5 Organizational Setup and Implementation Plan

5-1 Interview Survey and Analysis of ITS Related Agencies

The JICA Study Team conducted interview surveys with the related agencies in view of introduction/implementation of ITS in Hyderabad. The purpose of the survey is:

- To clarify their roles, jurisdictions and how they are inter-related,
- To clarify current systems and plans,
- To identify issues from the organizational viewpoint, and
- To identify issues from the system viewpoint.

5-1-1 Organisations

Based on the current review, the organizations related to introduction / implementation of ITS in Hyderabad is identified as follows:

Table 72 Related Organizations

1.	**Road Planning Authority**
(1)	Hyderabad Metropolitan Development Authority (HMDA)
2.	**Road Operation and Managing Body**
(1)	Hyderabad Growth Corridor Limited (HGCL)
(2)	Greater Hyderabad Municipal Corporation (GHMC)
(3)	National Highway Authority of India (NHAI)
(4)	Road and Building Department (R&B Department)
3.	**Traffic Management Body**
(1)	Hyderabad Traffic Police
(2)	Cyberabad Traffic Police
4.	**Vehicle Registration Authority**
(1)	Regional Transport Authority (RTA)
5.	**Public Transportation Operator**
(1)	Hyderabad Metropolitan Railway Limited (HMRL)
(2)	South Central Railway(SCR)
(3)	Andhra Pradesh State Road Transport Corporation(APSRTC)
(4)	Taxi Companies (MERU Cab, Easy Cab, Sky Cab, etc.)
6.	**Emergency Response Agency**
(1)	Emergency Management and Research Institute (EMRI)
7.	**IT Related Agency**
(1)	Centre for Development of Advanced Computing (C-DAC)
(2)	National Informatics Centre (NIC)
(3)	National Institute of Technology (NIT)
(4)	Centre for Railway Information Systems (CRIS)
8.	**Environmental Monitoring Agency**
(1)	Andhra Pradesh Pollution Control Board (APPCB)
9.	**Meteorological Monitoring Agency**
(1)	India Meteorological Department (IMD)

5-1-2 Entire Picture of Organisations and Relations

The figure below shows the relations among the organizations related with transport sector and ITS implementation:

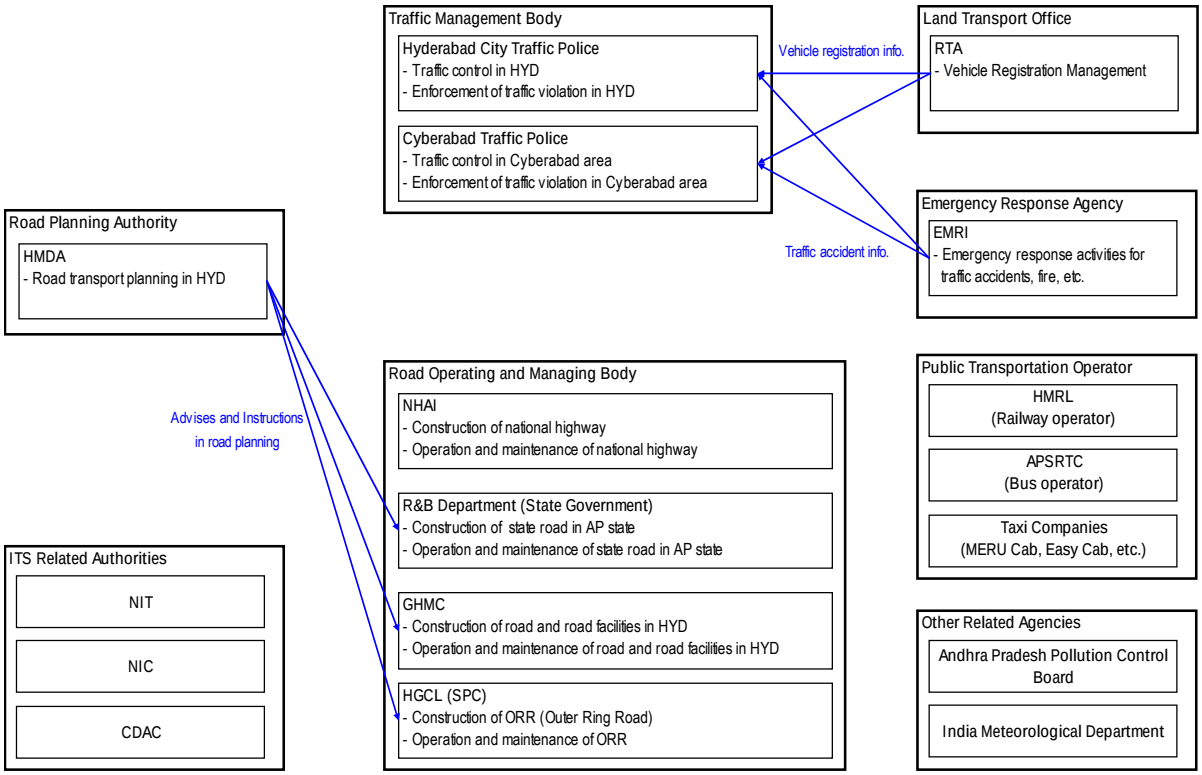


Figure 178 Relation among Related Organizations

5-1-3 Hyderabad Metropolitan Development Authority: HMDA

(1) Summary of Roles and Current Systems of ITS Related Organizations

The following tables summarize the roles and current systems.

Table 73 Hyderabad Metropolitan Development Authority (HMDA)

Roles	Current Systems
• Planning Body for Development of Hyderabad Metropolitan Region including: • Planning, • Co-ordination, • Supervision, • Promotion, • Development, • Coordination with Local Bodies • Maintenance and Management of Hyderabad Development Fund, • Development of Amenities and Infrastructure Facilities	• IT Systems: • File Monitoring System • Document Warehouse System • • ITS Related Studies • JICA SAPI for Introduction of ITS on Road Network in Hyderabad Metropolitan Area • Comprehensive Transport Study (CTS)

(2) Summary of Organizational / Operational Issues and System Issues

Based on the interview surveys, the issues are summarized in the organizational and system view points in the following tables:

Table 74 Hyderabad Metropolitan Development Authority (HMDA)

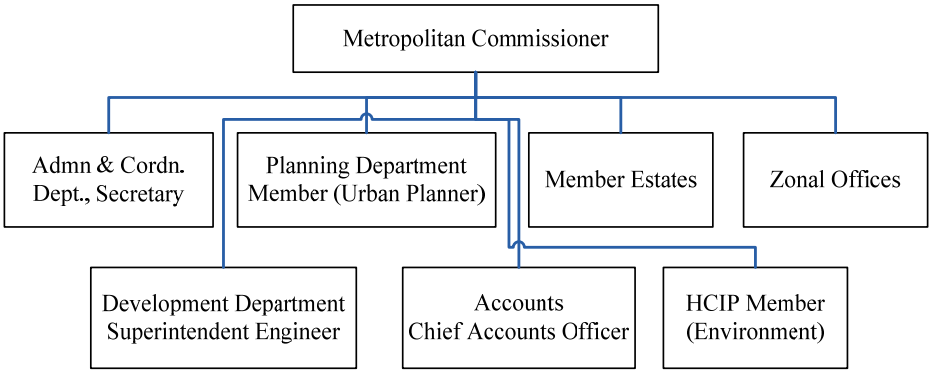
Organizational/Operational Issues	System Issues
• N/A	• Preparation of Traffic Survey Database System Required. • Introduction of Road and Infrastructure Inventory System for Planning Required.

(3) Organizational Structure and Responsibilities of HMDA

The Hyderabad Metropolitan Development Authority (HMDA) was formed in the year 2008, with an area of 7,100 sq km under its purview. HMDA was formed by the merging of the erstwhile entities - Hyderabad Urban Development Authority (HUDA), Hyderabad Airport Development Authority (HADA), Cyberabad Development Authority (CDA) and Buddha Poornima Project Authority (BPPA). HMDA was set up for the purpose of planning, co-ordination, supervising, promoting and securing the planned development of the Hyderabad Metropolitan Region. It coordinates the development activities of the municipal corporations, municipalities and other local authorities. HMDA is a planning body for urban infrastructure development including road transport infrastructure.

(4) Organization

The figure below shows the current organizational structure of HMDA.

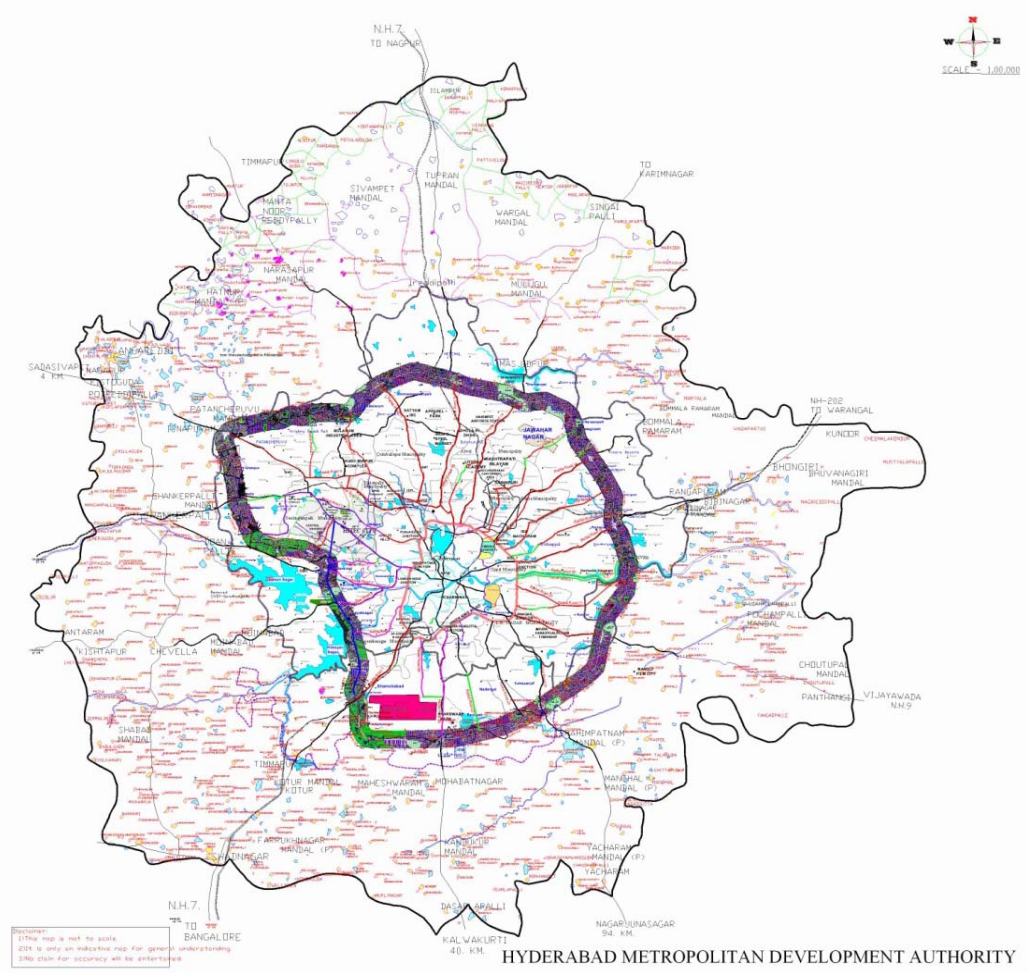


Source: Edited by JICA Study Team based on HMDA Website

Figure 179 Organizational Structure of HMDA (to be Updated)

(5) Jurisdiction of HMDA

The map below shows the jurisdictional area of Hyderabad Metropolitan Development Authority and Greater Hyderabad Municipal Corporation.



Source: HMDA Website

Figure 180 Jurisdiction Map of HMDA

GHMC was formed with the erstwhile Municipal Corporation of Hyderabad and by combining adjoining municipalities and panchayats. 10 municipalities & 8 panchayats in Ranga Reddy district and 2 municipalities in Medak district were combined with GHMC and this resulted in the increase of jurisdiction of Municipal Corporation of Hyderabad.

HMDA was formed by combining entire suburbs with the Greater Hyderabad Municipal Corporation. The jurisdiction of HMDA now consists of 54 Mandals located in five districts with a total area of nearly 7,100 square km. The HMDA is responsible for planning, co-ordinating, supervising, promoting and securing the planned development of Hyderabad Metropolitan Region. It coordinates the development activities of the municipal corporations, municipalities and other local authorities like the Hyderabad Metropolitan Water Supply, Sewerage Board, the Andhra Pradesh Transmission Corporation, the Andhra Pradesh Industrial Infrastructure Corporation, the Andhra Pradesh State Road Transport Corporation, and other such bodies. The HMDA also maintains and manages the Hyderabad Management Development Fund, allocating finances based on the plans and programs of local bodies to undertake development of amenities and infrastructure facilities.

(6) Current Issues on HMDA

With the exponential growth of Hyderabad Metropolitan Region, transportation issues have assumed critical importance. Traffic congestion and frequent traffic jams have become a common phenomenon in the core areas, and traffic gridlocks on major corridors. The phenomenal growth of cars and the decline in 2-wheelers have resulted in drastic changes in traffic as well as travel characteristics

(7) ITS Developed or Planned by HMDA

The Intelligent Transport System is proposed to be developed for the Outer Ring Road. Its key components are follows:

(a) Highway Traffic Management System (HTMS)

- Emergency Communication System
- Variable Message Signs (VMS)
- Meteorological Data System
- Automatic Traffic Counter-cum-classifier (ATCC)
- Traffic Control Centre (TCC)

(b) Toll Management System (TMS)

- Manual, Touch-and-go (or Smart Card) , On-Board Unit (with Smart Card)

5-1-4 Hyderabad Growth Corridor Limited: HGCL

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 75 Hyderabad Growth Corridor Limited (HGCL)

Roles	Current Systems
Special Purpose Vehicle (SPV) for Development of Outer Ring Road (ORR)	ITS Planned on ORR 1) Highway Traffic Management System (HTMS) ・ Emergency Communication System ・ Variable Message Signs (VMS) ・ Meteorological Data System ・ Automatic Traffic Counter-cum-classifier (ATCC) ・ Traffic Control Centre (TCC) 2) Toll Management System (TMS) ・ Manual and Touch-And-Go ・ On Board Unit with Smart Card

(2) Organizational Structure and Responsibilities of HGCL

The Government of Andhra Pradesh formed a Special Purpose Vehicle (SPV) for development of Outer Ring Road (ORR) named as “Hyderabad Growth Corridor Limited" under Companies Act 1956 on 26th December 2005 with Registration No.01-48580 with the equity participation from INCAP (40%) and HUDA (60%). Subsequently, the equity participation is restructured as to INCAP (26%) and HUDA (74%). The HGCL started functioning from the day it is incorporated at the HUDA complex, Tarnaka as per the resolution passed in first meeting of Board of Director's held on 27th Dec 2005.

The Government of Andhra Pradesh, proposed major infrastructure facilities in Hyderabad city and one of them is the orbital linkage to decongest the traffic flow on the existing major arterials. The Outer Ring Road should be viewed as road -cum- area development project since the aim is the

development of well planned and well connected Urban settlements around the Hyderabad Metropolitan area. The 159 km long ring road connects Patancheru - Shamshabad – Hayathnagar - Medchal - Patancheru providing connectivity to various State Highway and National Highways, to bypass the city of Hyderabad. The ORR project is proposed to be implemented in 2 phases as follows:

- Phase-1 Construction of 22 Km from Gachibouli in to Shamshabad NH 7 In.
- Phase-2 Construction of 140 km Connecting: Narsingi- Kollur- Patancheru- Medchal- Shamirpet- Peddamberpet-Turkayamanjil-Tukkuguda-Shamshabad.

(3) Summary of Organizational / Operational Issues and System Issues

Table 76 Hyderabad Growth Corridor Limited (HGCL)

Organizational/Operational Issues	System Issues
• Annuity contract is expected to be applied for operation and maintenance of ORR •	• Promotion of Diffusion of OBUs is required • Integrated Smart Card Applicable to All Transportation Systems Required • Information Exchange with Other Agencies Required

5-1-5 Greater Hyderabad Municipal Corporation: GHMC

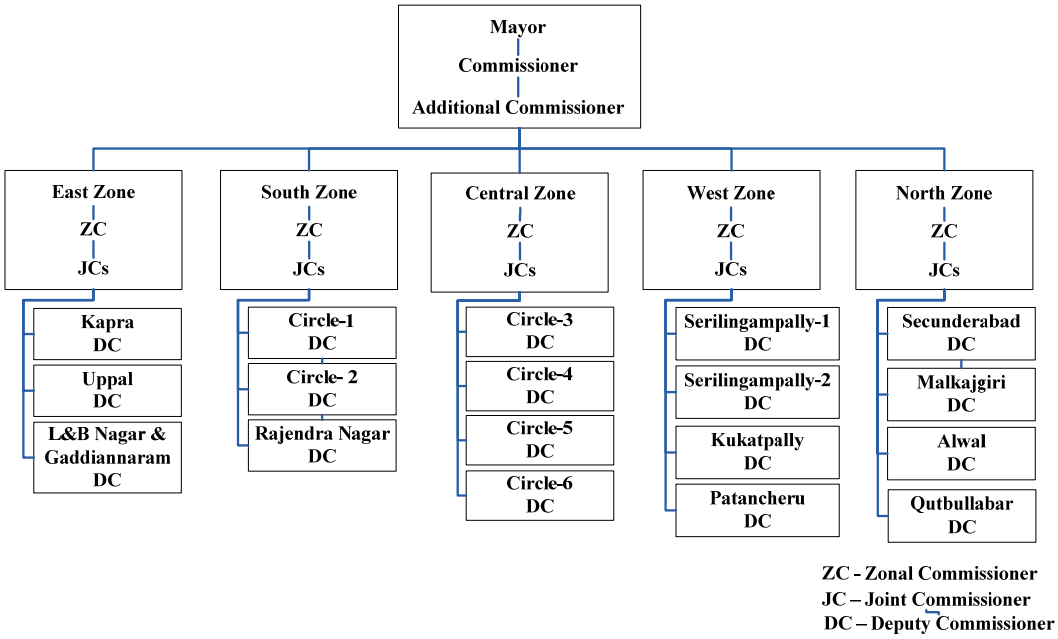
(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 77 Greater Hyderabad Municipal Corporation (GHMC)

Roles	Current Systems
• Urban Planning and Implementation / Administration Authority • Enforcement • Construction & Maintenance of Roads in GHMC Jurisdiction • Municipal Water, Sanitation • Tax Collection, Trade Licenses • Issues Birth/Death Certificate • Installation & Maintenance of Advertisement Boards • Construction & maintenance of Traffic Signals, Parking & Playgrounds • Town Planning • Construction and Maintenance of Bus Stops • Lighting • Permissions for Constructions, • Studies & Analysis • Provision of Services to Citizens	• Intelligent Parking System (Planned): • Contact less Smart Parking Card • OSRT System: • Binds Reported Data (Map, Image) • Vehicle Data (to be prepared) • *OSRT: Off Site Realtime

(2) Outline

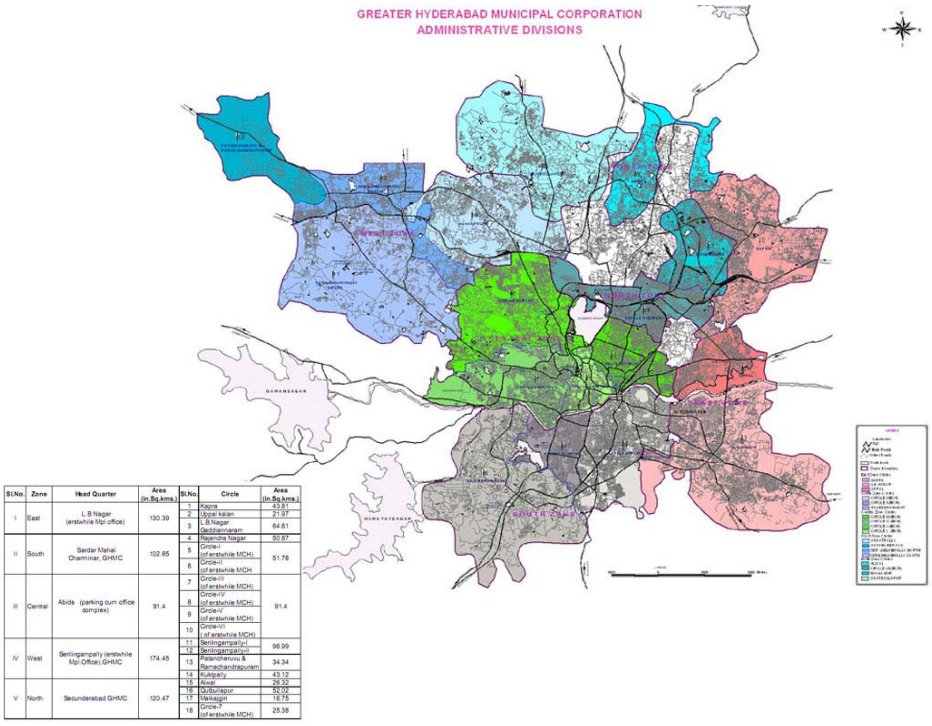
The organizational structure and responsibilities of GHMC are as follows:



Source: Edited by JICA Study Team based on GHMC Website

Figure 181 Organizational Structure of GHMC

(3) Jurisdiction of GHMC



Sl.No.	Zone	Head Quarter	Area (in Sq.kms.)	Sl.No.	Circle	Area (in Sq.kms.)
I	East	L.B.Nagar (erstwhile Mpl office)	130.39	1	Kapra	43.81
				2	Uppal kalan	21.97
				3	L.B.Nagar	64.61
				4	Gaddiannaram	
II	South	Sardar Mahal Charminar, GHMC	102.85	4	Rajendra Nagar	50.97
				5	Circle-I (of erstwhile MCH)	51.78
				6	Circle-II (of erstwhile MCH)	
III	Central	Abids (parking cum office complex)	91.4	7	Circle-III (of erstwhile MCH)	91.4
				8	Circle-IV (of erstwhile MCH)	
				9	Circle-V (of erstwhile MCH)	
				10	Circle-VI (of erstwhile MCH)	
IV	West	Serilingampally (erstwhile Mpl.Office) GHMC	174.45	11	Serilingampally-I	96.99
				12	Serilingampally-II	
				13	Patancheruvu & Ramachandrapuram	34.34
				14	Kukatpally	43.12
V	North	Secunderabad GHMC	120.47	15	Alwal	28.32
				16	Qutbullapur	52.70
				17	Malkajgiri	16.75
				18	Circle-7 (of erstwhile MCH)	25.38

Source: GHMC Website

Figure 182 GHMC Jurisdiction Map

(4) Summary of Organizational / Operational Issues and System Issues

Table 78 Greater Hyderabad Municipal Corporation (GHMC)

Organizational/Operational Issues	System Issues
• Insufficient Human Resources • Infrastructure Development •	• Planning Assistance Systems: • Infrastructure Data Base • Road Inventory System/Database • Parking Information Provision System • Traffic Monitoring System • Traffic Counting • CCTV Monitoring • Integrated System to Coordinate with Local Agencies for Planning and Development

5-1-6 National Highway Authority of India: NHAI

The NHAI is a road operation and management agency responsible for the national highways in India.

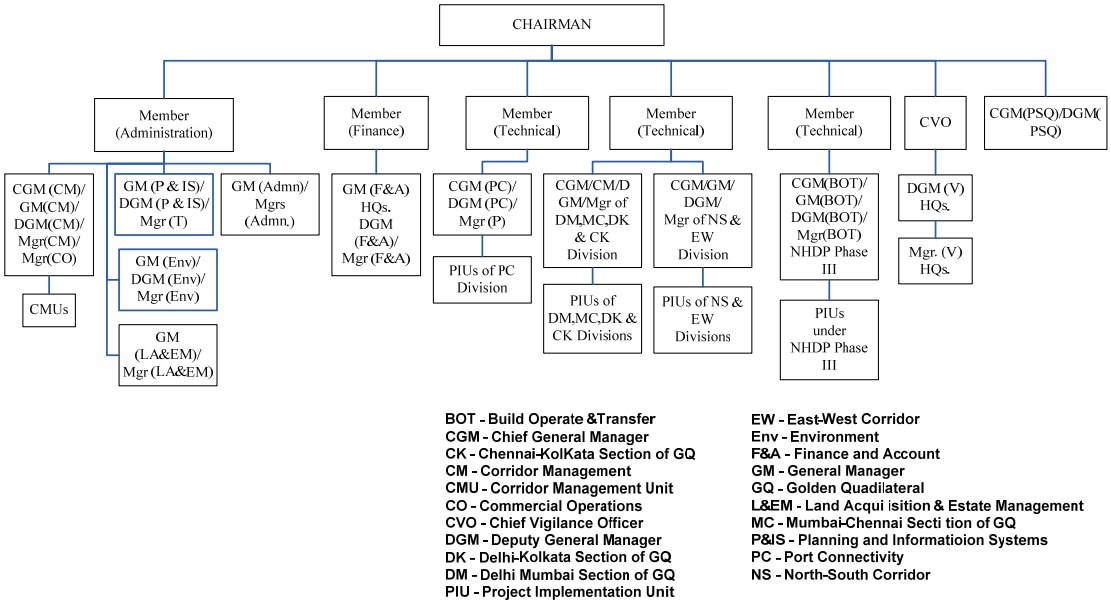
(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 79 National Highway Authority of India (NHAI)

Roles	Current Systems
• Development, Maintenance and Management of National Highways •	• Highway Traffic Management System (HTMS) • Emergency Call Box (ECB) • Variable Message Signs (VMS) • Meteorological Data System (MDS) • Automatic Traffic Counter-cum-classifier (ATCC) • Traffic Control Centre (TCC) • Vehicle Tracking System • Weigh in Motion • Toll Management System (TMS) • Manual, Touch-and-Go (or Smart Card)

(2) Organizational Structure and Responsibilities of NHAI

The National Highways Authority of India (NHAI) was constituted by an act of Parliament, the National Highways Authority of India Act, 1988. The NHAI is responsible for the development, maintenance and management of National Highways entrusted to it and for matters connected or incidental thereto. The NHAI became operational in February 1995 with the appointment of full time Chairman and other Members. Figure below shows the current organizational structure of NHAI.



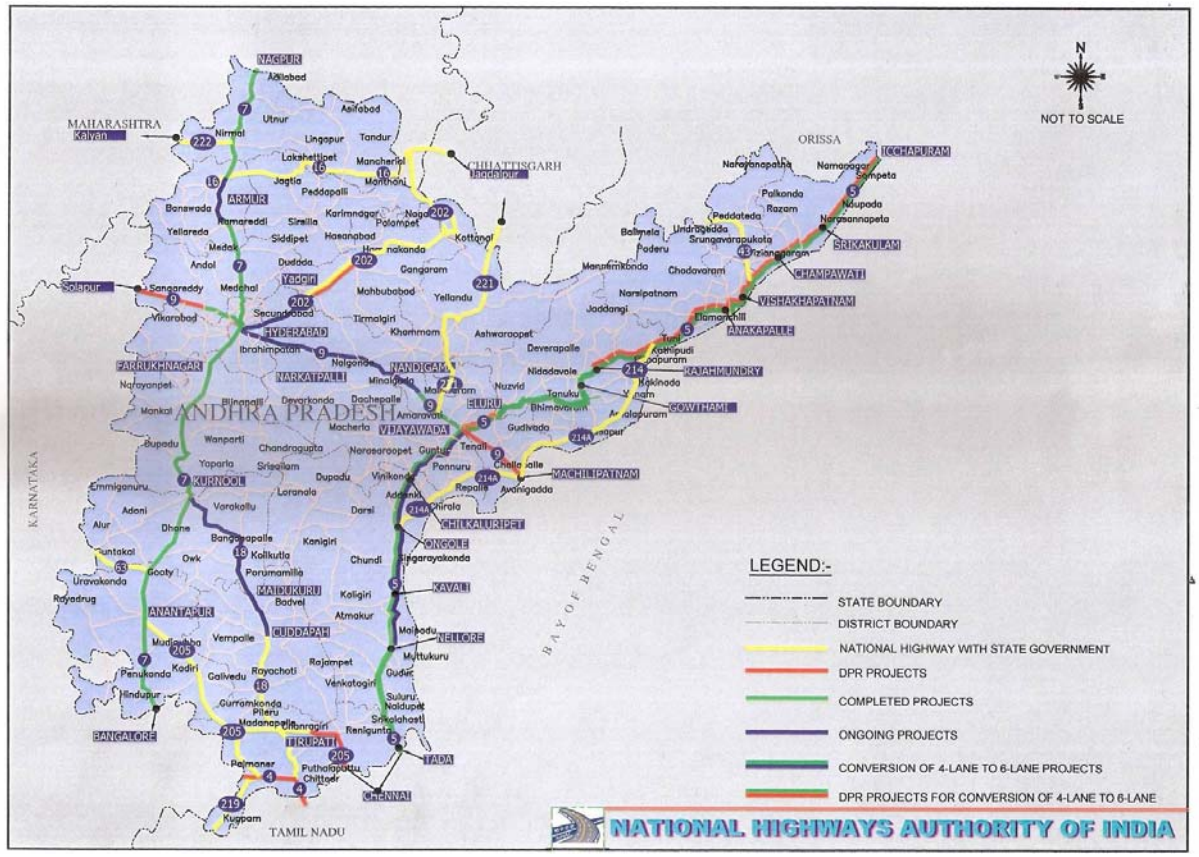
Source: Edited by JICA Study Team based on NHAI Website

Figure 183 Organizational Structure of NHAI

The NHAI is divided into two (2) main units, that is, Project Implementation Unit (PIU) which is responsible for road construction, and Corridor Management Unit (CMU) which is in charge of road operation and maintenance. There exists one (1) PIU in Andhra Pradesh State named PIU Hyderabad.

(3) Jurisdiction of NHAI in Andhra Pradesh State

The total length of National Highways is 70,934 km to serve as the arterial network of the country. In Andhra Pradesh State, 1724.3 km of National Highways had been completed by NHAI and 754.3 km of work is currently going on as depicted in figure below. The construction of National Highways is performed by NHAI and the operation and maintenance works of National Highways is basically being entrusted to R&B wing of NHAI or BOT model to private agencies except special cases such as National Highway No.7 in Hyderabad which is maintained by NHAI.



Source: NHAI

Figure 184 National Highways in AP State

(4) ITS Developed or Planned by NHAI

The NHAI introduced Highway Traffic Management System (HTMS) to control and monitor their highways. The HTMS consists of control centre system and various roadside facilities installed along the highways such as emergency call box, CCTV surveillance camera, meteorological monitoring stations, etc. Eight (8) control centres are being implemented.

