REPUBLIC OF INDIA
HYDERABAD METROPOLITAN DEVELOPMENT AUTHORITY/
HYDERABAD GROWTH CORRIDOR LIMITED

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

ITS Master Plan for Hyderabad Metropolitan Area

March 2014

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
JICA STUDY TEAM Consisted by

N I P P O N K O E I C O . , L T D .
EAST NIPPON EXPRESSWAY CO., LTD.
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1 Background

Hyderabad is one of six (6) major metropolises in India. It is the capital city of Andhra Pradesh state in South India and located almost in the middle of the country surrounded by Mumbai in west, Bangalore in south and Chennai in southeast.

Hyderabad has been developing as a growth base of international business, represented by the industries of information technology and pharmacy. Traffic has been significantly increasing with rapid urbanisation in recent years. As a result, severe traffic congestion is becoming a social problem, hindering smooth business activities. Thus, there is an urgent need to alleviate traffic congestion.

Under this situation, construction of Outer Ring Road (ORR) is underway to ease congestion by reducing the number of vehicle passing through the city, thereby contributing to regional economic development in suburban area and improvement of the urban environment. Intelligent Transport Systems (ITS) will be developed on ORR by Japanese yen loan project for efficient management of highway and toll collection In the city of Hyderabad, some governmental bodies and private enterprises recently began developing ITS. However the status of ITS in the city remains in a piecemeal manner, and the systems are planned by individual bodies in an uncoordinated way.

In this background, the state government of Andhra Pradesh requested the government of Japan to carry out a study to prepare a comprehensive ITS Master Plan for Hyderabad Metropolitan Area (HMA).

As a result, Hyderabad Growth Corridor Limited (HGCL) under Hyderabad Metropolitan Development Authority (HMDA) and Japan International Cooperation Agency (JICA) agreed that both parties would sincerely cooperate with each other with a view to contributing towards the smooth introduction of ITS in Hyderabad Metropolitan Area by formulating ITS Master Plan.

2 Objectives of ITS Master Plan

ITS is one of the methods for achieving ideal traffic society. The areas in which ITS brings benefits are:

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

To achieve above benefits, a number of issues in HMA such as road infrastructure, traffic discipline, organisation, etc., need to be addressed. To solve these issues, both hard measures and soft measures are required. The hard measures include improvement of road and public transport infrastructures, etc. The soft measures include utilisation of information technology, improvement of organisation arrangement for planning in coordinated manner, etc.

The ITS Master Plan aims to contribute to tackling traffic issues by envisaging a long term holistic picture of ITS in HMA addressing required hard and soft measures toward realising benefits above.

3 Current Condition

3-1 Outline of Hyderabad Metropolitan Area

Hyderabad is a capital city of Andhra Pradesh state. Hyderabad Metropolitan Area (HMA) is one of six (6) major metropolises in India and located almost in the middle of Mumbai, Bangalore and Chennai. The total area of HMA is nearly 7,200 sq. km.

It has been a growth base for international business such as information technology, pharmacy, etc. in recent years. The population and number of vehicles have been rapidly growing in the HMA.

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

3-2 Socio-Economic Characteristics

(1) Hyderabad Population Growth

The population in HMA is rapidly growing. The core area and Ragareddy district area are mostly populated. According to the population census of Directorate of Census Operations, the population in 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.

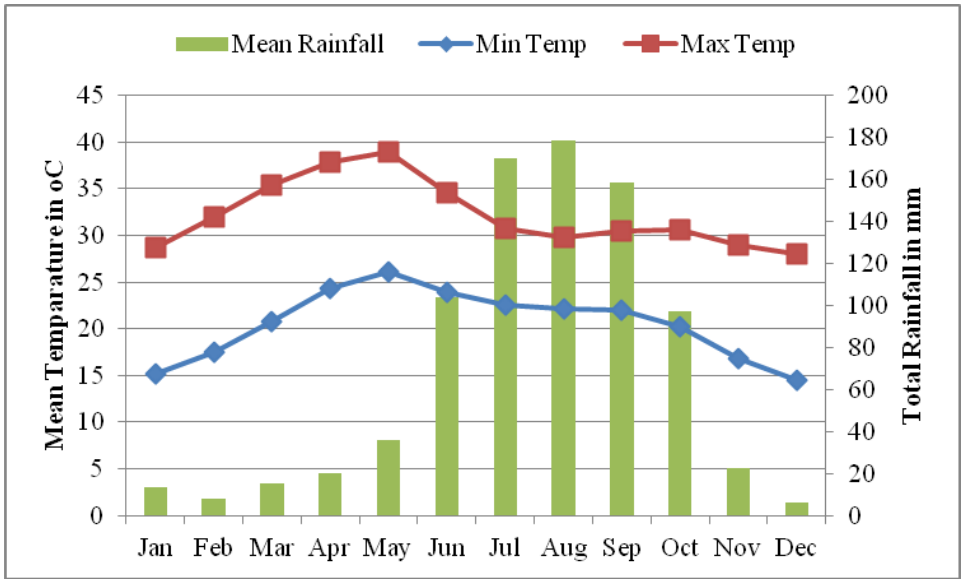
Table 3-1 Population in HMA

Year	HMA Population					
	Hyderabad	Rangareddy	Medak	Mahabubnagar	Nalgonda	Total
1991	31,42,214	17,70,965	5,29,117	89,412	2,51,441	57,83,149
2001	38,29,753	27,45,304	6,47,744	1,14,002	2,90,025	76,26,828
2011	39,00,238	43,51,939	7,78,624	1,22,250	3,02,650	94,55,701

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

(2) Climate Conditions in Hyderabad

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



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

Figure 3-1 Average Climate Condition in Hyderabad

Source: JICA Study Team

Figure 3-2 Water Logged Road in Monsoon Season - Near Necklace Road

(3) Gross Domestic Product (GDP) Growth

India is an economic superpower in the world after China. But rapidly increasing inflation and other economic issues are major hurdles for further development, in recent years.

Hyderabad is a centre of the economic growth in the state of Andhra State. According to the 2011 GDP statistics, Hyderabad is ranked at the 5th amongst the top 10 cities of India.

Table 3-2 Top 10 Cities of GDP in India in 2011

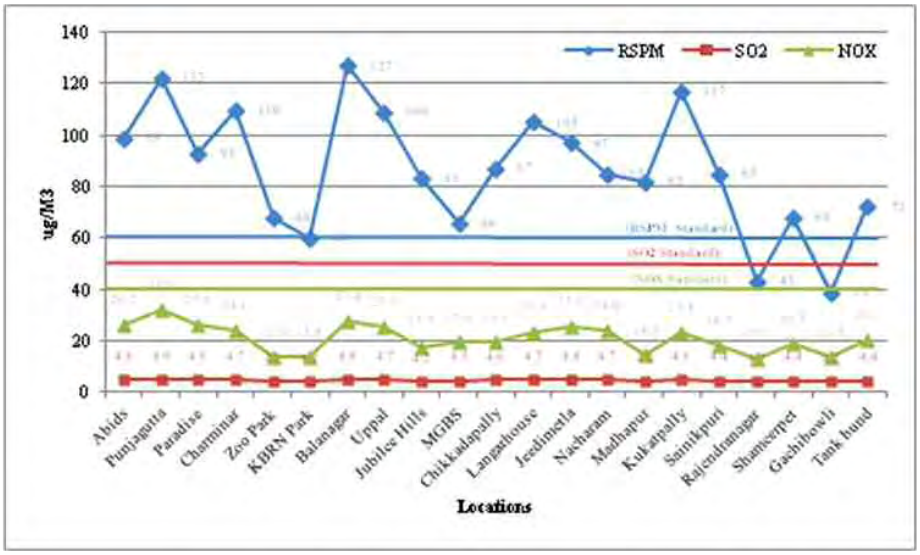
Rank	City	2011 GDP (in Billion USD)
1	Mumbai	209
2	Delhi	167
3	Kolkata	150
4	Bangalore	83
5	Hyderabad	74
6	Chennai	66
7	Ahmadabad	64
8	Pune	48
9	Surat	40
10	Visakhapatnam	26

Source: Yahoo Finance Website

3-3 Environment, Tourism and Administration

(1) Ambient Air Quality

Air quality in HMA has been seriously deteriorated. Andhra Pradesh Pollution Control Board (APPCB) publishes the annual report on air quality and noise level in HMA and entire Andhra Pradesh. According to the report in 2012, the respirable suspended particulate matter (RSPM) and total suspended particulate matter (TSPM) were exceeding their upper limit whilst sulphur dioxide (SO_x) and nitrogen dioxide (NOx) stay within the limits. The yearly average of air quality is shown in the figure below.



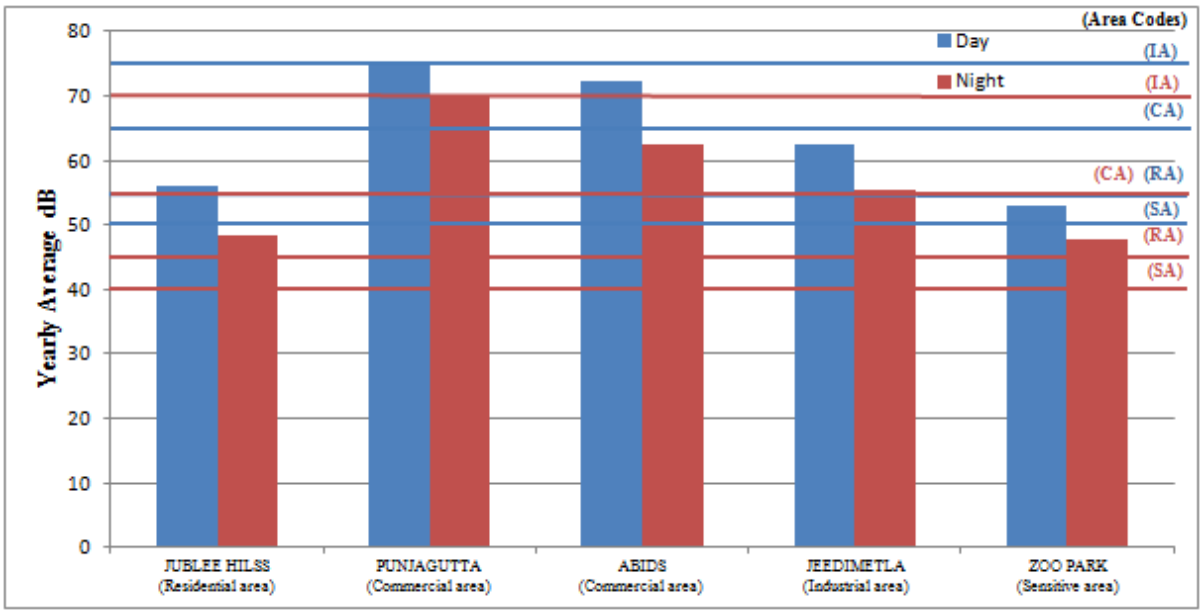
Source: Andhra Pradesh Pollution Control Board, 2012

Figure 3-3 Yearly Average of Air Quality Level in Hyderabad against NAAQ Standards

(2) Noise Level

The annual report on the noise in 2012 shows that the noise level in HMA exceeds the upper limit, as summarised below:

- The noise levels are measured at approximately 73 dB in commercial areas.
- Higher noise levels of 52 and 54 dB are measured in noise-sensitive locations, which are Zoo Park and Kasu Brahmananda Reddy National Park (KBRN).



Unit=dB

Area	Noise Level Limit (Standard)		Yearly Average Noise Level (Actual)	
	Day Time	Night Time	Day Time	Night Time
Residential Area (RA)	55	45	56	49
Commercial Area (CA)	65	55	75	70
Industrial Area (IA)	75	70	63	55
Sensitive Area (SA)	50	40	53	48

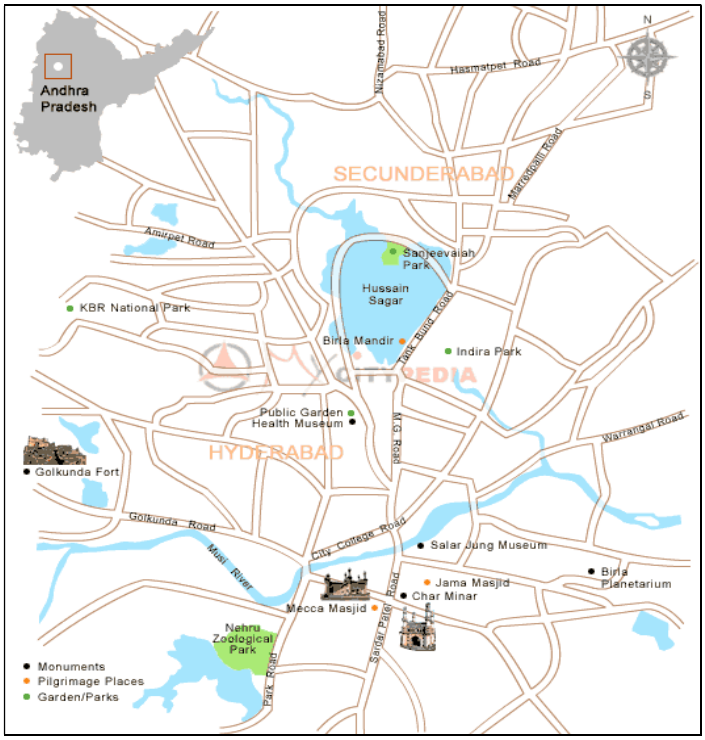
Source: Andhra Pradesh Pollution Control Board, 2012

Figure 3-4 Noise Level Standard and Yearly Average Noise Level in Hyderabad

(3) Tourism

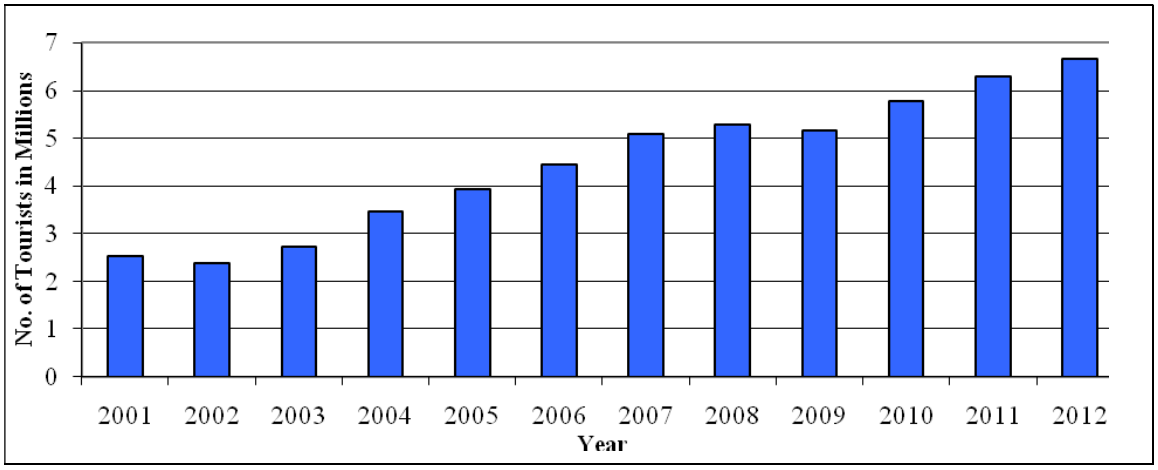
Tourism is an important industry for Indian economy. The number of foreign tourists, called Foreign Touris Arrivals (FTA), has been rapidly growing and it has doubled during the last decade. In 2012, FTA in India was 6.64 million with a growth rate of 5.4% from 2011. Andhra Pradesh state is ranked at 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 recently 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 in these places. There is a potential for attracting more tourists if more appropriate information on tourism is provided to visitors.



Source: Clickindia Website

Figure 3-5 Major Tourism Spots in HMA



Source: Ministry of Tourism

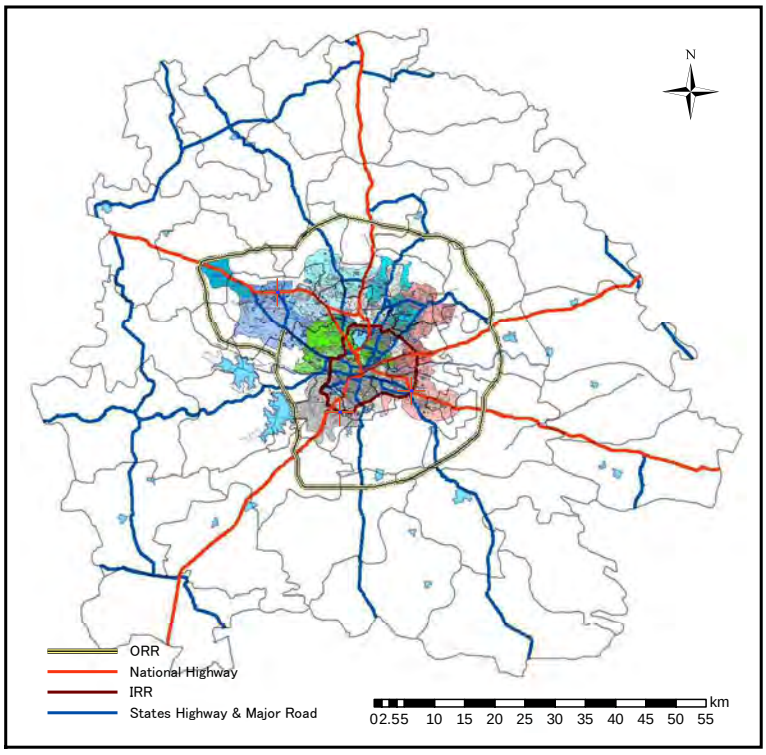
Figure 3-6 Number of Foreign Tourists to India 2001-2012

(4) Administration in Hyderabad

Hyderabad Metropolitan Development Authority (HMDA) is a responsible body for planning, co-ordination, supervision and promotion of development in HMA. It coordinates the development activities of related bodies such as municipal corporations, municipalities and other authorities including Hyderabad Metropolitan Water Supply, Sewerage Board (HMWS&SB), Transmission Corporation of Andhra Pradesh Limited (APTRANSCO), Andhra Pradesh Industrial Infrastructure Corporation (APIIC), Andhra Pradesh State Road Transport Corporation (APSRTC), etc. HMDA manages Hyderabad Management Development Fund, which finances for development of infrastructures.

HMDA was constituted by the Andhra Pradesh government order in 2008. The authorities such as Hyderabad Urban Development Authority, Hyderabad Airport Development Authority and Cyberabad Development Authority were dissolved and merged into HMDA. HMDA was formed by combining the entire suburbs of Greater Hyderabad Metropolitan Corporation (GHMC). The jurisdiction of HMDA consists of 55 mandals, which is lower local bodies in district, 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 jurisdiction area of HMDA is approximately 7,200 sq. km.

Unified Metropolitan Transport Authority (UMTA) is a high level coordinating and decision-making body for urban transport in Andhra Pradesh state. 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 convenor of UMTA. The figure below shows entire Hyderabad Metropolitan area.



Source: JICA Study Team

Figure 3-7 Hyderabad Metropolitan Area

3-4 Road Transport

(1) Overall Road Condition

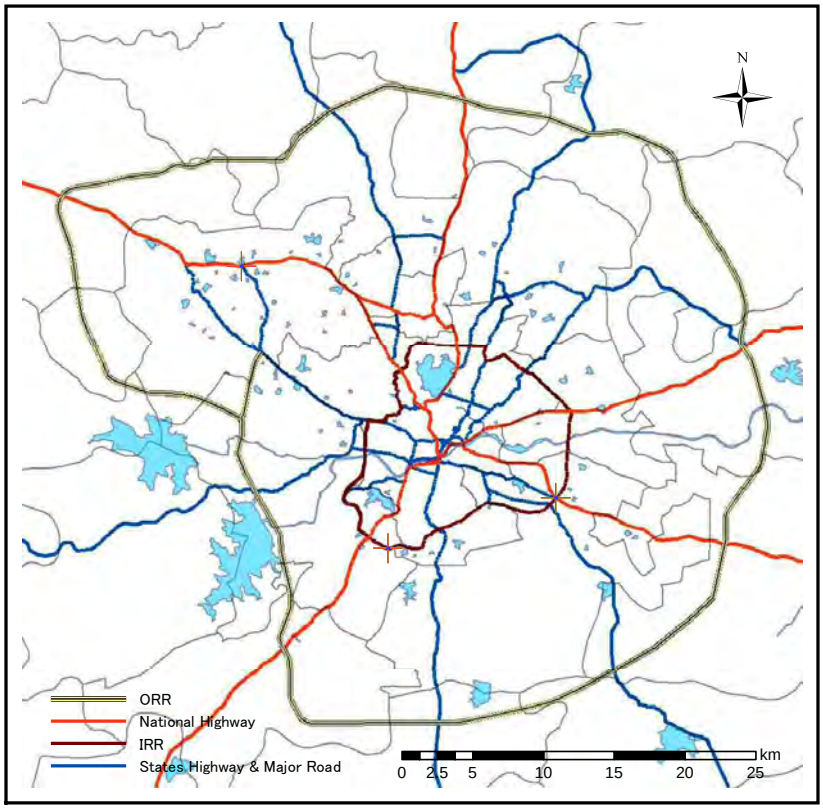
Major national highways (NH) and state highways (SH) pass through Hyderabad. The national highways include NH-44 (old NH-7), NH-65 (old NH-9) and NH-163 (old NH-202), and the state highways include SH-1 (to Karimnagar), SH-2 (to Nagarjunasagar), SH-4 (to Vikarabad), SH-5 (to Srisailam) and SH-6 (to Medak). These highways are 4 or 6 lanes and other roads are basically double-lane.

Inner Ring Road (IRR) passes around the centre of the city and connects with major surrounding areas. Outer Ring Road (ORR) is currently under construction and will pass through the suburban area in HMA.

(2) Major Road Network

The state road network is developed to link the national highways and major road network of the city. IRR connects with major junctions in the city and accommodates the inner city traffic. ORR is constructed to divert the traffic in the central areas of the city, thereby enhancing economic development in surrounding region.

HMA road network consists of 5,443 km roads including NHs, SHs, HMDA roads, IRR (50 km), and ORR (158 km).



Source: JICA Study Team

Figure 3-8 Major Road Network in HMA

(3) Road Traffic Volume

The major traffic studies carried out in HMA are listed in the table below.

Table 3-3 Major Traffic Studies

No	Report Name	Description
1	Hyderabad Area Traffic Study (HATS) I (1983-1988), HATS II (2000)	Comprehensive traffic study was conducted
2	L&T Ramboll, 2003	Development of Hyderabad Multi Modal Suburban Commuter Transportation System on Commercial Format
3	GHMC, City Development Plan (CDP), 2007	Traffic Volume Data
4	Assistance for the Introduction of ITS Related to the Hyderabad ORR Construction Project, 2010	Traffic survey on 22 cross-sections near outer ring road planned site Origin Destination (OD) survey at roadside
5	Comprehensive Transportation Study (CTS), 2011	Including traffic survey

CTS identified that the largest volume of traffic, in terms of average daily traffic volume, is approximately 2,03,966 PCU at Begumpet ROB. The traffic congestion is especially severe in the areas around IRR.

Table 3-4 Average Daily Traffic at Various Locations

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

Source: CTS Report, 2011

(4) Overall Condition of Road Infrastructure in Hyderabad

Road infrastructure is not properly developed in Hyderabad. One of the purposes of ITS is to enhance the capacity of road and transport infrastructure but it become possible only if the basic road and transport infrastructure facilities are properly developed.

There are a number of issues of the road infrastructure in Hyderabad such as,

- Unclear lane marking and lane width.
- Unclear demarcation of border between private and public land.
- Frequent delay of land acquisition due to religious and legal issues.
- Insufficient passes for pedestrians and the handicapped.
- Lack of footpaths for pedestrians
- Lack of parking bays

Source: JICA Study Team

Figure 3-9 Road Conditions in Hyderabad

(5) Traffic Signals

175 signals in total are currently in place in the city, which are 126 in Hyderabad and 49 in Cyberabad region.

Table 3-5 Existing Traffic Signals

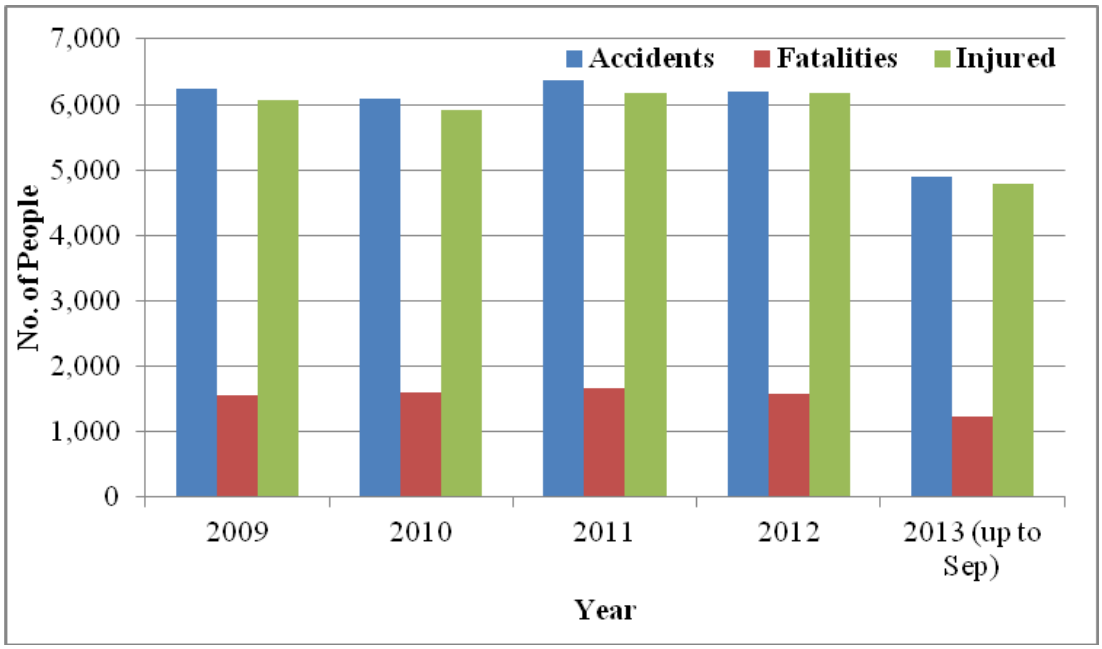
Description	Hyderabad	Cyberabad	Total
3-way	56	31	87
4-way	63	18	81
5-way	7	0	7
Total	126	49	175

Source: RFP for HTRIMS

The current traffic signals are standalone type and are either the timer based or manually operated by traffic constable. The traffic signals are not adequate in number. Most of the traffic signals are not in operation for a variety of reasons such as power-failure and improper maintenance. GHMC and the Traffic Police recently initiated Hyderabad Traffic Integrated Management System (HTRIMS) project by the state funds. 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 controlled from Traffic Command Centre (TCC). It is planned to establish TCC which is equipped with a 25 ft x 5 ft video wall in Hyderabad Police Commissioner Office.

(6) Accidents

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



Source: Hyderabad and Cyberabad Traffic Police

Figure 3-10 Accident Statistics in HMA

(7) Driving Manners

Driving manners is a major issue in HMA. Distinctive manners that adversely affects traffic are frequently observed. A great majority of the drivers ignore the traffic lanes and a number of vehicles are running in parallel without lane discipline.

The major examples are:

- Drivers take right turns at intersections where it is prohibited
- Traffic signals are usually ignored
- Three or four persons ride on 2-wheelers without helmets
- Opposite driving on the road is frequently observed
- Frequent gridlock at roundabout caused by vehicles to enter the roundabout ignoring yielding to the traffic inside the roundabout

Figure 3-11 Typical Driving Manners in Hyderabad

(8) Inadequate Facilities for Non Motorised Transport

Non-Motorised Transport (NMT) is a mode of transport such as bicycle or tricycle (cycle rickshaw), hand-pulled rickshaw, etc. NMT is not a major transport in the Hyderabad yet. The existing major transport studies points out the inadequate facilities for NMT in the city. The attention has been recently paid to NMT as environmentally sustainable transport. The planning agencies are considering introduction of bicycle tracks in Hyderabad on a pilot basis.

(9) Growth of Intermediate Public Transport

Intermediate Public Transport (IPT) is a mode of public transport that is used to go to bus stops or train stations. It generally means auto-rickshaws and taxis. Last-mile connections of the major public transport such as city bus, metro and railways have not been adequately developed 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 IPT in Hyderabad. It constitutes approximately 12% of all modes of transport and increased 30% in number during the last decade. The basic fee, which begins from INR 14 and increases based on distance, is affordable for people. Thus it is widely used.

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

(10) Footpaths, Foot Over Bridges and Underpasses

Footpaths, pedestrian walkways and underpasses are not sufficient in Hyderabad. The footpaths are generally obstructed by trees and poles in the middle of the footpaths, 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 underpasses exist in the city. However, they are not properly located nor designed. Many of them are left without proper maintenance.

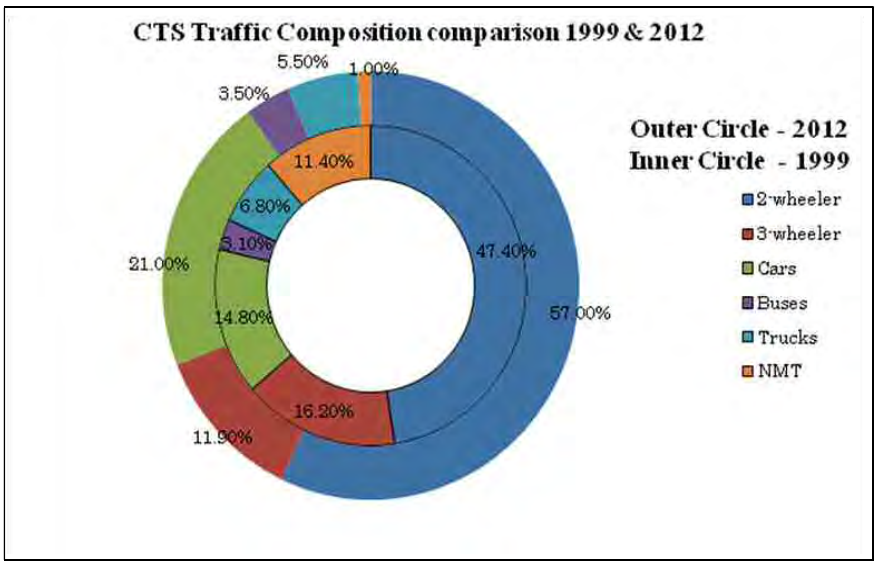
Some NGOs have been recently striving for raising public awareness of improvement of road infrastructure for pedestrians. GHMC began taking some measures in the city.

(11) Road Traffic Composition of Vehicle

The most 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:

- 2-wheelers (motorcycle)
- 3-wheelers (auto-rickshaws)
- Buses (APSRTC and private bus)
- Private cars
- Taxi and cabs
- Commercial vehicles

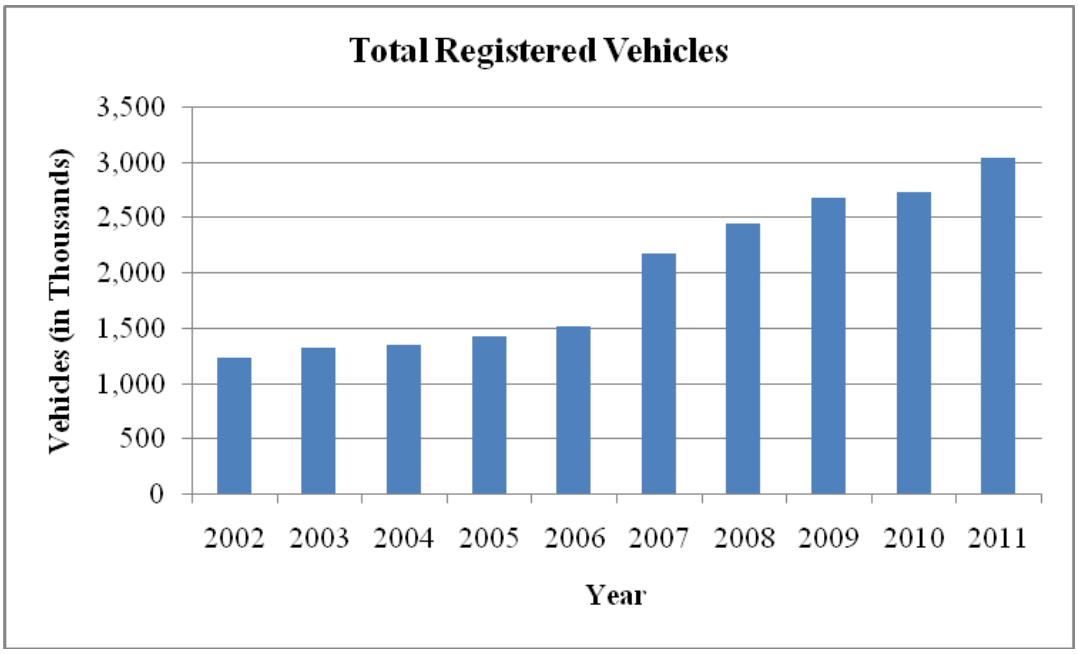
The public transport in the city is heavily dependent on road-based modes such as buses, auto-rickshaws (3-wheelers) and taxies. The rail-based mode is not a major public transport in Hyderabad city yet.



Source: CTS Report, 2011

Figure 3-12 Comparison of Vehicular Composition

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



Source: MoRTH Report, 2011

Figure 3-13 Total Registered Vehicles

3-5 Public Transport

(1) Bus Transport - APSRTC

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.

APSRTC operates approximately 22,500 buses in total (19,500 APSRTC owned buses and 3,500 hired buses) on 7,500 routes. They operate approximately 3,800 buses on 865 routes for city bus service in Hyderabad. The daily passengers are approximately 3.4 million. There are 27 bus depots in the city.

The major bus terminal in Hyderabad is 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.

The route map of APSRTC Bus in Hyderabad is shown in Figure 3-14.

The bus schedules are shown on static sign boards at the bus stops. The dynamic information such as expected bus arrival time is not provided yet.

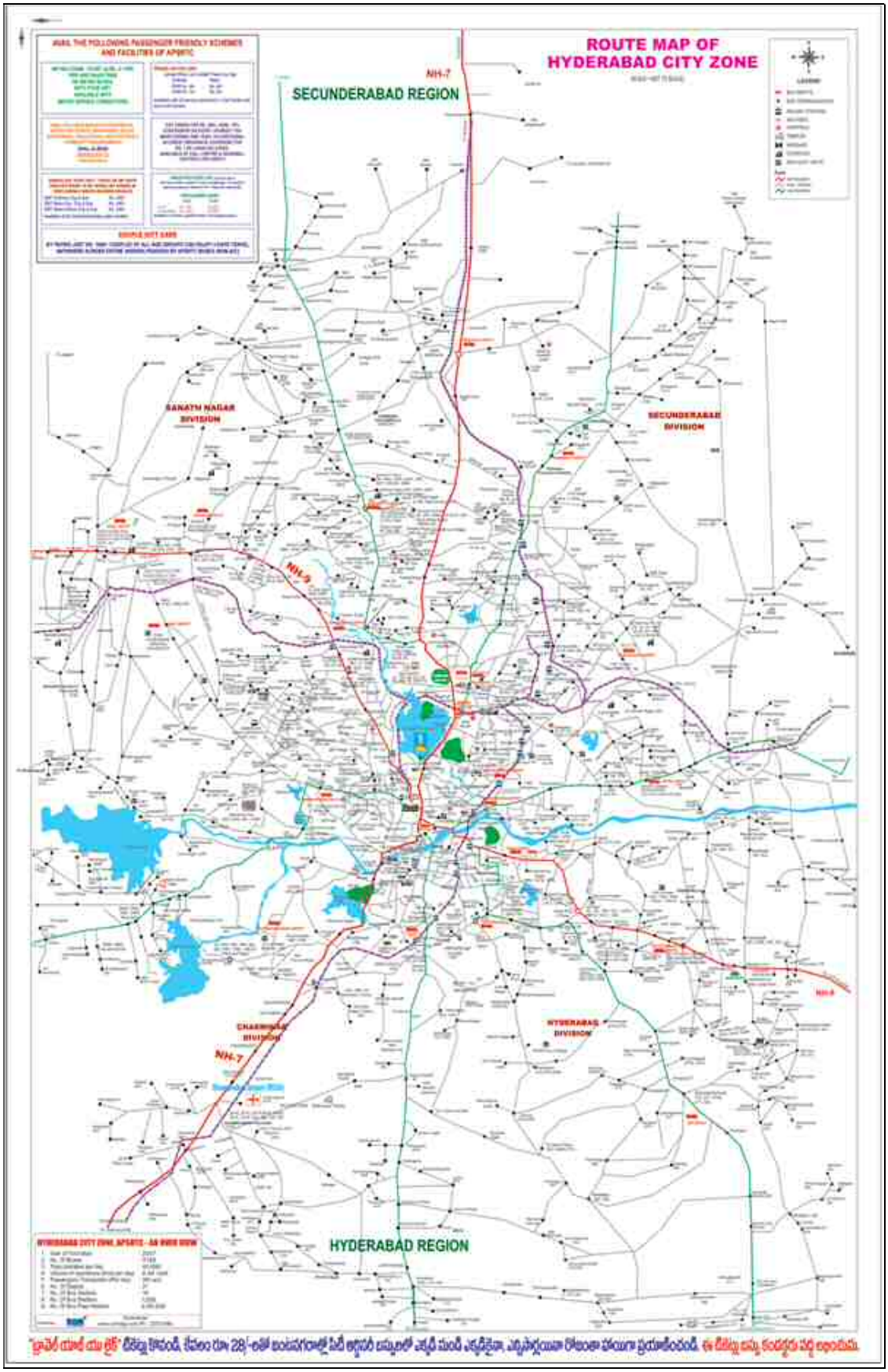
(2) Local/Suburban Rail System - Multi-Modal Transport System

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. There are 27 stations and MMTS carries approximately 1,500,000 passengers per day. There are first class, general class and special ladies compartments. Route map of Hyderabad MMTS is shown in Figure 3-15.

Smart card is issued by the SCR. It can be 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.

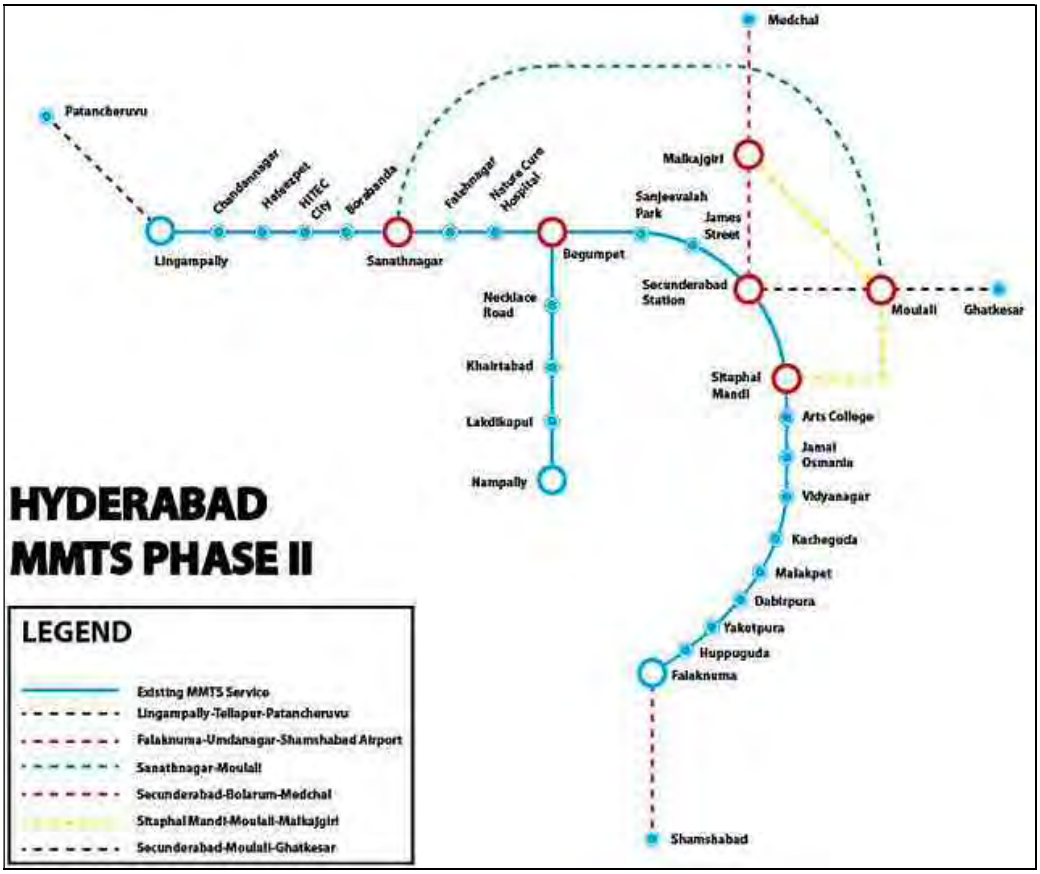
In May 2010, Indian Railways decided to implement the 107-km Phase-II project for extension of MMTS at the estimated cost of Rs. 641 crore. The railway board cleared Phase-II after the state government agreed to fund two-thirds of the cost. It will carry 300,000 passengers a day. The phase II is comprised 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 - Malkajgiri chord line (10 km)



Source: APSRTC Website

Figure 3-14 Hyderabad City APSRTC Bus Route Map



Source: Website (URL: http://www.railnews.co.in/?p=5003)

Figure 3-15 Hyderabad MMTS Route Map

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

Hyderabad Metro Rail is a mass rapid transit and it is now under construction in Hyderabad.. Phase I of the project includes three (3) corridors with total length of approximately 72 km. The stations will be located roughly at every one kilometre. The trains will run every three to five minute in peak hours. The three corridors are as follows:

- Corridor 1: Miyapur – L.B.Nagar (29 km)
- Corridor 2: Jubliee Bus Stand - Falaknuma (15 km)
- Corridor 3: Nagole – Shilparamam (28 km)

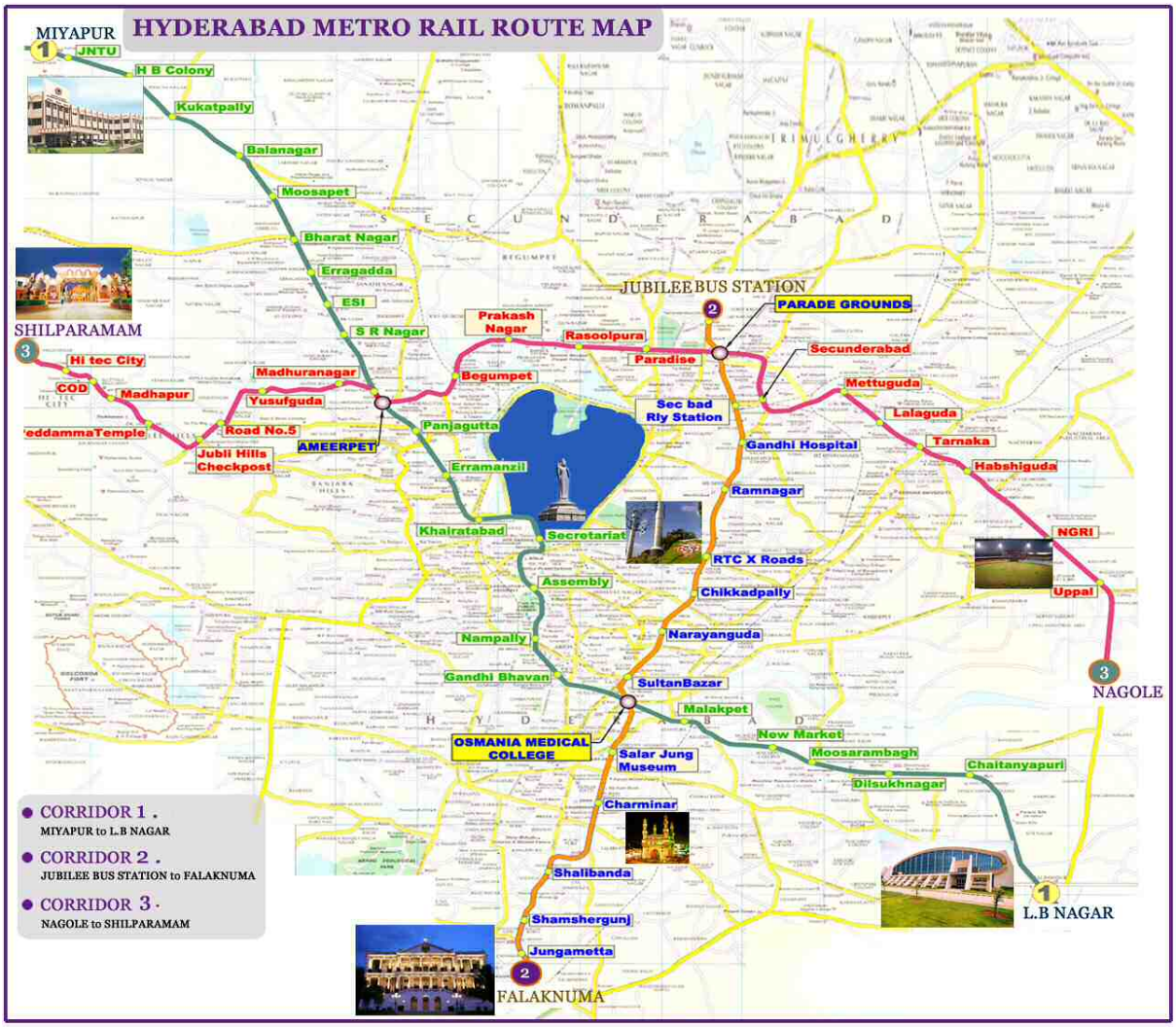
The project cost is estimated at INR 141.32 billion. It is expected that there will be 1.5 million passengers per day in 2015. The project is executed on Design, Build, Finance, Operate, Maintain and Transfer basis in Public Private Partnership (PPP) model. The implementing agency is Hyderabad Metro Rail Limited (HMRL) and the 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 package by subcontractors under the prime contractor of L&TMRHL.

