</td>
<td>• Road closure data</td>
<td>• Historical traffic volume in a road section</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• New road construction</td>
<td>• Reports on road development requirements (possible new roads, repair works, etc..)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Regulation data such as no-horn zones, etc.,</td>
<td>• Parking guidance information provision</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Parking data</td>
<td>• Asset data management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Asset data (Flyovers, FOBs etc.)</td>
<td></td>
</tr>
<tr>
<td>Road and Buildings (R&amp;B)</td>
<td>• Management of state roads in the city</td>
<td>• Road closure data</td>
<td>• Historical traffic volume in a road section</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• New road construction</td>
<td>• Reports on road development requirements (possible new roads, repair works, etc..)</td>
</tr>
</tbody>
</table>
## ITS Master Plan for HMA

<table>
<thead>
<tr>
<th>Major Stakeholder</th>
<th>Major Role in regard of ITSC</th>
<th>Required Data from Stakeholder to ITSC</th>
<th>Information Provision by ITSC</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;B - NHAIDepartment</td>
<td>• Management of national highways in the city</td>
<td>• Road closure data • New road construction</td>
<td>• Historical traffic volume of road sections • Provide reports on requirements of road facilities</td>
</tr>
<tr>
<td>Andhra Pradesh Road Transportation Corporation (APSRTC)</td>
<td>• Public city bus operations</td>
<td>• Bus probe data • Bus schedule information (electronic time table) • Bus fare payment mode (smart card, common mobility card, etc..) • Park &amp; ride details • Public information on bus operations</td>
<td>• Providing traffic and congestion information • Provide optimum route guidance information • Information on other transport modes • Provide data on routes which require more public transport facilities</td>
</tr>
<tr>
<td>Hyderabad Metro Rail (HMR)</td>
<td>• Elevated rapid rail transit operations in the city</td>
<td>• Metro rail schedule data (electronic time table) • Metro rail fare payment mode details (smart card, common mobility card, etc..) • Park &amp; ride details • Public information on rail operations</td>
<td>• Travel options information • Optimum route guidance information • Information on other transport modes • Public transport demand reports</td>
</tr>
<tr>
<td>Multi-Modal Transportation System (MMTS)</td>
<td>• Suburban rail system operations in the city</td>
<td>• MMTS rail schedule data (electronic time table) • MMTS rail fare payment mode details (smart card, common mobility card, etc..) • Park &amp; ride details • Public information on MMTS rail operations</td>
<td>• Travel options information • Optimum route guidance information • Information on other transport modes • Public transport demand reports</td>
</tr>
</tbody>
</table>
### ITS Master Plan for HMA

<table>
<thead>
<tr>
<th>Major Stakeholder</th>
<th>Major Role in regard of ITSC</th>
<th>Required Data from Stakeholder to ITSC</th>
<th>Information Provision by ITSC</th>
</tr>
</thead>
</table>
| Transport Department (RTA) | • Vehicle registration and implementation of central motor vehicle rules | • Registered vehicle data  
 • Vehicle enforcement data | • Identify the violated vehicle (in regard of traffic, CMV rules) |
| AP Pollution Department (APPCB) | • Collect and monitor pollution data in the city  
 • Enforcement agency for violations in environmental rules | • Real-time pollution data  
 • Enforcement data | • Disseminate pollution information to road users through VMS / Website |
| Andhra Pradesh State Development Planning Society (APSDPS) | • Collect and provide meteorological data in the city | • Real-time meteorological data | • Disseminate meteorological information to road users through VMS / Website |
5-9-3 Equipment Installation Policy

In accordance with the above policy for implementation, the ITS equipment will be installed with the following policies:

(1) **Road Classification:**

It was recommended by the previous different studies to prepare the hierarchical system of the road classification for road administration. But it seems that any such kind of the classification has yet been established. Hence, the roads are classified in this Master Plan for prioritizing the target roads for equipment implementation as follows;

<table>
<thead>
<tr>
<th>No</th>
<th>Classification</th>
<th>Road</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Highway</td>
<td>ORR</td>
<td>Partially in operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intermediate Ring Road</td>
<td>Planned</td>
</tr>
<tr>
<td>2</td>
<td>Principal Road</td>
<td>NH-44 (old NH-7), NH-65 (old NH-9), NH-163 (NH-202)</td>
<td>(National Highway)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inner Ring Road</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Distribute Road</td>
<td>State Highway</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Radial Road</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Link Road</td>
<td>Road which connects above road</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Road which connects major intersection/junction in city</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Residential Road</td>
<td>Colony Road</td>
<td></td>
</tr>
</tbody>
</table>

(2) **Basic Principle:**

The ITS equipment will be installed to cover the major roads and important areas in the city at first in the Phase-1. The targets include national roads, Inner Ring Roads and other critical locations including heavily congested sections in the centre of the city. The coverage areas will be gradually expanded in the following phases and ultimately covers the entire areas of Hyderabad in the phase-3.

The prioritisation is set out in accordance with the road classification shown above.

(3) **Conditions:**

(a) **Intermediate roads and expressway planned in the revised master plan of HMDA**

They are under planning. But the specific locations/alignments have not been identified yet. Hence they are excluded from the target.
(b) Radial Road

The improvement of the radial roads is under planning. Some sections/roads will be newly constructed, and others will be extended or widened. The specific location/alignment of some sections is not clear. Hence, the existing radial roads are basically considered by the location plan.

(c) ORR

The ITS installation is planned by other project. Hence they are excluded from the scope of the location plan of this Master Plan. Instead, the integration/information exchanges are considered.

(d) Others

The installation of the equipment on some particular sections in phase-1 shall be postponed/adjusted to avoid rework in case of the road-widening, alignment change and overlap with metro construction.

(4) Installation Policy:

Based on the above disciplines, the following implementation policies are set out;

<table>
<thead>
<tr>
<th>Phases</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase-1 (5 years)</td>
<td>The equipment will be installed on principal roads in the city, which are National Highway (NH) and Inner Ring Road (IRR), major state highway (SH), and other critical locations in city to cover the major traffic.</td>
</tr>
<tr>
<td>Phase-2 (10 years)</td>
<td>The equipment will be expanded along the distribute roads, which are other state highway (SH) and existing radial road, major link road connecting between the state highway and the radial road, and other critical locations in the city.</td>
</tr>
<tr>
<td>Phase-3 (After 10 years)</td>
<td>The equipment will be expanded along other link roads, which are major link roads connecting the major junctions, and major residential roads.</td>
</tr>
</tbody>
</table>

Based on the above basic policies, the location plans for the individual equipment are set out as described in the conceptual design section.
5-9-4 Relation between ITSC and Existing Plans

(1) Hyderabad Traffic Integrated Management System (HTRIMS)

Hyderabad traffic police has the control centre in the head quarter and operates CCTV monitoring at junctions. Currently the CCTV monitoring in the jurisdiction of Cyberabad traffic police is separately conducted by the Cyberabad traffic police head quarter. The traffic signals in both of jurisdictions are stand alone and not connected to their head quarters, and many of them are not properly working.

Hyderabad traffic police along with GHMC is planning to introduce HTRIMS. The outline of the plan is;

- Prepare TCC at Hyderabad police commissioner office,
- The existing centre of the Cyberabad police commissioner office will become the back-up,
- CCTV monitoring in both jurisdiction of Hyderabad traffic police and Cyberabad traffic police will be conducted at the Hyderabad police commissioner office,
- Two hundred twenty one (221), including existing one hundred eighty (180) and new forty one (41) signals will be prepared at junctions,
- Seventeen (17) VMS will be installed in the city,
- A centralised management information system for supporting a decision making in the traffic event such as traffic disaster, VIP movement will be prepared, and
- A Video Wall System will be prepared at the TCC.

The relation between ITSC and HTRIMS is show in the Figure below;
ITS Master Plan for HMA

Figure 5-24 Relation between ITSC and HTRIMS
(2) APSRTC Bus Location System

APSRTC is planning to introduce GPS/GPRS based bus location system for its fleet of 12,000 buses in phase I and extended it to the remaining buses in the next phases. The main purpose of the planned system is to track the location of their buses from the central control room in APSRTC and provide the bus location information to passengers at bus stops.

It has been agreed that the bus location data measured by their GPS devices and collected by their centre will be transmitted to ITSC. This data will be used for traffic congestion information generation in Hyderabad.

The relation between ITSC and APSRTC is shown in the Figure below.

Figure 5-25 Relation between APSRTC and ITSC
As described earlier, it is important that the hardware and software measures such as improvement of traffic discipline are taken in parallel with the preparation of ITS.

The figure below shows the ITS in the context of the required software and hardware measures for road transport. The steps from A to E need to be taken in order to achieve the goals, which are reduction of congestion, enhancement of safety, improvement of environment and consequently growth of economy. The required steps are A) Improvement of Road Network, B) Improvement of Intersections, C) Improvement of Drivers’ and Pedestrians’ Manner, D) Proper Operation and Maintenance, E) Preparation of Financial Arrangement. On the ground of this preparation, the ITS is introduced to realise the goals in the road transport sector.
Figure 5-26 Conditions and Concept of ITS in the context of Transportation Improvement
### Implementation Schedule

#### Master Plan Schedule

Based on all the considerations so far, the Master Plan of ITS for Hyderabad shall be implemented as shown in Table below.

**Table 5-15 Master Plan Implementation Schedule**

<table>
<thead>
<tr>
<th>Items</th>
<th>Phase-1</th>
<th>Phase-2</th>
<th>Phase-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>· Major road: NH-44 (old NH-7), NH-65 (old NH-9), NH-163 (old NH202), IRR, SH</td>
<td>· Distribute road: radial road</td>
<td>· Link road: the road linking between major junctions</td>
</tr>
<tr>
<td>Priority</td>
<td>· Other important locations in city</td>
<td>· Link road: the road linking between above roads</td>
<td>· Residential road:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>· Other important locations</td>
<td>· Important locations on colony road</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collection</td>
<td>· ITSC establishment, Organisation setup, Preparation of 1st phase systems</td>
<td>· Expansion of system in 2nd phase.</td>
<td>· Expansion of system in 3rd phase.</td>
</tr>
<tr>
<td>ITSC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>· ITSC Roles:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>· Traffic monitoring and analysis, traffic information provision, traffic control</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>· Planning, implementation, evaluation of ITS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>· System integration, ITS development initiative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provision</td>
<td>CCTV, ATCC, Prove, Human based information from agencies and citizens</td>
<td>Expansion of same as left</td>
<td>Expansion of same as left and Human Probe</td>
</tr>
<tr>
<td>Method</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>VMS, Website, SMS, E-Mail and Call Centre</td>
<td>Expansion of same as left</td>
<td>Expansion of same as left</td>
</tr>
<tr>
<td>Traffic</td>
<td>Signals on the Road, VMS on the road</td>
<td>· Expansion of the left</td>
<td>· Expansion of the left</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>· Variable Lane System</td>
<td>· ERP (Electric Road Pricing)</td>
</tr>
<tr>
<td>Method</td>
<td></td>
<td>· Park &amp; Ride Guidance</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>· Multi modal transport guidance</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>· Parking information guidance</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>To be expanded in 2nd and 3rd phases in line with preparation of</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>· Public &amp; Lane Parking, Public Based Multi Modal Transportations</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Important Issues Which Shall Come Along With

In addition to the above implementation, the following issues need to come along with in order for ITS to be smoothly implemented.

- For ITSC to take off successfully, ITS specialist shall be dispatched from JICA.
- ITS shall be prepared in accordance with other road infrastructure improvement such as fly-over construction, road widening and side-walk preparation for pedestrian.

Road Map for ITS in Hyderabad

The road map for ITS in Hyderabad is set out as shown in the Figure below based on the following concepts;

(a) Phase-1 (1-5 years):
   - **Policy**: Establishment of ITSC, Preparation of Basic ITS Component
   - **Concept**: During this period, the basic mechanism which enables proper road traffic information collection, processing, provision and accumulation, in turn proper road and traffic management, together with necessary basic component for ITS such as digital road map will be prepared. The hardware measures such as road infrastructure improvement and software measure such as traffic discipline improvement will be taken in parallel.

(b) Phase-2 (6 – 10 years):
   - **Policy**: Expansion of Basic ITS Component, Introduction of Advanced ITS Component
   - **Concept**: During this period, the systems prepared in the phase-1 will be reviewed. Based on the review, the components already introduced will be expanded and additional component will be introduced. The expansion of the existing system and introduction of additional components will be carried in accordance with improvement realised by the hardware and software measures.

(c) Phase-3 (After 10 years):
   - **Policy**: Expansion of More Advance ITS Component
   - **Concept**: During this period, the systems prepared in the phase-2 will be reviewed. However as the advancement of information technology is very rapid, it is almost impossible to identify the specific ITS components in this period at the time of this Master Plan. Hence, the ITS components will be further identified towards the end of the phase-2, in accordance with the maturity of ITS industry in Hyderabad, new technologies emerged and improvements realised by the hardware and software measures.
(d) Others to Be Noted:

**ITS Menus Prepared by Private Sector:** The ITS menus which are generally prepared by the private sector are not included in the ITS Master Plan. The ITS Master Plan lists the menus which shall be initiated by the public sector. Hence those to be prepared by the private sector are differently categorized as such.
Road Map for ITS Hyderabad

**Phase 1 (Basic Project)**
- Establish ITS Center (Function of ITS Centre)
- Collect Traffic Related Data (Traffic Volume, Weather, Traffic Accident, Disaster and Emergency)
- Provide Traffic Related Information
- Optimize Traffic Flow by using ITS Equipment
- Provide Emergency and Disaster Alert and Response
- Store and Analyze Traffic Related Data
- Preparation of Data Collecting System
- Weather Information Collecting System
- Air & Noise Pollution Collecting System
- Traffic Volume Counter System
- Bus Probe System
- Accident, Disaster and Emergency Information Collection System (Database and GIS System)
- Preparation of Information Provision System
- VMS and Control System
- Internet Information System (Website, E-Mail, SMS)
- Media Center for mass communication (FM Radio)
- Preparation of Data Management System
- Traffic Monitoring System
- Optimum Route Guidance
- Traffic Accident Data Analysis
- Database System (Traffic Data, Disaster Data, Emergency Data and Accidental Data)
- GIS System
- Preparation of Basic Information
- Digital Road Map (Standard is Required)
- Registered Road Map (Result of Road Inventory Survey)
- Others
  - Road Inventory Survey
  - Registered Road Map Preparation
  - OMG Introduction to Hyderabad (Gov. or BOT Scheme)
  - Bus Information System (by APSRTC)
  - Signal Replacement by GHMC & Traffic Police

**Phase 2**
- Collection System
  - Extend Weather Information System
  - Extend Traffic Volume Counting System
  - Extend Probe Car System to Private Car
  - Integrate CCTV Monitoring Image with Traffic Police
  - Extend Air & Noise Pollution Measuring System
- Data Management
  - Disaster Operation Assistance
  - Optimum Route Guidance
  - Park and Ride Guidance
  - Road Management System
- Preparation System
  - Extend VMS and Control System
  - Maintain Web Site and Installed Equipment
  - FM and AM Radio Broad casting
  - Traffic Control System
  - Optimization and Area-wide Coordination System for Signal Control
  - Lane Control System
  - ERP System
- Others
  - Public Parking System
  - Emergency Vehicle Operation System
  - Pedestrian Guidance System
  - Tourist Information Provision System
  - Vulnerable People Guidance System
  - Extend Area of CMC to General Commercial
  - Maintain DRM and RRM
  - Information Exchanging with Hyderabad Metro Railway (HMR)

**Phase 3**
- Extend Existing ITS System
- Maintain Existing ITS System
- Advanced Railway Crossing Operation System
- BRT (Bus Rapid Transit)
- Bicycle Route Information System
- Other Advanced and Applied ITS
- Need Review of ITS Master Plan

**ITS Merit for Citizen**
1) Mitigated Congestion, 2) Mitigated Air Pollution, 3) Improved Safety, 4) Economic Growth, 5) Improved Comfort & Fun to Drive

**ITS Selecting Criteria**
- Excluded with ITS system
  - which will be conducted by Traffic Police such as Enforcement System.
  - which will be conducted by car manufacturer, which will be conducted by company in general.

**Phase 1 Include:**
- which will be utilized basically.
- which are practical at current situation.
- which should be initiated by public agency.
- which does not include heavy hardware improvement.
- which does not need to accompany important policy changes.

**Phase 2 Include:**
- extension of the Phase-1.
- Applied ITS.
- all of ITS Menu will be reviewed by evaluation of Phase-1 of ITS

**Phase 3 Include:**
- advanced and applied ITS.
- future ITS.

**By Car Manufacturer and Car Navigation Maker**
- Driving Support System
  - Driving Support System for Bad Visibility Spot
  - Driving Support System on Intersection
  - Driving Support System for Forward Obstacles
  - Driving Support System for Lane Changing
  - Driving Support System for Departure Lane
  - Driving Support System for Merging Section
  - Driving Support System for Diverging Section
  - Driving Support System for Rear-End Collision
  - Driving Support System for Preventing Pedestrian
  - Alert System for Abnormality of Driver
  - Missing Car Tracking System
  - Optimum Route Guidance
  - Fleet Management System

**By ITS Expert from JICA**
- Taxi Operation System
- Commercial Vehicle Operation System
- Private Parking Management System

**By Traffic Police**
- Automated Speed Enforcement
- Automated Signal Jumping Enforcement
- Automated Excess Riding Capacity Enforcement
- Automated Wrong Way Driving Enforcement
- Automated Illegal Parking Enforcement
- Automated Overloaded Vehicle Enforcement

**By GHMC & Traffic Police**
- Automated Overloaded Vehicle Enforcement
- Automated Enforcement
- Automated Traffic System

**By Other Road Improvement Projects**
- construction of flyover, road widening and sidewalk for pedestrian.

**By Other Road Improvement Projects**
- extending other road improvement projects such as construction of flyover, road widening and sidewalk for pedestrian.

**By ITS Expert from JICA**
- Taxi Operation System
- Commercial Vehicle Operation System
- Private Parking Management System

**By Traffic Police**
- Automated Speed Enforcement
- Automated Signal Jumping Enforcement
- Automated Excess Riding Capacity Enforcement
- Automated Wrong Way Driving Enforcement
- Automated Illegal Parking Enforcement
- Automated Overloaded Vehicle Enforcement

**By ITS Expert from JICA**
- Taxi Operation System
- Commercial Vehicle Operation System
- Private Parking Management System

**By Traffic Police**
- Automated Speed Enforcement
- Automated Signal Jumping Enforcement
- Automated Excess Riding Capacity Enforcement
- Automated Wrong Way Driving Enforcement
- Automated Illegal Parking Enforcement
- Automated Overloaded Vehicle Enforcement
6 Conceptual Design

6-1 Overview of Systems to be Deployed

(1) Automatic Traffic Classifier and Counter (ATCC)

It measures the traffic volume speed and occupancy by section. The measured data is utilized for traffic control and road management. It will also be utilized for traffic congestion information provision to the users.

(2) Probe Car System (Floating Car)

It measures area-wise traffic condition. The GPS unit mounted on the vehicle records the travel record of the vehicle. The recorded data is transmitted to the centre. The collected data at centre is aggregated and the congestion level by section is identified.

(3) Flood Sensor

It measures the flooding situations on the roads and used for providing warning alert to the drivers through VMS and other information devices and accumulated for analysis. It will be installed at the flood-prone areas in the city.
(4) **Meteorological Sensors**

It measures the weather conditions on road side and used for providing warning to the drivers through VMS and other information devices and accumulated for analysis. The measured data includes rainfall, temperature, wind velocity/direction and visibility.

![Image of Meteorological Sensors](Source: JICA Study Team)

(5) **Air Pollution Sensors**

It measures the air pollution conditions and used for providing measured information to the drivers and citizens. The measured data includes NOx, SOx, COx and others. The measured pollution data will be utilized for evaluation of effect of reduction of traffic congestion and taking required countermeasures.

![Image of Pollution Sensors](Source: JICA Study Team)

(6) **CCTV Camera**

It captures the image on the road side condition and provides the moving image at the centre. It is used as supporting method at the centre to visually confirm the road condition at site for taking necessary action.

![Image of CCTV Camera](Source: JICA Study Team)
(7) **Variable Message Signboard (VMS)**

It provides the information of road, traffic and weather conditions on the road to the driver to take notice to them and divert the traffic.

![Variable Message Signboard](image)

(Source: JICA Study Team)

(8) **Signal System**

It controls the traffic at junction/intersection in the city. The signal phase is to be adjusted from the centre if required.

The signals will be prepared as a part of the scope of the HTRIMS by the Traffic Police. Hence, the installation of the signals by the ITS Master Plan is included as phase-2 and 3.