(5) Summary of Organizational / Operational Issues and System Issues

Table 80 National Highway Authority of India (NHAI)

Organizational/Operational Issues	System Issues
• Concessionaire of NH operation and management: Not authorized for enforcement against overloaded vehicles even though the weigh-in-motion is installed •	• Information Exchange System with Other Organizations • Information Exchange System with Other Concessionaires in Different Section of NH • Coordination with Enforcement Agencies

5-1-7 Roads and Buildings Department: R&B

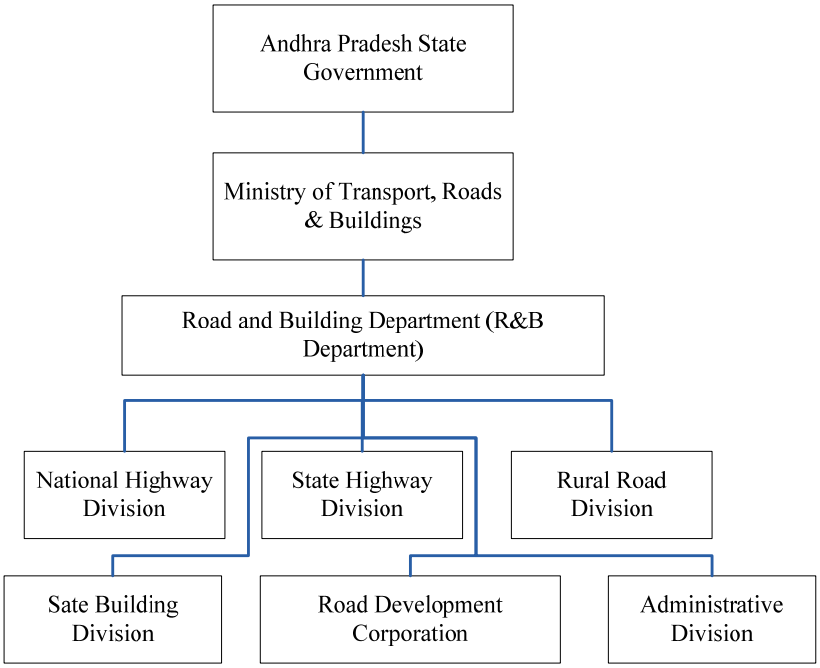
(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 81 Roads and Buildings Department (R&B)

Roles	Current Systems
• Execution of Works Below: • Construction and Maintenance of Roads, Bridges, Causeways. • Construction and Maintenance of National Highways with Fund Support from Government of India.	• N/A •

(2) Organizational Structure and Responsibilities of R&B Department

The Roads and Building Department (R&B department) is one of the state government departments and responsible for construction, operation and maintenance of roads and buildings within Andhra Pradesh State as a road operating and managing body. The R&B Department consists of six (6) divisions, that is, national highway division, state highway division, rural road division, state building division, Road Development Corporation.



Source: Information from R&B Department

Figure 185 Organizational Structure of R&B Department

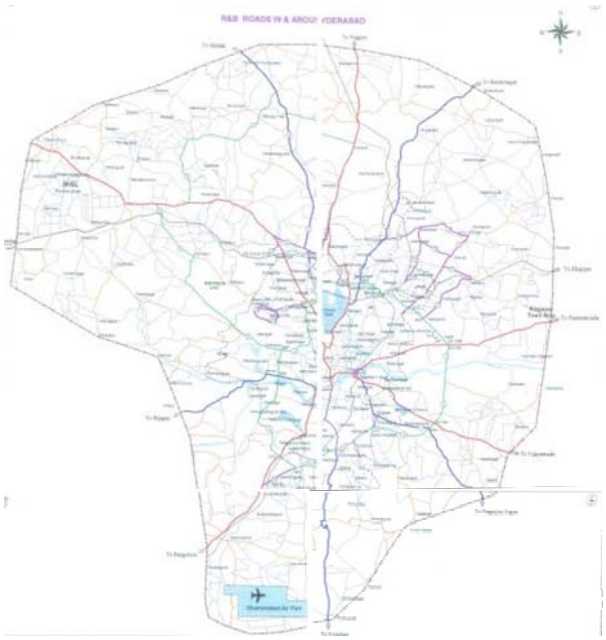
(3) Jurisdiction of R&B Department

The R&B department has been operating and managing the state principal road network including national highways (instead of NHAI), state highways and major district roads in Andhra Pradesh State. Entire road length of their jurisdiction in and around Hyderabad is 174.98 km as shown in the table and map below.

Table 82 Jurisdiction of R&B Department

No.	Highway	Section		Length (km)	Type	Code No.
1	Hyderabad to Nagarjunanagar	KM0+000	KM7+400	7.400	SH	19
2	Hyderabad Medak Bodhan Road	KM0+000	KM13+000	13.000	SH	6
3	Inner Ring Road	KM0+000	KM52+000	52.000		5464
4	Intermediate Ring Road	KM0+000	KM15+700	30.800		5440
		KM16+800	KM31+900			
5	Hyderabad-moulali Road	KM6+400	KM15+700	9.300		5402
6	Sec'bad-kukatpally Road	KM0+000	KM5+600	5.600		5418
7	Old Airport Road	KM0+000	KM3+400	3.400		5416B
8	Balangar-fathenagar Road	KM0+000	KM1+800	1.800		5449
9	Hitech City Road	KM0+000	KM3+800	3.800		5465b
10	Old 'kurnool Road	KM0+000	KM1+000	4.000		5439
		KM9+000	KM12+000			
11	Midhani Road	KM0+000	KM3+000	3.000		5462
12	Malkajgiri Station Road	KM0+000	KM1+000	1.000		5415
13	Sanathnagar Goods Shed Road	KM0+000	KM1+000	1.000		5466a
14	Mizralguda To Neredmet Road	KM0+000	KM5+200	5.200		5406
15	Uttam Nagar To Zts Road	KM0+000	KM2+700	2.700		5417
16	Trimalgari-moulali	KM0+000	KM7+400	7.400		5401
17	I.d.a. Nacharam Road	KM0+000	KM7+600	7.600		5405
18	Low Level Bridge At Chaderghat	KM0+000	KM0+600	0.600		
19	Kbr Park Road	KM0+000	KM5+000	5.000		
20	Bahadurpally To Kompally Road	KM33+600	KM40+500	7.000		
21	Indian Airlines Road	KM0+000	KM0+600	0.600		
22	Internal roads in	KM0+000	KM1+800	1.800		
23	Road Connecting IRR to Hyd	KM0+000	KM0+980	0.980		
Total				174.980	km	

Source: Information from R&B Department



Source: R&B Department

Figure 186 R&B Department Jurisdiction Map

(4) Current Issues on Road Operation and Maintenance

During the interview survey, some of the major issues highlighted by staff of R&B Department are as listed below.

- R&B Department is facing a lot of difficulties in road maintenance during rainy season as water is overflowing from drainage on roads at various locations leading to traffic congestions.
- The water supply and drainage systems were designed 60 years back for a city population

of 1 lack and now the city has grown to 1.5 crore population. The city water and drain systems have to be re-designed to cater the current requirements.

(5) ITS Developed or Planned by R&B Department

According to the interview survey, R&B Department currently doesn't have any ITS and there is no plan to develop it.

(6) Summary of Organizational / Operational Issues and System Issues

Table 83 Roads and Buildings Department (R&B)

Organizational/Operational Issues	System Issues
• Infrastructure Development • Insufficient Human Resources • Sewage • Water Supply	• Road Monitoring System • Road Inventory System/Database • System Integration with Other Organizations

5-1-8 Hyderabad Traffic Police

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 84 Hyderabad Traffic Police

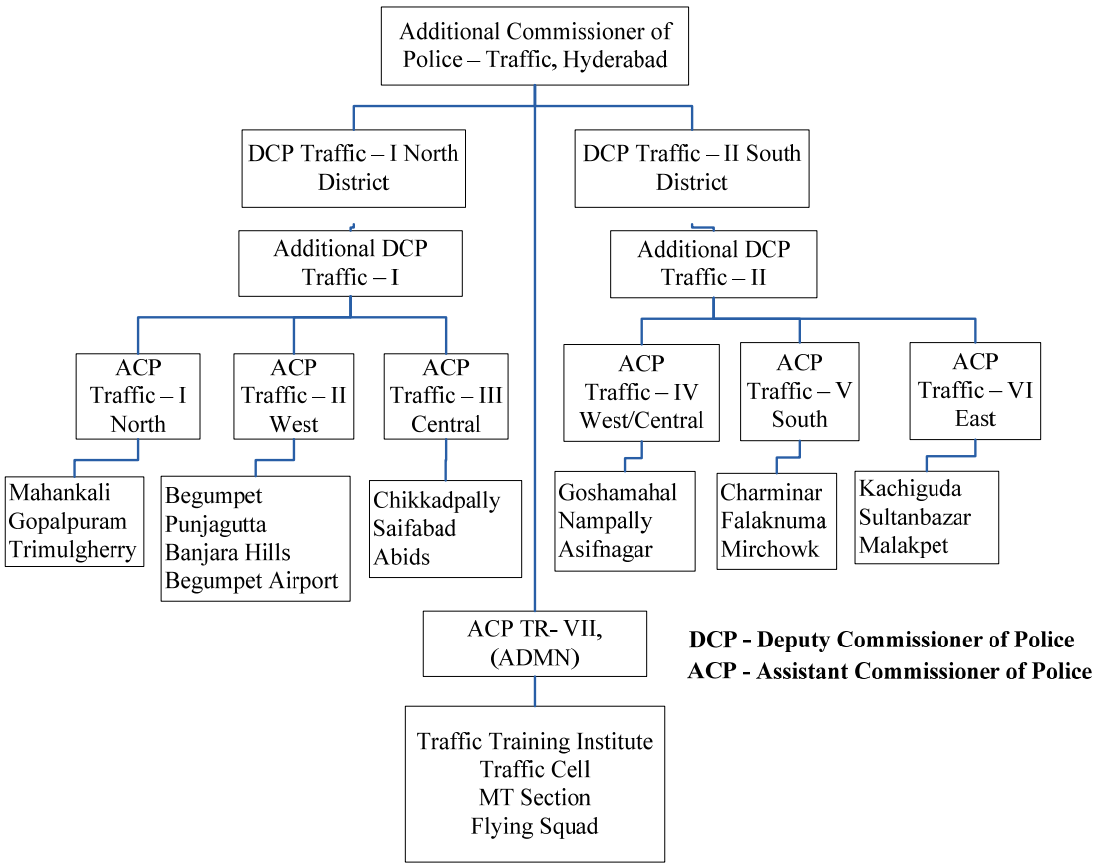
Roles	Current Systems
• Traffic Administrator in Hyderabad Jurisdiction including: • Enforcement • Traffic Regulations • Public Safety	• Provision of Following Information by Website: • Alternate Routes • Towing Zones • Parking Zones • Area with no Right Turns • Accident Prone Areas • Water Logging Areas • Fly Over in Hyderabad • No entry for Lorries and Buses • Accidents Information • Traffic alerts through SMS • E-Challan System • Vehicle Data Collection from RTA • Traffic Violation Database • PDAs • Surveillance System • CCTVs • Emergency Call 100 • Digital Map

(2) Summary of Organizational / Operational Issues and System Issues

Table 85 Hyderabad Traffic Police

Organizational/Operational Issues	System Issues
• Insufficient Human Resources • More Effective Enforcement Scheme/System • Insufficient Funds available for System Upgrade	• Proper Installation of Traffic Signals and Signal Coordination • Quantitative Traffic Information System • Integration of Internal Systems • Upgrade of Existing Systems • Integration with RTA Database • Automated Enforcement System • Systems for Other Offences • Information Exchange System with Other Organizations

(3) Organizational Structure of Hyderabad Traffic Police (HTP)



Source: Edited by JICA Study Team based on HTP Website

Figure 187 Organizational Structure of Hyderabad Traffic Police

(4) Jurisdiction of HTP:

It is responsible for traffic control within Hyderabad area which falls under its jurisdiction.

(5) ITS Developed or Planned by HTP

The Hyderabad Traffic Police together with the GHMC is planning to introduce the Hyderabad Traffic Integrated Management Systems (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 headquarters of the Hyderabad Traffic Police, and backup centre at the Cyberabad Traffic Police.
- To prepare the signals without any break at 221 Junctions (180 existing + 41 new) including 15 Secunderabad Cantonment Board Junctions.
- To demonstrate the virtual loops for management of the traffic flow at two junctions as a pilot basis and is managed from the TCC.
- To remotely operate the signalling parameters from the TCC / or at site of the signals based on the existing traffic.
- To monitor the health of the signal facilities from the TCC.
- To create a Management Information System (MIS) for decision making in traffic emergency such as heavy rainfall, accidents, terrorist attack, VIP movements etc

5-1-9 Cyberabad Traffic Police

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 86 Cyberabad Traffic Police

Roles	Current Systems
• Traffic Administrator in Cyberabad Jurisdiction including • Enforcement • Traffic Regulations • Public Safety	• E-Challan System • Vehicle Data Collection from RTA • Traffic Violation Database • PDAs • Surveillance System • CCTVs • Emergency Call 100 • Digital Map • TETRA System • Automatic Vehicle Location System • GPS • Digital Map • Signals • Fixed Signal System Controlled in Each Sites

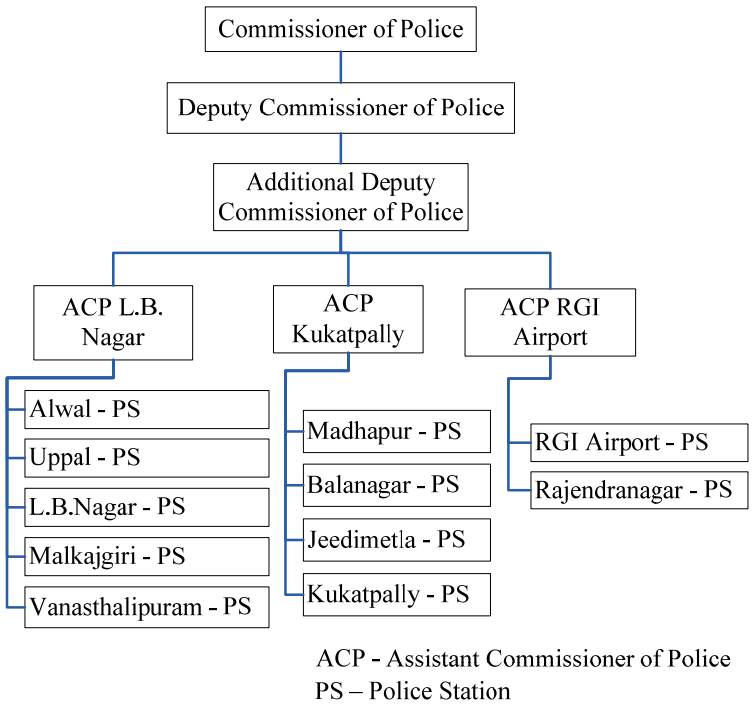
(2) Summary of Organizational / Operational Issues and System Issues

Table 87 Cyberabad Traffic Police

Organizational/Operational Issues	System Issues
• Insufficient Human Resources • More Effective Enforcement Scheme/System • Insufficient Funds available for System Upgrade	• Proper Installation of Traffic Signals and Signal Coordination • Quantitative Traffic Information System • Integration of Internal Systems • Upgrade of Existing Systems • Integration with RTA Database • Automated Enforcement System • Systems for Other Offences

	• Information Exchange System with Other Organizations

(3) Organizational Structure and Responsibilities of Cyberabad Traffic Police (CTP)



Source: Edited by JICA Study Team based on CTP Website

Figure 188 Organizational Structure of Cyberabad Traffic Police

(4) Jurisdiction of CTP

It is responsible for the traffic control within CTP limits like Kukatpally, Malayasion Township, KPHB Colonies, Gachibowli, V V Nagar, IDL Factory, Miyapur, Hafeeapet, etc.

(5) ITS Developed or Planned by CTP

The existing traffic control centre of the Cyberabad Traffic Police is planned to be a backup centre under the plan of the H-TRIM, of which details are described in the above clause of the Hyderabad Traffic Police.

5-1-10 Regional Transport Authority: RTA

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 88 Regional Transport Authority (RTA)

Roles	Current Systems
• Registration and Issuance of Certificate including • Motor Vehicle Registration • Issuance of Driving License • Issuance of Certificate of Transport Vehicles • Taxes and Fees Collection • Enforcement of Motor Vehicles Act and Rules	• RTA Database: • Registered Motor Vehicles Database • Driving License Information • Violations Database • Online Services

(2) Summary of Organizational / Operational Issues and System Issues

Table 89 Regional Transport Authority (RTA)

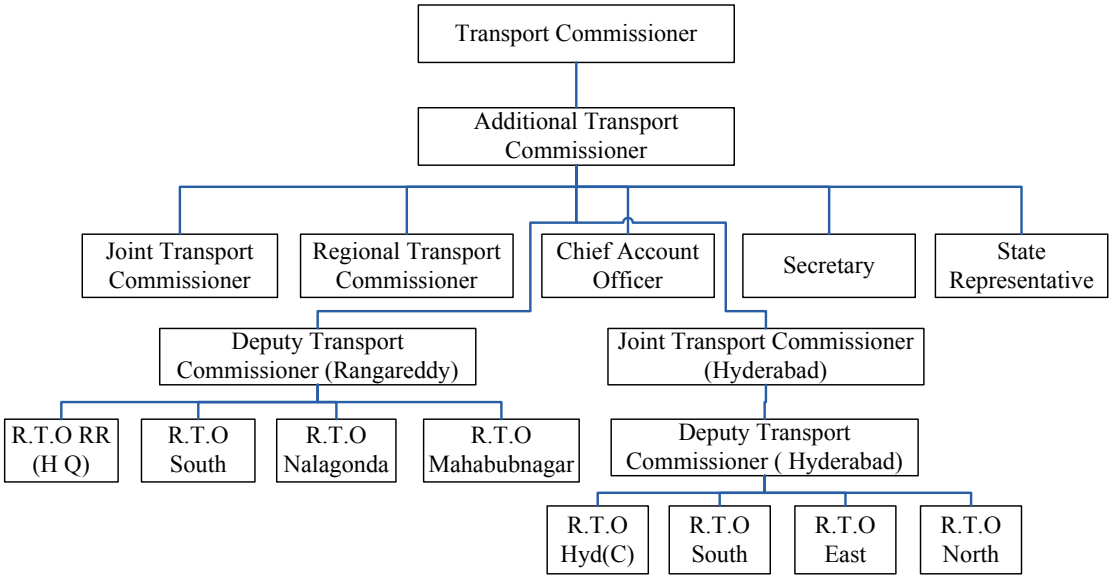
Organizational/Operational Issues	System Issues
• Insufficient Human Resources • More Effective Enforcement Systems	• Vehicle Data Available Online to Other Enforcement agencies for E-Challan and Traffic Management Control with Car Registration Plate System in the Future

(3) Organization Structure and Responsibilities of RTA

The Transport Department (RTA) is a state government authority that functions under the provisions of section 213 of the Motor Vehicle Act, 1988. The RTA is primarily established for enforcement of the provisions of the Motor Vehicle Act, 1988, Andhra Pradesh Motor Vehicles Taxation Act, 1963 and the rules framed there under.

The major functions of the RTA are the enforcement of the motor vehicles act and rules, collection of taxes and fees and issuance of driving licenses, certificate of fitness to transport vehicles, registration of motor vehicles, etc. The RTA also carries out road safety work by conducting awareness campaigns, pollution check of vehicles and enforces measures such booking speeding vehicles through laser guns and interceptor vehicles and detects drunken drivers through breath analyzers.

The RTA is headed by the Transport Commissioner who is assisted by an Additional Transport Commissioner, four (4) Joint Transport Commissioners, three (3) Regional Transport Officers, one (1) Regional Transport officer. At the field level the Transport Commissioner is assisted by one Joint Transport Commissioner in charge of Hyderabad and by Deputy Transport Commissioner's of Transport who provide the overall supervision and coordination of all transport offices at the district level. The figure below shows the organizational hierarchy of RTA.



Source: Edited by JICA Study Team based on RTA Website

Figure 189 Organizational Hierarchy of RTA

(4) Jurisdiction of RTA

The individual regional offices of the RTA are responsible for the following areas:

- Ranga Reddy: Ranga Reddy (RTO), Uppal, Ibrahimpatnam, Medchal
- Hyderabad: Hyderabad (C) RTO-1, Hyderabad (C) RTO-2,M'Pet(E-RTO), Bahadurpur (S-RTO), Secunderabad (N-RTO)

5-1-11 Hyderabad Metro Rail Ltd: HMRL

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 90 Hyderabad Metro Rail Ltd (HMRL)

Roles	Current Systems
• Government of AP for Implementation of Hyderabad Metro Rail Project in PPP Scheme.	• N/A

(2) Summary of Organizational / Operational Issues and System Issues

Table 91 Hyderabad Metro Rail Ltd (HMRL)

Organizational/Operational Issues	System Issues
• N/A	• Integrated Smart Card Applicable to all Transportation Systems • Train Approaching Information Provision System • Operational Information Exchanging System • Next Station Information (in the car) • Time Table Information Provision System

(3) Outline of HMR

The Hyderabad Metro is an approved mass rapid transit system for the city of Hyderabad, India. Hyderabad Metro rail project is the first Public Private Partnership (PPP) Metro rail project approved by Govt. of India. It is one of the largest Metro rail projects in the world to be taken up at one go in PPP mode. The Project Report, made by Delhi Metro Rail Corporation, was the result of an extensive study of the geophysical features of routes, international best practices and economics. The Project is expected to be completed at an estimated cost of Rs. 12,132 Crore. The Project was awarded to the M/s. Larsen & Toubro Limited at their quoted grant amount of Rs 1,458 crore and Concession Agreement (CA) was signed by Government of Andhra Pradesh and L&T Hyderabad Metro Rail Private Limited on Design, Build, Finance, Operate and Transfer (DBFOT) basis.

(4) Planned Route

Hyderabad Metro Rail project covers three high density traffic corridors of Hyderabad covering length of 71.16 km with 66 stations.

- Miyapur-LB Nagar (28.87 km - 27 stations)
- JBS-Falaknuma (14.78 km - 16 stations)
- Nagole-Shilparamam (27.51 km - 23 stations)

5-1-12 SCR/MMTS/Centre for Railway: CRIS

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 92 SCR/MMTS/Centre for Railway (CRIS)

Roles	Current Systems
• IT System and Service Provider for Indian Rail. •	• Train Approaching Information Provision System • MMTS Smart Card (Cashless System) • Other Railway Systems

(2) Summary of Organizational / Operational Issues and System Issues

Table 93 SCR/MMTS/Centre for Railway (CRIS)

Organizational/Operational Issues	System Issues
N/A	N/A

(3) Outline

The Centre for Railway Information Systems (CRIS) was established in the year 1986 by Ministry of Railways with focus to provide consulting and IT services to Indian Railways - as partners to conceptualize and realize technology driven business transformation initiatives. The CRIS is mainly a project oriented organization engaged in the development of the major computer systems for the railways.

The major projects under CRIS are as follows:

- Unreserved Ticketing System
- Control Office Application
- Freight Operations Information System
- Integrated Coach Management System
- National Train Enquiry System
- Passenger Reservation System
- Software Aided Train Scheduling

5-1-13 Andhra Pradesh State Road Transport Corporation: APSRTC

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 94 Andhra Pradesh State Road Transport Corporation (APSRTC)

Roles	Current Systems
• Public Bus Operator in Andhra Pradesh •	• ITS Introduction by JNNURM (On-going Pilot): • LEDs for Bus Information • GPS Devices on JNNURM Buses and TIMS • Other Related Planning • CCTVs (for security in bus) • SMS Bus Information • Back Office System • GPS/GPRS • Passenger Information System

	• ETMs

(2) Summary of Organizational / Operational Issues and System Issues

Table 95 Andhra Pradesh State Road Transport Corporation (APSRTC)

Organizational/Operational Issues	System Issues
• Introduction of More Buses of JNNURM • Insufficient Funds for New Buses • Insufficient Funds available for ITS Implementation • Insufficient Human Resources • Absence of Long-Distance Bus Location Information	• Timetable Information Provision System • Automated Fare System • Smart Card System • Bus Location System • Passenger Information System • SMS Alerts • System Integration with Other Agencies

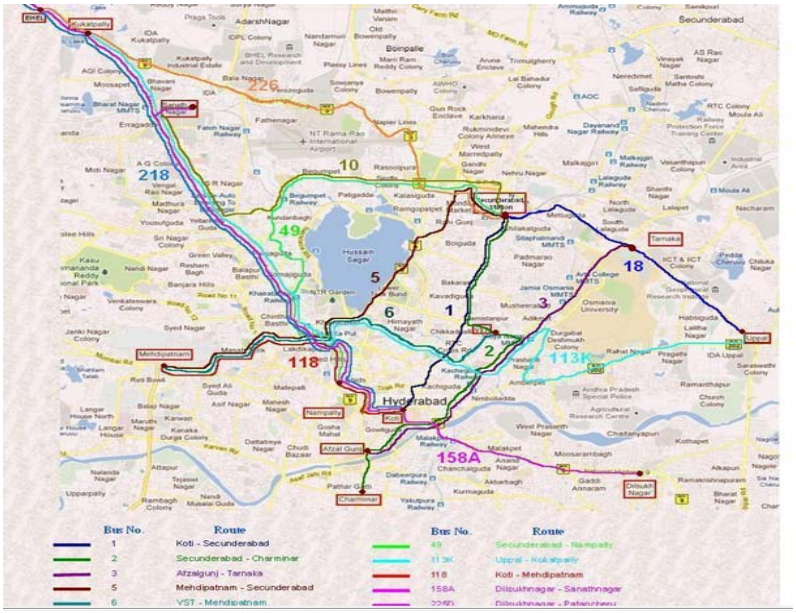
(3) Outline of APSRTC

The Andhra Pradesh State Road Transport Corporation (APSRTC) is a public bus operator established by the State of Andhra Pradesh under Section 3 of the Road Transport Corporations Act, 1950, having its Head Office at Bus Bhavan, Mushirabad, Hyderabad, and Andhra Pradesh, India. APSRTC is the only company in the world with 22,222 buses. In APSRTC jurisdiction, there exist 773 bus stations which have been constructed by GHMC. In Hyderabad city, APSRTC operating a total of 3872 buses in which 940 buses are under JNNURM scheme. The entire bus network is under the administrative control of 23 Regional Managers in 7 Zones.

(4) Bus Route Map

The APSRTC's buses cover 79.54 lakh km connecting 24,336 villages to all major towns and cities in A.P and also play to important towns and cities in the neighbouring States of Tamilnadu, Karnataka, Maharashtra, Goa, Orissa and Chattisgarh. Figure below shows a bus route map in Hyderabad city zone.

(5) APSRTC Bus Route Map in Hyderabad City Zone



Source: APSRTC Website

Figure 190 APSRTC Bus Route Map in Hyderabad City Zone

(6) ITS Developed or Planned by APSRTC

The APSRTC is going to implement ITS initiatives in JNNURM buses by two phases (Phase-I with 940 buses, Phase-II with all other buses). Under this ITS implementation plan, a GPS pilot project on 20 buses was already conducted by Ashok Leyland Telematics, Chennai. The GPS pilot project consists of two video cameras for security and surveillance with 72 hour backup, in-bus LED screens with visual and audio features for next bus stop information to passengers and GPS tracking system. The GPS tracking data is only stored in OBU and currently not transmitted to centre server or any other places. Such function would be implemented in next phase.

5-1-14 MERU Cab

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 96 MERU Cab

Roles	Current Systems
• Taxi Company with the Following Features • One of the First Companies Launched Metered "Radio-Cabs" in India. • Applied GPS/GPRS Enabled Technology to All Taxi Vehicles.	• Taxi Dispatching System: • GPS/GPRS • Mapmyindia Map Application • OBU with Swipe

(2) Summary of Organizational / Operational Issues and System Issues

Table 97 MERU Cab

Organizational/Operational Issues	System Issues
• N/A	• System Integration with Other Agencies

(3) Taxi Companies (MERU Cab, Easy Cab, Sky Cab, etc.)

The Radio Cab: The Regional Transport Authority granted a permission as the licensed operator of the motor cab fitted with tracking devices to play as a Radio Cab with state vide permission. The Radio Cab operator is required to obtain the license from the Secretary, State Transport Authority to operate as Radio cab.

The licensed operator is eligible to operate radio cabs not less than 100 and not more than 1,000 that are fitted with electronic fare meters with printer facility. Also such Radio Cabs is required to equip the air condition and GPS/GPRS devices enabling communication with the central control unit for live tracking of the cabs.

(4) ITS Developed or Planned by MERU Cab:

The MERU Cab developed and is operating the GPS tracking system for the taxi dispatching services and the control centre sends the detailed information such as customer's address, contact number to the cab OBU through GPRS (General Packet Radio Service) communication carriers.

5-1-15 GVK Emergency Management and Research Institute: EMRI 108

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 98 GVK Emergency Management and Research Institute (EMRI 108)

Roles	Current Systems
• Emergency Management Service Provider	• Emergency Response System: • Hot Spots Based on Collected Data System • Locating Ambulances at Critical Locations • Dispatching Ambulance to the Site

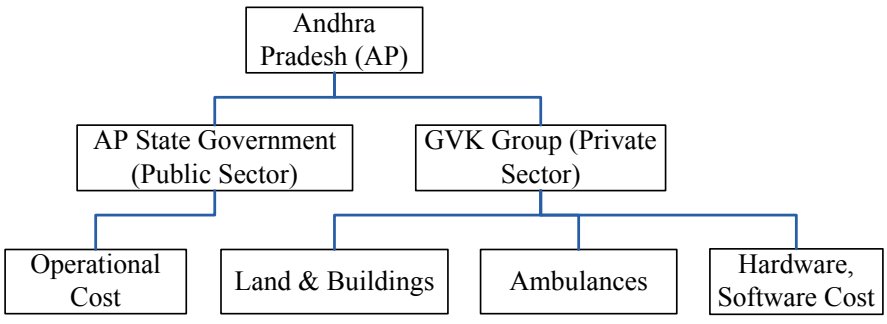
(2) Summary of Organizational / Operational Issues and System Issues

Table 99 GVK Emergency Management and Research Institute (EMRI 108)

Organizational/Operational Issues	System Issues
• Improved Response Time • More Ambulances	• Ambulance Tracking System • Integration of Accident Database with Enforcement Agencies • Information Exchange System with Other Agencies

(3) Outline

The EMRI handles medical, police and fire emergencies through the “108 emergency service". This is a free service delivered through state- of -art emergency call response centres and founded in 2005 with Public Private Partnership (PPP) scheme. Under this scheme, the fund is provided by the state government, and the operation and technical support for emergency response are provided by the private organizations. The chart below shows the PPP scheme of GVK EMRI.