Table 3-6 Package by Sub-contractor of Hyderabad Metro

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

Source: HMR Website



Source: HMR Website

Figure 3-16 Planned Hyderabad Metro Lines

3-6 Transport Related Studies and Plans in Hyderabad

(1) Major Transport Related Studies

A number of traffic and transport related studies were previously conducted in Hyderabad. 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

Comprehensive Transportation Study (CTS) is being carried out by HMDA with the approval of UMTA. It covers HMA and is funded partly by Ministry of Urban Development (MoUD), Government of India. LEA Group is a consultant for the study. 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, and
- 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 3-7 Proposed Metro, MMTS and BRTS for 2021, 2031 and 2041

No.	Proposed Transport	2021	2031	2041	Total
1	Metro network in km	98	175	48	321
2	MMTS network in km	147	116	165	428
3	BRTS network in km	67	53	273	393

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. Primary considerations were cover transit oriented development, multi nuclei concept developing alternative centres, and public transport and road development for urban development of the HMA.

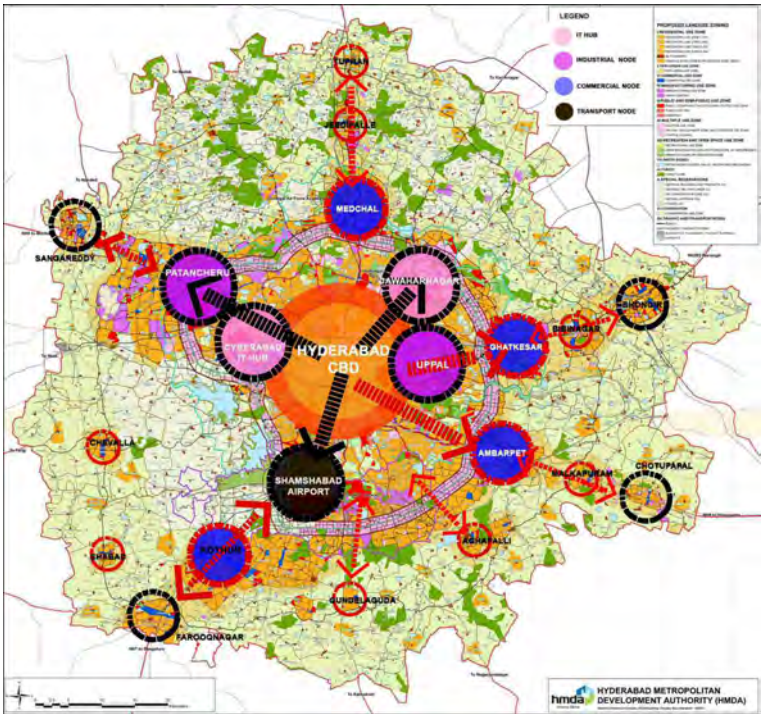
(a) Major Development in Recent Years Including Transit Oriented Development (TOD):

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's travel patterns in the city.

Several economic hubs, called 'multiple nuclei centres' are planned to disperse the economic activities under such situation, and Transit Oriented Development (TOD) which facilitates better connectivity in the city incorporating all above aspects is included 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 by 2031. It is critical to properly disperse the growing economic and commercial activities in the urban area. Multiple nuclei centres/sub centres which are distributed economic/commercial hubs are planned as shown in the figure below.

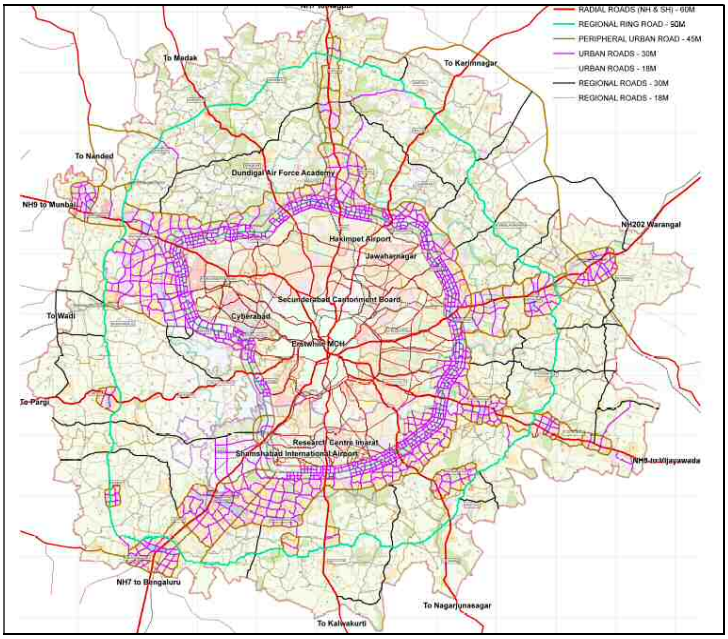


Source: HMDA Master Plan - 2031

Figure 3-17 Multiple Nuclei Concept for Alternative Centres and Sub Centres

(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, etc.

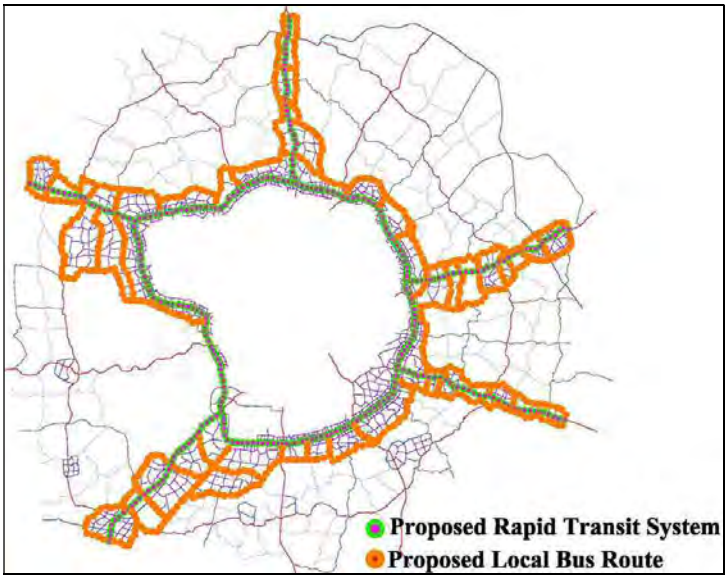


Source: HMDA Master Plan - 2031

Figure 3-18 Proposed Major Road Network

(d) Proposed Public Transport Development:

The figure below shows the major public transport development proposed by the master plan. It is planned that 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.



Source: HMDA Master Plan - 2031

Figure 3-19 Proposed Public Transport Development

3-7 Current Conditions of ITS in India and Hyderabad

3-7-1 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 well 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, etc. The Greater Mumbai Municipal Corporation (MCGM) operates the facility monitoring centre which monitors the above roadside 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 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.

3-7-2 Current Conditions and Existing Plans of ITS-Related Facilities in Hyderabad

The ITS facilities have not been substantially put 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 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 roadside 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 include the following components:

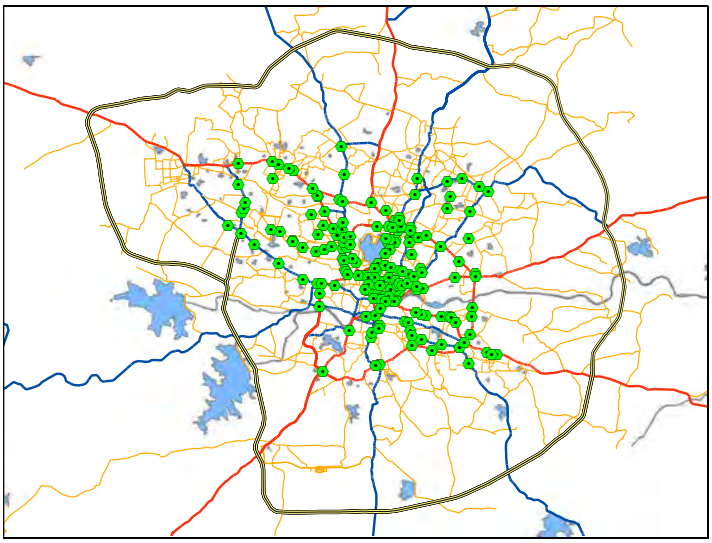
- Manual and Touch & Go lane equipment,
- ETC lane equipment,
- POS system at toll plaza office for issuance and re-charge of smart card,
- Plaza server system, and
- Toll management centre.

(2) Hyderabad Traffic Integrated Management System

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

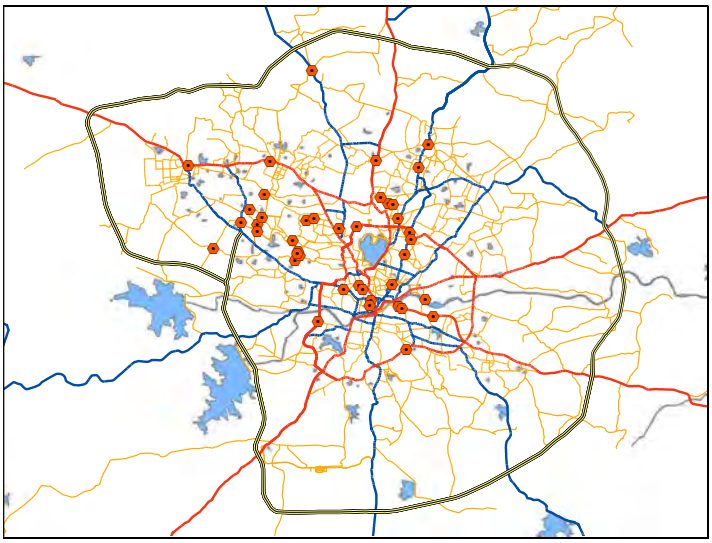
- To prepare the Traffic Command Centre (TCC) at the location of the existing headquarter of the Hyderabad police commissioner office and back-up centre at the Cyberabad police commissioner office.
- To equip the TCC with large display board called ‘video wall’, which is 25 ft X 5 ft to monitor the traffic 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.



Source: JICA Study Team

Figure 3-20 Location of Existing Traffic Signals to be Replaced by HTRIMS Project



Source: JICA Study Team

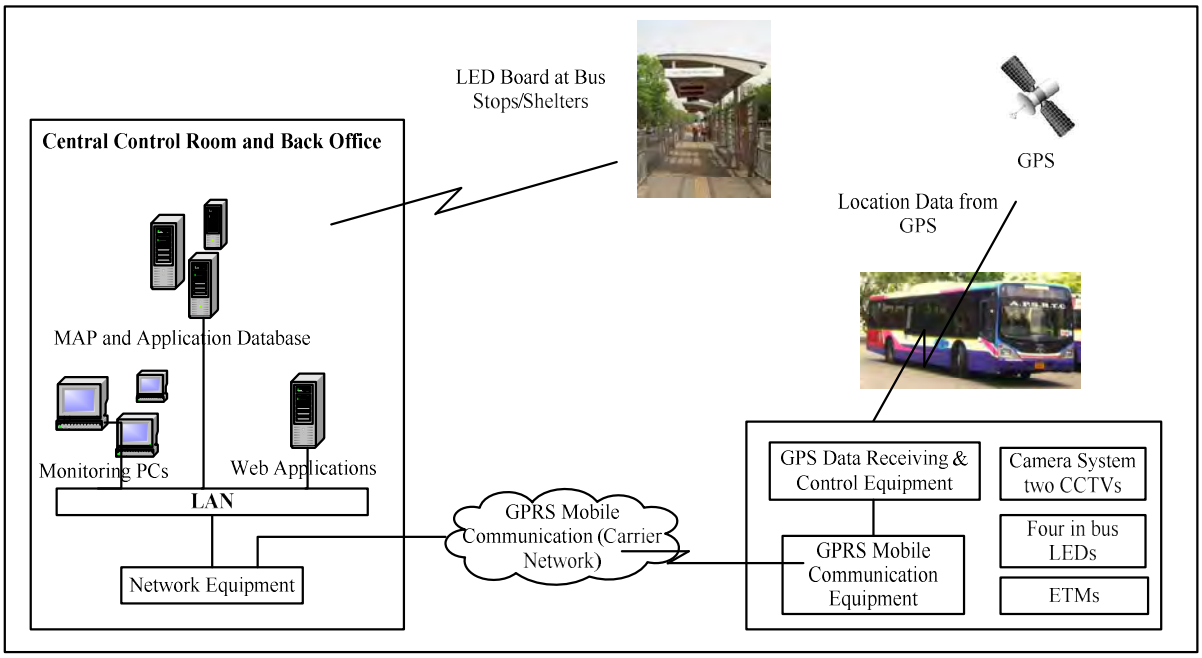
Figure 3-21 Location of New Traffic Signals to Be Installed by HTRIMS Project

(3) Bus Information System by APSRTC

Andhra Pradesh State Road Transport Corporation (APSRTC) owns 22,500 buses in total and operates approximately 3,800 buses for city bus service in Hyderabad.

It is planned to develop Vehicle Tracking System installing GPS units on 3,502 buses including city buses and inter-city/state buses. The project was awarded to M/s CMC Ltd. It includes 1,347 city buses in Hyderabad. Further, additional buses will be procured under JNNURM phase-2, and they will also be covered by the project in the future. Approximately 100 LED display message boards, which display the information of estimated arrival time of buses, are planned to install at important locations in Hyderabad

The figure below shows an overall configuration of the system planned by APSRTC. The GPS unit mounted on the bus transmits data on location of the bus to the centre. The centre monitors bus operation. The buses will be equipped with in-bus LED message boards to show next bus stop information. The LED message board at bus stop will display the information such as expected arrival/ departure time, bus operating status, bus route, etc., for passengers. In-bus units, message board at bus stop and centre exchange data through GPRS communication.



Source: JICA Study Team

Figure 3-22 Bus Location System as Planned by APSRTC

(a) Vehicle Tracking and Passenger Information System:

APSRTC is implementing Vehicle Tracking and Passenger Information System for 3,502 buses, out of which 1,616 are special type buses for long distance. 1,347 city buses (937 JNNURM buses and 410 conventional buses) in Hyderabad are also covered under the project. Remaining 539 buses are procured by JNnURM which are operated in Vijayawada (239 buses), Visakapanam (250 buses) and Thirupathi (50 buses).

The project has been awarded to M/s CMC Ltd. GPS will be used for tracking the buses and GPRS communication will be used for data transmission.

A Vehicle Tracking Unit will be installed in all buses covered under the project. An onboard camera with recording unit (for recording up to 48 hours) and, an in-bus LED display with voice announcement for information about expected time of next bus stops will be installed in the buses procured under JNNURM.

Approximately 100 LED displays are proposed to be installed at important locations in Hyderabad for displaying information of the estimated time of arrival of buses. The city bus in Hyderabad will be monitored from control centre established in Jubilee bus station.

The APSRTC data centre equipment is hosted in the AP state data centre facility.

3-8 Identified Issues

3-8-1 Summary of Identified Issues

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

Table 3-8 Summary of Identified Issues

Category	Identified Issues
Regional Socio-Economic Characteristics	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.
Regional Traffic Characteristics	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).
Regional Transportation Characteristics	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.
Road Infrastructure	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.
Traffic Manners	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 and motorcycles, unsafe overtaking. Insufficient awareness of importance of traffic discipline.
Existing Facilities	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.
Facility Management	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 out-sourced to the private company for operation by BOT)

Category	Identified Issues
	The responsibility becomes unclear and results in lack of consistency for proper operation and management.
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.

3-8-2 Most Critical Issues from a View Point of ITS

In addition to the above, the most critical issues in Hyderabad from the viewpoint of ITS are as follows:

Table 3-9 Most Critical Issues in Hyderabad

Most Critical Issues in Hyderabad
1. Absence of Quantitative Traffic Data
2. Absence of Centrally Coordinated Administrative Structure
3. Lack of Basic Infrastructure
4. Insufficient Proper Facility Maintenance
5. Absence of National Framework

The details are explained below.

(1) Absence of Quantitative Traffic Data

The road infrastructure and traffic management need to be properly planned, implemented and improved for greater positive effects. This can be realised by utilizing the accumulated quantitative traffic data. However there are no basic facilities which can collect, cumulate and evaluate the measures taken. In addition, no major initiatives have been taken 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 CCTV to be used to visually confirm the conditions at site to assist the operations. 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 a fundamental solution.

(2) Absence of Centrally Coordinated Administrative Structure

A variety of different agencies are planning ITS related facilities in Hyderabad. However these plans are not sufficiently coordinated among the involved agencies and this results in lack of integration and proper maintenance. The planning, implementation and evaluation of 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 many issues in Hyderabad.

(3) Lack of Basic Infrastructure

ITS is one of soft measures. Road infrastructure needs to be properly developed to bring out effect of ITS. For example, properly designed junctions/intersections, strait-structured road, footpath appropriately developed for pedestrians, etc. are basic conditions. However such road infrastructure is not sufficiently developed in Hyderabad. In addition, lack of driving manners is also challenging issue although it is not infrastructure in Hyderabad. For example, keeping lane is important factor to measure traffic by ITS.

(4) Insufficient Proper Facility Maintenance

Some preliminary facilities are in place in Hyderabad. They include CCTV at junctions, traffic signals, signal jumping violation equipment, 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, 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 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 would be ideal to prepare the ITS under the framework of the National Policies. However the introduction of ITS has just started in recent years in India, and thus National policies have yet been established.

4 Policy Framework for Introduction of ITS

4-1 Methodology for ITS Master Plan for Hyderabad

ITS is composed by a number of different subsystems including advanced ones that are implemented in various countries in the world. For applying ITS to Hyderabad Metropolitan Area, the particular local condition needs to be well considered. However, there are many good examples from other countries 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 to best suit Hyderabad Metropolitan Area.

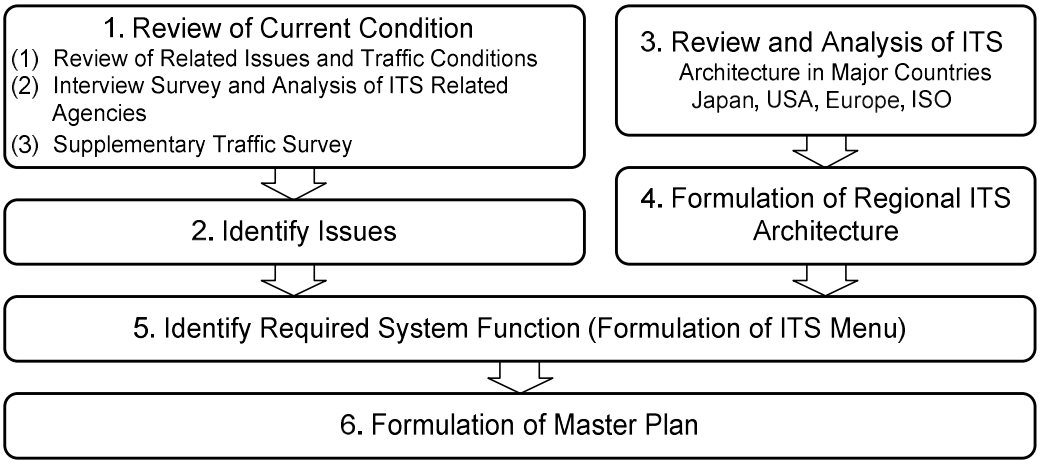


Figure 4-1 Methodology for Formulation of ITS Master Plan for Hyderabad

4-2 What is ITS?

The goals of ITS are to enhance safety, improve road environment, comfort in road usage and leading to enhanced economic growth of the region. In order to realise these, the main area to be addressed is improvement of traffic condition. In the adverse traffic congestion, the safety, environment and user conveniences are sacrificed and consequently economic growth suffers. 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, flyover 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 to accompany with the hardware measures. ITS addresses the software measures and consequently enables greater enhancement of the hardware measures.

4-3 Best Practices of ITS in the World

The best practices of ITS in the world are 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, 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 traffic by traffic signals and providing information to road users through VMS, Website, SMS, etc.

Figure 4-2 below shows an example of the traffic control centre in Japan and Figure 4-3 below shows a congestion map on the website provided by the road operator in Japan. The red lines in Figure 4-3 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 computers and mobile phones via the internet.

Figure 4-2 Example: Image of Traffic Control Centre

Figure 4-3 Example: Image of Congestion Information

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

(2) Variable Message Signboard

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

The LED is usually used as a light source because of its efficient energy consumption and long lifetime. VMS devices are controlled from the traffic control centre.

Examples of VMS in Japan are shown in the figures below. Figure 4-4 is the graphic type VMS to show the real-time simplified road image showing the traffic status such as road closure and congestion. Figure 4-5 is multi-colour and character type VMS. This type of VMS is often used on expressways in Japan. Figure 4-6 is a simplified road image type. It shows the traffic information such as road closure, congestion and travel time to 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 his destination. It is often used on expressways in Japan.

Figure 4-4 Example: Image of Graphic Variable Message Sign Board

(Showing road disaster and road closure ahead/ and providing alternative route guidance)

Figure 4-5 Example: Image of Variable Message Signboard

Figure 4-6 Example: Image of Variable Message Signboard

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

Figures shown below are examples of VMS in Europe.

The left picture in Figure 4-7 shows the combined graphic and character type of VMS. The right picture in Figure 4-7 shows two types of VMS: 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.

Figure 4-7 Example: Image of Variable Message Signboards in Europe

(3) Camera System

The camera 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 roadside at critical locations, flood prone locations and congestion points.

Figure 4-8 shows the CCTV camera attached to structure pole. The camera is covered by special case to protect it against rain. Figure 4-9 is a large screen in the traffic control centre where 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 4-8 Example: Image of CCTV on Roadside

Figure 4-9 Example: Image of Visual Confirmation by Moving Picture Captured by CCTV

Figure 4-10 and 4-11 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 processer recognizes the vehicle in real time.

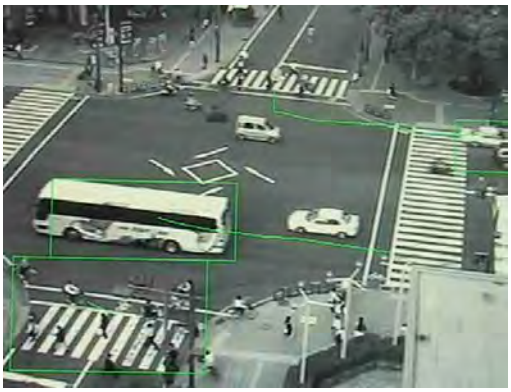


Figure 4-10 Example: Image of Image Processing Analysis for Traffic Measurement (Traffic Volume, Speed, Occupancy)

Figure 4-11 Example: Image of Image Processing Analysis (At different location)

The camera system is not only used for surveillance purpose. It is also used for traffic counting which is generally known as Automatic Traffic Counter and Classifier (ATCC), and number plate recognition which is generally called as Automatic Number Plate Recognition (ANPR).

(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 planning.

Human probe system is nowadays developed as an advanced probe system and is increasingly utilised by several agencies. Smart phones such as iPhone and android phones are used as human probe systems. The location is identified by GPS embedded in the smart-phone 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 birds-eye-views of road network by the satellite picture of a city in Japan. The light blue line means smooth traffic, yellow line slightly congested and red line highly congested. Figure 4-12 shows the damaged road after the massive earthquake in Tohoku-area in Japan in 2011. These maps are generated by utilising probe car data.

Figure 4-12 Example Image of Probe System
(Identified congested section and level of congestion)

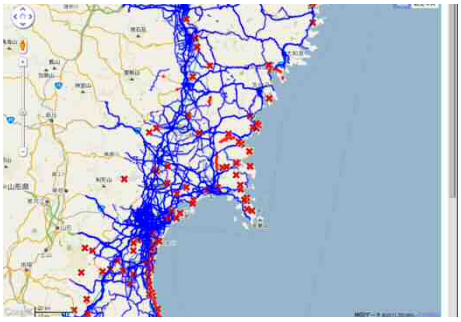


Figure 4-13 Example Image of Probe System
(Identified damaged road section after massive earthquake in Japan)

(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 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 bus users know the arrival time. The below images are examples of the bus location system operated by bus agency in Japan. Figure 4-14 shows the bus locations and their travelling status on the city roads shown on the website. Figure 4-15 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.

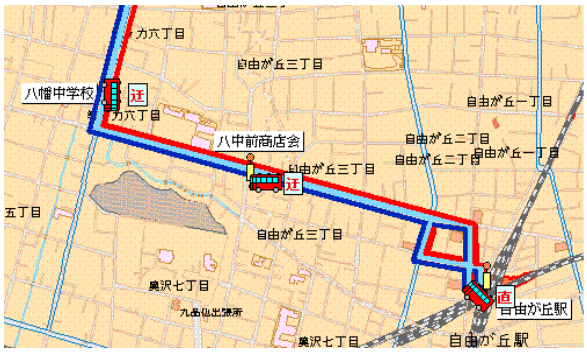


Figure 4-14 Example: Image of Bus Location Information Provided on Website

Figure 4-15 Example: Image of 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 over the 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 4-16.

Figure 4-16 Example Image of Entire Overview of Traffic Information Provision:VICS in Japan

The information provided by VICS is shown by the car navigation unit. It includes congested section, congestion level, road closure notification, etc.

Figure 4-17 Example: Image of 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 for multi-purposes including buses, railways, shopping, etc. It is an electronic money rechargeable card and can be recharged at a shop or by internet. An 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.

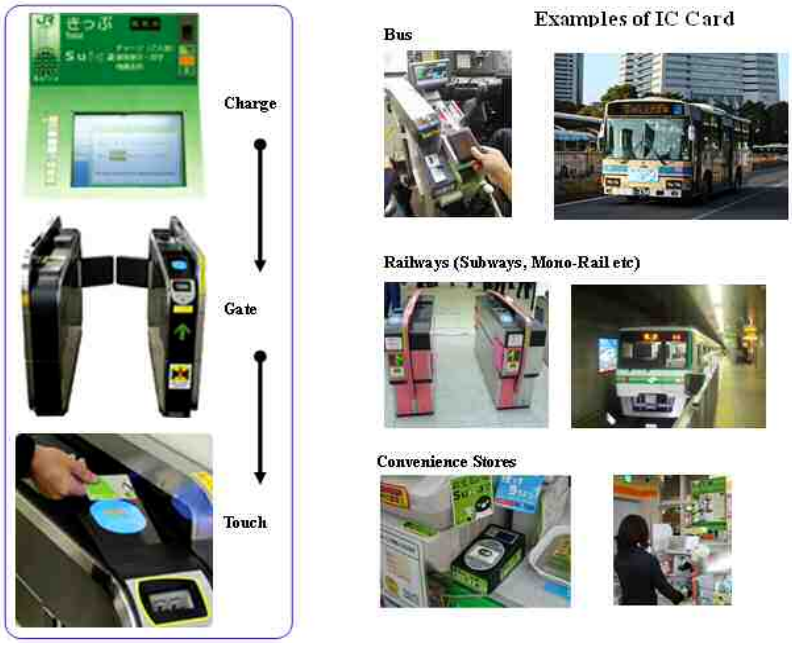


Figure 4-18 Example: Image of Multipurpose Smart Card

(8) Congestion Charging

The congestion charging is one of the methods for traffic demand management (TDM) to alleviate traffic congestion by imposing fees for road usage on road users. In recent years, the fees are electronically charged, using ITS. It is called, electronic road pricing (ERP). There are different methods and technologies of ERP implemented in the world. The major examples are DSRC based ERP in Singapore, ANPR based ERP in London, as exemplified below.

(a) Congestion Charging in Singapore:

ERP in Singapore was introduced in 1998 to regulate traffic flowing into central area of city. Currently, it is DSRC (Dedicated Short Range Communication) based ERP. It consists of on-board unit in vehicle, antenna on gantries on roadside and centre system. The fees are flexibly changed in accordance with traffic volume in charging area. The vehicles to be charged include private 4 wheeler, taxi, truck, bus and 2 wheeler.

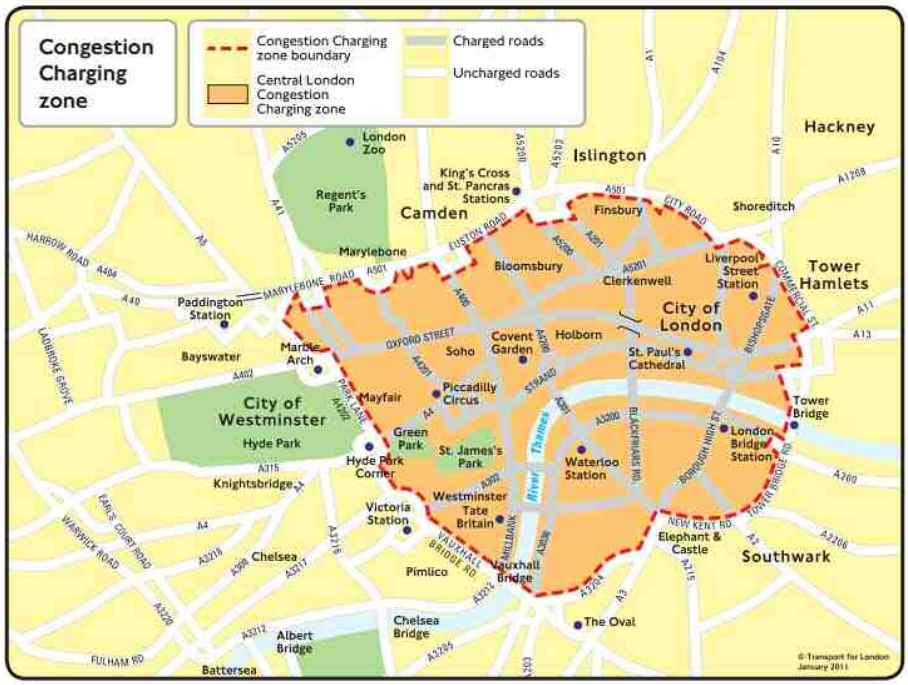
Figure 4-19 shows the ERP in Singapore. Singapore was the first city in the world to implement the electronic road toll collection system for the purpose of congestion pricing.

(b) Congestion Charging in London:

Congestion charging in London was introduced in 2003. It was initially applied to limited core area in the city and expanded to 40 sq. km. of central London including administrative district, financial district, major commercial areas, etc. It adopts automatic number plate recognition (ANPR) system. The number plates are registered in the database of Transport for London. The road users make payment, basically in advance. The payment can be made by various means such as on internet, by telephone, at counter in retail shops or petro station, etc.

The cameras monitor the number plate of vehicles. If they detect the vehicles which do not make payment in the charging area, the vehicle owner will be fined.

Figure 4-19 Example: Image of Electronic Road Pricing in Singapore



Source: Transport for London Website

Figure 4-20 Example: Image of Congestion Charging Zone in London

(9) Lane Control System

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

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

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

The variable speed controlled lane is a system that changes lane speed by displaying variable speed limit according to time and traffic conditions. Figure 4-20 shows the variable speed controlled lane system in USA.

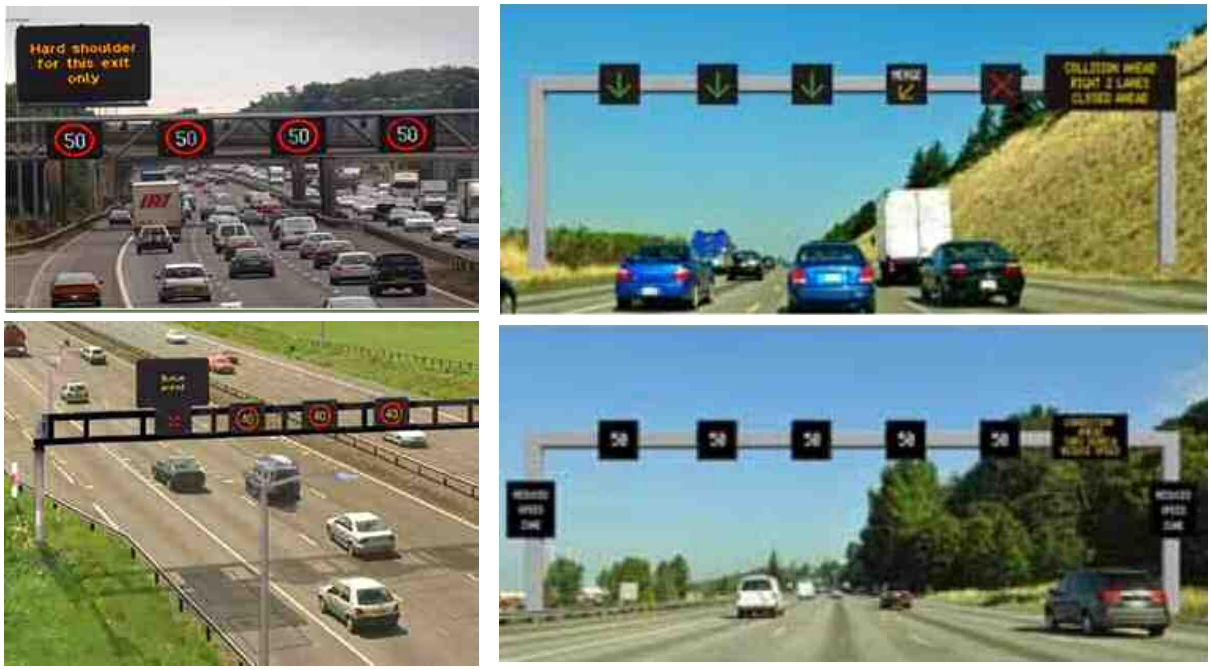


Figure 4-21 Example: Image of Lane Control by Showing Variable Speed Limit According to Time and Traffic Conditions in UK and USA

(10) Automatic Abnormal Traffic Detection

The automatic abnormal traffic detection is usually adopted at incident-prone locations such as blind curves, tunnels, merging sections on expressway, etc. It detects abnormal behaviour of traffic such as stopping vehicle caused by break-down, congestion, etc. by , in many cases, image processing. The main purpose of the system is to take prompt actions for accidents and pre-emptive measures to prevent secondary accidents.

The system provides, for example, warning message on occurrence of accident by VMS to the drivers running behind when it detects accident. The operators in the control centre take necessary actions upon receiving alarm announced by the system.

(11) Emergency Vehicle Preemption Systems

Fast Emergency Vehicle Preemption Systems (FAST) is one of the major examples of Emergency Vehicle Preemption System. It is available in Japan. It assists emergency vehicles such as police car, ambulance, etc. to arrive accident site as quickly as possible by giving them traffic signal priority along their path. It controls traffic signals to prioritise driving of emergency vehicles.

It is a part of the traffic control system and consists of in-car devices mounted on emergency vehicles and overhead infrared beacons installed along the roads as shown in the figure below.

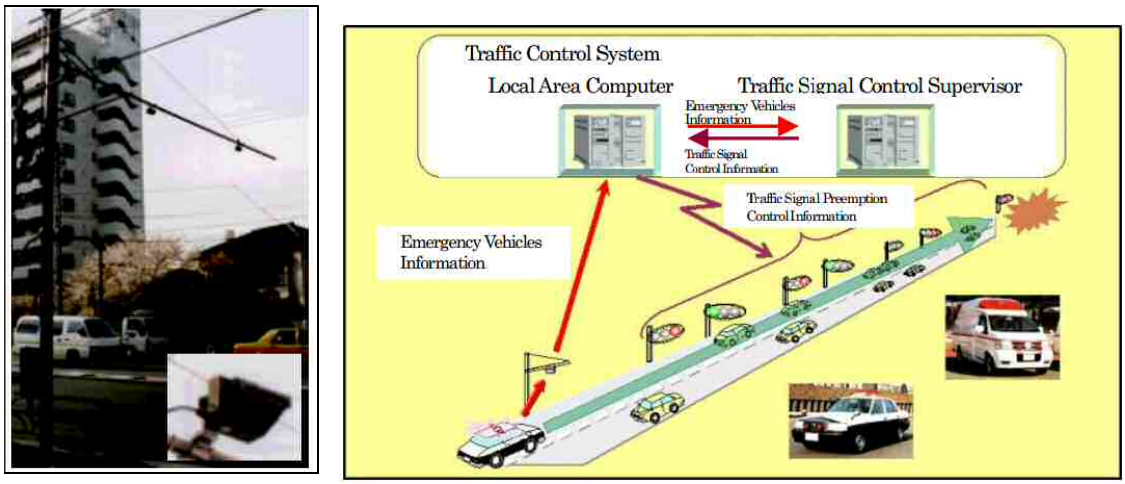


Figure 4-22 Example: Image of FAST System Configuration

The major benefits of the system are as follows:

- Improve life-saving rate
- Improve criminal arrest rate
- Prevent traffic accidents at intersections involving emergency vehicles

4-4 Important Distinction between Developed and Developing Country's ITS (Integrated Transportation System)

In all countries, an information strategy, which is a soft measure, is essential for the traffic network in addition to hard measures.

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

In developing countries, ITS may also be introduced as an advanced tool. However, the implication of ITS would be different in the developing countries where the hard measures such as the preparation of road infrastructure are not yet sufficient. In such situation, the soft measures are not limited to the domain of the information strategy, but imply more fundamental ways by which it can reinforce the hard measures for realizing better traffic flow. Under such scenario, ITS is regarded as an inclusive traffic strategy which equally encompasses the hard and soft measures in the developing country. In this sense, the meaning of the abbreviation ITS expresses '***Integrated Transportation System***', whereas generally it is '***Intelligent Transportation System***'.

4-5 Differences between National Level ITS and Regional Level ITS

National level ITS addresses standards for the entire country whereas regional level ITS addresses the particular local conditions. In case regional level ITS develops independently, the information exchange beyond the state border becomes difficult and manufacturers are required to provide different products for different regions.

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

In a huge country such as India, major transport is not limited to vehicles but also includes various transport modes such as airplanes, railways and sea vessels. Hence, it is necessary that an information strategy for 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 vision.

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 of the ITS Systems
- Implementation of Pilot Projects
- Fibre Optic Cable Network Development
- Standardisation of ITS Data Exchange and 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 Particular Regional Needs
- Developed and Deployed In Line With Regional Road Network
- Customized to Incorporate the Framework of the National ITS Strategy

4-6 Review of ITS Architectures in Major Countries

The word “architecture” is a term used with a specialized meaning in the field of information technology. It is the framework which summarizes the policy and roles of the elements. In the field of ITS, the developed countries have already prepared their own ITS Architecture.

For this study, the ITS Architectures prepared in Japan, USA, Canada, Europe and ISO were reviewed because these countries are leading in research, development and deployment of ITS technologies. Brief descriptions of the ITS Architectures in these countries are provided below.

(1) Japan

The Japanese national ITS architecture was completed in 1999. It was prepared in collaboration among five (5) related 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. In this method, systems are developed 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 complete and functional in itself.

The ITS architecture prepared by object-oriented methodology aims 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.

(2) United States of America

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

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 be regularly maintained.
- The maintaining and revising tasks are complex processes and require large amount of budget.

(3) Canada

The Canadian ITS architecture incorporates all aspects of the USA national ITS architecture. An 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 with the guidance of a steering committee consisting of representatives from public and private transportation sectors. The Border Information Flow Architecture (BIFA) is undertaken in partnership with USA Federal Highway Administration.

(4) 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.

(5) ISO 14813-1 (ISO TC204)

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 4-1 Comparison Analysis of ITS Architecture of Major Counties

Country	U.S.A	Canada	Japan	Europe	ISO
Name / Year Established	National ITS Architecture / 1996	ITS Architecture for Canada / 1999	Japanese National ITS Architecture / 1999	The FRAME Architecture / 2000	Reference Model Architecture / 2006
Agencies Owned by or Developed	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.	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.	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	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	ISO technical committees prepared ISO 14813-1 as a reference model Architecture for the ITS sector.
The No. of User Services	It is comprised of 33 user services and they bundled into 8 groups.	It is comprised of 37 user services and bundled into 9 groups.	It is composed 21 user services (56 specific user services) and bundled into 9 groups of development areas.	It is comprised of 677 user needs and bundled into 9 groups.	ISO 14813-1 identifies 11 service domains and 43 service groups.
Analysis Result	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.	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.	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.	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.	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.

(7) Summary of ITS Architectures in the World

In view of above, the ITS Architectures in the world are summarized on the basis of the ISO reference model architecture. 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 4-2 Summary of ITS Architecture in the World

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

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.

The above services are basically the most important ones as these are commonly in place across the major countries. The ITS services for Hyderabad will be 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 4-3 Goals and Objectives of ITS

No.	Goal	Objectives
1	Safety	• To reduce risk in transportation • To reduce traffic accidents • To enhance communication and response in emergency • To reduce damage in disaster
2	Environment and Energy	• To reduce air pollution • To reduce CO_2 emissions • To reduce energy consumption
3	Productivity	• To increase national or regional economic output through efficient utilisation of transport facilities
4	Mobility	• To increase efficiency in reaching destination • To reduce travel time • To reduce travel costs • To give care to disabled people
5	Efficiency	• To invest efficiently in traffic related infrastructure • To increase efficiency in road use • To reduce cost of road management • To enhance appropriate management of ITS data
6	User Satisfaction	• To increase satisfaction with safety, environment and mobility • To increase satisfaction with convenient life

(9) General Measures and Examples of Required ITS Services

The table outlines goals, objectives, general measures to achieve the objectives, and examples of required ITS services.

Table 4-4 General Measures and Examples of Required ITS Services

Goal	Objectives	General Measures	Examples of Required ITS Services
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	o Improving communication and response system for emergency o Enhancing cooperation amongst related organisations	▪ Emergency response system ▪ Emergency vehicle tracking system ▪ Emergency vehicle dispatching system ▪ Optimum route guidance provision ▪ Priority signal control
	• 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

Goal	Objectives	General Measures	Examples of Required ITS Services
Environment and Energy	• To reduce air pollution	o Reduce vehicular emission gas together with promoting public transport use	▪ Sensing for air pollution
	• To reduce CO_2 emissions • To reduce energy consumption	o Enhancing public transport o Promoting electric vehicle usage	(Same as the description of safety)
		o Improving fuel efficiency of vehicle o Promoting electric vehicle usage	▪ Electric vehicle/hybrid car ▪ Power charge facilities for electric vehicles
Productivity	• To increase national or regional economic output through efficient utilisation of transport facilities	o Enhancing smooth traffic o Reducing congestion	▪ Traffic signals and appropriate control ▪ Congestion information provision by VMS and Internet ▪ Optimum route guidance and selection by car navigation ▪ Congestion prediction and provision of information to road users ▪ Electronic road pricing for controlling traffic demand and restricting vehicle passage
		o Using ITS for commercial purpose	▪ Vehicle tracking ▪ Vehicle dispatch control
Mobility	• To increase efficiency in reaching destination • To reduce travel time	o Enhancing public transport o Promoting public transport usage o Enhancing convenience of public transport	(Same as the description of safety)

Goal	Objectives	General Measures	Examples of Required ITS Services
	• To reduce travel costs	o Preparing parking	▪ Parking location guidance system ▪ Parking status information system
		o Enhancing smooth traffic o Reducing congestion	(Same as the description of productivity)
	• To give care to disabled people	o Enhancing barrier-free measures	▪ ITS services for disabled people
Efficiency	• To invest efficiently in traffic related infrastructure	o Preparing appropriate urban plan o Preparing appropriate transport plan	▪ 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
	• To increase efficiency in road use	o Enhancing smooth traffic o Reducing congestion	(Same as the description of productivity
	• To reduce cost of road management	o Integrating road management and organisation in terms of structure, budget, and authority o Saving labour by introducing ITS	▪ ITS control centre ▪ ITS for road management e.g. CCTV, vehicle probe, vehicle detector, meteorology monitoring, disaster detection, etc.
	• To enhance appropriate management of ITS data	o Managing road and traffic data e.g. probe data, traffic volume data, etc.	▪ ITS Data Centre (ITS control centre)
User Satisfaction	• To increase satisfaction with safety, productivity, environment, and mobility	o Realising all above measures and achieving the goals	▪ Questionnaire survey and user interviews
	• To increase satisfaction with convenience life	o Replacing properly public and commercial facilities and improving road environment	▪ Information provision of public and commercial facilities ▪ Questionnaire survey and user interviews

4-7 Consideration of ITS for Hyderabad

4-7-1 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 4-5 The Issues in Hyderabad

The Issues in Hyderabad
• Absence of Quantitative Traffic Data
• Absence of Centrally Coordinated Administrative Structure
• Lack of Basic Infrastructure
• Insufficient Proper Facility Management
• Absence of National Framework

4-7-2 Required Measures by ITS for Hyderabad

Under the above conditions, the required measures which shall be realised by the ITS in Hyderabad are:

Table 4-6 Required Measures by ITS for Hyderabad

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

The issues addressed by the above measures as interrelated in the Figure below.