It is necessary to have enough adjustment between HTRIMS and ITSC for assuring exchanging information of signal status including fail status in well coordinated manner.

![Signal System](image)

(Source: JICA Study Team)
(9) Centre Side System

The Centre Side System will be prepared in order to monitor the traffic condition on the road and control the traffic and manage the road side equipments. It comprises i) the centre side systems for the data collection which are broadly divided into measurement equipment and CCTV, ii) central processing units which include analysis of the traffic, mapping system which maps the collected data and Geographical Information System (GIS), iii) centre side systems for information provision which includes SMS, Internet and VMS and etc, and iv) diagnostic and control system for the road-side equipment. The video wall system is prepared for monitoring, by the large display board, the status of the congestion in the city which is measured by the sensors and conditions at site which is captured by the CCTV along the road side. The monitor is used for sharing the information amongst the staff at the centre.

The figure below shows the image of the centre system of the ITSC. (It shall be noted that the figure does not include the components which are to be prepared in the phase-2 and 3.)
Mapping system (GIS), traffic analyzing system, large monitor control system, optimum route guidance system (traffic simulator), road inventory system and database system are also necessary for management of ITSC.

(Source: JICA Study Team)

Figure 6-9 Image of Central System
Other Systems Which Will be Deployed in Future

(a) Electronic Road Pricing (ERP)

The ERP is a method for electronically collecting toll charge for the purpose of traffic demand management. It is so called as a usage-based taxation mechanism.

It consists of ERP gantries located at all roads linking into central areas. They are also located along the expressways and arterial roads with heavy traffic to discourage the road usage during the peak hours if necessary. It comprises the sensors on 2 gantries, one of which is in front and the other in the back. The cameras are also attached at the gantries to capture the rear license number plate of the passing vehicles.

In the case of Singapore, approximately eighty (80) ERP gantries are installed in the city. The additional gantries are prepared where congestion becomes severe, including expressways and other roads depending on the condition.

The ERP system is proposed in the phase-3 in the ITS Master Plan.

Figure 6-10 Image of Traffic Signal

(b) Lane Control System (A Reversible Lane)

The traffic demand of the road changes depending on time a day. The reversible lane control is used to dynamically maximise the capacity of the road infrastructure. It shifts the median or changes the direction of one-way road in accordance with the traffic demand to reduce the congestion.

The lane control system is proposed in the phase-3 in the ITS Master Plan.
(c) Parking System

It provides the information on the parking availability before and during the trip. It also electronically collects the parking charge and stores the usage record of the parking. This contributes the maximum usage of the parking, preventing the fraud acts and assisting the proper parking planning based on the area wise demand.

The parking system is proposed in the phase-3 in the ITS Master Plan.

![Image of Information Board of Parking System](image)

Figure 6-12 Image of Information Board of Parking System

(d) Kiosk Terminal

The kiosk terminal is an information terminal equipped with interactive screen. The users can access and retrieve their necessary information by touch panel, in general. It is recommended to install the kiosk terminals at some major key locations in the city in the near future.

The kiosk terminal would be installed at such locations as traffic node, metro and railway stations, airport, shopping centres, tourist locations and major public spaces. The purpose of the kiosk terminal varies depending on where it is introduced. It usually provides such information as sightseeing, travel routes, time to destination, office locations and floors in the building and etc.

The kiosk terminal is equipped with the touch panel in general. The software which controls the touch panel and retrieves the enquired information is installed in the terminal.

There is a stand-alone type kiosk. But generally, the kiosk is composed of the terminal device, communication line and central monitoring and control system. In this case, central control is possible and managing becomes easier. For example, the central control includes remotely monitoring the operation status of the kiosk terminals, retrieving the enquired information from the central server.

The kiosk terminal is generally located indoors. This is for assuring the visibility of the monitor to avoid the direct sunlight, protecting the terminal device from rainfalls, outside temperature and theft, and etc.
Figure 6-13 Example of Kiosk Terminals
6-2 Deployment Policy for Individual Equipment

The deployment policies for the individual equipment are set out, based on the studies so far. The purposes, installation policies and proposed location maps by phase manner are described in this section.

It shall be noted that the number and location of the individual equipment in this section may be further adjusted and changed based on more detailed studies in the design stage of the pilot project.

6-2-1 ATCC

(1) Purpose

The ATCC will be installed to measure, at the cross section, the traffic volume by vehicle-size, speed and occupancy by section. The measured data is utilised for proper traffic management and road operation such as planning/evaluation of road-widening/by-pass construction, etc. It will be also utilised for traffic congestion information provision to the users.

There are different types of the traffic counter, including i) ultra-sonic type, ii) loop-coil type, and iii) image processing type. Due to the absence of lane-keeping discipline in Hyderabad, the image proceeding type will be introduced. However, the measurement of the motorcycle is difficult for any of these sensors. Thus, the compensation such as utilising the registered number of the motorcycles and the periodical survey shall be additionally provided.

![Figure 6-14 Image of ATCC](image-url)

Figure 6-14 Image of ATCC

![Figure 6-15 Image Processing Analysis for Traffic Measurement](image-url)

Figure 6-15 Image Processing Analysis for Traffic Measurement
(2) Installation Policy

(a) Phase-1

It will be placed in the middle of each section of the Principal Roads of the city, which are National Highway NH-44 (old NH-7), NH-65 (old NH-9) and NH-163 (old NH-202) within Hyderabad Metropolitan Area, IRR and State Highways (SH-1, SH-2, SH-4, SH-5 and SH-6). The section means the division between the junctions of these major roads. It becomes possible to measure the traffic condition by section by placing the counters in accordance with this policy. The major roads are selected because of the scale of the traffic volume in the Hyderabad Metropolitan Area.

(b) Phase-2

It will be placed in the middle of each section of the Distribute Roads, which are Radial Roads, and Major Link Roads connecting the principal roads and distribute roads. This will cover the traffic on the secondary level road network in the Hyderabad Metropolitan Area.

(c) Phase-3

1) Inside IRR:

It will be placed in the middle of each section of the Link Roads, which have not been covered in the phase-2 and major Residential Road.

2) Outside IRR:

It will be placed in the middle of each section of Radial Roads, which have not been covered in the phase-2, and Link Road connecting these radial roads. This will cover almost entire traffic in the Hyderabad Metropolitan Area.

3) Note:

It is required to place the counter at the interval of 500m in order to measure the congestion length in more detail. However, it would not be appropriate to simply apply this policy across the entire stretch in the Hyderabad Metropolitan Area because of the following reasons;

- The road infrastructure is not properly constructed and the installation may not be accordingly possible at many of the locations, and
- The cost will become unnecessarily high. Thus, the installation span shall be further identified in the phase-2 and 3 after proving certain level of effectiveness after the phase-1.
(3) Location Plan

The proposed location maps by phase manner are as shown below.

Table 6-1  Proposed Location Map of Road Side Equipment (ATCC)

<table>
<thead>
<tr>
<th>Location Map</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;PHASE-1&gt; ATCC will be placed in the middle of each section of the National Highway NH-44 (old NH-7), NH-65 (old NH-9) and NH-163 (old NH-202), IRR and State Highway to measure the traffic condition by section. 34 locations are identified and 2 sets at one location will be placed. Thus, 68 units at 34 locations will be placed at Phase-1.</td>
<td></td>
</tr>
</tbody>
</table>

| <PHASE-2> ATCC will be placed in the middle of each section of the State Highway, the Radial Road and Major Link Roads connecting the principal roads. It will cover the traffic on the secondary level road network in the Hyderabad Metropolitan Area. ATCC of 170 units at 85 locations will be placed at Phase 2. The accumulated number is 238 units. |

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Note: The diagrams and maps are not transcribed in this text format. The tables and diagrams contain detailed information on the proposed location maps by phase manner.
(4) **Typical Specification**

The typical specification of the equipment is as follows:

- Assuming 2 sets of ATCC at 1 location for monitoring both inbound and outbound traffic
- 2 image sensors for 1 place
- 2 processing units for 1 place
- 1 local control unit including control switch and communication unit for 1 place
- 1 backup power supply system for 1 place
- 1 central monitoring system at ITSC
- 1 supporting pole and foundation for 1 place
- Use optical fibre cable or GPRS for communication

**Legend**

- Power
- Communication

**Figure 6-16 Image of ATCC Local Unit**
6-2-2  Probe Car System (Floating Car)

(1)  Purpose

The probe car (floating car) system will be introduced for area-wise traffic measurement. The GPS unit mounted on the vehicle measures the location of the vehicle i.e. latitude, longitude, altitude and time stamp of the record. The measured data is transmitted to the centre via GPRS network. It becomes enabled to comprehend the average traffic speed, in turn, the level of congestion by section by aggregating the data obtained from the certain number of the vehicles.

Furthermore, it is not economically viable to install the traffic counter at large scale on road-side in the city. On the other hand, the probe system can be prepared at much lower cost because the road-side equipment is not required. However, the traffic volume at cross section cannot be measured by the probe system. Thus, the traffic will be measured by combination of the probe system and traffic counter by supplementing as a whole.

Figure 6-17 ATCC Installation Image

Figure 6-18 Image of Probe Car System
(2) Particular Condition to Be Noted

The more number of vehicles are mounted with GPS device (called probe car), the more accurate congestion information can be obtained. However it is difficult to specifically identify how many vehicles are required. In theory, it would be sufficient to refresh every 5 minute from the data recorded by every 10 second on the vehicle which is sent to the centre by every 1 minute. For example in case of 1000 vehicles, the traffic is to be measured by 30,000 data (60 sec/10 sec*5min=30 data. 30 data*1000 vehicles=30,000 data). However in practice, the accuracy depends on the number of the vehicles which exist in every road section, and the existence of the probe car shall evenly cover the entire areas.

(3) Installation Policy

(a) Phase-1

In consideration of above, the public buses operated by the APSRTC are selected for the Phase-1. Approximately 3,800 buses are under operation in the city and their service areas cover nearly entire areas of the Hyderabad Metropolitan Area. The APSRTC is planning to prepare the bus location system installing the GPS devices together with other equipment e.g. information board at the bus stops, under the JNNURM scheme. The GPS devices will be installed on 12,000 buses (3,800 for city buses and rest of them for inter-city buses). It will be prepared within one year. Thus, the probe data collected from each bus by the APSRTC will be transmitted to the ITSC and utilized as the input data.

(b) Phase-2 and 3

As described above, the measurement result will become more accurate as the number of the probe car increases. Thus, the target of the probe car shall be expanded to other mode of the transport, which includes; taxies, commercial vehicles (trucks, DHL cars), public owned cars etc.

Table 6-2 Proposed Policy of Road Side Equipment

<table>
<thead>
<tr>
<th>Phase-1</th>
<th>Phase-2</th>
<th>Phase-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>• 12,000 Units by APSRTC Bus</td>
<td>• 10,000 Units by APSRTC Bus (Outside HMA Area)</td>
<td>• Extension of Phase-2 (Taxi, Freight / Commercial Vehicle and Public Car Probe)</td>
</tr>
<tr>
<td></td>
<td>• Taxi Probe</td>
<td>• Mobile based human tracking system in future</td>
</tr>
<tr>
<td></td>
<td>• Freight / Commercial Vehicle Probe</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Public Car Probe</td>
<td></td>
</tr>
</tbody>
</table>

(4) Typical Specification

The typical specification of the equipment is as follows;
Assuming 1 set of OBU (On Board Unit) at 1 Vehicle for monitoring Vehicle Location

- 1 GPS sensor in 1 OBU
- 1 communication unit in 1 OBU
- Man-Machine interface for operation of OBU
- DC12/24V power supply available
- WAAS available
- Time base measurement and distance base measurement available
- Local memory for buffering measuring data
- Availability of data transmission
- Self check available
- Buttery for keeping stored memory

### 6-2-3 Flood Monitoring System

#### (1) Purpose

The flood monitoring system is to measure flooding situations on the roads and provide warning alert to the drivers through VMS and other information devices. The system shall be introduced in the Project with following objectives:

- To detect and measure flooding situations on the roads in Hyderabad Metropolitan area,
- To provide the waterlogged information and alerting signals to the road users so that the drivers can avoid such flooding area,
- To utilize measured data for road facility improvement planning such as road drainage rehabilitation, etc, and,
- To share the above waterlogged information with road planning agencies (GHMC, R&B and HGCL/HMDA), road operators and traffic police.
(2) Installation Policy

The flood monitoring sensors will be located at water logging areas in Hyderabad Metropolitan Area identified by Hyderabad Traffic Police.

(a) Phase-1

According to the website of Hyderabad Traffic Police, around 125 flooding prone spots in the city are scoured. In the newspaper on 29th May 2011, 14 areas among them are shortlisted as the most troublesome and demanded immediate action. Thus in Phase-1, the flood monitoring sensors will be installed at 14 water logging spots mentioned above.

(b) Phase-2

In phase-2, installation of flood monitoring sensors will be expanded over all of 125 water logging spots identified by Hyderabad Traffic Police.
(3) Location Plan

The proposed location maps by phase manner are as shown below.

Table 6-3 Proposed Location Map of Road Side Equipment (Flood Sensor)

<table>
<thead>
<tr>
<th>Location Map</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;Phase-1&gt;</td>
<td>According to the Traffic Police, 125 flood points in total including 14 serious points were identified and provided by the website. The flood monitoring sensors will be installed at 14 serious water logging locations in Phase-1.</td>
</tr>
<tr>
<td>&lt;Phase-2&gt;</td>
<td>The flood monitoring sensors will be installed at the remaining 111 water logging locations identified by Hyderabad Traffic Police. The accumulated number is 125 units.</td>
</tr>
</tbody>
</table>

(4) Typical Specification

The typical specification of the equipment is as follows;
- Assuming 1 flood sensor (water depth gauge) for 1 place
- 1 alarm local control unit including control switch and communication unit for 1 place
- 1 backup power supply system for 1 place
- 1 central monitoring system at ITSC
- 1 supporting pole and foundation for 1 place
- Use optical fibre cable or GPRS for communication
6-2-4 Meteorological Sensors

(1) Purpose

The meteorological monitoring system is one of indispensable systems to measure weather conditions, take appropriate countermeasures in bad weather conditions, and provide warning information to the drivers. The system shall be introduced in the Project with following objectives:

- To measure weather conditions including rainfall, temperature, wind velocity/direction and visibility on the roads in Hyderabad Metropolitan area,
- To utilise measured meteorological data as a parameter for taking appropriate countermeasures such as road closure, etc. in case hazardous weather condition is detected,
- To provide the weather information to the road users through the information provision systems in order for them to take necessary cautious measures.
- To share measured meteorological data with alerting signals among road operators and traffic polices, etc.

Figure 6-22 Image of Meteorological Sensors
(2) **Installation Policy**

The meteorological monitoring sensors will be located at roadside in accordance with following criteria to meet the system objectives and requirements above.

- It is generally said that the meteorological sensors must be located to cover certain catchment area for measurement and identification of localized torrential rain. According to practices and experiences in Japan, the catchment area is normally set up around 300 square meters (equal to radius of 10km). Thus, it is assumed that 10 meteorological sensors would be placed to cover entire Hyderabad Metropolitan Area.

- Four (4) meteorological sensors will be prepared by the ORR ITS Project, as one of the components of the Highway Traffic Management System (HTMS). These locations are excluded from the scope of this Project. Thus, six (6) sensors will be prepared by the project.

It is planned to cover all HMA area by which every sensor covers the circle of 20 km diameter. Thus, 10 sensors will be necessary including 4 sensors which will be prepared by the ORR ITS Project. The proposed location maps are shown below.

*Figure 6-23 Concept of Location Plan for Meteorological Sensors*

**Note:** The meteorological data received from the related agencies shall be considered and the installation policy may be altered.
(3) **Location Plan**

The proposed location maps by phase manner are as shown below.

**Table 6-4 Proposed Location Map of Road Side Equipment (Meteorological Sensor)**

<table>
<thead>
<tr>
<th>Location Map</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;Prepared by ORR ITS Project&gt;</td>
<td></td>
</tr>
<tr>
<td>4 units will be prepared by ORR ITS Project, as one of the components of Highway Traffic Management System (HTMS).</td>
<td></td>
</tr>
<tr>
<td>These locations are shown in the figure left.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location Map</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;Phase-1&gt;</td>
<td></td>
</tr>
<tr>
<td>It is planned to cover all HMA area by which every sensor covers the circle of 20 km diameter.</td>
<td></td>
</tr>
<tr>
<td>10 sensors will be necessary including 4 sensors which will be prepared by ORR ITS Project.</td>
<td></td>
</tr>
<tr>
<td>Thus, 6 units will be placed by this Project in Phase-1. These locations are shown in the figure left.</td>
<td></td>
</tr>
</tbody>
</table>

(4) **Typical Specification**

The typical specification of the equipment is as follows;

- Assuming 1 meteorology unit including following 5 sensor at 1 place
  - 1 thermometer sensor
  - 1 rain gage sensor
  - 1 rainfall detector sensor
  - 1 vane anemometer sensor
  - 1 visibility meter sensor
1 meteorological observation station including local control switch and communication unit for 1 place
1 backup power supply system for 1 place
1 central monitoring system at ITSC
1 supporting pole and foundation for 1 place
Use optical fibre cable or GPRS for communication

Figure 6-24 Image of Road Side Unit of Meteorological Sensor

### 6-2-5 Air Pollution Sensor

#### (1) Purpose

The air pollution sensor is one of indispensable systems to measure the condition of air pollution and provide the measured information to the drivers and the citizens. The system shall be introduced in the Project with the following objectives:

- To measure air pollution conditions including NOx, SOx, COx on the roads in Hyderabad Metropolitan area,
- To utilize measured pollution data as a parameter for taking appropriate countermeasures
- To provide the pollution information to the road users through the information provision systems in order for them to take necessary cautions measures.
- To share the measured pollution data for alerting signals among the road operators and traffic polices, etc.
- To evaluate the improvement of the condition of air pollution by alleviating the traffic condition.
(2) **Installation Policy**

The air pollution sensors will be located at same location of the meteorological sensor. Thus 10 meteorological sensors will be placed to cover the entire Hyderabad Metropolitan Area.

(a) **Phase-1**

It is proposed to prepare 10 units in Phase-1 to cover the entire Hyderabad Metropolitan Area.

(b) **Phase-2**

It is not planned to prepare the air pollution sensor in Phase-2.

**Note:** The pollution data received from the related agencies shall be considered and the installation policy may be altered.

(3) **Location Plan**

The proposed location maps are as shown below.

<table>
<thead>
<tr>
<th>Location Map</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;Phase-1&gt;</td>
<td>It is proposed to prepare 10 units in Phase-1 to cover the entire Hyderabad Metropolitan Area.</td>
</tr>
<tr>
<td>&lt;Phase-2&gt;</td>
<td>It is not planned to prepare the air pollution sensor in Phase-2.</td>
</tr>
</tbody>
</table>
(4) Typical Specification

The typical specification of the equipment is as follows;

- Assuming 1 pollution unit including 5 pollution sensor (NOx, SO2, CO, CO2, O2) for 1 place
- 1 local control unit including control switch and communication unit for 1 place
- 1 backup power supply system for 1 place
- 1 central monitoring system at ITSC
- 1 supporting pole and foundation for 1 place
- Use optical fibre cable or GPRS for communication

![Diagram of Road Side Unit of Air Pollution Sensor](Image)

Figure 6-26 Image of Road Side Unit of Air Pollution Sensor

6-2-6 CCTV Camera

(1) Purpose

The CCTV camera will be introduced for confirmation on the condition at site for traffic and road management with the following purposes;

- To visually monitor road, traffic and weather conditions on major roads in Hyderabad Metropolitan Area from ITSC
- To detect abnormal conditions on the roads within the coverage of CCTV to take necessary actions such as lane control, in case of the incidents.
- To confirm the traffic flows on the road by live images to regulate the traffic by instructing the police at site, providing information to the uses
- To share live images among the road operators and traffic polices etc.
(2) **Installation Policy**

(a) **Phase-1**

It is planned, by Hyderabad and Cyberabad traffic police, to prepare the 334 CCTV cameras at the junctions, and expected to complete within one year. Hence the CCTV camera by this project will be prepared at the different locations to fulfil the above purpose as follows;

- They will be placed at the same locations with the traffic counter, which is between junctions, to visually monitor the actual traffic flows.
- They will be placed at the same locations with the flood monitoring sensor to confirm the water logging condition by image.
- Above both are on the assumption that one unit will be placed at one location because the CCTV will have pan, tilt and zoom functions.