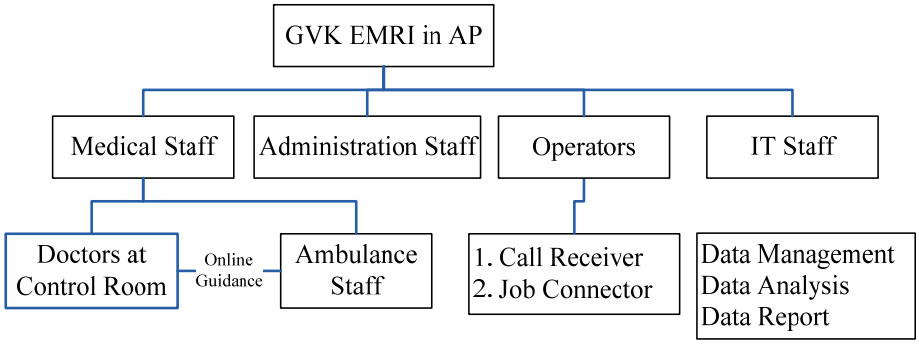


Source: Information from GVK EMRI

Figure 191 PPP Scheme of GVK EMRI

The GVK EMRI operates in the 11 states and 2 union territories in India, and its headquarters is located in Hyderabad. The GVK EMRI in Andhra Pradesh State operates 752 ambulances and a call centre with 72 staff. The call centre is located in Secunderabad and provides 108 emergency services for the entire Andhra Pradesh state. The figure below shows the organization structure of the GVK EMRI in Andhra Pradesh State.

(4) Organizational Structure of GVK EMRI



Source: Information from GVK EMRI

Figure 192 Organizational Structure of GVK EMRI

5-1-16 Centre for Development of Advanced Computing: C-DAC

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 100 Centre for Development of Advanced Computing (C-DAC)

Roles	Current Systems
• Premier R&D Organization under the Department of Information Technology for R&D in IT, Electronics and Associated areas.	• N/A

(2) Summary of Organizational / Operational Issues and System Issues

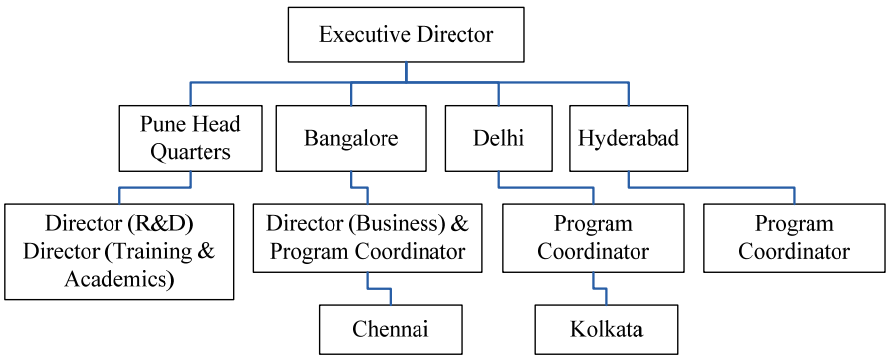
Table 101 Centre for Development of Advanced Computing (C-DAC)

Organizational/Operational Issues	System Issues
• N/A	• N/A

(3) Outline

The Centre for Development of Advanced Computing (C-DAC) is a premier R&D organization of the Department of Information Technology (DIT), Ministry of Communications & Information Technology (MCIT) for carrying out R&D in IT, electronics and associated areas.

(4) Organization Structure of CDAC



Source: Information from CDAC

Figure 193 Organizational Structure of CDAC

5-1-17 National Informatics Centre: NIC

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 102 National Informatics Centre (NIC)

Roles	Current Systems
• E-Governance Implementing/Supporting agency. Major roles include: • Provision of Network Backbone and E-Governance Support to Central Government, UT Administrators, Districts and other Government bodies. • Provision of Wide Range of ICT Services for Government. • Assistance in implementing Information Technology Projects in Collaboration with Central and State Government.	• N/A

(2) Summary of Organizational / Operational Issues and System Issues

Table 103 National Informatics Centre (NIC)

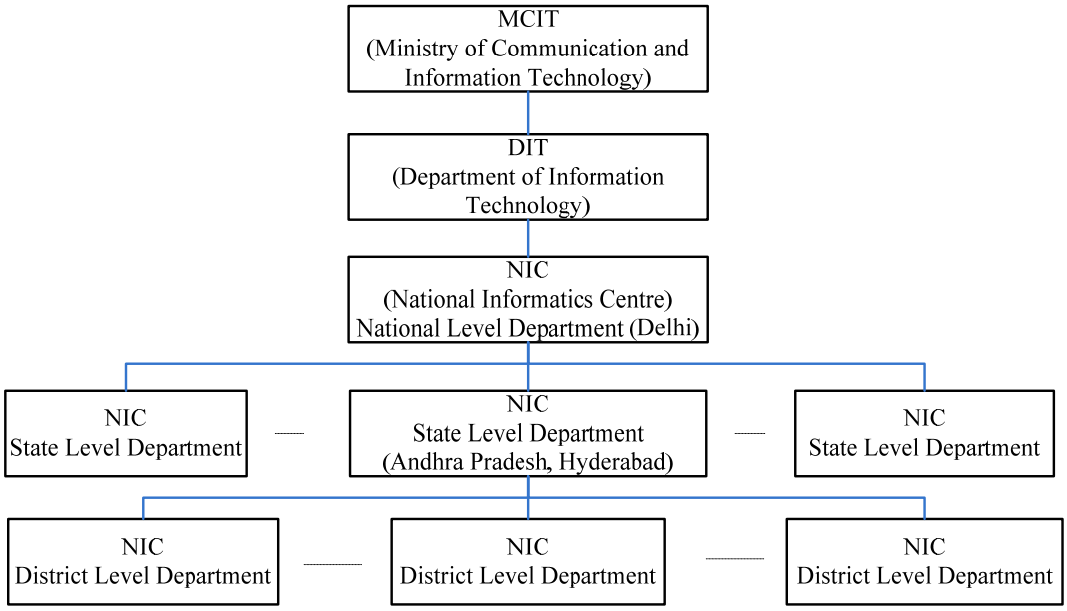
Organizational/Operational Issues	System Issues
• N/A	• N/A

(3) Outline

The National Informatics Centre (NIC) of the Department of Information Technology (DIT) is an authority under Ministry of Communications and Information Technology providing network backbone and e-Governance support to Central Government, State Governments, UT Administrations, Districts and other Government bodies. The NIC offers a wide range of ICT services including nationwide communication network for decentralized planning, improvement in Government services and wider transparency of national and local Governments. The NIC assists in implementing Information Technology Projects, in close collaboration with Central and State Governments, in the areas of (a) Centrally sponsored schemes and Central sector schemes, (b) State sector and State sponsored projects, and (c) District Administration sponsored projects.

(4) Organizational Structure of NIC

The NIC, Hyderabad centre was established in 1986 and had implemented and IT technology systems for state government departments such as Traffic Police, GHMC, District Administrations, etc. Those systems include website operation of these departments, utility mapping GIS for GHMC, etc. NIC is in progress of developing a web-based e-Challan system for Cyberabad Traffic Police and it will be in operation by end of November 2011. NIC is also planning to implement a national level RTA database system.



Source: Information from NIC

Figure 194 Organizational Structure of NIC

5-1-18 National Institute of Technology: NIT

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 104 National Institute of Technology

Roles	Current Systems
• R&D Institute/Technology Consultation • Research and Development • Industrial Consultancy • Provision of Education and Training Programs for Teachers and Industrial Personnel	• N/A

(2) Summary of Organizational / Operational Issues and System Issues

Table 105 National Institute of Technology

Organizational/Operational Issues	System Issues
• N/A	• N/A

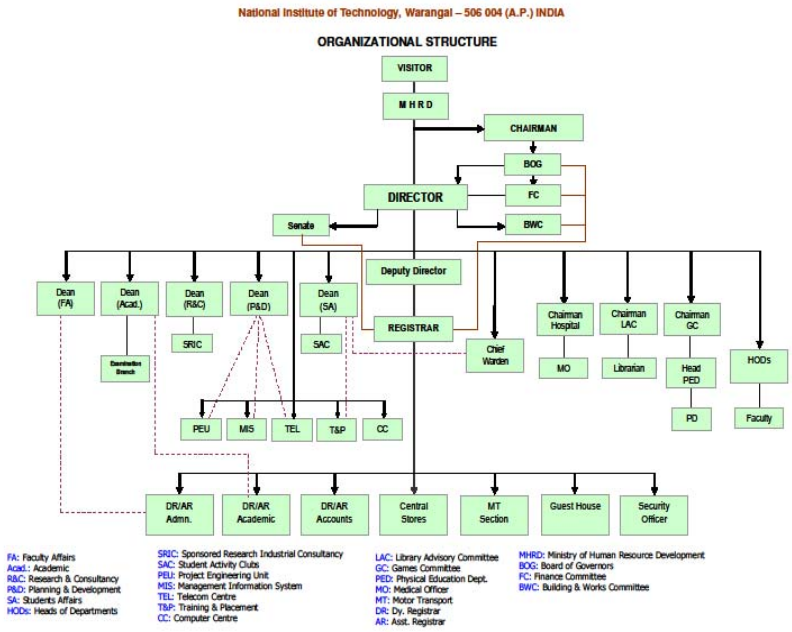
(3) Outline

The National Institute of Technology, Warangal (NIT-W) is an undergraduate and post graduate engineering institute located in Warangal, India. Formerly known as the Regional Engineering College, Warangal (REC-W) is the first among the 17 Regional Engineering Colleges established in India and was founded in 1959 by the then Prime Minister Pandit Jawaharlal Nehru. It was started with an objective of National Integration by reserving specific number of seats for various states in India to encourage students from all the states of India to live and learn together and understand each other's culture and traditions. Today it is an Institute of National Importance awarding bachelor, masters and doctoral degrees in engineering, technology, basic sciences and management.

The NIT Warangal is an autonomous T-school and functions under the NIT act. The governing body consists of The Minister of Human Resource and Development, Government of India, who is the

Chairman of the Council. Each NIT has Board of Governors who handles administration matters.

(4) Organization Structure of NIT



Source: NIT Website

Figure 195 Organization Structure of NIT

5-1-19 Andhra Pradesh Pollution Control Board: APPCB

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 106 Pollution Control Board

Roles	Current Systems
• Statutory Authority for Environment Administration • Implementation of Environmental Laws/Regulations within the Jurisdiction of Andhra Pradesh State. • Ensuring Proper Implementation of the State, Judicial and Legislative Pronouncements Related to Environment Protection within the State. • Implementation of Series of Other Related Environmental Regulations	• Pollution Monitoring Stations: • Online/Offline Stations for Air Quality Monitoring • Collection and Display of Noise Pollution

(2) Summary of Organizational / Operational Issues and System Issues

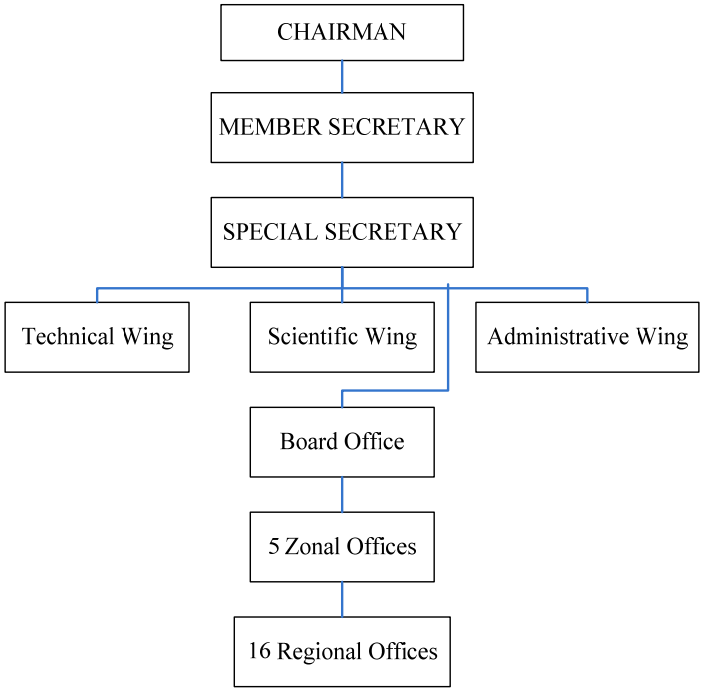
Table 107 Pollution Control Board

Organizational/Operational Issues	System Issues
• Insufficient Number of Online-Monitoring Stations	• Information Display via VMS • Enforcement System of Pollution Control against

• Insufficient Pollution Information Provision	Vehicles • System Integration with Enforcement Agencies, Traffic Administrator in Particular

(3) Outline

The Andhra Pradesh Pollution Control Board (APPCB) is a statutory authority to implement environmental laws and rules within the jurisdiction of the State of Andhra Pradesh, India and was constituted in the year 1976 with the enactment of the Water Act, 1974 (Prevention and Control of Water Pollution). The board functions through its head office in Hyderabad, five zonal offices headed by five joint chief environmental engineers and nineteen regional offices headed by nineteen environmental engineers as shown in the figure below.



Source: Information from APPCB

Figure 196 Organizational Structure of APPCB

The APPCB monitors the air pollution by 1 on line station, 21 manual stations and noise pollution at five locations in Hyderabad. The regional offices installed the manual stations to monitor the air, water, soil, etc., and the pollution levels in sensitive areas.

The major roles and responsibilities of APPCB are summarized as below:

- Advise the State Government on any matter concerning the prevention, control or abatement of air, water, bio-medical, soil, hazardous waste, municipal waste, plastic, chemical, industrial, etc., pollution,
- Collect and disseminate information relating to air, water, etc., pollution,
- Set or modify quality standards for air, water, etc., by collaborating with the Central Pollution Control Board,
- The online air pollution monitoring station with its server was installed in the head office and air pollution monitoring data is processed and stored in the server on hourly basis. The APPCB also developed GIS mapping system for overlay analysis.

Photo-1: Air pollution sensors

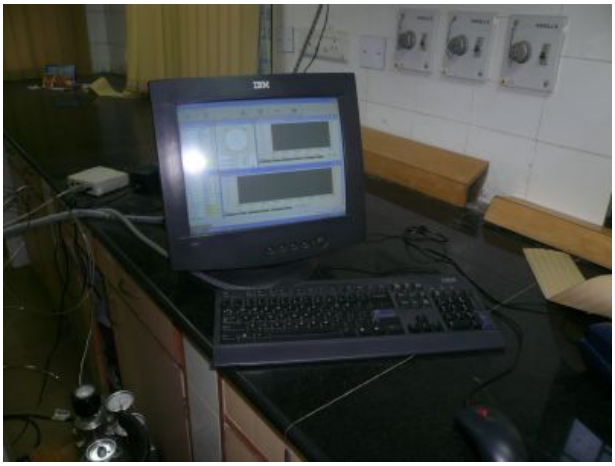


Photo-2: Server Monitor

Figure 197 Facilities at APPCB

5-1-20 India Meteorological Department: IMD

(1) Summary of Roles and Current Systems of ITS Related Organizations

Table 108 Meteorological Department

Roles	Current Systems
• State Government Department for: • Weather Forecasting • Provision of Meteorological Information Required to Aviation Sector • Provision of Hazardous Weather Information for Rescue Activities	• N/A

(2) Summary of Organizational / Operational Issues and System Issues

Table 109 Meteorological Department

Organizational/Operational Issues	System Issues
N/A	N/A

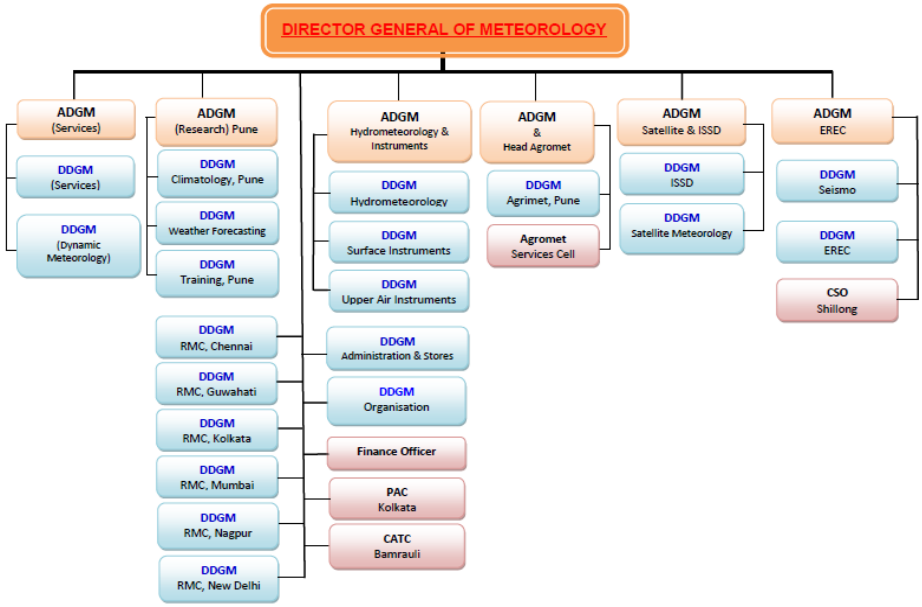
(3) Outline

The Director General of Meteorology is a head of the India Meteorological Department (IMD) headquartered in New Delhi. It has six(6) regional meteorological centres, headed by a Deputy Director General in Mumbai, Chennai, New Delhi, Calcutta, Nagpur and Guwahati. It has different types of operational centres such as Meteorological Centres at state capitals, forecasting offices, agro-meteorological advisory service centres, flood meteorological offices, area cyclone warning centres and cyclone warning centres. There are separate divisions to deal with the specialized subjects, as well, which include:

- Agricultural Meteorology
- Civil Aviation
- Climatology
- Hydrometeorology
- Instrumentation
- Meteorological Telecommunication
- Regional Specialized Meteorological Centre
- Positional Astronomy
- Satellite Meteorology
- Seismology
- Training

(4) Organizational Structure of IMD

The IMD is under the Ministry of Earth Sciences (MoES) and the Hyderabad centre is under the technical and administrative control of the Regional Meteorological Centre in Chennai.



Source: IMD Website

Figure 198 Organizational Structure of IMD

5-2 Examples of Control Centres in Other Countries

5-2-1 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 is approximately 322 km. There are three (3) control centres in the area and each centre covers approximately 100 km of expressway. Since the metropolitan expressway is a complicated road network, the centres carry out 'management by area' by exchanging information among them for purposes such as providing alternative route information for users, taking necessary actions within its own jurisdiction, etc.

(4) Expressway Operator: Inter-City Expressway Company

(a) Roles

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

(b) Centre and Coverage Areas

Each expressway company has basically four (4) centres and each centre covers approximately 400–1,000 km of expressway. The Inter-City Expressway is not a complicated road network but it covers a long-distance and vehicles travel at high speed. Thus, each centre exchanges information in a way that the users can comprehend the conditions ahead to assure their 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.

5-2-2 Singapore

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

(1) ITS Control Centre

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

- **Expressway Monitoring and Advisory System (EMAS)**, which monitors traffic along the expressway and provides information to users.
- **Green Link Determining System (GLIDE)**, which controls the traffic signals.

- **Junctions Eyes (J-Eyes)**, which monitors the condition at the signalised junctions by CCTV.
- **Integrated Transport System,** which integrates the related sub-systems by combining all collected data from sub-systems and analyses for planning of the improvement of traffic and road infrastructure.
- **Traffic Scan**, which provides the traffic conditions on the entire area of Singapore through various medias including website to the user.
- **Parking Guidance System**, which provides the availability of the parking.

(2) ERP Control Centre

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

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.

5-3 Considerations for Establishment of ITS Centre

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).

5-3-1 Purpose of ITS Centre Establishment

It is regarded that ITS provides indispensable social infrastructure which shall be prepared together with the road infrastructure development. It is necessary to establish 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 can be provided to the private sector with or without charge. But the coordination and collaboration with the private sector is necessary. Moreover, an entity for continuous promotion of ITS in Hyderabad is strongly required since ITS implementation has not achieved full scale yet in India.

Hence, it is strongly recommended that a single entity, ITS Centre (ITSC) be established as the integrated planning and management body. ITS shall be implemented and promoted by the control and supervision of ITSC under its comprehensive coordination.

The absence of the ITSC would result in different planning initiatives, without proper and sufficient coordination, would be independently carried out by individual agencies such as GHMC, Traffic Police, APSRTC, HMDA, etc. The integrated ITS development at a later date would be difficult in such condition, and more importantly, it would result in huge loss of investment, and furthermore, additional cost and more time would be required for future re-integration.

The roles of ITSC are summarized in the figure below.

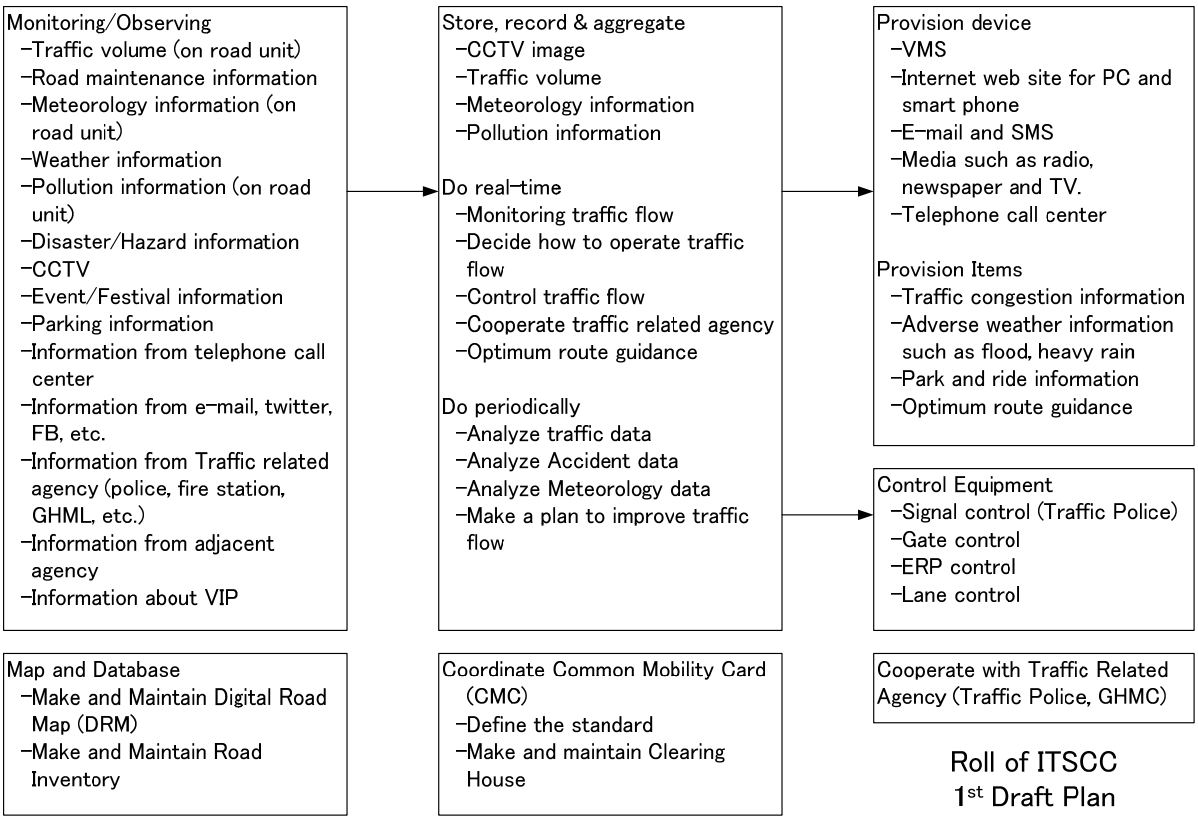


Figure 199 Role of ITSC

5-3-2 Considerations for Establishment for ITS Centre

The major issues for the establishment of ITSC are: (i) authority to be vested in the ITSC, and (ii) the scheme for the establishment. The major purposes of ITS are traffic flow measurement and traffic control. The traffic flow is measured by the traffic volume and travel time collected by probe cars

together with the traffic counters on the roadside. The generated traffic information is provided to the users from such media as VMS. The traffic is controlled by such methods as traffic signal control, electronic road pricing (ERP), lane control, lane-parking, etc.

However, the traffic information is provided and the traffic is controlled by the traffic police. Therefore, the demarcation needs to be clarified with the traffic police through coordination with them. Moreover, there must be legal restriction on traffic control if executed by the ITSC. The roadside equipment is maintained by GHMC as their own assets. The issue of the ownership, installation and maintenance of the ITS roadside equipment needs to be resolved and clarified by coordination with GHMC.

Thus, it would be ideal that the ITSC is established as the Special Purpose Vehicle (SPV) under the legal act, holding the equity powers as SPV. Thus some portion of the authority of the traffic police may be vested to the ITSC.

However it is expected that establishing the SPV may require a certain period of time for legal approval procedures. Hence, it would be practical that the operation of ITS Centre be taken care by the department of HMDA in the initial phase, and be converted into SPV in the near future once the operation is fully carried out.

5-3-3 Roles of ITS Centre: Proposed for Hyderabad

(1) Purpose of ITS Centre

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 ITS Centre

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.

(3) Schematic Entire Image of the Functions of the ITSC

The above functions are depicted in the following schematic image:

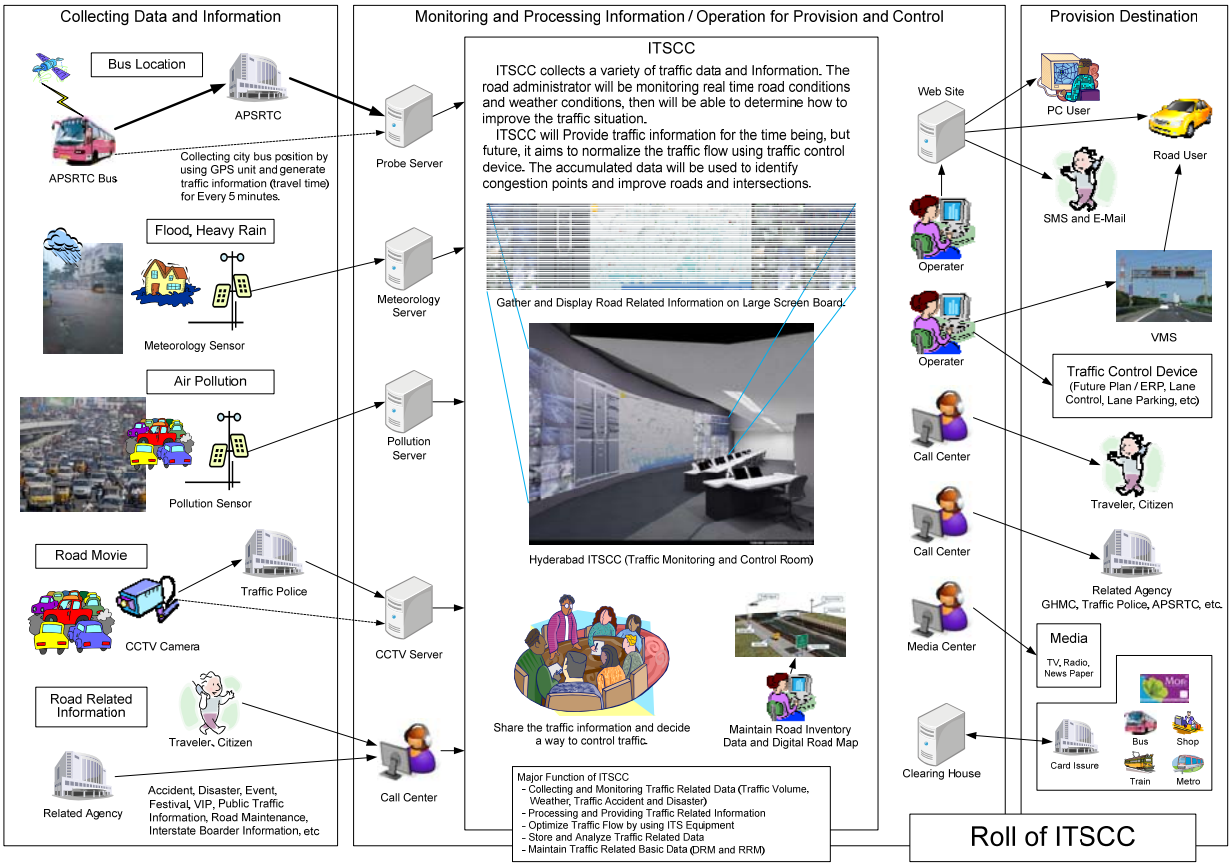


Figure 200 Schematic Image of Functions of ITSC

5-4 Organization Structure of ITS Centre

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

(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.