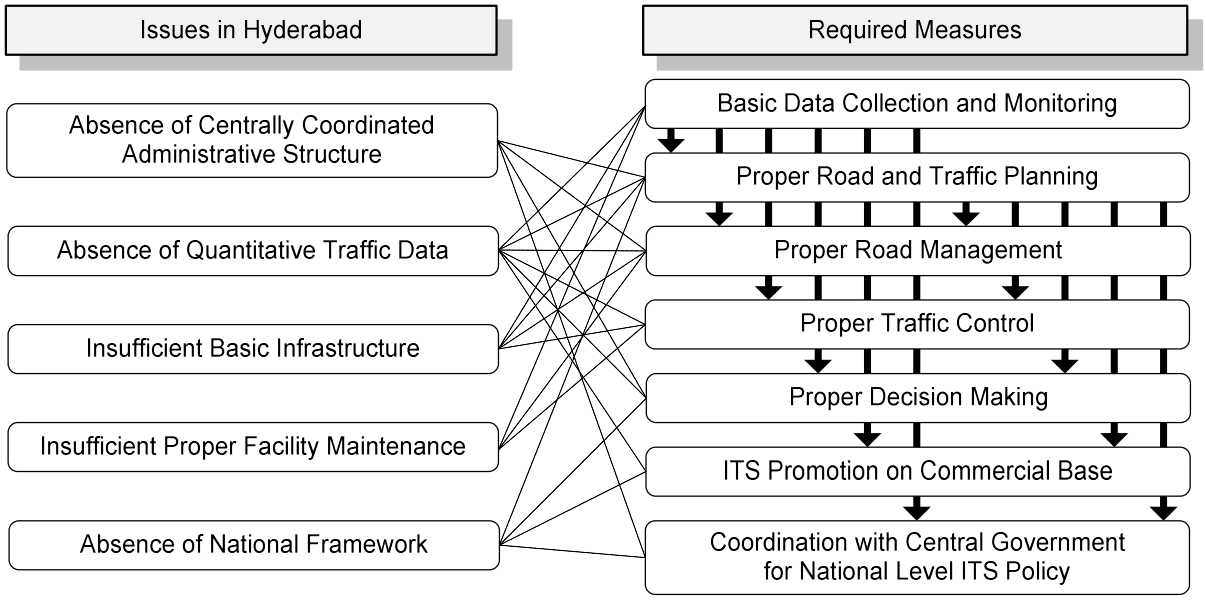


Figure 4-23 Target Items and Required Measures by ITS for Hyderabad

It is strongly stressed that it is important to start taking steps toward preparation and development of ITS in Hyderabad, as a soft measure for road and traffic management.

The measures which shall be taken are explained in detail below.

(1) Basic Data Collection and Proper Monitoring

The basic environment which enables collection of basic traffic data and proper monitoring of traffic shall be put 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 Planning

Development/improvement of road network and required traffic measures need to be properly planned. Cumulated basic traffic data which is collected by ITS needs to be utilised for planning. Such basic environment which enables proper planning based on quantitative traffic data shall to be prepared.

(3) Proper Road Management

The basic environment which enables proper road management needs to be put in place. For example, major bottle neck on road network needs to be quantitatively identified by traffic volume. The necessary action needs to be taken by monitoring flood condition on road. Such data shall be utilised for road improvement, construction and evaluation.

(4) Proper Traffic Control

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

(5) Proper Decision Making

The basic environment which enables proper decision making on road and traffic measures needs to be put in place. For example, result of quantitative analysis on traffic condition based on cumulated traffic data can be used for making policy for short, mid and long term on road and traffic measures. Furthermore, such result can also become a basis for accountability to public for investment of public project.

(6) ITS Promotion on Commercial Base

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

(7) Coordination with National Government for National ITS Policy

As discussed above, a National ITS policy needs to be put in place 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

An entity to enable all items described above needs to be established. It will have 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, flyover construction, 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.

4-8 Proposed ITS Service for Hyderabad

ITS services for Hyderabad were identified as detailed below based on the ITS Architectures studied so far.

(1) Criteria for Selection of ITS Services

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

Table 4-7 The Criteria for Selection of ITS Services

The Criteria for Selection of ITS Services
1. To introduce critical components as basic ITS infrastructure as the first priority
2. To introduce the components that are critically necessary and practical for the current conditions and issues in Hyderabad
3. To introduce the components which shall be initiated by the public sector/governmental agencies

The Criteria for Selection of ITS Services
4. To introduce ITS in phase suitably in line with budget and policies
5. To introduce the components which do not immediately require large scale hard/ infrastructure improvements at the beginning of implementation
6. To introduce the components which do not require immediate drastic policy changes at the beginning of implementation

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

- Components which will be prepared by car manufacturers
- Components which will be prepared by private companies
- Components which will be prepared on general commercial basis

(2) ITS Services to be Introduced in Hyderabad

The ITS services which need to be introduced in Hyderabad are identified as shown in the Table below. They were selected by referring to practices included in the user services in 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 4-8 ITS Services for Hyderabad

No.	User Service Bundle of World ITS Architecture	ITS Services for Hyderabad
1	Traffic Management and Operations (ISO)	Data Collection
		Information Provision
		Traffic Control
		Optimum Route Guidance
		Parking Management
2	Public Transport (ISO)	Bus Operation
		Rail Transportation
		Taxi / Auto Rickshaw Operation
3	Emergency (ISO)	Emergency Alert and Response
		Emergency Optimum Route Guidance
		Emergency Signal Control
4	Transport-Related Electronic Payment	Transport-Related Electronic Financial Transactions
		Integration of Transport-Related Electronic Payment Services
5	Road Transport-Related Personal Safety (ISO)	Driving Support
		Signal Dedicated for Pedestrian
6	Weather and Environmental Conditions	Collection of Weather Information

No.	User Service Bundle of World ITS Architecture	ITS Services for Hyderabad
	Monitoring(ISO)	Collection of Air Pollution Information
7	Disaster Response Management and Coordination (ISO)	Disaster Alert and Response
		Disaster Operation Assistance
8	ITS Data Management	Collection, Store and Aggregation of Data
		Traffic Data Analysis
		Traffic Accident Analysis
		Emergency and Disaster Information Analysis
9	Maintenance and Construction Management	Road Management
10	Law Enforcement	Assistance of Police Activities
		Automated Speed Enforcement
		Automated Signal Jumping Enforcement
		Automated Wrong way Driving Enforcement
		Automated Illegal Parking Enforcement
		Automated Overloaded Vehicle Enforcement
		Automated Over-height Vehicle Enforcement

Note: The ITS services along with examples, detailed description, technologies, benefits to stakeholders and flow diagrams are provided in Appendix–I.

The items below which are defined by 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 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 need to be initiated and implemented at the national level.

Table 4-9 ITS Services Excluded from Above

No.	User Service Bundle of World ITS Architecture	Sub-System in Hyderabad
1	Traveller Information(ISO)	To be Implemented by Private Sector
2	Vehicle Systems(ISO)	
3	Freight Transport(ISO)	
4	Advances in Navigation Systems	
5	National Security(ISO)	National Level Implementation

4-9 Road Map for ITS in Hyderabad

4-9-1 Phased-Wise Implementation Policy

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

On the basis of this approach, the following phased expansion policies are set out:

Table 4-10 Phased Implementation Policy

Phases	Policy
Phase-1 (1-5 years)	Establishment of ITS Centre (ITSC) Preparation of Basic ITS Component
Phase-2 (6-10 years)	Expansion of Basic ITS Component Introduction of Advanced ITS Component
Phase-3 (After 10 years)	Expansion of More Advanced ITS Component

Notes:

- **Number of Years Set Out:** Information technology advancement is very rapid. Hence, it is appropriate to set out 5 years for Phase-1 and 10 years for Phase-2. The systems to be introduced in Phase-3 will have to be re-considered because the surrounding environment will become significantly different with emergence of new technology in the future, due to the same reason of rapid technological advancement.
- **System Review:** During the following phases after 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.
- **Equipment Replacement:** It should be noted that the equipment needs to be replaced at certain intervals as indicated below;

Table 4-11 Equipment Replacement Term

Items	Replacement Term
Central Processing Unit	5 years
Roadside Equipment	10 – 15 years
Communication	10 – 15 years
Electric Equipment	20 years
Civil Work	30 years

4-9-2 Establishment of ITS Centre (ITSC)

ITS is indispensable social infrastructure which should be prepared together with the road infrastructure development. In the absence of a single central 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. Integrated ITS development, traffic control and road management will become difficult in such condition, and more importantly, it will result in huge loss of manpower, 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 sector with/without charge. The coordination and collaboration with the private sector will become necessary as well, from this viewpoint. Moreover, an engine for continuous promotion of ITS in Hyderabad is strongly required under conditions where ITS implementation is not 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 include 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. 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 to be equipped are as follows:

(1) Purpose of ITSC

The purpose of ITSC is as follows:

- Central engine for continuous ITS initiatives to expand in Hyderabad.
- Assures the coordination with the National ITS Policy for ITS expansion in Hyderabad.
- Carries out business with the private sector by selling the generated traffic information for assuring the revenue for the operation of ITSC.
- Functions as a central single agency responsible for planning, implementing, evaluating the ITS systems and development/expansion.
- Collects all the road/traffic data and provides to the users and relevant agencies.

(2) Functions of ITSC

The following functions will be handled by ITSC:

- Collection of traffic data from the road-side/probe based sensors and personal information through 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 roadside
- Automatic traffic signal control and related facilities for traffic flow control
- Analysis of real-time dynamic data and offline based accumulated data for identifying

bottleneck of traffic, before and after evaluation of the project

- Planning and evaluation of traffic management and road infrastructure
- Owning the rights 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
- Operation and management of clearinghouse of common mobility card.

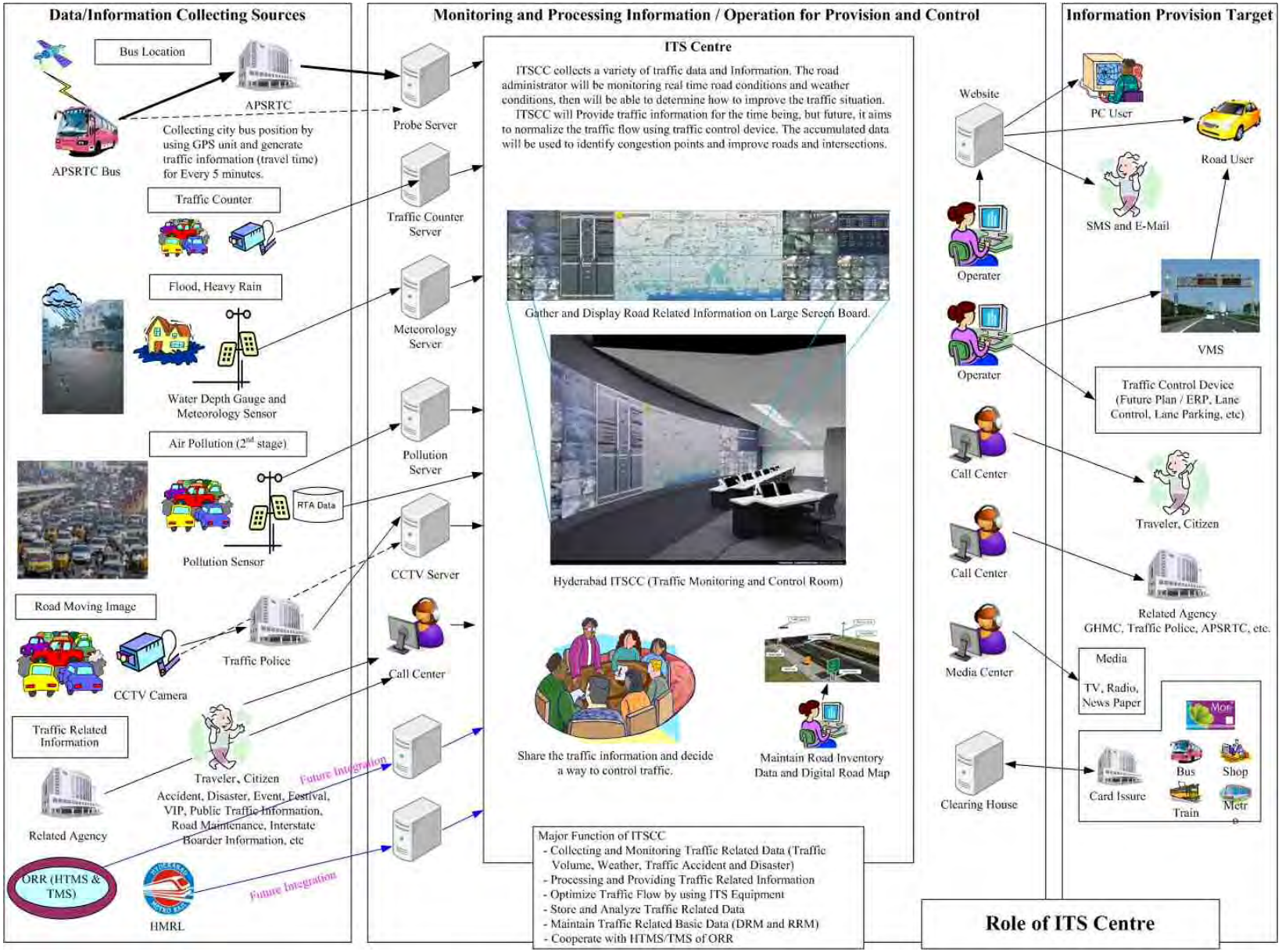


Figure 4-24 ITSC to be Established in Phase-1

(3) Important Issues in Establishment of ITSC

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

(a) Establishment Scheme

The most recommendable scheme is that ITSC be established as Special Purpose Vehicle (SPV) invested by the related agencies such as HMDA, GHMC, Traffic Police, etc. in consideration of its functions. However 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 ITSC will start as a 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 afterwards.

(b) Authority for Traffic Control Vested with ITSC

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

(c) Property Right of Traffic Data/Information

Various kinds of traffic related data will be collected through a number of different equipments such as traffic counter, flood monitoring sensors, bus probe systems, etc. Then the collected data will be processed and traffic information will be generated at 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 it to the interested parties including the public and private sectors. In order to assure this, the property rights of the collected data and generated information need to belong to ITSC.

The detail diagram of function of ITSC and the image of ITSC stakeholders responsibilities in Phase-1 are shown in the following figures.

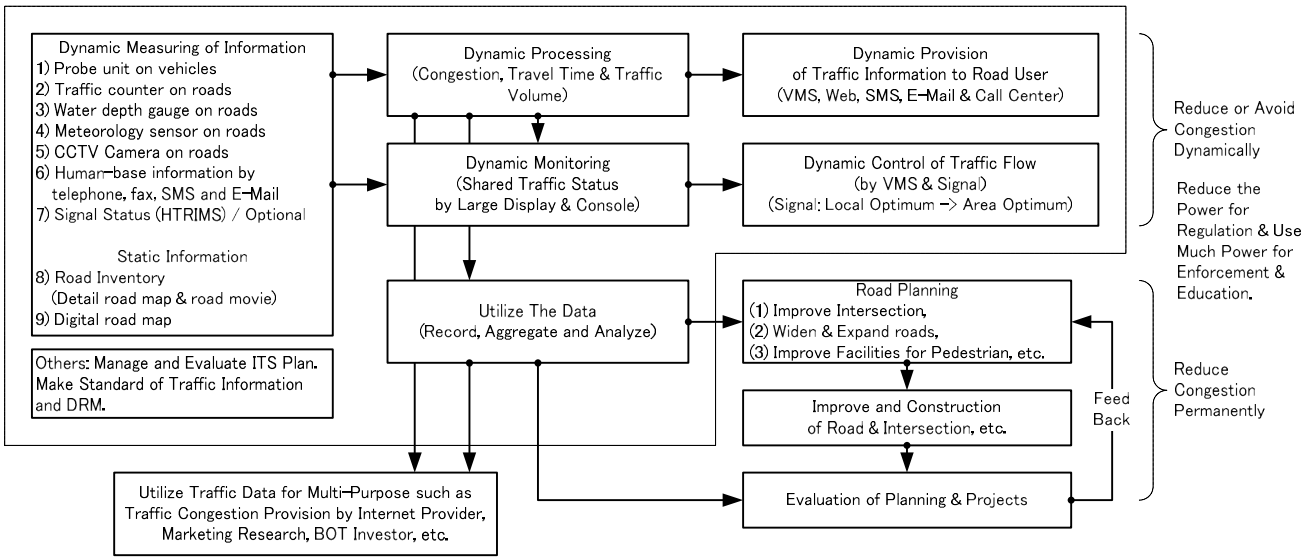


Figure 4-25 Example: Image of Detail Diagram of Functions of ITSC

(d) Stakeholder Responsibilities in terms of ITSC

Table 4-12 Role of Stakeholders to ITSC

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

Major Stakeholder	Major Role in regard of ITSC	Required Data from Stakeholder to ITSC	Information Provision by ITSC
Andhra Pradesh Road Transportation Corporation (APSRTC)	• Public city bus operations	• Bus probe data • Bus schedule information (electronic time table) • Bus fare payment mode (smart card, common mobility card, etc.,) • Park & ride details • Public information on bus operations	• 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
Hyderabad Metro Rail (HMR)	• Elevated rapid rail transit operations in the city	• Metro rail schedule data (electronic time table) • Metro rail fare payment mode details (smart card, common mobility card, etc.,) • Park & ride details • Public information on rail operations	• Travel options information • Optimum route guidance information • Information on other transport modes • Public transport demand reports
Multi-Modal Transportation System (MMTS)	• Suburban rail system operations in the city	• MMTS rail schedule data (electronic time table) • MMTS rail fare payment mode details (smart card, common mobility card, etc.,) • Park & ride details • Public information on MMTS rail operations	• Travel options information • Optimum route guidance information • Information on other transport modes • Public transport demand reports
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

4-9-3 Equipment Installation Policy

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

(1) Road Classification:

It was recommended by other previous studies to prepare a 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 4-13 Road Classification

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

(2) Basic Principle:

The ITS equipment will be installed to cover the major roads and important areas in the city at first in 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 cover the entire area 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, so 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 another 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 road-widening, alignment change and overlap with metro construction.

(4) Installation Policy:

Based on the above discussion, the following implementation policies are set out:

Table 4-14 Installation Policy

Phases	Policy
Phase-1 (5 years)	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.
Phase-2 (10 years)	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.
Phase-3 (After 10 years)	The equipment will be expanded along other link roads, which are major link roads connecting the major junctions, and major residential roads.

Based on the above basic policies, the location plans for the individual equipment are set out as described in the conceptual design section.

4-9-4 Relation between ITSC and Existing Plans

(1) Hyderabad Traffic Integrated Management System (HTRIMS)

Hyderabad traffic police have a control centre in its headquarters and it operates CCTV monitoring at junctions. Currently the CCTV monitoring in the jurisdiction of Cyberabad traffic police is separately conducted by the Cyberabad traffic police headquarters. The traffic signals in both of jurisdictions are standalone and not connected to their headquarters, 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 commissioners office.
- Prepare 221 signals at junctions: existing 180 and new 41.
- Install seventeen (17) VMS in the city.

- Prepare a centralised management information system for supporting decision- making in a traffic event such as traffic disaster or VIP movement.
- Prepare a Video Wall System at TCC.

The relation between ITSC and HTRIMS is show in the Figure below.

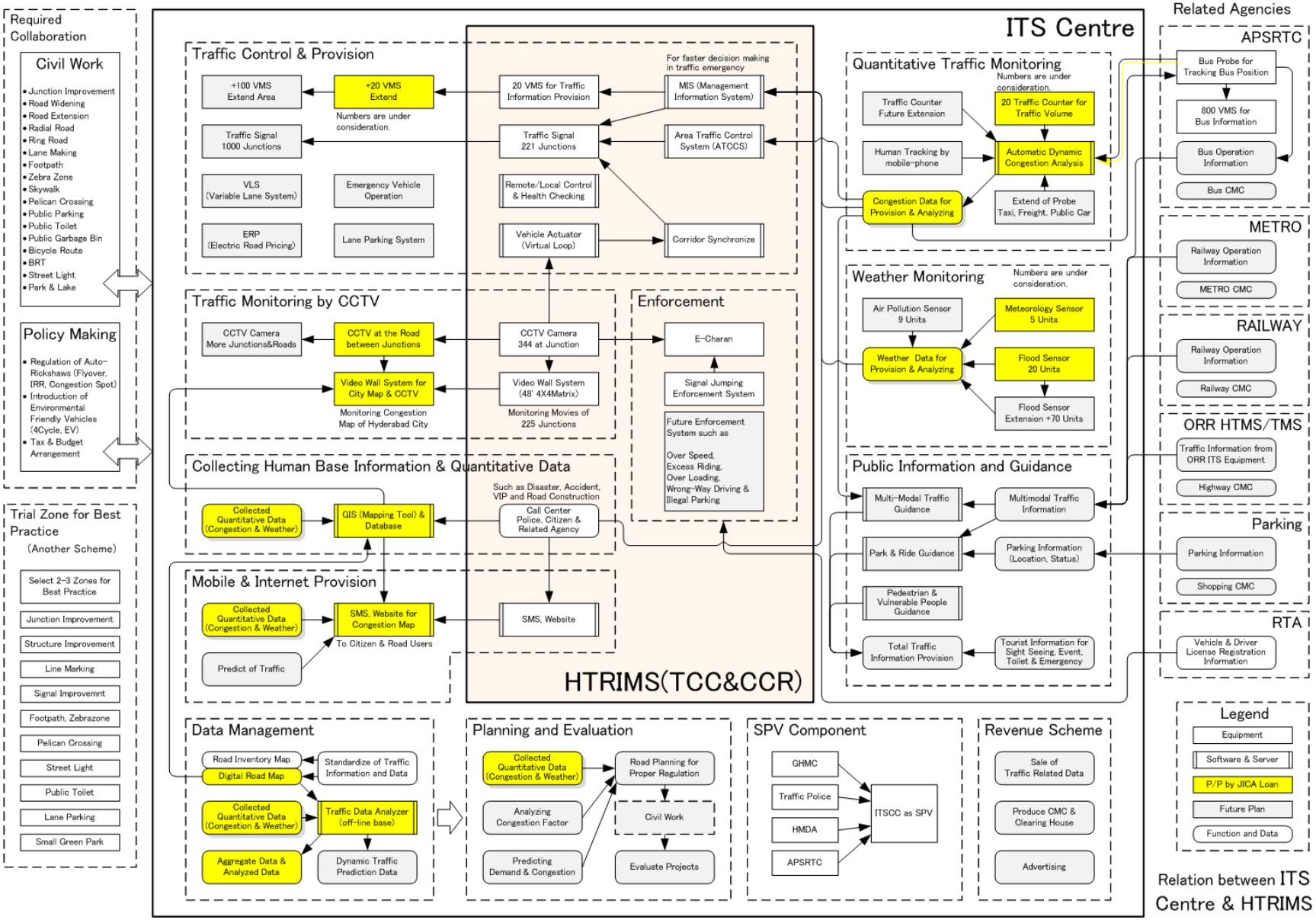


Figure 4-26 Relation between ITSC and HTRIMS

(2) APSRTC Bus Location System

APSRTC is planning to introduce GPS/GPRS based bus location system for its fleet of 1,347 buses in Hyderabad. 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.

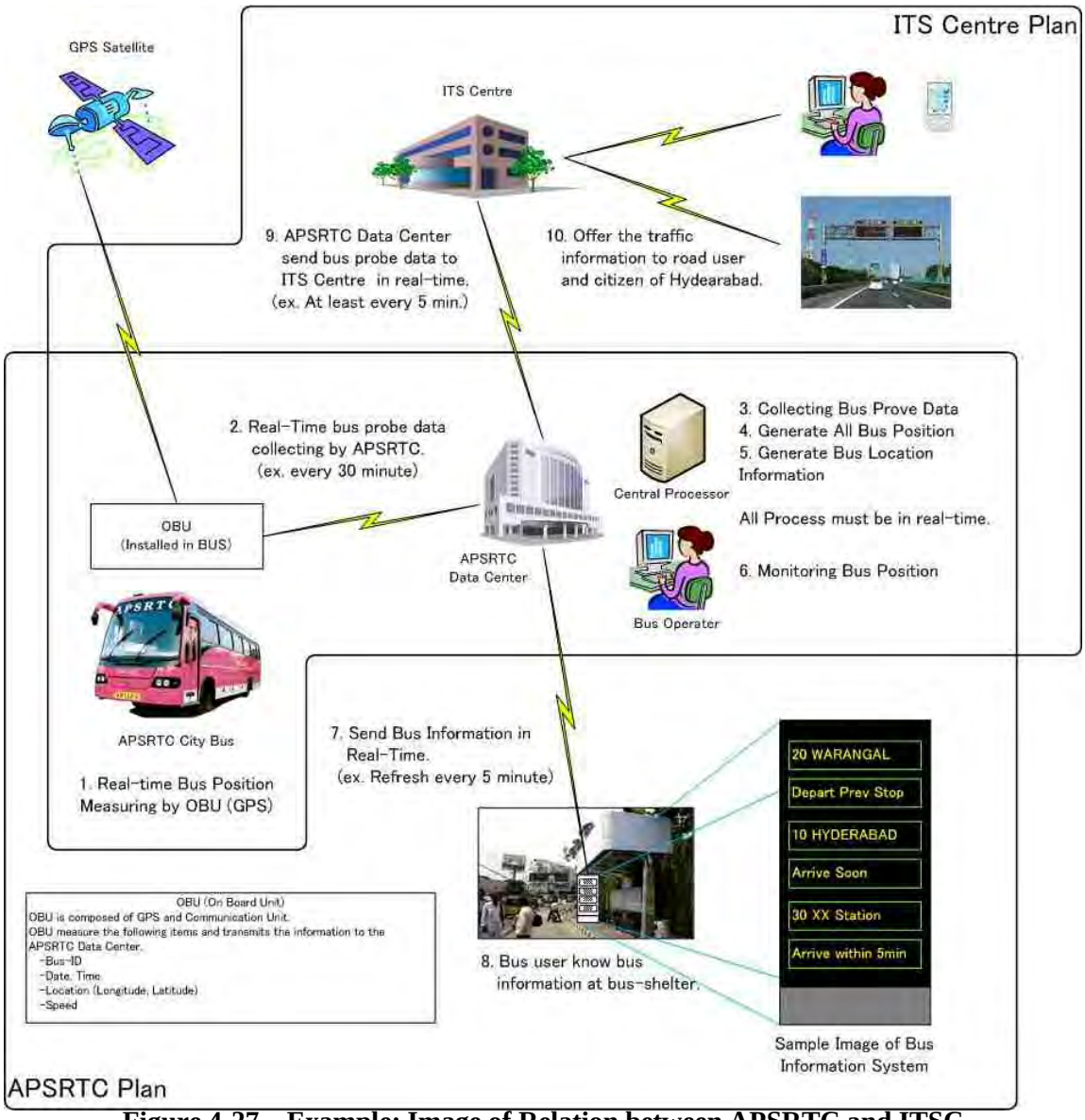


Figure 4-27 Example: Image of Relation between APSRTC and ITSC

4-9-5 Required Hard and Soft Measures in Parallel with ITS Preparation

As described in the previous clause, it is important that the hard and soft measures such as improvement of traffic discipline are taken in parallel with preparation of ITS.

The figure below shows ITS in the context of the required soft and hard 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 assisting growth of the economy. The required steps are: A) Improvement of Road Network, B) Improvement of Intersections, C) Improvement of Driver and Pedestrian Manners, D) Proper Operation and Maintenance, E) Preparation of Financial Arrangement. On top of this preparation, ITS will be introduced to realise the goals in the road transport sector.

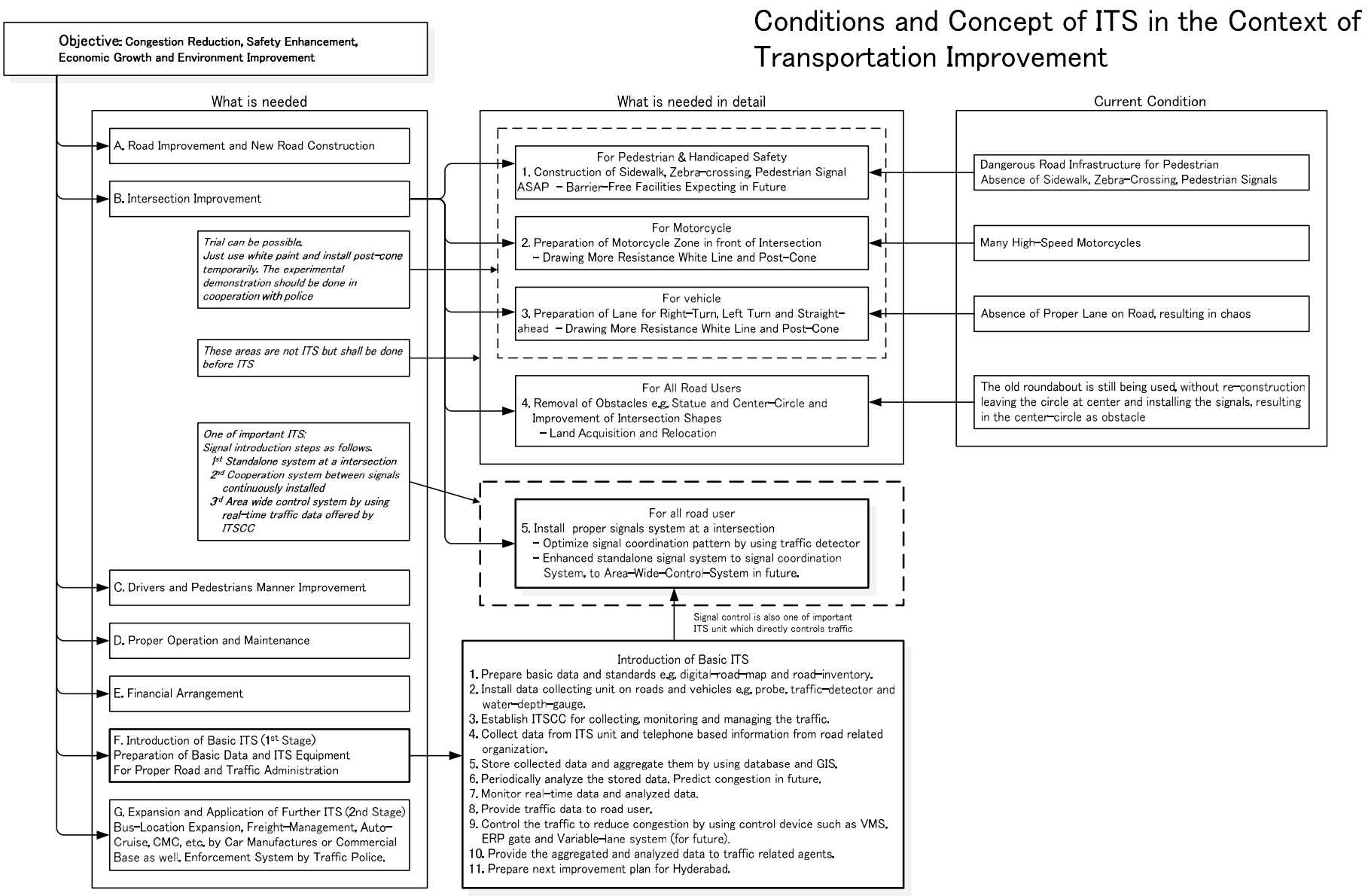


Figure 4-28 Conditions and Concept of ITS in the context of Transportation Improvement

4-9-6 Implementation Schedule

(1) Master Plan Schedule

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

Table 4-15 Master Plan Implementation Schedule

Items	Phase-1	Phase-2	Phase-3
Installation Priority	- Major road: NH-44 (old NH-7), NH-65 (old NH-9), NH-163 (old NH202), IRR, SH - Other important locations in city	- Distribute road: radial road - Link road: the road linking between above roads - Other important locations	- Link road: the road linking between major junctions - Residential road - Important locations on colony road
	Installation shall be postponed to avoid re-working on the sections with planned civil construction/improvement which includes e.g.: ・ Widening/Extension on Radial Road ・ Sections along Planned Metro Construction		
ITSC	- ITSC establishment - Organisation setup - Preparation of 1st phase systems	- Expansion of system in 2nd phase.	- Expansion of system in 3rd phase.
	ITSC Roles: ・ Traffic monitoring and analysis, traffic information provision, traffic control ・ Planning, implementation, evaluation of ITS ・ System integration, ITS development initiative		
Collection Method	CCTV, ATCC, Probes, personal information from agencies and citizens	Expansion of those left	Expansion of those left and Human Probes
Provision Method	VMS, Website, SMS, E-Mail and Call Centre	Expansion of those left	Expansion of those left
Traffic Control Method	Signals on the Road VMS on the road	- Expansion of those left - Variable Lane System - Park & Ride Guidance - Multi modal transport guidance - Parking information guidance	- Expansion of those left - ERP (Electronic Road Pricing)
	To be expanded in 2nd and 3rd phases in line with preparation of - Public & Lane Parking, Public Based Multi Modal Transportations		

(2) Important Parallel Issues

In addition to the above implementation, the following parallel issues need to be addressed 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 flyover construction, road widening and sidewalk preparation for pedestrian.

(3) Road Map for ITS Development in Hyderabad

The road map for ITS Development 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 Components

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 components for ITS such as digital road map will be prepared. The hard measures such as road infrastructure improvement and soft measures such as traffic discipline improvement will be taken in parallel.

(b) Phase-2 (6 – 10 years):

Policy: Expansion of Basic ITS Components, Introduction of Advanced ITS Components

Concept: During this period, the systems prepared in Phase-1 will be reviewed. Based on the review, the components already introduced will be expanded and additional components will be introduced. The expansion of the existing system and introduction of additional components will be carried in accordance with improvement realised by the hard and soft measures.

(c) Phase-3 (After 10 years):

Policy: Expansion of More Advance ITS Components

Concept: During this period, the systems prepared in 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 at the time of this Master Plan. Hence, the ITS components will be further identified towards the end of Phase-2, in accordance with the maturity of ITS industry in Hyderabad, new technologies emerged, and improvements realised by the hard and soft measures.

(d) Others to Be Noted:

ITS Services Prepared by Private Sector: The ITS services which are generally prepared by the private sector are not included in the ITS Master Plan. The ITS Master Plan lists the services which shall be initiated by the public sector. Hence those to be prepared by the private sector will be differently categorized.

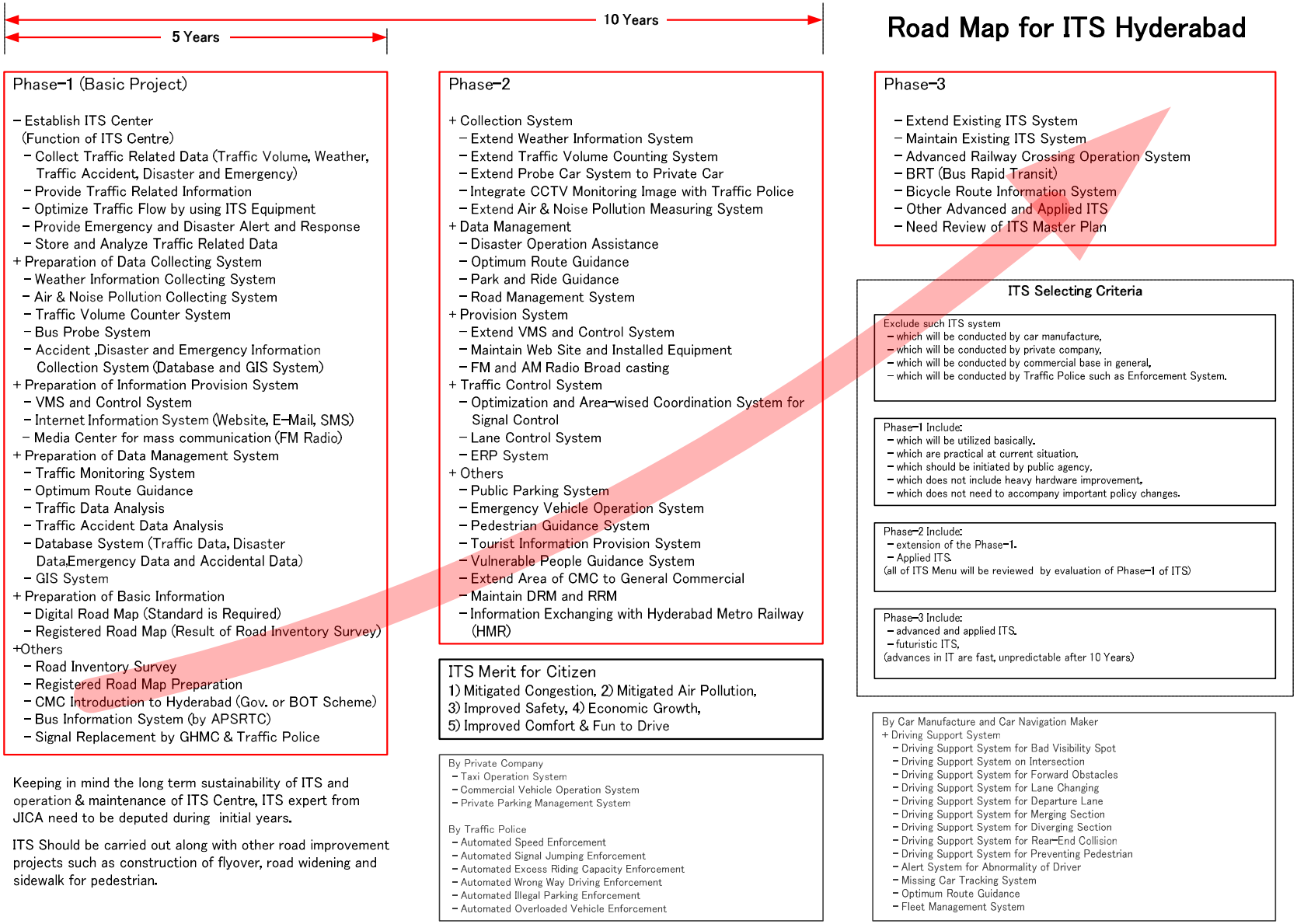


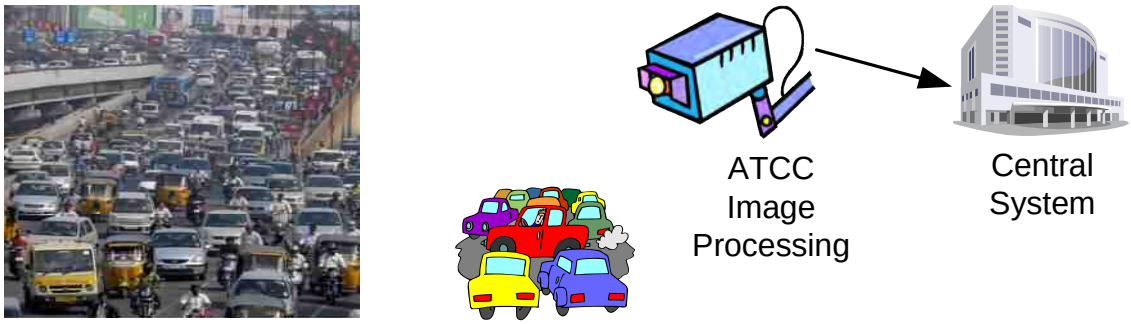
Figure 4-29 Road Map for ITS in Hyderabad

5 Conceptual Design

5-1 Overview of Systems to be Deployed

(1) Automatic Traffic Classifier and Counter (ATCC)

ATCC measures the traffic volume speed and occupancy by section. The measured data is utilised for traffic control and road management. It will also be utilised for traffic congestion information provision to the users. There are several types of ATCC. The figure below shows one of examples of ATCC.

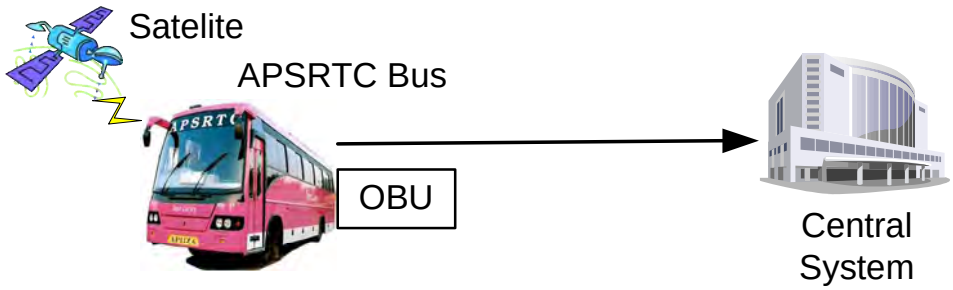


(Source: JICA Study Team)

Figure 5-1 Example: Image of ATCC

(2) Probe Car System (Floating Car)

Probe Car measures area-wise traffic conditions. The GPS unit mounted on the vehicle records the travel history 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.

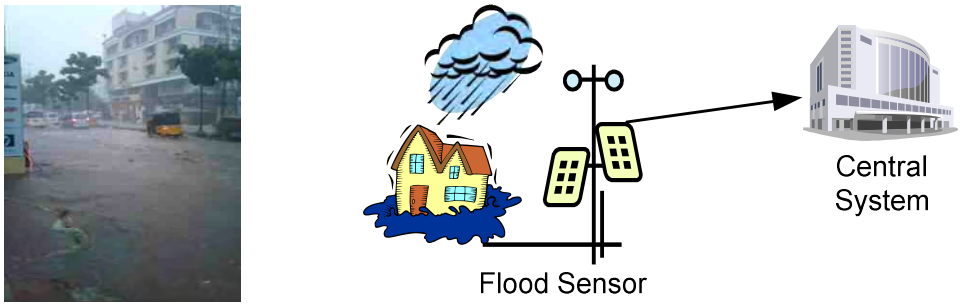


(Source: JICA Study Team)

Figure 5-2 Example: Image of Probe Car System

(3) Flood Sensor

Flood Sensor measures flooding situations on roads and its data is used for providing warning alert to the drivers through VMS and other information devices, and is also accumulated for analysis. It will be installed at the flood-prone areas in the city.

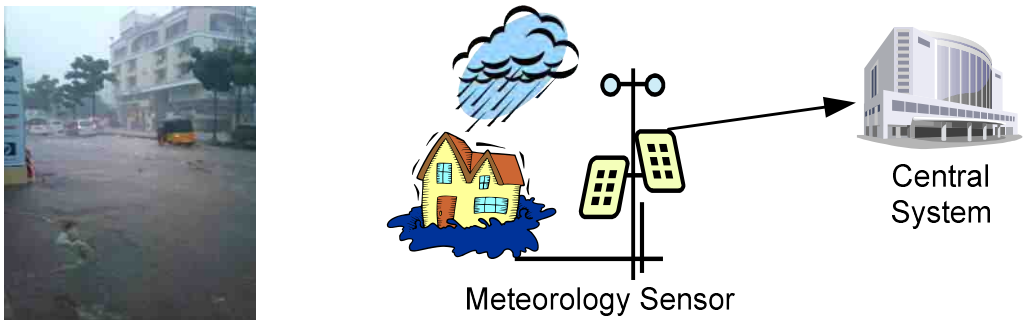


(Source: JICA Study Team)

Figure 5-3 Example: Image of Flood Sensor

(4) Meteorological Sensors

Meteorological Sensor measures the weather conditions on roadside and its data is used for providing warning to the drivers through VMS and other information devices and is also accumulated for analysis. The measured data includes rainfall, temperature, wind velocity/direction and visibility.

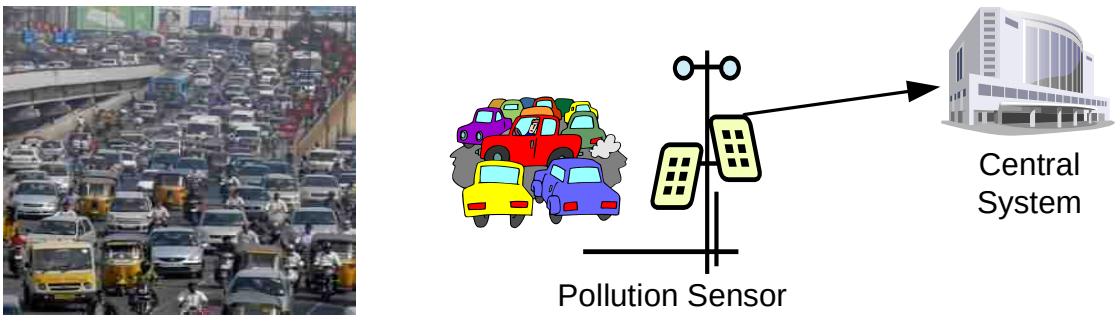


(Source: JICA Study Team)

Figure 5-4 Example: Image of Meteorological Sensors

(5) Air Pollution Sensors

Air Pollution Sensor measures the air pollution conditions and its data is 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.

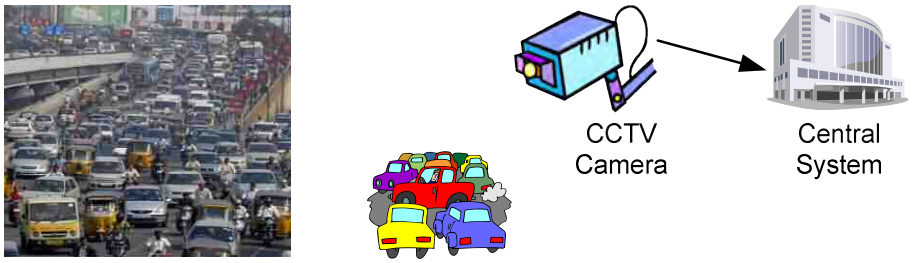


(Source: JICA Study Team)

Figure 5-5 Example: Image of Pollution Sensors

(6) CCTV Camera

CCTV captures video images of roadside conditions and provides the images to the centre. The images are used as a supporting method at the centre to visually confirm the road condition at site for taking necessary action.