(b) **Phase-2 and Phase-3**

The CCTV cameras will be installed with the following policies;

- They will be placed at the same location with the traffic counter prepared in the Phase-2/Phase-3.
- They will be placed at the same location with the flood sensor prepared in the Phase-2/Phase-3.
- They will be placed at the same location with the traffic signals prepared in the Phase-2/Phase-3.
- All above are on the assumption the one unit will be placed at one location because the CCTV will have pan, tilt and zoom functions.
(3) Location Plan

The proposed location maps by phased manner are shown below.

Table 6-6 Proposed Location Map of Road Side Equipment (CCTV)

<table>
<thead>
<tr>
<th>Location Map</th>
<th>Policy</th>
</tr>
</thead>
</table>
| ![Location Map](image1.png) | <CCTV Prepared by Traffic Police>
| | According to the Traffic Police, 334 CCTV will be prepared by the project of the Traffic Police. 
| | They will be placed at the junctions. 
| | The exact locations are not clear at the time of preparation of ITS Master Plan. 
| | The left figure shows the location of the junctions where the traffic signals will be prepared by the Traffic Police as part of HTRIMS. 
| | It is assumed that some of the CCTV may be placed at the locations shown in the left figure. |

| ![Location Map](image2.png) | <Phase-1> 
| | 55 units in total will be prepared by this Project in Phase-1. 
| | (One unit at one location) 
| | The breakdown of 55 units are; 
| | - 41 units at the same location with ATCC between junctions to monitor the traffic condition. 
| | - 14 units at the same location with flood sensor to monitor the flood condition. |

| ![Location Map](image3.png) | <Phase-2> 
| | 196 units will be prepared by the Project in Phase-2. 
| | The breakdown of 196 units are; 
| | - 85 units at the same location with ATCC between junctions to monitor the traffic condition. 
| | - 111 units at the same location with flood sensor to monitor the flood condition. |
### Typical Specification

The typical specification of the equipment is as follows:

- Assuming 1 CCTV camera for 1 place (pan, tilt and zoom remote operation and auto focus)
- 1 local control unit including control switch and communication unit for 1 place
- 1 backup power supply system for 1 place
- 1 central monitoring system at ITSC
- 1 supporting pole and foundation for 1 place
- Use optical fibre cable or GPRS for communication
6-2-7 Variable Message Signboard (VMS)

(1) Purpose

The VMS system is to provide the information of road, traffic and weather conditions on the road to the driver. The VMS is one of the most effective measures for the information provision since the information can be provided to every road user even when the vehicle and driver has no other devices to collect the information. The VMS system is introduced in the Project with following objectives;

- To provide road users with information of road, traffic and weather conditions on the major roads in Hyderabad Metropolitan Area, i.e. National Highways, the IRR, etc.,
- To utilize for diverting driver’s travelling route from the congested places or the areas under bad weather condition inside the city by providing such information to the drives in advance who are intending to enter inside the city.
- To control the VMS at ITSC, where all information related to road, traffic and weather conditions are collected, for realizing the objectives mentioned above, and
- To apply to VMS as information provision device that can provide the information to every road user without any special user’s devices.

Figure 6-30 Image of VMS
(2) **Installation Policy**

The VMS board will be located on the roadside at the location of diversion in accordance with following criteria to meet the objectives above.

(a) **Phase-1**

- The VMS will be placed beside major junctions and intersections on National Highways in the city area to provide road, traffic and weather information to drivers entering toward the city.
- The VMS will be located at major junctions and intersections on the IRR, as well.
- The VMS will be located at all junctions and intersections on radial roads crossing the IRR to provide the information to drivers entering into the IRR.
- Installation of VMS on the ORR will be excluded from this project since the VMS board on the ORR will be prepared within the scope of ORR project. However, road, traffic and weather data exchange between ITSC and Highway Traffic Management System (HTMS) procured by ORR project shall be made for realisation of flexible and interactive VMS information provisions each other.
- The VMS will be placed beside junctions and intersections on major roads inside Hyderabad Metropolitan Area including road No.2 connecting with IRR and High-tech city.
- The VMS will be located at junctions and intersections in front of flooding prone areas so that drivers can divert to alternative travelling route when flooding happens.
- Apart from VMS being planned by this project and ORR project, traffic police will implement 20 sets of VMS under the HTRIMS project. Location of those VMSs implemented by traffic police is not currently clarified. After identifying the location of VMSs provided by the HTRIMS project, the VMS may be cancelled from this project in case the locations are overlapping with HTRIMS project.

(b) **Phase-2**

The VMS will be located beside all junctions and intersections on the radial roads crossing the ORR to provide road, traffic and weather information on the ORR to drivers.

The VMS will be basically placed at all junctions and intersections on the radial roads crossing the ORR. However, the VMS installed at junctions and intersections on the National Highways crossing the ORR has been implemented by the ORR project. Thus, those VMSs are excluded from the scope of this project.

(c) **Phase-3**

The VMS may be further located inside the city for the purpose of information provisions related to parking area information, detailed traffic information or others.
(3) Location Plan

The proposed location maps by phased manner are shown below.

Table 6-7 Proposed Location Map of Road Side Equipment (VMS)

<table>
<thead>
<tr>
<th>Location Map</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;Phase-1&gt;</td>
<td>42 units in total will be prepared by the Project in Phase-1. The breakdown of 42 units are - 18 units at the location of diversion according to the installation policy - 13 units at the location of diversion before flood prone areas - 11 units at the location of diversion of the radial road</td>
</tr>
<tr>
<td>&lt;Phase-2&gt;</td>
<td>54 units will be prepared by the Project in Phase-2. The accumulated number is 96 units.</td>
</tr>
</tbody>
</table>

10 VMS will be prepared by the ORR ITS Project as shown in the left figure. These numbers are excluded from above. And 20 VMS will be prepared by HTRIMS. The above number (42 units) may be further adjusted and changed, by coordinating with HTRIMS Project.
<table>
<thead>
<tr>
<th>Location Map</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;Phase-3&gt; It is assumed that approximately 100 units would be prepared in Phase-3. However, the locations of the VMS in Phase-3 shall be further investigated in the future because it may include information provision of parking, more detailed traffic information etc.</td>
</tr>
</tbody>
</table>

(4) Typical Specification

The typical specification of the equipment is as follows;
- Assuming 1 VMS board for 1 place
- 1 cantilever supporting pole and foundation for 1 place
- 1 local control unit including control switch and communication unit for 1 place
- 1 backup power supply system and stabilizer for 1 place
- 1 central monitoring and control system at ITSC
- 1 supporting pole and foundation for 1 place
- Use optical fibre cable and/or GPRS for communication

![Image of VMS Local Unit](image)

Figure 6-31 Image of VMS Local Unit

6-2-8 Signal System

(1) Purpose

The traffic signals are used to assure the orderly movement of vehicular and pedestrian traffic and to prevent excessive delay of the traffic. They are installed with the objectives of
- Assuring the traffic in an orderly manner
- Minimizing delay of the vehicles and pedestrians
- Reducing the crash conflicts and
- Maximizing the capacity of the intersection at each direction
It needs to be noted that the well-designed junctions are required before the traffic signals are installed to properly utilise the traffic signals and achieve the above objectives. There are a number of such junctions, in Hyderabad Metropolitan Area, which need to be properly constructed to maximise the capacity of the junction and assure the smooth traffic flow by the signals.

(2) Location Plan

The proposed location maps by phase manner are as shown below.

<table>
<thead>
<tr>
<th>Location Map</th>
<th>Policy</th>
</tr>
</thead>
</table>
| ![Location Map 1](image1) | **<Phase-1>**: Prepared by HTRIMS<br>The signals at 221 junctions in total will be prepared by HTRIMS Project.  
The breakdown of 221 junctions are;<br>- 180 junctions: Replacing the existing signals  
- 41 junctions: Installing the new signals  
Thus, any of signals will not be prepared by this project in Phase-1. |
| ![Location Map 2](image2) | **<Phase-2>**<br>The location plan for the traffic signal is basically based on the installation policy of the Master Plan described earlier. In this sense, the signals in phase2 shall cover the important locations on the roads which shall be covered by the installation policy for Phase-1 and 2, which was not covered by the above HTRIMS.  
The signals at 179 junctions in total will be prepared in Phase-2. |

Note: The road and intersections structures such as proper u-turn point, modification of round-about intersections, etc shall be properly prepared as a basic condition for preparation of the traffic signals.
<table>
<thead>
<tr>
<th>Location Map</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Location Map" /></td>
<td>&lt;Phase-3&gt;</td>
</tr>
</tbody>
</table>

Other major locations in accordance with the installation policy of the Master Plan will be covered in the Phase-3. The signals at 222 junctions will be prepared in Phase-3.

(a) Note for the pedestrian signals:

The approximate road length in the city becomes 1,500km. If the pedestrian signals are to be prepared every 1km, at least 1,500 units will be necessary. On the other hand, 622 traffic signals in total from Phase1 to 3 will be prepared. On the condition that the pedestrian signals will be prepared together with the traffic signals at these locations, the required remaining number of pedestrian signals will become approximately 900 (1500 – 622).

It would not be practical to prepare these 900 pedestrian signals in the Phase-1, particularly concerning the current conditions of the road infrastructure and the structures of the existing intersections. Thus, those shall be placed in Phase2 and Phase3 in accordance with improvement of the infrastructure. It would be around 400 in Phase-2 and 500 in Phase-3 respectively.

(3) Typical Specification

The typical specification of the equipment is as follows;

- Assuming 4 ways junction
- 2 vehicle signals for 1 way
- 4 lumps for 1 signal (blue, yellow, red and right turn)
- 1 countdown timer for 1 way
- 2 pedestrian signals for 1 way
- 2 lumps for 1 pedestrian signal (red and blue)
- 2 Vehicle Actuators for 1 way
- 1 Local control unit including control switch and communication unit for 1 junction
- 1 backup power supply system for 1 junction
- 1 central monitoring and control system at ITSC
- Use optical fibre cable and/or GPRS for communication
The typical specification of the equipment is as follows:

- Assuming pelican crossing on a road (not a junction)
- 2 vehicle signals for 1 place
- 3 lumps for 1 signal (blue, yellow and red)
- 2 pedestrian signals for 1 place
- 2 lumps for 1 pedestrian signal (red and blue)
- Local control unit including push button and communication unit for 1 place
- 1 central monitoring and control system at ITSC
- Use optical fibre cable and/or GPRS for communication

### 6-3 Traffic Volume Coverage by ITS Implementation based on CTS Field Survey Report

As described in above sections, ITS Hyderabad implementation policy is formulated based on consideration of various traffic studies that were conducted in Hyderabad.

CTS had conducted traffic volume study by strategically identifying 3 screen lines to cover major traffic corridors within Hyderabad. CTS had identified 61 locations from all 3 screen locations (26 in survey location 1, 18 in survey location 2, 17 in survey location 3) so that major traffic volume is covered in all screen lines.

The screen lines identified by CTS are:

1. Screen Line-1: N-S Railway Line
2. Screen Line-2: E-W Railway Line
3. Screen Line-3: Musi River

Source: CTS Field Surveys Report, May 2012

Figure 6-32 CTS Survey Screen Line Locations
Hyderabad ITS study has taken into consideration CTS traffic volume study pattern while formulating the device implementation policy. The details of the device coverage by Hyderabad city ITS in comparison with the CTS traffic volume study is listed below.

Table 6-9 Screen Lines in CTS Report and Device Coverage under City ITS

<table>
<thead>
<tr>
<th>Screen Lines Identified by CTS</th>
<th>Number of Locations Covered in CTS Study</th>
<th>Total Traffic Volume Count as Mentioned in CTS Report</th>
<th>Number of Locations Covered by Devices in ITS Hyderabad &amp; HTRIMS</th>
<th>Total Traffic Volume Count Covered by ITS Hyderabad &amp; HTRIMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SL - 1</td>
<td>26</td>
<td>12,01,722</td>
<td>19</td>
<td>10,67,085</td>
</tr>
<tr>
<td>SL - 2</td>
<td>18</td>
<td>13,09,881</td>
<td>17</td>
<td>11,78,264</td>
</tr>
<tr>
<td>SL - 3</td>
<td>16</td>
<td>9,56,421</td>
<td>12</td>
<td>9,28,619</td>
</tr>
</tbody>
</table>

As listed in the above table, 19 out of 26 locations in screen line-1, 17 out of 18 locations in screen line-2 and 12 out of 16 locations in screen line-3 were covered by the device implementation of city ITS and HTRIMS. This total traffic volume count coverage mentioned in the above table is an overall indicative of percentage coverage of the traffic volume by the city ITS device implementation in each of the screen locations.

To understand the device coverage pattern by city ITS in terms of traffic composition, CTS report on traffic composition based traffic volume study is considered in all the 3 screen lines and the details are listed below.

Table 6-10 CTS Screen Line-1 and Device Coverage under City ITS

<table>
<thead>
<tr>
<th>Traffic Composition</th>
<th>Screen Line-1 (SL-1)</th>
<th>Actual % in Total Traffic Volume (CTS Study)</th>
<th>Vehicle numbers in Traffic Volume (CTS Study)</th>
<th>Device Coverage by city ITS &amp; HTRIMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Wheeler</td>
<td></td>
<td>56.80%</td>
<td>682,578</td>
<td>606,104</td>
</tr>
<tr>
<td>3-Wheeler</td>
<td></td>
<td>13.1%</td>
<td>157,426</td>
<td>139,788</td>
</tr>
<tr>
<td>Cars</td>
<td></td>
<td>18.7%</td>
<td>224,722</td>
<td>199,545</td>
</tr>
<tr>
<td>Bus</td>
<td></td>
<td>3.2%</td>
<td>38,455</td>
<td>34,147</td>
</tr>
<tr>
<td>NMT</td>
<td></td>
<td>1.9%</td>
<td>22,833</td>
<td>20,275</td>
</tr>
<tr>
<td>others</td>
<td></td>
<td>6.3%</td>
<td>75,708</td>
<td>67,226</td>
</tr>
</tbody>
</table>

Table 6-11 CTS Screen Line-2 and Device Coverage under City ITS

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Wheeler</td>
<td></td>
<td>58.50%</td>
<td>7,66,280</td>
<td>6,89,284</td>
</tr>
<tr>
<td>3-Wheeler</td>
<td></td>
<td>11.30%</td>
<td>1,48,017</td>
<td>1,33,144</td>
</tr>
<tr>
<td>Cars</td>
<td></td>
<td>21.10%</td>
<td>2,76,385</td>
<td>2,48,614</td>
</tr>
<tr>
<td>Bus</td>
<td></td>
<td>3.3%</td>
<td>43,226</td>
<td>38,883</td>
</tr>
<tr>
<td>NMT</td>
<td></td>
<td>1%</td>
<td>13,099</td>
<td>11,783</td>
</tr>
<tr>
<td>others</td>
<td></td>
<td>4.80%</td>
<td>62,874</td>
<td>56,557</td>
</tr>
</tbody>
</table>
Table 6-12  CTS Screen Line-3 and Device Coverage under City ITS

<table>
<thead>
<tr>
<th>Traffic Composition</th>
<th>Screen Line-3 (SL-3)</th>
<th>Vehicle numbers in Traffic Volume (CTS Study)</th>
<th>Device Coverage by city ITS &amp; HTRIMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual % in Total Traffic Volume (CTS Study)</td>
<td>Vehicle numbers in Traffic Volume (CTS Study)</td>
<td>Device Coverage by city ITS &amp; HTRIMS</td>
<td></td>
</tr>
<tr>
<td>2-Wheeler</td>
<td>61.80%</td>
<td>5,91,068</td>
<td>5,73,887</td>
</tr>
<tr>
<td>3-Wheeler</td>
<td>12.30%</td>
<td>1,17,640</td>
<td>1,14,220</td>
</tr>
<tr>
<td>Cars</td>
<td>14.10%</td>
<td>1,34,885</td>
<td>1,30,995</td>
</tr>
<tr>
<td>Bus</td>
<td>2.80%</td>
<td>26,780</td>
<td>26,011</td>
</tr>
<tr>
<td>NMT</td>
<td>2.50%</td>
<td>23,911</td>
<td>23,215</td>
</tr>
<tr>
<td>others</td>
<td>6.50%</td>
<td>62,167</td>
<td>60,360</td>
</tr>
</tbody>
</table>

As mentioned in the above tables, traffic composition coverage by city ITS and HTRIMS is calculated from total traffic volume count covered by devices in city ITS (refer table 6-10) and the percentage composition of each category of traffic (refer tables 6-11, 6-12 & 6-13). This data shows the coverage pattern of city ITS devices in terms of 2-wheeler, 3-wheeler and car traffic volume.

From the above data, it can be understood that major part of the 2-wheeler, 3-wheeler and car composition of the total traffic volume is covered by device implementation in city ITS and HTRIMS.

Figure 6-33  CTS Survey Screen Locations and City ITS Device Locations
6-4 Centre Side System

6-4-1 Purpose

The centre side system is prepared to encourage data exchange between the sub-system components and manage the total system to realise their functions and achieve the following objectives:

- To collect, manage and integrate all data related to road and traffic conditions, incidents, weather condition and any other necessary data,
- To process, store, record and analyse the necessary data for effective road planning, operation and maintenance,
- To provide the collected and processed information to the road users in order to take notice of the road conditions and/or detour drivers’ travelling route from the congested area hazardous area,
- To display and monitor the above collected and processed information on real-time basis, and share the information with road planning agencies (e.g. GHMC, R&B and HGCL/HMDA), road operators and traffic polices in the Centres, and
- To monitor and manage the sub-system component.

The centre side system is divided into the systems for i) Data Collection Units, ii) Analysis, iii) Information Provision Units and iv) Traffic Control Units. The image of the central system is illustrated in the Figure below.
The outlines of central system are as follows.
6-4-2 Centre Side System for Data Collection Units

(1) Outline

The centre side system for data collection units is prepared to collect the data from the devices and remotely monitor the operation conditions of these devices from the centre. It includes the following devices:

- ATCC
- Probe Car System
- Flood Sensor
- Meteorological Sensor
- Pollution Sensor
- CCTV

(2) System Diagram

The processor for communicating (data collecting), data storing, data analyzing and contents processing for display are necessary as the centre side system of 1-5.

![Diagram of Centre Side System for Data Collecting]

Figure 6-35 Image of Centre Side System for Data Collecting

The processor for communicating, image storing and displaying are necessary as the centre side system of 6.

![Diagram of Centre Side System for CCTV]

Figure 6-36 Image of Centre Side System for CCTV

The network equipments and display units are necessary as a common unit. The routers and LAN switches for CCTV shall be installed independently from other data collecting system because of high traffic of image data communication.
Typical Specification

The typical specification of the equipment is as follows:

- Assuming 1 router for data communication units and 1 router for CCTV units. Both routers have functions of connecting internet and firewall.
- Assuming 2 LAN switches for the network of data communication and CCTV network.
- Independent servers for each functional unit such as ATCC and flood sensor.
- Several functions are required such as communication, database, data analyzing, contents processing for each functional unit. One or more servers will be required according to its capability. Assumed server is windows server and Linux server.
- UPS and power stabilizers are required.
- Operation console is required.

Table 6-13 Typical Specification of Central System

<table>
<thead>
<tr>
<th>Items</th>
<th>Central System</th>
<th>Rough Specification</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common System</td>
<td>Network Router: 1</td>
<td>1 Internet port</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 LAN ports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Network Switch: 4</td>
<td>24 port</td>
<td></td>
</tr>
<tr>
<td>ATCC</td>
<td>Server: 1 (*1)</td>
<td>Windows or LINUX (*2)</td>
<td>With operation console.</td>
</tr>
<tr>
<td>Probe Car</td>
<td>Server: 1 (*1)</td>
<td>Windows or LINUX (*2)</td>
<td></td>
</tr>
<tr>
<td>Flood Sensor</td>
<td>Server: 1 (*1)</td>
<td>Windows or LINUX (*2)</td>
<td></td>
</tr>
<tr>
<td>Meteorological Sensor</td>
<td>Server: 1 (*1)</td>
<td>Windows or LINUX (*2)</td>
<td></td>
</tr>
<tr>
<td>Pollution Sensor</td>
<td>Server: 1 (*1)</td>
<td>Windows or LINUX (*2)</td>
<td></td>
</tr>
<tr>
<td>VMS</td>
<td>Server: 1 (*1)</td>
<td>Windows or LINUX (*2)</td>
<td></td>
</tr>
<tr>
<td>Signal</td>
<td>Server: 1 (*1)</td>
<td>Windows or LINUX (*2)</td>
<td></td>
</tr>
<tr>
<td>CCTV Camera</td>
<td>Server: 1 (*1)</td>
<td>Windows or LINUX (*3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Console: 1</td>
<td>Windows latest version</td>
<td></td>
</tr>
</tbody>
</table>

*1: The number of the servers will be changed according to their abilities.
*2: The server shall have enough ability to process the required functions such as communication, data collection, data processing, data analysing and contents processing. The console with keyboard and mouse is required. The devices of USB and LAN are required. Enough storage is required for OS, application and data storing.