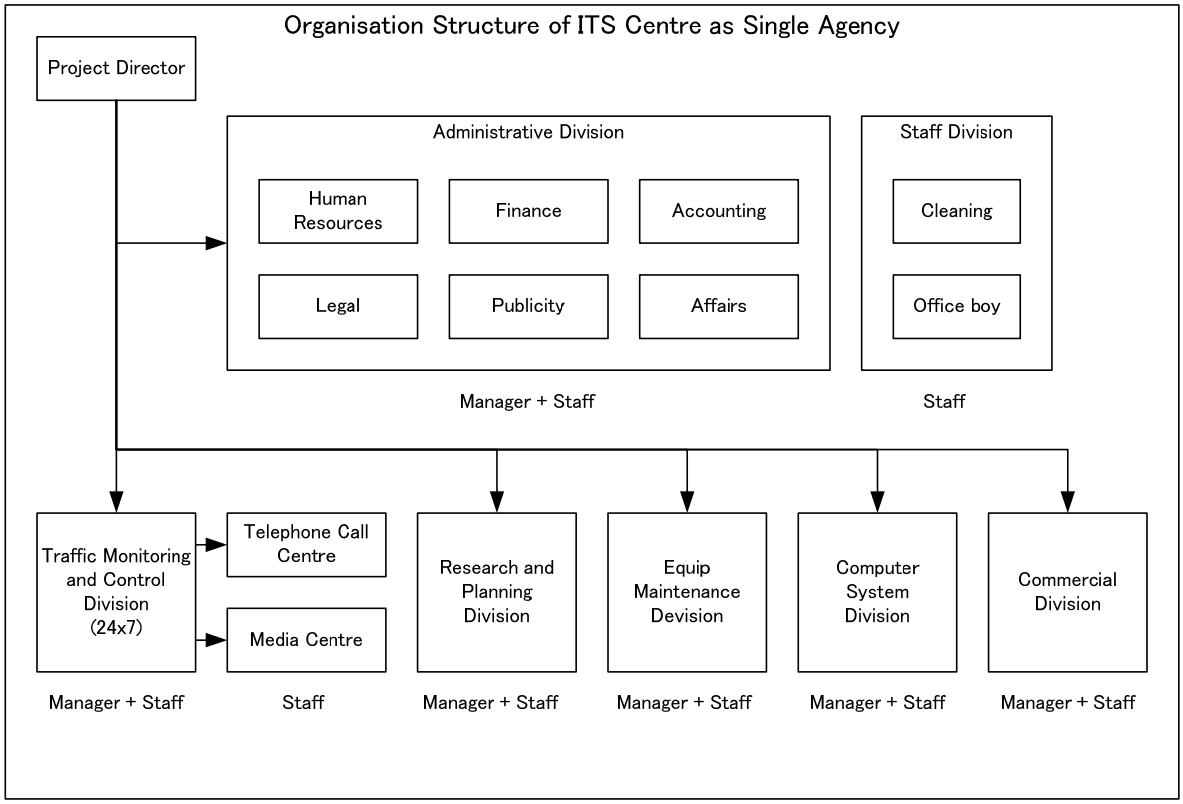


Figure 201 Organisation Structure (Single Agency)

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

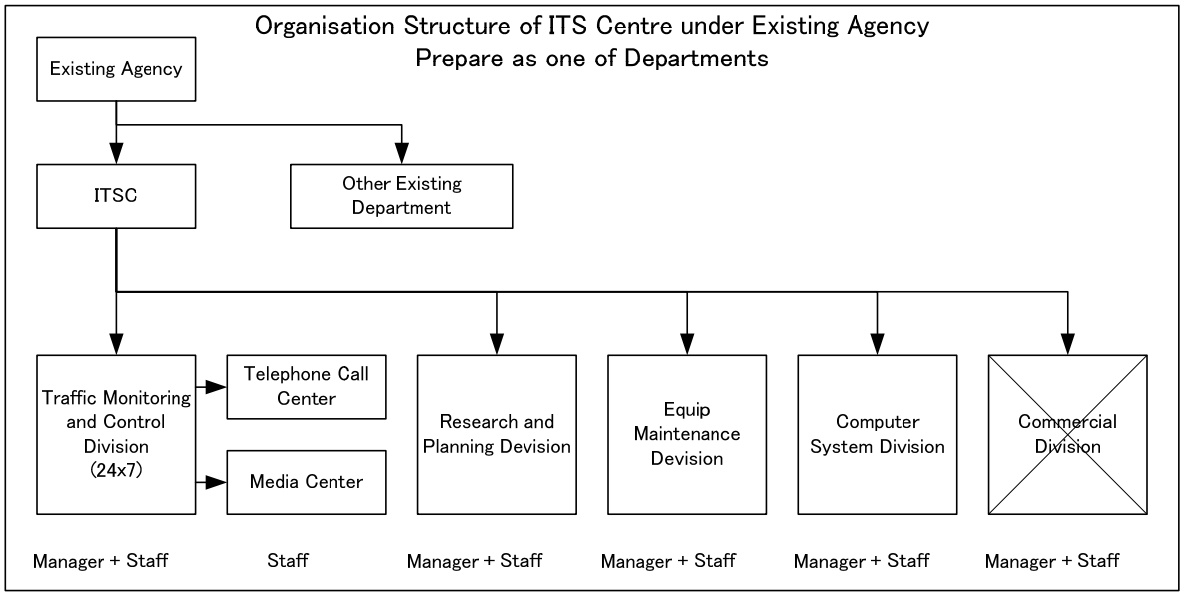


Figure 202 Organisation Structure (Under Existiong Agency)

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.

5-5 Comparison Study for ITS Centre

5-5-1 Consideration of Scheme for Establishment

There are two possible schemes for establishment of the ITSC as follows:

Scheme-1: ITSC will be entirely newly established as SPV invested by agencies such as HMDA, GHMC and Traffic Police. Personnel will be provided by these agencies. The ITSC will own and maintain the ITS equipment, and monitor the traffic flow and control traffic. The decisions on traffic control will be made by the personnel of the traffic police stationed in the ITSC.

Scheme-2: ITSC will not be established. Instead, the GHMC will own and maintain the ITS equipment. The traffic police will operate most of the equipment as they operate the traffic signals.

Scheme-1 is strongly recommended because of the necessity of the leadership and coordination among the related agencies. Strong leadership is required for continuous promotion of ITS since almost no ITS services have been implemented in Hyderabad. Furthermore, coordination among agencies such as the central government, neighbouring administrative bodies and parties in private sector is required for ITS. The development/improvement of road and transportation infrastructures such as road expansion, flyover construction, etc. needs to be carried out in parallel with and in accordance with the improvement of ITS. In this sense, an independent cross-jurisdictional agency is required.

Most important of all, the establishment of the ITSC should be initiated by the Indian government since coordination and consensus for the establishment among the involved agencies and legal preparation for the SPV are required.

5-5-2 Scheme-1: ITS Centre as SPV

(1) Methodology Outline

Major stakeholders will invest in the ITSC , namely HMDA as planning agency, GHMC as road/facilities management agency, Traffic Police as traffic management agency and APSRTC as public bus operator. APSRTC is also important to provide bus probes. The involvement of these agencies is legitimate in terms of the purpose/roles of the ITSC and provision of the personnel, as well.

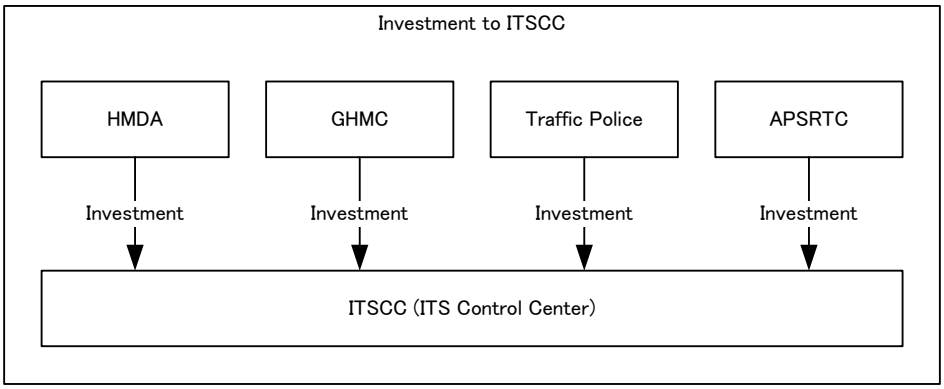


Figure 203 Agencies related to ITSC

The roles of the ITSC are: (i) promotion of ITS, (ii) ownership of the ITS equipment, (iii) monitoring the traffic condition based on the collected data and analysis/storing/utilization of the data, (iv) provision of the generated traffic information, and (v) implementation of proper traffic control

including introduction of more sophisticated traffic signal coordination, and electronic road pricing (ERP) in the future.

(2) Organizational Structure

It will consist of an administrative department and technical department under the director at the top. The administrative department includes the human resource section, finance section, accounting section, legal section, general affairs section, etc. The technical department includes the traffic monitoring and control division which monitors the collected data and conduct the traffic control, research and planning division which aggregates/analyzes the traffic data, investigate the traffic problems and reflect the plans, maintenance division for ITS equipment, and advertise division which handles the advertisement revenue. In case CMC management falls under the ITSC, another special organization in charge will be needed. Staff for the call centre will be also required if a call centre is deployed.

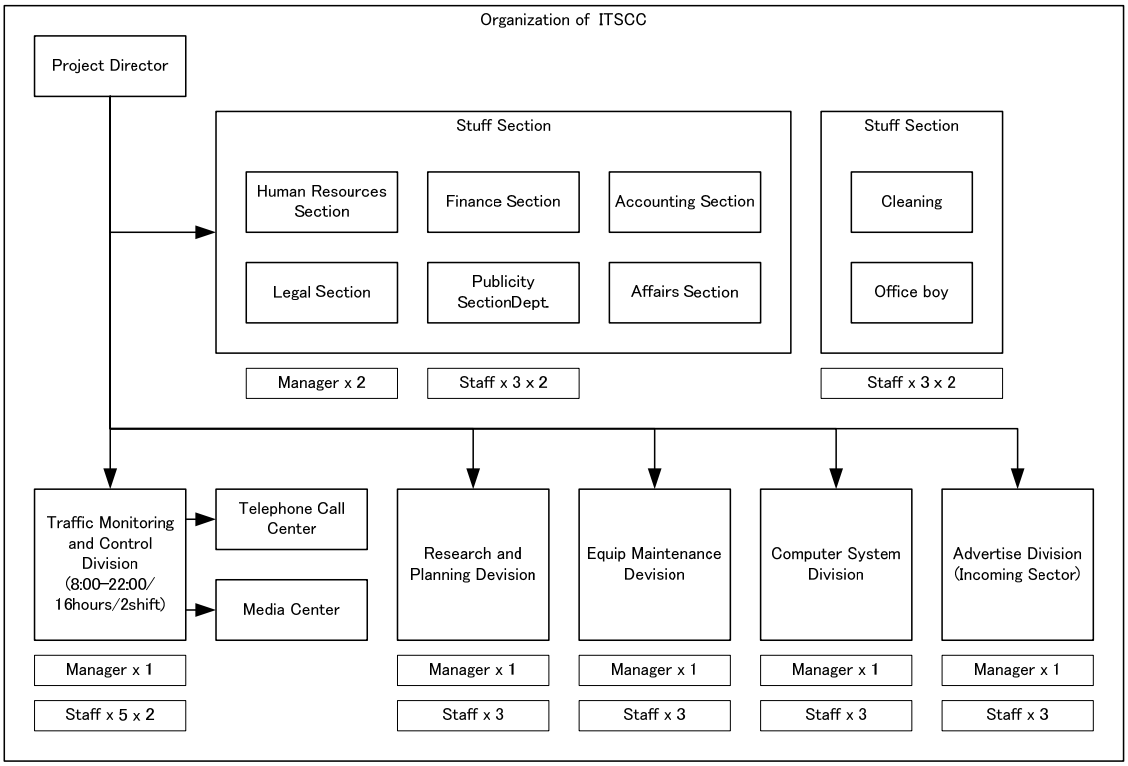


Figure 204 ITSC Organization

(3) Rough Estimate of Initial Investment and Annual Maintenance for Facilities Scheme-1

The estimated rough cost for ITS facilities to cover the initial investment and annual maintenance is summarized in the table below.

Table 110 Rough Cost Estimate for Initial Investment and Annual Maintenance

	Number of Equipment (Roadside)	Number of Equipment (Centre)	Initial Cost (INR/Crore)	Annual Maintenance Cost (INR/Crore)
ITS Centre		1	11.5	1.7
CCTV System	50	1	3	0.5

ATCC System	50	1	10	1.5
MET System	20	1	10	1.5
Probe System	1,000	1	6	0.9
VMS System	30	1	42	6.2
Web System		1	1	0.2
Total			83.5	12.5

Note: ITSC : ITS Centre
ATCC : Automatic Traffic Counter (Motion Picture Analysis)
MET : Meteorological Measurement
VMS : Variable Message Sign Board

(4) Rough Estimate of Annual Expenditure Scheme-1

The estimated rough cost for annual expenditure is summarized in the table below.

Table 111 Rough Cost Estimate for Annual Expenditure

	INR (Crore)
Human Resource	3
Facilities	1
Office Expense	0.5
Communication	2
Fuel and Electricity	1
Maintenance (*1)	12.5
Total	20.0

Note (*1): Annual Maintenance of ITS Equipment

5-5-3 Scheme-2: ITS Centre Not Established

(1) Methodology Outline

GHMC owns and maintain the ITS equipment. The traffic police operate the ITS equipment for traffic monitoring and control, the same as the traffic signals currently operated. However, the organization of ITSC will be prepared under the traffic police. The required organizational structures and personnel will be at discretion of the traffic police.

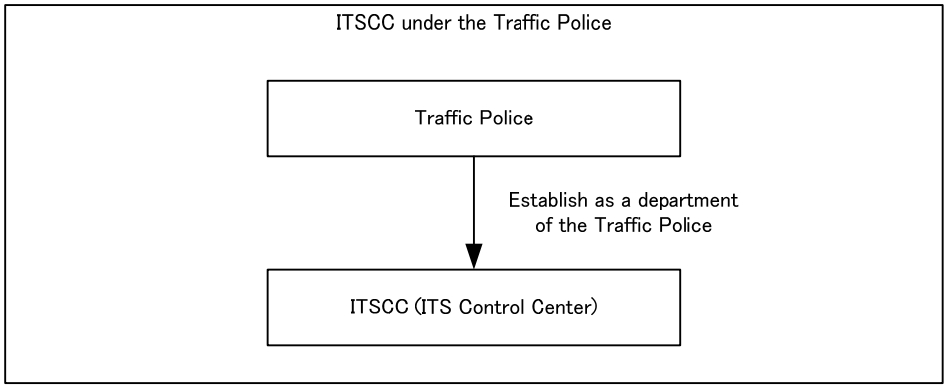


Figure 205 ITSC under Traffic Police

(2) Organizational Structure

The administrative department will be an extension of the existing corresponding divisions/departments of the traffic police. The existing technical department shall be incorporated as

well. But additional tasks and personnel will be required for monitoring the collected data, conducting traffic control, aggregating/analyzing traffic data, investigating traffic problems, and providing maintenance for the equipment. However, the division for handling the revenue from the advertisements is not to be included because the traffic police, as a governmental organization, should not be dealing with the commercial activities such as selling the traffic data. The additional staff at the call centre may not be required since it already exists.

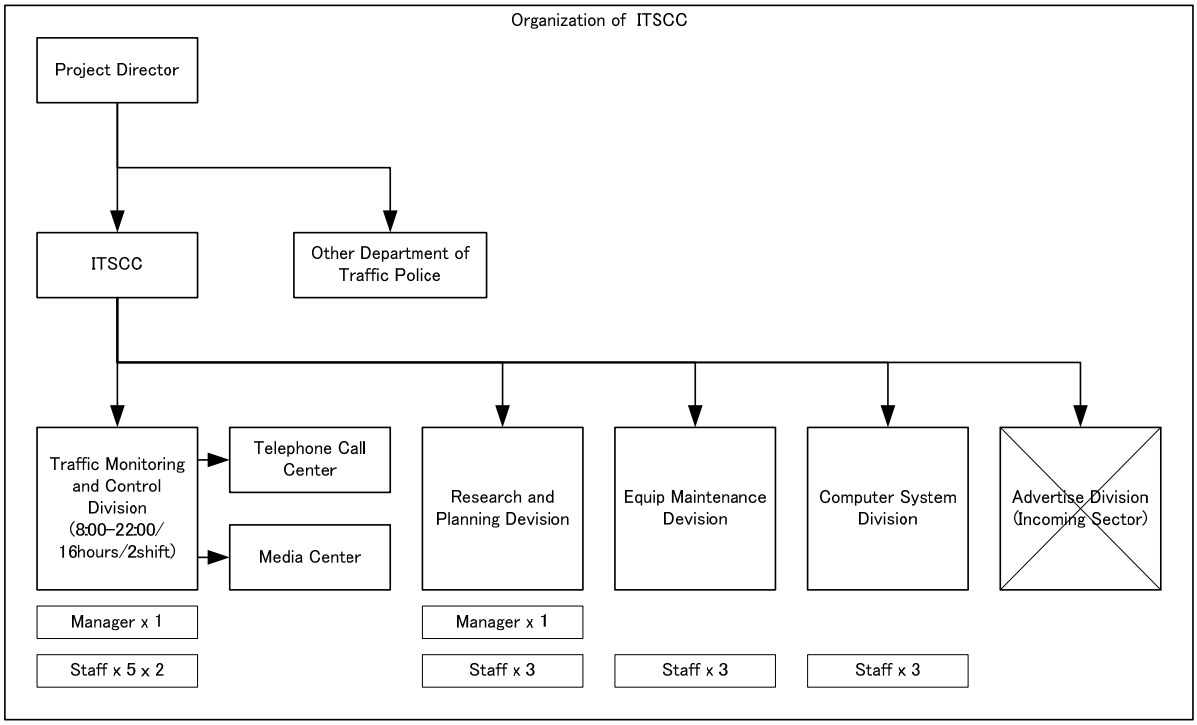


Figure 206 ITSC Organisation when under Police

(3) Rough Estimate of Initial Investment and Annual Maintenance on Facilities for Scheme-2

The estimated rough cost for ITS facilities covering the initial investment and annual maintenance is summarized in the table below. The cost becomes slightly lower than the case of the scheme-1 because of the utilization of the existing systems and equipment, although adjustments will be required.

Table 112 Rough Cost Estimate for Initial Investment and Annual Maintenance

	Number of Equipment (Roadside)	Number of Equipment (Centre)	Initial Cost (INR/Crore)	Annual Maintenance Cost (INR/Crore)
ITS Centre		1	11.5	1.7
ATCC System	50	1	10	1.5
MET System	20	1	10	1.5
Probe System	1,000	1	6	0.9
VMS System	30	1	42	6.2
Web System		1	1	0.2
Total			80.5	12.0

Note: ITSC : ITS Centre
ATCC : Automatic Traffic Counter (Motion Picture Analysis)

MET : Meteorological Measurement
VMS : Variable Message Sign Board

(4) Rough Estimate of Annual Expenditure Scheme-2

The estimated rough cost for annual expenditure is summarized in the table below.

Table 113 Rough Cost Estimate for Annual Expenditure

	INR (Crore)
Human Resource	1.5
Facilities	1
Office Expense	
Communication	2
Fuel and Electricity	1
Maintenance (*1)	12
Total	17.5

Note (*1): Annual Maintenance of ITS Equipment

5-5-4 Comparison of Scheme-1 and Scheme-2

The table shows the comparison of the scheme-1 and scheme-2.

Scheme-1: Newly Establish ITS Centre (ITSC) as SPV

Scheme-2: Not Establish ITSC. ITS Facilities Owned by GHMC, Traffic Monitoring/Control Operated by Traffic Police.

Table 114 Comparison of Schemes

Items		Scheme-1	Scheme-2
ITSC (SPV) Establishment		Newly Establish	Not Establish
Owner of Equipment		ITSC	GHMC
Role	Maintenance	ITSC	GHMC
	Traffic Monitoring	ITSC	Traffic Police
	Traffic Data Processing	ITSC	Traffic Police ITS Centre
	Traffic Information Provision	ITSC	Traffic Police
	Traffic Control	ITSC (by Traffic Police Staff)	Traffic Police
Cost (INR)	Initial Cost	83,50,00,000	80,50,00,000
	Maintenance Cost (p.a.)	4,17,50,000 (5% of Initial Cost)	4,02,50,000 (5% of Initial Cost)
	Operation Cost (p.a.)	5,50,00,000	3,80,00,000
Revenue		5,00,00,000	-
Merit		Suitable for Business with Private Sector Suitable for Obtaining Revenue by Business	Less Costly compared to Plan 1 (by Utilizing Existing Centres/Systems, Equipment, Staff)

	Suitable for Coordination with Stakeholder Suitable for Coordination with National Level Authority Much Potential for Expansion of Future ITS Application	Common Scheme in India Communication Network Not Required for CCTV
Demerit	Little More Costly than Scheme- 2 (because of creation of new organization/centre) Communication Network Installation for CCTV Required	Required to Cover the Expenses in the Budget of the Police Difficult in Taking Revenue Except E-Challan Difficulty in Expansion of Future ITS Application Required GPS on APSRTC Maintenance (if GPS prepared by JICA)
Items to be Confirmed	SPV can be authorized for traffic control? (Staffed by Police for decision on traffic control) Sharing of Roles with Police for Traffic Control Information Exchange with Police on Traffic Coordination for VMS Required (RFP)	Police can conduct business with private sector? (e.g. selling traffic data, optimum route guidance etc) Coordination for VMS Required (RFP)

5-5-5 Recommendation of ITS Centre as SPV

Based on the considerations so far, it is recommended to establish a Special Purpose Vehicle (SPV) for ITS Centre for the following reasons:

- Strong leadership is required for continuous initiatives for ITS in Hyderabad especially since no substantial ITS has been implemented.
- Strong coordination among related agencies is required since the domain of ITS extends across different agencies. The different agencies include the central government in line with national ITS policy, neighbouring administrative bodies in Andhra Pradesh State, agencies in transportation sector, and parties in the private sector.
- A simplified structure for operation and coordination among the related agencies is more favourable, considering the current complex jurisdictional structures in the road transportation sector.
- ITS Centre shall have a function for conducting businesses for revenue generation by interacting with private sector.

The SPV shall function as execution body for operation, planning, evaluation of the project on the bases of the above concepts. It shall be invested by agencies such as HMDA, GHMC, RTA and APSRTC. The personnel will be provided by these agencies. It will own and maintain the ITS equipment, monitor the traffic flow and control traffic. The decisions on the traffic control will be made by the staff deputed from the traffic police to the ITS Centre.

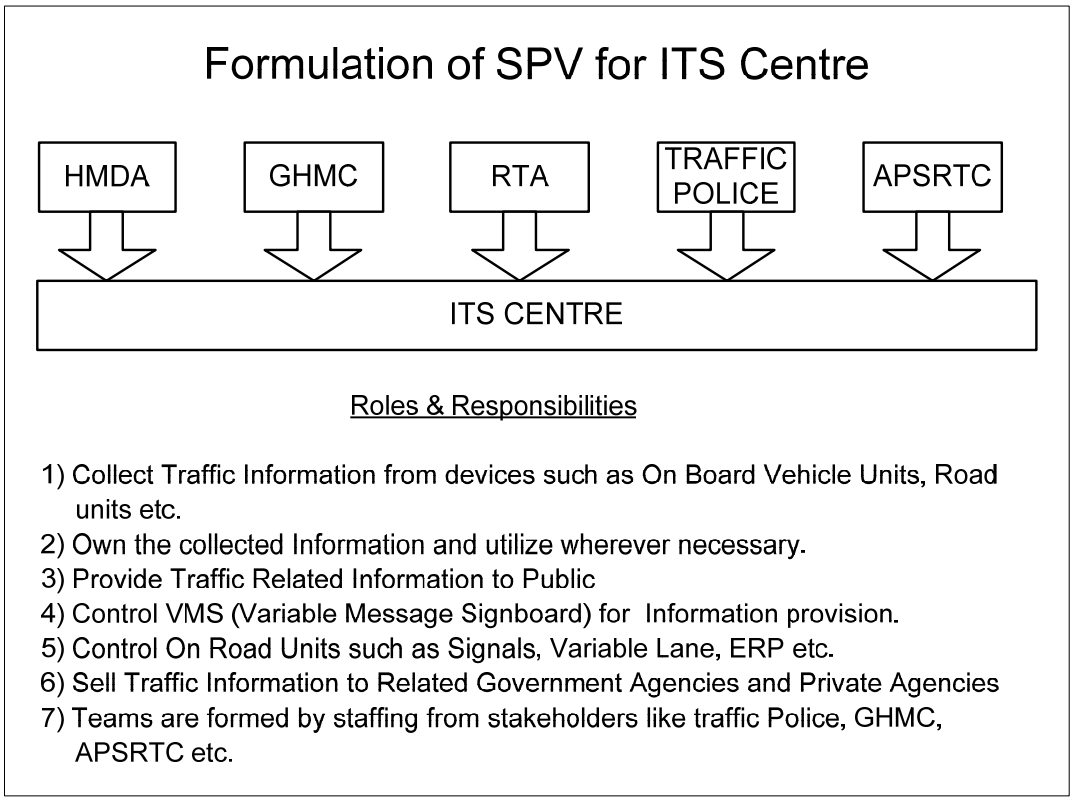


Figure 207 Formulation of SPV for ITS Centre

6 Financing Plan and Funding Scheme

6-1 Approximate Cost of Phased Implementation

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

Table 115 Approximate Cost by Phase (Unit=INR)

Cost Type	Items	PHASE 1	PHASE 2
Capital Cost	Equipment Capital Cost	1,10,36,00,000	3,22,40,00,000
Equipment Maintenance Cost	1st stage Cost (10% of Capital Cost)	11,03,60,000	11,03,60,000
	2nd stage Cost (10% of Capital Cost)	0	32,24,00,000
Cost spread across 5 years	Equipment Maintenance Cost	33,10,80,000	1,51,90,00,000
	Human Resource 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. Equipment cost of phase-2 includes the cost of phase-1 equipment also.

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

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

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

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

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

Table 116 Approximate Capital Cost by Phase

No.	Devices	PHASE 1		PHASE 2	
		Units	Approx Cost	Units	Approx Cost
1	ITS CENTRE		18,21,21,500		5,11,80,000

No.	Devices	PHASE 1		PHASE 2	
		Units	Approx Cost	Units	Approx Cost
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**

6-2 Life Cycle of ITS Equipment Impacting Required Cost

It should be noted that the life cycle differs by the ITS component. The components of ITS are roughly categorized as: i) information facilities, ii) communication facilities, iii) electricity facilities and iv) civil facilities. The approx. life cycle of the information facilities is, in general, five to ten (5-10) years with the average of seven (7) years because they mostly consist of the computers. The approximate life cycle of the communication facilities is, in general, ten to twenty (10-20) years with the average of fifteen (15) years, and the electric facilities, fifteen to twenty five (15-25) years with the average of twenty (20) years, the civil facilities, twenty to forty (20-40) years with the average of thirty (30) years. These values differ depending on factors such as the condition of the maintenance and installed environment, etc.

In view of the above and targeting ITS operation for thirty (30) years, it is required that the information facilities shall be replaced at least three (3) times, and likewise, the communication facilities and electricity facilities once during the thirty (30) years operation. The table below summarizes the life cycles of the ITS equipment by the component category. These factors shall be considered for the maintenance cost of ITS.

Table 117 Life Cycle of ITS Equipment by Component Category in General

Category	Life Cycle in General (Years)			Remark
	Min	Max	Avg	
Information Facility	5	10	7	Mainly Computers
Communication Facility	10	20	15	
Electricity Facility	15	25	20	
Civil Facility	20	40	30	

6-3 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.

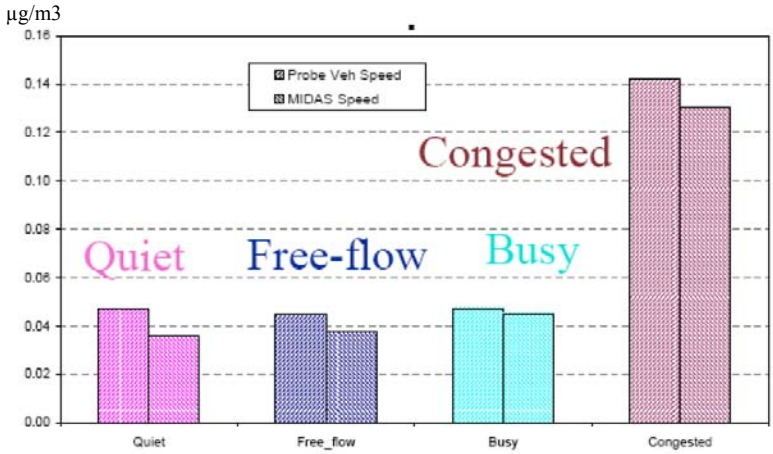


Figure 208 Levels of Pollution Depends on Congestion Level

(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).

6-4 Proposed Revenue Scheme for ITS Centre

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

- Public fund such as tax.
- Selling the traffic information to interested parties in public and private sectors.

(1) Tax & Annuity Model

In essence, the traffic information is to be provided to the public as public services. The traffic flow control is also to be offered to the public for improving traffic conditions. Thus, these do not generate any revenues. In other words, this aspect holds legitimacy for being covered by public funds. In this case, provision of annuity is required to cover the operation and maintenance of ITS Centre.

(2) Commercial Model

On the other hand, the generated traffic information based on the dynamic realtime traffic movement or aggregated data on traffic based on the statistics will have added-value. They can be utilised for a number of purposes. For example utilization 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 a possibility that the generated traffic data by the ITS Centre can be sold to the interested parties in both government and private sector.

(3) Proposed Model (Combination of Above)

In case that the ITS Centre is established as SPV, the combination of the tax & annuity and

commercial model, called Hybrid Model, is appropriate.