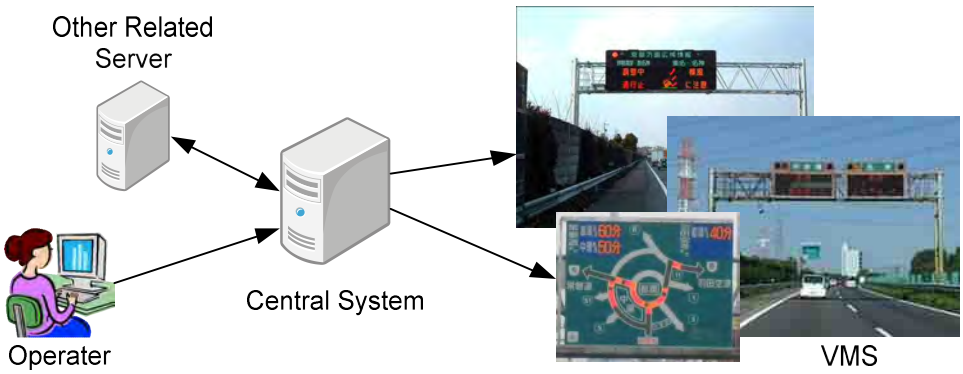


(Source: JICA Study Team)

Figure 5-6 Example: Image of CCTV

(7) Variable Message Signboard (VMS)

VMS provides drivers with information of road, traffic and weather conditions on the road so they have the possibility to divert to a better route.



(Source: JICA Study Team)

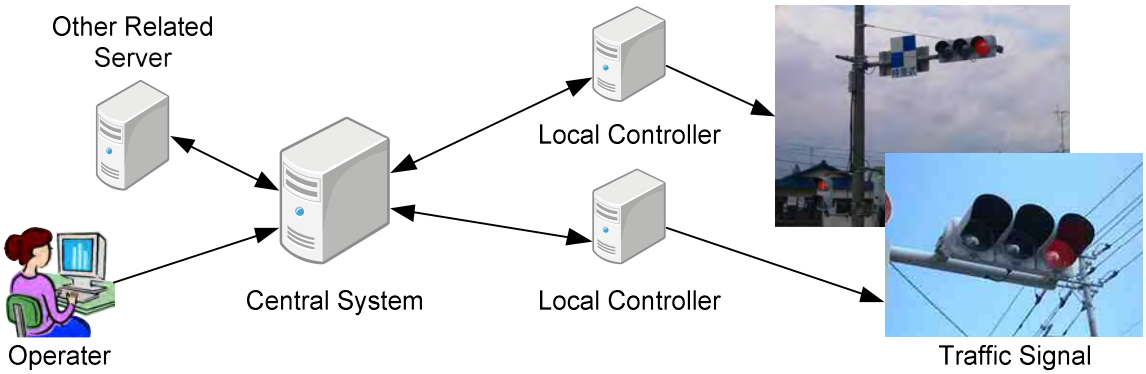
Figure 5-7 Example: Image of VMS

(8) Signal System

Signal System controls the traffic at junction/intersection in the city. The signal phase can be adjusted from the centre when 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 in Phases -2 and -3.

It is necessary for there to be enough linkage between HTRIMS and ITSC to assure exchange of signal status information (including fail status) in a well-coordinated manner.



(Source: JICA Study Team)

Figure 5-8 Example: Image of Traffic Signal

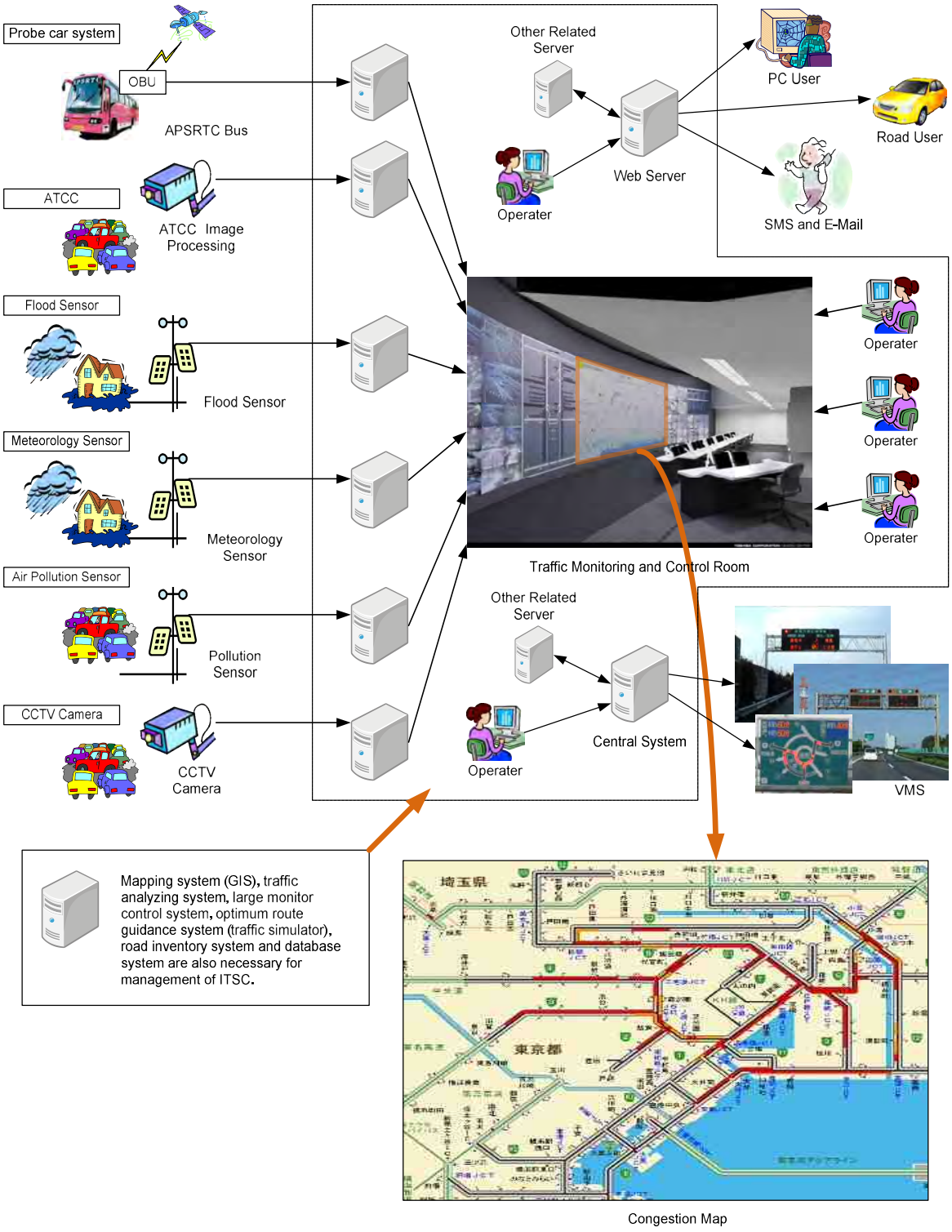
(9) Centre Side System

The Centre Side System will be prepared in order to monitor the traffic condition on the road, and control the traffic and manage the roadside equipment. It includes:

- Centre side systems for the data collection which are broadly divided into measurement equipment and CCTV.
- Central processing units which include analysis of the traffic, mapping system which maps the collected data and Geographical Information System (GIS).
- Centre side systems for information provision which includes SMS, Internet and VMS and etc.

Diagnostic and control system for the road-side equipment. A 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 roadside. The monitor is used for sharing the information amongst the staff at the centre.

The figure below shows the image of the centre side system of ITSC. (It should be noted that the figure does not include the components which are to be prepared in Phases -2 and -3.)



(Source: JICA Study Team)

Figure 5-9 Example: Image of Centre Side System

(10) Other Systems Which Will be Deployed in the Future

(a) Electronic Road Pricing (ERP)

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

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

It consists of ERP gantries located on all roads linking to 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. ERP includes sensors on 2 gantries: one is in front and the other in back. Cameras are also attached at the gantries to capture the rear license number plate of the passing vehicles. The ERP system is proposed in Phase-3 in the ITS Master Plan.

(Source: Wikipedia)

Figure 5-10 Example: Image of Traffic Signal

(b) Lane Control System (A Reversible Lane)

Traffic demand of the road changes depending on time of day. 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 Phase-3 in the ITS Master Plan.

Figure 5-11 Example: Image of Reversible Lane

(c) Parking System

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

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

Figure 5-12 Example: Image of Information Board of Parking System

(d) Kiosk Terminal

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

The kiosk terminal would be installed at locations such 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 information such as sightseeing, travel routes, time to destination, office locations and floors in the building, etc.

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

The kiosk may be a standalone type, but generally, it 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 can 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 rainfall, outside temperature, theft, etc.

The photo show below is a example of Kiosk terminal installed in the Hyderabad Rajiv Gandhi International Airport.

(Source: JICA Study Team)

Figure 5-13 Example: Image of Kiosk Terminals

5-2 Deployment Policy for Individual Equipment

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

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

5-2-1 ATCC

(1) Purpose

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

There are mainly three different types of traffic counters: 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 processing type is recommended to be introduced. However, the counting of motorcycles is still difficult for any of these sensors. Thus, the registered number of the motorcycles shall be utilized, and periodic survey be additionally carried out as supplement for proper comprehension of traffic volume.

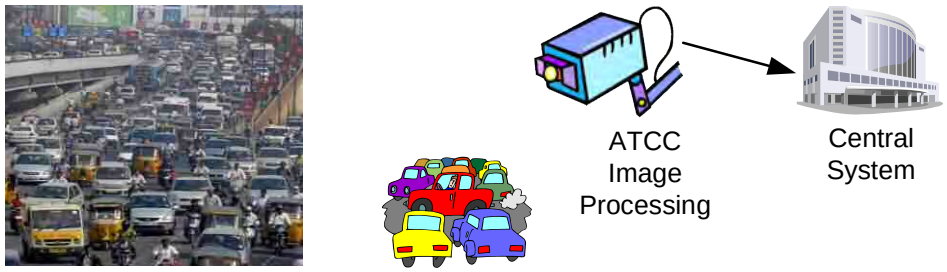


Figure 5-14 Example: Image of ATCC

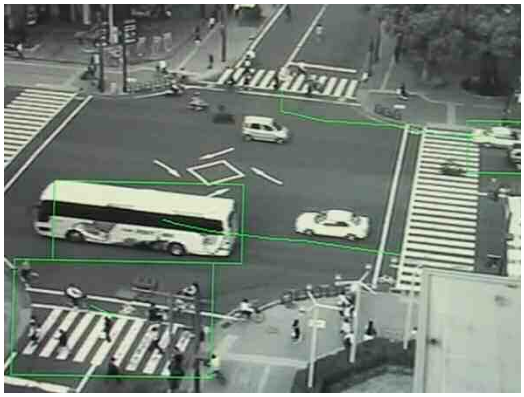


Figure 5-15 Example: Image of Processing Analysis for Traffic Measurement

(2) Installation Policy

(a) Phase-1

ATCC 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 is the length between the junctions of these major roads. By placing the counters in accordance with this policy, it will be possible to measure the traffic condition by section. The major roads are selected because of their scale of traffic volume in the Hyderabad Metropolitan Area.

(b) Phase-2

ATCC 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:

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

2) Outside IRR:

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

3) Note:

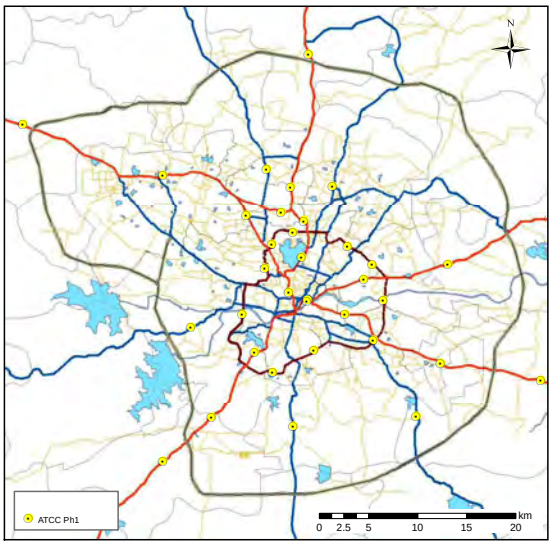
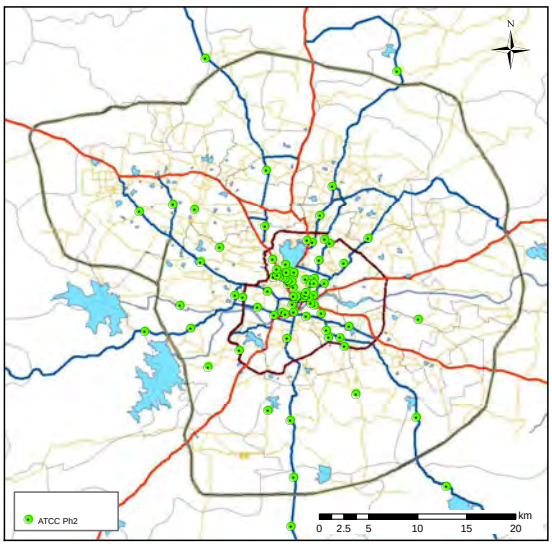
It is required to place the counters at the interval of 500 m in order to measure the congestion length in more detail. However, it would not be appropriate to simply apply this policy across the entire stretch in the Hyderabad Metropolitan Area for the following reasons:

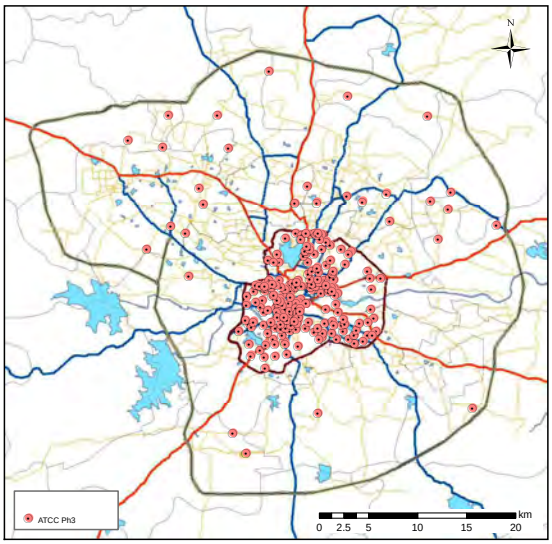
- Road infrastructure is not properly constructed and the installation may not be possible at many of the locations.
- The cost will become unnecessarily high. Thus, the installation span shall be further identified in Phases -2 and -3 after proving certain level of effectiveness after Phase-1.

(3) Location Plan

The proposed location maps by phase are as shown below.

Table 5-1 Proposed Location Map of Roadside Equipment (ATCC)

Location Map	Policy
	<PHASE-1> 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 will be identified and 2 sets at one location will be placed. Thus, 68 units at 34 locations will be placed in Phase-1.
	<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 in Phase-2. The cumulated number is 238 units.

Location Map	Policy
	<PHASE-3> Inside IRR: ATCC will be placed on the Link Roads, which have not been covered in the Phase-2, and major Residential Roads. Outside IRR: It will be placed on the Radial Roads, which have not been covered in the Phase-2, and Link Road connecting these radial roads. / These will cover almost entire traffic inside ORR Area. / ATCC of 454 units at 227 locations will be placed at Phase-3. The cumulated number is 792 units.

(4) Example Configuration

The example configuration of equipment is as follows:

- Assuming 2 sets of ATCC at each 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 and/or GPRS for communication

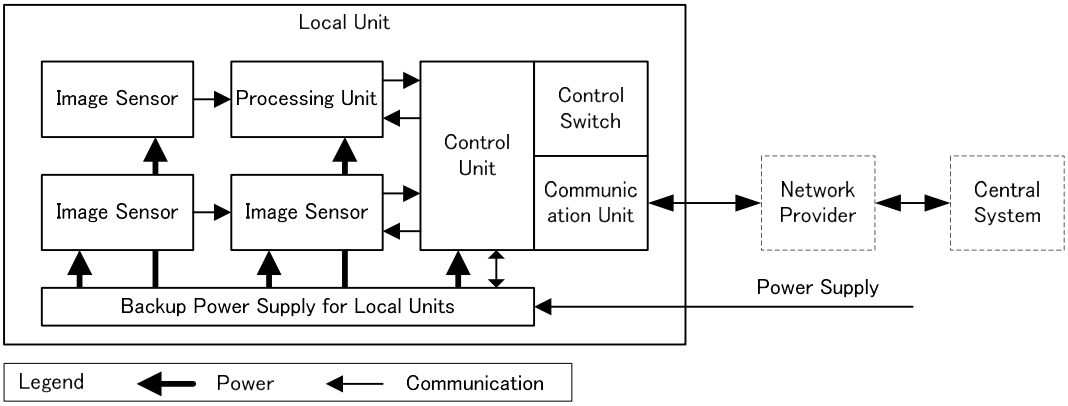


Figure 5-16 Example: Image of ATCC Local Unit

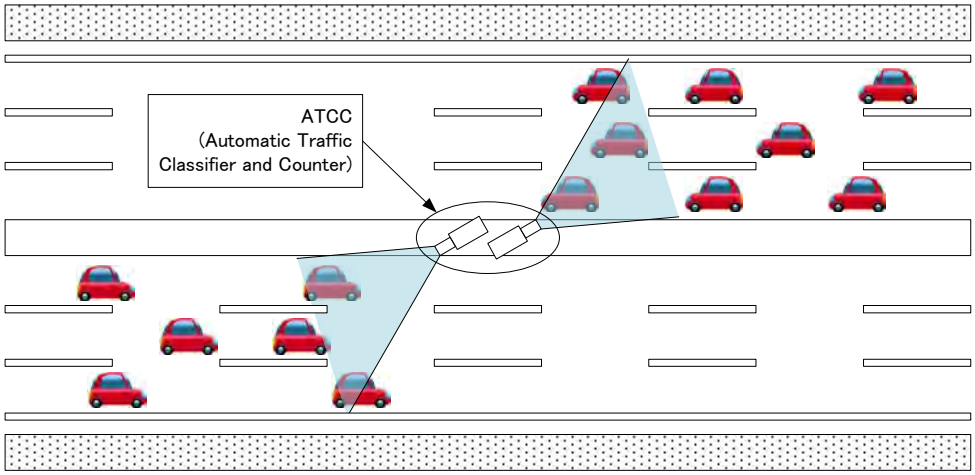


Figure 5-17 Example: Image of ATCC Installation Image

5-2-2 Probe Car System (Floating Car)

(1) Purpose

Probe car (floating car) system will be introduced for area 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 will allow comprehending the average traffic speed, in turn, the level of congestion by section by aggregating the data obtained from each of the vehicles.

It is not economically viable to install the traffic counter over large area on roadside in the city. However, the probe system can be prepared at much lower cost because the roadside equipment is not required. However, the traffic volume at cross sections cannot be measured by the probe system. Thus, the traffic will be measured by combination of the probe system and traffic counter.

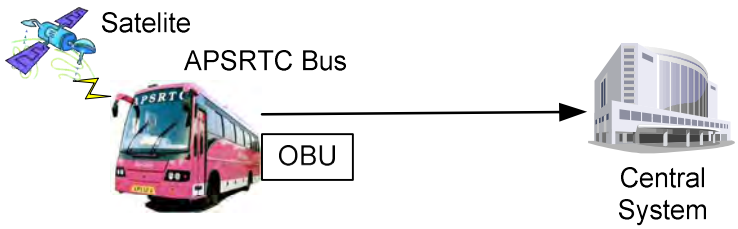


Figure 5-18 Example: Image of Probe Car System

(2) Particular Condition to Be Noted

The more vehicles are mounted with GPS device (called probe car), the more accurate congestion information will 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 every 10 seconds on the vehicle which is sent to the centre every 1 minute. For example in case of 1000 vehicles, the traffic to be measured covers 30,000 data points (60 sec/10sec*5min=30 data points. 30 data points*1000 vehicles=30,000 data points). In practice, the accuracy depends on the number of the vehicles which are in every road section, and the existence of the probe cars to evenly cover all the areas.

(3) Installation Policy

(a) Phase-1

In consideration of above, the public buses operated by APSRTC are selected for the Phase-1. Approximately 1,347 buses are in operation in the city and their service areas cover nearly all areas of the Hyderabad Metropolitan Area. 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 1,347 for city buses.. It will be prepared within one year. Thus, the probe data collected from each bus by APSRTC will be transmitted to ITSC and utilized as input data.

(b) Phases -2 and -3

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

Table 5-2 Proposed Policy of Roadside Equipment

Phase-1	Phase-2	Phase-3
・ 1,347 Units by APSRTC Bus	・ Remaining APSRTC buses ・ Taxi Probe ・ Freight / Commercial Vehicle Probe ・ Public Car Probe	・ Extension of Phase-2 (Taxi, Freight / Commercial Vehicle and Public Car Probe) ・ Mobile based human tracking system in future

(4) Example Configuration

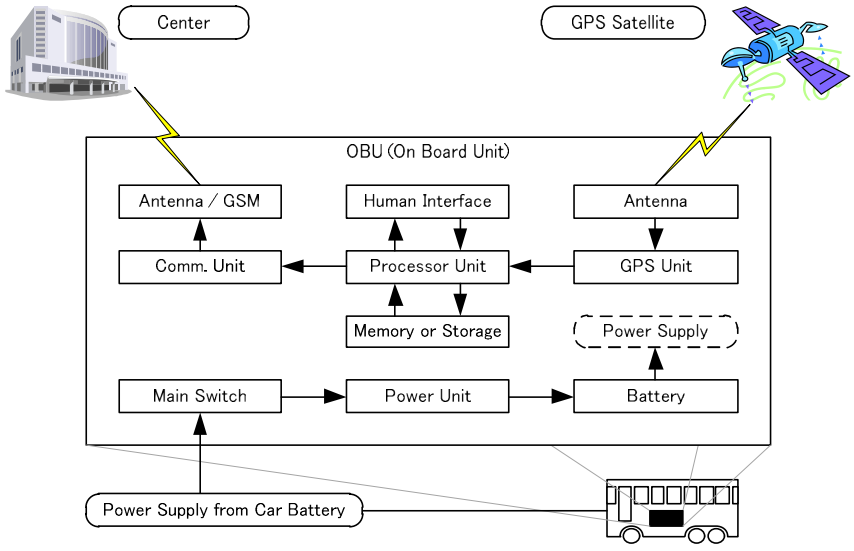


Figure 5-19 Example: Image of Car Probe Installation Image

The example configuration of 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 based measurement and distance based measurement available
- Local memory for buffering and measuring data
- Availability of data transmission
- Self-check available
- Battery for maintaining stored memory

5-2-3 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 will be introduced in the Project with following objectives:

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

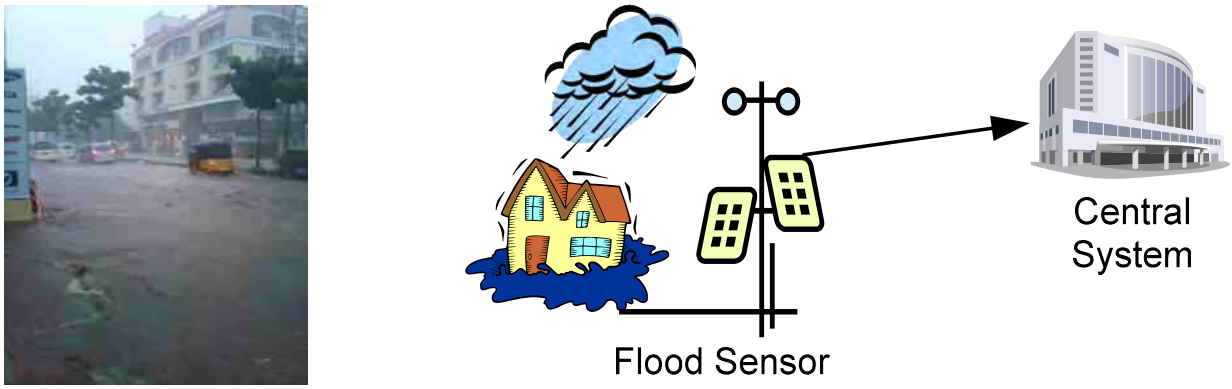


Figure 5-20 Example: Image of Flood Sensor

(2) Installation Policy

The flood monitoring sensors will be located at waterlogged 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 identified. In the newspaper on 29th May 2011, 14 areas among them were shortlisted as the most troublesome and demanding immediate action. Thus in Phase-1, the flood monitoring sensors will be installed at 14 water logging spots mentioned above.

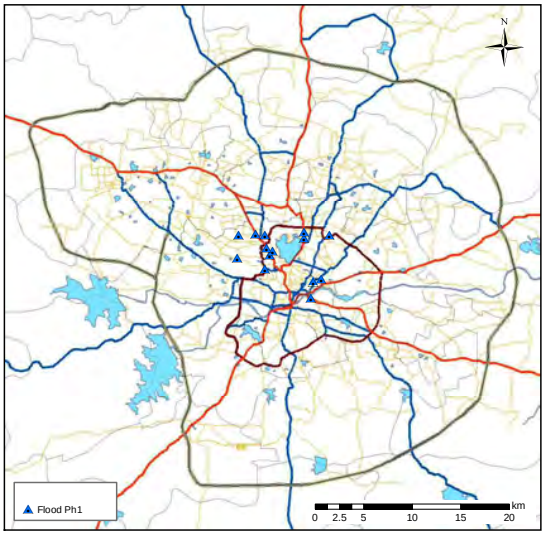
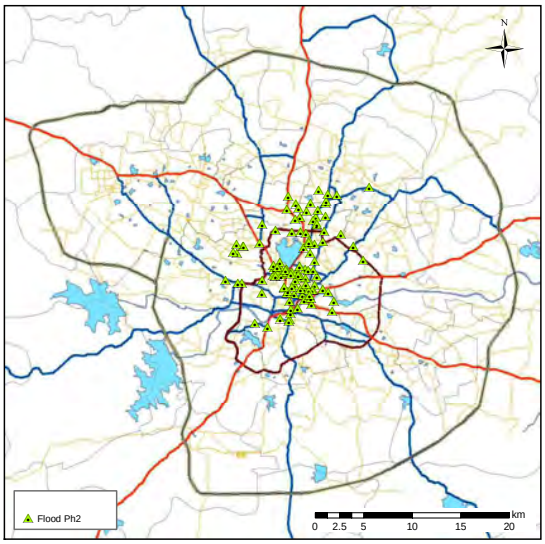
(b) Phase-2

In phase-2, installation of flood monitoring sensors will be expanded over all of 125 waterlogging spots identified by Hyderabad Traffic Police.

(3) Location Plan

The proposed location maps by phase are as shown below.

Table 5-3 Proposed Location Map of Roadside Equipment (Flood Sensor)

Location Map	Policy
	<Phase-1> 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.
	<Phase-2> The flood monitoring sensors will be installed at the remaining 111 water logging locations identified by Hyderabad Traffic Police. The cumulated number is 125 units.

(4) Example Configuration

The example configuration of equipment is as follows:

- Assuming 1 flood sensor (water depth gauge) for each 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 and/or GPRS for communication

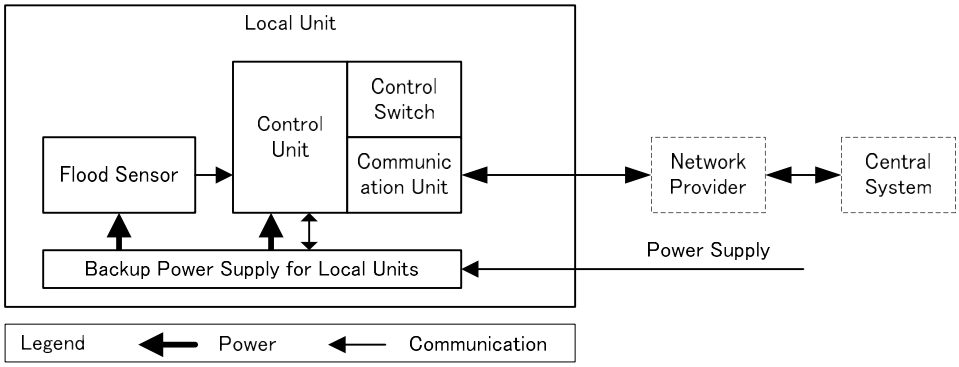


Figure 5-21 Example: Image of Flood Sensor Local Unit

5-2-4 Meteorological Sensors

(1) Purpose

The meteorological monitoring system is an indispensable system to measure weather conditions, take appropriate countermeasures in bad weather conditions, and provide warning information to 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 road users through information provision systems in order for them to take necessary precautionary measures.
- To share measured meteorological data with alerting signals among road operators and traffic polices, etc.

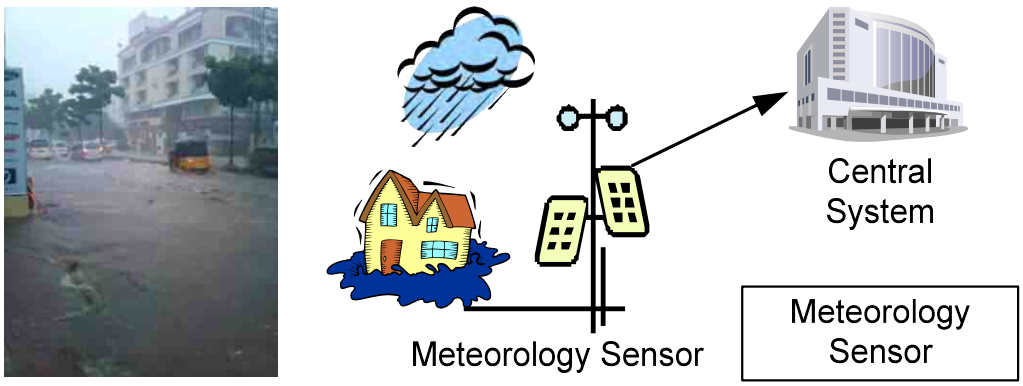


Figure 5-22 Example: Image of Meteorological Sensors

(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.

- Generally the meteorological sensors must be located to cover a 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 sq. kilometres (equal to radius of 10 km). 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.

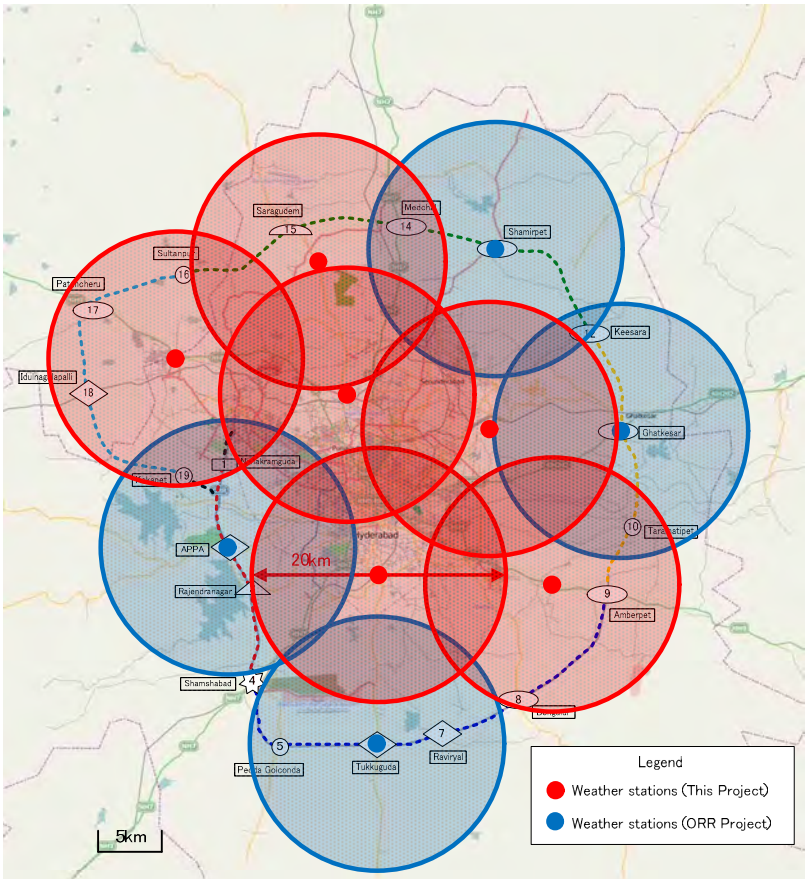


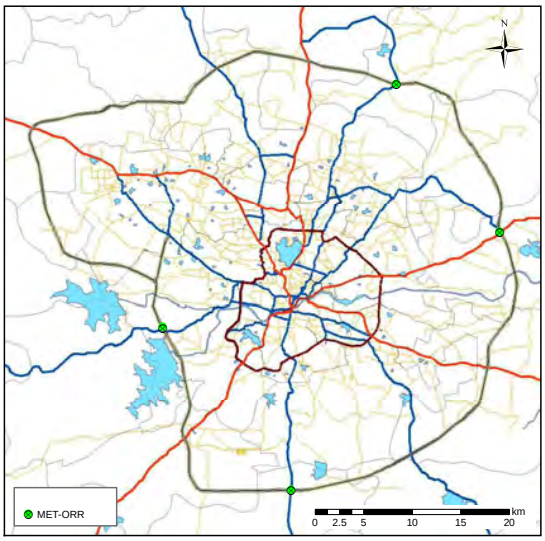
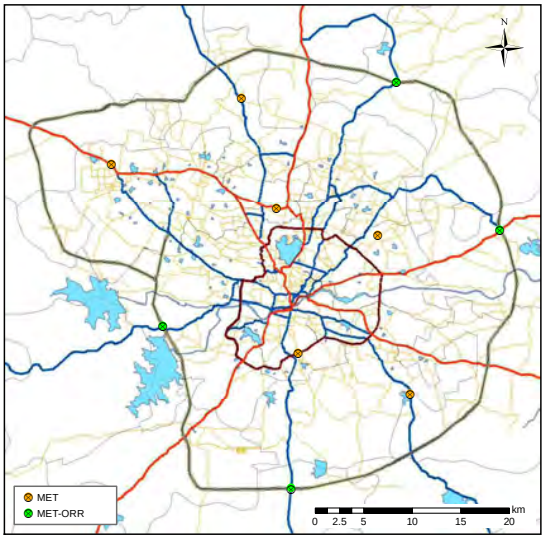
Figure 5-23 Example: Image of Concept of Location Plan for Meteorological Sensors

Note: After meteorological data received from the related agencies is evaluated, the installation policy may be altered.

(3) Location Plan

The proposed location maps by phase are as shown below.

Table 5-4 Proposed Location Map of Roadside Equipment (Meteorological Sensor)

Location Map	Policy
	<Prepared by ORR ITS Project> 4 units will be prepared by ORR ITS Project, as one of the components of Highway Traffic Management System (HTMS). These locations are shown in the figure left.
	<Phase-1> It is planned to cover all HMA area by which every sensor covers the circle of 20 km diameter. 10 sensors will be necessary including 4 sensors which will be prepared by ORR ITS Project. Thus, 6 units will be placed by this Project in Phase-1. These locations are shown in the figure left.

(4) Example Configuration

The example configuration of equipment is as follows:

- Assuming 1 meteorology unit including following 5 sensors at each 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 and/or GPRS for communication

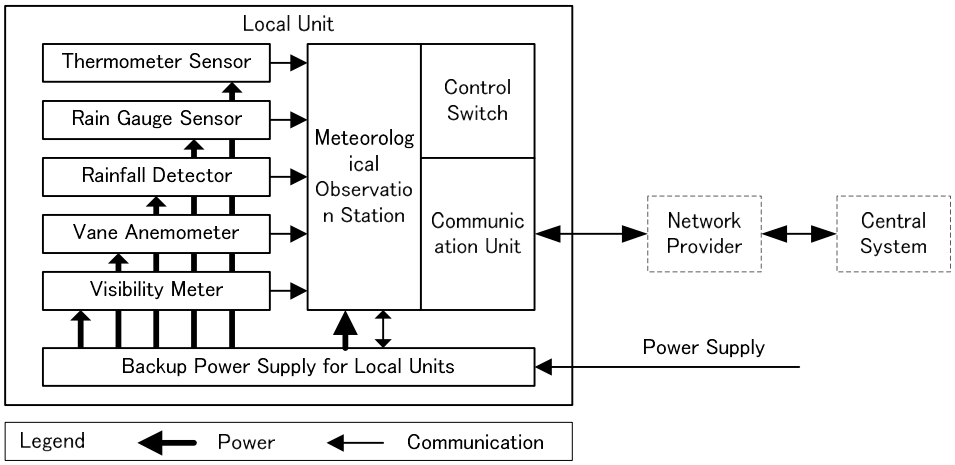


Figure 5-24 Example: Image of Roadside Unit of Meteorological Sensor

5-2-5 Air Pollution Sensor

(1) Purpose

The air pollution sensor is an important component. There are two main concepts of measurement of air pollution. One is to comprehend overall condition of pollution covering wide area. The other is to measure local pollution level in the locations such as pollution-sensitive places, road side, etc. The air pollution sensor in ITS Master Plan for HMA is proposed based in the former concept. The system will be introduced in the Project with the following objectives:

- To measure air pollution conditions including NOx, SOx, COx in Hyderabad Metropolitan area.
- To utilise measured pollution data as a parameter for taking appropriate countermeasures.
- To provide the pollution information to road users through information provision systems in order for them to take necessary precautionary measures.
- To share the measured pollution data for alerting signals among the road operators and traffic police, etc.
- To evaluate improvement of the condition of air pollution by alleviating traffic conditions.

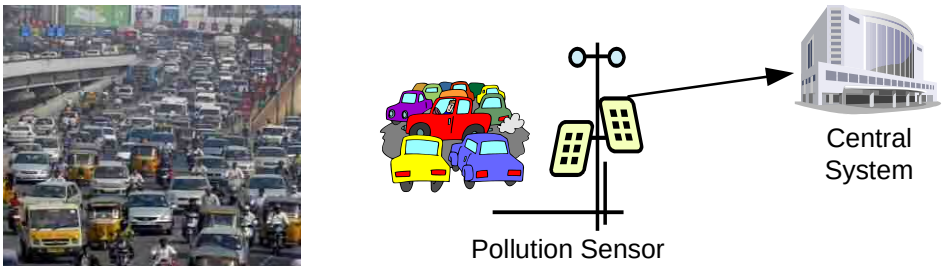


Figure 5-25 Example: Image of Pollution Sensors

(2) Installation Policy

Air pollution sensors will be located at same location as the meteorological sensors. 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

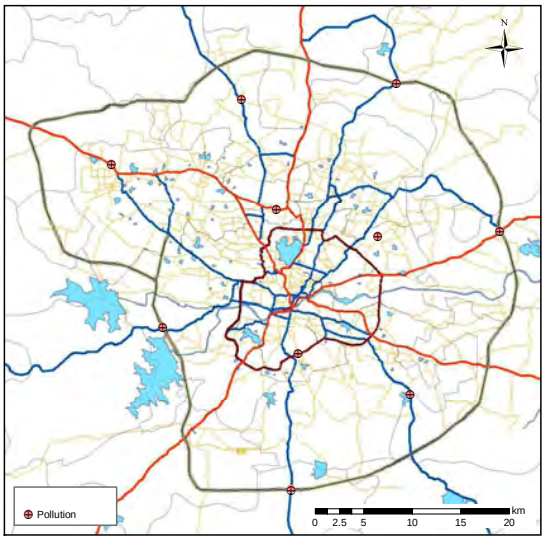
No more air pollution sensors are planned in Phase-2.

Note: After pollution data is received from the related agencies, it will be evaluated and the installation policy may be altered.

(3) Location Plan

The proposed location maps are as shown below.

Table 5-5 Proposed Location Map of Roadside Equipment (Air Pollution Sensor)

Location Map	Policy
	<Phase-1> It is proposed to prepare 10 units in Phase-1 to cover the entire Hyderabad Metropolitan Area.
	<Phase-2> It is not planned to prepare more air pollution sensors in Phase-2.

(4) Example Configuration

The example configuration of equipment is as follows:

- Assuming 1 pollution unit including 5 pollution sensor (NOx, SO2, CO, CO2, O2) for each 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 and/or GPRS for communication

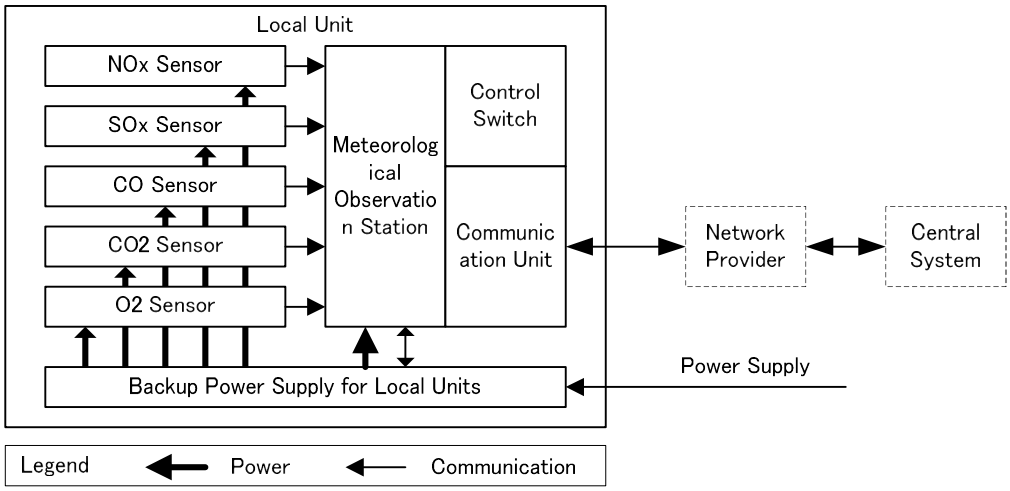


Figure 5-26 Example: Image of Roadside Unit of Air Pollution Sensor

5-2-6 CCTV Camera

(1) Purpose

CCTV cameras will be introduced for confirmation of conditions 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 in order to take necessary actions such as lane control, in case of the incidents.
- To confirm the traffic flow on the road using live video images to regulate the traffic by instructing the police at site, providing information to drivers.
- To share live video images among the road operators and traffic police, etc.

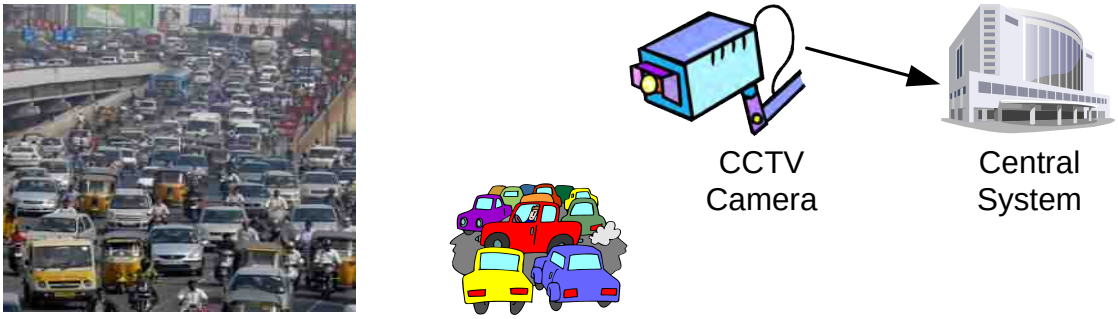


Figure 5-27 Example: Image of CCTV Camera

Figure 5-28 Example: Image of CCTV Camera

(2) Installation Policy

(a) Phase-1

It is planned, by Hyderabad and Cyberabad traffic police, to prepare 334 CCTV cameras at the junctions; this work is expected to be completed 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 counters, which is between junctions, to visually monitor the actual traffic flow.
- They will be placed at the same locations with the flood monitoring sensors 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

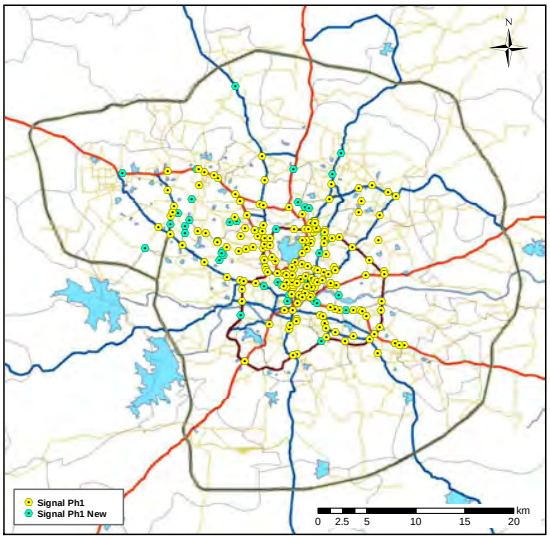
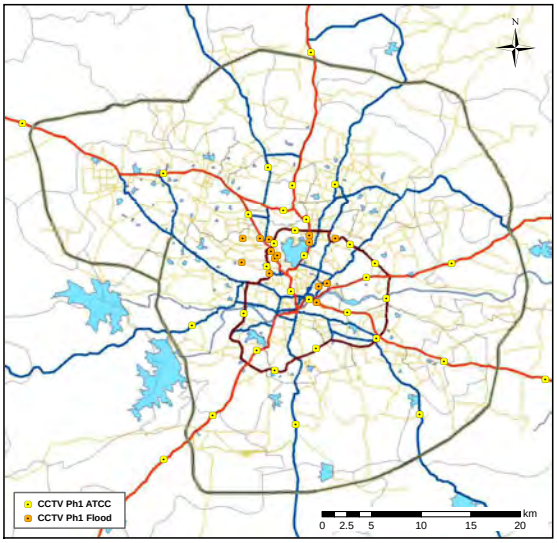
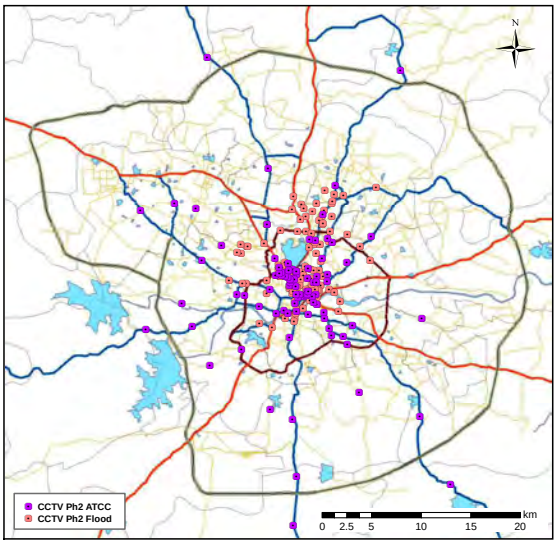
The CCTV cameras will be installed with the following policies:

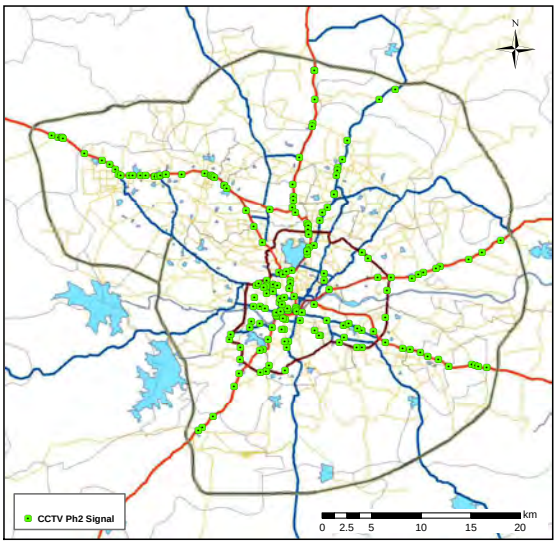
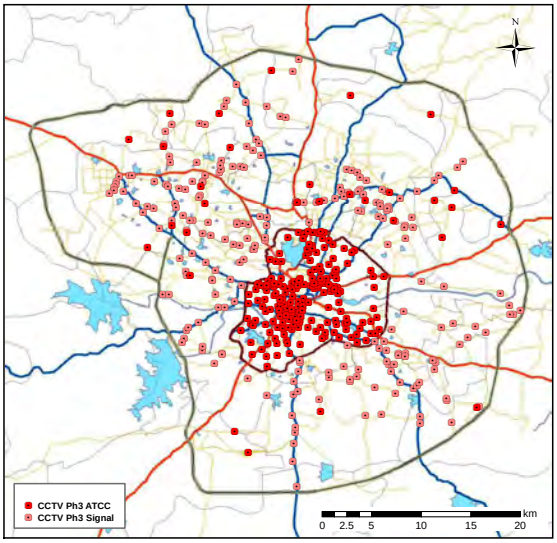
- They will be placed at the same location with the traffic counters prepared in Phase-2/Phase-3.
- They will be placed at the same location with the flood sensors prepared in Phase-2/Phase-3.
- They will be placed at the same location with the traffic signals prepared in Phase-2/Phase-3.
- All items above assume that the CCTV will have pan, tilt and zoom functions to view a wide area.