*3: The server shall have enough ability to process the required functions such as communication, image data storage and image provision.
The large monitor and associate equipment will be installed for monitoring the status of congestion in the city, which are measured by the sensors, and conditions at site which are captured by the CCTV which is newly installed at critical site. The video wall system is used for sharing the collected information amongst the staff at the centre.

The Figure below shows the image of the video wall system at traffic control centre.

![Image of Video Wall System](image)

**Table 6-14 Typical Specification of Video Wall System**

<table>
<thead>
<tr>
<th>Items</th>
<th>Central System</th>
<th>Rough Specification</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video Wall System</td>
<td>Large Monitor 20 (=4x5)</td>
<td>55” HDTV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Matrix Switch: 1</td>
<td>Input: more than 16 ports</td>
<td>Full Matrix</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Output more than 16 ports</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Image Controller: 1</td>
<td>Input: more than 16 ports</td>
<td>With operation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Output more than 16 ports</td>
<td>console.</td>
</tr>
</tbody>
</table>
The Figure below shows a basic component of the video wall system with the associated units.

The centre side system for analysis is prepared for processing the collected data, mapping onto the digital road map on the video wall or console, analysing the traffic related data, storing and reporting.

The GIS, Geographical Information System, is a tool for displaying the map and some information to be placed on the map. The GIS will be prepared for storing and analysis for the collected data such as accident, event, festival and disaster and traffic congestion. It is necessary to prepare several licenses of GIS.

In addition to the GIS, the system for data analysis shall be prepared as follows;
- Traffic Analyser
- Road Inventory
- Optimum Route Guidance as Simulator
- Database System for Storing and Analysing Traffic Data, Accident Data and Other Collected Data which includes Flood, Air Pollution, Meteorology, etc.,
The system for data analysis will include, but not limited to, following functions:

- Process and analyse the traffic conditions such as traffic volume, average speed, traffic congestion, travelling time, etc.
- Process and analyse the weather conditions including heavy rain, strong wind, water logged, etc.
- Manage and handle traffic incidents and regulations such as traffic accident, fire accident, obstacle, natural disaster, construction work on road, road closure, etc.
- Manage and handle road inventory data
- Analyse and estimate traffic flow pattern, traffic prediction, etc.
- Evaluate the system availability as key performance indicator
- Produce and guide optimum route
- Database management for all collected and processed data.

The Figure below exemplifies the image of the congestion map. It shows the congestion level by the section of the road, by mapping the processed data onto the simplified city road map.

![Image of Congestion Map](image-url)
The centre side system for information provision units are prepared to provide the collected and processed traffic related information to the users. The traffic related information will be provided to the users through the website and SMS/E-mail. The traffic information and traffic event such as flooded point, accident, and lane closure will be plotted on the simplified map and provided in the form of the website. The major traffic event will also be provided in the form of the simplified message through SMS/E-mail.

- Website
- SMS, E-mail

Figure 6-40 Image of Information Provision System by Website

The centre side system for traffic control units are prepared to control and monitor the following devices. The component for VMS will be prepared at centre in the phase-1. Others will be prepared in the following phases in accordance with expansion of the functions of the ITSC, as described in the earlier sections.

- VMS
- Signal
- ERP
- Lane Control System
- Parking System
Figure 6-41 Image of VMS System

Figure 6-42 Image of Traffic Signal System
6-5 Other ITS
6-5-1 ERP System

(1) Purpose

The Electronic Road Pricing System, which is referred as ERP system is used for electronically collecting the toll charge from the passing vehicles. The toll charge is dynamically adjusted according to the traffic demand and time. The transport administrator regulates the traffic flow, incoming into the central area of city by imposing the charges on motorists. This is called as 'Traffic Demand Management’ (TDM) in transportation terms. This is also introduced for the purpose of fund generation. The ERP is being implemented in the different countries for transportation sector (e.g. road infrastructure development, ITS management etc).

The Figure below exemplifies the locations of the gantries of ERP installed in the city of Singapore.

![Map of Selected Area](http://www.sgcarmart.com/news/carpark_index.php?LOC=all&SRH=&TYP=erp)

Figure 6-43 Good practice of ERP locations at Singapore

(2) Typical Specification

The typical specification of the equipment is as follows;

- Assuming 3 lanes road and only targeted for in-coming vehicle
- 1 local server for 1 place
- 2 Antennas for 1 lane
- 1 CCTV camera for 1 lane
- 1 vehicle detector for 1 lane
- 3 barrier gates for 1 lane
- 1 signal with 2 lumps (red and blue) for 1 lane
- 1 local control unit including control switch and communication unit for 1 lane
1 backup power supply system for 1 place
1 central monitoring and control system at ITSC
Excluding communication media such as optical fibre cable and GPRS

6-5-2 Lane Control System

(1) Purpose

The traffic demand of the road changes depending on the time of a day. The lane control system is used to dynamically maximise the capacity of the road infrastructure. It shifts the median or changes the direction of one-way in accordance with the traffic demand to reduce the congestion.

The necessary information for conducting the lane control is exchanged between the ITSC and related agencies such as the road administrators and traffic police. The information for the notification of the lane control is provided to the drivers through VMS from the ITSC. The lane shift is controlled by the ITSC. The historical record of shifting the lane is also accumulated in the server in the ITSC and utilised for analysis and planning for improvement of the traffic demand control.

(2) Service Flow

The overall service flow becomes as follows;

(a) Reversible Lane Control
- The ITSC collects the necessary information for reversible lane control from the road administrators and etc.
- The ITSC analyses and processes the collected information from road administrators.
- The ITSC sends necessary information to the traffic police when the road capacity becomes saturated.
- The ITSC displays the information on VMS for notification to the driver and start controlling the lanes as per the request of police.
- The ITSC provides the information of the status of the lane to the road administrators and related-agencies.

(b) One-way Driving Control
- The ITSC collects information of OD and vehicle class through in-vehicle device.
- The ITSC analyses and processes the collected information from road administrators.
- The ITSC sends necessary information to the traffic police when road capacity becomes saturated.
• The ITSC displays the information on VMS for notification to the drivers and start controlling one-way driving as per the request of police.
• The ITSC provides the information of the status of the one-way road to the road administrators and related-agencies.

(3) Typical Specification

The typical specification of the equipment is as follows;
• Assuming 1 shared lane on 1 flyover
• 2 sets for 1 lane (both sides of flyover)
• 2 signals with 2 lumps (red and blue) for both sides of flyover
• 2 information boards for both sides of flyover
• 2 barrier gates for both sides of flyover
• 1 local control unit including control switch and communication unit for 1 flyover
• 1 backup power supply system for 1 flyover
• 1 central monitoring and control system at ITSC
• Excluding communication media such as optical fibre cable and GPRS

6-5-3 Parking System

(1) Purpose

It provides the information on the parking availability before and during the trip. It also electronically collects the parking charge and stores the usage record of the parking. This contributes the maximum usage of the parking, preventing the fraud acts and assisting the proper parking planning based on the area wise demand.

The parking usage is monitored by the ITSC and the data on the parking usage record is collected and stored in the ITSC and utilised for planning for the improvement of parking facilities.

(2) Typical Specification

(a) Parking System (Basic System)

The typical specification of the equipment is as follows;
• Assuming a monitoring system which monitors vehicles at entrance and exit only
• 2 vehicle actuators at 1 entering lane and 1 exit lane
• 2 barrier gates at 1 inlet entering lane and 1 exit lane
• 1 outside information board for 1 parking area
• 1 local controller including control switch and communication unit for 1 parking area
• 1 local server for monitoring and operation for 1 parking area
• 1 backup power supply system for 1 parking area
(b) Parking System (Advanced System)

The typical specification of the equipment is as follows:

- Assuming a monitoring system that monitors each vehicle at each parking space
- 100 vehicle spaces for parking
- 100 vehicle actuators for each parking space
- 2 barrier gates at 1 entering lane and 1 exit lane
- 1 outside information board for 1 parking area
- 5 inside information boards for 1 parking area
- 1 local controller including control switch and communication unit for 1 parking area
- 1 local server for monitoring and operation for 1 parking area
- 1 backup power supply system for 1 parking area
- 1 central monitoring system at ITSC

Excluding communication media such as optical fibre cable and GPRS
### 6-6 Number of Proposed Devices to be Installed

The proposed numbers of devices are listed below.

Table 6-15: Number of Proposed Devices to be Installed

<table>
<thead>
<tr>
<th>Device</th>
<th>Phase-1</th>
<th>Phase-2</th>
<th>Phase-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATCC</td>
<td>68</td>
<td>170</td>
<td>454</td>
</tr>
<tr>
<td>MET SENSORS</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>FLOOD SENSORS</td>
<td>14</td>
<td>111</td>
<td>-</td>
</tr>
<tr>
<td>CCTV</td>
<td>55</td>
<td>375</td>
<td>449</td>
</tr>
<tr>
<td>VMS</td>
<td>42</td>
<td>54</td>
<td>100</td>
</tr>
<tr>
<td>SIGNAL (Part of HTRIMS)</td>
<td>221</td>
<td>179 (400 for Pedestrian)</td>
<td>222 (500 for Pedestrian)</td>
</tr>
<tr>
<td>POLLUTION</td>
<td>10</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>ERP</td>
<td>-</td>
<td>-</td>
<td>10</td>
</tr>
<tr>
<td>LANE CONTROL</td>
<td>-</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>PARKING SYSTEM</td>
<td>-</td>
<td>-</td>
<td>30</td>
</tr>
</tbody>
</table>

**Note:** Number of ERP, Lane Control and Parking System are roughly estimated.

It shall be noted that the number of the devices shown above in the phase-3 is approximate base. Those figures need to be re-examined in the future again.
ITS Master Plan for HMA
Hyderabad ITS
JICA SAPI Team

7 ITS Centre (ITSC) - Organisation Set Up
7-1 Examples of Control Centres in Other Countries

7-1-1 Japan

The Administrative Divisions are broadly categorised into four (4) groups in terms of management of the roads and traffic in Japan. They are:

- Traffic management
- General Road Management
- Metropolitan Expressway Management and
- Inter-city Expressway Management.

These four agencies have different roles and ITS control centres and facilities are prepared based on their roles.

(1) Traffic Administrator: Police

(a) Roles

The police are responsible for traffic management, stipulated by ‘Road Traffic Act’. The act defines the traffic management as ‘to assure and maintain smooth traffic by assuring the function of traffic and avoiding the traffic hazard’. The police are entitled for traffic regulation and traffic management by controlling the traffic signals and providing the traffic information to fulfil their roles.

(b) Centre and Coverage Areas

The Local Administrative Divisions are divided into forty seven (47) Prefectural Divisions. The Prefectural police department exists in each prefecture. Basically, one (1) control centre is prepared for each prefecture, and it monitors on the general roads (major roads excluding minor roads) and provides the traffic information for controlling the traffic.

In the case of Tokyo, one control centre covers approximately 25,000km, in terms of road length, in the area of approximately 2,200km² in Tokyo.

(2) National Road Administrator: Ministry of Land, Infrastructure, Transport and Tourism (MLIT)

(a) Roles

The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) is a national ministry for assuring comprehensive and systematic use of national land, development and security, and carrying out development of social capital, traffic policies, and maritime securities.
In terms of the road traffic, the MLIT is a national road administrator which is responsible for the management of the national road

(b) Centre and Coverage Areas

The Regional Development Bureau is a regional branch division under the MLIT, which is the in charge for development and management of national road, rivers, dam and port. There are ten (10) regional development bureaus under the MLIT in Japan. The national roads are management by the several branch offices under the regional development bureaus. Basically, one (1) control centre is prepared for one regional development bureau and the road condition is monitored.

In the case of Kinki regional development bureau, which is the second largest metropolitan area in Japan, one control centre covers approximately 2,000km in terms of road length.

(3) Expressway Operator: Metropolitan Expressway Company

(a) Roles

The metropolitan expressway company limited is an expressway operator for the metropolitan expressway in the capital region in Japan.

(b) Centre and Coverage Areas

The total length of the metropolitan expressway reaches approximately 322km. There are three (3) control centres in the area and each centre covers approximately 100km expressway. The feature of the metropolitan expressway is a complicated road network in the metropolitan area. Thus the centre carries out ‘area-wise management’ by exchanging information among them for such purposes as providing the alternative route information for the users, taking necessary actions within its own jurisdiction and etc.

(4) Expressway Operator: Inter-City Expressway Company

(a) Roles

The Administrative Divisions for the Inter-City Expressway in Japan are divided into three (3) divisions, East, Central and West, and they are managed by three (3) Inter-City Expressway companies, accordingly.

(b) Centre and Coverage Areas

Each expressway company has basically four (4) centres and each centre covers approximately 400 – 1,000km expressway. The feature of the Inter-City Expressway is not a complicated road network but long-distance and high speed. Thus, each centre exchanges information in a way that the road users comprehend the condition ahead to assure the safety.
(5) Japan Road Traffic Information Centre (JARTIC)

(a) Roles

In addition to the above, Japan Road Traffic Information Centre (JARTIC) is an important organisation for handling the traffic data. It collects all traffic data and information which was collected, across the nation, by ITS equipment installed by Police, MLIT and Expressway Operators, and provides the traffic information to public via internet homepage and mass communication such as radio and TV.

In particular, the JARTIC is a single organisation which is authorised by the law to sell the traffic data collected by the public sector to the private agencies such as information providers and navigation manufactures. The gained profit is used for the operation of JARTIC. The private agencies which purchase the traffic data provide more value-added traffic information services to the end users.

JARTIC also sends the collected data to Vehicle Information and Communication System Centre (VICS Centre). The VICS Centre is another ITS organisation for handling the traffic data to deliver to Police, MLIT and Expressway Operators and the traffic information is provided to the drivers via car navigation through ITS equipment on the road side installed by these agencies. Such traffic data is updated every five (5) minutes.

Public road users know the traffic condition via TV, radio, internet devices and car navigation system, and they can select either smooth traffic road or endure congestion at their discretion.

(b) Centre and Coverage Areas

JARTIC covers the entire areas in Japan. It is composed by two (2) major data centres. One is a backup centre. Thus all traffic data is collected and handed by a single huge data centre.

7-1-2 Singapore

The Traffic is controlled substantially by a single ITS Centre in Singapore, including collecting and providing the traffic information. In addition to this, there are two (2) different control centres in Singapore for specific purposes.

(1) ITS Control Centre

(a) Roles

It is a major single control centre which controls the traffic in Singapore. It is managed by Land and Transport Authority (LTA) Singapore. The roles include:

- Expressway Monitoring and Advisory System (EMAS), which monitors traffic along the expressway and provides information to the users,
- Green Link Determining System (GLIDE), which controls the traffic signals,
• Junctions Eyes (J-Eyes), which monitors the condition at the signalised junctions by CCTV,
• Integrated Transport System, which integrates the related sub-systems by combining all collected data from sub-systems and analyses for planning of the improvement of traffic and road infrastructure,
• Traffic Scan, which provides the traffic conditions on the entire area of Singapore through various medias including website to the user,
• Parking Guidance System, which provides the availability of the parking

(2) ERP Control Centre

(a) Roles
The electronic road pricing system (ERP) has been under operation in Singapore. The control centre for ERP is prepared exclusively for management of the ERP. The major roles include the facility monitoring, processing of the financial transactions and processing of violation of the ERP.

(3) Kallang Paya Lebar (KPE) Control Centre

(a) Roles
The KPE control centre is monitors the ITS equipment of the underground tunnel, which extends approximately 12km stretch. The equipment to be monitored includes speed enforcement camera, communication system, tunnel ventilation system and environment control systems.

The centres above reviewed have their own different roles and the ITS are deployed in accordance with their roles. The particular feature, in terms of the entire structure of these centres, is that any of these are not comprised as hierarchical structures. Rather, the operations are conducted by exchanging the necessary information among these centres especially between neighbouring centres to fulfil their roles.

7-2 Consideration for Hyderabad – ITS Centre Establishment

As exemplified above in the case of Japan and Singapore, it is a general practice to have a single control centre for monitoring roads and traffic at city level and the related information is exchanged as necessary among other neighbouring agencies such as road management agency, expressway operators.

The ‘management’ shall be considered in two different categories. One is monitoring the road and traffic condition by control centre, which shall include improvement planning as well, and the other is taking necessary spot actions at site such as dispatching the patrol cars or maintenance vehicles.
In terms of monitoring the road and traffic condition by control centre, the data management becomes complicated and difficult if they are managed by more than one centre. Thus in the case of traffic police in Japan, the traffic conditions are monitored by one single centre covering one prefecture.

In the case of Hyderabad, the case of the traffic police in Japan would be quite similar of its kind in terms of the roles and coverage areas. Hence, it is mostly appropriate to prepare one single centre and it exchanges the necessary information among the related agencies. In addition, it is expected that the data centre at national level, which collects the traffic data from the regional centres, will be prepared by the central government in the near future in India. In such case, the centre prepared in Hyderabad shall be a single point for collecting the data from the site and sending the data to the national data centre.

The structure for road and traffic management for taking spot actions at site shall be followed by the existing management structure which is currently taken by the traffic administrators i.e. traffic police and road administrators such as GHMC.

### 7-3 Roles of ITS Centre – Proposed for Hyderabad

**(1) Purpose of ITSC**

It is proposed to establish a single agency which plays a central roles for planning, operation, evaluation of ITS, traffic management and road infrastructure. The purposes of ITSC are as follows;

- It plays as a central engine for continuous ITS initiative to expand in Hyderabad,
- It assures the coordination with the National ITS Policy for ITS expansion in Hyderabad,
- It carries out the business with the private sector by selling out the generated traffic information for assuring the revenue for the operation of the ITSC,
- It functions as a central single agency responsible for planning, implementing, evaluating the ITS systems and development/expansion, and
- It collects all the road/traffic data and provides to the users and relevant agencies.

**(2) Functions of ITSC**

To realise the above, it is proposed to equip the following functions with the ITSC,

- Collection of traffic data from the road-side/probe based sensors and human based information through the related agencies (like Probe data of APSRTC etc),
- Traffic information provision to the public through internet, SMS, call centre,
- Traffic information provision for traffic flow control through VMS on road-side,
- Automatic traffic signal control and related facilities for traffic flow control,
- Analysis of real-time dynamic data and off-line based accumulated data for identifying bottle neck of traffic, before and after evaluation of the project,
• Planning and evaluation of traffic management and road infrastructure,
• Owning the right of traffic data generated by ITSC,
• Sales of the generated traffic information to private sector,
• Management of standardisation of ITS technologies and related data such as digital road map,
• Management of road inventory,
• Management of ITS equipment, and
• Operation and management of clearing house of common mobility card.

7-4 Organisation Structure

For the above functions, the following organisation structures Teams and skilled personal are at least required for the ITSC;

7-4-1 Organisation Structure - Teams

(1) Project Director

She/he is a personnel who supervises and is responsible for overall operations of the ITSC. She/he takes responsibility for reporting/coordination to/with upper level/external agencies as well.

(2) Traffic Monitoring and Control Division

It dynamically monitors the real time traffic conditions in the city by the data measured by the ITS equipment and supported by CCTV. It instructs to the officers at site as necessary in the case of traffic events, manipulates the ITS equipment for traffic control and coordinates with the necessary external agencies.

(3) Telephone Call Centre

It handles the enquiries from the general public and provides the advices and verbal information on traffic to them.

(4) Media Centre

It handles the enquiries from media such as new papers, radio stations, TV stations and etc and provides the information on traffic to them to be published.

(5) Research and Planning Division

It analyses the off-line based stored data on traffic. It plans necessary measures on infrastructure improvement and traffic management based on the analysis.
(6) **Equipment Maintenance Division**

It maintains the hardware ITS equipment.

(7) **Computer System Division**

It takes care for server systems in ITSC, software maintenance and network monitoring for ITS. The tasks include taking care for office system equipment in the Centre.

(8) **Commercial Division**

It handles the business for selling out the generated traffic information to governmental/non-governmental agencies for assuring the profit for ITSC operation.

(9) **Administrative Division**

This is a division which is required for running activities of ITSC as an organisation.