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

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

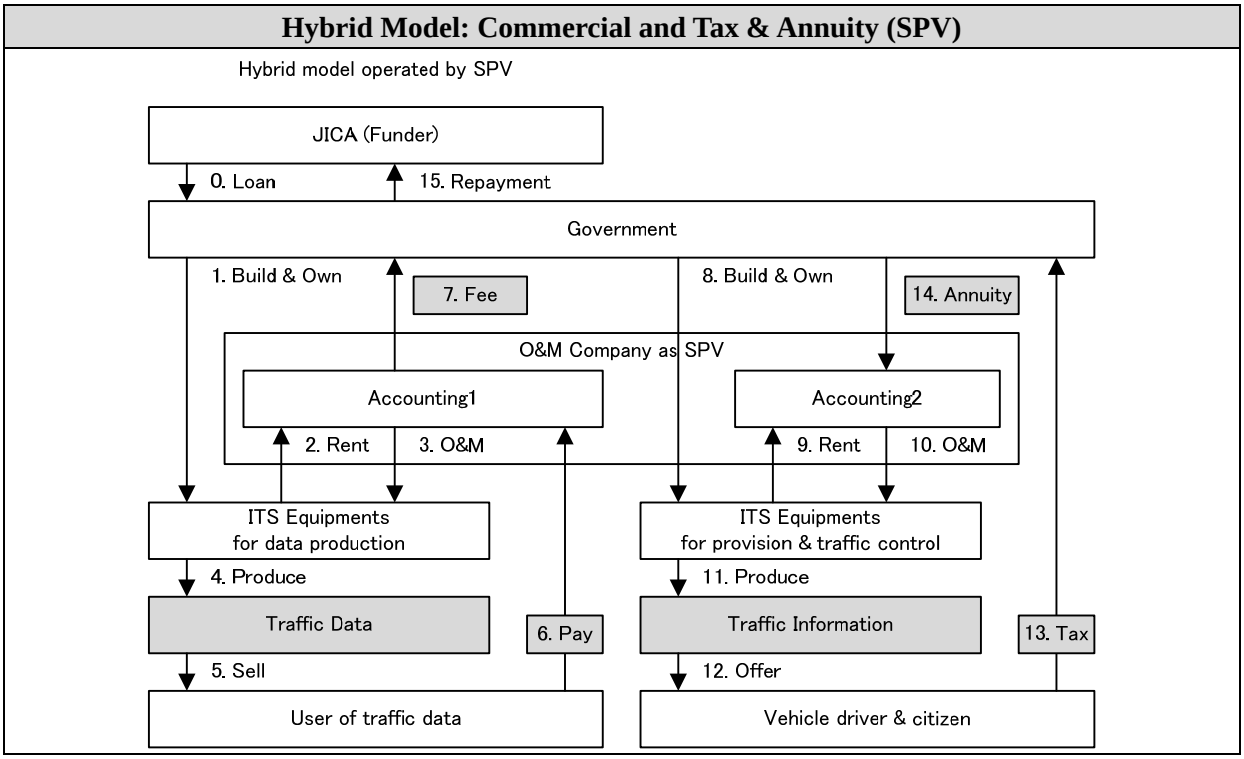


Figure 209 Hybrid Model: Commercial and Tax & Annuity (SPV)

(4) Other Options

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

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

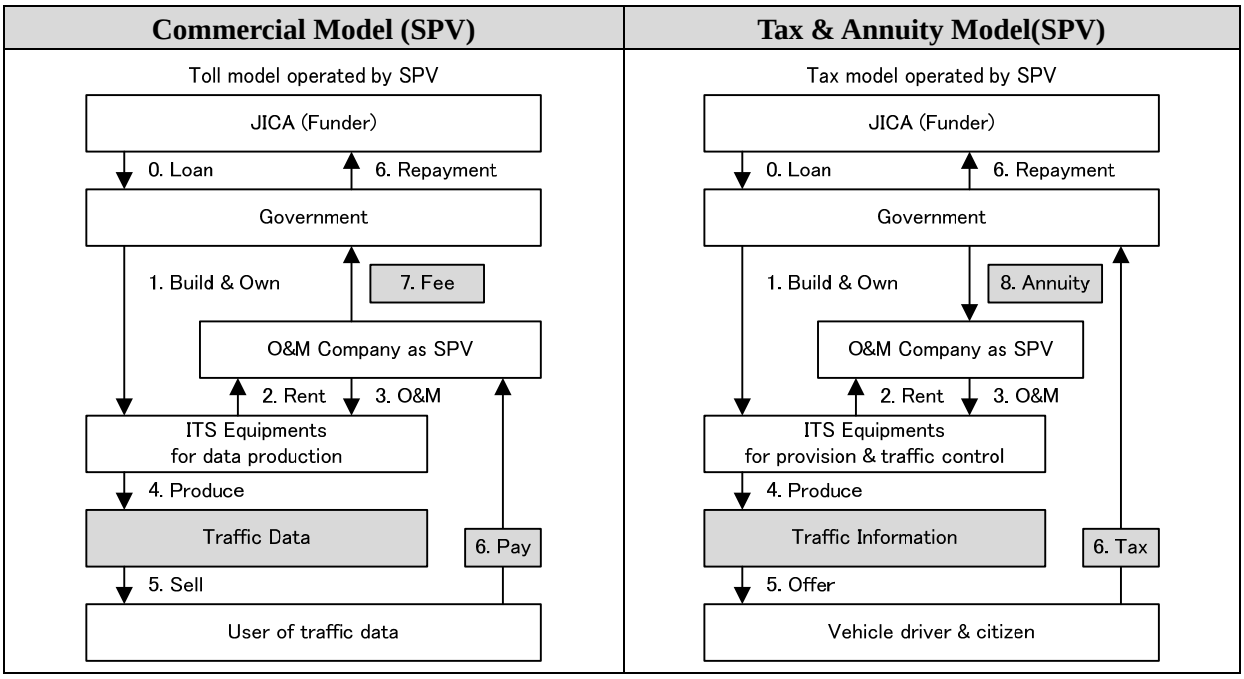


Figure 210 Build by Government, Operated and Maintained by SPV

The above cases both show creation of SPV for operation and maintenance of ITS equipment and facilities. In this case, the Government builds ITS equipment and facilities and the SPV operates and maintains, as shown in the recommended hybrid model above in this aspect. The differences between the figure on the left and right are the revenue sources: namely either commercial base or tax base.

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

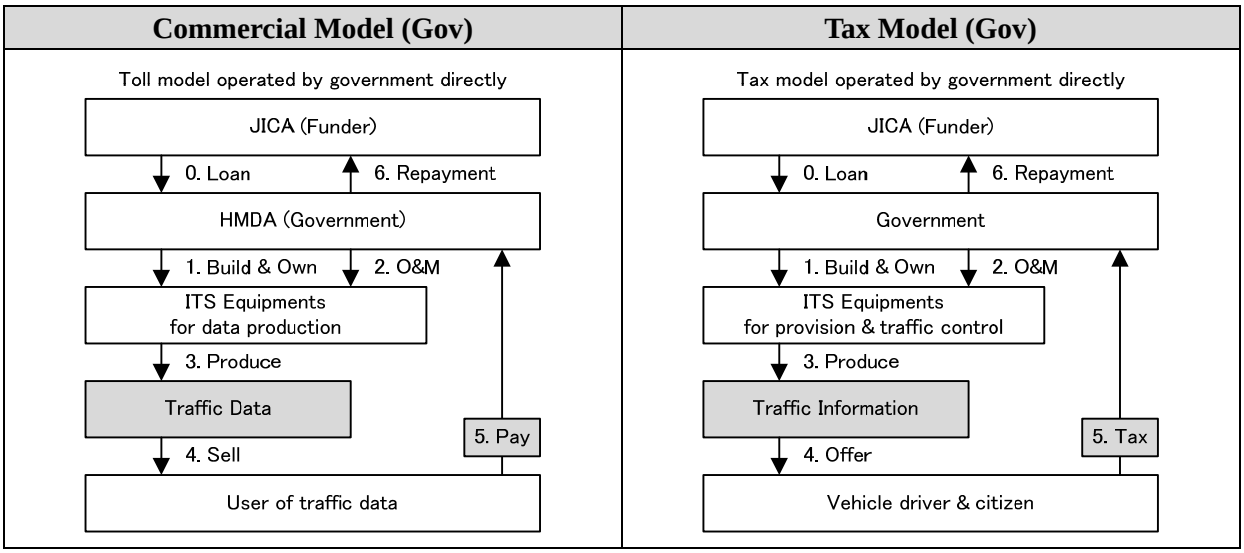


Figure 211 Build, Operated and Maintained by Government

The above cases both show cases 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, the ITS Centre will be prepared and operated under the division of the existing governmental agency.

The figure on the left shows the fee collection model under this scheme. The Government

directly earns revenue by selling the traffic data as their product to the interested parties.

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

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

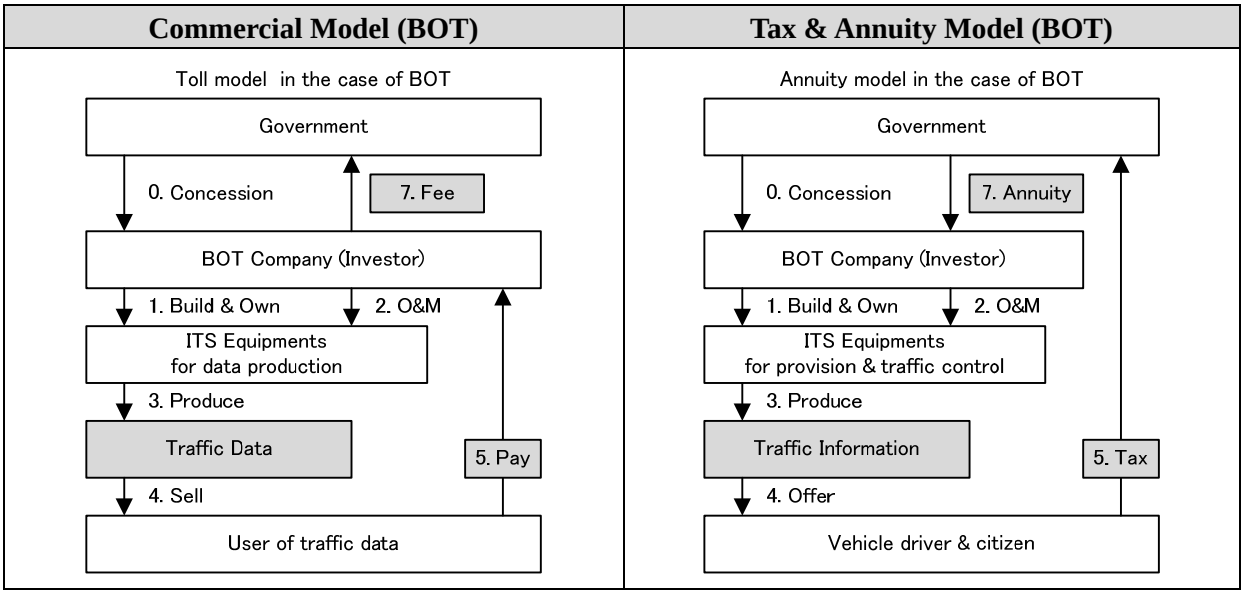


Figure 212 Build, Operated and Maintained by Private Firm (BOT)

The above cases both show cases that the ITC Centre is built and operated under BOT scheme by the private firm. The differences between the figures on the left and right are the revenues sources: namely by commercial base or tax/annuity base.

Neither above are recommendable due to the following reasons:

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

6-5 Possible Schemes for Revenue Generation

6-5-1 Most Likely Scenario

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

The provision of ITS services realised by the ITS Centre as proposed in the Master Plan is the first of its kind in India. Thus, it may take a certain period until the general public become aware of the benefits of the ITS services provided by the ITS Centre. In such circumstances, it would not be practical to leverage revenue sources such as tax or user fee collection from the public for covering the required cost unless the general public sufficiently appreciate the benefit. 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 Governmental funds during this initial period. Once the benefit is fully recognised by the public, the following options will become possible:

Table 118 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
	Reallocation of life tax
	Reallocation of e-Challan
	Reallocation of property tax
Commercial Model	Advertising
	Sales of traffic data

6-5-2 Tax and Annuity Model

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

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

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

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

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

Table 119 ITS User Charge for Revenue Generation

Items	Amount
Vehicles Registered per Year in Hyderabad City	3,50,000
Estimated 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 workload of the traffic police is spent on traffic regulation and only 30% of the work-load on enforcement. It is mostly assumed that such large proportion on the traffic regulation is due to the adverse traffic conditions and existing traffic signals, which 40% are not properly working.

If the road traffic infrastructure is improved, enforcement can be strengthened spending more of the traffic police time on the enforcement activities. It will consequently lead to increment of 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 ITS Centre.

(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 ITS Centre.

(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 ITS Centre.

6-5-3 Commercial Model

(1) Revenue Generation by Advertisements

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

Estimated revenue generation from advertising is summarized below.

Table 120 Estimated Revenue Generation by Advertisement

Items	Amount
Vehicle Population in Hyderabad City (RTA figures 2010)	Vehicle count: 36,83,000
Consider 5% of total vehicle owners use Traffic Information provision	Assumed user count: 2,00,000
Consider Vehicle Owners use 10 times/day	20,00,000 usages / day (200,000 x 10 = 20,00,000)
Consider Advertisement 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 Traffic Related Data

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

It shall be offered to public free of charge. However, 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 freely copied and modified by unknown users.

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

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

- Traffic volume
- Travel speed
- Congestion status

- Vehicle classification
- Weather condition

6-5-4 Conclusion

Conceivable annual revenue scenarios have been summarised in the above section. As explained above, 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 be difficult to convince the public about the benefits of such utility initially and generate revenue for the ITS Centre from the day one of the project operation. But with the continuous usage and provision of basic user services by the ITS Centre, the public will surely recognize the benefits of the system and accept to pay for additional services.

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

To supplement the revenue, the ITS Centre can generate additional revenue through selling the data to various Organizations, advertising while data provision to users and other avenues as mentioned in the above sections.

6-6 Economic Analysis

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

6-6-1 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

6-6-2 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

Signal Installation

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

Information Provision

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

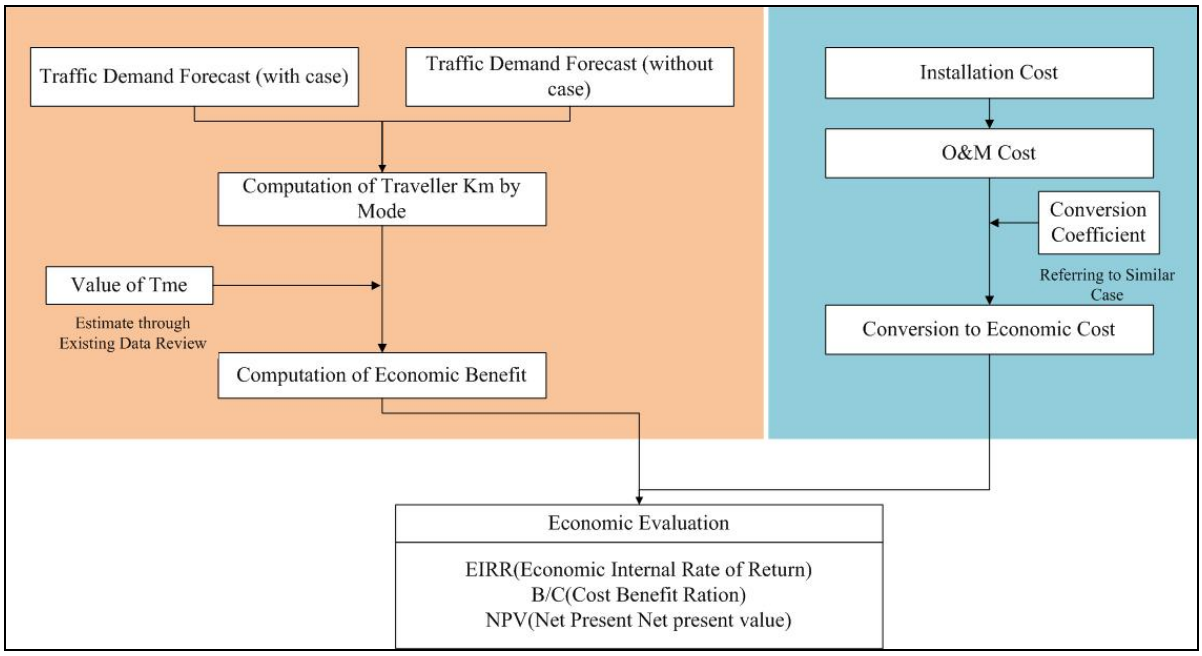
In strict terms for estimating the benefit brought by ITS implementation, the evaluation of 'Information Provision' would be sufficient. However with and without cases of signal installation are also provided because the signals are one of the important factors influencing traffic.

(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 213 Workflow of Economic Analysis

The cost for installation and operation and maintenance which are incorporated into the above

shown economic evaluation is estimated as presented below.

The details of approximate cost mentioned in the table below are provided in the clause 6-1Approximate Cost of Phased Implementation.

Cost Type	Items	PHASE 1	PHASE 2
Capital cost	Equipment Capital Cost	1,10,36,00,000	3,40,66,00,000
Equipment Maintenance Cost	1st stage Cost	11,03,60,000	11,03,60,000
	2nd stage Cost	0	34,06,60,000
Cost spread across 5 years	Equipment maintenance Cost	33,10,80,000	1,57,37,80,000
	Human Resource 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	2,02,13,60,000

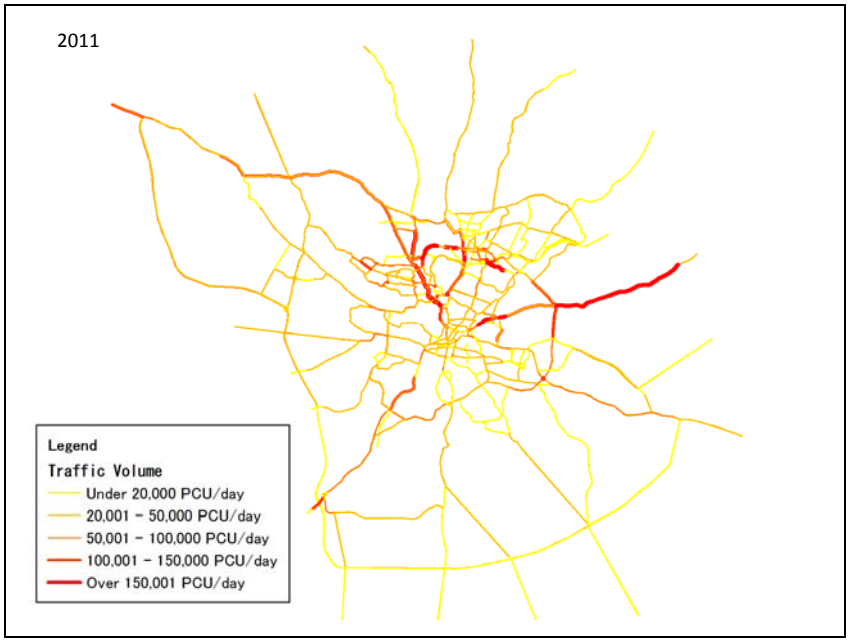
Source: JICA Study Team

Figure 214 ITSC Installation Cost

6-6-3 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 215 Current Traffic Analysis (Year 2011)

(2) Future Traffic Demand

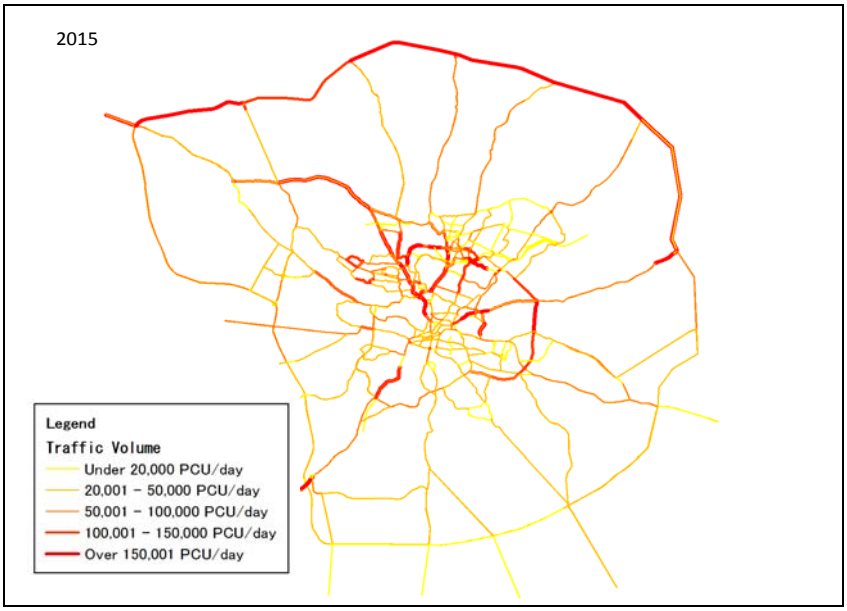
The traffic demand will be diverted to the Outer Ring Road and the roads which connect with ORR due to the development of ORR. Concentration of traffic is observed on NH9, NH7, NH202, IRR, ORR and others in the vicinity of Hussainsagar, in particular. It is expected that the traffic will further be concentrated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

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

Table 121 Result of Traffic Assignment at Arterial Road

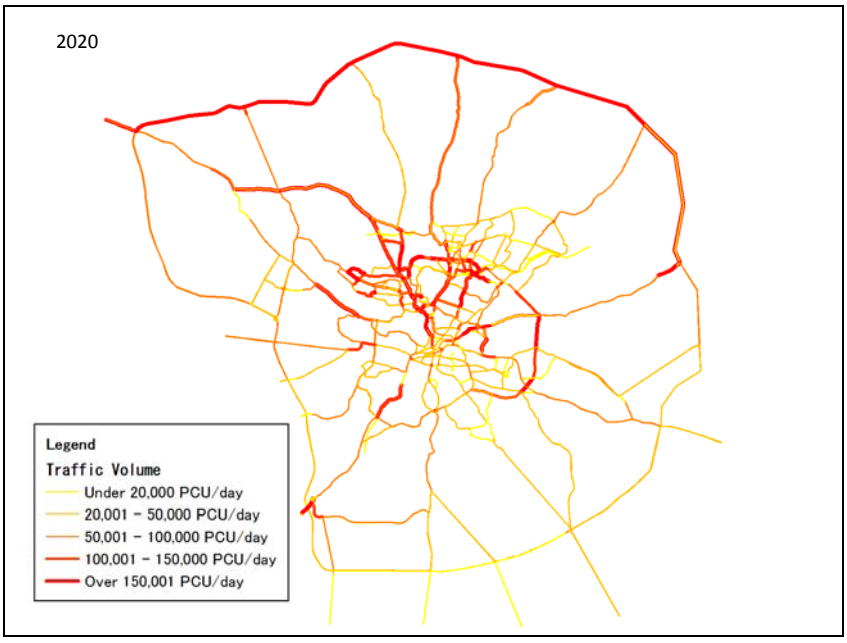
Year / Road	Traffic Volume (Average PCU/day)			
	2011	2015	2020	2030
NH7	42,875	59,075	72,100	130,930
NH9	80,803	98,674	118,796	179,579
NH202	98,868	114,243	129,984	191,190
IRR	65,807	85,654	105,443	207,933
ORR	22,408	38,901	46,226	73,738
Others	32,817	43,754	53,950	104,137

Source: JICA Study Team



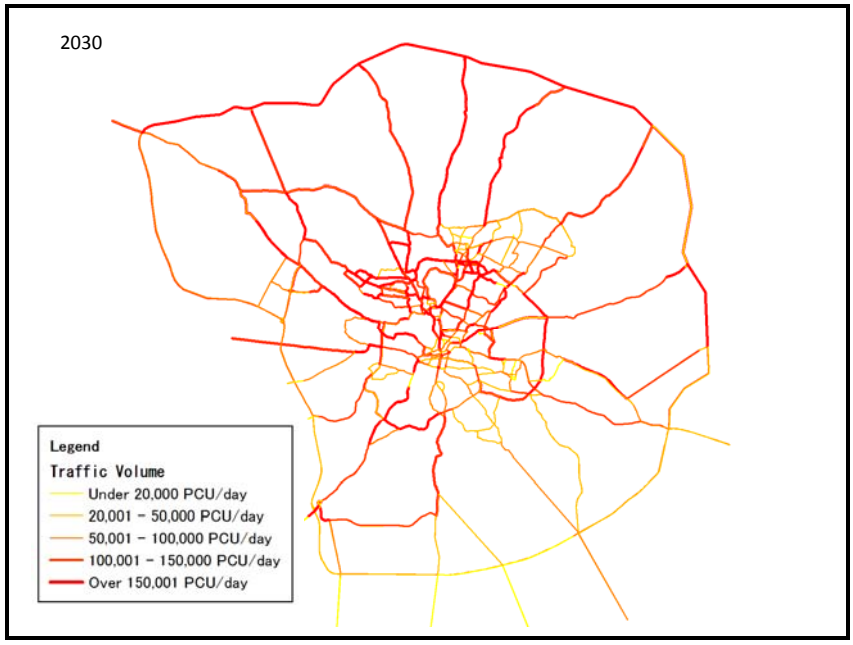
Source: JICA Study Team

Figure 216 Traffic Assignment Result 2015



Source: JICA Study Team

Figure 217 Traffic Assignment Result 2020



Source: JICA Study Team

Figure 218 Traffic Assignment Result 2030

6-6-4 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 122 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 case 2, Information Provision (only), and case 3, Signal Installation and Information Provision (combined).

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

In consideration of this, the availability of the realtime 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 123 Result of Economic Evaluation for Case 3

Evaluation Indicators	Values
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.

6-7 Financial Analysis

(1) Condition of Financial Analysis

The Internal Rate of Return (IRR) was calculated based on the traditional discount cash flow method. The financial analysis was carried out for ITS proposed in phase-1. The following conditions were considered;

- Basic Conditions
  - ✓ JICA loan at 1.2% rate
  - ✓ 10 years grace period
  - ✓ 30 years repayment period
- Expenditure
  - ✓ One time capital cost for ITS equipment in phase-1
  - ✓ Equipment replacement cost
  - ✓ Operation and maintenance cost
- Revenue
  - ✓ Mandatory Revenue:
    Mandatory one time ITS user charge, assumed at INR 130 for 4-wheeler and INR 30 for 2-wheelers
  - ✓ Optional Revenue:
    Selling traffic data, assumed at INR 50,000,000 per annum

The one time capital cost, which is ITS equipment in phase-1, is assumed to be funded by JICA loan. The equipment replacement cost consideres the expected life span of equipment. It is assumed by IT unit for 7.5 years, communication facilities for 15 years, electric facilities for 20 years and civil facilities for 30 years. The maintenance cost is assumed to incure 5% of initial cost every year after defect liability period for 2 years. The operation cost is due to human resource cost after commencement of operation.. The equipment replacement plan is shown in the table below.

Table 124 Equipment Replacement Plan

Replacement Years	Remark
7.5	IT Unit
15	Communication System
20	Electric Equipment
30	Civil Works

It is assumed to collect a mandatory one time ITS user charge from 4-wheeler users at INR 130 and 2-wheeler users at INR 30 at the time of vehicle registration. This is on the assumption that the users pay the one-time charge for ITS as public service. The currently registered number of 4-wheelers and 2-wheelers in Hyderabad and approximate forecasted growth rate for the next 30 years are considered.

As optional revenue for ITS in addition to the mandatory one time ITS charge, it was considered that the road and traffic information generated by ITS centre would be sold to public and private sectors for planning, marketing, etc. at INR 50,000,000 per year. The sales will start 5 years after commencement of operation of ITS centre, considering that the data which has commercial value may be generated after accumulation of data collection.

The Hyderabad city has recorded in recent years a phenomenal growth of 4-wheeler and 2-wheeler vehicles with increase of middle class population. The city population recorded a growth rate of around 2.8% during the year of 2010-11, and it is assumed to slow down gradually to around 1.34% by the next 30 years. As per the indicative patterns, at present an approximate 5% of city dwellers own 4-wheelers and an approximate 20% own 2-wheeler vehicles. The number of the vehicles including 4-wheelers and 2-wheelers will keep on growing during the next 30 years. On the other hand, it is assumed that the increment rate of the vehicles will gradually decrease as the ownership ratio increases in the future, as a natural phenomenon which is commonly observed in general. It is also expected that the growth of 2-wheelers may peak-out in the near future as the majority of the population shift to 4-wheelers owners if the economy steadily grows.

The table shown in Table 126 provides the calculation of the amount of revenue generated by collecting the one-time ITS user charge of the amount described above at the time of registration, which is based on the forecast of the number of registered vehicles above described.

The table shown in Table 127 shows the balance of payment remaining under two possible schemes: inclusive of Optional Revenue and without Optional Revenue. The table in the next page provides the details of these calculations by year.

The IRR (Internal Rate of Return) is prepared based on the balance calculated for the loan repayment period of 30 years. The balance is arrived at by considering expenditures such as loan payment, O&M cost, replacement cost, and income such as mandatory ITS User charge and optional revenue (e.g. advertisement and data sales).

The IRR is the interest rate (also known as the discount rate) that will bring a series of cash flows (positive and negative) to a net present value (NPV) of zero. Higher IRR is beneficial for the Organization as it indicates the discounted rate at which the current NPV will become zero within the stipulated period of loan of payments.

(2) Result of Financial Analysis

In the case of ITS Pilot project, the financial analysis presented an NPV for INR 169 crore with a loan period of 30 years. Based on the cash inflows and outflows as presented in the financial analysis, it is calculated that IRR (the discount rate) with inclusive of optional revenue is 21% and without optional revenue is 20%.

Table 125 Internal Rate of Return (IRR)

	Balance with Optional Revenue	**Balance without Optional Revenue**
IRR	**21%**	**20%**

The table on the next page shows the calculation of financial analysis.