(3) Location Plan

The proposed location maps by phase are shown below.

Table 5-6 Proposed Location Map of Roadside Equipment (CCTV)

Location Map	Policy
	<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.
	<Phase-1> 55 units in total will be prepared by this Project in Phase-1. The breakdown of 55 units is: - 41 units at the same locations with ATCC between junctions to monitor the traffic condition. - 14 units at the same locations with flood sensors to monitor the flood condition.
	<Phase-2> 196 units will be prepared by the Project in Phase-2. The breakdown of 196 units is: - 85 units at the same locations with ATCC between junctions to monitor the traffic condition. - 111 units at the same location with flood sensors to monitor the flood condition.

Location Map	Policy
	<Phase-2> Another 179 units will be prepared by the Project in Phase-2. They will be placed at the same locations with traffic signals to be prepared by the project. This is on the assumption of CCTV with pan, tilt and zoom functions.
	<Phase-3> 449 units in total will be prepared by the Project in Phase-3. The breakdown of 449 units is: - 227 units at the same locations with ATCC between junctions to monitor the traffic condition. - 222 units at the same locations with traffic signals

(4) Example Configuration

The example configuration of equipment is as follows:

- Assuming 1 CCTV camera for each 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 and/or GPRS for communication

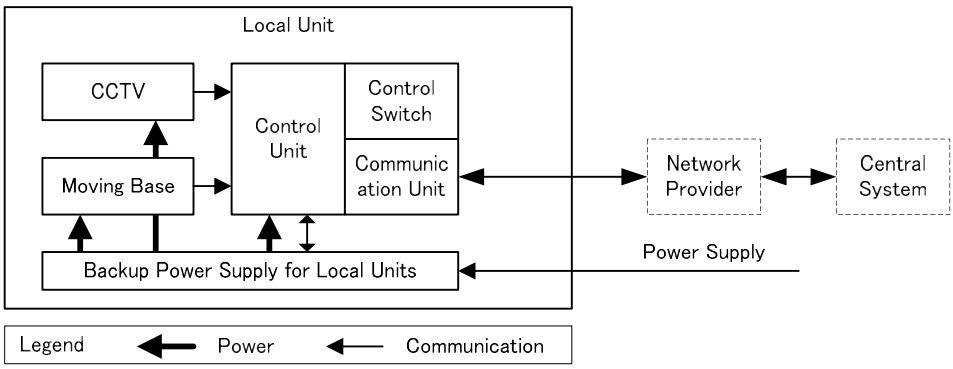


Figure 5-29 Example: Image of CCTV Local Unit

5-2-7 Variable Message Signboard (VMS)

(1) Purpose

VMS system is to provide the information of road, traffic and weather conditions on the road to the driver. 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. 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, IRR, etc.)
- To utilize VMS information for diverting driver's travelling route from congested places or the areas under bad weather condition inside the city by providing such information to the drivers 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.
- To apply to VMS to provide the information to every road user without any special user devices.

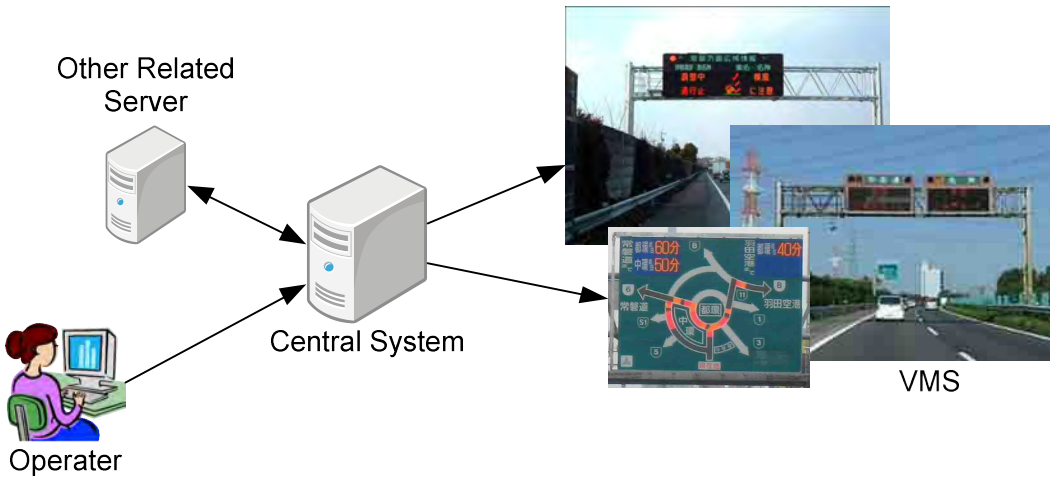


Figure 5-30 Example: Image of VMS

(2) Installation Policy

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

(a) Phase-1

- VMS will be placed at upstream decision location of major junctions and intersections on National Highways in the city area to provide road, traffic and weather information to drivers moving toward the city.
- VMS will be located at upstream decision location of major junctions and intersections on IRR, as well.
- VMS will be located at upstream decision location of all junctions and intersections on radial roads crossing the IRR to provide the information to drivers entering the IRR.
- Installation of VMS on ORR will be excluded from this project since the VMS board on 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) from ORR project shall be made for realisation of flexible and interactive VMS information provisions each other.
- VMS will be placed at upstream decision location of junctions and intersections on major roads inside Hyderabad Metropolitan Area including road No.2 connecting with IRR and High-Tech city.
- VMS will be located at upstream decision location of junctions and intersections in front of flooding prone areas so that drivers can divert to alternative travelling route when flooding occurs.
- 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 locations of VMSs provided by the HTRIMS project, VMS may be cancelled from this project when the locations are overlapping with HTRIMS project.

(b) Phase-2

VMS will be located at upstream decision location of all junctions and intersections on the radial roads crossing ORR to provide road, traffic and weather information on ORR to drivers.

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

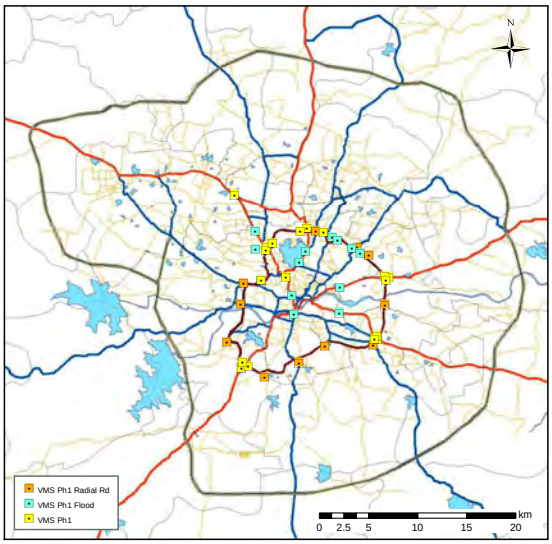
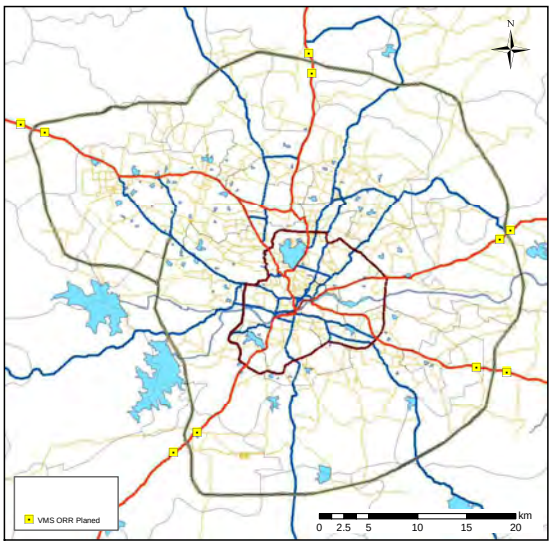
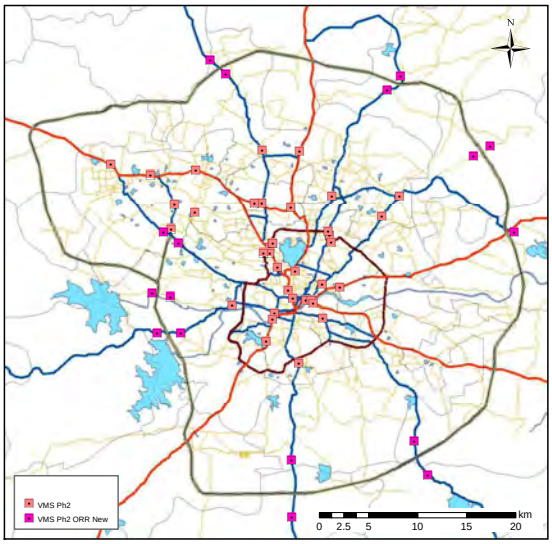
(c) Phase-3

VMS may be further located inside the city for the purpose of information provision related to parking area information, detailed traffic information, or others.

(3) Location Plan

The proposed location maps by phase are shown below.

Table 5-7 Proposed Location Map of Roadside Equipment (VMS)

Location Map	Policy
	<Phase-1> 42 units in total will be prepared by the Project in Phase-1. The breakdown of 42 units is: - 18 units at the locations of diversion according to the installation policy - 13 units at the locations of diversion before flood prone areas - 11sunits at the locations of diversion of the radial roads
	10 VMS will be prepared by the ORR ITS Project as shown in the left figure. These numbers are excluded from above. Also 20 VMS will be prepared by HTRIMS. The above number (42 units) may be further adjusted and changed, after coordinating with HTRIMS Project.
	<Phase-2> 54 units will be prepared by the Project in Phase-2. The cumulated number is 96 units.
	<Phase-3> It is assumed that approximately 100 units would be

Location Map	Policy
	prepared in Phase-3. However, the locations of VMS in Phase-3 shall be further investigated in the future because it may include information provision for parking, more detailed traffic information, etc.

(4) Example Configuration

The example configuration of equipment is as follows:

- Assuming 1 VMS board for each place
- Cantilever structure for small VMS and gantries for large VMS
- 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

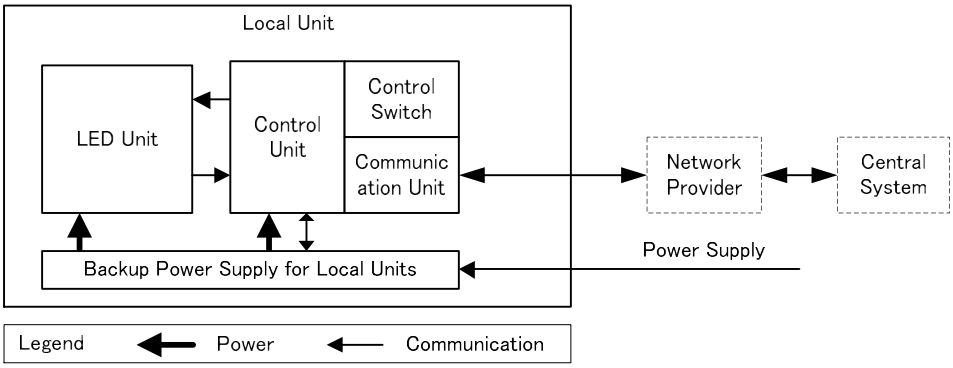


Figure 5-31 Example: Image of VMS Local Unit

5-2-8 Signal System

(1) Purpose

Traffic signals are used to assure the orderly movement of vehicular and pedestrian traffic, and to prevent excessive delay of traffic flows. They are installed with the objectives of:

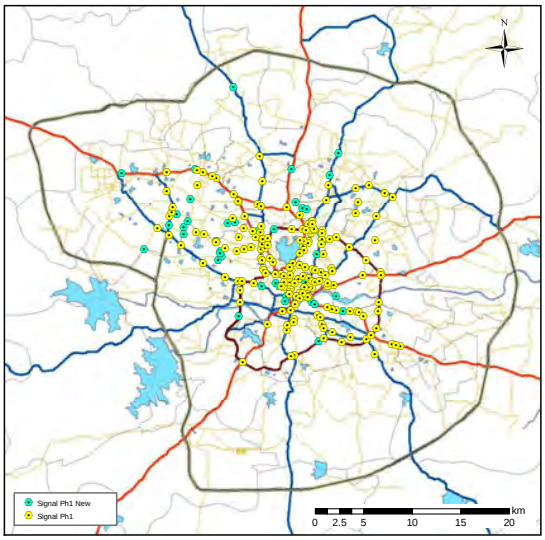
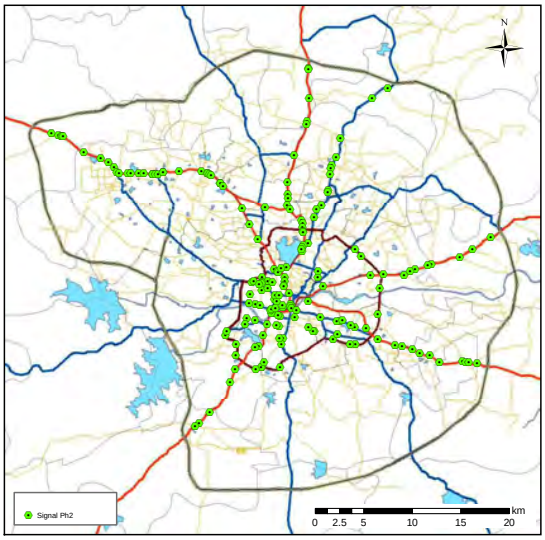
- Assuring the traffic in an orderly manner
- Minimizing delay of the vehicles and pedestrians
- Reducing conflicts with accidents, obstacles, etc.
- Maximizing the capacity of the intersection in each direction

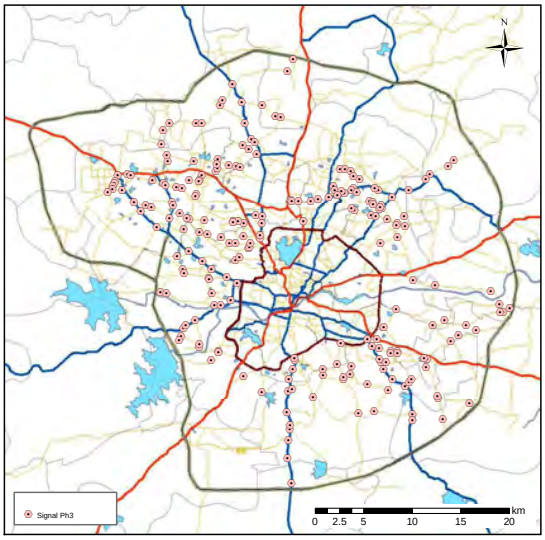
Note: Well-designed junctions are required before the traffic signals are installed to properly utilise the signals and achieve the above objectives. There are a number of such junctions, in Hyderabad Metropolitan Area, which need proper structures constructed to maximise the capacity of the junction and assure the smooth traffic flow by the signals.

(2) Location Plan

The proposed location maps by phase are shown below.

Table 5-8 Proposed Location Map of Roadside Equipment (Signal)

Location Map	Policy
	<Phase-1: Prepared by HTRIMS> Signals at 221 junctions in total will be prepared by HTRIMS Project. The breakdown of 221 junctions is: - 180 junctions: Replacing the existing signals - 41 junctions: Installing new signals Thus, no signals will be prepared by this project in Phase-1.
	<Phase-2> 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 Phase-2 will cover the important locations on the roads for the installation policy for Phases -1 and -2, which are not covered by the above HTRIMS. Signals at 179 junctions in total will be prepared in Phase-2.
Note: Road and intersections structures such as proper u-turn point, modification of round-about intersections, etc. will be improved as basic conditions for preparation of the traffic signals.	

Location Map	Policy
	<Phase-3> Other major locations in accordance with the installation policy of the Master Plan will be covered in Phase-3. Signals at 222 junctions will be prepared in Phase-3.

(a) Note for pedestrian signals:

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

It is 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, they shall be placed in Phases -2 and -3 in accordance with improvement of the infrastructure with around 400 in Phase-2 and 500 in Phase-3 respectively.

(3) Example Configuration

The example configuration of traffic signals is as follows:

- Assuming 4 ways junction
- 2 vehicle signals for 1 way
- 4 lamps for 1 signal (Green, Amber, Red and Right Turn)
- 1 countdown timer for 1 way
- 2 pedestrian signals for 1 way
- 2 lamps for 1 pedestrian signal (Red and Green)
- 2 Vehicle detectors 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 example configuration of pelican signals is as follows:

- Assuming pelican crossing on a road (not a junction)
- 2 vehicle signals for each place

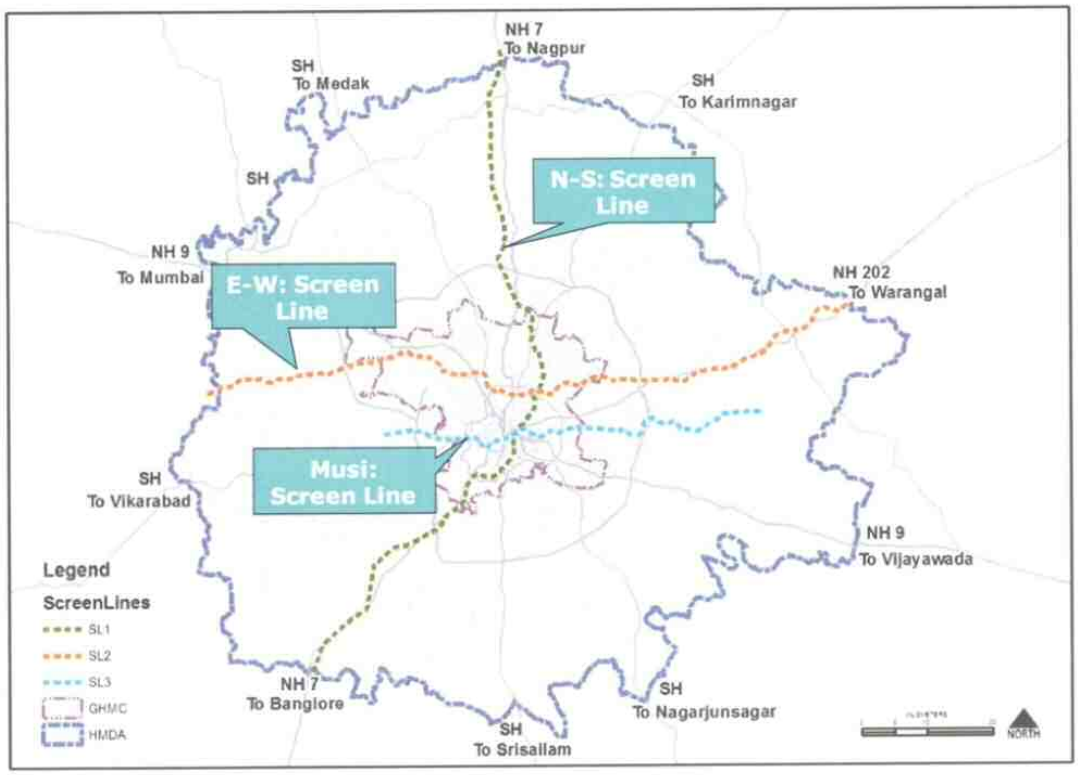
- 3 lamps for 1 signal (Green, Amber and Red)
- 2 pedestrian signals for 1 place
- 2 lamps for 1 pedestrian signal (Red and Green)
- Local control unit including push button and communication unit for 1 place
- 1 central monitoring and control system at ITSC
- Use optical fibre cable and/or GPRS for communication

5-3 Traffic Volume Coverage by ITS Implementation based on CTS Field Survey Report

The traffic volume survey was conducted by CTS. It identified 3 screen lines and 61 survey locations on these 3 screen lines, including 26 survey locations on screen line-1, 18 on screen line-2 and 17 on screen line-3.

The screen lines identified by CTS are:

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



Source: CTS Field Surveys Report, May 2012

Figure 5-32 CTS Survey Screen Line

The result of the traffic survey of CTS is used to verify the traffic volume which is covered by ITS equipment. The figures shown below are traffic volume which is covered by ITS equipment in Phase-1 proposed by ITS Master Plan in Hyderabad and HTRIMS.

Table 5-9 Traffic Volume Identified by CTS and Covered by ITS

Screen Lines	Number of Survey Locations (CTS)	Traffic Volume (CTS)	Number of Locations Covered by ITS Hyderabad and HTRIMS	Traffic Volume Covered by ITS Hyderabad and HTRIMS
SL - 1	26	12,01,722	19	10,67,085
SL - 2	18	13,09,881	17	11,78,264
SL - 3	16	9,56,421	12	9,28,688
Total	60	34,68,024	48	31,74,037

As shown above, the traffic volume on three screen line was identified at 34,68,024 by CTS. 91.52% of the traffic volume will be covered by ITS equipment in Phase-1 of ITS Mater Plan and HTRIMS.

The above figures are drawn based on the traffic volume on the screen line. Thus it shall be constructed as overall indicative figure to be covered by ITS equipment, in terms of traffic volume.

The traffic volume by traffic composition to be covered is shown below.

Table 5-10 Traffic Volume by Traffic Composition: Screen Line-1

Traffic Composition	Traffic Composition Ratio (CTS)	Traffic Volume by Composition (CTS)	Traffic Volume by Composition by ITS and HTRIMS
2-Wheeler	56.80%	6,82,578	6,06,104
3- Wheeler	13.1%	1,57,426	1,39,788
4-Wheelr	18.7%	2,24,722	1,99,545
Bus	3.2%	38,455	34,147
NMT	1.9%	22,833	20,275
Others	6.3%	75,708	67,226
Total	100%	12,01,722	10,67,085

Table 5-11 Traffic Volume by Traffic Composition: Screen Line-2

Traffic Composition	Traffic Composition Ratio (CTS)	Traffic Volume by Composition (CTS)	Traffic Volume by Composition by ITS and HTRIMS
2-Wheeler	58.50%	7,66,280	6,89,284
3- Wheeler	11.30%	1,48,017	1,33,144
4-Wheeler	21.10%	2,76,385	2,48,614
Bus	3.3%	43,226	38,883
NMT	1%	13,099	11,783
Others	4.80%	62,874	56,556
Total	100%	13,09,881	11,78,264

Table 5-12 Traffic Volume by Traffic Composition: Screen Line-3

Traffic Composition	Traffic Composition Ratio (CTS)	Traffic Volume by Composition (CTS)	Traffic Volume by Composition by ITS and HTRIMS
2-Wheeler	61.80%	5,91,068	5,73,887
3- Wheeler	12.30%	1,17,640	1,14,220
4-Wheeler	14.10%	1,34,885	1,30,995
Bus	2.80%	26,780	26,011
NMT	2.50%	23,911	23,215
Others	6.50%	62,167	60,360
Total	100%	9,56,421	9,28,688

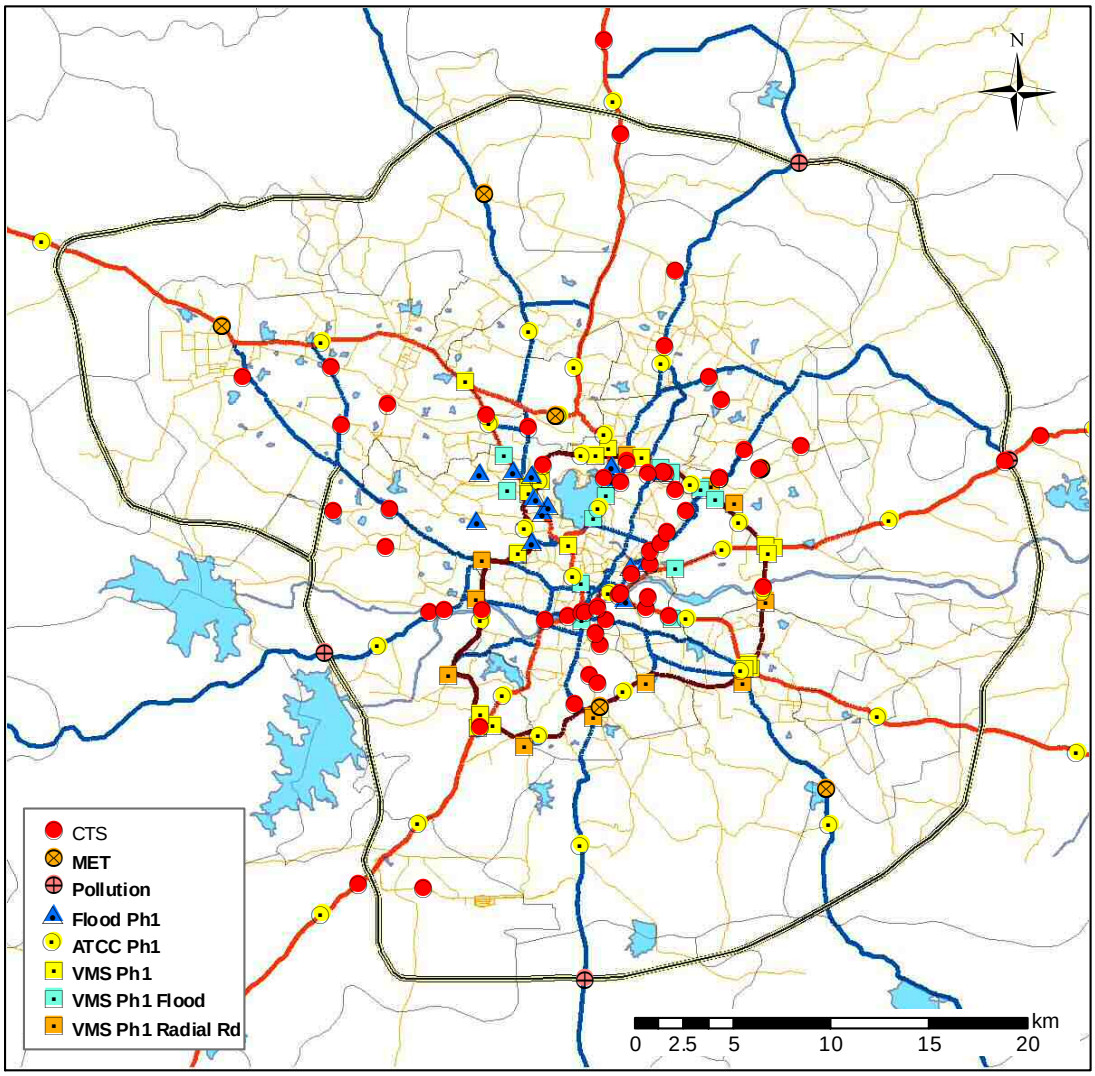


Figure 5-33 ITS Equipment in Phase 1 on Screen Lines

5-4 Centre System

5-4-1 Purpose

The centre system is prepared to encourage data exchange between the sub-system components and to manage the total system to realise its 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 away from the congested area or 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 sub-system components.

The centre system is divided into 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 Figure 5-34.

The outlines of central system are described below.

5-4-2 Centre System for Data Collection Units

(1) Outline

The centre 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

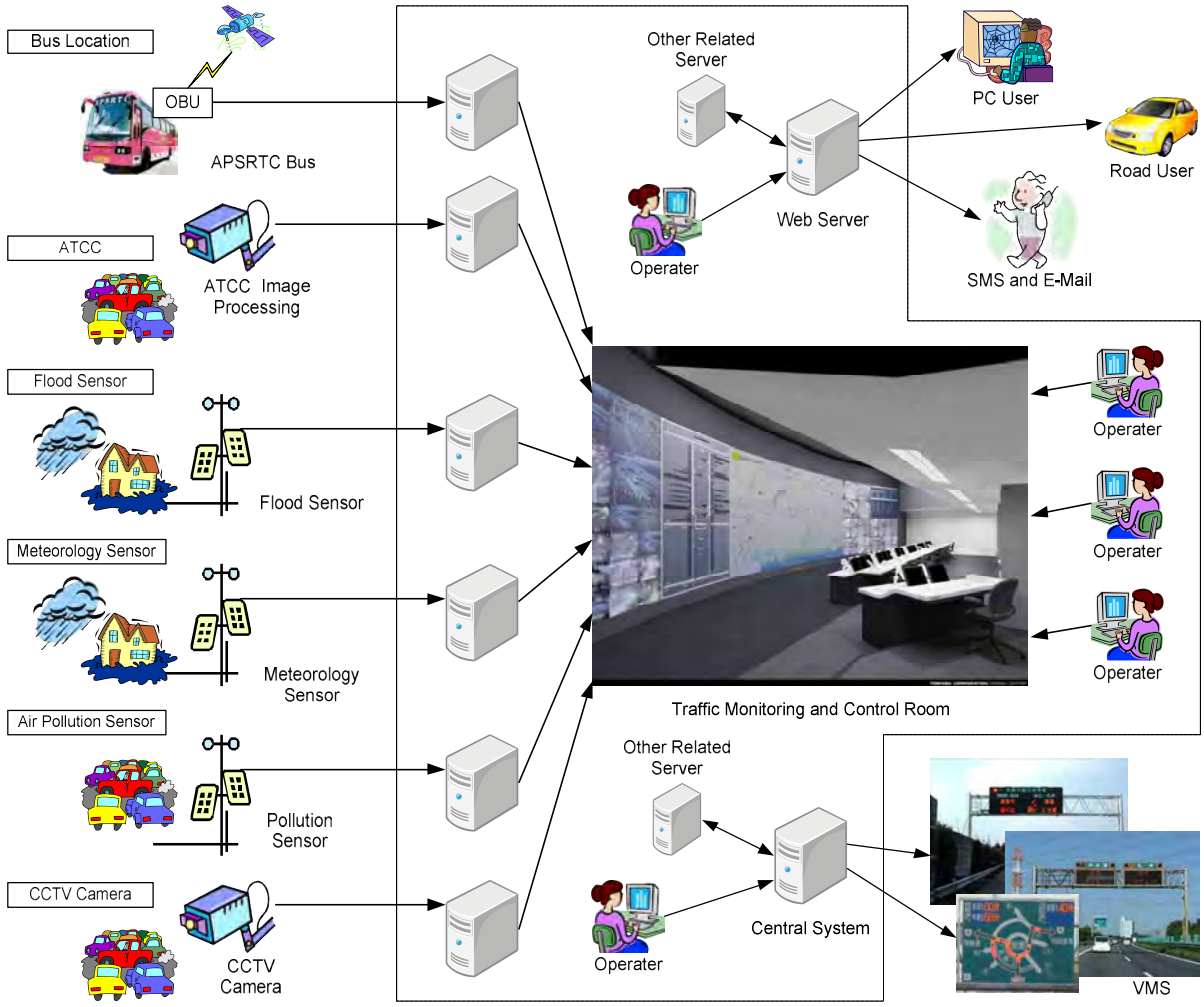


Figure 5-34 Example: Image of Central System

(2) System Diagram

The processor for communicating (data collecting), data storing, data analyzing and contents processing for display is necessary in the centre system described in items 1-5.

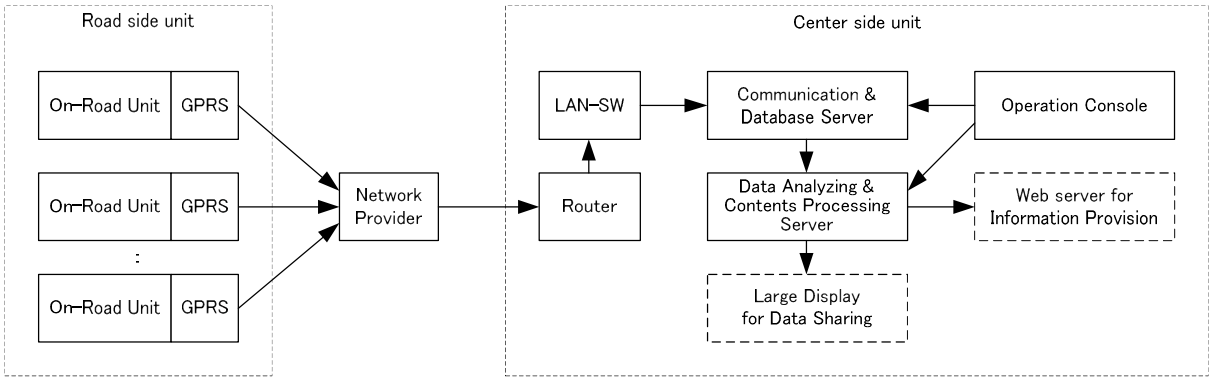


Figure 5-35 Example: Image of Centre System for Data Collecting

The processor for communicating, image storing and displaying is necessary in the centre system in item 6.

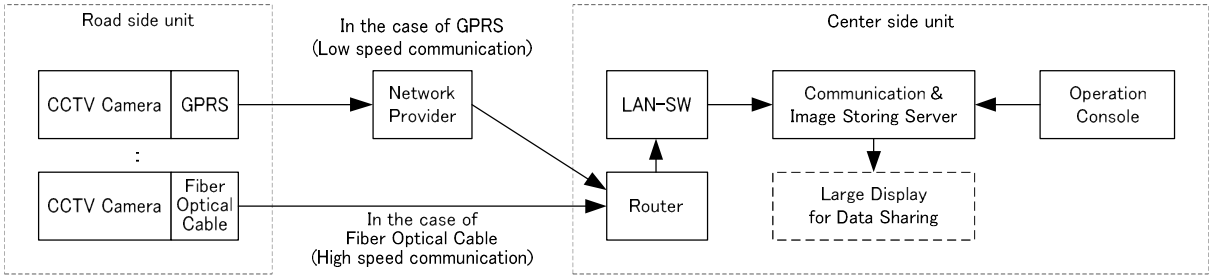


Figure 5-36 Example: Image of Centre System for CCTV

The network equipment and display units are necessary as a common unit. The routers and LAN switches for CCTV will be installed independently from other data collecting system because of high volume of image data communication.

(3) Example Configuration

The example configuration of equipment is as follows:

- Assuming 1 router for data communication units and 1 router for CCTV units. Both routers will have functions of connecting to 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 or Linux server.
- UPS and power stabilizers are required.
- Operation console is required.

Table 5-13 Typical Configuration of Centre System (Example)

Items	Centre System	Rough Specification	Remarks
Common System	Network Router: 1	1 Internet port 3 LAN ports	Firewall
	Network Switch: 4	24 port	
ATCC	Server: 1 (*1)	Windows or LINUX (*2)	With operation console.
Probe Car	Server: 1 (*1)	Windows or LINUX (*2)	
Flood Sensor	Server: 1 (*1)	Windows or LINUX (*2)	
Meteorological Sensor	Server: 1 (*1)	Windows or LINUX (*2)	
Pollution Sensor	Server: 1 (*1)	Windows or LINUX (*2)	
VMS	Server: 1 (*1)	Windows or LINUX (*2)	
Signal	Server: 1 (*1)	Windows or LINUX (*2)	
CCTV Camera	Server: 1 (*1)	Windows or LINUX (*3)	
	Console: 1	Windows latest non-touch screen version	

*1: The number of the servers will be changed according to their capabilities.

*2: The server shall have enough capability to process the required functions such as communication, data collection, data processing, data analysing and contents processing. Console with keyboard

and mouse is required. USB and LAN devices are required. Sufficient storage is required for OS, application and data storing.

*3: The server shall have enough capability to process the required functions such as communication, image data storage and image provision.

5-4-3 Centre System for Information Sharing (Video Wall)

Large monitor and associated 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 sites. The video wall system is used for sharing the collected information among the staff at the centre.

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

Figure 5-37 Example: Image of Video Wall System

The video wall system will provide, but not be limited to, the following functions by using web-based programming tools/languages:

- Monitor and/or manage real-time road, traffic conditions such as traffic congestion, travelling time, event and traffic regulation on geographical map of the city or list.
- Monitor real-time weather and waterlogged conditions on map or in list
- Monitor CCTV live video image
- Monitor VMS indication
- Monitor traffic signal
- Monitor equipment location and its status on map or in list
- Monitor historical traffic flow, weather conditions, etc.

The typical configurations of the video wall system are as follows:

Table 5-14 Typical Configuration of Video Wall System

Items	Centre System	Rough Specification	Remarks
Video Wall System	Large Monitor 20 (=4x5)	55’ HDTV	
	Matrix Switch: 1	Input: more than 16 ports	Full Matrix

Items	Centre System	Rough Specification	Remarks
		Output more than 16 ports	
	Image Controller: 1	Input: more than 16 ports Output more than 16 ports	With operation console.

The Figure below shows basic components of the video wall system with the associated units.

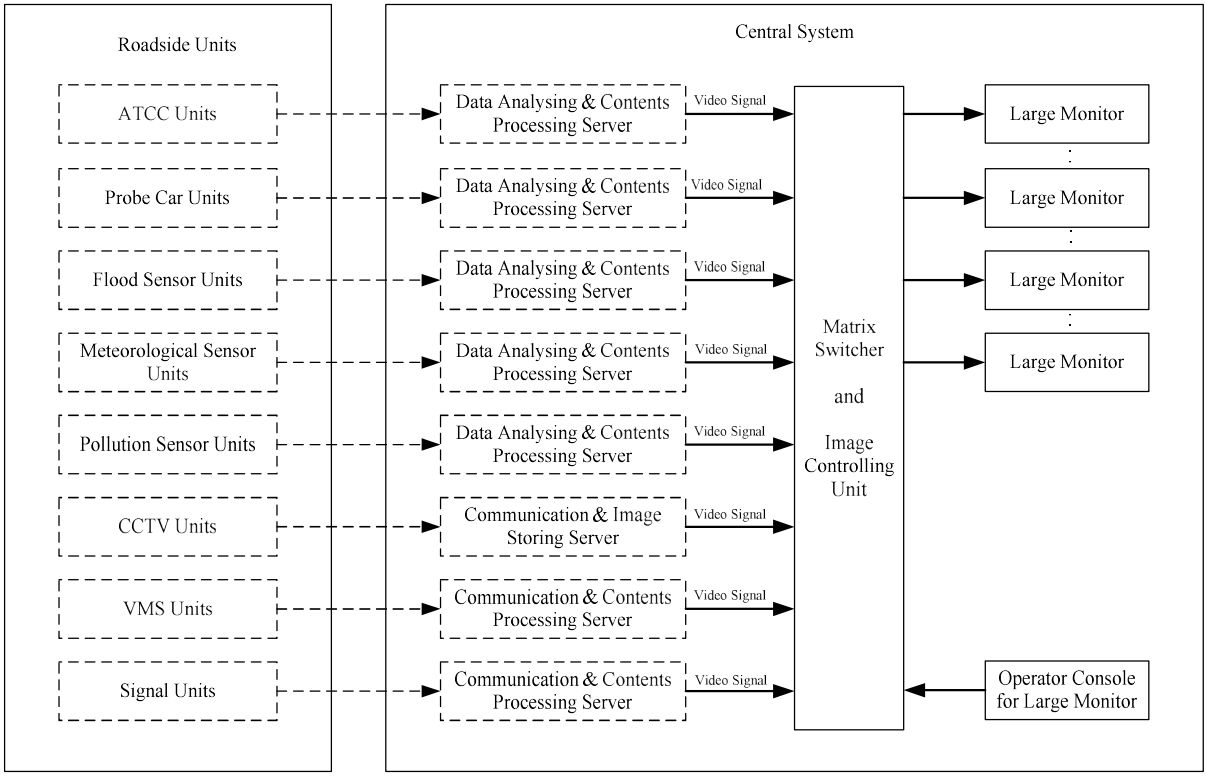


Figure 5-38 Example: Image of Basic Components of Video Wall System

5-4-4 Centre System for Analysis

The centre system for analysis will be 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.

GIS (Geographical Information System) is a tool for displaying maps and information placed on a map. 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 will 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 be limited to, the 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 logging, 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 shows an image of a congestion map. It displays the congestion level by the section of the road by mapping the processed data onto a simplified city road map.

Figure 5-39 Example: Image of Congestion Map

5-4-5 Centre System for Information Provision Units

The centre system for information provision units are prepared to provide the collected and processed traffic related information to users. The traffic related information will be provided to users through website and SMS/E-mail. The traffic information and traffic events such as flooded point, accident, and lane closure will be plotted on a simplified map and provided through a website. The major traffic events will also be provided by simplified message through SMS/E-mail.

- Website
- SMS, E-mail

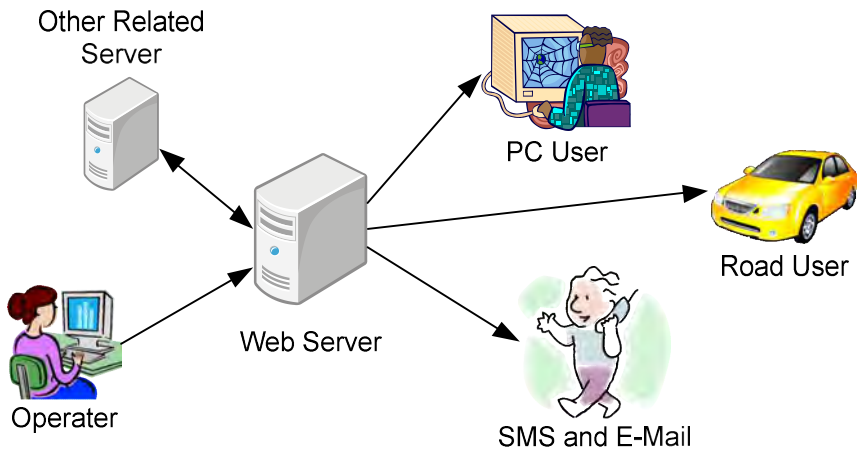


Figure 5-40 Example: Image of Information Provision System by Website

5-4-6 Centre System of Traffic Control Units

The centre system for traffic control units is prepared to control and monitor the devices listed below. The components for VMS will be prepared at centre in Phase-1. Others will be prepared in following phases in accordance with expansion of the functions of ITSC, as described in earlier sections.