- Human Resource Section: It handles the personnel affairs required for ITSC,
- Finance Section: It handles the financial affairs required for ITSC,
- Accounting Section: It handles the accounting affairs required for ITSC,
- Legal Section: It handles the legal affairs required for ITSC,
- Public Section: It handles public relations and accountabilities for ITSC, and
- General Affairs Section: It handles such affairs as labour management, welfares etc

(10) **Staff Division**

- Cleaning and Helpers: It takes care for cleanings and any support required for daily activities

The Figure below shows the structure of organisation in case that the ITSC is established as a single agency.
Figure 7-1 Organisation Structure (Single Agency)

The Figure below shows the structure of organisation in case that the ITSC is prepared as one of the departments under existing agency. The possible agency is HMDA or Traffic Police.

Figure 7-2 Organisation Structure (Under Existing Agency)
The structure will be more simplified if the ITSC is prepared under such agency. For example, the administrative division may not be required because the existing such division may be able to be utilised. However in such case, the commercial division which handles the business for selling out the generated traffic information for assuring the profit for ITSC operation will become required to be separately prepared because the existing such agency is a governmental sector.

### 7-4-2 Organisation Structure – Skilled Personnel

For the above mentioned functions at the ITSC, the following skilled personal are required at ITSC. These personal shall report to the project director and work under him.

(1) **Senior Transport/Traffic Engineer**

The senior transport/traffic engineer shall have at least 10 years of working experience in the road transport and traffic management. The roles and responsibilities of the transport/traffic engineer are as follows:

- Analysing and interpreting data gathered by transport studies
- Forecasting the impact of new developments
- Examining the scheme for traffic management.
- Exercising traffic modelling and simulation
- Investigating the accident 'black spots' to plan road safety improvements

(2) **Senior ITS Engineer**

The senior ITS engineer shall have at least 10 years of working experience with a minimum of 5 years in ITS development, operation and maintenance projects. He shall have extensive knowledge of ITS technology and sufficient experience of ITS operation and maintenance.

(3) **Senior Electric Engineer**

The senior electric engineer shall have at least 10 years of working experience with a minimum of 5 years working experience in the field of traffic and transport.
(4) **Senior Network Communication Engineer**

The senior network engineer shall have at least 10 years of working experience of managing computer hardware and software. He shall have expertise in managing hardware servers and workstations of all leading manufacturers such as HP, DELL, IBM, Sun Solar, Intel etc., and operating systems such as Windows, Mac, and Linux etc. He is responsible for installing, supporting and maintaining server hardware and software infrastructure, managing email, anti-spam and virus protection, setting up user access control, monitoring network and rectifying the communication related issues.

### 7-5 Organisation Framework - Formation of SPV

The benefits of ITS will only be realised by establishing a suitable framework of organisation. The organisation shall be vested with authority to coordinate with various stakeholders and take necessary policy decisions.

Based on such considerations, it is recommended to establish a Special Purpose Vehicle (SPV) by the following reasons:

- The strong leadership is required for continuous initiatives for ITS in Hyderabad regarding the condition where any substantial ITS have not been in place,
- The coordination among related agencies are strongly required due to the characteristics of ITS, of which domain extends across the different agencies. The different agencies include the central government in line with the National Level ITS Policy, neighbouring administrative bodies in Andhra Pradesh State, agencies in transportation sectors and parties in the private sectors,
- The simple structure for operation and coordination among the related agencies is more favourable, considering the current condition of the complex jurisdictional structures in the road transport sector, and
- The ITSC shall have a function for conducting businesses for revenue generation by interacting with the private sector.

The following steps shall be ensured for formulating the effective organisation as SPV:

- Identify the stakeholders of the ITS in the HMA,
- Identify and develop the shared responsibilities and goals for all the stakeholders,
- Identify and evolve a mechanism within the organisation for well established coordination among the stakeholders, public and private agencies,
- Involve the stakeholders during the phased wise implementation of ITS in the city, and
- Establish operation procedures in terms of processes and resource management within the organisation.
The major stakeholders are listed below:
- Hyderabad Metropolitan Agency (HMDA),
- Greater Hyderabad Municipal Corporation (GHMC),
- Hyderabad Traffic Police,
- Cyberabad Traffic Police,
- Andhra Pradesh State Road Transport Corporation Ltd (APSRTC), and
- Road Transport Authority (RTA)

Other Related Public Agencies:
- Hyderabad Metro Rail (HMR),
- Andhra Pradesh Pollution Control Board (APPCB),
- Andhra Pradesh State Development Planning Society (APSDPS),
- Road & Building Department,
- Emergency Management and Research Institute (EMRI),
- Centre for Development of Advanced Computing (C-DAC),
- National Informatics Centre (NIC),
- Centre for Railway Information System (CRIS), and
- Academic Institutions (such as NIT, Warangal)

Other Related Private Agencies:
- Taxi companies such as meru cabs, cell cabs, and etc.,

The SPV shall function as an execution body for operation, planning, evaluation of ITS. It shall be jointly invested by such agencies as HMDA, GHMC, RTA and APSRTC. The human resources are provided by these agencies. It owns and maintains the ITS equipment, monitors the traffic flow and controls the traffic. The decision on the traffic control is made by the personnel deputed from the traffic police to the ITSC.

It shall be ensured that the detail roles and responsibilities within the SPV are defined and adhered. The hierarchical structure, and roles and responsibilities of individual teams within organisation need to be defined so that the operation, planning and evaluation are properly handled. Then, the proper relationship within organisation needs to be defined and maintained to avoid ambiguity and communication gaps.

The organisation structure shall include management group, policy establishment group and a working group to continuously evaluate and evolve the ITS technology implementation in the city.

The management group shall be responsible for operation and management of ITS. The responsibility also includes coordinating amongst stakeholders, planning and carrying out capacity building and training.

The policy group shall be responsible for policy making, ensuring support for funding for ITS.
The working group shall be staffed by the experts from academics, private and public agencies to ensure sufficient collaboration amongst industry, private, public and academic institutions. The working group shall be responsible to report to the policy group on the evaluated benefits of ITS and recommendations for necessary actions.

![Organisation Framework - Formation of SPV](image)

Figure 7-3 Formulation of SPV for ITSC
8 Economic Analysis

The economic analysis is carried out to estimate benefits brought by the ITS and validate the implementation of ITS.

8-1 Basic Conditions for Analysis

The basic conditions for the economic analysis are set out as follows;

- Target Years: 2015, 2020, and 2030
- Project Period: 20 years
- Target Area: Inside Outer Ring Road

8-2 Methodology for Analysis

(1) Current and Future Traffic Demand Forecast

The effect of ITS is measured on how much the implementation of ITS contributes to alleviation of traffic congestion. Thus, the current traffic demand in the year of 2011 is reproduced, and the future traffic demand respectively in the year of 2015, 2020 and 2030 is forecasted on the condition of absence of ITS implementation, as the first step.

The reproduction of the current traffic demand is based on the result of current O/D and traffic volume survey and adjustment incorporating the existing relevant traffic data.

The future traffic demand is forecasted by extending the reproduced current O/D, applying the coefficient of extension obtained by the relevant existing data.

(2) Estimated Benefit of Three Cases: With and Without

The benefits for the following three cases, with and without for each case, are estimated. The benefits are expressed by monetary value in terms of saving travel time cost in USD per year.

Case 1: Signal Installation (only): With and Without
Case 2: Information Provision (only): With and Without
Case 3: Signal Installation and Information Provision (combined): With and Without

Signal Installation

It is presumed for the analysis that the signals are installed at the junctions of major roads in the city. The major roads include NH, SH, IRR and other major secondary roads.
Information Provision

It is presumed for the analysis that the real-time traffic information is provided to the drivers, and the drivers become enable to select the optimum route in the city.

In strict meaning in terms of estimating the benefit brought by ITS implementation, the evaluation of ‘Information Provision’ would be sufficient. However with and without cases of signal installation are also provided because the signal is one of the important influential factors on the traffic.

(3) Economic Evaluation: EIRR, NPV, B/C

The economic evaluation is carried out for the above case 3, signal installation and information provision (combined). The following three evaluation indicators are calculated based on the traditional Discount Cash Flow (DCF) method;

- Economic Internal Rate of Return (EIRR)
- Net Present Value (NPV)
- Benefit / Cost Ratio (B/C)

The flow of economic evaluation is shown in the figure below.

![Flow of Economic Analysis](image)

Source: JICA Study Team

Figure 8-1 Flow of Economic Analysis

The cost for installation and operation and maintenance which are incorporated into the above shown economic evaluation are estimated as presented below.

The details of the approximate cost mentioned in the below table are provided in the section of 9.1 ‘Approximate Cost of each Phase Implementation’.
8-3 Traffic Demand Forecast

(1) Current Traffic Demand

The figure below shows the result of reproducing the current traffic demand in the year of 2011. It shows that the major traffic flow is concentrated in the National Highways and Inner Ring Road.

![Current Traffic Analysis (Year 2011)](image)

(2) Future Traffic Demand

The traffic demand will be diverted to the outer ring road and the roads which connect with the ORR due to the development of the ORR. The concentration of the traffic is observed on NH9, NH7, NH202, IRR, ORR and others in the vicinity of Hussainsagar, in particular. It is expected that the traffic will further concentrated on these roads in the year of 2020 and 2030.
The result of traffic assignment and traffic demand are shown in the tables and figures below.

Table 8-1  Result of Traffic Assignment at Arterial Road

<table>
<thead>
<tr>
<th>Year</th>
<th>Road</th>
<th>Traffic Volume (Average PCU/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>NH7</td>
<td>42,875</td>
</tr>
<tr>
<td></td>
<td>NH9</td>
<td>80,803</td>
</tr>
<tr>
<td></td>
<td>NH202</td>
<td>98,868</td>
</tr>
<tr>
<td></td>
<td>IRR</td>
<td>65,807</td>
</tr>
<tr>
<td></td>
<td>ORR</td>
<td>22,408</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>32,817</td>
</tr>
</tbody>
</table>

Source: JICA Study Team

Figure 8-4  Traffic Assignment Result 2015
8-4 Result of Economic Analysis

(1) Estimated Benefit

The benefits of three cases derived by with and without are estimated as shown in the table below. The results indicate positive impact for all three cases. Thus the implementation of ITS can be judged as effective.
Table 8-2 Summary of Benefit

<table>
<thead>
<tr>
<th>Case</th>
<th>Benefit(Without-Without) Unit: Million USD/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2015</td>
</tr>
<tr>
<td>1. Signal Installation</td>
<td>80</td>
</tr>
<tr>
<td>2. Information Provision</td>
<td>16</td>
</tr>
<tr>
<td>3. Signal Installation &amp; Information Provision</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: JICA Study Team

Note: The following notes are supplemented for the above case 2, Information Provision (only), and case 3, Signal Installation and Information Provision (combined).

The ITS facilities for data collection and information provision will be introduced by step-wised manner. Furthermore, it is expected that the road users who are able to obtain the real-time traffic information generated by the ITSC by such means as terminal devices will be gradually increased.

Thus, in consideration of this, the availability of the real-time traffic information to the road users is adjusted respectively at 10% in 2015, 30% in 2020 and 50% in 2030.

(2) Economic Evaluation

The results of the economic evaluation for the case 3 are summarised below.

Table 8-3 Result of Economic Evaluation

<table>
<thead>
<tr>
<th>Evaluation Indicators</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIRR</td>
<td>83.7%</td>
</tr>
<tr>
<td>NPV</td>
<td>277.8 Mil USD</td>
</tr>
<tr>
<td>B/C</td>
<td>9.19</td>
</tr>
</tbody>
</table>

Source: JICA Study Team

It is concluded that the ITS implementation is economically feasible because the EIRR is higher than the opportunity cost of capital (>12%), positive value of NPV (>0) and B/C higher than unity (>1.0).

This is because that the ITS implementation does not require a large-scale infrastructure development and a low cost compared to general civil works such as road/bridge constructions.
# Financial Plan

## Approximate Cost of each Phase Implementation

The approximate cost for the phased-wise implementation is shown in the Table below. As the nature of ITS, the technological advancement is very rapid and the involved factors for estimate such as the systems to be introduced in future are not clear now. Therefore, the costs including the operation and maintenance are estimated only for phase-1 and phase-2 as follows.

### Table 9-1  Approximate Cost by Phase (Unit in INR)

<table>
<thead>
<tr>
<th>Cost Type</th>
<th>Items</th>
<th>PHASE 1</th>
<th>PHASE 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital cost</td>
<td>Equipment Capital Cost</td>
<td>1,10,36,00,000</td>
<td>3,40,66,00,000</td>
</tr>
<tr>
<td>Equipment Maintenance Cost</td>
<td>1st stage Cost</td>
<td>11,03,60,000</td>
<td>11,03,60,000</td>
</tr>
<tr>
<td></td>
<td>2nd stage Cost</td>
<td>0</td>
<td>34,06,60,000</td>
</tr>
<tr>
<td>Cost spread across 5 years</td>
<td>Equipment maintenance Cost</td>
<td>33,10,80,000</td>
<td>1,57,37,80,000</td>
</tr>
<tr>
<td></td>
<td>Human Resource Cost</td>
<td>14,19,50,000</td>
<td>22,87,10,000</td>
</tr>
<tr>
<td></td>
<td>Organisation Operation Cost</td>
<td>13,59,00,000</td>
<td>21,88,70,000</td>
</tr>
<tr>
<td></td>
<td>Total Maintenance Costs</td>
<td>6,08,930,000</td>
<td>2,02,13,60,000</td>
</tr>
</tbody>
</table>

Equipment maintenance cost estimated as 10% of equipment capital cost on year-to-year bases and escalation cost and DLP are not considered.

Human Resource cost includes salaries to the ITSC staff and is estimated for Phase-1 (for years 1 to 5) and Phase-2 (for years 6 to 10) on yearly basis considering year to year increment of 10% in the cost. An increment of 10% is considered based on the fact that inflation and other related economic factors influence the increase in the human resource costs.

Organisation Operation cost includes power usage, Communication usage, Transport usage and Water usage etc. These costs are also considered for Phase-1 (for years 3 to 5) and Phase-2 (for years 6 to 10) on yearly basis considering year to year increment of 10% in the cost, because of inflation and other influencing factors.

Despite the difficulties in estimating the cost in the phase-3 in regard of the nature of ITS as described above, the capital cost for the expectable major components are estimated.

**Note:** The ITSC cost, related to civil/infrastructure development costs were not considered as it is assumed that these will be arranged by HMDA. The Operational cost calculation mentioned above is based on the consideration of the devices proposed as part of city ITS and the related communication, power usage etc and not included for those devices/infrastructure proposed under HTRIMS.

The breakdown of the capital cost by phase is show in the Table below.
### Table 9-2: Approximate Capital Cost by Phase (Unit in INR)

<table>
<thead>
<tr>
<th>No.</th>
<th>Devices</th>
<th>PHASE 1</th>
<th>PHASE 2</th>
<th>PHASE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Units</td>
<td>Approx Cost</td>
<td>Units</td>
</tr>
<tr>
<td>1</td>
<td>ITS CENTRE</td>
<td>18,21,21,500</td>
<td></td>
<td>5,11,80,000</td>
</tr>
<tr>
<td>2</td>
<td>TRAFFIC SIGNALS</td>
<td>221</td>
<td>(HTRIMS) 0</td>
<td>179</td>
</tr>
<tr>
<td>3</td>
<td>PEDESTRAIN SIGNALS</td>
<td>0</td>
<td>0</td>
<td>400</td>
</tr>
<tr>
<td>4</td>
<td>TRAFFIC COUNTERS</td>
<td>68</td>
<td>15,03,04,000</td>
<td>170</td>
</tr>
<tr>
<td>5</td>
<td>CCTV</td>
<td>55</td>
<td>3,41,00,000</td>
<td>375</td>
</tr>
<tr>
<td>6</td>
<td>MET SENSORS</td>
<td>6</td>
<td>3,07,47,200</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>FLOOD SENSORS</td>
<td>14</td>
<td>1,29,80,000</td>
<td>111</td>
</tr>
<tr>
<td>8</td>
<td>VARIABLE MESSAGE SIGNS(VMS)</td>
<td>42</td>
<td>56,53,56,000</td>
<td>54</td>
</tr>
<tr>
<td>9</td>
<td>POLLUTION SENSORS</td>
<td>10</td>
<td>7,53,50,000</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>Subtotal</td>
<td>1,05,09,58,700</td>
<td></td>
<td>3,24,42,93,000</td>
</tr>
<tr>
<td>11</td>
<td>Contingency (Approx. 5% of Above Subtotal)</td>
<td>5,25,47,935</td>
<td></td>
<td>16,22,14,650</td>
</tr>
<tr>
<td>12</td>
<td>Total Estimated Approx Cost</td>
<td>Ph-1 (1,10,35,06,635)</td>
<td></td>
<td>Ph-2 (3,40,65,07,650)</td>
</tr>
</tbody>
</table>
9-2 Revenue Scheme in General

(1) Summary of Possible Revenue Schemes

The possible revenue schemes in general exist as follows;

- Expenditure by Tax (basic principle)
- Toll Charge Collected by Electronic Road Pricing (ERP), Imposed on the Road Usage
- Introduction of Special Purpose Fund for Road Sector (e.g. Increment of Fuel Tax, Vehicle Taxes etc)
- Advertisement
- Selling Out Data
- Selling Out Traffic Information to Road Traffic Information Providers
- Service Charges for Clearing House of Common Mobility Card

(2) Basic Principle

Preparation of ITS will be taken-up generally in parallel with Road infrastructure development and this helps the local authority to reduce the costs of implementations. Across the world, development of road infrastructure and the related instalments are generally part of the Government expenditure as a provision of public service/project and are covered by the tax collected. In essence, ITS shall be regarded as a social infrastructure which is an extension of road infrastructure.

However, funding for the Road and related infrastructure is taken-up under various schemes across the world. Many of the transport related infrastructure in the major cities of the world are prepared by the public private partnership (PPP) and are operated / managed by collecting various kinds of services charges from the users such as express way user charges, navigation guidance provision fees and BOT etc. Singapore is one of the countries where the electronic road pricing (ERP) as a traffic demand management has been successfully implemented and the scheme of the collection of the charges from the users are well established.

Some of the possible schemes for revenue generation are exemplified as follows.

(3) Expressway Usage Charges

It is a normal aspect to collect usage fee from the users in the case of the expressway, the toll road in a certain section, bridges and etc for the construction and maintenance these Road, Bridges and etc.
In Japan, Toll charges on the expressway are collected from the expressway road users on the bases of the beneficiary payment principle. Nowadays in Japan, the toll charges are collected at exit by the electronic toll collection system using the on-board unit installed on the vehicles. In U.S.A., the costs for the expressway are covered by the tax. In Europe, the toll charges on the expressways are collected from the large-sized trucks in recent years. As the road network expands to all over Europe nowadays; the cost for maintenance for the damage on the road caused by the passing vehicle became an issue. The toll charges are collected from the trucks based on the used distance by detecting the GPS.

(4) Congestion based Charges

Congestion Charge is a variable toll charge that depends on the level of congestion and is intended to reduce the congestion by discouraging vehicles to use specific roads during peak hours of traffic and also reduce the environmental pollution as pollution levels increase with the level of congestion. This kind of charge is collected in the form of ERP in Singapore.

These methods of road pricing were started with the theory that usage charges are not only for the construction and maintenance of roads, but these charges shall depend on externalities such as congestion because of using in peak hours, pollution and noise etc. It is a general opinion that Driver must pay for the externalities he impose on others.

The ERP system is based on a relatively simple dashboard-mounted device. Motorists insert a cash card into the In-vehicle Unit (IU) when they are on the road. As their cars pass overhead gantries set up along the strategic roads, the card-reader is activated by a microwave signal. There is a beep and the toll is deducted from a Cash Card – a pre-paid smart card, which can be credited at all local post offices, banks, petrol kiosks or automated teller machines.

![Figure 9-1 Levels of Pollution Depends on Congestion Level](image)
(5) Car Navigation, Smart Phone, Internet

In Japan, vehicle information communication system (VICS) is a leading road traffic information provision system which is available in nation-wide. The road and traffic data is collected from the road administrators and police and the data is edited and distributed by the VICS centre, a semi-governmental organisation. The road/traffic information distributed by the VICS centre is provided to the users by the car navigation. The car navigation manufactures are obliged to pay certain amount to the VICS centre for covering the cost. The small amount for this payment is included in the unit hardware price of the car navigation, in turn collected from the car navigation purchasers.

In the case of the smart phone and inter-net, the users pay the fees for the information on congestion to the service providers. But in the case that the information service is offered free of charge, the service providers cover their cost by the advertisement fees in general.

(6) BOT

The BOT scheme is applied to the road construction and maintenance in many cases particularly in the developing countries which face the chronic budgetary deficit. In general, the concessionaire is given a certain period for construction and operation, and they collect these costs by charging from the road users and cover the cost for construction, operation and maintenance.