Table 126 Revenue Generated from One-Time ITS User Charge

Willing to Pay for knowing congestion and disaster point

	4 Wheel	2 Wheel
WTP (INR/Year)	130	30

No.	Year	Number of Registration				Willing to Pay			growth rate	population	Rate of Owner	
		Assumed Growth Rate	4 Wheel	Assumed Growth Rate	2 Wheel	4 Wheel	2 Wheel	Total			4 Wheel	2 Wheel
1	2011	13.0%	500,000	15.0%	2,000,000	65,000,000	60,000,000	125,000,000	2.80%	10,000,000	5.0%	20.0%
2	2012	12.7%	563,472	13.5%	2,270,000	73,251,389	68,100,000	141,351,389	2.76%	10,280,000	5.5%	22.1%
3	2013	12.4%	633,280	12.0%	2,542,400	82,326,422	76,272,000	158,598,422	2.72%	10,563,671	6.0%	24.1%
4	2014	12.1%	709,802	10.5%	2,809,352	92,274,198	84,280,560	176,554,758	2.68%	10,850,885	6.5%	25.9%
5	2015	11.8%	793,400	9.0%	3,062,194	103,142,048	91,865,810	195,007,858	2.64%	11,141,508	7.1%	27.5%
6	2016	11.5%	884,421	7.5%	3,291,858	114,974,733	98,755,746	213,730,479	2.60%	11,435,396	7.7%	28.8%
7	2017	11.2%	983,181	6.0%	3,489,370	127,813,578	104,681,091	232,494,669	2.56%	11,732,399	8.4%	29.7%
8	2018	10.9%	1,089,966	4.5%	3,646,391	141,695,553	109,391,740	251,087,293	2.52%	12,032,357	9.1%	30.3%
9	2019	10.6%	1,205,018	3.0%	3,755,783	156,652,306	112,673,492	269,325,798	2.48%	12,335,105	9.8%	30.4%
10	2020	10.3%	1,328,532	1.5%	3,812,120	172,709,167	114,363,595	287,072,762	2.44%	12,640,467	10.5%	30.2%
11	2021	9.9%	1,460,647	0.0%	3,812,120	189,884,134	114,363,595	304,247,729	2.39%	12,948,263	11.3%	29.4%
12	2022	9.6%	1,601,437	0.0%	3,812,120	208,186,855	114,363,595	322,550,450	2.35%	13,258,302	12.1%	28.8%
13	2023	9.3%	1,750,905	0.0%	3,812,120	227,617,628	114,363,595	341,981,223	2.31%	13,570,387	12.9%	28.1%
14	2024	9.0%	1,908,973	0.0%	3,812,120	248,166,442	114,363,595	362,530,036	2.27%	13,884,316	13.7%	27.5%
15	2025	8.7%	2,075,477	0.0%	3,812,120	269,812,070	114,363,595	384,175,665	2.23%	14,199,875	14.6%	26.8%
16	2026	8.4%	2,250,163	0.0%	3,812,120	292,521,253	114,363,595	406,884,848	2.19%	14,516,848	15.5%	26.3%
17	2027	8.1%	2,432,677	0.0%	3,812,120	316,247,977	114,363,595	430,611,571	2.15%	14,835,009	16.4%	25.7%
18	2028	7.8%	2,622,561	0.0%	3,812,120	340,932,888	114,363,595	455,296,483	2.11%	15,154,127	17.3%	25.2%
19	2029	7.5%	2,819,253	0.0%	3,812,120	366,502,855	114,363,595	480,866,450	2.07%	15,473,963	18.2%	24.6%
20	2030	7.2%	3,022,082	0.0%	3,812,120	392,870,699	114,363,595	507,234,294	2.03%	15,794,274	19.1%	24.1%
21	2031	6.9%	3,230,270	0.0%	3,812,120	419,935,125	114,363,595	534,298,720	1.99%	16,114,810	20.0%	23.7%
22	2032	6.6%	3,442,930	0.0%	3,812,120	447,580,854	114,363,595	561,944,449	1.95%	16,435,315	20.9%	23.2%
23	2033	6.3%	3,659,069	0.0%	3,812,120	475,678,986	114,363,595	590,042,580	1.91%	16,755,530	21.8%	22.8%
24	2034	6.0%	3,877,597	0.0%	3,812,120	504,087,592	114,363,595	618,451,186	1.87%	17,075,188	22.7%	22.3%
25	2035	5.7%	4,097,327	0.0%	3,812,120	532,652,555	114,363,595	647,016,150	1.83%	17,394,020	23.6%	21.9%
26	2036	5.4%	4,316,990	0.0%	3,812,120	561,208,651	114,363,595	675,572,245	1.79%	17,711,751	24.4%	21.5%
27	2037	5.1%	4,535,237	0.0%	3,812,120	589,580,866	114,363,595	703,944,460	1.75%	18,028,103	25.2%	21.1%
28	2038	4.7%	4,750,661	0.0%	3,812,120	617,585,957	114,363,595	731,949,551	1.71%	18,342,793	25.9%	20.8%
29	2039	4.4%	4,961,802	0.0%	3,812,120	645,034,221	114,363,595	759,397,816	1.66%	18,655,538	26.6%	20.4%
30	2040	4.1%	5,167,165	0.0%	3,812,120	671,731,471	114,363,595	786,095,066	1.62%	18,966,049	27.2%	20.1%
31	2041	3.8%	5,365,240	0.0%	3,812,120	697,481,178	114,363,595	811,844,772	1.58%	19,274,036	27.8%	19.8%
32	2042	3.5%	5,554,514	0.0%	3,812,120	722,086,764	114,363,595	836,450,358	1.54%	19,579,209	28.4%	19.5%
33	2043	3.2%	5,733,492	0.0%	3,812,120	745,354,004	114,363,595	859,717,598	1.50%	19,881,272	28.8%	19.2%
34	2044	2.9%	5,900,719	0.0%	3,812,120	767,093,496	114,363,595	881,457,090	1.46%	20,179,933	29.2%	18.9%
35	2045	2.6%	6,054,794	0.0%	3,812,120	787,123,159	114,363,595	901,486,754	1.42%	20,474,896	29.6%	18.6%
36	2046	2.3%	6,194,390	0.0%	3,812,120	805,270,721	114,363,595	919,634,315	1.38%	20,765,867	29.8%	18.4%
37	2047	2.0%	6,318,278	0.0%	3,812,120	821,376,135	114,363,595	935,739,730	1.34%	21,052,552	30.0%	18.1%

Table 127 Calculation of Financial Analysis

Debt (INR)	Loan Rate	Term (Years)	Deferment Term (Years)	India Prime Rate
1,103,600,000	1.20%	30	10	12.0%

	4 Wheel	2 Wheel
WTP (INR/Year)	130	30

Replacement plan

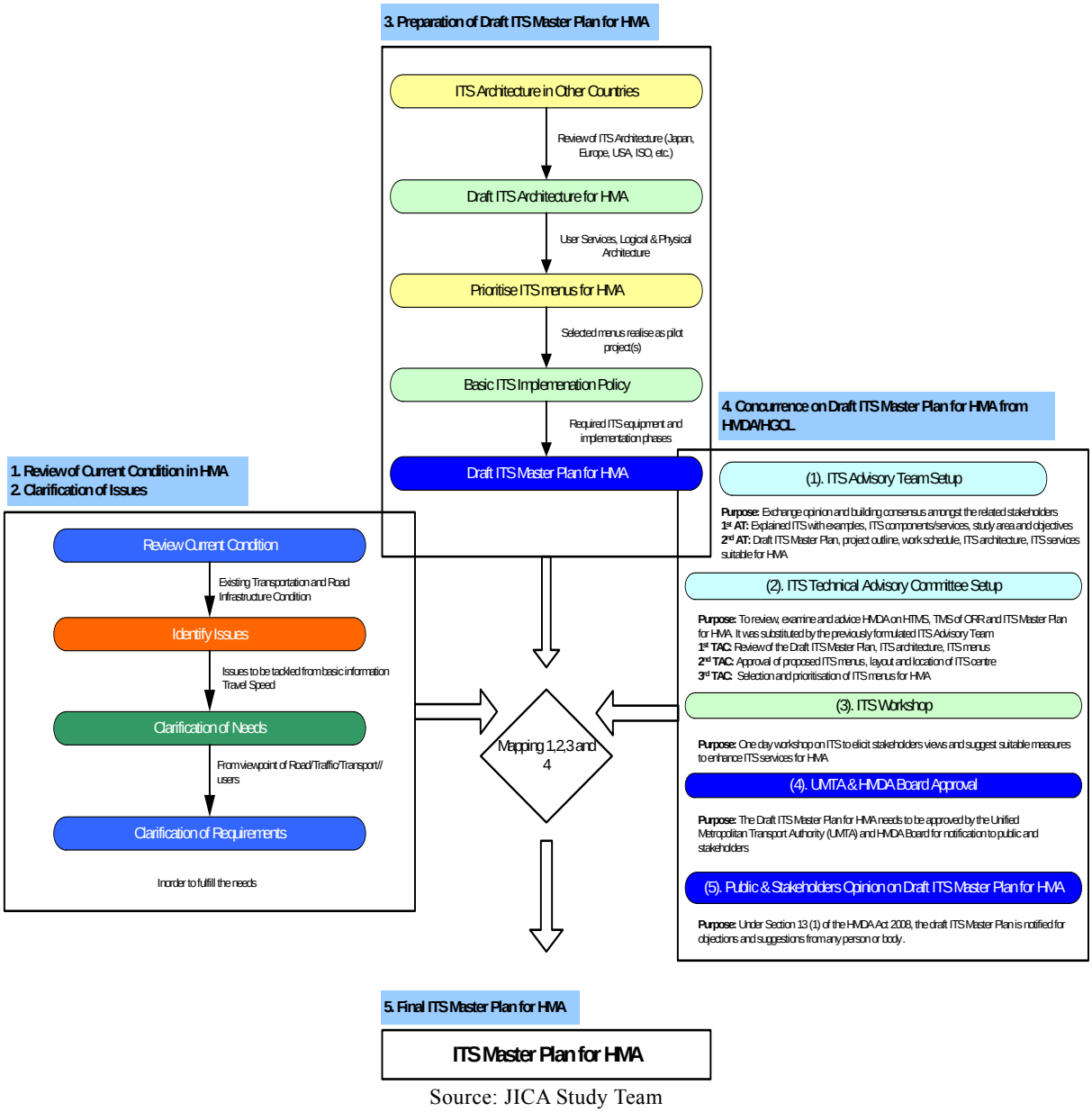
Replacement Term (years)	Amount	Notes
7.5	262,865,000	IT unit
15	22,000,000	Com. & Electric
20	646,592,000	Electric
30	23,960,000	Civil
	148,183,000	Installation
Total	1,103,600,000	

	Balance with Revenue
IRR=	21%

No.	Year	Debt (with Interest)	Interest	Repayment	Equipment Replacement	O&M			Revenue	O&M+Revenue	Willing to Pay (ref to another sheet)	Balance with Revenue
						Maintenance (5% of initial cost)	Salary, Facility	Subtotal of O&M				
	PV(2016)			-169,068,756	-259,704,471	-440,580,448	-322,207,359	-673,435,395	250,891,731	-422,543,664	3,110,818,634	2,259,501,743
	Total			-1,406,000,017	-1,457,187,000	-1,545,040,000	-1,200,000,000	-2,745,040,000	1,300,000,000	-1,445,040,000	16,855,662,381	12,547,435,364
												-1,103,600,000
1	2017	1,103,600,000	13,243,200	0	0		-40,000,000	-40,000,000	0	-40,000,000	232,494,669	192,494,669
2	2018	1,116,843,200	13,402,118	0	0		-40,000,000	-40,000,000	0	-40,000,000	251,087,293	211,087,293
3	2019	1,130,245,318	13,562,944	0	0	-55,180,000	-40,000,000	-95,180,000	0	-95,180,000	269,325,798	174,145,798
4	2020	1,143,808,262	13,725,699	0	0	-55,180,000	-40,000,000	-95,180,000	0	-95,180,000	287,072,762	191,892,762
5	2021	1,157,533,961	13,890,408	0	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	304,247,729	259,067,729
6	2022	1,171,424,369	14,057,092	0	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	322,550,450	277,370,450
7	2023	1,185,481,461	14,225,778	0	-262,865,000	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	341,981,223	33,936,223
8	2024	1,199,707,239	14,396,487	0	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	362,530,036	317,350,036
9	2025	1,214,103,726	14,569,245	0	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	384,175,665	338,995,665
10	2026	1,228,672,970	14,744,076	0	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	406,884,848	361,704,848
11	2027	1,243,417,046	14,921,005	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	430,611,571	315,131,571
12	2028	1,188,038,050	14,256,457	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	455,296,483	339,816,482
13	2029	1,131,994,506	13,583,934	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	480,866,450	365,386,449
14	2030	1,075,278,439	12,903,341	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	507,234,294	391,754,293
15	2031	1,017,881,779	12,214,581	-70,300,001	-284,865,000	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	534,298,720	133,953,719
16	2032	959,796,360	11,517,556	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	561,944,449	446,464,448
17	2033	901,013,915	10,812,167	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	590,042,580	474,562,579
18	2034	841,526,081	10,098,313	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	618,451,186	502,971,185
19	2035	781,324,394	9,375,893	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	647,016,150	531,536,149
20	2036	720,400,285	8,644,803	-70,300,001	-646,592,000	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	675,572,245	-86,499,756
21	2037	658,745,088	7,904,941	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	703,944,460	588,464,459
22	2038	596,350,028	7,156,200	-70,300,001	-262,865,000	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	731,949,551	353,604,551
23	2039	533,206,228	6,398,475	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	759,397,816	643,917,815
24	2040	469,304,702	5,631,656	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	786,095,066	670,615,065
25	2041	404,636,357	4,855,636	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	811,844,772	696,364,771
26	2042	339,191,993	4,070,304	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	836,450,358	720,970,357
27	2043	272,962,296	3,275,548	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	859,717,598	744,237,598
28	2044	205,937,842	2,471,254	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	881,457,090	765,977,089
29	2045	138,109,096	1,657,309	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	901,486,754	786,006,753
30	2046	69,466,404	833,597	-70,300,001	0	-55,180,000	-40,000,000	-95,180,000	50,000,000	-45,180,000	919,634,315	804,154,315
31	2047	-0	-0									

7 ITS Master Plan for HMA

The ITS Master Plan for the Hyderabad metropolitan area is prepared on the basis of the ITS architecture in the formulation of ITS Master Plan through the review of current conditions and analysis of issues to be resolved including related basic statistics, relevant plans related to ITS and travel speed surveys. The latest technical trend on ITS is well taken into account for the selection of the ITS services as well. It is taken into consideration of comments/feedback from various committees setup by HMDA as part concurrence exercise on ITS Master Plan finalisation. The process flow is shown below.



Source: JICA Study Team

Figure 219 ITS Master Plan for HMA Preparation Process

The major activities related to ITS Master Plan preparation are described hereunder and include the formulation of ITS Advisory Committee, Technical Advisory Committee, etc.

Based on the these process, “ITS Master Plan for HMA” was formulated and is attached in an appendix of this report.

7-1 ITS Advisory Team Setup

The ITS Advisory Team (AT) was initially formulated for the purpose of exchanging opinion and building consensus amongst the related stakeholders in September 2011. The members of the Advisory Team include:

- Mr. CSRK Prasad, Professor & Head of Transportation Division, Department of Civil Engineering, National Institute of Technology (NIT), Warangal
- The Director, Centre for Development of Advanced Computing (C-DAC)
- The Additional Commissioner, (Plg. & Dev., and T&T), Greater Hyderabad Municipal Corporation (GHMC)
- The Deputy Commissioner of Police, Cyberabad Traffic Police (CTP)
- The Additional Commissioner of Police, Hyderabad Traffic Police (HTP)
- The Executive Director, Andhra Pradesh State Road and Transport Corporation (APSRTC)
- The Deputy Director General, National Informatics Centre (NIC)
- The Managing Director, Hyderabad Metro Rail Ltd., (HMRL)
- The Joint Transport Commissioner, Regional Transport Authority (RTA)
- The Member Secretary, Andhra Pradesh Pollution Control Board (APPCB)
- Roads and Buildings Department (R&B)

The following ITS Advisory Team meetings were held.

(1) First Advisory Team Meeting

Date: September, 7th 2011

Purpose: The first Advisory Team meeting was held on September, 7th 2012. The Study Team explained about ITS with examples, various ITS components/services, study area and objectives to the members of Advisory Team.

Venue: The Commissioner Conference Hall, HMDA, Tarnaka, Hyderabad

Participants:

- Mr. Rajeshwar Tiwari, IAS, Metropolitan Commissioner, HMDA
- Mr. Manicka Raj, IAS, Managing Director, Hyderabad Growth Corridor Limited (HGCL)
- Mr. Madhwa Raja, Chief Engineer, HMDA
- Mr. Rajashekara Rao, Divisional Administrative Officer, HMDA
- Mr. Chiranjiva Chari, Deputy Executive Engineer, Transport Cell, HMDA
- Mr. M.J. Akbher, Officer on Special Duty (OSD), Bhudha Purnima Project, HMDA
- Mr. M. Manoj Kumar, Traffic & Transportation Planner, HMDA
- Ms. Vijayalakshmi, Deputy Chief Transport Manager, APSRTC
- Mr. V. V. Venkata Ramana, Technical Director, NIC
- Mr. V. Sunder, Regional Transport Officer, RTA
- Mr. K.P. Dileep, C-DAC
- Mr. S. V. Srikanth, C-DAC
- Mr. CSRK Prasad, Professor & Head of Transportation Division, NIT
- Mr. P.Y. Giri, Additional Deputy Commissioner of Police, CTP
- Mr. Chinna Reddy, Superintendent Engineer, R&B
- Mr. A. Bindu, Celcabs & Voyages Private Limited

Discussed Topics:

- The Study Team introduced the concepts on City ITS by showing the examples in the cities in Asian countries.
- The Study Team explained the pilot project identification process for implementing the most appropriate ITS component/service to HMA.
- The Study Team discussed the study target area, objectives and outcomes of study.
- The Study Team requested the stakeholders to support for the study including obtaining the available data/materials.
- The participants provided the suggestions on the suitable ITS Services for HMA.

Achievements:

- The first AT meeting served as a kickoff meeting and provided the opportunity for the Study Team to meet all the stakeholders.
- The Study Team explained the project in detail and exchanged the high level opinions amongst the members.

(2) Second Advisory Team Meeting

Date: December, 15th 2011

Purpose: The second Advisory Team meeting was held on December, 15th 2011. The Study Team reported the progress of the project by explaining the Draft ITS Master Plan, project outline, work schedule, ITS Architecture, ITS services suitable for HMA, etc., to the advisory team.

Venue: The Commissioner Conference Hall, HMDA, Tarnaka, Hyderabad

Participants:

- Mr. Rajeshwar Tiwari, IAS, Metropolitan Commissioner, HMDA
- Mr. Manicka Raj, IAS, Managing Director, HGCL
- Mr. P. Ranadhir Reddy, IRTS, General Manager, Centre for Railway Information System (CRIS)
- Mr. K. Dhananjay Reddy, Additional Commissioner, GHMC
- Mr. S. Chandrashekar Reddy, Deputy Commissioner of Traffic Police, CTP
- Mr. Taro OKAWA, Representative of JICA India Office
- Mr. Sanjeev Moholkar, Lead Development Specialist, JICA India Office
- Mr. CSRK Prasad, Professor & Head of Transportation Division, NIT
- Mr. Madhwa Raja, Chief Engineer, HMDA
- Mr. R. Sasidhar, Director, JnNURM, APSRTC
- Mr. Vara Prasad, Deputy Director, JnNURM, APSRTC
- Mr. R.V. Jayanth, Chief Engineer(IT), APSRTC
- Mr. P.M. Rao, Regional Transport Officer, RTA
- Mr. G. Sham Sudarshan, Executive Engineer, R&B
- Mr. D. Mallikarjun, Executive Engineer, HMRL
- Mr. M. Manoj Kumar, Traffic & Transportation Planner, HMDA
- Mr. T.S. Reddy, Team Leader, CTS, M/S. Lea Associates
- Mr. Pradeep Kumar, Associate Director, CTS, M/S. Lea Associates

Discussed Topics:

- The Study Team presented the details of draft ITS Master Plan, Project Outline, Work

Schedule, and ITS architectures of US, Japan, Europe and ISO and proposed ITS services for HMA.

- The Study Team explained the three prioritised ITS services such as Traffic Information System, Bus Operating System and Optimisation and Coordination System for Signal Control.
- HTRIMS and APSRTC (GPS devices installation) projects were explained by the respective officials.

Achievements:

- The progress of the project was shared amongst the members of the advisory team and the appropriateness of the ITS services for HMA were discussed.
- The Commissioner suggested that the Study Team shall work in close coordination with the relevant agencies including GHMC, APSRTC and Traffic Police, and ensure that the ITS Master Plan shall be prepared in well accordance with the existing plans including the HTRIMS and bus location system of APSRTC.

7-2 ITS Technical Advisory Committee Setup

The ITS Technical Advisory Committee (TAC) was newly formed by the new Commissioner, HDMA in December 2012 with the technical and domain experts of various ITS-related agencies in India. The purpose of the TAC is to review, examine and advice HMDA on HTMS, TMS of ORR and ITS Master Plan of Hyderabad City. It was substituted by the previously formulated ITS Advisory Team which was established in September 2011. The members of the ITS Advisory Committee include:

Table 128 ITS Technical Advisory Committee Members

No.	Name/Designation and Agency	Role in TAC
1	Managing Director, HGCL	Chairman
2	Prof. Vinay Maitri, School of Planning and Architecture (SPA), Delhi, Transport Planner	Member
3	Buddadeb Chakravarthy, Sr. General Manager, NISG	Member
4	R.C. Palekar, General Manager, Electronics, NHAI	Member
5	C. Krishna Kumar, ITS Consultant, Mumbai	Member
6	CSRK. Prasad, HoD of Transportation Division, NIT, Warangal	Member
7	V. Srinivasa Chary, ASCI, Director, Centre for Energy Environment, Urban Governance & Infrastructure Development	Member
8	Chief Engineer, HMDA	Member
9	Chief General Manager (T), HGCL	Member
10	General Manager (T), HGCL	Member-Convener
11	Any other experts	Co-opted by the chairman of this committee
12	Other major stakeholders	

The following ITS Technical Advisory Committee meetings were held.

(1) First Technical Advisory Committee Meeting

Date: December 1st, 2012

The first TAC meeting was held on December 1st, 2012. The agenda of the meeting was as mentioned below:

Agenda:

A. ORR ITS Project:

1. Toll Management System (TMS) on ORR
   - Electronic Toll Collection System (ETC) – Appropriate Technology to be adopted for ORR – Active DSRC Technology or RFID Technology.
   - IT Infrastructure – Approval of System Architecture.
2. Highway Traffic Management System (HTMS) on ORR
   - Variable Message Sign (VMS) --- Finalization of Specification.
   - Operation and Maintenance of HTMS & TMS.

B. ITS Master Plan for HMA:

1. Review of the Draft ITS Master Plan, ITS Architecture for HMA
2. Finalizing the proposed ITS Services that are suitable for HMA
3. Any other Discussions / Issues related to the ITS Master Plan for Hyderabad City Area

Venue: The Commissioner Conference Hall, HMDA, Tarnaka, Hyderabad

Participants:

- Mr. Neerabh Kumar Prasad, IAS, Metropolitan Commissioner, HMDA
- Prof. Vinay Maitri, Transport Planner, SPA
- Mr. Buddadeb Chakravarthy, Senior General Manager, NISG
- Mr. R.C. Palekar, General Manager, Electronics, NHAI
- Mr. C. Krishna Kumar, ITS Consultant, Mumbai
- Mr. CSRK. Prasad, Head of Transportation Division, NIT
- Mr. V. Madhwa Raja, Chief Engineer, HMDA
- Mr. N. Surya Prakash Reddy, Chief General Manager (T), HGCL
- Mr. B. Anand Mohan, General Manager (T), HGCL

Discussed Topics:

The salient features of TMS & HTMS for ITS ORR with special emphasis on the issues raised by HGCL including appropriate ETC technology to be adopted for ITS on ORR.

(2) Second Technical Advisory Committee Meeting

Date: January 19th, 2013

The second TAC meeting was held on January 19th, 2012. The agenda of the meeting was as mentioned below:

Agenda:

A. ITS for Outer Ring Road (ORR):

1. Finalisation of Tender document of HTMS of ORR
2. Finalisation of Tender document for O&M of Toll Management System of ORR
3. Estimate for construction of Toll Administrative Building & Toll Canopies for ORR
4. Schedule for construction of Toll Administrative Building

B. ITS for Hyderabad Metropolitan Area (HMA):

1. Approval of ITS services proposed by the consultant in the Master Plan for HMA area
2. Finalisation of layout and location of ITS Control Centre

Venue: The Commissioner Conference Hall, HMDA, Tarnaka, Hyderabad

Participants:

- Mr. Neerabh Kumar Prasad, IAS, Metropolitan Commissioner, HMDA
- Mr. I. Samuel Anand Kumar, IAS, Project Director, HGCL
- Mr. C.V. Anand, Additional Commissioner, Hyderabad Traffic Police
- Mr. K. Dhananjay Reddy, Additional Commissioner, GHMC
- Mr. Buddadeb Chakravarthy, Senior General Manager, NISG
- Mr. R.C. Palekar, General Manager, Electronics, NHAI
- Mr. C. Krishna Kumar, ITS Consultant, Mumbai
- Mr. Suresh, ITS Consultant, Hyderabad (Invitee Member)
- Mr. V. Madhwa Raja, Chief Engineer, HMDA
- Mr. N. Surya Prakash Reddy, Chief General Manager (T), HGCL
- Mr. B. Anand Mohan, General Manager (T), HGCL
- Mr. Manoj Kumar, Engineer, HMDA

Discussed Topics: Finalisation of tender document for TMS & HTMS of ITS ORR and implementation of the system components such as ATCC, CCTV, MET, etc.

(3) Third Technical Advisory Committee Meeting

Date: May 4th, 2013

The third TAC meeting was held on January 19th, 2012. The agenda of the meeting was as mentioned below.

Agenda:

1. Selection and prioritisation of ITS user services for HMA
2. Draft Tender Document

Venue: The Commissioner Conference Hall, HMDA, Tarnaka, Hyderabad

Participants:

- Mr. I. Samuel Anand Kumar, IAS, Project Director, HGCL
- Prof. Vinay Maitri, Transport Planner, SPA
- Mr. CSRK. Prasad, Head of Transportation Division, NIT
- Mr. Buddadeb Chakravarthy, Senior General Manager, NISG
- Mr. P. Ravi Kumar, Joint Director, C-DAC, Trivendrum
- Mr. Rajesh Krishnan, ITS Planners and Engineers Pvt. Ltd.
- Mr. V. Madhwa Raja, Chief Engineer, HMDA
- Mr. N. Surya Prakash Reddy, Chief General Manager (T), HGCL
- Mr. B. Anand Mohan, General Manager (T), HGCL
- Mr. Venkatesh, Assistant General Manager (T), HGCL

Discussed Topics: Finalisation of ITS user services for HMA.

7-3 ITS Workshop

(1) Purpose:

A one-day workshop on Intelligent Transportation System (ITS) was conducted by HMDA at Hyderabad to provide a platform to elicit stakeholder's views and suggest suitable measures to enhance ITS services for Hyderabad city. Deliberations covered critical issues and constraints like Technology, Operation and Maintenance in project implementation. The below topics were discussed in the workshop:

- Services to be delivered by the ITS
- Proposed Technology for the ITS
- Procurement methods
- Operation and Maintenance.

(2) Date: September 14th, 2012

Venue: Hotel Taj Deccan, Hyderabad

7-4 UMTA & HMDA Board Approval

- The 9th meeting of the UMTA held on 11th Nov 2013 in the Conference Hall, 4th Floor, Secretariat, Govt. of AP.
- The ITS Master Plan for HMA was approved by UMTA and it was suggested that HMDA publish the draft notification as per the provisions of HMDA Act duly inviting objections & suggestions from the public and further process it for the approval of the Government as per the provisions of HMDA Act.
- ITS Master Plan for HMA was also approved by HMDA board, chaired by Chief Minister of AP.

7-5 Public & Stakeholders Opinion on Draft ITS Master Plan for HMA

HMDA requested objections and suggestions on the draft ITS Master Plan from public & stakeholders. These can be submitted in person, through post or e-mail until 10th January 2014.

8 Other Proposed Measures

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

8-1 Best Practice Zone

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

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

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

A showcase to the public is to be demonstrated by providing the optimum route guidance for alternative route from High Tech City to the Hyderabad Rajiv Gandhi International Airport by the Graphical Variable Message Signboard (VMS). The information to be provided to the public will include 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 NH7 from IRR to the Airport, bus probe data and graphical VMS. The installation interval of ATCC shall be 1 – 2 km.

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

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

The Seconderabad is the area where many ordinary people perform activities such as shopping.

A showcase to the public is to be demonstrated by providing the congestion information by VMS in Seconderabad. 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 the Seconderabad, bus probe data and VMS. The installation interval of ATCC shall be 1 – 2 km.

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

(3) Alternative-3: Demonstration of Comprehensive Practice (Development of Kasu Brahmananda Reddy Park Facilities)

The area around the Kasu Brahmananda Reddy Park (KBR Park) is fairly developed. In particular, the roads surrounding KBR park are relatively more appropriately prepared comparing 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. In consideration of these factors, the following components are to be comprehensively developed and prepared in this area as a comprehensive demonstration model zone combined with preparation of infrastructure and ITS

facilities:

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

(4) Alternative-4: Demonstration of 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.

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 holds a great potential demand for a well prepared walk-able environment. Thus, it is proposed to intensively prepare, in this area, the footpath along with improvement of junctions/intersections and installation of signals and pelican crossing and prepare the environment where people are able to safely walk and make jogging in certain designated areas. The ITS facilities including VMS, ATCC and CCTV shall also be prepared to measure the traffic and provide the traffic information in this area.

The exact locations will be further identified.

8-2 Other Required Measures for Road Infrastructure

Apart from the ITS itself, the city of Hyderabad is facing more basic problems of road infrastructure. In particular, the major critical issues are: i) structure of intersections/junctions, and ii) ii) absence of pedestrian crossing infrastructures 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 are legacy of round-about and they are equipped with signals. But their structures are left round-about shaped. Others are cases such as absence of stop line/centre line, median which is properly designed around the intersection, improperly shaped intersections/junctions, etc. It is assumed that the improvement of the intersection/junction will greatly contribute assuring smoother traffic flow.

The required measures are as follows:

- Improvement of Intersection/Junction Structure together with:
  - ✓ Preparation of zebra crossing
  - ✓ Preparation of stop line for motorcycle
  - ✓ Preparation of stop line for 4-wheelers, separate from motorcycles
  - ✓ Preparation of properly shaped median at the intersection/junction
  - ✓ Preparation of lanes to keep traffic order
  - ✓ Preparation of signals

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

- The figure on the left shows the stop line for 4-wheeler, zebra crossing, spaces for bicycle to cross, waiting space for the vehicle in the middle of the intersection for right-turn and associated facilities such as lighting around the intersection.
- The figure on the right shows the separated lanes, one of which is for vehicles going to the left and straight and the other is dedicated for vehicles going to the right indicated/guided by the arrow.

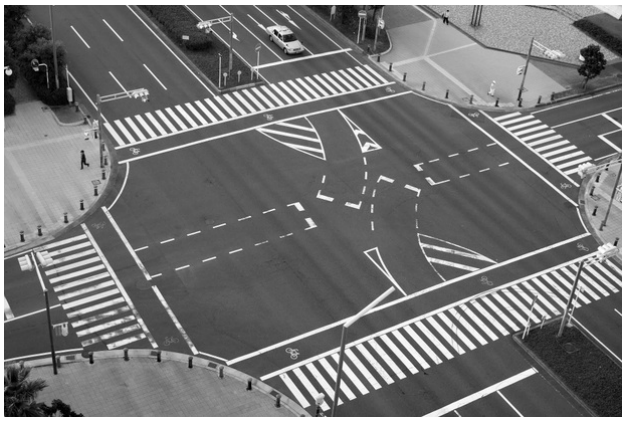


Figure 220 Intersection (1) in Japan

Figure 221 Intersection (2) in Japan

Source: JICA Study Team

(2) Pedestrian Crossing (Zebra Crossing, Signals for Pedestrian, Skywalk)

The absence of 'walkable environment' such as well prepared footpath is one of the major critical issues for both pedestrians and road traffic in Hyderabad.

These include the zebra crossing, signals for the pedestrians and skywalk. These infrastructures and facilities need to be put in place not only on the major roads but also across the city.

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

The total needed number of pedestrian crossing facilities, in terms of the number of the locations, is roughly calculated as follows:

Basic Condition: Approximately 1,500 km total length of road network inside IRR

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

Although the above totals are provided at approximate locations, zebra crossings together with the signals for pedestrians in the metropolitan area such as Tokyo in Japan are in place almost every 100 m, in general. In the case of Hyderabad where such infrastructures are not in

place, these shall be prepared at least in line with the above cases.

The zebra crossings are to be prepared on the roads with narrow-width and the skywalks are to be prepared over the roads with wide-width. The images of the zebra crossings in the case of Japan are shown in the figure below.

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

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

Figure 222 Zebra Crossing (1) in Japan

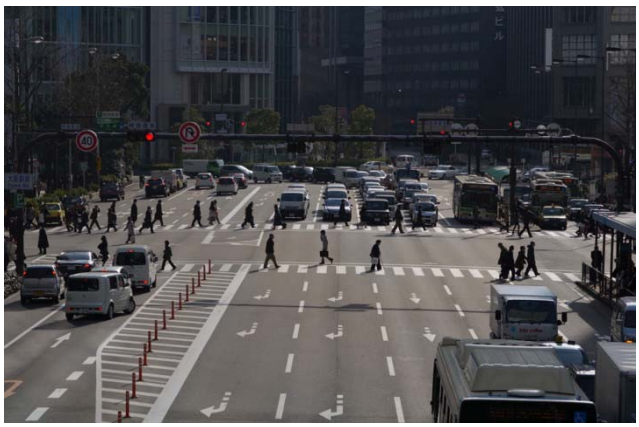


Figure 223 Zebra Crossing (2) in Japan

9 Capacity Building for Staff in ITS Centre and Related Agencies

Capacity building is one of the most important components that shall be put in place to assure sustainable operation and management of ITS over a long period of time, in regard to new technology in particular.