- VMS
- Signal
- ERP
- Lane Control System
- Parking System

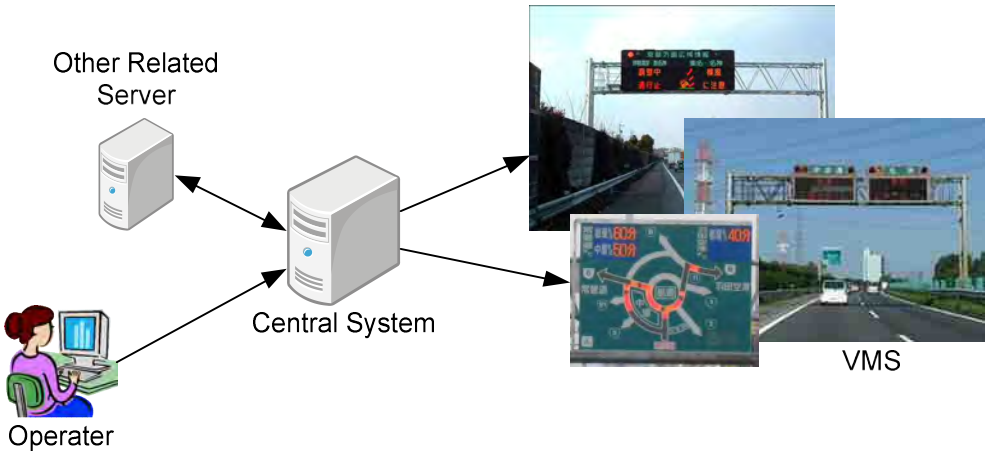


Figure 5-41 Example: Image of VMS System

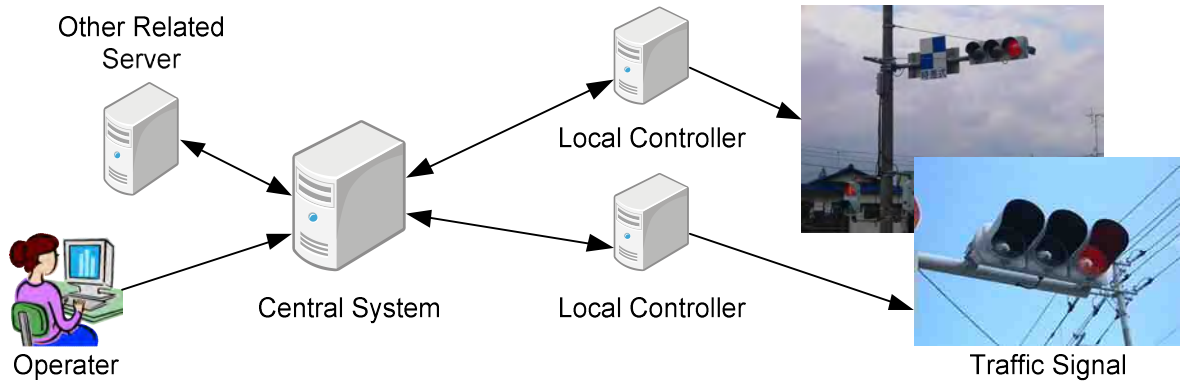


Figure 5-42 Example: Image of Traffic Signal System

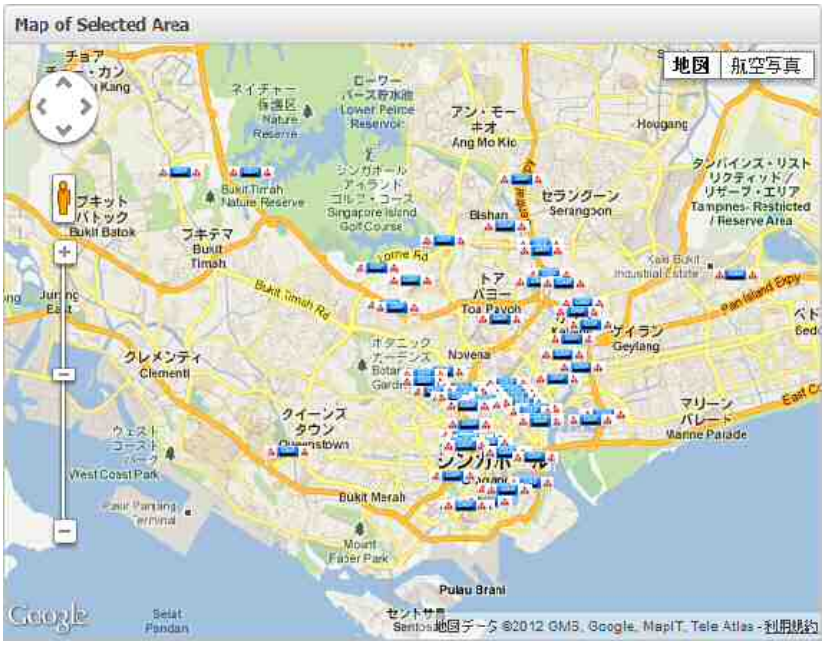
5-5 Other ITS Systems

5-5-1 ERP System

(1) Purpose

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

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



Source: http://www.sgcarmart.com/news/carpark_index.php?LOC=all&SRH=&TYP=erp

Figure 5-43 Example: Image of ERP gantry locations in Singapore

(2) Example Configuration

The example configuration of equipment is as follows:

- Assuming 3 lanes road and only targeting of incoming vehicles
- 1 local server for each 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 lamps (red and green) 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/or GPRS

5-5-2 Lane Control System

(1) Purpose

The traffic demand for a road changes depending on the time of 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 a one-way lane in accordance with the traffic demand to reduce congestion.

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

(2) Service Flow

The overall service flow becomes as follows:

(a) Reversible Lane Control

- ITSC collects the necessary information for reversible lane control from the road administrators, etc.
- ITSC analyses and processes the collected information.
- ITSC sends necessary information to the traffic police when the road capacity becomes saturated.
- ITSC displays the information on VMS for notification to drivers and starts controlling the lanes as per the police request.
- ITSC provides the information of the status of the lane to the road administrators and related-agencies.

(b) One-way Driving Control

- ITSC collects information of OD and vehicle class through in-vehicle device.
- ITSC analyses and processes the collected information from road administrators.
- ITSC sends necessary information to the traffic police when road capacity becomes

saturated.

- ITSC displays the information on VMS for notification to drivers and starts controlling one-way driving as per the police request.
- ITSC provides the information of the status of the one-way road to the road administrators and related-agencies.

(3) Example Configuration

The example configuration of equipment is as follows:

- Assuming 1 shared lane on 1 flyover
- 2 sets for 1 lane (both sides of flyover)
- 2 signals with 2 lamps (red and green) 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/or GPRS

5-5-3 Parking System

(1) Purpose

Parking System provides information on parking availability to drivers before and during their 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 fraud and assisting the proper parking planning based on the area demand.

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

(2) Example Configuration

(a) Parking System (Basic System)

The example configuration of 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
- 1 central monitoring system at ITSC
- Excluding communication media such as optical fibre cable and/or GPRS

(b) Parking System (Advanced System)

The example configuration of 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 vehicle spaces
- 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
- 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/or GPRS

5-5-4 Enforcement System and Vehicle Registration Database

The vehicle number plates are not standardised in India. They employ different materials, fonts, character sizes, languages, equipping positions on the vehicles, etc. It is technically difficult to automatically detect and recognise the number plate by the system in such condition. The vehicle registration database is developed by state, and it is not linked to any other systems such as driving licence mechanism, resident registrations and etc. Thus, enforcement is facing difficulties in tracing the violated owners such as the ones from other states, or changed his addresses, etc.

The enforcement system is available in Hyderabad for i) traffic signal violations, and ii) over speed violations. The number plates of the violated vehicles are captured by CCTV cameras installed on the roadside. The plate number information is manually entered by the staff at the centre by referring the captured pictures. A notification of the fine is sent to the owner of the vehicle later. The vehicle registration and issuance of driver's licence are under the jurisdiction of the Road Transport Authority (RTA). The vehicle registration database which links the information of the vehicle owners and vehicle numbers was prepared. However, it is facing the following issues;

- The owners of the vehicles registered in other states can't be traced because the database is independently developed by state.
- A residence registry such as the one available in Japan is not in place in India. The vehicle inspection system/scheme is not sufficiently prepared in India. Therefore, the vehicle owners who changed their residence addresses and not reported to the RTA cannot be traced.
- The vehicle number plates are not captured automatically for enforcement or other purposes.

Standardisation of vehicle number plate has been recently initiated in India. Acceleration of number plate standardisation and improvement of vehicle registration are highly recommended for proper enforcement.

5-6 Summary of Proposed ITS Devices to be Installed

The total proposed number of ITS devices by phase is summarized below.

Table 5-15 Total Number of Proposed ITS Devices to be Installed by Phase

Device	Phase-1	Phase-2	Phase-3
ATCC	68	170	454
MET SENSORS	6	-	-
FLOOD SENSORS	14	111	-
CCTV	55	375	449
VMS	42	54	100
SIGNALS	221 (Part of HTRIMS)	179 (400 for Pedestrians)	222 (500 for Pedestrians)
POLLUTION SENSORS	10	-	-
ERP	-	-	10
LANE CONTROL	-	-	20
PARKING SYSTEM	-	-	30

Note: Number of ERP, Lane Control and Parking Systems are rough estimates.

Note: The number of the devices shown above in Phase-3 is approximate. The figures need to be re-examined in the future.

6 ITS Centre (ITSC) - Organisational Set Up

6-1 Examples of Control Centres in Other Countries

6-1-1 Japan

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
- Inter-city Expressway Management.

These four groups 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, as 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 traffic hazards'. The police are tasked with traffic regulation and traffic management by controlling the traffic equipment and providing the traffic information to fulfil their roles.

(b) Centre and Coverage Areas

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

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

In terms of the road traffic, MLIT is the national road administrator which is responsible for the management of national roads.

(b) Centre and Coverage Areas

The Regional Development Bureau is a regional branch division under MLIT, which is in charge of development and management of national roads, rivers, dams and ports. There are 10 regional development bureaus under MLIT in Japan. The national roads are managed by several

branch offices under regional development bureaus. Basically, one (1) control centre is prepared for each 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 2,000 km 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 322 km. There are 3 control centres in the area and each centre covers approximately 100 km of expressway. The metropolitan expressway is a complicated road network in the metropolitan area. Thus the centre carries out 'area management' by exchanging information among them for such purposes as providing the alternative route information for users, taking necessary actions within its own jurisdiction, etc.

(4) Expressway Operator: Inter-City Expressway Company

(a) Roles

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

(b) Centre and Coverage Areas

Each expressway company has basically 4 centres and each centre covers approximately 400 – 1,000 km of expressways. The Inter-City Expressway is not a complicated road network but has long-distance and high speed. Thus, each centre exchanges information in a way so that the road users can comprehend the condition ahead to assure 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 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 the public via internet page and mass communication such as radio and TV.

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

JARTIC also sends the collected data to Vehicle Information and Communication System Centre (VICS Centre). 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 drivers via car

navigation system through ITS equipment on the roadside installed by these agencies. Such traffic data is updated every five (5) minutes by these agencies as well as by the FM multiplex broadcasting.

Public road users learn about traffic conditions via TV, radio, internet devices and car navigation system, and they can select either smooth traffic road or endure congestion.

(b) Centre and Coverage Areas

JARTIC covers all the areas in Japan. It is composed of 2 major data centres of which one is a backup centre. Thus all traffic data is collected and handled by a single huge data centre.

6-1-2 Singapore

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

(1) ITS Control Centre

A major single control centre 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 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 makes 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 users.
- Parking Guidance System, which informs the availability of parking.

(2) ERP Control Centre

Electronic Road Pricing System (ERP) automatically collects charges on road usage to reduce road traffic in the congested area in the city. It has been implemented as one of traffic demand management in Singapore. The control centre for ERP in Singapore was established exclusively for management of ERP. The major roles include facility monitoring, processing financial transactions and the ERP violations.

(3) Kallang Paya Lebar (KPE) Control Centre

The KPE control centre monitors the ITS equipment of the underground tunnel which extends approximately 12 km. The equipment for monitoring includes speed enforcement camera, communication system, tunnel ventilation system and environment control systems.

The centres above have their own different roles and ITS is deployed in accordance with their roles. The unique feature, in terms of the entire structure of these centres, is that none of them are 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.

6-2 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 with other neighbouring agencies such as road management agency and 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, 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 would be quite similar to Japan in terms of the roles and coverage areas. Hence, it is mostly appropriate to prepare one single centre and have it exchange the necessary information with 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 will be a single point for collecting the data from sites and sending the data to the national data centre.

The structure for road and traffic management for taking spot actions at sites will follow the existing management structure which is currently taken by traffic administrators (i.e. traffic police and road administrators such as GHMC).

6-3 Roles of ITS Centre – Proposed for Hyderabad

(1) Purpose of ITSC

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

- Central engine for continuous ITS initiatives to expand in Hyderabad
- Assures coordination with the National ITS Policy for ITS expansion in Hyderabad
- Carries out business with the private sector by selling the generated traffic information to assure revenue for the operation of ITSC
- Functions as a central single agency responsible for planning, implementing, evaluating ITS systems and development/expansion
- Collects all the road/traffic data and provides to users and relevant agencies.

(2) Functions of ITSC

To realise the above, it is proposed to have the following functions in ITSC:

- Collection of traffic data from roadside/probe based sensors and related information from

relevant agencies
- Traffic information provision to public through internet, SMS, call centre
- Traffic information provision for traffic flow control through VMS on roadside
- Automatic traffic signal control and related facilities for traffic flow control
- Analysis of real-time dynamic data and offline based accumulated data for identifying bottlenecks 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
- Operation and management of clearing house of common mobility card.

6-4 Organisation Structure

For the above functions, the following organisational structures Teams and skilled personnel are at least required for ITSC.

6-4-1 Organisation Structure - Teams

(1) Project Director

This person supervises and is responsible for overall operations of ITSC, and takes responsibility for reporting/coordination to/with upper level/external agencies as well.

(2) Traffic Monitoring and Control Division

The Traffic Monitoring and Control Division dynamically monitors the real-time traffic conditions in the city from 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

Telephone Call Centre handles enquiries from the general public and provides the advice and verbal information on traffic.

(4) Media Centre

Media Centre handles the enquiries from media such as newspapers, radio stations, TV stations, etc. and provides the information on traffic to be published.

(5) Research and Planning Division

Research and Planning Division analyses the offline stored data on traffic. It plans necessary measures on infrastructure improvement and traffic management based on the analysis.

(6) Equipment Maintenance Division

Equipment Maintenance Division maintains the hardware ITS equipment.

(7) Computer System Division

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

(8) Commercial Division

Commercial Division handles the selling of generated traffic information to governmental/non-governmental agencies to assure revenue for ITSC operation.

(9) Administrative Division

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

- 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
- General Affairs Section: It handles such affairs as labour management, welfare, etc.

(10) Staff Division

- Cleaning and Helpers: They take care of cleanings and any manpower support required for daily activities.

The Figure below shows the structure of organisation in case that ITSC is established as a single agency.

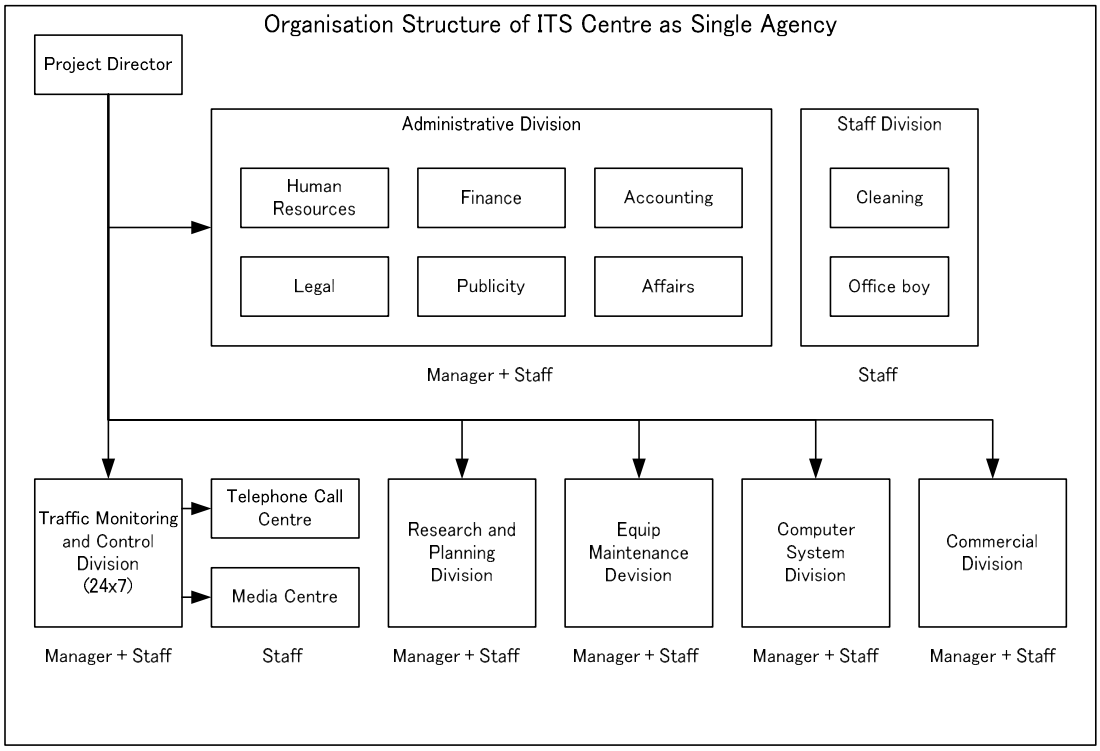


Figure 6-1 Organisation Structure (Single Agency)

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

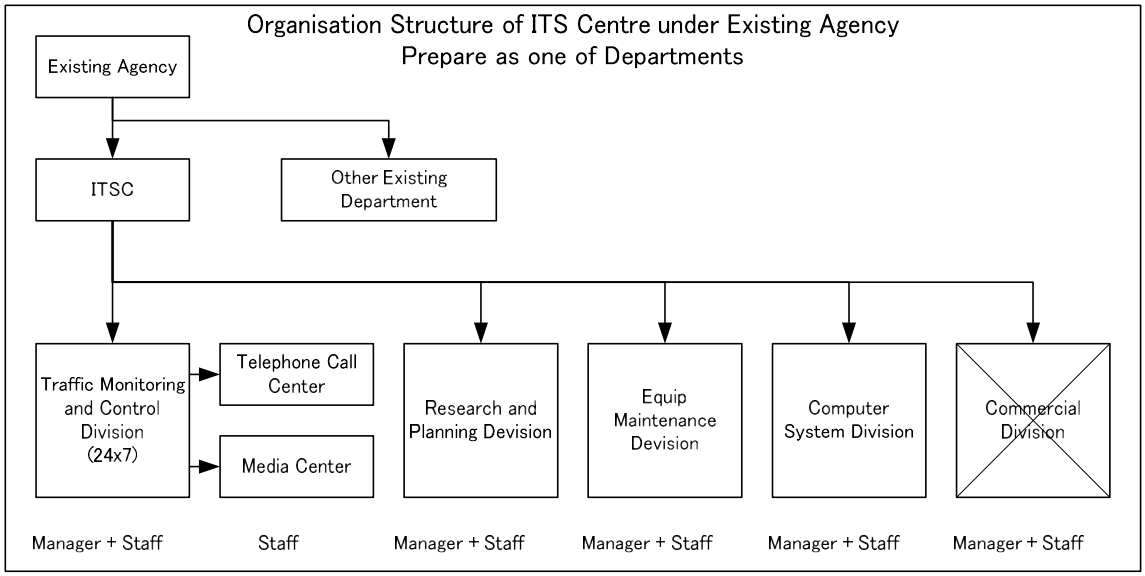


Figure 6-2 Organisation Structure (Under Existing Agency)

The structure will be more simplified if ITSC is prepared under such agency. For example, the administrative division may not be required because the existing division may be able to be utilised. However in such case, the commercial division which handles the selling of the generated traffic information to assure revenue for ITSC operation will need to be separately prepared because the existing such agency is in the governmental sector.

6-4-2 Organisation Structure – Skilled Personnel

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

(1) Senior Transport/Traffic Engineer

The senior transport/traffic engineer shall have at least 10 years of working experience in 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 Solaris, 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 the network and rectifying communication related issues.

6-5 Organisation Framework - Formation of SPV

The benefits of ITS will only be realised by establishing a suitable organisational framework. The organisation must be vested with the 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) for the following reasons:

- Strong leadership is required for continuous initiatives for ITS in Hyderabad since no substantial ITS systems are in place.
- Coordination among related agencies is strongly required due to the characteristics of ITS,

which domain extends across 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 sector.

- 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.
- ITSC shall have the 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 HMA.
- Identify and develop the shared responsibilities and goals for all stakeholders.
- Identify and evolve a mechanism within the organisation for well-established coordination among the stakeholders, public and private agencies.
- Involve the stakeholders during phased implementation of ITS in the city.
- 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)
- 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)
- Academic Institutions (such as NIT, Warangal)

Other Related Agencies:

- Taxi companies such as meru cabs, cell cabs, etc.
- Auto-rickshaw Unions

SPV shall function as an execution body for operation, planning, evaluation of ITS. It shall be jointly invested by agencies such as HMDA, GHMC, RTA and APSRTC. The human resources are to be provided by those agencies. It will own and maintain the ITS equipment, monitor the traffic flow,

and control the traffic. The decision on traffic control will be made by the personnel deputed from the traffic police to ITSC.

It shall be ensured that the detail roles and responsibilities within the SPV are defined and followed. 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 experts from academia, 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 for evaluating benefits of ITS and recommendations for necessary actions.

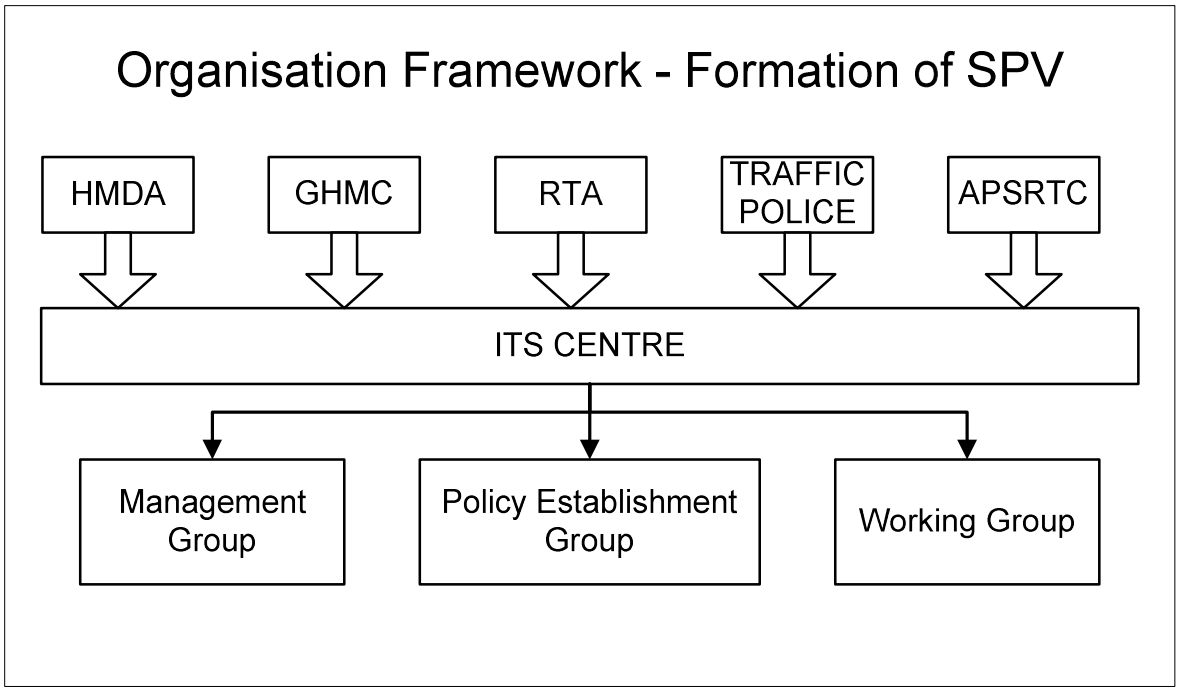


Figure 6-3 Formulation of SPV for ITSC

7 Economic Analysis

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

7-1 Basic Conditions for Analysis

The basic parameters 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

7-2 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 traffic demand in the year of 2011 is used as current demand data, and the future traffic demand for the years 2015, 2020 and 2030 is forecast on the condition of absence of ITS implementation, as the first step.

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 forecast by extending the current O/D, and 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 as monetary values 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

(a) 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.

(b) Information Provision

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

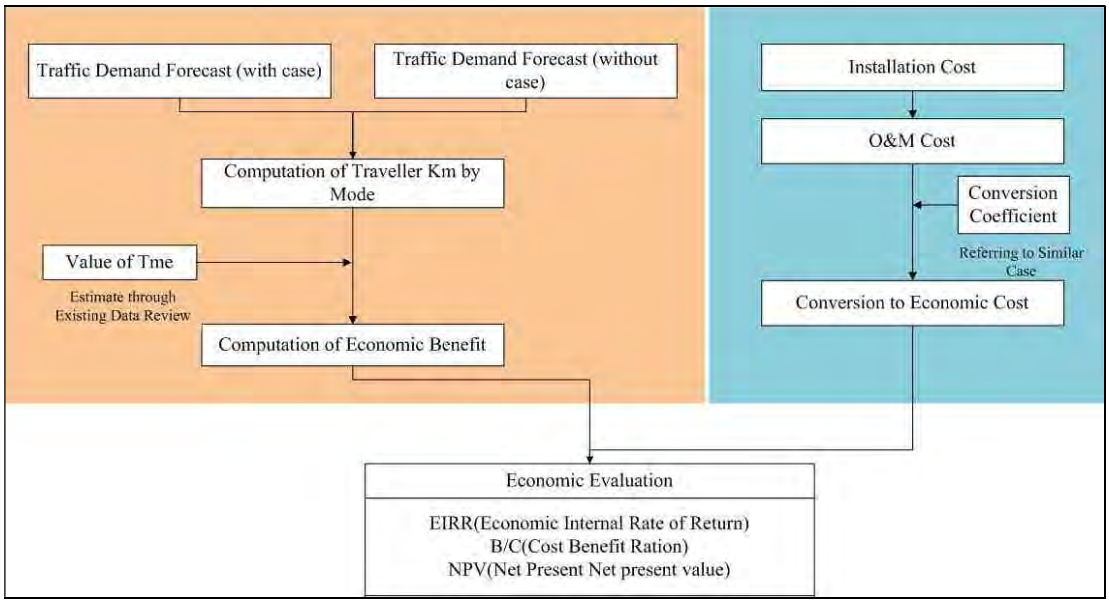
In strict terms for estimating the benefit brought by ITS implementation, the evaluation of ‘Information Provision’ would be sufficient. However with and without cases of signal installation are also provided because the signals are one of the important factors influencing traffic.

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

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 workflow of economic evaluation is shown in the figure below.



Source: JICA Study Team

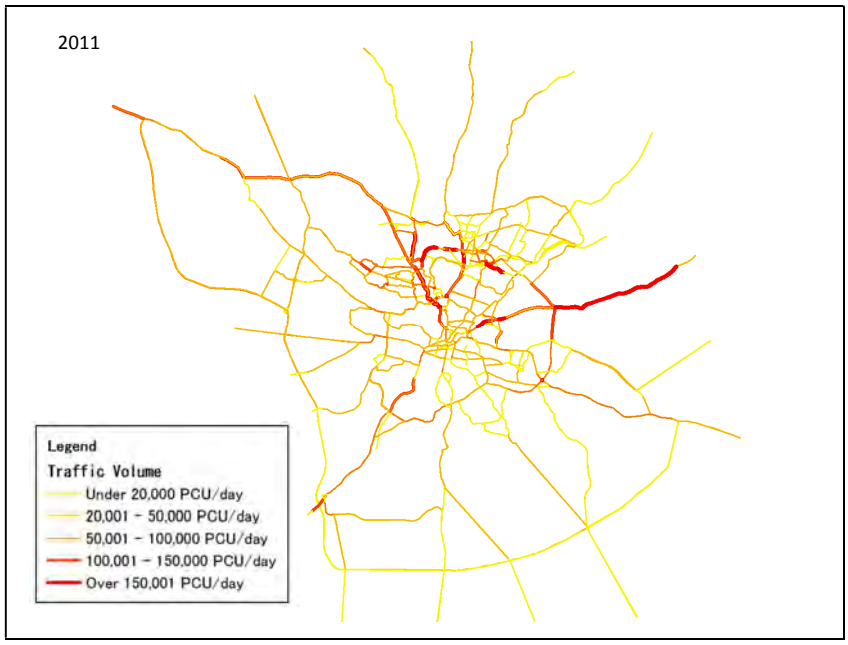
Figure 7-1 Workflow of Economic Analysis

The cost for installation and operation and maintenance which are incorporated into the above shown economic evaluation is estimated as shown in Table 8-1 in the clause “8-1 Approximate Cost of Implementation by Phase”.

7-3 Traffic Demand Forecast

(1) Current Traffic Demand

The figure below shows the results of using the traffic demand in 2011 as current data. It shows that the major traffic flow is concentrated in the National Highways and Inner Ring Road.



Source: JICA Study Team

Figure 7-2 Current Traffic Analysis (Year 2011)

(2) Future Traffic Demand

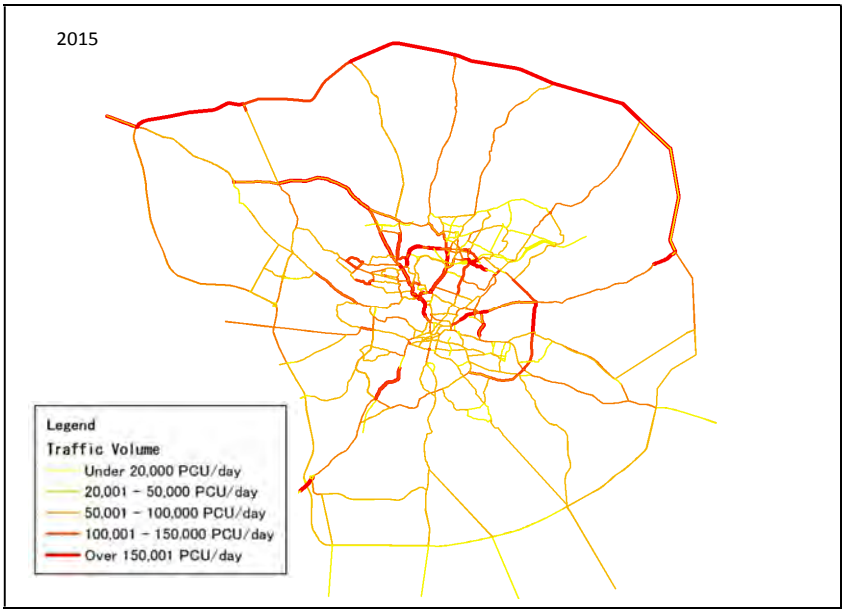
The traffic demand will be diverted to the Outer Ring Road and the roads which connect with ORR due to the development of ORR. Concentration of traffic is observed on NH9, NH7, NH202, IRR, ORR and others in the vicinity of Hussainsagar, in particular. It is expected that the traffic will further be concentrated on these roads in 2020 and 2030.

The result of traffic assignment and traffic demand are shown in the tables and figures below.

Table 7-1 Result of Traffic Assignment at Arterial Road

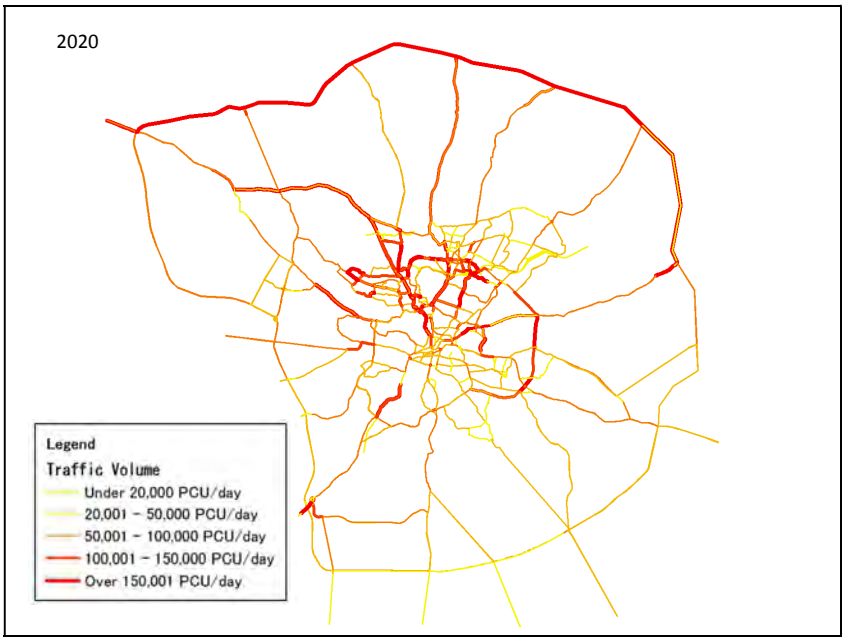
Year / Road	Traffic Volume (Average PCU/day)			
	2011	2015	2020	2030
NH7	42,875	59,075	72,100	130,930
NH9	80,803	98,674	118,796	179,579
NH202	98,868	114,243	129,984	191,190
IRR	65,807	85,654	105,443	207,933
ORR	22,408	38,901	46,226	73,738
Others	32,817	43,754	53,950	104,137

Source: JICA Study Team



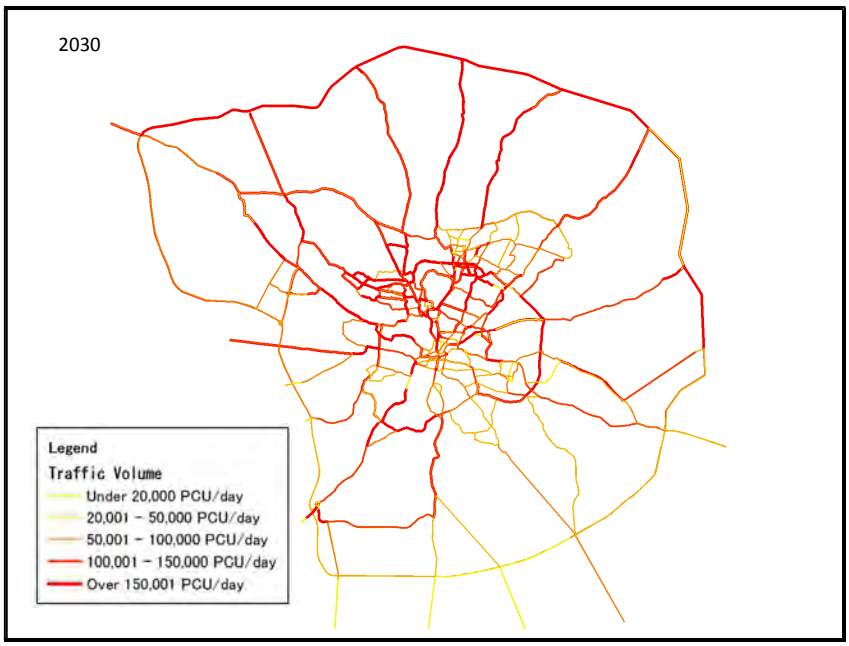
Source: JICA Study Team

Figure 7-3 Traffic Assignment Result 2015



Source: JICA Study Team

Figure 7-4 Traffic Assignment Result 2020



Source: JICA Study Team

Figure 7-5 Traffic Assignment Result 2030

7-4 Result of Economic Analysis

(1) Estimated Benefit

The benefits of three cases derived from with and without cases 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 7-2 Summary of Benefit

Case	Benefit(Without-With) Unit: Million USD/Year		
	2015	2020	2030
1. Signal Installation	80	200	223
2. Information Provision	16	78	291
3. Signal Installation & Information Provision	25	117	315

Source: JICA Study Team

Note: The following notes are supplements to the above two, “case 2; Information Provision”, and “case 3; Signal Installation and Information Provision”.

- The ITS facilities for data collection and information provision will be introduced in steps. Furthermore, it is expected that road users who are able to receive the real-time traffic information generated by ITSC by such means as terminal devices will be gradually increased.
- 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 Case 3 are summarised below.

Table 7-3 Result of Economic Evaluation for Case 3

Evaluation Indicators	Values	Unit
EIRR	83.7	%
NPV	277.8	Mil USD
B/C	9.19	

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%), has positive value of NPV (>0) and B/C is higher than unity (>1.0).

This is because ITS implementation does not require any large-scale infrastructure development and has low cost compared to general civil works such as road/bridge construction.

8 Financial Plan

8-1 Approximate Cost of Implementation by Phase

The approximate cost for the implementation by phase is shown in the Table below. Since technology advancement is very rapid and the factors for estimate such as the systems to be introduced in future are not clear now, the costs including the operation and maintenance are estimated only for Phases -1 and -2.

Table 8-1 Approximate Cost by Phase (Unit in INR)

Cost Type	Items	PHASE 1 (years 1 to 5)	PHASE 2 (years 6 to 10)
Capital cost	Equipment Capital Cost	1,10,36,00,000	3,22,40,00,000
Equipment Maintenance Cost	1st stage Cost	11,03,60,000	11,03,60,000
	2nd stage Cost	0	32,24,00,000
Cost spread across 5 years	Equipment maintenance Cost	33,10,80,000	1,51,90,00,000
	Human Resources Cost	14,19,50,000	22,87,10,000
	Organisation Operation Cost	13,59,00,000	21,88,70,000
	Total Maintenance Costs	6,08,930,000	1,96,65,80,000

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

Human Resource cost includes salaries to the ITSC staff and is estimated on yearly basis considering year to year increment of 10% to the cost. The increment of 10% is adopted based on the inflation trend and other related economic factors that increase human resources costs.

Organisation Operation cost covers power usage, communication usage, transport usage and water usage, etc. These costs are also estimated on yearly basis with year to year increment of 10% to the cost because of inflation and other influencing factors.

Despite the uncertainties in estimating the cost in the Phase-3 with regard to the development of ITS technology as described above, the capital cost for the expectable major components is estimated.

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

The breakdown of the capital cost by phase is shown in the Table below.

Table 8-2 Approximate Capital Cost by Phase (Unit in INR)

No.	Devices	PHASE 1		PHASE 2	
		Units	Approx Cost	Units	Approx Cost
1	ITS CENTRE		18,21,21,500		5,11,80,000
2	TRAFFIC SIGNALS	221	(HTRIMS) 0	179	1,10,51,26,000
3	PEDESTRAIN SIGNALS	0	0	400	48,84,00,000
4	TRAFFIC COUNTERS	68	15,03,04,000	170	37,27,90,000
5	CCTV	55	3,41,00,000	375	22,16,50,000
6	MET SENSORS	6	3,07,47,200	0	0
7	FLOOD SENSORS	14	1,29,80,000	111	10,08,70,000
8	VARIABLE MESSAGE SIGNS(VMS)	42	56,53,56,000	54	73,04,22,000
9	POLLUTION SENSORS	10	7,53,50,000	0	0
10	Subtotal		1,05,09,58,700		3,07,04,38,000
11	Contingency (Approx. 5% of Above Subtotal)		5,25,47,935		15,35,21,900
12	**Total Estimated Approx Cost**		**(1,10,35,06,635) ≒1,10,36,00,000**		**(3,22,39,59,900) ≒ 3,22,40,00,000**

8-2 Revenue Scheme in General

(1) Possible Revenue Schemes

Possible revenue schemes in general are 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)
- Displaying Advertisements
- Selling Data
- Selling Traffic Information to Road Traffic Information Providers
- Service Charges for Clearing House of Common Mobility Card

(2) Basic Principle

Preparation of ITS will be generally taken-up in parallel with Road infrastructure development.

This will help the local authority to reduce the costs of implementations. Across the world, development of road infrastructure and the related infrastructure 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 social infrastructure which is an extension of road infrastructure.

Across the world, funding for the Road and related infrastructure is taken-up under various schemes. Many 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 users such as expressway user charges, navigation guidance provision fees and BOT, etc. Singapore is one of the countries where Electronic Road Pricing (ERP) as traffic demand management has been successfully implemented and the collection scheme of charges from users is well-established.

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

(3) Expressway Usage Charges

It is quite normal to collect usage fee from users in the case of expressways, toll roads in a certain section, bridges, etc. for the construction and maintenance these Road, Bridges and etc.

In Japan, Toll charges on expressways are collected from the expressway road users under the beneficiary payment principle. Nowadays in Japan, the toll charges are collected at exits by the electronic toll collection system using on-board units installed in the vehicles.

In USA, the costs for expressways are covered by tax. In Europe, the toll charges on the expressways are collected from the large-size trucks in recent years. Since the road network is expanding all over Europe nowadays, the cost for maintenance of road damage caused by the wear and tear of passing vehicles has become an issue. Toll charges are collected from 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 it by discouraging vehicles use of specific roads during peak hours and also reduce the environmental pollution levels increase that with the level of congestion. This kind of charge is collected in the form of ERP in Singapore.

Methods of road pricing started with the idea that usage charges are not only for the construction and maintenance of roads, but to address side effects such as congestion because of use in peak hours, pollution and noise, etc. It is a general opinion that drivers must pay for the side effects they impose on others.

The ERP system uses 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 strategic roads, the card-reader is activated by a microwave signal. There is a beep and the toll is deducted from a Cash Card which is a pre-paid smart card. The card can be charged at all local post offices, banks, petrol kiosks or ATMs.

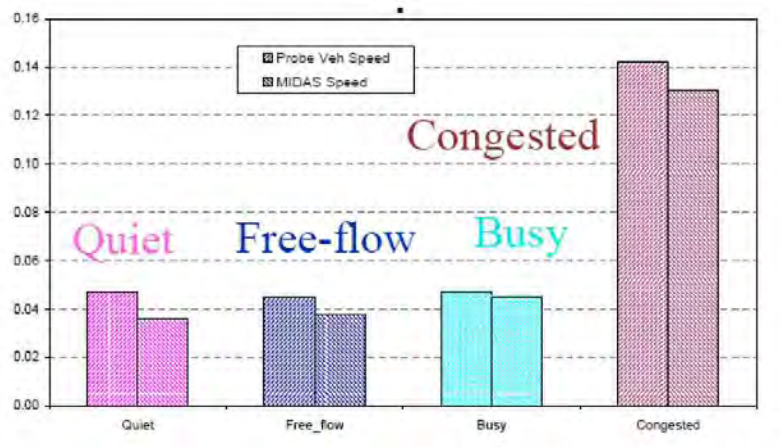


Figure 8-1 Levels of Pollution Depends on Congestion Level

(5) Car Navigation, Smart Phone, Internet

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

In the case of the smart phone and internet, users pay a fees for congestion information to the service providers. If the information service is offered free of charge, the service providers cover their cost by general advertising fees.

(6) BOT

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

BOT scheme is applied to the southern section of ORR, and the concessionaire is paid an annuity by the AP government. The source of the annuity is covered by tax, which means that the cost for the operation and management of ORR is being borne by the general public. The advantage of this case is that the concessionaire's road management is stable because their revenue is assured.

The traffic signal jumping enforcement system (E-Challan System) of the traffic police has also been prepared and operated by BOT. The concessionaire obtains 20% of the penalties collected from the violating road users. It is assumed that the increased cost of 20% to add a concessionaire to the system can be covered by increase in violation penalties amount.

The concessionaire of the bus location system, which is under preparation by the APSRTC, gets 10% of the bus fees. It is also assumed that the increased cost of 10% to add a concessionaire to the system can be covered by the increased bus usage because of improved convenience from 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 a scheme such as preparation of a fund with such components such as tax collection on fuel, fee for vehicle registration renewals once in 2 to 3 years, electronic road pricing (ERP), etc.

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 decreased by 17%.

In Indonesia, as part of efforts to ease traffic congestion, the Government 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).

8-3 Proposed Revenue Scheme for ITS Centre

Possible revenues usually come from two main sources as follows:

- Public funds such as tax.
- Sale of traffic information to interested parties in public and private sectors.

(1) Tax & Annuity Model

In essence, traffic information is to be provided to the public as a public service. Traffic flow control is also to be offered to the public for realizing better traffic conditions. Therefore, these do not generate any revenues and they are legitimately covered by public funds. In such case, provision of annuity is required to cover the operation and maintenance costs of ITSC.

(2) Commercial Model

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

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

(3) Proposed Model (Combination of Above)

When ITSC is established as SPV, the combination of the tax & annuity and commercial model, called Hybrid Model, is appropriate. It is described below.

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 by SPV to the interested parties. Some proportion of the income obtained will be utilized for operation and maintenance of ITSC and the remaining proportion will be given to the government for Loan repayment.