The BOT scheme is applied to the southern section of the ORR. In the case of the BOT on ORR, the concessionaire is paid the annuity by the AP government. The source of the annuity is covered by the tax, which means that the cost for the operation and management of the ORR is being borne by the general public. The advantage of this case is that the management of the road by the concessionaire as the private sector becomes stable because the revenue for them is assured.

The traffic signal jumping enforcement system (E-Challan System) of the traffic police has been prepared and operated by the BOT. The concessionaire obtains 20% of the penalties collected from the violated road users. It is assumed that the costs for 20% increment provided to the concessionaire can be sufficiently covered by the violation penalties amount increased by introduction the system.

The concessionaire of the bus location system, which is under preparation by the APSRTC, obtains 10% of the bus fees. It is also assumed that the cost for 10% can be covered by the increased bus usage because of improved convenience by introducing the bus location system.
(7) Cases in Other Countries

For ITS implementation on highways, the road construction includes the cost of ITS implementation and can be executed under BOT scheme. The maintenance cost is supported through collection of charges such as ETC toll collection. However, in the case of the roads in the city, the ITS cost has to be managed by employing scheme as preparation of a fund with such components as tax collection on fuel, fee for vehicle registration renewals once in 2 to 3 years, electronic road pricing (ERP), etc.

In the case of Japan, ITS maintenance is the responsibility of police and is run through state funding.

In Singapore, the ERP system has been in place since 1998 for traffic demand management in the city and on the 1st day of its implementation, the usual morning rush hour traffic from 7:30 a.m. to 9:30 a.m. along one of the heavily congested roads were decreased by 17%.

In Indonesia, as part of efforts to ease traffic congestion, the Government has passed the regulatory law in June, 2011 for ERP implementation in five major cities Medan, Jakarta, Surabaya, Bandung and Makassar.

In Vietnam, as a communist country, all systems are owned by the Government and ERP was implemented in Ho Chi Minh City (HCM).

9-3 Proposed Revenue Scheme for ITS Centre

The possible revenues can be mainly categorized into two (2) different sources as follows

- The one is from public fund such as tax.
- The other is from selling out the traffic information to the interested parties including public and private sectors.

(1) Tax & Annuity Model

In essence, the traffic information is to be provided to the public as public services. The traffic flow control is also to be offered to the public for realizing better condition of the traffic. Thus these do not generate any revenues. In other words, this aspect holds legitimacy for being covered by the public funds. In this case, provision of annuity is required to cover the operation and maintenance of ITSC.
(2) **Commercial Model**

On the other hand, the generated traffic information based on the dynamic real time traffic movement or aggregated data on traffic based on the statistics will have added-value. They can be utilised for a number of purposes. For example utilisation for more accurate arrival time of APSRTC buses or taxies, infrastructure improvement/urban development, market analysis for commercial activities by private companies and etc.

In other words, it holds a possibility that the generated traffic data by the ITSC can be sold out to the interested parties in both government and private sectors.

(3) **Proposed Model (Combination of Above)**

Suppose that the ITSC is established as SPV, the combination of the tax & annuity and commercial model, called Hybrid Model is appropriate.

The capital cost is provided by JICA Loan to the Government. The ITS equipment is prepared and owned by the Government through the SPV. The SPV assures the quality of services and products which is generation of traffic data. The traffic data is to be sold out by SPV to the interested parties. Some proportion of the income obtained by this will be utilized for operation and maintenance of ITSC and remaining proportion will be given to the government for the Loan repayment.

The traffic information and traffic control will be offered to the users as public services. The certain amount of the cost for the operation and maintenance of ITSC will be collected through the tax from the users to the government in return of the services provided by the ITSC. The required cost for operation and maintenance will be provided by the government to the ITSC in the form of the annuity.
(4) Other Options

In addition to the above recommended model, other options are exemplified for considerations as follows;

(a) ITS Centre: Build by Government, Operated and Maintained by SPV

Figure 9-3 Build by Government, Operated and Maintained by SPV
The above both show the cases of creation of SPV for operation and maintenance of ITS equipment and facilities. In this case, the Government builds ITS equipments and facilities and the SPV operates and maintains, which are the same with the recommended hybrid model above in this aspect. The differences between the figure on the left and right are the revenue sources, namely either commercial base or tax base.

(b) ITS Centre: Build, Operated and Maintained by Government

The above both show the cases directly operated by the Government. The Government builds the ITS equipment and facilities and takes care for operation and maintenance as well. In these cases, the ITSC will be prepared and operated under the division of the existing governmental agency.

The figure on the left shows the fee collection model under this scheme. The Government directly gains the revenue by selling the traffic data as their products to the interested parties.

The figure on the right shows the tax collection model under this scheme. The operation cost will be covered by the tax revenue.
The above both show the cases that the ITC Centre is built and operated under BOT scheme by the private agency. The differences between the figures on the left and right are the revenues sources, namely by commercial base or tax/annuity base.

Neither above are recommendable due to the following reasons;

- The revenue is not sufficient for assuring both benefit for the concessionaires and covering the cost for the operation,
- The entire system will be handled by the concessionaires in these cases. This is not suitable in regard of the concept and roles/responsibilities of the ITSC. The initiatives need to be taken by the governmental side.

**9-4 Possible Schemes for Revenue Generation**

**9-4-1 Most Likely Scenario**

Whilst the Hybrid Model which is a combination of Tax& Annuity and Commercial Model is proposed, the most likely scenario is more elaborated to realise the revenue generation.

The provision of ITS services realised by the ITSC as proposed in the Master Plan is first of its kind in India. Thus, it may take certain period until the general public become aware of the benefits of the ITS services provided by the ITSC. In such circumstances, it would not be practical to leverage avenues such as tax or user fee collection from the public for covering the required cost unless the general public sufficiently appreciate the benefit. It shall expect that such a process may take at least two (2) years, at the shortest, after commencement of the operation.
Thus, the operation and maintenance cost may need to be covered solely by the Governmental fund during this initial period. Once the benefit is fully recognised by the public, the following options will become possible;

Table 9-3 Possible Schemes for Revenue Generation

<table>
<thead>
<tr>
<th>Model</th>
<th>Revenue Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tax &amp; Annuity Model</td>
<td>Collection of ITS User charge at the time of new Vehicle registration</td>
</tr>
<tr>
<td></td>
<td>Strengthened Enforcement</td>
</tr>
<tr>
<td></td>
<td>Reallocation of life tax</td>
</tr>
<tr>
<td></td>
<td>Reallocation of e-Challan</td>
</tr>
<tr>
<td></td>
<td>Reallocation of property tax</td>
</tr>
<tr>
<td>Commercial Model</td>
<td>Advertising</td>
</tr>
<tr>
<td></td>
<td>Sales of traffic data</td>
</tr>
</tbody>
</table>

9-4-2 Tax & Annuity Model

(1) Collection of ITS User Charges at the Time of New Vehicle Registration

The nominal fee called ITS charge to be collected at the time of vehicle registration is one of the conceivable options for revenue for ITSC.

The RTA currently collects three types of fees from the car owner at the registration of new vehicle as follows:

- Life tax (12% or 14 % according to car price)
- Registration fee (INR 20-600 according to car type)
- User charge (INR 100-200 according to car type)

The vehicle registration per year is approximately estimated at 3,50,000. It is suggested that an amount of INR 1,000 is collected from each vehicle at the time of new vehicle registration and generates an annual revenue of 35 crore INR.

Table 9-4 ITS User Charge for Revenue Generation

<table>
<thead>
<tr>
<th>Items</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Registered per Year in Hyderabad City</td>
<td>3,50,000</td>
</tr>
<tr>
<td>Consider ITS User Charge per Vehicle</td>
<td>INR 1,000</td>
</tr>
<tr>
<td>Annual Revenue from ITS User Charge Collection</td>
<td>INR 35,00,00,000</td>
</tr>
</tbody>
</table>
(2) Increase of Fine Collected by Enforcement

It is reported that 70% of work-load of the traffic police is spent on traffic regulation and only 30% of the work-load on the enforcement. It is mostly assumed that such large proportion on the traffic regulation is due to the adverse traffic conditions and existing traffic signals, of which 40% are not properly working.

If the road traffic infrastructure is improved, the enforcement can be strengthened spending more human resource of the traffic police on the enforcement activities. It will consequently lead to increment of collection of e-Challan.

(3) Lift Tax Collected by RTA

The annual life tax is collected by RTA and the amount is reported at about INR 673 crore per year. It is proposed that a few % of this amount be relocated to ITSC.

(4) E-Challan Collected by Traffic Police

Yearly E-Challan amount collected by traffic police is estimated to be INR 36 crore. It is proposed that a few % of this amount be relocated to ITSC.

(5) Property Tax Collected by GHMC

Yearly property tax collected by GHMC is estimated to be about INR 517 crore. It is proposed that a few % of this amount be relocated to ITSC.

9-4-3 Commercial Model

(1) Revenue Generation by Advertisements

When the ITSC offers traffic information to public through website, SMS and E-mail, advertisement can be introduced to generate revenue. The income generated by advertisements will proportionally increase with the increase in number of users of the ITS System.

Possible revenue generation from advertising is as summarized below.
Table 9-5  Revenue Generation by Advertisement

<table>
<thead>
<tr>
<th>Items</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Population in Hyderabad City (RTA figures 2010)</td>
<td>Vehicle count: 36,83,000</td>
</tr>
<tr>
<td>Consider 5% of total vehicle owners use Traffic Information provision</td>
<td>Assumed user count: 2,00,000</td>
</tr>
<tr>
<td>Consider Vehicle Owners use 10 times/day</td>
<td>20,00,000 usages / day</td>
</tr>
<tr>
<td></td>
<td>(200,000 x 10 = 20,00,000)</td>
</tr>
<tr>
<td>Consider Advertisement fee</td>
<td>Assuming INR 0.10 per usage</td>
</tr>
<tr>
<td>Estimated Total Revenue from Advertisement</td>
<td>7.30 Crore INR/Annum</td>
</tr>
<tr>
<td></td>
<td>(20,00,000 x INR 0.10 x 365 days)</td>
</tr>
</tbody>
</table>

(2) Revenue Generation by Selling Out Traffic Related Data

The ITSC collects and aggregates various data such as travel speed, traffic volume, vehicle type, vehicle density, flood, rainfall, wind direction and etc.

It shall be offered to public by free of charge. But the ownership of the data should belong to the owner of ITS equipment. If the ownership of the data is not defined, the data can be copied and modified by unknown users.

Such aggregated data is quite useful and valuable in terms of comprehension of the traffic conditions and analysis for future status. Hence, there is high possibility of demand for the data by such agencies as government, marketing companies, consultant and investors etc.

The examples of the aggregated data which can be sold include;

- Traffic volume
- Travel speed
- Congestion status
- Vehicle classification
- Weather condition
9-4-4 Conclusion

The conceivable annual revenue scenarios are summarised in the above section. As is being explained above, Hyderabad city is going to be the first Indian city to have the ITS in India and it is very important to take necessary measures by the administration during the initial phases of such implementation to promote and build confidence of the public for such initiatives. It may be difficult to convince the public about the benefits of such utility initially and generate revenue for the ITSC from the day one of the project operation. But with the continuous usage and provision of basic user services by the ITSC, public will surely recognize the benefits of the system and accept to pay for additional services.

Under such scenario, it is proposed that the ITSC may provide the basic services to the public free of charge during the initial 2 years of the system operation and slowly introduce the collection of ITS user charge on all new vehicle registrations. This shall generate substantial amount of revenue for the ITSC for its long term sustainability and introduction of new ITS initiatives in Hyderabad city.

To supplement the revenue, the ITSC can generate additional revenue through selling the data to various organisations, advertising while data provision to users and other avenues as mentioned in the above sections.
The capacity building is one of the most important components that shall be in place to assure sustainable operation and management of ITS over a long period of time, in regard of such aspect as new technology in particular.

The involved personnel and professionals shall be equipped with adequate skills and competencies of ITS technologies and operations. Thus, it is important to draw plans for training and surely carry out them to enable continuous improvement of their skills for proper operation and management, understanding the overall trends of current ITS and available technologies in the world.

(1) **Target**

The target of the capacity building shall be i) the staff in the ITSC and ii) personnel in the related agencies.

(2) **Component**

The following components shall be included.

**Attending the Seminar:** Including domestic and international seminars

**Participating in the Technical Study Tour:** Including ITS world congress, site tour in India and overseas to learn the best practices such as Delhi Integrated Multi-Modal Transit System in New Delhi, ERP/LTA Systems in Singapore, ETC/Traffic Control Systems in Japan, etc

**On the Job Training (OJT):** Including conducting operation/management of ITS analysis of collected data using analysers at ITSC, participating in consultancy services as project members of ITS project, etc

**Presentation:** Including making presentation at domestic/international congress and publishing technical papers on domestic/international forum, etc

**Assessment:** Including self assessment and third-party assessment on skill improvement

(3) **Methodology**

The above components shall be carried out like PDCA cycle so that the skills are progressively improved as illustrated in the figure below.
(4) Supporting Unit

The Project Management Unit (PMU) shall be formed and involved in implementing ITS projects and operating the ITS facilities. The JICA experts shall be dispatched and assist for operation and management of ITSC and facilities. The PMU and JICA experts shall collaborate in these activities.

The figure below shows the process of capacity building program by the PDCA cycle.

![Diagram](image)

Figure 10-1 Methodology for Capacity Building

The above components for the capacity building shall be carried out like PDCA manner so that the competency can be progressively reinforced. The cycle among OJT, presentation and assessment can be repeated.
11 Other Proposed Measures

Apart from the all above, the following measures are recommended to be carried out.

11-1 Best Practice Zone

In order to demonstrate the effectiveness of measures on improvement of the traffic and show the best practice to the citizens, the following measures are recommended to be carried out in a selected areas/sections as best practice zone.

(1) Alternative-1: Demonstration of ITS in High Tech City (Route Guidance to Airport)

The High Tech City is the area where relatively affluent people reside and commute to the centre of the city.

The show-case to the public is to be demonstrated by providing the optimum route guidance for alternative route from High Tech City to the Hyderabad Rajiv Gandhi International Airport by the Graphical Variable Message Signboard. The information to be provided to the public includes highly accurate expected travel time to the airport as well.

This will be realized by combination of intensive installation of the ATCC on radial road 6 and NH-44 (old NH-7) from IRR to the Airport, bus probe data and graphical VMS. The installation interval of the ATCC shall be 1 – 2 km.

This will also be carried out for the purpose of demonstration of the technical experiment for generation of travel time and congestion information calculated based on the data from ATCC and bus probe.

(2) Alternative-2: Demonstration of ITS in Secunderabad (Congestion Information Provision)

The Secunderabad is the area where a number of ordinary people enjoy their activities such as shopping.

The show-case to the public is to be demonstrated by providing the congestion information by the Variable Message Signboard in Secunderabad. The information to be provided to the public includes highly accurate expected travel time in the area.

This will be realized by combination of intensive installation of the ATCC in the area of the Secunderabad, bus probe data and VMS. The installation interval of the ATCC shall be 1 – 2 km.

This will also be carried out for the purpose of demonstration of the technical experiment for generation of travel time and congestion information calculated based on the data from ATCC and bus probe.
(3) Alternative-3: Demonstration of Comprehensive Practice (Development of Kasu Brahmananda Reddy Park Facilities)

The area around the Kasu Brahmananda Reddy Park (KBR Park) is fairly developed. In particular, the roads surrounding KBR park is relatively more appropriately prepared comparing to other areas in Hyderabad. In addition, there is a plan that the station of the metro railway will be constructed at the edge of the north-west side of the KBR park. In consideration of these factors, the following components are comprehensively developed and prepare this area as a comprehensive demonstration model zone combined with preparation of infrastructure and ITS facilities;

- Preparation of signals and intersection/junction at the existing round-about around the KBR park to improve the traffic flow
- Preparation of parking around the KBR park to accommodate the vehicles of the users of the park
- Development of the KBR park to attract more people to use
- Preparation of VMS around the KBR park to provide the traffic information as demonstration
- Preparation of the parking VMS installed on the above prepared parking lots and provide the information of availability of the parking space

(4) Alternative-4: Demonstration of Foot Path and ITS Facilities

The absence of ‘walk-able environment’ such as well prepared foot path is one of the major issues in terms of road infrastructure in Hyderabad.

The High Tech City is the area where relatively affluent people and foreigners reside with a number of foreign companies such as Microsoft, Google and etc. This area holds a great potential of the needs for well prepared walk-able environment. Thus, it is proposed to intensively prepare, in this area, the foot path along with improvement of junctions/intersections and installation of signals and pelican crossing and prepare the environment where people are able to safely walk and make jogging in certain designate area. The ITS facilities including VMS, ATCC and CCTV shall also be prepared to measure the traffic and provide the traffic information in this area.

The exact locations will be further identified.

11-2 Other Required Measure for Road Infrastructure

Apart from the ITS itself, the city of Hyderabad is facing more basic problems of road infrastructure. In particular, the major critical issues are i) structure of intersection/junction, and ii) ii) absence of pedestrian crossing infrastructure and facilities.
(1) **Structure and Design of Intersection/Junction**

It shall be mentioned that there does not exist properly structured intersections/junctions in Hyderabad. For example, many of the existing intersections are legacy of round-about and they are equipped with signals. But their structures are left remained round-about shaped. Others are such cases as absence of stop line/centre line, median which is properly designed around the intersection, improperly shaped intersections/junctions and etc. It can be mostly assumed that the improvement of the intersection/junction will greatly contribute assuring more smooth traffic flow.

The required measures are as follows;

- Improvement of Intersection/Junction Structure
- Preparation of zebra crossing together with above
- Preparation of stopping line for motorcycle together with above
- Preparation of stopping line for four-wheelers, separate from the motorcycle together with above
- Preparation of properly shaped median at the intersection/junction together with above
- Preparation of lanes to keep traffic order together with above
- Preparation of signals together with above

The image of the proper intersection in the case of Japan is shown in the figure below.

The figure on the left shows the stop line for four-wheeler, zebra crossing, spaces for bicycle to cross, waiting space for the vehicle in the middle of the intersection for right-turn and associated facilities such as lightening around the intersection.

The figure on the right shows the separated lanes one of which is for the vehicle to the left and direct and the other is dedicated for the vehicle to the right indicated/guided by the arrow.

![Figure 11-1 Intersection (1) in Japan](image1)

![Figure 11-2 Intersection (2) in Japan](image2)
Pedestrian Crossing (Zebra Crossing, Signals for Pedestrian, Skywalk)

The absence of ‘walk-able environment’ such as well prepared footpath is one of the major critical issues for both pedestrians and road traffic in Hyderabad. These include the zebra crossing, signals for the pedestrians and skywalk. These infrastructure and facilities need to be in place not only on the major roads but also across the city.

It is almost clear that the pedestrians are always crossing in the middle of the roads everywhere due to the critical absence of these infrastructure and facilities in Hyderabad. Such situation is consequently disturbing the smooth traffic flow and resulting in very dangerous condition for the pedestrian.

The overall necessary volume, in terms of the number of the locations, for the pedestrian crossing facilities is roughly provided as follows:

Basic Condition: Approximately 1500km total length of road network inside IRR

Case-1: 1,500 locations (1,500km / 1 km where the pedestrian crossing facilities at every 1km)
Case-2: 3,000 locations (1,500km / 500m where the pedestrian crossing facilities at every 500m)
Case-3: 6,000 locations (1,500km / 250m where the pedestrian crossing facilities at every 250m)
Case-4: 15,000 locations (1,500km / 100m where the pedestrian crossing facilities at every 100m)

Although above are provided at approximate bases, the zebra crossings together with the signals for pedestrians are in place almost every 100m, in general, in the metropolitan area such as Tokyo in Japan. In the case of Hyderabad where such infrastructure is not in place, these shall be prepared at least in line with such above theories.

The zebra crossings are prepared on the roads with narrow-width and the sky-walks are prepared over the roads with wide-width.

The images of the zebra crossings in the case of Japan are shown in the figure below.

The figure on the left shows the zebra crossing prepared with the pedestrian signal in front of the school. In particular, this infrastructure needs to be prepared near such facilities as school to assure the security of pedestrian.

The figure on the right shows the relatively large-sized zebra crossing in the centre area of the metropolitan. Although the skywalk is not in place in this case, the zebra crossing can manage the pedestrian crossing if the traffic is properly controlled.
Figure 11-3  Zebra Crossing (1) in Japan

Figure 11-4  Zebra Crossing (2) in Japan
12 Measurable Outcome for ITS Projects

The measurable outcome is performance indicators which measure the progress achieved in terms of the goals and objectives defined for the implementation of ITS projects. It is necessary to evaluate the ITS implementations by each phase to take the required actions for better outcome. For an objective evaluation it is necessary to define the measurable parameters that provide accurate values, effectiveness and impacts of the ITS projects.