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

(1) Target:

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

(2) Component

The following components shall be included.

- **Attending the Seminar**: Including domestic and international seminars
- **Participating in the Technical Study Tour**: Including ITS World Congress, site tour in India and overseas to learn the best practices such as 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 ITS Centre, participating in consultancy services as project members of ITS project, etc

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

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

(3) Methodology

The above components shall be carried out like PDCA (Plan, Do, Check, Adjust) cycle so that the skills are progressively improved as illustrated in the figure below.

(4) Supporting Unit

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

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

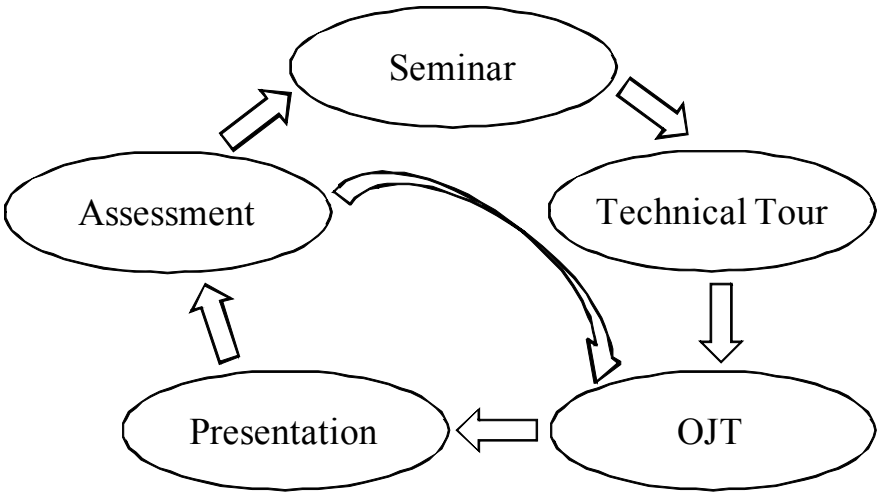


Figure 224 Methodology for Capacity Building

The above components for the capacity building shall be carried out by PDCA so that the competency can be progressively reinforced. The cycle among OJT, presentation and assessment can be repeated.

10 Pilot Project

10-1 Selection of Pilot Project

10-1-1 Phased Implementation Set Out by ITS Master Plan

The Table below shows the phased implementation which is set out by the ITS Master Plan.

Table 129 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 phase-1 systems	- Expansion of system in phase-2.	- Expansion of system in phase-3.
	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, related 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 phases –2 1nd -3 in line with preparation of • Public & Lane Parking, Public Based Multi Modal Transportations		

10-1-2 Policy for Pilot Project

Based on the study thus far, the major critical issues for tackling the traffic problem in Hyderabad in view of ITS are summarised as follows:

The real road and traffic conditions including traffic flow and traffic volume are not properly comprehended by the road and traffic administrators.

The proper planning for traffic and road management based on the quantitative and historical road and traffic data are not realised.

There are a number of services and subsystems of ITS. However in the case of Hyderabad, the first priority shall be placed on preparation of the basic environment where the above measures can be realised by establishing a mechanism by which the road and traffic administrators become enabled to collect, accumulate and utilise the basic and important road and traffic information/data. In addition, it is important to regulate/control the traffic by providing the road and traffic information which is generated by the system to the road users.

Therefore, the ITS Master Plan emphasises to realise the following:

- To timely and properly comprehend the road and traffic condition specifically on the major roads
- To timely and properly comprehend the road conditions on the sections that are prone to be frequently affected by the adverse weather such as flood
- To establish the system which enables to realise appropriate traffic flow in the city and proper road improvement based on the cumulated quantitative road and traffic data
- To strengthen the capability of the road and traffic administrators by enabling proper utilisation of the road and traffic information/data
- To provide the proper and useful road and traffic information to the road users specifically on the major roads
- To prepare the basic platform which enables proper coordination amongst the related organisations including Outer Ring Road for traffic control

Thus, the basic important components which realise the above shall be prepared by the pilot project and be gradually expanded as shown in the Phased Implementation Policy below.

Table 130 Phased Implementation Policy

Phases	Policy
Phase-1 (1-5 years)	Establishment of 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

10-1-3 ITS Components of Pilot Project

Based on the above concept, the following subsystems which are proposed in the first phase of the ITS Master Plan shall be prepared in Hyderabad as the pilot project. They are very basic ITS subsystems.

- (1) ATCC: Automatic Traffic Counting and Classification
- (2) Probe Car System (Floating Car)

- (3) Flood Sensor
- (4) Meteorological Sensors
- (5) Air Pollution Sensors
- (6) CCTV Camera
- (7) VMS: Variable Message Sign Board
- (8) ITS Control Centre

10-1-4 Life Cycle of System and Equipment

The life cycle of the system and equipment shall be taken into consideration for proper operation and maintenance. The below clauses describe the key concepts of this.

(a) Number of Years Set Out for Phases

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 such as emergence of new technology in the future, due to rapid technological developments.

(b) System Review

After Phase-1, the systems prepared shall be reviewed and evaluated, and the systems to be further upgraded or newly introduced shall be identified.

(c) Equipment Replacement

The equipment needs to be replaced at certain intervals as indicated below.

Table 131 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

10-1-5 JICA Loan Applied to ITS Pilot Project

The exchange of notes (E/N) was signed between Government of Japan and Government of India for Japanese ODA Loan totaling 99 Billion 19 Million Japanese Yen on 22nd October 2008.

The funding for the pilot project in this study is applied by the JICA Loan on Hyderabad Outer Ring Road Project Phase-2, which is included in the above loan. The ORR phase-2 covers the construction of highway in the north-east section with length of 33 km.

The final payment of the defect liability needs to be completed by 1st quarter 2017. In general, the defect liability period is two (2) years. Thus, the construction/installation and handover of the ITS needs to be completed by end 2014, starting the operation at the beginning of 2015 at the latest.

The conditions of the loan are described in the table below.

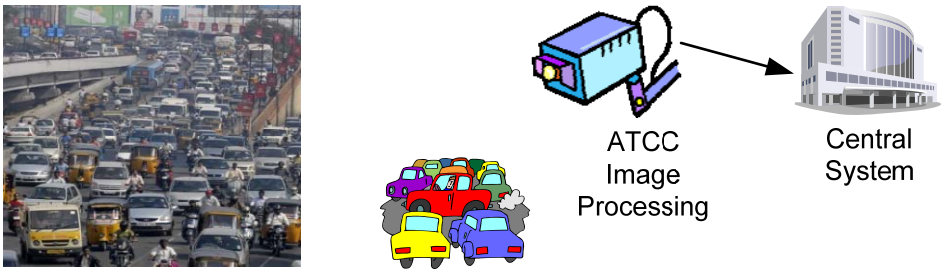
Table 132 Condition of JICA Loan on ORR Phase-2

Total Amount	42.027 Billion (JPY)
Repayment Period	30 Years
Grace Period	10 Years
Interest Rate	1.2%
Procurement Condition	Untied Loan
Final Disbursement	1st Quarter 2017
Defect Liability	2 years in General

10-1-6 Overview of Systems to be Deployed

(1) ATCC (Automatic Traffic Classifier and Counter)

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

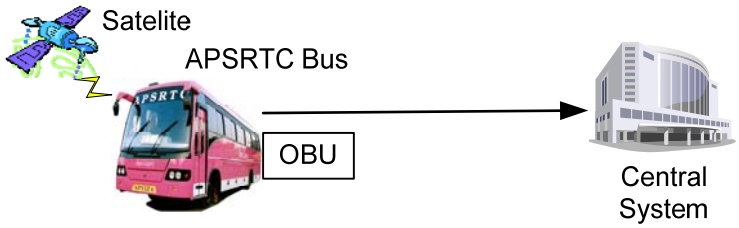


Source: JICA Study Team

Figure 225 Image of ATCC

(2) Probe Car System (Floating Car)

Probe Car System (Floating Car) measures traffic condition by area. The GPS unit mounted on the vehicle records the travel record of the vehicle. The recorded data is transmitted to the centre. The collected data at centre is aggregated and the congestion level by section is identified.

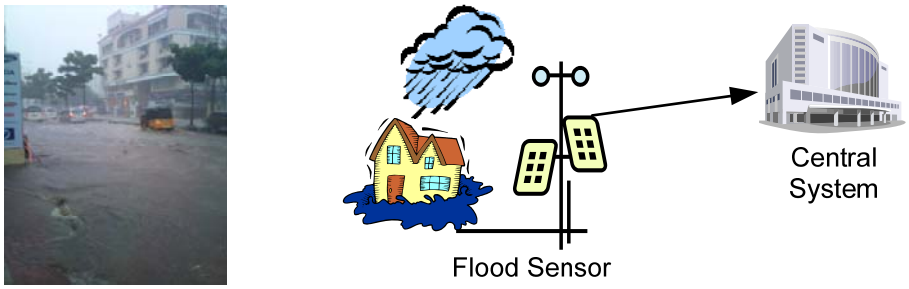


Source: JICA Study Team

Figure 226 Image of Probe Car System

(3) Flood Sensor

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

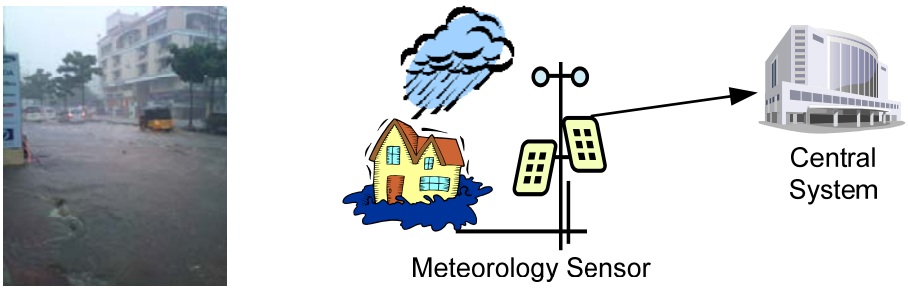


Source: JICA Study Team

Figure 227 Image of Flood Sensor

(4) Meteorological Sensors

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

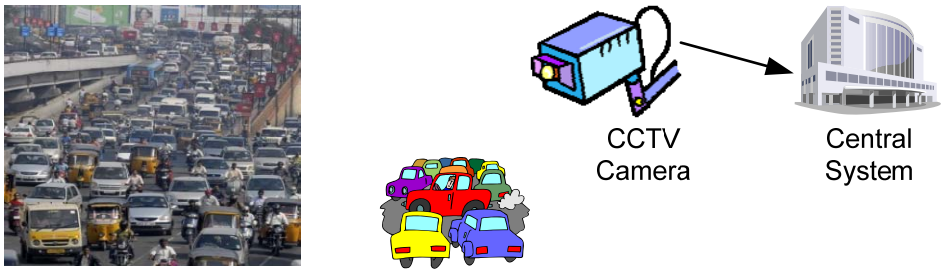


Source: JICA Study Team

Figure 228 Image of Meteorological Sensors

(5) CCTV Camera

CCTV Camera captures the image of the roadside condition and provides a moving image at the centre. It is used as supporting method at the centre to visually confirm the road condition at site for taking necessary action.

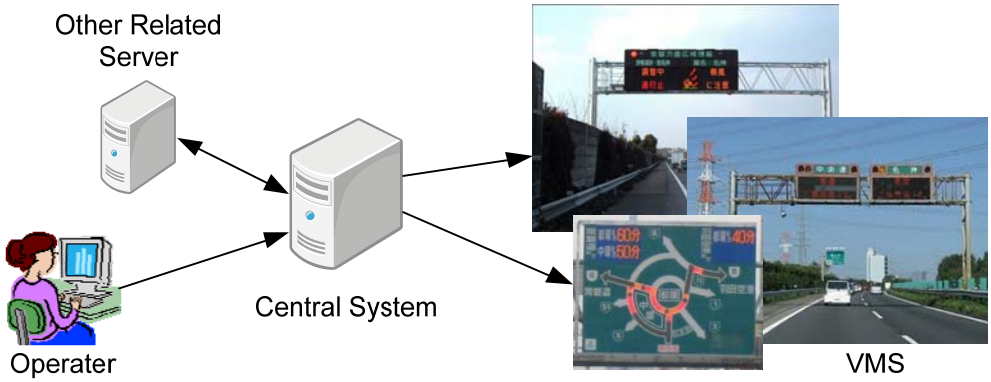


Source: JICA Study Team

Figure 229 Image of CCTV

(6) VMS (Variable Message Sign)

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



Source: JICA Study Team

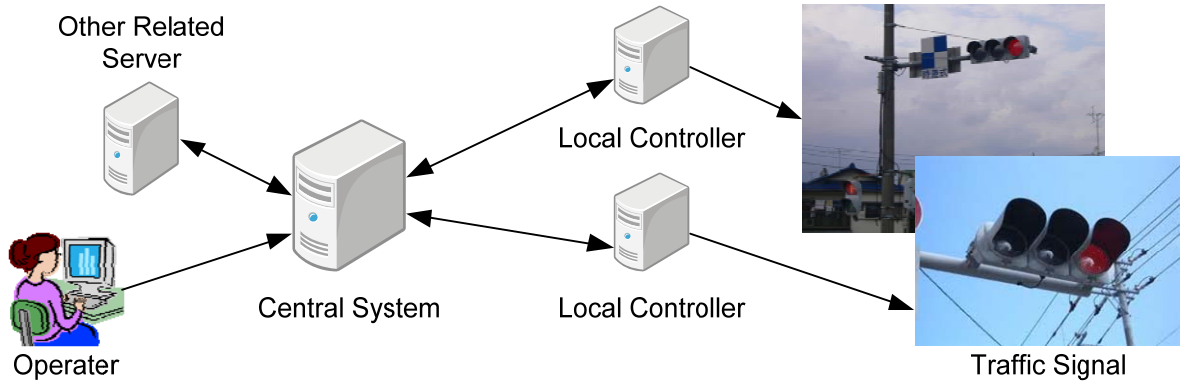
Figure 230 Image of VMS

(7) Signal System (In the future)

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

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

It is necessary to have enough adjustment between H-TRIMS and ITS Centre for assuring exchanging information of signal status including fail status in well coordinated manner.



Source: JICA Study Team

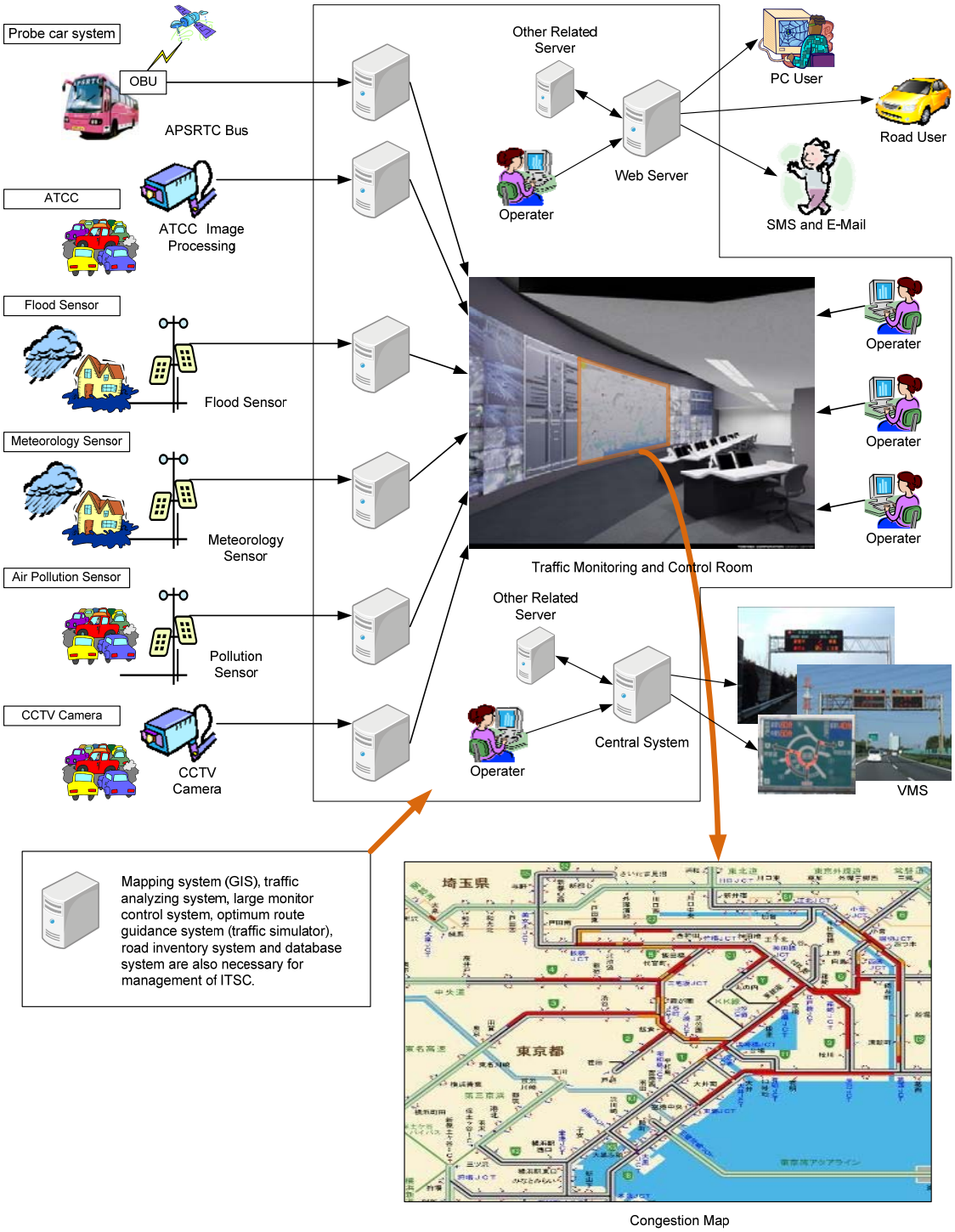
Figure 231 Image of Traffic Signal

(8) Centre System

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

The figure below shows the image of the centre system of the ITS Centre. (It should be

noted that the figure does not include the components which are to be prepared in the phases -2 and -3.)



Source: JICA Study Team

Figure 232 Image of Central System

10-2 Design of Pilot Project

Based on the proposed master plan, the basic design for the following eight (8) systems selected as ITS pilot project components was carried out.

- Automatic Traffic Counter and Classifier System
- Probe Car System
- CCTV Camera System
- Meteorological Monitoring System
- Pollution Monitoring System
- Flood Monitoring System
- Variable Message Sign System
- ITS Centre System

10-2-1 Automatic Traffic Counter and Classifier System

(1) System Objectives

This section states ATCC System to be installed as one of the Sub-Systems of Hyderabad City ITS. ATCC System shall be introduced with following objectives.

- To measure the traffic volume and vehicle speed on major roads in HMA including National Highways, Inner Ring Road (IRR) and State Highways to be used for planning on future road widening and additional road construction
- To measure the traffic volume, vehicle speed, road occupancy rate and vehicle type on major roads in HMA including National Highways, Inner Ring Road (IRR) and State Highways.
- To monitor the real-time status of major road in HMA by using measured traffic data.
- To calculate travel speed and judge road congestion by using measured traffic data.
- To store measured traffic data and use for planning and evaluation of road infrastructure improvement such as road widening, road construction, etc
- The ATCC Roadside Equipment shall detect, count and classify vehicles.
- To measure large-sized vehicle traffic for planning of future pavement repair or other road facility maintenance
- To share the measured and analysed traffic information with road planning agencies, road administrators and traffic police.

The traffic flow parameters measured by the ATCC Roadside Equipment shall be transmitted to the ATCC Server in the ITSC. The system shall operate on a 24-hour a day 7-day a week basis.

It shall be the responsibility of the Contractor to furnish all necessary hardware and software, install equipment at the specified location, provide necessary cabling, integrate all system components, and deliver a completely operational ATCC System.

(2) System Requirements

The system requirements of the ATCC system are as follows.

- The ATCC System shall measure and analyse following traffic information. Unit duration of measurement, detection and calculation shall be within one (1) minute.

- ✓ Traffic Volume
- ✓ Large-sized Vehicle Traffic
- ✓ Vehicle Speed
- ✓ Traffic Congestion

- ATCC System shall measure both inbound/outbound traffic volumes on the on major roads of IRR, National Highways, and State Highways in IRR between major junctions.
- ATCC System shall measure and detect required traffic information even under complex traffic and road conditions in Hyderabad.
- The traffic data shall be monitored in the ITSC on real-time basis and the data shall be stored for a certain period in order to utilize for road planning, road operation and maintenance.
- The traffic data collected and analysed by ATCC System shall be provided to road users through VMS System and other information provision systems such as E-mail, Website and SMS.
- The ATCC Roadside Equipment shall be not be loop-coil and be easily installable at site with simple operation and maintenance. Supporting pole shall have a structure to avoid a maintenance work of the ATCC Roadside Equipment on the carriageway.
- Image recognition type for ATCC Equipment shall be adopted and it shall detect multiple lane/zone traffic.
- Two sets of detector for both bound detection shall be installed at each location.
- Wherever possible, the ATCC Roadside Equipment along with the CCTV camera shall be mounted either on a dedicated pole at road shoulder or on the pole at median.
- Required visible clearance shall be kept in the detection area of ATCC Equipment.
- The detection target of ATCC shall be vehicles passing through the sensor area at a speed not less than 1 km/h and not more than 160 km/h.
- ATCC System is expected to have at least 90% overall counting accuracy under the road conditions in the HMA.

(3) Location Plan of ATCC Roadside Equipment

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

(a) [Phase-1]

- ATCC roadside equipment will be placed on each section of National Highways (NH-7, NH-9 and NH-202 within Hyderabad Metropolitan Area) and State Highways (SH-1, 2, 4, 5 and 6) which is divided by major junctions.
- The roadside equipment will be located on each section of IRR, as well.
- For the purpose of measurement of entering traffic volumes into Hyderabad Metropolitan Area, the roadside equipment will be placed on National Highways outside the Outer Ring Road (ORR).
- Minimum two (2) sets of equipment must be installed at each location to measure both bound traffic volumes.
- The location plan of equipment must be proposed in consideration of METRO implementation planning. In case physical difficulties of equipment installation are

identified, such location will be cancelled in phase-1 and will be set up in phase-2 when the METRO construction is completed.

- The roadside equipment on ORR will be prepared within the scope of ORR project. Thus, the implementation of the equipment on ORR will be dropped from this project.
- In phase-1, the ATCC roadside equipment will be introduced at total of 34 locations.

(b) [Phase-2]

- In phase-2, the ATCC roadside equipment will be placed on major highway sections between junctions within the Hyderabad Metropolitan Area.
- Total of 85 ATCC equipment will be introduced in phase-2.

(c) [Phase-3]

- In phase-3, 227 ATCC equipment will be further set up on the highway sections to obtain detailed traffic volume data in the Hyderabad Metropolitan Area.

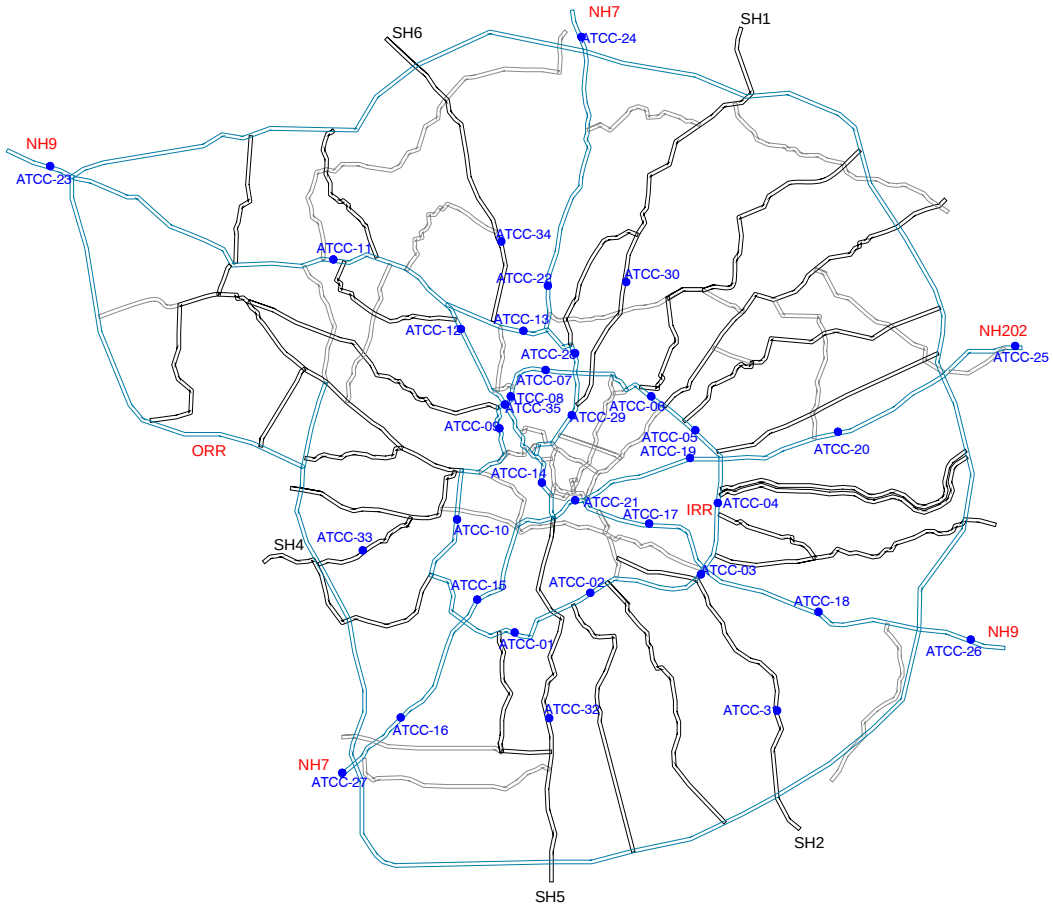
The proposed location plan of ATCC roadside equipment in Phase-1 is shown in the Tables and Figures below.

Table 133 Proposed Locations of ATCC Roadside Equipment in Phase-1

ATCC No.	Road	Location/Landmark
ATCC-01	IRR	Chandrayanagutta,near Palle Cheruvu road
ATCC-02	IRR	DRDL, Kanchanbagh
ATCC-03	IRR	LB Nagar Ring road
ATCC-04	IRR	Nagole Junction
ATCC-05	IRR	Genpact, Habsiguda
ATCC-06	IRR	Railway Golf Course, Mettuguda
ATCC-07	IRR	ACP Office, Begumpet
ATCC-08	IRR	Green Lands,CM Office
ATCC-09	IRR	Taj Banjara, Banjara Hills
ATCC-10	IRR	Spencers Stores, Attapur
ATCC-11	NH9	Miyapur, near Prajay City
ATCC-12	NH9	Hyderabad Industries Ltd, Moosapet
ATCC-13	NH9	Air Force Station, Bowenpally Junction
ATCC-14	NH9	Nampally, near Gandhi Bhavan
ATCC-15	NH7	National Police Academy,Shivarampalli
ATCC-16	NH7	Airport Road, near Shamshabad town
ATCC-17	NH9	Dilsukhnagar, near Chandnabrothers
ATCC-18	NH9	Hayathnagar, near All India Radio Station
ATCC-19	NH202	Ramanthapur, near HPS & Cheruvu
ATCC-20	NH202	Boduppal, near Central Power Research Institute (CPRI)
ATCC-21	NH9	Esama Bazar Road, near MGBS
ATCC-22	NH7	Medchal Road, near Dairy farm road turn
ATCC-23	NH9	Muthangi village after Patancheru
ATCC-24	NH7	Medchal, near CMR Engineering College
ATCC-25	NH202	HP Petroleum Tanks, Ghatkesar
ATCC-26	NH9	Inamguda near Ramoji Film City

ATCC-27	NH7	Thondapally village
ATCC-28	NH7	Tarbond near JBS
ATCC-29	NH7	Tankbund, at Makhdum Mohiuddin Statue
ATCC-30	Siddipet Rd (SH1)	Military College, Siddipet Road, Alwal
ATCC-31	Nagarjuna Sagar Rd (SH2)	Nagarjuna Sagar Road, Turkayamjal
ATCC-32	Srisailam Highway (SH5)	Pahadisharif, near RCI
ATCC-33	Chevella Rd (SH20)	Chevella Road, near Shadan College
ATCC-34	HMT Rd (SH6)	Medak Road, near HMT
ATCC-35	IRR	Under Punjagutta Flyover

Source: Prepared by JICA Study Team



Source: Prepared by JICA Study Team

Figure 233 Proposed Location Map of ATCC Roadside Equipment in Phase-1

(4) Site Reconnaissance for ATCC Roadside Equipment

The site reconnaissance at the locations of ATCC roadside equipment was carried out by the JICA Study Team to investigate the following:

- Location of roadside equipment
- Installation space for roadside equipment
- Road conditions (road width, number of lanes, width of median, road alignment in the vicinity of roadside equipment)
- Power receiving point (identifying the nearest pole and its pole number)

- Network connecting point (Service provider's optic fibre connection point)
- Mobile cellular communication availability
- Other conditions

(5) ATCC System Design

(a) Measurement Items

Generally, the ATCC system is installed to detect and process data on a traffic volume, large-sized vehicle traffic, a time occupancy rate and a vehicle average speed for the purpose of followings;

Table 134 Purpose of ATCC Measurements

Item	Main Purpose
1. Traffic volumes	・ Use as statistics for planning of future road widening
2. Large-sized vehicle traffic (Vehicle length)	・ Use as statistics for planning of future structure and pavement repair
3. Time occupancy rate	・ Detect traffic congestion and incident from time occupancy rate
4. Vehicle average speed	・ Provide travel time information to the drivers

Source: Prepared by JICA Study Team

The ATCC system in the project will be introduced to mainly measure the traffic volumes and the large-sized vehicle traffic in major sections on National Highways, IRR and State Highways in phase-1 with the aim of planning for road widening or other road operation and maintenance activities such as pavement repair on major roads. Also, traffic congestion and incident identified by time occupancy rate and vehicle average speed would be detected and calculated by the system to be used as supplemental data of probe car system.

The ATCC system would be expanded in next stages to measure traffic volumes in further detail and detect the traffic congestion and incident on the entire sections in Hyderabad Metropolitan Area.