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

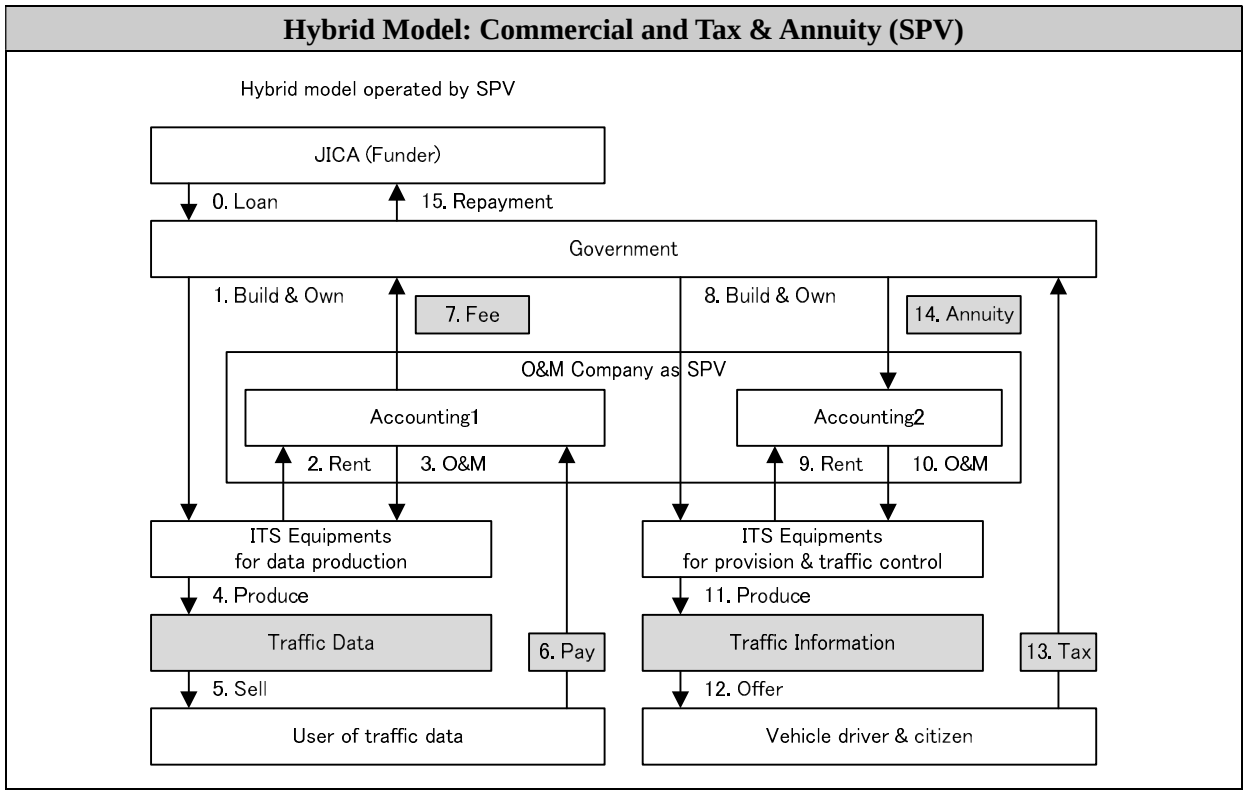


Figure 8-2 Hybrid Model: Commercial and Tax & Annuity (SPV)

(4) Other Options

In addition to the above recommended model, other options are shown for consideration as follows:

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

The figure below shows two cases of creation of SPV for operation and maintenance of ITS equipment and facilities. Thus, the Government builds ITS equipments and facilities and the SPV operates and maintains them, which is the same with the recommended hybrid model above. The differences between the figure on the left and right are the revenue sources: namely, either commercial base or tax base.

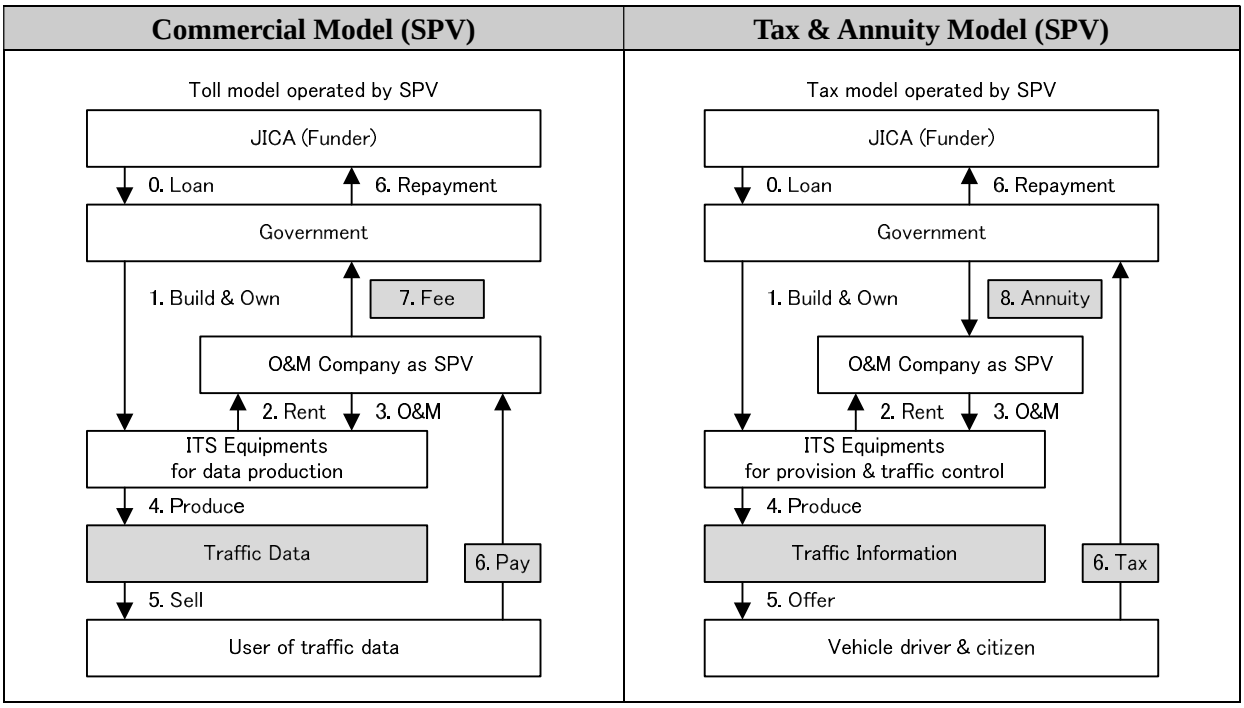


Figure 8-3 Build by Government, Operated and Maintained by SPV

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

The figure below shows two cases of direct operation by the Government. The Government builds the ITS equipment and facilities and takes care of operation and maintenance as well. In these cases, ITSC will be prepared and operated under a division of the existing governmental agency.

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

The figure on the right shows the tax collection model under this scheme. The operation cost will be covered by tax revenue.

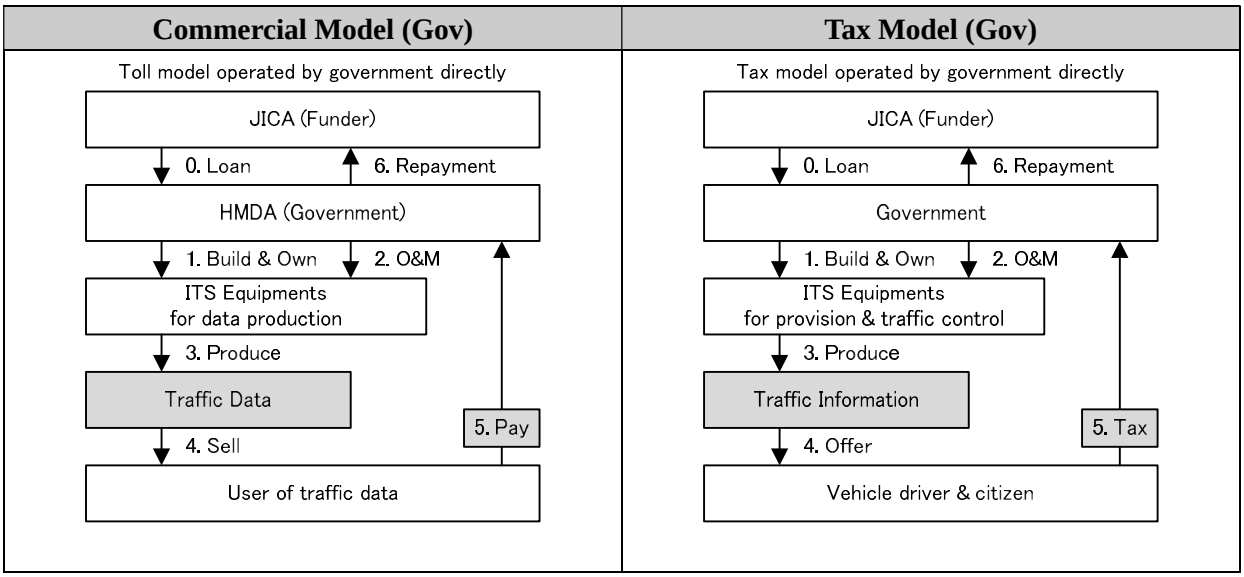


Figure 8-4 Build, Operated and Maintained by Government

(c) ITS Centre: Build, Operated and Maintained by Private (BOT)

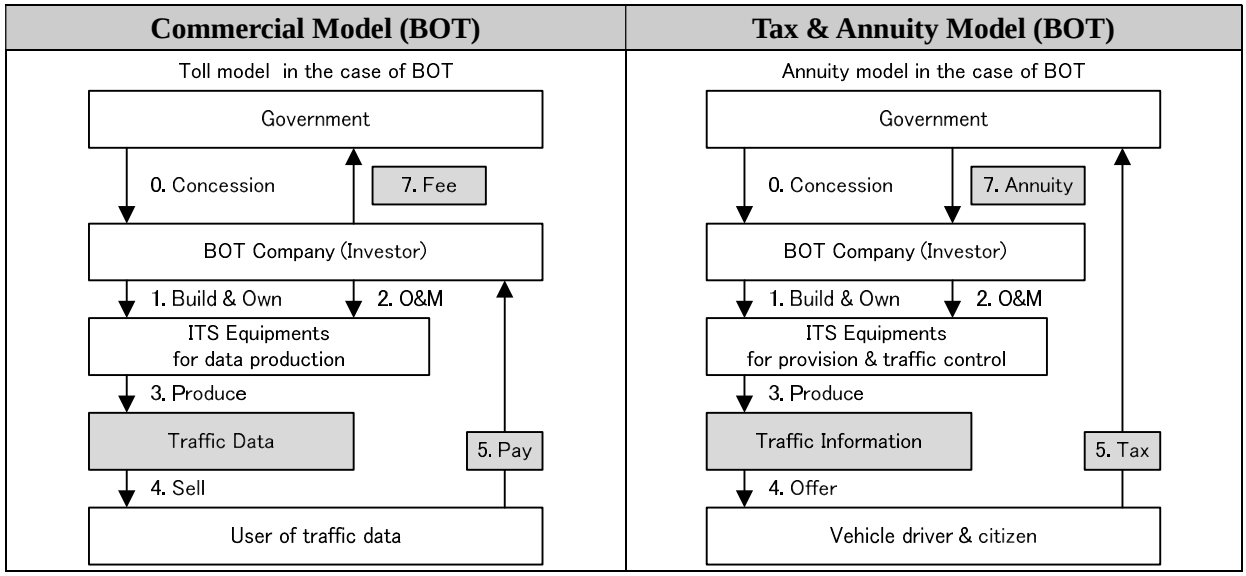


Figure 8-5 Build, Operated and Maintained by Private (BOT)

The above Figure shows two cases where the ITC Centre is built and operated under BOT scheme by a 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 cases are recommendable due to the following reasons:

- The revenue is not sufficient for assuring both benefit for the concessionaires and covering the cost of operation.
- To allow the entire system to be handled by the concessionaires, in these cases, is not suitable with regard to the concept and roles/responsibilities of ITSC where the initiative needs to be taken by the government side.

8-4 Possible Schemes for Revenue Generation

8-4-1 Most Likely Scenario

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

The provision of ITS services realised by ITSC as proposed in the Master Plan is the first of its kind in India. Thus, it may take certain period until the general public becomes aware of the benefits of the ITS services provided by ITSC. Unless the general public sufficiently appreciates the benefit, it would not be practical to utilize tax or user fee collection from the public for covering the required cost. It is expected 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 Government funds during this initial period. Once the benefit is fully recognised by the public, the following options will become possible:

Table 8-3 Possible Schemes for Revenue Generation

Model	Revenue Items
Tax & Annuity Model	Collection of ITS User Charge at the time of new Vehicle registration
	Strengthened Enforcement
	Re-allocation of vehicle Life Tax
	Re-allocation of e-Challan
	Re-allocation of property tax
Commercial Model	Advertisement Service
	Sales of traffic data

8-4-2 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 options for revenue for ITSC.

RTA currently collects three types of fees from car owners at the time of registration of new vehicles 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 annual vehicle registration fee is approximately estimated at 3,50,000. It is suggested that an amount of INR 1,000 be collected from each vehicle at the time of new vehicle registration to generate annual revenue of 35 crore INR.

Table 8-4 ITS User Charge for Revenue Generation

Items	Amount
Vehicles Registered per Year in Hyderabad City	3,50,000
Considered ITS User Charge per Vehicle	INR 1,000
Annual Revenue from ITS User Charge Collection	INR 35,00,00,000

(2) Increase of Fine Collected by Enforcement

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

If the road traffic infrastructure is improved, enforcement can be strengthened to allow spending more time of the traffic police on the enforcement activities. This will consequently lead to increased collection of e-Challan.

(3) Life 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 percent of this amount be re-allocated 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 percent of this amount be re-allocated 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 percent of this amount be re-allocated to ITSC.

8-4-3 Commercial Model

(1) Revenue Generation by Advertisement Service

When ITSC offers traffic information to public through website, SMS and E-mail, advertisement service 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 service is as summarized below.

Table 8-5 Revenue Generation by Advertisement Service

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

(2) Revenue Generation by Selling Out Traffic Related Data

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

Data shall be offered to the public 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 to comprehend traffic conditions and to make analysis of its future status. Hence, there is the possibility of high demand for the data by such agencies as government, marketing companies, consultants, investors, etc.

Examples of the aggregated data which can be sold include:

- Traffic volume
- Travel speed
- Congestion status
- Vehicle classification
- Weather condition

8-4-4 Conclusion

Estimated annual revenue scenarios are summarised in the above sections. As explained, Hyderabad city is going to be the first Indian city to have 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 take time to convince the public about the benefits of such utility initially and to generate revenue for ITSC after start of project operation. But with the continuous usage and provision of basic user services by ITSC, the public will surely come to recognize the benefits of the system and accept to pay for additional services.

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

ITSC can generate additional revenue through sale of the data to various organisations, and other avenues as mentioned in the above sections.

9 Capacity Building for Staff in ITS Centre (ITSC) and Related Agencies

Capacity building is one of the most important components to assure sustainable operation and management of ITS over a long period of time, especially in regard to new technology.

The staff of personnel and professionals should have adequate skills and competencies of ITS technologies and operations. Thus, it is important to draw plans for training and definitely carry out them to enable continuous improvement of their skills for proper operation and management, and keeping up with 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 ITSC and ii) personnel in related agencies.

(2) Components

The following components shall be included.

- **Attending Seminars:** Including domestic and international seminars
- **Participating in Technical Study Tours:** 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.
- **Presentations:** 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 using PDCA cycle so that the skills are progressively improved.

(4) Supporting Unit

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

The figure below shows the process of capacity building program.

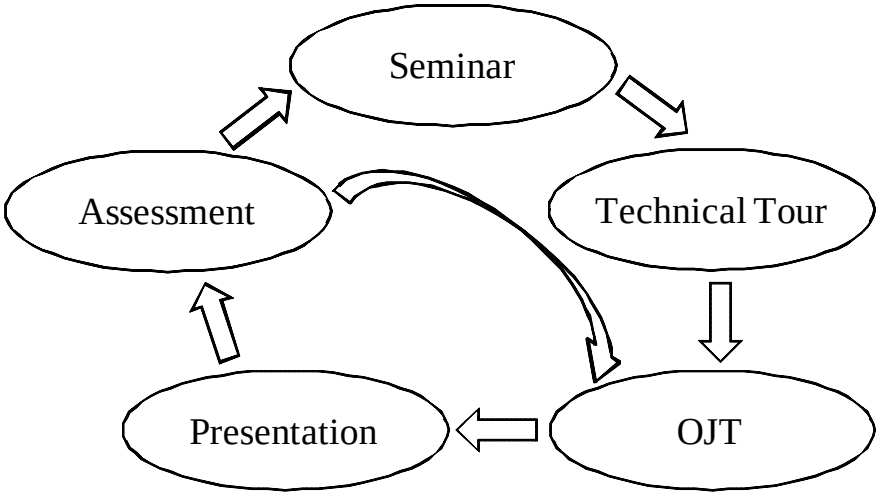


Figure 9-1 Process for Capacity Building

The above components for the capacity building shall be carried out in PDCA (Plan, Do, Check, Act) manner so that the competency can be progressively reinforced. The cycle for OJT, presentation and assessment can be repeated.

10 Other Proposed Measures

In addition to the above, the following measures are recommended to be carried out.

10-1 Best Practice Zone

In order to demonstrate the effectiveness of measures on improvement of the traffic and demonstrate best practices to citizens, the following measures are recommended to be carried out in selected area/section as best practices 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.

Demonstrations to the public are to be showcased by providing optimum route guidance for alternative route from High Tech City to the Hyderabad Rajiv Gandhi International Airport by 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 ATCC on radial road 6 and NH-44 (old NH-7) from IRR to the Airport, using bus probe data and graphical VMS. The installation interval of ATCC shall be 1 – 2 km.

This will also be carried out as a 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)

Secunderabad is the area where a number of ordinary people enjoy activities and do shopping.

The demonstrations to the public are to be showcased 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 ATCC in the area of Secunderabad, bus probe data and VMS. The installation interval of ATCC shall be 1 – 2 km.

This will also be carried out as a 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 Kasu Brahmananda Reddy Park (KBR Park) is fairly well developed. In particular, the roads surrounding KBR park are relatively more appropriately prepared compared to other areas in Hyderabad. In addition, there is a plan that a metro railway station will be constructed at the edge of the north-west side of KBR park. Thus, the following components are to be comprehensively developed. This will prepare this area as a comprehensive demonstration model zone with infrastructure and ITS facilities.

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

(4) Alternative-4: Demonstration of Footpath and ITS Facilities

The absence of 'walk-able environment' such as well prepared footpath is one of the major issues in terms of road infrastructure in Hyderabad since pedestrians currently mix with vehicular traffic flows.

The High Tech City is the area where relatively affluent people and foreigners reside with a number of foreign companies such as Microsoft, Google, etc. This area has a great potential need for well-prepared walk-able environment. Thus, it is proposed to intensively prepare, in this area, footpaths 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 do jogging in certain designated area. 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 identified in the future.

10-2 Other Required Measures for Road Infrastructure

Apart from ITS, the city of Hyderabad is facing more basic problems of road infrastructure. In particular, major critical issues include: i) structure of intersection/junction, and ii) absence of pedestrian crossing infrastructure and facilities.

(1) Structure and Design of Intersection/Junction

Properly structured intersections/junctions do not exist in Hyderabad. For example, many of the existing intersections have legacy round-about structures but are equipped with signals. Others lack stopping line/centre line and medians which should be properly designed around the intersection. Additionally, there are improperly shaped intersections/junctions, etc. It can be assumed that improvement of the intersection/junction will greatly contribute to assuring smoother traffic flows.

The required package of measures are as follows:

- Improvement of Intersection/Junction Structure
- Preparation of zebra crossings
- Preparation of stopping line for motorcycles
- Preparation of stopping line for 4-wheelers, separate from the motorcycles
- Preparation of properly shaped median at intersections/junctions
- Preparation of lanes to keep traffic order
- Preparation of signals

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

- The figure on the left shows the stopping line for 4-wheelers, zebra crossings, spaces for bicycle to cross, waiting space for vehicles in the middle of the intersection for right-turn, and associated facilities such as lighting around the intersection.
- The figure on the right shows separated lanes with guide arrows: one is for vehicles to turn left or straight and the other is for vehicles to turn right.

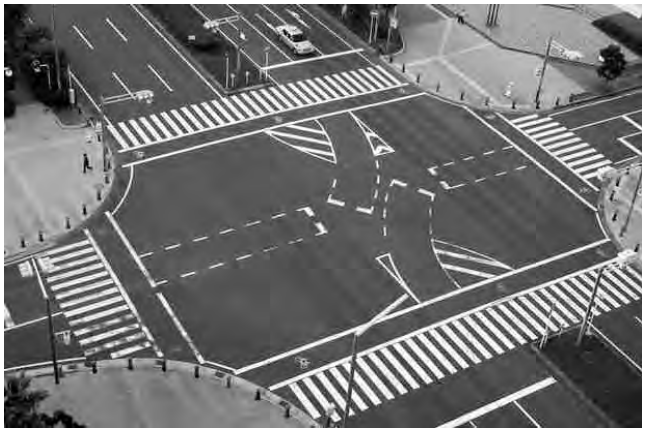


Figure 10-1 Example: Image of Intersection (1) in Japan

Figure 10-2 Example: Image of Intersection (2) in Japan

(2) Pedestrian Crossing (Zebra Crossing, Signals for Pedestrians, 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.

Measures include the zebra crossings, signals for the pedestrians and skywalk. These infrastructure and facilities need to be in place not only on the major roads but also throughout the city.

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 consequently interrupts the smooth traffic flow and results in very dangerous conditions for pedestrians.

The overall necessary number of the locations for the pedestrian crossing facilities is roughly estimated as follows:

- Basic Condition: Approximately 1500 km total length of road network inside IRR
  - Case-1: 1,500 locations (1,500 km / 1 km (pedestrian crossing facility at every 1 km)
  - Case-2: 3,000 locations (1,500 km / 500 m (pedestrian crossing facility at every 500 m)
  - Case-3: 6,000 locations (1,500 km / 250 m (pedestrian crossing facility at every 250 m)
  - Case-4: 15,000 locations (1,500 km / 100 m (pedestrian crossing facility at every 100 m)

Generally, zebra crossings together with the signals for pedestrians are in place almost every 100 m in a metropolitan area such as Tokyo in Japan. In the case of Hyderabad where such infrastructure is not in place, these shall be prepared in line with such practice.

Zebra crossings are to be prepared on roads with narrow-width, and sky-walks are to be prepared over roads with wide-width.

Photos of 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 a school. In general, this infrastructure needs to be prepared near facilities such as school to assure the safety of pedestrians.

The figure on the right shows a relatively large–size zebra crossing in the centre area of a metropolitan street. Although the skywalk is not used in this case, the zebra crossing can manage pedestrian crossings if the traffic is properly controlled.

Figure 10-3 Example: Image of Zebra Crossing (1) in Japan

Figure 10-4 Example: Image of Zebra Crossing (2) in Japan

11 Measurable Outcomes for ITS Projects

Measurements of ITS Project outcomes should be made with 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 ITS implementation by phase to take the required actions for better outcomes. 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 Hyderabad city are as follows:

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

Safety improvement involves the enhancement of public transport, improvement of road infrastructure such as development of pedestrian facilities, introduction and revision of appropriate regulation, enforcement, education and improvement of traffic manners. 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 from website and SMS
- The number of emergencies dispatched
- The response time taken to report the incident

Environment / Energy involve the mitigation of pollution, environmental conservation, and improvement of fuel efficiency of vehicles. The measures to achieve these goals include educating road users about pollution levels at different traffic junctions, and encouraging the usage of public transport and electric vehicles.

The measurable outcomes of environment / energy include:

- Usage of public transport (increase/decrease)
- Measurement of air pollution and dissemination of the information to road users from website and VMS.
- Vehicle emissions (increase/decrease)
- Vehicle energy consumption (increase/decrease)

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 from websites, VMS and optimal route selection by car navigation system or mapping system.

The measurable outcomes of productivity include:

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

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 from website, VMS, SMS, etc., parking guidance, electronic timetables for various modes of transport, and common mobility cards.

The measurable outcomes of mobility include:

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

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 of efficiency include:

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

User 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 from website, VMS, SMS, etc., optimal route guidance, and travel and transit information from website, SMS, VMS,, kiosks, etc.

The measurable outcomes of user satisfaction include:

- Usage of ITS services (increase / decrease)
- Customer satisfaction surveys

12 List of Abbreviations

The table below is the list of abbreviations used in the master plan document.

Table 12-1 Abbreviations

Abbreviation	Description
APIIC	Andhra Pradesh Industrial Infrastructure Corporation
APPCB	Andhra Pradesh Pollution Control Board
APSDPS	Andhra Pradesh State Development Planning Society
APSRTC	Andhra Pradesh State Road Transport Corporation
ATCC	Automatic Traffic Counting and Classification
CCTV	Closed Circuit Television
CDP	City Development Plan
CTS	Comprehensive Transportation Study
ECB	Emergency Call Box
ERP	Electronic Road Pricing
FTA	Foreign Tourist Arrivals
GDP	Gross Domestic Product
GPS/GPRS	Global Positioning System/ General Packet Radio Service
HATS	Hyderabad Area Transportation Study
HGCL	Hyderabad Growth Corridor Limited
HMA	Hyderabad Metropolitan Area
HMDA	Hyderabad Metropolitan Development Authority
HMR	Hyderabad Metro Rail
HMWS&SB	Hyderabad Metropolitan Water Supply, Sewerage Board
HTMS	Highway Traffic Management System
HTRIMS	Hyderabad Traffic Integrated management System
IMD	India Meteorological Department
IPT	Intermediate Public Transport
IRR	Inner Ring Road
ITS	Intelligent Transportation System
ITSC	Intelligent Transportation System Centre
JICA	Japan International Cooperation Agency
KBRN	Kasu Brahmananda Reddy National Park
L&T	Larsen and Toubro
MET	Meteorological Stations
MMTS	Multi-Modal Transport System
MoUD	Ministry of Urban Development
NAAQS	National Ambient Air Quality Standards
NH	National Highway
NMT	Non-Motorised Transport
NOx	Nitrogen Dioxide
NUTP	National Urban Transport Policy

Abbreviation	Description
OD	Origin-Destination
ORR	Outer Ring Road
ORR	Outer Ring Road
PCU	Passenger Car Unit
RSPM	Respirable Suspended Particulate Matter
RTA	Road Transport Authority
SCR	South Central Railway
SO_x	Sulphur Dioxide
SPV	Special Purpose Vehicle
TCC	Traffic Command Centre
TMS	Toll Management System
TSPM	Total Suspended Particulate Matter
UMTA	Unified Metropolitan Transport Authority
VMS	Variable Message Signboards

(End of M/P)

Appendix - I

1 ITS services for Hyderabad

The table below shows the examples of ITS services for Hyderabad.

Table 1 ITS services for Hyderabad

No.	User Service Bundle of World ITS Architecture		Example of ITS	Priority		
				1	2	3
1	**Traffic Management and Operations (ISO)**					
	1.1	Data Collection	Collecting information on traffic volume by using the vehicle detector	√	√	
			Collecting information on travel speed by using the vehicle probe sensor	√	√	
			Collecting Closed-circuit Television (CCTV) image by using the CCTV camera	√	√	
			Collecting traffic information from relevant system such as Hyderabad Traffic Integrated Management System (HTRIMS), Vehicle Tracking & Passenger Information System (VT&PIS), and Outer Ring Road Highway Traffic Management Systems (ORR HTMS)		√	
			Collecting information on travel time and origin-destination (OD) from other sources like mobile tracking		√	√
			Collecting operation information on public transport operations such as bus, metro rail, Multi-Modal Transport System (MMTS) trains, local trains, and regional bus services		√	
			Collecting information related to all emergency and disaster response services from the agencies such as police, fire, Emergency Management and Research Institute (EMRI), Greater Hyderabad Municipal Corporation (GHMC), and hospitals		√	
			Collecting information on road condition & maintenance from related agencies such as GHMC, Hyderabad Metropolitan Development Authority (HMDA), Roads & Buildings (R&B), National Highways (NH), Hyderabad Metropolitan Water Supply & Sewerage Board (HMWS&SB), Traffic Police, and Central Power Distribution Company Limited (CPDCL)		√	√
			Collecting data on traffic accident from traffic police	√	√	
			Collecting information on noise levels from Andhra Pradesh Pollution Control Board (APPCB), no horn zones from GHMC and traffic police, heavy vehicle		√	

No.	User Service Bundle of World ITS Architecture		Example of ITS	Priority		
				1	2	3
			entry restriction from traffic police			
			Collecting information on vehicle registration from Road Transport Authority (RTA)		√	
			Collecting information on large tourist locations and pilgrimage locations from tourism department		√	
			Collecting information on park & ride facilities		√	
			Collecting information on parking availability from the parking		√	
	1.2	Information Provision	Providing traffic information via provision tool such as Variable Message Sign (VMS), Website, E-mail, SMS, Call Centre, FM Radio and Other Media	√	√	√
			Providing information on public transport operation via provision tool		√	
			Providing adverse weather information via provision tool	√	√	
			Providing emergency and disaster information via provision tool	√	√	
			Providing road work information via provision tool	√	√	
			Providing information on noise levels, no horn zones, and heavy vehicle entry restriction		√	
			Providing information on parking availability and location		√	
	1.3	Traffic Control	Traffic monitoring system with large display at monitoring room	√		
			Controlling traffic signals from control centre		√	√
			Introducing signal coordination system		√	√
			Traffic management for Very Important Persons (VIP) movement		√	
			Video based adaptive control of traffic signals		√	√
			Dynamically controlling one-way driving			√
			Introducing reversible lane control			√
	1.4	Optimum Route Guidance	Guiding optimum route based on traffic management		√	√
			Providing information on travel time to destination	√	√	√
			Providing information on optimum route		√	√
	1.5	Parking Management	Automatic parking operation such as automatic gate operation, number plate recognition, billing, and		√	

No.	User Service Bundle of World ITS Architecture		Example of ITS	Priority		
				1	2	3
			receipt			
			Providing information on real-time parking availability		√	
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, 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)		√	
			Providing information to vehicles of an emergency vehicle approaching		√	
	3.2	Emergency Optimum Route Guidance	Providing minimum time route for emergency vehicle to reach the incident scene and if required from the incident scene to a suitable hospital		√	
	3.3	Emergency Signal Control	Controlling traffic signals for priority to the emergency vehicle		√	
4	**Transport-Related Electronic Payment**					
	4.1	Transport-Related Electronic Financial	Electronic transit fare payment			√
			Electronic toll collection			√

No.	User Service Bundle of World ITS Architecture		Example of ITS	Priority		
				1	2	3
		Transactions	Electronic parking payment			√
			Electronic service payment			√
	4.2	Integration of Transport-Related Electronic Payment Services	Common mobility card, clearing house		√	√
5	**Road Transport-Related Personal Safety (ISO)**					
	5.1	Driving Support	Providing information on accident occurred in the vicinity			√
			Providing information on travel time to destination			√
			Providing information on optimal route			√
	5.2	Signal Dedicated for Pedestrian	Pelican crossing		√	
			Dedicated signal time for safe pedestrian movement		√	
6	**Weather and Environmental Conditions Monitoring(ISO)**					
	6.1	Collection of Weather Information	Collecting road weather information by using the roadside weather sensor	√	√	
			Collecting weather information from the metrological agency	√	√	
	6.2	Collection of Air Pollution Information	Collecting road pollution by using the roadside pollution sensor	√	√	
			Collecting the pollution observation record from the pollution related agency	√	√	
7	**Disaster Response Management and Coordination (ISO)**					
	7.1	Disaster Alert and Response	Collecting information related to all emergency and disaster response services from the agencies such as police, fire, EMRI, GHMC, and hospitals		√	
			Providing emergency & disaster information via provision tool	√	√	
	7.2	Disaster Operation Assistance	Traffic management when disaster and/ or adverse weather		√	√
			Assisting driver to stop in an emergency		√	√
			Assisting vehicles for the purpose of restoration and rescue works when disaster occurred		√	√
			Providing to notify the need of emergency		√	√
			Providing to accurate location of vehicle /site		√	√
8	**ITS Data Management**					
	8.1	Collection, Store and Aggregation	Collecting, storing and aggregating of information from all the roadside equipments	√	√	√

No.	User Service Bundle of World ITS Architecture		Example of ITS	Priority		
				1	2	3
		of Data	Collecting, storing and aggregating of information from the related agencies such as traffic police, GHMC, APSRTC, ORR TCC, APPCB, tourism , HMWS&SB, CPDCL, etc.	√	√	√
	8.2	Traffic Data Analysis	Assisting of traffic management in planning for wide and /or specific area	√	√	√
			Assisting of decision making and provision of information of traffic restrictions	√	√	√
			Assisting of traffic survey	√	√	√
			Analysing and evaluating of traffic restriction plans	√	√	√
			Collecting and providing of statistical data for traffic demand control	√	√	√
	8.3	Traffic Accident Analysis	Collecting information from the related agencies such as police, GHMC, and ORR TCC	√	√	√
			Storing disaster information to database and aggregate stored data periodically	√	√	√
	8.4	Emergency and Disaster Information Analysis	Collecting information from the related agencies such as police, GHMC, and ORR TCC	√	√	√
			Storing disaster information to database and aggregate stored data periodically	√	√	√
9	**Maintenance and Construction Management**					
	9.1	Road Management	Assisting road maintenance inspection such as Pavement, FOB, Flyover, etc.		√	
			Assisting operation and maintenance of traffic control facilities		√	
			Online monitoring of road condition		√	
10	**Law Enforcement**					
	10.1	Assistance of Police Activities	Assisting police activities (provide and support security of society used by ITS monitoring system)		√	
	10.2	Automated Speed Enforcement	Monitoring over speed	√	√	√
	10.3	Automated Signal Jumping Enforcement	Monitoring violation of traffic signals	√	√	√
	10.4	Automated Wrong way Driving Enforcement	Monitoring wrong way driving vehicles			√
	10.5	Automated Illegal Parking Enforcement	Monitoring illegal parking vehicles and other violated vehicles			√

No.	User Service Bundle of World ITS Architecture		Example of ITS	Priority		
				1	2	3
	10.6	Automated Overloaded Vehicle Enforcement	Monitoring overloaded vehicle operation			√
	10.7	Automated Over-height Vehicle Enforcement	Monitoring over-height vehicle operation			√

Overall description of each user service along with technologies, benefits to stakeholders and flow diagrams are as follows:

2 Overall Description of User Services

2-1 Traffic Management and Operations

2-1-1 Data Collection

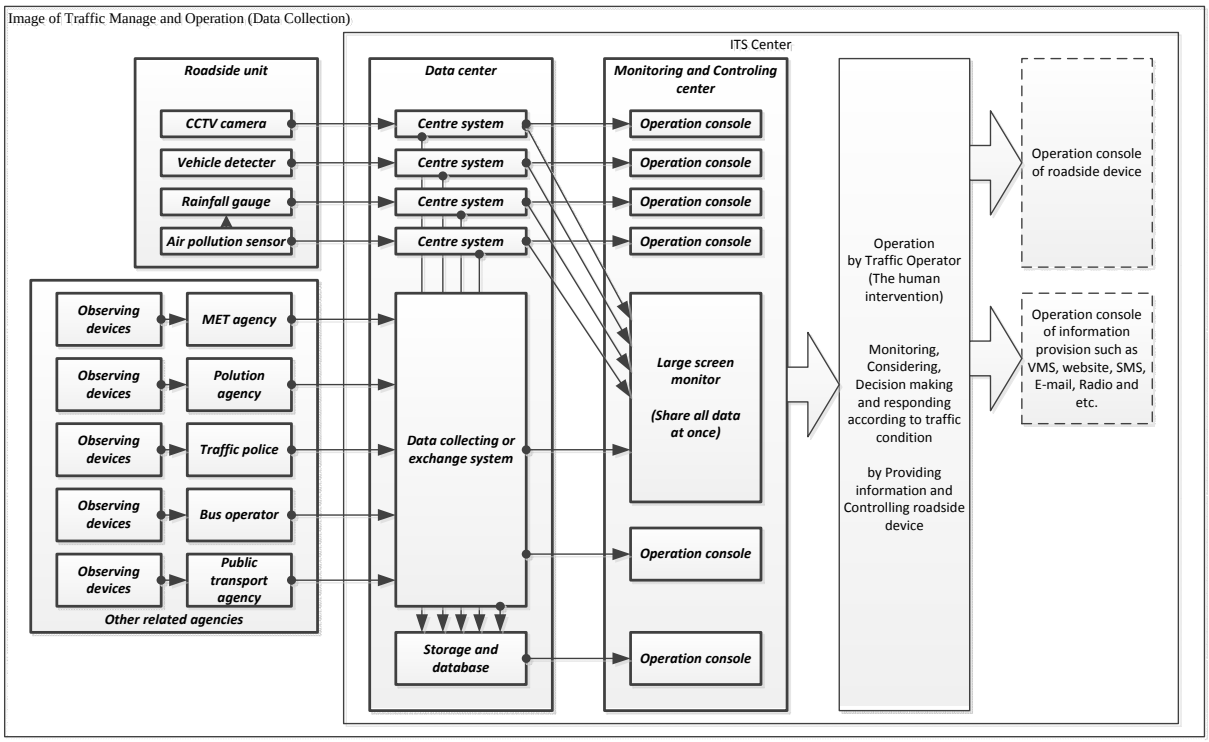
(1) Description

Road and traffic data are collected 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 roadside 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.

(2) 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, etc.

(3) Flow of Data



(4) Benefits to Users and/or Stakeholders

Road users benefited by receiving road traffic information such as congestion, time to destination, road work, road closure, weather on road, etc. They also benefited by proper traffic control and appropriate utilisation of the collected data. The road and traffic related agencies such as traffic police, GHMC, R&B and HMDA 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.

2-1-2 Information Provision

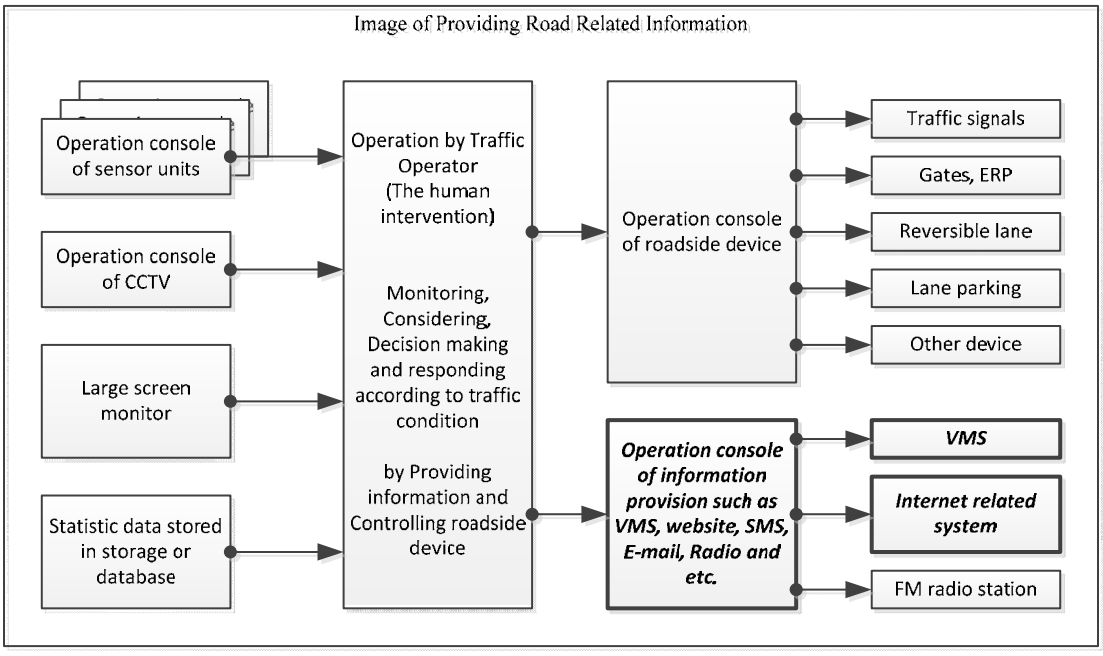
(1) Description

The collected data from the roadside 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.

(2) 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, etc.

(3) Flow of Data



(4) Benefits to Users and/or Stakeholders

Road users benefited by the road traffic information such as congestion, time to destination, road work, road closure, weather on road, etc by various media such as VMS, Website, SMS and FM radio. The congestion will be alleviated by properly guiding the traffic and providing traffic information.

2-1-3 Traffic Control

(1) Description

Control and regulation of the traffic flow on the road is necessary to alleviate the congestion, and major types include traffic signals and reversible lanes. For example, the optimum signal phase can be dynamically adjusted according to the traffic volume. The position of the median on the carriageway can be changed depending on the traffic volume by direction during morning and evening peak hours.

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

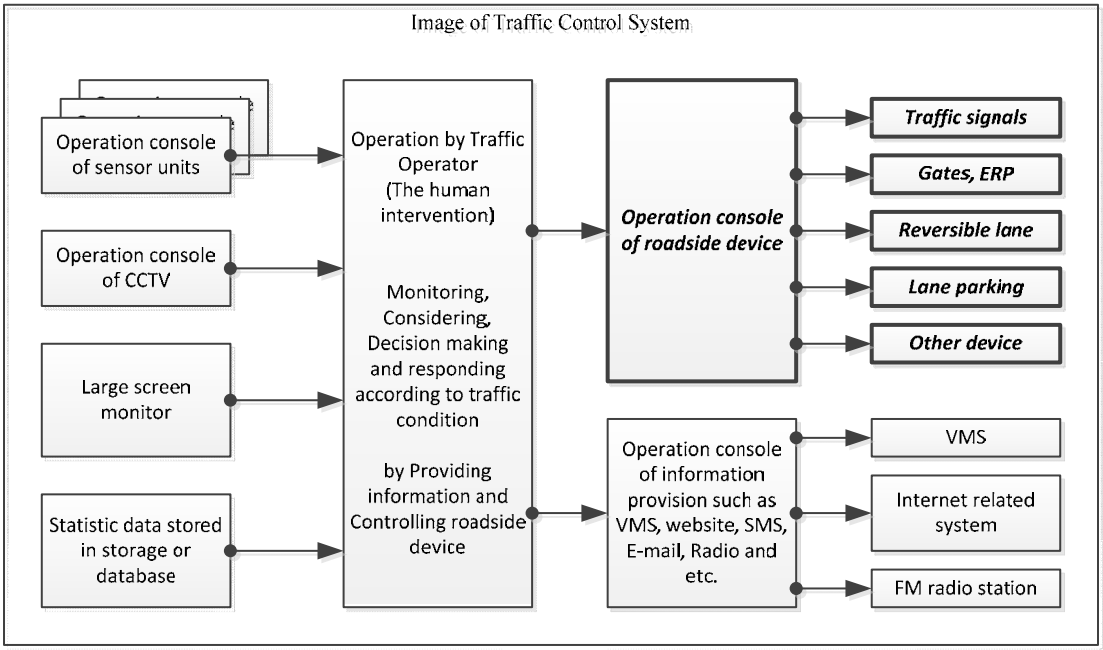
(2) Technologies

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

(3) Benefits to Users and/or Stakeholders

Road users benefit by the alleviated traffic congestion so they can arrive at their destinations faster, save vehicle fuel, etc. The reduced congestion and improved fuel consumption result in improvement of environment and this benefits society.

(4) Flow of Data



2-1-4 Optimum Route Guidance

(1) Description

Optimum Route Guidance dynamically provides the travelers with the most relevant routes to the destination. It calculates the best routes taking into consideration things like current congestion level on road network, major traffic events such as road work, road closure, weather, 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, etc. is increasingly available nowadays.

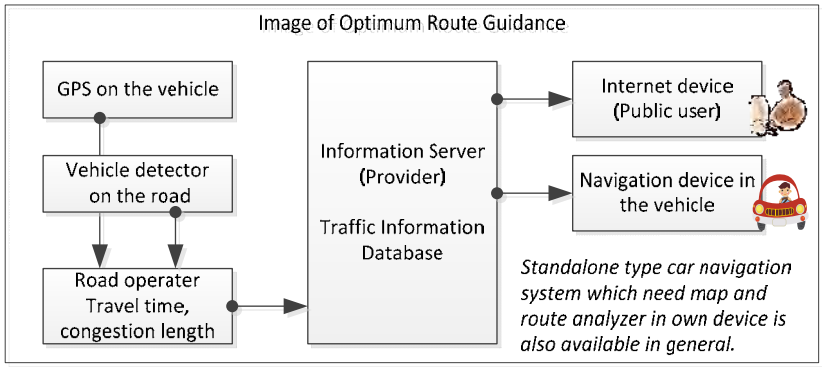
(2) Technologies

The technologies applied to 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, etc.

(3) Benefits to Users and/or Stakeholders

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 benefit by increased business opportunities for their value-added services when road traffic information such as road closure, road work that the public sector holds is shared.

(4) Flow of Data



2-1-5 Parking Management

(1) Description

Parking Management monitors and provides the information on parking availability to users. Parking availability information is generally provided in the vicinity of the parking lot by information board. The information together with the parking location on the Internet is recently increasingly available. Parking usage records are 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.

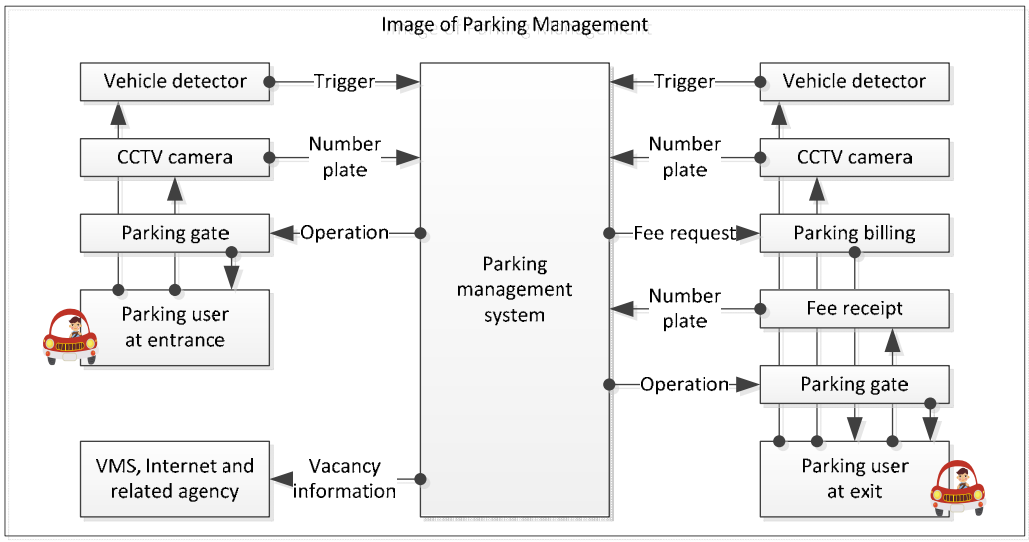
(2) Technologies

The technologies applied to 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, etc.