The ITS goals and targets identified for the Hyderabad city are as follows:

- Safety
- Environmental / Energy
- Productivity
- Mobility
- Efficiency
- User Satisfaction

The safety improvement involves the enhancement of public transport and its usage, improvement of road infrastructure such as development of pedestrian facilities, introduction and revision of appropriate regulation, enforcement, education and improvement of traffic manners and safety. The measures to achieve these goals include public transport assistance and transit information provision through website, SMS, VMS, kiosks etc, installation of pedestrian signals, introduction of automatic enforcement systems, safety measures by automobile manufacturers and improvement of emergency response systems.

The measurable outcomes for the ITS facilities are:

- The number of traffic accidents (increase/decrease)
- The number of pedestrian accidents (increase/decrease)
- The number of users registered for access of travel/transit information through website and SMS
- The number of emergencies dispatched
- The response time taken to report the incident

The environment/energy involves the mitigation of pollution, environment conservation and improvement of fuel efficiency of vehicles. The measures to achieve these goals include educating the road users for pollution levels at different traffic junctions, encouraging the usage public transport and electric vehicles.

The measurable outcomes include:

- Usage of public transport (increase/decrease)
- Measurement of air pollution and dissemination of the information to road users through website and VMS.
- Vehicle emissions (increase/decrease)
- Vehicle energy consumption (increase/decrease)
The productivity involves the increase of the economic output of nation or region through efficient utilisation of transportation facilities. The measures to achieve the goal include installation of traffic signals and appropriate traffic controls, provision of traffic/transit guidance information to road users through websites, VMS and optimal route selection by car navigation system or mapping system.

The measurable outcomes include:

- Travel time (increase/decrease)
- Congestion level (increase/decrease)

The mobility involves the increase in the usage of public transport, reduction in travel time and travel cost. The measures to achieve the goal include provision of public transport assistance through website, VMS, SMS etc., parking guidance, electronic time tables for various modes of transport and common mobility card.

The measurable outcomes include:

- Travel time (increase / decrease)
- Travel cost (increase / decrease)

The efficiency involves in road usage, efficient investment in traffic related infrastructure, reduction of the cost of road management and efficient management of ITS data for road and infrastructure planning. The measures to achieve the goal include collection of traffic census information and analysis, adherence to traffic rules, introduction of variable lane system, introduction of ITS components such as quantitative real-time traffic data collection, analysis and information provision systems, preparation of ITSC and utilisation of collected and analysed ITS data for proper road planning.

The measurable outcomes include:

- Travel time (increase / decrease)
- Road facility maintenance cost (increase / decrease)

The satisfaction involves the safety, productivity, environment, mobility for convenient life. The measures to achieve the goal include provision of better road infrastructure facilities, traffic congestion information through website, VMS, SMS etc., optimal route guidance, and travel and transit information through website, SMS, VMS, kiosks etc.

The measurable outcomes include:

- Usage of ITS services (increase / decrease)
- Customer satisfaction surveys
The table below shows the examples of ITS menus for Hyderabad.

<table>
<thead>
<tr>
<th>No.</th>
<th>User Service Bundle of World ITS Architecture</th>
<th>Example of ITS</th>
<th>Phase-wise Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Traffic Management and Operations (ISO)</td>
<td>Collecting information on traffic volume by using the vehicle detector</td>
<td>✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting information on travel speed by using the vehicle probe sensor</td>
<td>✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting Closed-circuit Television (CCTV) image by using the CCTV camera</td>
<td>✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting traffic information from relevant system such as HTRIMS, VT&amp;PIS, and ORR HTMS</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting information on travel time and origin-destination (OD) from other sources like mobile tracking</td>
<td>✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting operation information on public transport operations such as bus, metro rail, MMTS, MMTS trains, local trains, and regional bus services</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting information related to all emergency and disaster response services from the agencies such as police, fire, EMRI, GHMC, and hospitals</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting information on road condition &amp; maintenance from related agencies such as GHMC, HMDA, Roads &amp; Buildings (R&amp;B), NH, HMWS&amp;SB, Traffic Police, and CPDCL</td>
<td>✓ ✓</td>
</tr>
<tr>
<td>No.</td>
<td>User Service Bundle of World ITS Architecture</td>
<td>Example of ITS</td>
<td>Phase-wise Priority</td>
</tr>
<tr>
<td>-----</td>
<td>---------------------------------------------</td>
<td>----------------</td>
<td>---------------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 2 3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting data on traffic accident from traffic police</td>
<td>✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting information on noise levels from Andhra Pradesh Pollution Control Board (APPCB), no horn zones from GHMC and traffic police, heavy vehicle entry restriction from traffic police</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting information on vehicle registration from Road Transport Authority (RTA)</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting information on large tourist locations and pilgrimage locations from tourism department</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting information on park &amp; ride facilities</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Collecting information on parking availability from the parking</td>
<td>✓</td>
</tr>
<tr>
<td>1.2</td>
<td>Information Provision</td>
<td>Providing traffic information via provision tool such as Variable Message Sign (VMS), Website, E-mail, SMS, Call Centre, FM Radio and Other Media</td>
<td>✓ ✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Providing information on public transport operation via provision tool</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Providing adverse weather information via provision tool</td>
<td>✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Providing emergency and disaster information via provision tool</td>
<td>✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Providing road work information via provision tool</td>
<td>✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Providing information on noise levels, no horn zones, and heavy vehicle entry restriction</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Providing information on parking availability and location</td>
<td>✓</td>
</tr>
<tr>
<td>1.3</td>
<td>Traffic Control</td>
<td>Traffic monitoring system with large display at monitoring room</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Controlling traffic signals from control centre</td>
<td>✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introducing signal co-ordination system</td>
<td>✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Traffic management for Very Important Persons (VIP) movement</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Video based adaptive control of traffic signals</td>
<td>✓ ✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dynamically controlling one way driving</td>
<td>✓</td>
</tr>
</tbody>
</table>
### ITS Master Plan for HMA

#### JICA SAPI Team

<table>
<thead>
<tr>
<th>No.</th>
<th>User Service Bundle of World ITS Architecture</th>
<th>Example of ITS</th>
<th>Phase-wise Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Introducing reversible lane control</td>
<td>✓</td>
</tr>
<tr>
<td>1.4</td>
<td>Optimum Route Guidance</td>
<td>Guiding optimum route based on traffic management</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Providing information on travel time to destination</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Providing information on optimum route</td>
<td>✓</td>
</tr>
<tr>
<td>1.5</td>
<td>Parking Management</td>
<td>Automatic parking operation such as automatic gate operation, number plate recognition, billing, and receipt</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Providing information on real-time parking availability</td>
<td>✓</td>
</tr>
</tbody>
</table>

### 2 Public Transport (ISO)

#### 2.1 Bus Operation

- Tracking by using the Global Positioning System (GPS) unit installed in the bus | ✓ |
- Observing the real-time bus position by using the Geographic Information System (GIS) based system | ✓ |
- Exchanging information with APSRTC on bus operation (time schedule / delay / accident of bus and etc.) | ✓ |
- Pre-trip reservation of the bus | ✓ |
- Dispatch control for bus and drivers | ✓ |

#### 2.2 Rail Transportation

- Exchanging information on metro rail between ITS Centre (ITSC) and Hyderabad Metro Rail Limited (HMRL) | ✓ |
- Exchanging information on MMTS trains between ITSC and South Central Railway (SCR) | ✓ |

#### 2.3 Taxi / Auto Rickshaw Operation

- Tracking by using GPS unit installed in the taxi | ✓ |
- Information on reservation of taxi | ✓ |
- Taxi dispatching system | ✓ |
- Sending probe data information to ITSC | ✓ |

### 3 Emergency (ISO)

#### 3.1 Emergency Alert and Response

- Tracking of the emergency vehicle | ✓ |
- Dispatching nearest emergency vehicle to destination (instruct the direction to the emergency vehicle) | ✓ |
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The detailed description of each user service along with technologies, benefits to stakeholders and flow diagrams as follows:

(1) **Traffic Management and Operations**

1) **Data Collection**

   a) **Description**

      It collects the road and traffic data for the purpose of traffic management. The data to be collected includes traffic volume by vehicle type, vehicle speed, weather, pollution etc. Such data is generally measured and collected by the road side sensors, analysed and processed at the ITS Centre. The vehicle speed can also be identified by collecting the GPS data from vehicles called “probe car”. The traffic congestion is calculated by the centre and provided to the road users by such means as VMS, SMS and internet. The actual traffic condition is monitored by the CCTV and viewed on the large display board at the centre called “video wall”. The collected data is stored in the centre and utilized for planning and evaluation of road and traffic measures.

   b) **Technologies**

      The technologies applied to the data collection include probe-car, GPS, vehicle detector, traffic counter, CCTV, weather sensor, pollution sensor, flood sensor, wired communication such as fibre optic cable, wireless communication such as 2G/3G/LTE, digital road map, centre system for processing and analysing, database management and etc.

   c) **Benefits to Users and/or Stakeholders**

      The road users are benefited by the provided road traffic information such as congestion, time to destination, road work, road closure, weather on road and etc. They are also benefited by proper traffic control. It is realised by appropriate utilisation of the collected data. The road and traffic related agencies such as traffic police, GHMC, R&B and HMDA gain benefit by utilising the collected road traffic data for planning, implementation and evaluation of the measures such as traffic control, road infrastructure improvement and urban development.
d) Flow of Data or Operation

2) Information Provision

a) Description
The collected data from the road side equipment and other related agencies is analyzed and processed at the ITS centre. The processed information such as traffic congestion at a particular road section, travel time to destination, incident, flood and weather is provided to the road users by such means as VMS, SMS, internet and FM radio broadcast.

b) Technologies
The technologies applied to the information provision include VMS, website, SMS, FM radio broadcast, wired communication such as fibre optic cable, wireless communication such as 2G/3G/LTE, map matching, data analytics, database management and etc.

c) Benefits to Users and/or Stakeholders
The road users are benefited by the road traffic information such as congestion, time to destination, road work, road closure, weather on road and etc by various media such as VMS, Website, SMS and FM radio. The congestion is alleviated by properly guiding the traffic through road and traffic information provision.
d) Flow of Data or Operation

3) Traffic Control

a) Description

It controls and regulates the traffic flow on the road to alleviate the congestion. The major examples are traffic signal and reversible lane. For example, the optimum signal phase is dynamically adjusted according to the traffic volume. The position of the median on the carriage way is changed depending on the traffic volume by direction during morning and evening peak hours.

The electronic road pricing is also categorised as the ITS to control the traffic in broad meaning. It controls the traffic demand by imposing the road usage fee on the road users.

b) Technologies

The technologies applied to the traffic control include traffic signals, traffic counters, CCTV, VMS for showing the allowed lane to pass and maximum speed, road side antennas for ERP, wired communication such as fibre optic cable, wireless communication such as 2G/3G/LTE ,centre side system to control the road side devices and etc.

c) Benefits to Users and/or Stakeholders

The road users are benefited by the alleviated traffic congestion such as arrive their destinations faster, saving vehicle fuel and etc. The reduced congestion and improved fuel consumption result in improvement of environmental affect and bring benefit to the society.
d) Flow of Data or Operation

4) Optimum Route Guidance

a) Description

It dynamically provides the travelers with the most relevant routes to the destination. It calculates the best routes generally taking into consideration of current congestion level on road network, major traffic events such as road work, road closure, weather and etc. Such data is collected by road sensors and probe car, or provided by road and traffic administrators and related agencies. The route guidance information is generally provided by the user terminals such as car navigation, smart phone and computer. More holistic route guidance including the combination of public transport, walking routes usage and etc. is increasingly available nowadays.

b) Technologies

The technologies applied to the optimum route guidance include probe-car, GPS, wired communication such as fibre optic cable, wireless communication such as 2G/3G/LTE, traffic sensors, weather sensors, flood sensors, digital road map, data analytics, user applications on the terminal devices, internet, car navigation and etc.

c) Benefits to Users and/or Stakeholders

The road users are enabled to choose the most optimum route for their travel, avoid the congestion and save their time. The manufacturers and software vendors in private sector gain benefit by the increased business opportunities for their value added services if the road traffic information such as road closure, road work that the public sector holds is properly opened and shared.
d) Flow of Data or Operation

![Diagram showing the flow of data in ITS systems]

5) Parking Management

a) Description

It monitors and provides the information on the parking availability to the users. The parking availability information is generally provided in the vicinity of the parking by information board. The information together with the parking location on the Internet is recently increasingly available. The parking usage record is also utilised for parking management purpose. The major examples include providing information on real-time parking availability and automatic parking operation such as automatic gate open-close, number plate recognition, billing, and payment.

b) Technologies

The technologies applied to the parking management include vehicle detector to identify the entry and exist of the vehicle, CCTV for monitoring, automatic number plate recognition to record the vehicle and for automated gate open for the vehicles which completed the payment, parking payment system, parking sensors, database management, communication via fibre optic cable/2G/3G/LTE and information board for parking information and etc.

c) Benefits to Users and/or Stakeholders

The users are benefited by the real-time information on the availability of parking by which the users are enabled to choose the available parking, reduced time for entry and exit realised by the automated parking operation.
d) Flow of Data or Operation

![Image of Parking Management]

(2) Public Transport

1) Bus Operation

a) Description

It collects the real-time bus location related information for the purpose of bus operation management. The collected data includes the bus number, bus type, location (latitude and longitude), travel speed and etc. Such data is collected by the GPS device installed on the bus and transmitted to the bus control centre through the communication media. The operation status and locations of the bus are identified by the centre and provided to the user by such means as information boards at the bus shelters, internet and etc. The processed data is stored in the centre and utilised by the bus operator for planning such as increasing/decreasing the number of buses in specific routes, introduction of new bus routes and evaluation of bus operation measures.

b) Technologies

The technologies applied to the bus operation include probe device (GPS and GPRS device) for collection of real-time bus location data, communication via 2G/3G/LTE for transmitting the GPS data to the bus control centre, map matching for identification of bus location, database management, data analysis and related centre side software, information boards at the bus shelter, internet and etc.

c) Benefits to Users and/or Stakeholders

The users are benefited by the real-time bus location and operation information provided at the bus shelter such as bus route number, scheduled bus arrival time, delay time, expected bus arrival time and etc. It enables the users to plan their travel efficiently. The efficient bus operation is realised by the bus operation agency by appropriate planning. The bus agency gains benefit by utilising the data for planning and evaluation such as increasing/decreasing the number of buses in specific routes, introduction of new bus routes and the bus operation measures.
2) Taxi Operation

a) Description

It collects the real-time taxi location information for the purpose of taxi operation management. The collected data includes the taxi number, location (latitude and longitude) and etc. Such data is collected by the GPS device installed on the taxi and transmitted to the taxi control centre through the communication media. The actual taxi location information is calculated at the centre and provided to the operator at the control centre by such means as schematic interface on large display board and etc. The schematic map based interface enables the call centre operator to identify the taxi location and address the taxi booking of the users. The data is stored in the centre and utilised by the taxi operator for planning and evaluation of taxi operation measures.

b) Technologies

The technologies applied to the taxi operation include probe device (GPS and GPRS device) for collection of real-time taxi location data, communication via 2G/3G/LTE for transmitting the GPS data to the taxi control centre, map matching, database management, data analytics and related centre side software, internet and etc.

c) Benefits to Users and/or Stakeholders

The taxi passengers are benefited by booking and etc. The proper taxi operation is realised by the taxi operation agency by appropriate planning. The taxi agency gains benefit by utilising the data for planning and evaluation of the taxi operation measures.
d) Flow of Data or Operation

(3) Emergency

1) Emergency Alert and Response

a) Description

The term of ITS user service, “Emergency Alert and Response”, includes broad meaning. It broadly means a concept of handling emergency by human supported by several different kinds of individual ITS technologies. As one of the typical examples, the emergency related information e.g. flood, heavy rain fall, severe traffic event is generally collected by road-side equipment or reported by human via emergency call. An alert is sent to the related agencies if required. The hazardous alert information is also provided to the users by such media as VMS, SMS, Internet and etc.

The location of emergency is identified by the centre and the emergency vehicles such as ambulance or fire truck are dispatched from the branch which is the nearest the emergency. In recent years, the advanced vehicle technologies, which notify the driver of the emergency vehicle which is approaching his car is increasingly developed by auto-manufacturers.

b) Technologies

The technologies applied to the emergency alert and response includes CCTV, flood sensor, meteorological measurement equipment, VMS, SMS, internet, ECB, GPS, vehicle-to-vehicle communication and etc.

c) Benefits to Users and/or Stakeholders

The people in emergency such as injured person are benefited by swift response of emergency. The related agencies such as fire department, hospital, and police gain benefit by improved efficiency in their emergency operation supported by the technologies.
d) Flow of Data or Operation

Image of Emergency Alert and Response

Emergency alert (Heavy rainfall, flooding) → Operation Console → Incident management → Large monitor screen → Consider the measure and response → Response

Emergency situation (observed by CCTV) → Incident database →
Emergency call →

2) Emergency Optimum Route Guidance

a) Description

The locations of the emergency vehicles such as ambulance and fire truck are monitored by the centre. The locations of the emergency occurred are also identified by the centre. The road condition such as road closure and road work and traffic condition such as congestion are gathered and provided by the related agencies such as road and traffic administrators.

The centre provides guidance on the optimum route based on such information in the emergency vehicles.

b) Technologies

The technologies applied to the emergency optimum route guidance include GPS, road side sensors such as vehicle detector, CCTV, wired/wireless communication such as fibre optic cable/2G/3G/LTE, navigation terminal and centre system.

c) Benefits to Users and/or Stakeholders

The people in emergency such as injured person are benefited by swift response of emergency. The related agencies such as fire department, hospital, and police gain benefit by improved efficiency in their emergency operation supported by the technologies.

d) Flow of Data or Operation

Image of ETC

Vehicle Detector at ETC Gates → Real Time Authentication → ETC Operator → Invoice → Payment via Bank → Car Owner or Driver

Gate Operation Open / Close → Use ETC Device → Vehicle (ETC Device) →
3) Emergency Signal Control

a) Description
The signals are prioritised for the emergency vehicles such as ambulance and fire truck to enable to arrive quickly at the emergency locations. The signal phases are controlled either automatically by system or manually.

b) Technologies
The technologies applied to emergency signal control include road side sensors such as vehicle detector and CCTV, signal terminal, signal controller, centre systems and etc.

c) Benefits to Users and/or Stakeholders
The people in the emergency such as injured person are benefited by the swift arrival of emergency vehicles. The emergency vehicles are enabled to choose the most optimum route and avoid congestion to arrive quickly at the incident locations.

d) Flow of Data or Operation

(4) Transport-Related Electronic Payment

1) Transport-Related Electronic Financial Transactions
The explanation is provided in the clause of a) Description below, together with Integration of Transport-Related Electronic Payment Services.

2) Integration of Transport-Related Electronic Payment Services
The explanation is provided in the clause of a) Description below, together with Transport-Related Electronic Financial Transactions.
a) Description

It enables the road user to complete all the transport related payments electronically. Such electronic payments include transit fare, toll collection, parking payment and etc. The electronic payment of transit fare, parking fare, toll fare and etc enables the road user to pay using such mode as common mobility card, ETC system and etc. In case of common mobility card, the road user is allowed to use a pre paid electronic card. It is called as pre-paid electronic card because money is added to it at a bank ATM, internet and etc before it is used for payments. The common mobility card enables the user to swipe the card at the terminal to pay railway, bus and taxi fare. In case of ETC system, the road user inserts the electronic card into an on board device in the vehicle and the radio antenna installed on the road section reads the information in the card and deducts the fare electronically.

b) Technologies

The technologies applied to transport related electronic payment system include electronic card with a chip, road side sensor, road side antenna, OBU, electronic card swipe terminal, wire/wireless communication via fibre optic cable/2G/3G/LTE, database management, clearing house, centre side software and hardware and etc.

c) Benefits to Users and/or Stakeholders

The road users are benefitted by the convenience of electronic payment that reduces the waiting time at the fare collection centres. It enables the road user to travel comfortably because of reduction of vehicle congestion at the toll collection centres. The fare collection operation agency is benefited by the reduction in the cost of operation, fraud and etc because of minimising the manual collection. Such electronic payment measures enable improvement in economic and environmental benefits of the society in general.

d) Flow of Data or Operation

![Flowchart of Electronic Payment System](image)
(5) Road Transport-Related Personal Safety

1) Driving Support System

a) Description

The ITS services for driving support is largely realised by the private sector side services. The typical example is anti-collision braking system detecting the abnormally short distance from the vehicle running ahead. Such technology is generally developed by the automobile manufacturers.