(3) Benefits to Users and/or Stakeholders

Users benefited from real-time information on the availability of parking which enables them to choose available parking, and reduce time for entry and exit realised by automated parking operation.

(4) Flow of Data



2-2 Public Transport

2-2-1 Bus Operation

(1) Description

Bus Operation collects real-time bus location and related information for the purpose of bus operations management. The collected data includes bus number, bus type, location (latitude and longitude), travel speed, 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 users by means such as information boards at bus shelters, internet, 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 on specific routes, introduction of new bus routes and evaluation of bus operation measures.

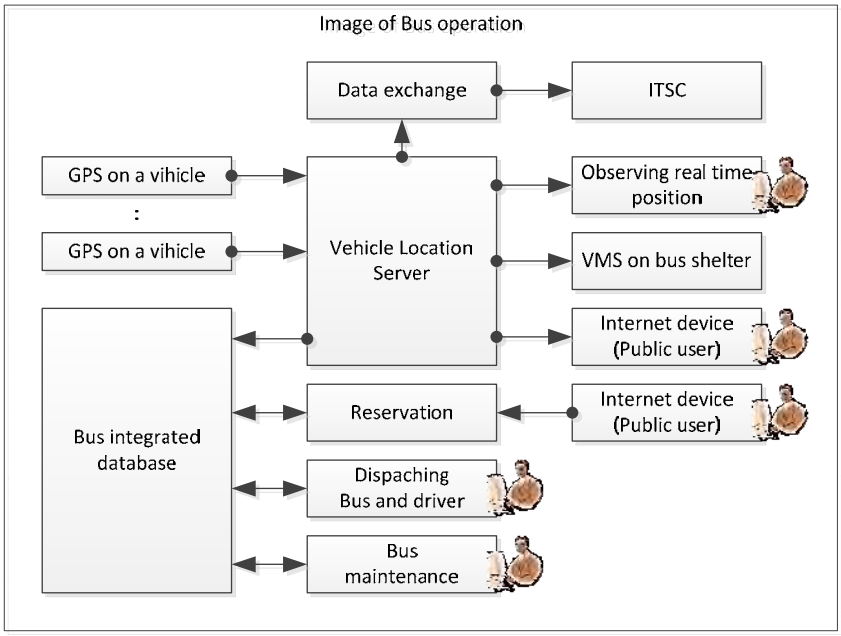
(2) Technologies

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 central software, information boards at the bus shelters, internet, etc.

(3) Benefits to Users and/or Stakeholders

Users benefited by receiving 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, etc. This enables users to plan their travel efficiently. Efficient bus operation is realised by facilitating the bus operation agency to perform appropriate planning. The bus agency benefits 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 bus operation measures.

(4) Flow of Data



2-2-2 Taxi Operation

(1) Description

Taxi Operation collects real-time taxi location information for the purpose of taxi operations management. The collected data includes the taxi number, location (latitude and longitude), 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 means such as schematic interface on large display board, etc. The schematic map based interface enables the call centre operator to identify the taxi location and respond to user taxi booking. The data is stored in the centre and utilised by the taxi operator for planning and evaluation of taxi operation measures.

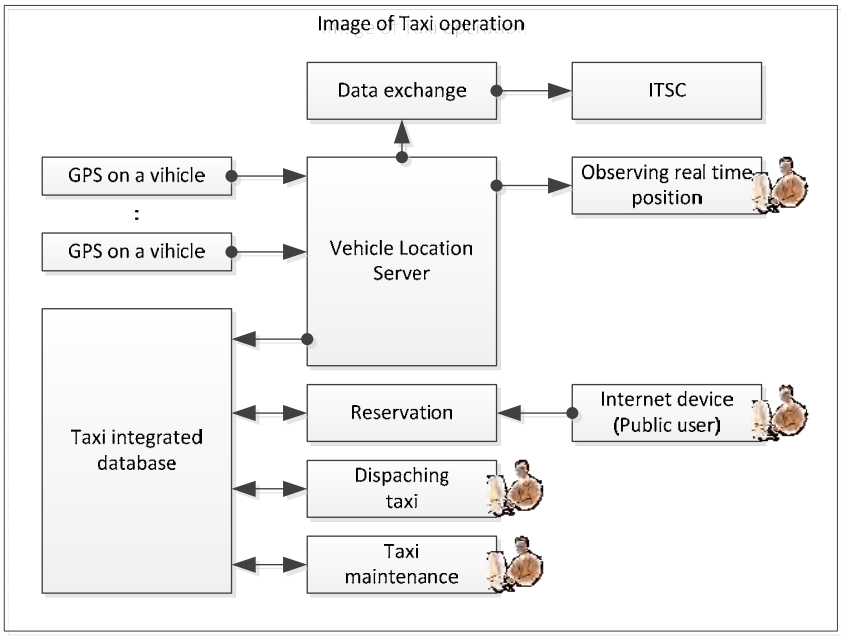
(2) Technologies

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, etc.

(3) Benefits to Users and/or Stakeholders

Taxi passengers are benefited in the area of booking, etc. Proper taxi operation is realised by the taxi operation agency by appropriate planning. The taxi agency benefits by utilising the data for planning and evaluation of taxi operation measures.

(4) Flow of Data



2-3 Emergency

2-3-1 Emergency Alert and Response

(1) Description

The ITS user service, “Emergency Alert and Response”, is a broad concept for the handling of emergency response supported by several different kinds of ITS technologies. Emergency related information includes flood, heavy rainfall, severe traffic event which are generally collected by roadside equipment or reported by a person’s emergency call. An alert is sent to the related agencies if required. Hazardous alert information is also provided to the users by media such as VMS, SMS, Internet, etc.

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

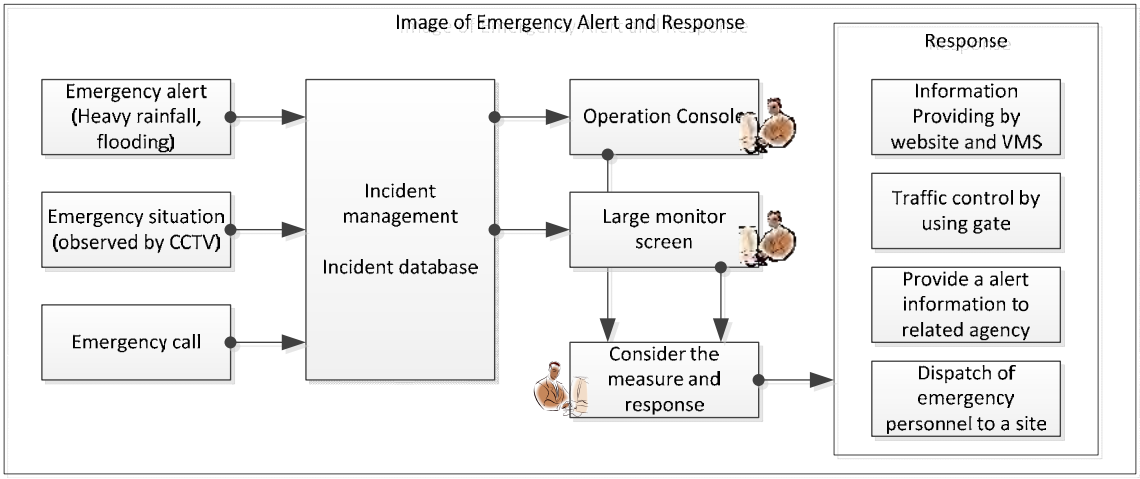
(2) Technologies

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

(3) Benefits to Users and/or Stakeholders

The people in an emergency such as injured persons benefited by swift response to the emergency. Related agencies such as fire department, hospital, and police benefit by improved efficiency in their emergency operations supported by the technologies.

(4) Flow of Data



2-3-2 Emergency Optimum Route Guidance

(1) Description

The location of emergency vehicles such as ambulance and fire truck is monitored by the centre. The location of the emergency 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 related agencies such as road and traffic administrators.

Based on such information, the centre provides guidance on the optimum route to the emergency vehicles.

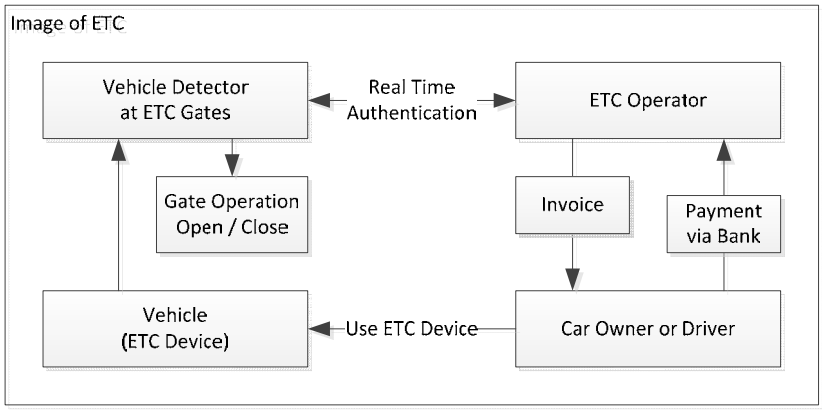
(2) Technologies

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

(3) Benefits to Users and/or Stakeholders

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

(4) Flow of Data



2-3-3 Emergency Signal Control

(1) Description

Signals can be prioritised for emergency vehicles such as ambulance and fire truck to enable them to arrive quickly at the emergency location. The signal phases are controlled either automatically by system or manually.

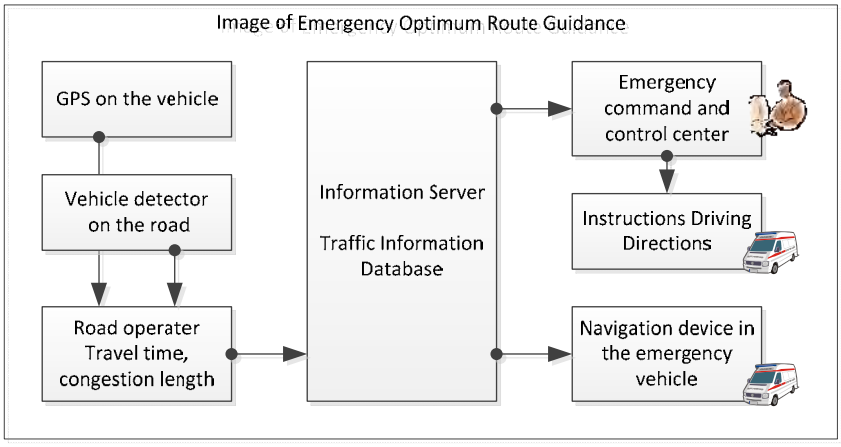
(2) Technologies

The technologies applied to emergency signal control include roadside sensors such as vehicle detector and CCTV, signal terminal, signal controller, centre systems, etc.

(3) Benefits to Users and/or Stakeholders

The people having the emergency such as injured person benefit 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 location.

(4) Flow of Data



2-4 Transport-Related Electronic Payment

2-4-1 Transport-Related Electronic Financial Transactions, and Integration of Transport-Related Electronic Payment Services

These topics are discussed together below.

(1) Description

Transport-Related Electronic Payment enables the road user to complete all the transport related payments electronically. Such electronic payments include transit fare, toll collection, parking payment, etc. The electronic payment of transit fare, parking fare, toll fare, etc. enables the road user to pay using such mode as common mobility card, ETC system, etc. In case of common mobility card, the road user is allowed to use a pre-paid electronic card. It is called pre-paid electronic card because payment at a bank ATM, internet, etc must be made before it can be used. The common mobility card enables users to swipe the card at a terminal to pay railway, bus and taxi fares. In case of ETC system, the road user inserts the electronic card into an on-board device in the vehicle, and a radio antenna installed on the road section reads the information in the card and deducts the fare electronically.

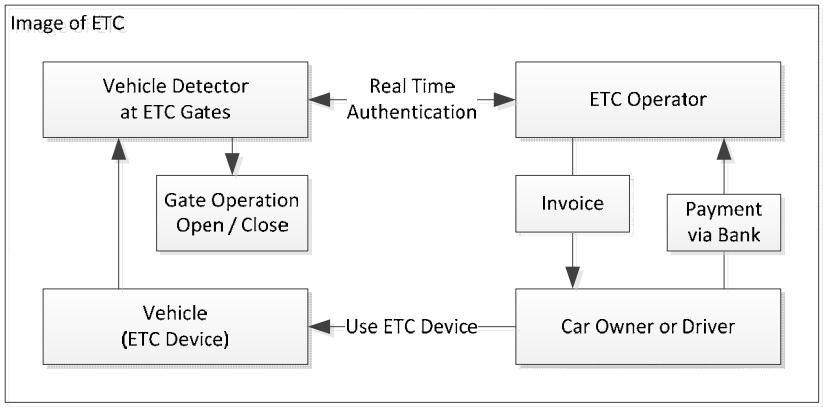
(2) Technologies

The technologies applied to transport related electronic payment system include electronic card with a chip, roadside sensor, roadside antenna, OBU, electronic card swipe terminal, wire/wireless communication via fibre optic cable/2G/3G/LTE, database management, clearing house, central software and hardware, etc.

(3) Benefits to Users and/or Stakeholders

Road users are benefited by the convenience of electronic payment that reduces the waiting time at the fare collection centres. This enables road users to travel more comfortably because of reduction of vehicle congestion at the toll collection centres. The fare collection operation agency benefited by the reduction in the cost of operation and fraud, etc because of minimised manual collection. Such electronic payment measures enable improvement in economic and environmental benefits for society in general.

(4) Flow of Data



2-5 Road Transport-Related Personal Safety

2-5-1 Driving Support System

(1) Description

ITS services for driving support are largely realised by private sector services. A typical example is anti-collision braking system detecting abnormally short distance to the vehicle running ahead. Such technology is generally developed by automobile manufacturers.

In fact, driving support by ITS is promoted by both public and private sectors. 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 accidents occurring in the vicinity, congestion is alerted and real-time road condition image is provided by a high-end car navigation terminal. Such warning information is alerted to the driver at such locations prior to curves to avoid any collision. The warning is alerted only when the actual congestion or accident occurs beyond a curve ahead. The required infrastructure such as roadside sensors, wireless communication bandwidth for large data transmission, 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 standards jointly prepared by public and private sectors to realise such ITS services. This is called “Smart way” in Japan. Such system also provide highly accurate optimum route guidance covering wide area road network.

(2) Technologies

The technologies applied to 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, etc.

(3) Benefits to Users and/or Stakeholders

The drivers are benefited by increased safety, timely alerts on specific locations and incidents. They also benefited by being enabled to access highly accurate route guidance information. Private companies such as navigation manufacturers and application developers benefit by the increased business opportunities generated by public-private joint promotion of ITS services.

2-5-2 Signals Dedicated for Pedestrians

(1) Description

Signals Dedicated for Pedestrians assists crossing intersections with a pedestrian traffic signal called pelican crossing that displays time for crossing safely.

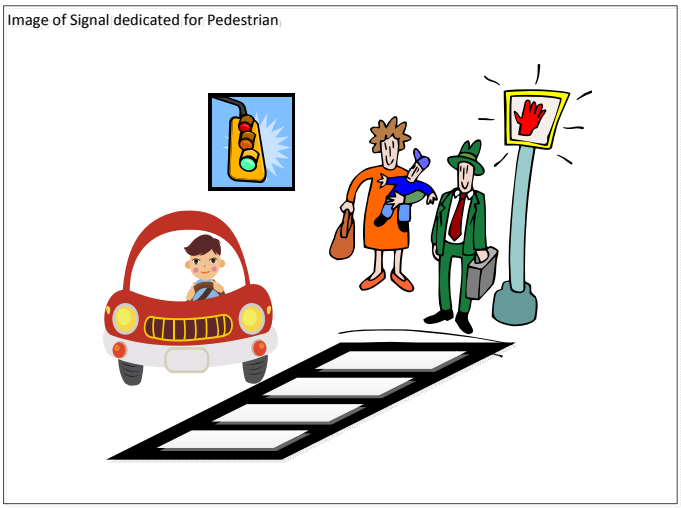
(2) Technologies

The technologies applied to signals dedicated for pedestrians include pedestrian traffic signal, CCTV, wire/wireless communication via optic fibre/2G/3G/LTE, etc.

(3) Benefits to Users and/or Stakeholders

Pedestrians are benefited by having a dedicated signal to cross road intersections safely and the vehicle drivers are alerted to stop at the intersection until the dedicated time for pedestrian signal is completed.

(4) Flow of Data



2-6 Weather and Environmental Conditions Monitoring

2-6-1 Collection of Weather Information

(1) Description

Weather and Environmental Conditions Monitoring collects real-time weather data on roadways. Such data includes rainfall, temperature, wind velocity, wind direction, etc. The collected data is processed at the centre and stored in a database. The weather information is provided to road users by means such as VMS, internet, FM Radio, etc and to the related stakeholders such as traffic operator, road operator (such as GHMC and R&B).

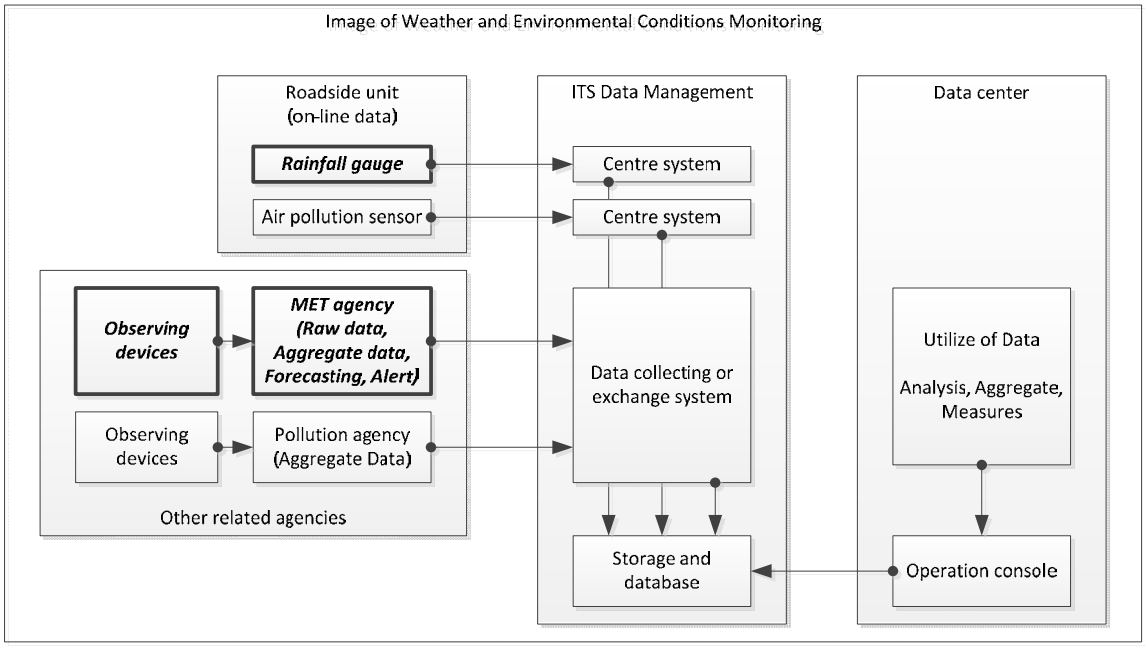
(2) Technologies

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, etc.

(3) Benefits to Users and/or Stakeholders

Road users are benefited by the weather information to efficiently plan their trip and avoid rain and flood prone roadways. Traffic and road operating agencies benefit by the weather data to enable them to effectively plan the traffic regulation, road maintenance, road closure and other related activities.

(4) Flow of Data



2-6-2 Collection of Air Pollution Information

(1) Description

Collection of Air Pollution Information is made on the roadways. Such data includes NOx, SOx, SPM and noise level. The pollution data is collected from pollution sensors installed on roadside and at related environmental agencies. The collected data is processed and stored in the database in the centre.

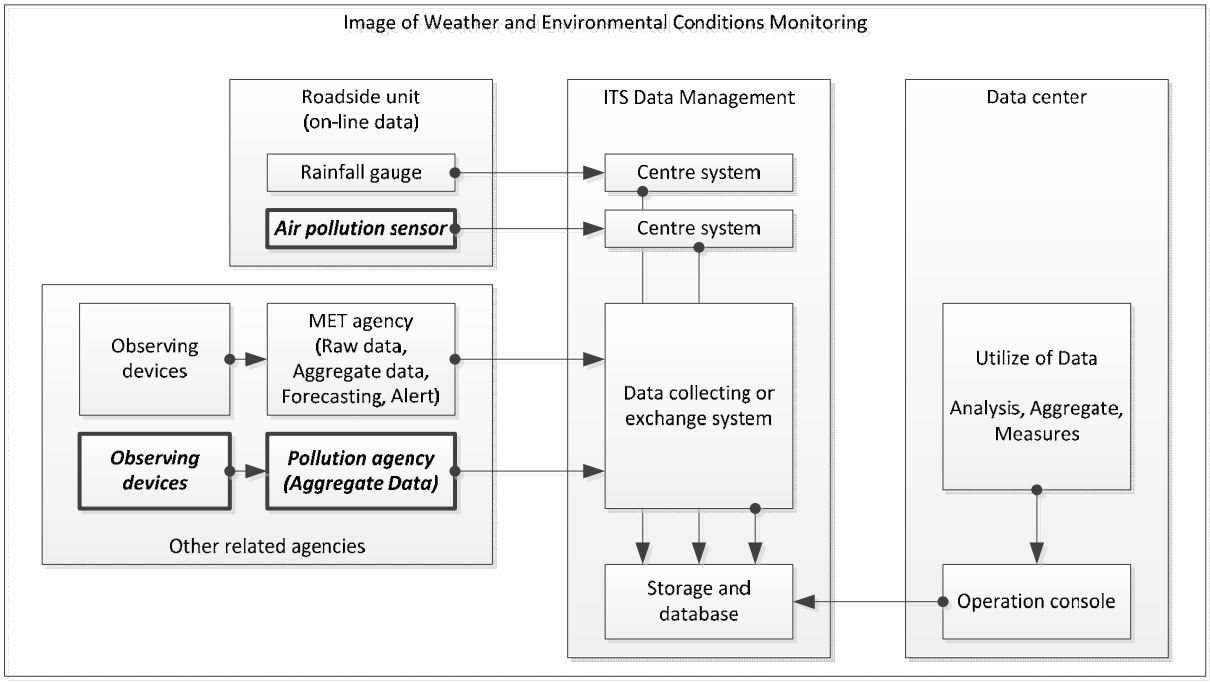
(2) Technologies

The technologies applied to the collection of pollution information include pollution sensors, wire/wireless communication via fibre optic network/2G/3G/LTE, database, etc.

(3) Benefits to Users and/or Stakeholders

The aggregated and analysed pollution data is useful for the environmental agencies of the state/central government to take necessary measures to improve pollution levels in the city. The improved environment will bring benefit to society.

(4) Flow of Data



2-7 Disaster Response Management and Coordination

2-7-1 Disaster Alert and Response, and Disaster Operation Assistance

These topics are discussed together below.

(1) Description

'Disaster Alert and Response' and 'Disaster Operation Assistance' are broad concepts of handling disasters, supported by several different kinds of ITS technologies.

Situations requiring disaster alert to the public via Internet, SMS, TV/Radio broadcast cover occasions such as massive earthquake, tsunami, strong hurricane, volcano explosion, terrorist attack, military invasion by enemy, and so on.

In the more specific sense of road traffic and ITS, it means providing a disaster alert to 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, etc.

(2) Technologies

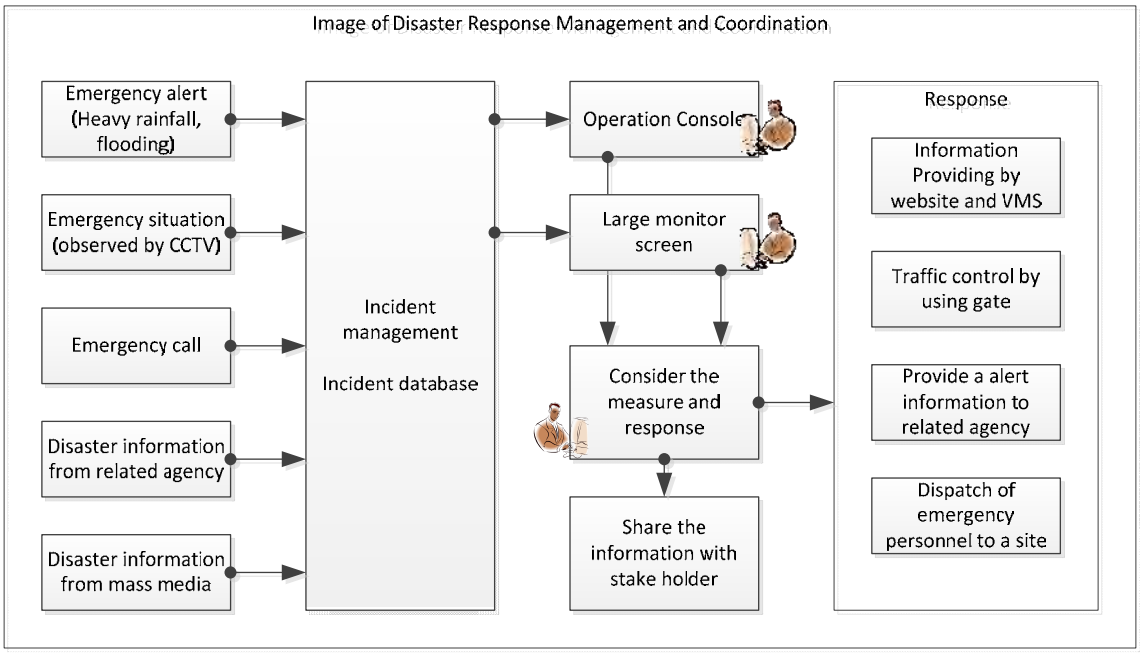
The technologies applied to disaster response management and coordination include Internet, SMS, TV/Radio broadcast, VMS, car navigation, traffic signals, CCTV, emergency call box, hot-line, rescue/army dispatching system, flood/rainfall sensors, seismic sensors, meteorological satellite, tsunami gauge, bomb detection, etc.

(3) Benefits to Users and/or Stakeholders

Road users are benefited by the disaster alert information that to avoid to the site of a disaster. People in the area of disaster are provided with quick rescue to save their lives by proper control of traffic in a disaster. Proper traffic control is realised by utilising disaster information coordinated amongst related agencies.

(4) Flow of Data

Disaster management and coordination involves a broad range of technologies and different aspects of operation. The figure below shows one example.



2-8 ITS Data Management

2-8-1 Collection, Store and Aggregation of Data

(1) Description

There are two different methods for data collection: online and offline data collection. In the case of the online data collection, the data is collected by a system for data such as real-time traffic condition, probe, weather, flood, etc.

In the case of the offline data collection, the information is generally reported and exchanged by people for information such as accident, disaster, VIP movement, major event, etc.

The online data is stored in the database in the centre. The offline information is generally input onto the system by an operator in the centre and stored. The stored data/information is aggregated and utilised to define necessary measures, for example, traffic control, road management, infrastructure improvement, etc.

(2) Technologies

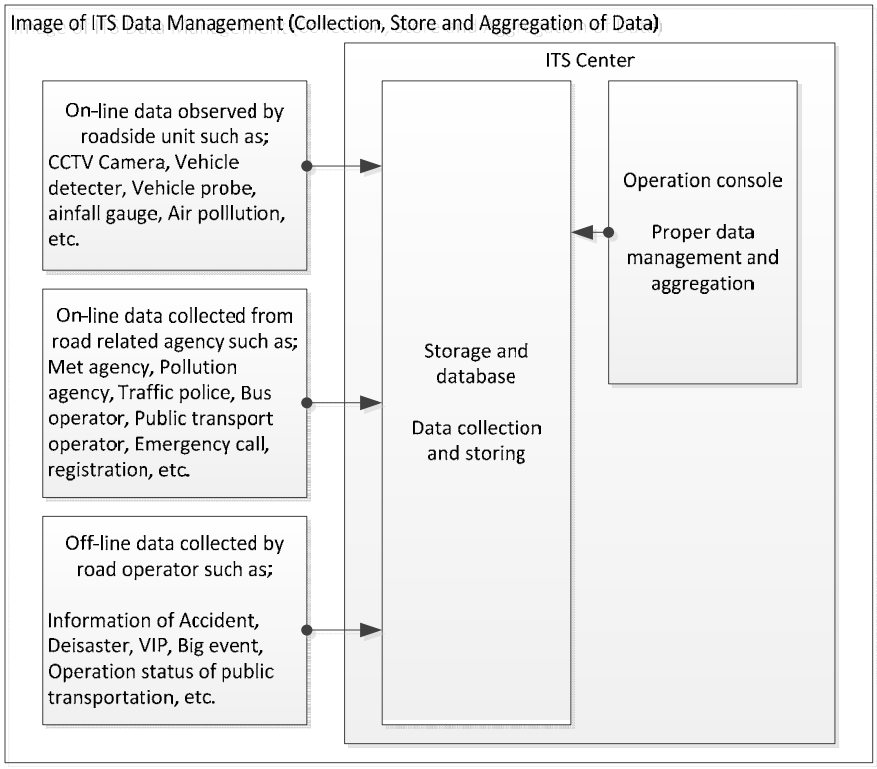
The technologies applied to collection, storage and aggregate of data include vehicle detector, rainfall gauge, flood sensors, pollution sensors, CCTV, probe system including GPS, wire/wireless communication such as fibre optic network, 2G/3G/LTE, database, etc.

(3) Benefits to Users and/or Stakeholders

Related agencies are enabled to carry out proper measures based on the quantitative aggregation of collected data and information. Related agencies include traffic police, road operators, planning department, etc. The proper measures include traffic control, road management, urban development, etc.

As a consequence, general citizens benefit from having proper measures.

(4) Flow of Data



2-8-2 Traffic Data Analysis

(1) Description

Collected traffic data is processed and analysed at the centre. The results of analysis are usually utilised to identify road and traffic measures.

A typical example is 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 in a year.

Another example is utilisation of traffic counter. For example, it clarifies significant large volume of heavy vehicle at certain sections of highway.

Such results assist proper decisions on necessary measures. For example, it can be judged that bypass construction, as a hard measure may be required to alleviate congestion in identified areas, or that restricting incoming traffic of heavy vehicle by imposing higher congestion fee to protect the pavement on the certain sections of highway, as a soft measure may be effective.

(2) Technologies

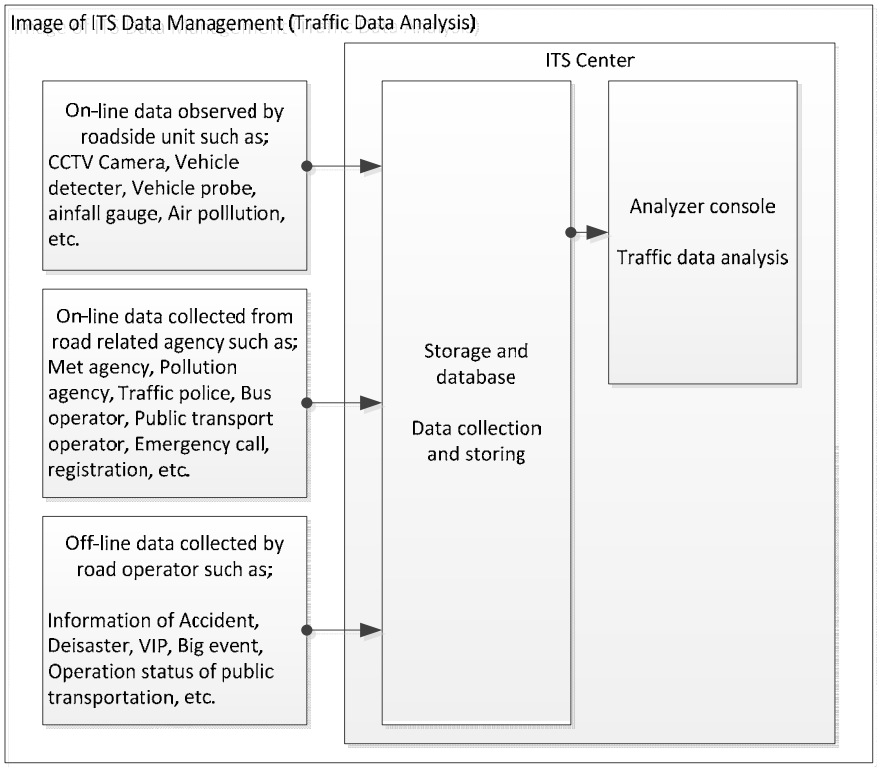
The technologies applied to traffic data analysis include vehicle detector, rainfall gauge, flood sensors, pollution sensors, CCTV, probe system including GPS, wire/wireless communication such as fibre optic network, 2G/3G/LTE, database, etc.

(3) Benefits to Users and/or Stakeholders

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, etc. The proper measures include transport administration, road management, urban development, etc.

As a consequence, general citizens benefit from having proper measures.

(4) Flow of Data



2-8-3 Traffic Accident Analysis

(1) Description

Accident is generally reported by people such as drivers in the accident, traffic police at site, etc. by media such as phone, emergency call box on highway, walky-talky, etc. Accident is also monitored by surveillance system such as CCTV at accident-prone section.

The information reported by people and monitored data on accident are input onto system and stored such stored data is analysed and utilised for necessary measures to improve traffic accident.

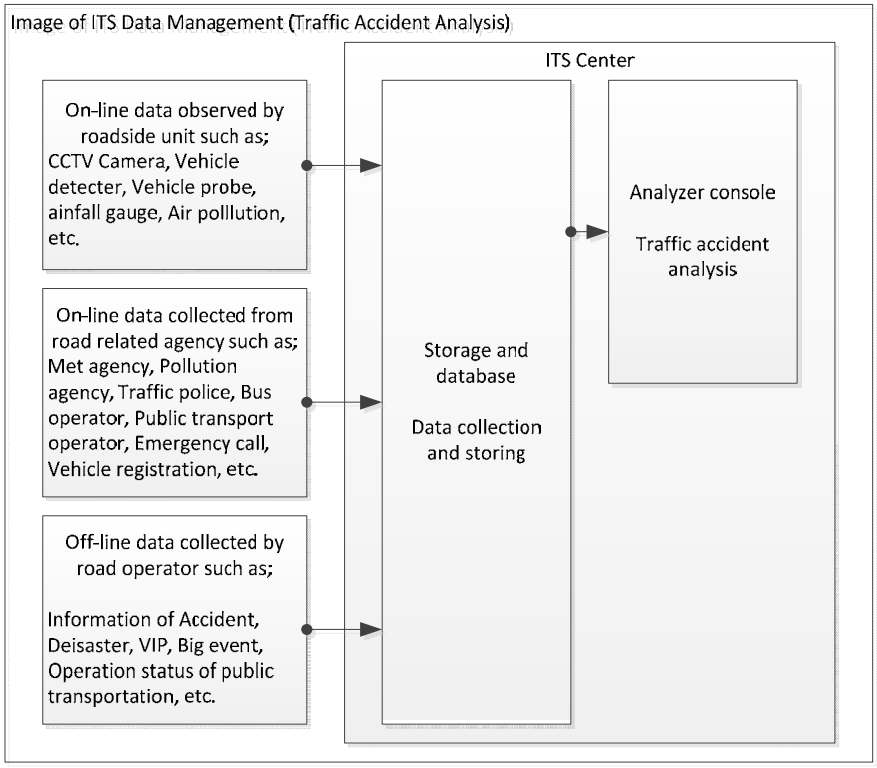
(2) Technologies

The technologies applied to traffic accident analysis include electronic data from traffic operator, roadside sensors, wire/wireless communication via fibre optic network/2G/3G/LTE, database management, data analytics, data warehouse, etc.

(3) Benefits to Users and/or Stakeholders

The benefits gained by the agencies such as traffic police, road operator, road planning agency, etc. include the enforcement of restrictions on vehicle speed, provision of accident prone area information to road users, proper planning of road and infrastructure development, etc.

(4) Flow of Data



2-8-4 Emergency and Disaster Information Analysis

(1) Description

The emergency and disaster data which is collected and stored at the ITS centre is analysed and provided to related agencies such as traffic police, road operator, etc. The provided information is used by the agencies to improve their coordination ability amongst the agencies in the event of emergency situations. The disaster data is collected and emergency situation is evaluated to identify better response strategies to emergency situations.

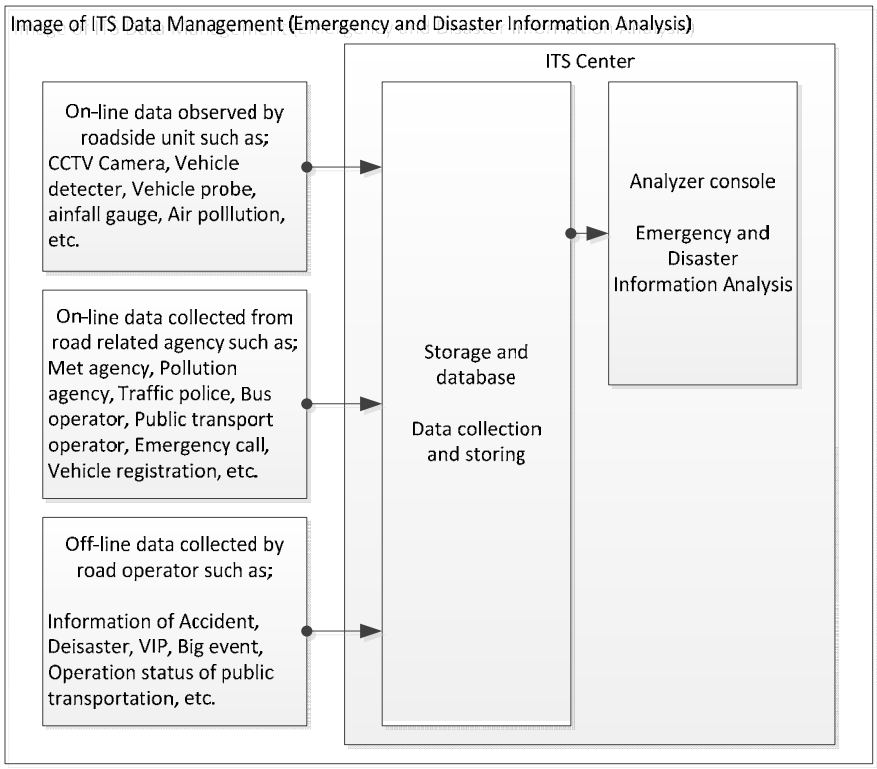
(2) Technologies

The technologies applied to emergency and disaster information analysis system include roadside sensors, CCTV, wire/wireless communication via fibre optic network/2G/3G/LTE, database management, data analytics, data warehouse, etc.

(3) Benefits to Users and/or Stakeholders

The agencies such as traffic police, road operator and road planning agency benefit by the emergency and disaster analysis information that enables them to develop and implement proactive emergency management strategies. Road users are benefited from having improved strategies for more efficient and safer evacuation.

(4) Flow of Data



2-9 Maintenance and Construction Management

2-9-1 Road Management

(1) Description

Road Management enables the road operator to monitor and sustainably maintain road and related infrastructure. Road and related infrastructure data is collected from roadside devices and related agencies and stored in the database at ITS centre. Such data includes the flyovers, bridges, foot over bridges 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, etc. Such agencies utilise the information to take appropriate measures to improve roadways and related infrastructure.

(2) 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, etc.

(3) Benefits to Users and/or Stakeholders

Road management and planning agencies are benefited by the road and related asset data collected and aggregated at the ITS centre because such data contributes to efficient management of roadways. Damaged road surface, for example, may cause accidents; thus proper maintenance is useful for optimum use of roadside facilities. Road users benefit from improved roadways to travel on.

2-9-2 Law Enforcement

ITS user services categorised in law enforcement are discussed together below.

(1) Assistance of Police Activities

Assistance of Police Activities enables police to better perform activities to ensure safety by protecting people. Police use various surveillance technologies such as monitoring traffic by CCTV and large display, called video wall in centre.

(2) Automated Speed Enforcement

Automated Speed Enforcement detects, alert and enforces laws on speeding. The speeding vehicle on roadway is detected by speed detectors installed on roadside. The speed is recorded by the detector, and the vehicle and number plate are captured by camera. The driver or vehicle owner is identified by the number plate. Penalty fee is calculated according to the speed. The penalty fee is issued to the driver or vehicle owner.

(3) Automated Signal Jumping Enforcement

Automated Signal Jumping Enforcement detects, alert and enforces laws on signal jumping. The vehicle jumping signal is detected by sensors installed at junction. The vehicle and number plate are captured by camera. The driver or vehicle owner is identified by the number plate. Penalty fee is issued to the driver or vehicle owner.

(4) Automated Wrong-Way Driving Enforcement

Automated Wrong-Way Driving Enforcement detects, alert and enforces laws on wrong-way driving. The vehicle running in the wrong-way is detected by sensors on roadside. The vehicle and number plate are captured by camera. The driver or vehicle owner is identified by the number plate. Penalty fee is issued to the driver or vehicle owner.

The wrong-way warning system is generally deployed at on-ramp of expressway. It alerts the driver by warning message on message board on roadside and siren to prevent the vehicle from entering on the wrong direction into the expressway for safety.

(5) Automated Illegal Parking Enforcement

Automated Illegal Parking Enforcement detects, alerts the drivers on illegal parking. Generally CCTV images of major junctions, important sections on trunk road, congested areas near shopping malls and station, etc are monitored at traffic control centre.

The drivers intending to park illegally are warned by speakers. The system is generally composed of CCTV and speakers at these locations, TV monitors, microphone and operation consoles in the control centre.

Automated detection of illegal parking vehicle utilising image processing and sensors is also increasingly available nowadays.

(6) Automated Overloaded Vehicle Enforcement

Automated Overloaded Vehicle Enforcement detects, alerts and enforces laws on overloading vehicle. The vehicle weight is measured by weigh measurement sensors installed on roadways. If the weight exceeds the permitted load, it gives warning. Generally, the weight measurement is deployed at on-ramp of expressway or trunk road to prevent the overloaded large-size vehicles from entering. When the overload is detected, measures such as un-loading cargo, restricting entering, instructing to exit at the next off-ramp, etc are taken. The weight is generally measured by either axle load or whole vehicle weight. There are generally two types of measurement: the one which measures running vehicle or the other which measures stopped vehicle. The former is called ‘weigh-in-motion’.

(7) Automated Over-height Vehicle Enforcement

Automated Over-height Vehicle Enforcement detects, alerts and enforces laws on over-height. The vehicle height is measured by height measurement sensors installed on roadways. If the height exceeds the permitted height, it gives warning. Generally, the height measurement is deployed at on-ramp of expressway or trunk road to prevent the over-height large-size vehicles from entering. When the over-height is detected, measures such as restricting entering, instructing to stop, etc are taken.

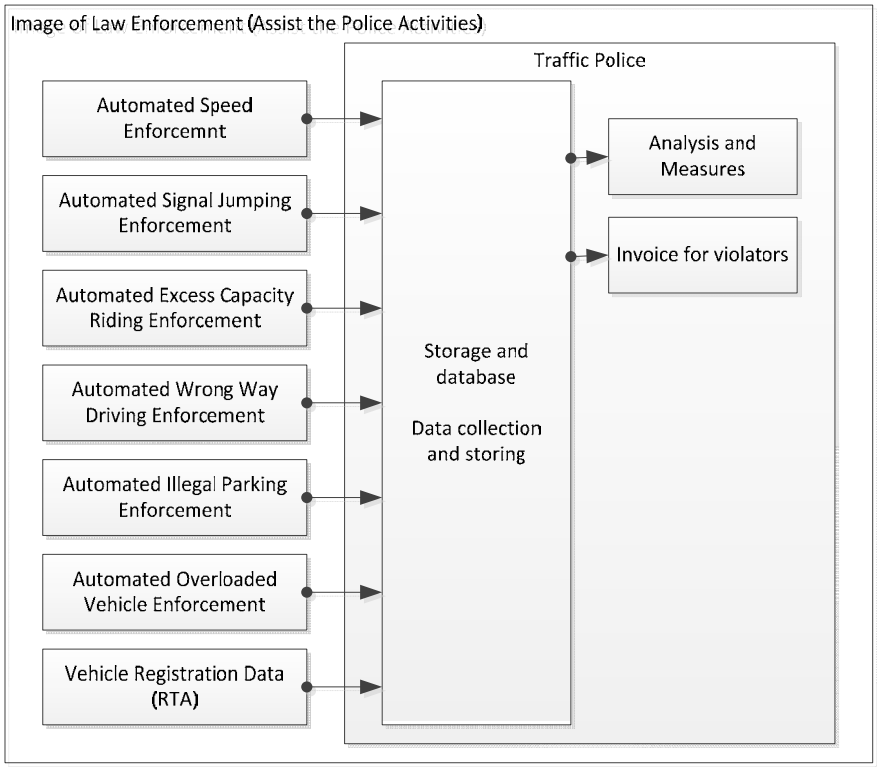
(a) Technologies

The technologies applied to the law enforcement system include the laser guns, roadside sensors, CCTV, traffic signal system, wire/wireless communication via fibre optic network/2G/3G/LTE, related central software systems, database management, etc.

(b) Benefits to Users and/or Stakeholders

The traffic operators such as traffic police benefit by the law enforcement system. It enhances the capabilities of these agency in implementing the traffic laws and regulations by minimising inefficient manual operations in enforcement. The collected data is utilized for efficient police investigation. Road users benefit by the better traffic enforcement mechanism in general because it enables proper road manners and safe driving.

(c) Flow of Data



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