However, the driving support by ITS is also promoted by both public and private sector. The infrastructure required for ITS service is generally developed by public sector, and user-side applications and terminal devices are prepared by private sector.

For example, in the case of providing information on accident occurred in the vicinity, congestion is alerted and real-time road condition image is provided by the high-end car navigation terminal. Such warning information is alerted to the driver at such locations before curve to avoid the collision. The warning is alerted only when the actual congestion or accident occurs beyond the curve ahead. The required infrastructure such as road-side sensors, wireless communication bandwidth for large data transmission and etc are prepared and provided by public sector. The user side applications and terminals such as high-end car navigation are prepared by private sector according to technical standard jointly prepared by public and private sectors to realise such ITS services. This is called Smart way in Japan. Such system as ‘Smart way’ also provides highly accurate optimum route guidance taking into consideration of wide-area road and traffic conditions.

b) Technologies

The technologies applied to the driving support include CCTV, vehicle detectors, wired and wireless communication such as dedicated short range communication, vehicle-to-vehicle communication, vehicle-to-infrastructure communication, car navigation and etc.

c) Benefits to Users and/or Stakeholders

The drivers are benefited by increased safety, timely being alerted on the specific locations and occasions. They are also benefited being enabled to access highly accurate route guidance information. The private companies such as navigation manufacturers and application developers gain benefit by the increased business opportunities generated by public-private joint promotion of ITS services.

2) Signal Dedicated for Pedestrian

a) Description

It assists the pedestrians to cross the intersections by the pedestrian traffic signal called pelican crossing and allocating certain time for crossing for safety.

b) Technologies

The technologies applied to the signal dedicated for pedestrian include pedestrian traffic signal, CCTV, wire/wireless communication via optic fibre/2G/3G/LTE, and etc.
c) **Benefits to Users and/or Stakeholders**

The pedestrians are benefited by the dedicated signal to cross the road intersections safely and the vehicle drivers are alerted to stop at the intersection till the dedicated time for pedestrian signal is completed.

d) **Flow of Data or Operation**

(6) **Weather and Environmental Conditions Monitoring**

1) **Collection of Weather Information**

a) **Description**

It collects the real-time weather data on the roadways. Such data includes rainfall, temperature, wind velocity, wind direction and etc. The collected data is processed at the centre and stored in the database. The weather information is provided to the road users by such means as VMS, internet, FM Radio and etc and the related stakeholders such as traffic operator, road operator such as GHMC and R&B.

b) **Technologies**

The technologies applied to collection of weather information include meteorological sensors, flood sensors, VMS, website, SMS, FM radio, wire/wireless communication via optic fibre/2G/3G/LTE, database management and etc.

c) **Benefits to Users and/or Stakeholders**

The road user is benefited by the weather information to efficiently plan the trip and avoid the rain and flood prone roadways. The traffic and road operating agencies are benefitted by the weather data to enable them to effectively plan the traffic regulation, road maintenance, road closure and other related activities.
d) Flow of Data or Operation

2) Collection of Air Pollution Information

a) Description

It collects the air pollution data on the roadways. Such data includes NOx, SOx, SPM and noise. The pollution data is collected from pollution sensors installed on roadside and the related environmental agencies. The collected data is processed and stored in the database in the centre.

b) Technologies

The technologies applied to the collection of pollution information include pollution sensors, wire/wireless communication via fibre optic network/2G/3G/LTE, database, and etc.

c) Benefits to Users and/or Stakeholders

The aggregated and analyzed pollution data is useful for the environmental agencies of the state/central government to apply necessary provisions to ensure improvement of the pollution levels in the city, improvement of environmental affect and bring benefit to the society.
d) Flow of Data or Operation

(7) Disaster Response Management and Coordination

1) Disaster Alert and Response

The explanation is provided in the clause of a) Description below, together with Disaster Operation Assistance.

2) Disaster Operation Assistance

The explanation is provided in the clause of a) Description below, together with Disaster Alert and Response.

a) Description

In term of ITS services, ‘Disaster Alert and Response’ and ‘Disaster Operation Assistance’, includes broad meaning. It basically means a concept of handling disaster by human, supported by several different kinds of ITS technologies.

In a broad sense of disaster management supported by information technology, it includes, for example, disaster alert to the public via Internet, SMS, TV/Radio broadcast on such occasions as massive earthquake, tsunami, strong hurricane, volcano explosion, terrorist attack, military invasion by enemy and so on.

In more specific sense in view of road traffic, and ITS it would include providing the disaster alert to the drivers via such media as car navigation, regulating the traffic by controlling the signals or providing guidance by VMS to assist the rescue teams to arrive quickly at site, information exchange amongst related departments and etc. under the above occasions.
b) Technologies

The technologies applied to disaster management and coordination include Internet, SMS, TV/Radio broadcast, VMS, car navigation, traffic signals, CCTV, emergency call box, hot-line, rescue/army dispatching system, flood/rainfall sensors, seismic sensors, meteorological satellite, tsunami gauge, bomb detection, and etc.

c) Benefits to Users and/or Stakeholders

The road users are benefited by the disaster alert information to avoid travelling to the site of disaster. The people in the area of disaster are provided with quick rescue to save their lives by proper control of traffic on the occasion of disaster. The proper traffic control is realised by utilising disaster information coordinated amongst the related agencies.

d) Flow of Data or Operation

The disaster management and coordination involve a broad range of technologies and different aspects of operation. The figure below shows one example amongst them.

(8) ITS Data Management

1) Collection, Store and Aggregation of Data

a) Description

There are two different methods for data collection. One is on-line data collection and the other is off-line data collection. In the case of the on-line data collection, the data is collected by the system. It includes such data as real-time traffic condition, probe, weather, flood, and etc.

In the case of the off-line data collection, the information is generally reported and exchanged by human. It includes such information as accident, disaster, VIP movement, major event, and etc.
The on-line data is stored in the database in the centre. The off-line information is generally inputted onto the system by the operator in the centre and stored. The stored data/information is aggregated and utilised for the necessary measures. The necessary measures include for example, traffic control, road management, infrastructure improvement, and etc.

b) Technologies

The technologies applied to collection, storage and aggregate of data include vehicle detector, rainfall gauge, flood sensors, pollution sensors, CCTV, probe system including GPS, wire/wireless communication such as fibre optic network, 2G/3G/LTE, database, and etc.

c) Benefits to Users and/or Stakeholders

The related agencies are enabled to carry out proper measures based on the quantitative aggregation by the collected data and information. The related agencies include traffic police, road operators, planning department, and etc. The proper measures include traffic control, road management, urban development, and etc.

As a consequence, the general citizens gain benefit by such proper measures.

d) Flow of Data or Operation

![Image of ITS Data Management (Collection, Store and Aggregation of Data)](image)

- On-line data observed by roadside unit such as; CCTV Camera, Vehicle detector, Vehicle probe, rainfall gauge, Air pollution, etc.
- On-line data collected from road related agency such as; Met agency, Pollution agency, Traffic police, Bus operator, Public transport operator, Emergency call, registration, etc.
- Off-line data collected by road operator such as; Information of Accident, Disaster, VIP, Big event, Operation status of public transportation, etc.

- ITS Center
  - Storage and database
  - Data collection and storing
  - Operation console
  - Proper data management and aggregation
2) Traffic Data Analysis

a) Description

The collected data is processed and analysed at the centre. The result of analysis is usually utilised for the road and traffic measures.

A typical example is the utilisation of probe data. The congestion level by road link is identified by the probe data. The characteristic of the congestion by section becomes clear by aggregating the accumulated historical data, for example the tendency of congestion level at particular section or areas during certain hours a day or particular period a year.

Another example is the utilisation of traffic counter. For example, significant large volume of heavy vehicle may become clear at certain sections of highway.

Such results assist proper decisions on the necessary measures. For example, it can be judged that a by-pass construction, as a hardware measure may be required to alleviate the congestion in the identified areas, or restricting incoming traffic of heavy vehicle by imposing higher traffic to protect the pavement on the certain sections of highway, as a software measure may be effective.

b) Technologies

The technologies applied to traffic data analysis include vehicle detector, rainfall gauge, flood sensors, pollution sensors, CCTV, probe system including GPS, wire/wireless communication such as fibre optic network, 2G/3G/LTE, database, and etc.

c) Benefits to Users and/or Stakeholders

The related agencies are enabled to carry out proper measures based on the processed and analysed results from traffic related data. The related agencies include traffic police, road operators, planning department, and etc. The proper measures include transport administration, road management, urban development, and etc.

As a consequence, the general citizens gain benefit by such proper measures.

d) Flow of Data or Operation
3) Traffic Accident Analysis

a) Description

The accident data is collected from road side surveillance systems such as CCTV, from traffic operators and etc. The collected traffic accident data is analysed at the ITS centre and provided to the agencies such as traffic police, road operator, road planning agency and etc for taking appropriate measures.

b) Technologies

The technologies applied to traffic accident analysis include electronic data from traffic operator, road side sensors, wire/wireless communication via fibre optic network/2G/3G/LTE, database management, data analytics, data warehouse and etc.

c) Benefits to Users and/or Stakeholders

The benefits gained by the agencies such as traffic police, road operator, road planning agency and etc includes the enforcement of restrictions on vehicle speed, provision of accident prone area information to road users, proper planning of road and infrastructure development and etc.
d) Flow of Data or Operation

4) Emergency and Disaster Information Analysis

a) Description

The emergency and disaster data collected at the ITS centre is analysed and provided to the related agencies such as traffic police, road operator and etc. The provided information is used by the agencies to enhance the ability in improving the coordination among the agencies in the event of emergency situations. The disaster data is collected and emergency situation is evaluated to identify the better response strategies to emergency situations.

b) Technologies

The technologies applied to emergency and disaster information analysis system include road side sensors, CCTV, wire/wireless communication via fibre optic network/2G/3G/LTE, database management, data analytics, data warehouse and etc..

c) Benefits to Users and/or Stakeholders

The agencies such as traffic police, road operator and road planning agency are gained by the emergency and disaster analysis information to enable them to develop and implement proactive emergency management strategies. The road users are benefited because of improved strategies for more efficient and safer evacuation.
d) Flow of Data or Operation

(9) Maintenance and Construction Management

1) Road Management

a) Description

It enables the road operator to monitor, operate, maintain and develop the road and related infrastructure facilities. The road and related infrastructure data is collected from the road side devices, the related agencies and stored in the database at ITS centre. Such data includes the flyovers, bridges, FOBs and all other facilities installed on the road. The collected data is analysed at the ITS centre and provided to the agencies such as road operator and etc. Such agencies utilise the provided information to take appropriate measures to improve the efficiency of the roadways and the related infrastructure.

b) Technologies

The technologies applied to the asset management system include the road sensors, surveillance equipment like CCTV, wire/wireless communication via fibre optic cable/2G/3G/LTE, data analyzer, database management, data warehousing and etc.

c) Benefits to Users and/or Stakeholders

The road management and planning agencies are gained by the road and related asset data collected and aggregated at the ITS centre because such data is a critical for the efficient management of roadways. The damaged road surface may cause accidents and proper maintenance is useful for optimum use of roadside facilities. The road users are benefited because of improved and better roadways to travel.
Law Enforcement

It comprises the application of ITS technologies for the enforcement of traffic law and regulations. It includes the user services as described below. Although each of these services addresses a separate function, they all contribute to the common goal of assisting the law enforcement agencies in implementing the traffic laws and regulations.

1) Assistance of Police Activities

It is to enable the police personnel to perform the activities to ensure the safety and protection of individuals and society. The police personnel use various surveillance techniques such as monitoring the traffic using CCTV console and video wall at the ITS centre to perform the law enforcement activities.

2) Automated Speed Enforcement

It is to enable the traffic police to enforce the traffic laws and regulations for over-speeding vehicles. The purpose is to detect, alert and enforce the over speeding vehicles. The over speeding vehicles on the roadways are identified using the speed detectors installed on road side and the data is transmitted to the ITS centre. Such data is used by the traffic police to alert the vehicle drivers against over speeding and enforce the speed limit by applying the penalty.

3) Automated Signal Jumping Enforcement

It is to the enforcement of traffic laws and regulations for offences related to jumping of traffic signals. The purpose is to detect, alert and enforce the vehicles jumping the traffic signals. The image of the vehicles jumping the traffic signal at the traffic junctions are recorded and transmitted to the ITS centre by the CCTV device installed at the traffic junction. The traffic signal jumping enforcement system at the ITS centre reads the registration number of the vehicle from the image data and a challan is generated on the name of the vehicle owner. The challan is issued to the address of the vehicle owner.

4) Automated Wrong Way Driving Enforcement

It is to the enforcement of traffic laws and regulations for offences related to driving vehicles in wrong direction. The purpose is to detect, alert and enforce the vehicles passing on improper directions. The image of the vehicles driving in wrong way are recorded and transmitted to the ITS centre by the CCTV device installed at the road sections. The wrong way direction enforcement system at the ITS centre reads the registration number of the vehicle from the image data and a penalty challan is generated on the name of the vehicle owner. The challan is issued to the address of the vehicle owner.
5) **Automated Illegal Parking Enforcement**

It is to the enforcement of traffic laws and regulations for offences related to illegal parking of vehicles. The purpose is to detect, alert and enforce the vehicles parked at improper locations. The image of the vehicles parked illegally on the roadway are recorded and transmitted to the ITS centre by the CCTV device installed at the road sections. The parking enforcement system at the ITS centre reads the registration number of the vehicle from the image data and a penalty challan is generated on the name of the vehicle owner. The challan is issued to the address of the vehicle owner.

6) **Automated Overloaded Vehicle Enforcement**

It is to the enforcement of traffic laws and regulations for offences related to vehicles carrying more than the permissible load (weight of carrying goods). The purpose is to detect, alert and enforce the vehicles carrying excessive load. The image of the overloaded vehicles driving on the roadways are recorded and transmitted to the ITS centre by the CCTV device installed at the road sections. The overloaded vehicle enforcement system at the ITS centre reads the registration number of the vehicle from the image data and a penalty challan is generated on the name of the vehicle owner. The challan is issued to the address of the vehicle owner.

d) **Technologies**

The technologies applied to the law enforcement system include the laser guns, road side sensors, CCTV, traffic signal system, wire/wireless communication via fibre optic network/2G/3G/LTE, related centre side software systems, database management and etc.

e) **Benefits to Users and/or Stakeholders**

The traffic operator such as traffic police are benefitted by the law enforcement system. It enhances the capabilities of these agency in implementing the traffic laws and regulations by minimising the manual operations in enforcement. The collected data is utilized for efficient police investigation. The road user is benefitted by the better traffic enforcement mechanism in general that enables proper road manners and safe driving.
f) Flow of Data or Operation

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<table>
<thead>
<tr>
<th>Automated Speed Enforcement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated Signal Jumping Enforcement</td>
</tr>
<tr>
<td>Automated Excess Capacity Riding Enforcement</td>
</tr>
<tr>
<td>Automated Wrong Way Driving Enforcement</td>
</tr>
<tr>
<td>Automated Illegal Parking Enforcement</td>
</tr>
<tr>
<td>Automated Overloaded Vehicle Enforcement</td>
</tr>
<tr>
<td>Vehicle Registration Data (RTA)</td>
</tr>
</tbody>
</table>
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Image of Law Enforcement (Assist the Police Activities)

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<table>
<thead>
<tr>
<th>Analysis and Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invoice for violators</td>
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</tbody>
</table>
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Traffic Police

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<table>
<thead>
<tr>
<th>Storage and database</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data collection and storing</td>
</tr>
</tbody>
</table>
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# List of Abbreviations

The table below shows the list of abbreviations used in the master plan document.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>APIIC</td>
<td>Andhra Pradesh Industrial Infrastructure Corporation</td>
</tr>
<tr>
<td>APPCB</td>
<td>Andhra Pradesh Pollution Control Board</td>
</tr>
<tr>
<td>APSDPS</td>
<td>Andhra Pradesh State Development Planning Society</td>
</tr>
<tr>
<td>APSRTC</td>
<td>Andhra Pradesh State Road Transport Corporation</td>
</tr>
<tr>
<td>ATCC</td>
<td>Automatic Traffic Counting and Classification</td>
</tr>
<tr>
<td>CCTV</td>
<td>Closed Circuit Television</td>
</tr>
<tr>
<td>CDP</td>
<td>City Development Plan</td>
</tr>
<tr>
<td>CTS</td>
<td>Comprehensive Transportation Study</td>
</tr>
<tr>
<td>ECB</td>
<td>Emergency Call Box</td>
</tr>
<tr>
<td>ERP</td>
<td>Electronic Road Pricing</td>
</tr>
<tr>
<td>FTA</td>
<td>Foreign Tourist Arrivals</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GPS/GPRS</td>
<td>Global Positioning System/ General Packet Radio Service</td>
</tr>
<tr>
<td>HATS</td>
<td>Hyderabad Area Transportation Study</td>
</tr>
<tr>
<td>HGCL</td>
<td>Hyderabad Growth Corridor Limited</td>
</tr>
<tr>
<td>HMA</td>
<td>Hyderabad Metropolitan Area</td>
</tr>
<tr>
<td>HMDA</td>
<td>Hyderabad Metropolitan Development Authority</td>
</tr>
<tr>
<td>HMR</td>
<td>Hyderabad Metro Rail</td>
</tr>
<tr>
<td>HMWS&amp;SB</td>
<td>Hyderabad Metropolitan Water Supply, Sewerage Board</td>
</tr>
<tr>
<td>HTMS</td>
<td>Highway Traffic Management System</td>
</tr>
<tr>
<td>HTRIMS</td>
<td>Hyderabad Traffic Integrated management System</td>
</tr>
<tr>
<td>IMD</td>
<td>India Meteorological Department</td>
</tr>
<tr>
<td>IPT</td>
<td>Intermediate Public Transport</td>
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<tr>
<td>IRR</td>
<td>Inner Ring Road</td>
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<tr>
<td>ITS</td>
<td>Intelligent Transportation System</td>
</tr>
<tr>
<td>ITSC</td>
<td>Intelligent Transportation System Centre</td>
</tr>
<tr>
<td>JICA</td>
<td>Japan International Cooperation Agency</td>
</tr>
<tr>
<td>KBRN</td>
<td>Kasu Brahmananda Reddy National Park</td>
</tr>
<tr>
<td>L&amp;T</td>
<td>Larsen and Toubro</td>
</tr>
<tr>
<td>MET</td>
<td>Meteorological Stations</td>
</tr>
<tr>
<td>MMTS</td>
<td>Multi-Modal Transport System</td>
</tr>
<tr>
<td>MoUD</td>
<td>Ministry of Urban Development</td>
</tr>
<tr>
<td>NAAQS</td>
<td>National Ambient Air Quality Standards</td>
</tr>
<tr>
<td>NH</td>
<td>National Highway</td>
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<tr>
<td>Abbreviation</td>
<td>Description</td>
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<td>--------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>NMT</td>
<td>Non Motorised Transport</td>
</tr>
<tr>
<td>NOx</td>
<td>Nitrogen Dioxide</td>
</tr>
<tr>
<td>NUTP</td>
<td>National Urban Transport Policy</td>
</tr>
<tr>
<td>OD</td>
<td>Origin-Destination</td>
</tr>
<tr>
<td>ORR</td>
<td>Outer Ring Road</td>
</tr>
<tr>
<td>ORR</td>
<td>Outer Ring Road</td>
</tr>
<tr>
<td>PCU</td>
<td>Passenger Car Unit</td>
</tr>
<tr>
<td>RSPM</td>
<td>Respirable Suspended Particulate Matter</td>
</tr>
<tr>
<td>RTA</td>
<td>Road Transport Authority</td>
</tr>
<tr>
<td>SCR</td>
<td>South Central Railway</td>
</tr>
<tr>
<td>SOx</td>
<td>Sulphur Dioxide</td>
</tr>
<tr>
<td>SPV</td>
<td>Special Purpose Vehicle</td>
</tr>
<tr>
<td>TCC</td>
<td>Traffic Command Centre</td>
</tr>
<tr>
<td>TMS</td>
<td>Toll Management System</td>
</tr>
<tr>
<td>TSPM</td>
<td>Total Suspended Particulate Matter</td>
</tr>
<tr>
<td>UMTA</td>
<td>Unified Metropolitan Transport Authority</td>
</tr>
<tr>
<td>VMS</td>
<td>Variable Message Signboards</td>
</tr>
</tbody>
</table>

(End of Report)