(b) Type of ATCC Sensor

Following types of detector are generally used as the ATCC sensor.

1) [Loop-coil type detector]

Loop-coil type detects passing vehicles by using electromagnetic induction. Though number of vehicles can be counted with relatively high accuracy by the detector, it is difficult to install in bridge sections because of difficulty to secure a sufficient distance from steels to the loop-coil. Also, the loop-coil type detector has disadvantage that require maintenance work on the road in case of detector troubles.

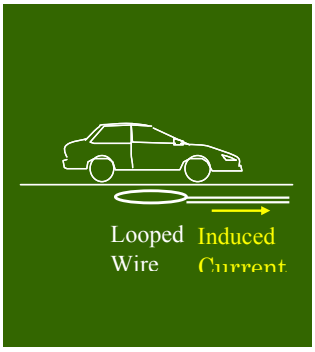
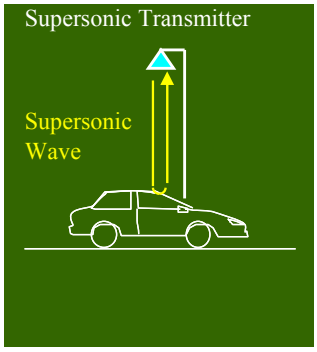
2) [Ultrasonic type detector]

Ultrasonic type detects passing vehicles by using arrival time difference of ultrasonic waves reflected from objects and from the road. Since the detector can be fixed on the supporting structure above the road, maintenance work on road is not required. Also, number of vehicles can be counted with relatively high accuracy. However, the ultrasonic type detector does not detect multiple lane traffics and it is difficult to distinguish the vehicles from the other objects on the road.

3) [Image recognition type detector]

Image recognition type is to detect moving objects in images captured from video cameras according to preset size/speed of the object. Comparing with other type detectors, the overall counting accuracy is not so high (around 95%). However, this type of detector has various advantages such as capability of multiple lane/zone detection, identification of traffics swerved from lanes, etc.

Table 135 Comparison of ATCC Sensors

Item \ Type	Loop-coil Type	Ultrasonic Type	Image Recognition Type
Outline			
principle	Sensor detects passing vehicles by using electromagnetic induction.	Sensor detects passing vehicles by using arrival time differences of ultrasonic waves reflected from objects on the road and from the road.	Sensor detects moving objects in images captured from video cameras according to preset size/speed of the object.
Installation	Buried under pavement with appropriate depth (100 - 150 mm)	Fixed on supporting structure (pole) with appropriate clearance (5.5m or more) from road	Fixed on supporting structure (pole) securing sight path
Unsuitable Location	Bridge section	None	None
Multiple lane/zone detection	Incapable	Incapable	Capable
Detection of swerved vehicle	Incapable	Incapable	Capable
Operation & Maintenance	Necessary to work on road and cut pavement in case of sensor trouble	Unnecessary to work on road	Unnecessary to work on road
Implementation Cost	Low	Average	Average
Recommendation	Average	Average	Recommended

Source: Prepared by JICA Study Team

The image recognition type detector is proposed as the ATCC sensor for this project in consideration of advantages such as:

- Multiple lane/zone detection by one (1) sensor is applicable,
- Image recognition camera can be located on any places of the road section including bridge section (but only limited to on the pier)
- Applicable to identify traffics swerved from lanes,
- Maintenance work on the pavement can be avoided

(c) Traffic Flow Analysis

1) Calculation on ratio of large-sized vehicle

A definition of large-sized vehicle must be set up to detect and calculate the ratio of large-sized vehicle. In the ORR project, vehicle classification for toll fare is defined as follows;

Table 136 Vehicle Classification for ORR Project

Class	Type	Classification
1	Car, Jeep, Van or Light motor vehicle	A motor vehicle that has a height above first axle of less than 1.97 meters, has two axles and the distance between the axels is equal to or less than 3,200 mm.
2	Light commercial vehicle, Light good vehicle, or Mini bus	A motor vehicle that has a height above first axle of equal to or more than 1.97 meters, has two axles and the distance between the axels is not more than 4,400 mm
3	Truck or bus	A motor vehicle that has two axles and the distance between the axels is more than 4,400 mm.
4	Multi-axel vehicle (3 to 6 axels)	Any vehicles having three or more axels but less than 7 axels irrespective of the height of the vehicle and the distance between the axels.
5	Oversized vehicle (7 or more axels)	Any vehicles having equaled to or more than seven axels irrespective of the height of the vehicle and the distance between the axels.

Source: Prepared by JICA Study Team

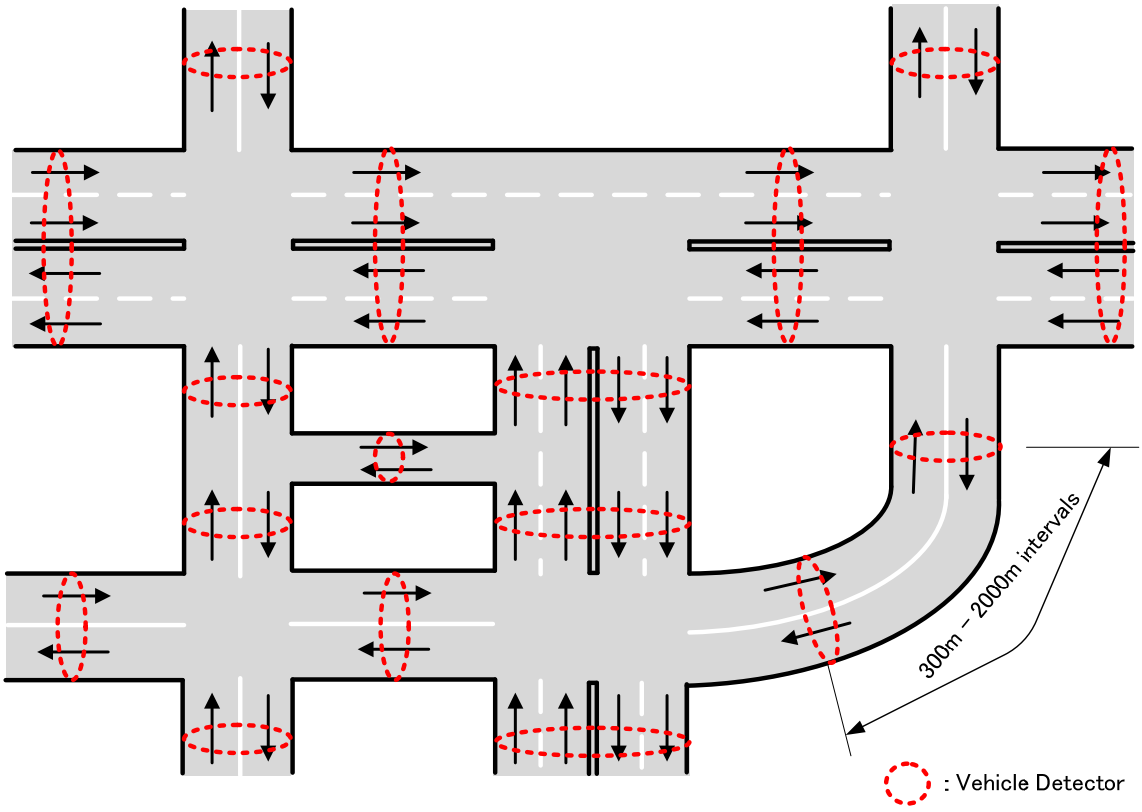
If the vehicles categorized from class 3 to class 5 in table above are defined as large-sized vehicle, the vehicles can be classified by measuring the distance between axles. However, the image recognition type sensor can only measure the length of vehicle and cannot detect the axles' distance itself. Therefore, 6,500 mm of vehicle length is temporally set up as threshold which is estimated by 4,400m distance of axles.

2) Traffic Congestion

The methodology of traffic congestion analysis by utilizing the ATCC system data is classified into:

- Analysis using average speed data
- Analysis applying to time occupancy ratio
- Analysis by combined data above

All of those traffic congestion analysis mythologies require huge number of traffic counter sensor on the road at certain distance intervals or one each between junctions as shown in figure below to precisely analyze the traffic congestion, and the current sensor arrangement of the system seems to be not enough to identify the congested section.



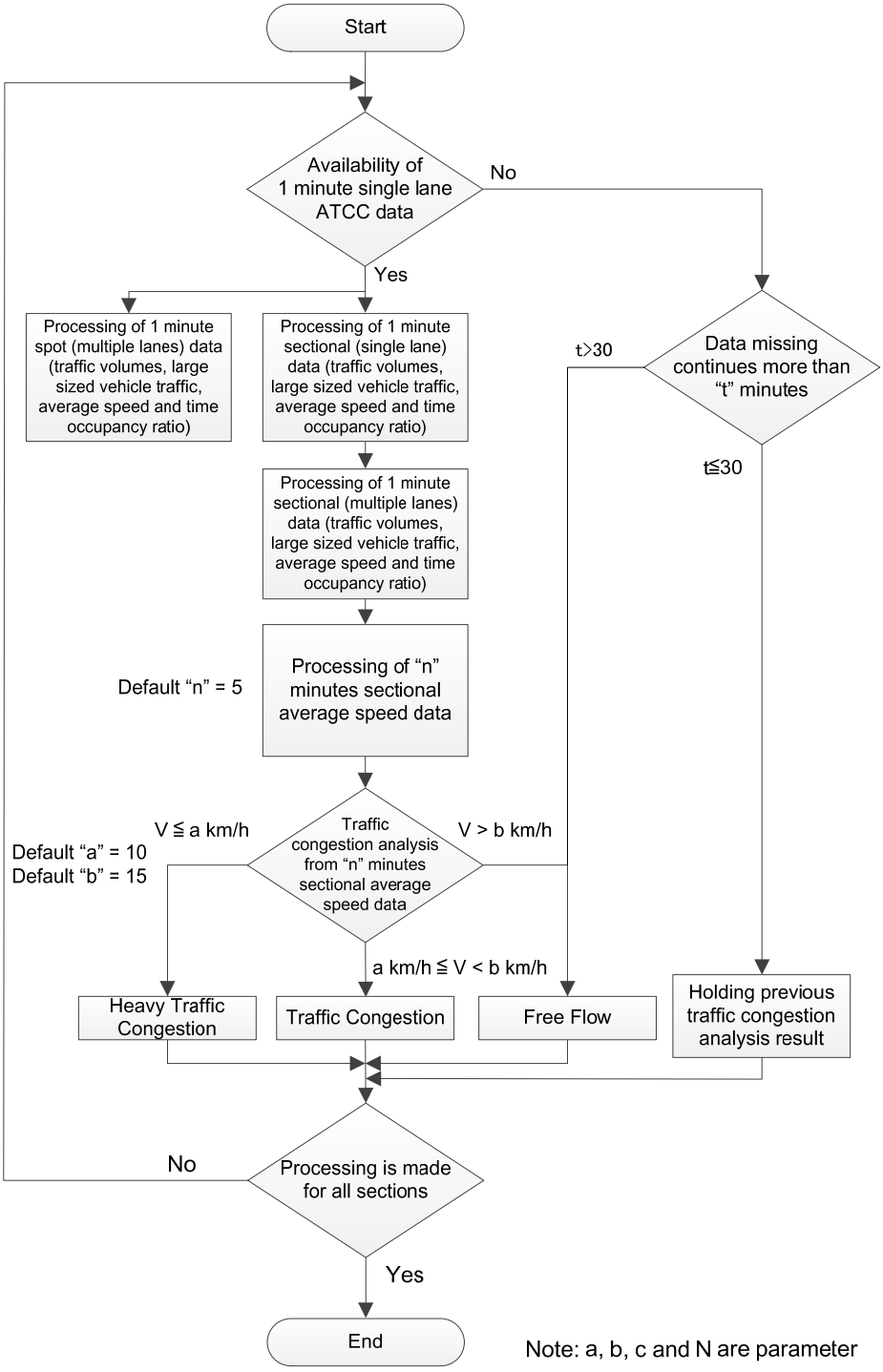
Source: Prepared by JICA Study Team

Figure 234 Typical ATCC Arrangement for Traffic Congestion Analysis

In the traffic congestion analysis only by using the ATCC system, in general, the sensors need to be installed on the expressway at a interval of 300m to 2km (in case of Metropolitan Expressway in Japan, interval of sensors is set as 300m) and at least one each between junctions for the other public road. Thus, it can be said that the traffic congestion analysis only by using the ATCC system is not economically feasible, especially for the analysis on the complex public roads.

On the other hand, the bus probe data including information about average traveling speed would be usable for this project by transferring such data from total of 12,000 buses via APSRTC Central Data Centre. Hence, the traffic congestion analysis using both of ATCC and bus prove average speed data will be applied to this project.

Figure below shows the processing flow and algorism for traffic congestion analysis.



Source: Prepared by JICA Study Team

Figure 235 Traffic Congestion Analysis Processing Flow and Algorism

The algorism for traffic congestion analysis must be configured to cope with the following factors and parameters.

- To avoid the fluctuation of analysis results, the average speed data for certain period (n) must be utilized in the processing. The default of the time period is initially set as five (5) minutes and this value must be changeable.
- The analysis result is classified into three (3) traffic congestion levels, that is, "Heavy Traffic Congestion", "Traffic Congestion" and "Free Flow". The thresholds of traffic

congestion level, “a” and “b” are tentatively set as 10km/h and 15km/h respectively in initial stage. Also, those thresholds must be variable and determinable by each location since average speed may differ according to the road conditions, alignment, etc. at the site and would be optimized in future after collecting the enough volumes of traffic data.

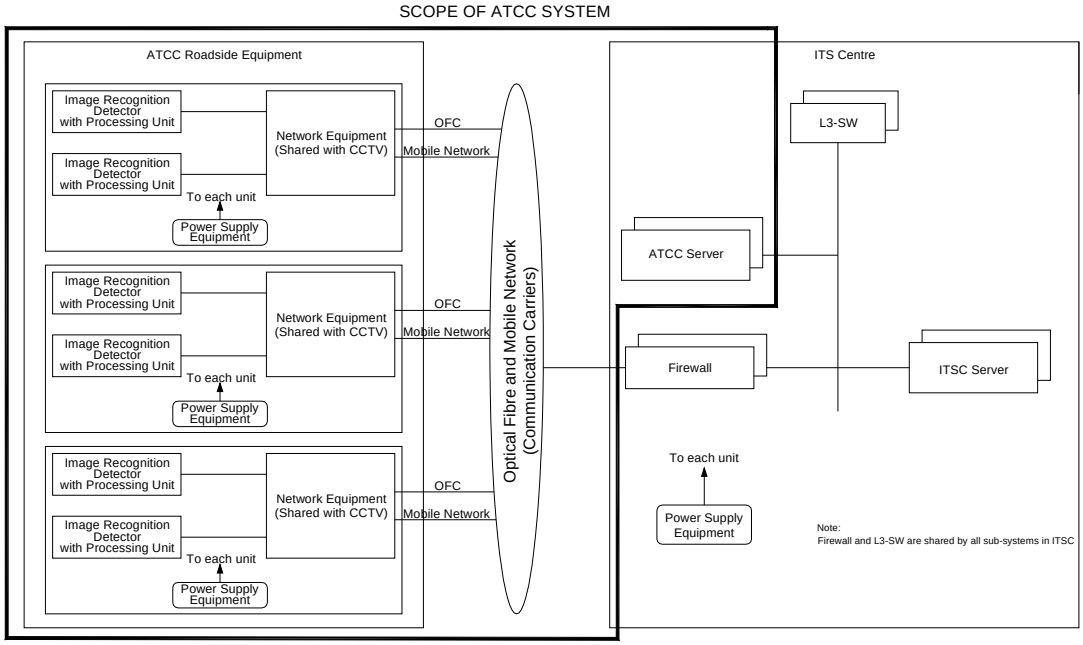
- In case any data are not available from the ATCC roadside equipment, previous analysis result has been held for 30 minutes. If the absence of data continues more than 30 minutes, previous data is reset and the traffic is processed as “Free Flow”.

(d) ATCC System Configuration

The ATCC system will consist of the following components;

- ATCC roadside equipment consisting of image recognition detector and processing unit with supporting structure at roadside;
- ATCC server with storage device in ITSC;
- Network equipment; and
- Power supply equipment and peripheral.

The proposed ATCC system would be initially configured as Figure below.



Source: Prepared by JICA Study Team

Figure 236 Proposed ATCC System Configuration

(e) ATCC System Functions

The ATCC system will be provided with the functions described below.

1) Traffic data measuring and processing functions at roadside

The **ATCC Roadside Equipment** shall continuously measure. It shall be possible to adjust the angle and coverage area of the image recognition detector to maximize the detection accuracy.

Images taken by the ATCC Equipment shall be processed to obtain the required traffic data. The processing unit shall be capable of:

- Detecting vehicles going in any direction.
- Recognizing the shape or edge of the vehicle.
- Counting the number of vehicles that pass the sensing area during the unit measurement time on a lane basis.
- Classifying the vehicle into large and small size. The definition of the large and small size shall be made according to the vehicle length and the classification parameter shall be adjustable.
- Calculating the time occupancy rate per unit measurement time.
- Calculating an average speed per unit time which is an average of the speed of vehicles that are passed during one unit measurement time.

ATCC System shall detect vehicles, measure and calculate the traffic data for each lane. ATCC System is expected to have 90% or better vehicle counting accuracy.

Unit duration of detection, measurement and calculation shall be one (1) minute time interval.

2) Data transmitting functions

The following data transmission functions between ATCC Roadside Equipment and ATCC Sever in ITSC shall be equipped:

- Measured data and processed data in the Roadside Equipment shall be sent from ATCC Roadside Equipment to ATCC Server for every one (1) minute. Data processing shall be also conducted within one minute.
- 1 minute spot (single lane), 1 minute spot (multiple lanes), sectional (single lane) and sectional (multiple lanes) data shall be sent to ATCC Server.
- Equipment failure status shall be sent to ATCC Server real-time base.
- ATCC Roadside Equipment shall response a request from ATCC Server real-time bases.
- Other necessary data shall be on demand base, if necessary.
- Unit transmitting interval, also referred as unit measurement interval, shall be one (1) minute.
- Traffic volume for every 1 minute by vehicle classification (at least large and small sized vehicle)
- Large-sized vehicle traffic for every 1 minute
- Time occupancy rate for every 1 minute
- Vehicle average speed for every 1 minute
- Equipment operation and failure status
- Other necessary data
- Unit time period of data transmitting shall be of one (1) minutes interval.
- “n” minutes sectional average speed data (default “n” = 5 minutes)
- Traffic congestion analysis result with each parameters

3) Error Checking and Substitution Function

The data sent from Roadside Equipment shall be tested first for possible errors. The thresholds shall be defined and data received from Roadside Equipment shall be checked with the threshold. If the data is judged as abnormal or error signal is sent from ATCC Roadside Equipment, it shall be marked malfunctioned and an alarm shall be issued to the ATCC Operator

Console. The faulty detector shall be recorded in the operation log. The data judged as abnormal shall not be used for further processing.

The data from the vehicle detector marked as malfunctioned shall be checked continuously for data abnormality. If data is judged normal, normal processing of the data shall be resumed automatically.

The following error-checking and substitution functions shall be equipped:

- The data sent from the Roadside Equipment shall be tested first by the ATCC Server for checking possible errors.
- The thresholds shall be defined.
- The ATCC Server shall check the collected data with the defined threshold.
- If the collected data is measured lower or higher than the threshold, the ATCC Server shall issue an alarm "ABNORMAL DATA TRANSMITTED" to the ATCC Operator Console and the collected data shall be marked as "Error".
- If an error signal is received from ATCC Roadside Equipment, the ATCC Server shall issue an alarm "ATCC Roadside Equipment FAULT" to the ATCC Operator Console and the collected data shall be marked as "Fault".
- The error and fault status shall be recorded in the operation log.
- The error data and the data from the faulted equipment shall not be used for further processing.

The error data and fault status shall be continuously checked. If the error data or fault status recovers to normal and they are judged normal by ATCC Server, the normal data processing shall be automatically resumed.

4) Data collecting function

- The ATCC Server shall collect the data from the ATCC Roadside Equipment per unit measurement interval.
- The unit measurement time shall be a system parameter and shall be adjustable.

5) Data processing and management function

The ATCC Server shall process the traffic data collected from the ATCC Roadside Equipment and identify the congested section from average speed and time occupancy ratio data as described in below processing flow and algorithm.

Data processing shall be also conducted within one minute.

The algorithm for traffic congestion analysis shall be configured to handle the following factors and parameters.

- To avoid fluctuation of analysis results, the average speed data for certain period (n) shall be utilized in the processing. The default of the time period is initially set as five (5) minutes and this value shall be changeable as a parameter of ITS Server.
- The analysis result is classified into three (3) traffic congestion levels, they are, "Heavy Traffic Congestion", "Traffic Congestion" and "Free Flow".
- The thresholds of traffic congestion level, "a" and "b", which are shownin the flow chart, are tentatively set as 10km/h and 15km/h respectively in initial stage.
- The thresholds shall be variable and determinable by each location since average speed may differ depending on the road conditions, alignment, etc. at the site. The threshold

shall be optimized during operation after collecting enough volumes of traffic data.

- In case that any data is not available from the ATCC Roadside Equipment, previous analysis result shall be held for 30 minutes. In case of absence of data continuously for more than 30 minutes, previous data is reset and the traffic is processed as "Free Flow".
- If the processed data at a lane or a section is lower or higher than the predetermined threshold, the server shall issue an alarm "abnormal traffic condition" to the Operator Console.
- The (n)-minute traffic flow data shall be accumulated and converted to hourly traffic data.
- It shall be possible for real-time monitoring of traffic flow data through Operator Console and printed report.
- Traffic flow data of single and multiple lanes can be specified for monitoring and both numerical and graphical presentation shall be provided. The data on the display shall be automatically updated for every processing interval.
- Real-time monitoring of operating condition of ATCC Roadside Equipment shall also be possible.
- The time occupancy rate to be detected in ATCC System shall be for reference. The accuracy of traffic congestion analysis can be improved by utilizing both average speed and occupancy data.

6) Data storage function

Data shall be processed in the ATCC Server and stored in the database of ITSC System at an interval of 5 minutes for total system management.

All data transmitted from the ATCC Roadside Equipment and processed data in the ITSC shall be stored in the ATCC Server for analysis and future usage.

Data retrieval and presentation software shall be provided to show the traffic data and operating condition of the specified Roadside Equipment location at the specified time, hour or day.

Graphical presentation of historical traffic data such as hourly variation and daily variation shall also be provided.

Status of ATCC Roadside Equipment (normal or abnormal) shall be recorded in the ATCC Server as operation log with error code and time stamp for future reliability analysis.

Table 137 Data Storage of ATCC

Sub-System	Storage Data		Type
ATCC System	1 minute spot (*2) (single lane) data	Traffic volume by vehicle classification (*1)	Raw data
		Large-sized vehicle traffic	
		Time occupancy rate	
		Vehicle average speed	
	1 minute spot (*2) (multiple lanes) data	Traffic volume by vehicle classification (*1)	Processed data
		Large-sized vehicle traffic	

		Time occupancy rate	
		Vehicle average speed	
	1 minute sectional (*2) (single lane) data	Traffic volume by vehicle classification (*1)	Processed data
		Large-sized vehicle traffic	
		Time occupancy rate	
		Vehicle average speed	
	1 minute sectional (*2) (multiple lanes) data	Traffic volume by vehicle classification (*1)	Processed data
		Large-sized vehicle traffic	
		Time occupancy rate	
		Vehicle average speed	
	"n" minutes spot average speed		Processed data
	"n" minutes sectional average speed		Processed data
	Traffic congestion analysis results		Processed data
	Equipment operational status		Raw data

- Source: Prepared by JICA Study Team

(*1): **ATCC** shall classify vehicles at least large and small.

(*2) "Spot" means the location where the **ATCC Roadside Equipment** is installed. The traffic status on the road with a certain distance is estimated by "Spot" data. Thus, the "Spot" represents a certain distance of the road. "Section" consists of one or several "Spot".

7) Diagnosis function

The ATCC system shall have a diagnosis function. The ATCC server shall inquire the connection with the ATCC roadside equipment and the status of equipment by sending the diagnosis signal in every five (5) minute. If the equipment fault signal is received or there is no response from the roadside equipment, the server shall issue an alarm and the fault shall be recorded in the log. The ATCC server shall also have self diagnosis function of the server.

8) Display and reporting functions

The information display of Operation Console shall be schematic map based interface and as well in the form of a list.

The display of Operation Console shall have both schematic map based and list form based interfaces.

The schematic map based interface on the display shall cover the entire HMA and shall be able to enlarge individual locations on the map when selected by the user. The enlarged view shall be able to display the details for each selected location. The details displayed shall cover the contents as described in the below table but not limited to.

The ATCC Server shall be capable of creating the following screen contents, but not limited to:

Table 138 Items and Contens of Display and Reporting of ATCC (1)

Item	Contents on Schematic Map	Other Contents
Equipment location	• Location of ATCC Roadside	• Location of ATCC Roadside

and status	Equipment and its status (Normal / Error)	Equipment and its status (Normal / Error) in the list
Observation (raw) data	•	• Observation record detail in the list and graph • Edit window to edit or remove an abnormal observation record
Processed data	•	• Processed data in tthe list and graph
Parameter setting	•	• Parameters in the list • Edit window to edit all the parameters
Traffic conditions	• Current traffic volume by vehicle type • Current traffic average speed • Hourly traffic volume variation in the graph • Hourly average speed variation in the graph	• Current traffic volume by vehicle type • Current average speed • Hourly traffic volume variation in the the list and graph • Hourly average speed variation in the the list and graph
Server status	•	• Server status (Normal / Error) in the list
Operation log	• Roadside Equipment	• List of Roadside Equipment in operation/out of operationt • Operation record • Data error record
Date and Time	• Current date and time	• Current date and time

The **ATCC Server** shall generate the reports listed below, but not limited to.

- The reports shall be generated according to the schedule and upon request
- The reports shall be selectable for either generating a file in Portable Document File (PDF) format or printing directory to a printer.

Table 139 Items and Contens of Display and Reporting of ATCC (2)

Item	Contents
Traffic volume by spot and section	• Daily report containing hourly traffic volume by vehicle class • Daily report containing hourly average speed • Monthly report containing daily and weekly traffic volume by vehicle class • Monthly report containing daily and weekly average speed
Operation and error log	• List of **Roadside Equipment** with its status (normal / abnormal) • Operation record • Error record

- Source: Prepared by JICA Study Team

9) Data transferring function

- Following data processed in the ATCC server shall be stored in the database of ITS centre system for total system management at interval of 5 minutes.

- Following every 1 minute spot (multiple lanes), sectional (single lane) and sectional (multiple lanes) data
- Traffic volume
- Large-sized vehicle traffic
- Time occupancy rate
- Vehicle average speed
- "n" minutes sectional average speed data (default "n" = 5 minutes)
- Traffic congestion analysis result with each parameters
- Equipment operational status

(f) ATCC Network Configuration

As for network connection between ITSCC and roadside equipment, it is difficult to apply to own cable network system because cable installation costs become very high due to the wide spreading equipment locations. In this case, two (2) types of option are considerable for network system provided by communication carriers. One is optic fiber network and the other is mobile network (GSM/GPRS). Both of them have advantages and disadvantages as shown in table below.

Table 140 Major Advantages and Disadvantages of Network System

Item \ Network		Optic Fibre Network	Mobile Network (GSM/GPRS)
Network Type		Dedicated Line Service, Broadband Service	GSM/GPRS
Transmission Speed		64kbps - 155Mbps or more	9.6 kbps - 115kbps
Data Transmission	Voice Com.	Yes	Yes
	Data Transfer	Yes	Yes
	Picture	Yes	Yes
	Moving Picture	Yes	No
Advantages		- High transmission speed (moving image can be transferred) - High reliability in case of dedicated line service	- Cheaper monthly cost
Disadvantages		- Higher monthly cost - Services are provided only within the coverage of provider	- Limited transmission capacity - Services are provided only within the coverage are of provider
Cost		8,000 RPs/line-month (1Mbps, dedicated line)	1,200 RPs/line-month (unlimited packet service)

Source: Prepared by JICA Study Team

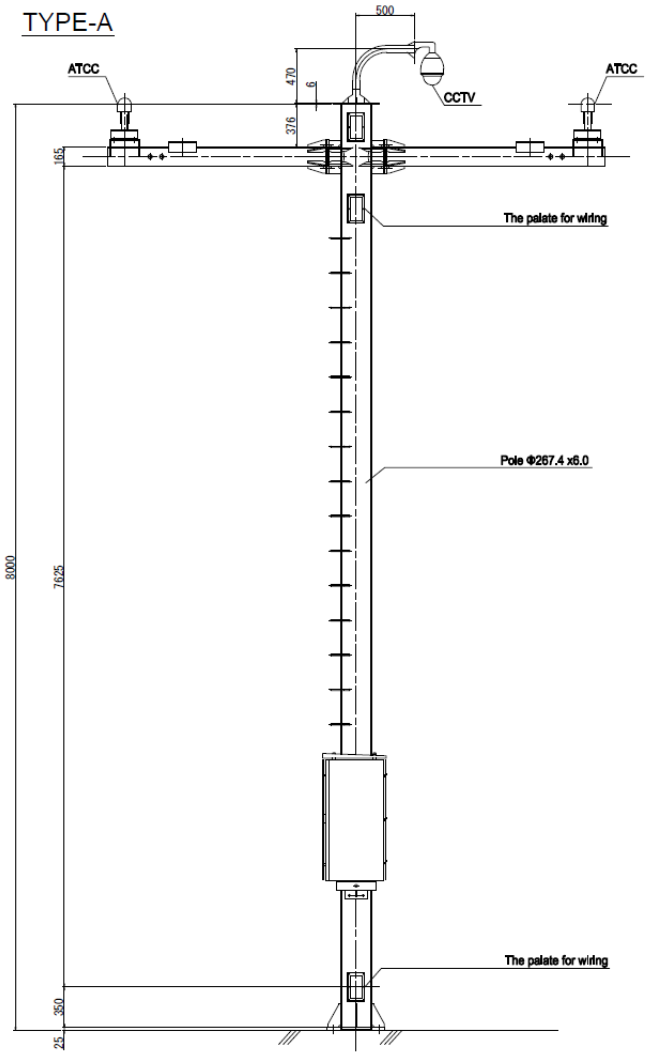
It is recommended that data transmission of the ATCC system be made either the optical fibre network or mobile network both provided by the communication carriers to enhance the network reliability. The optical fibre network shall be utilized as main communication line while the mobile network shall be used as backup. Should any communication failure occur in optical fibre network, the ATCC system shall automatically change over the communication line to mobile network.

(g) Installation Method

The ATCC roadside equipment will be installed at roadside as follows:

- Two (2) sets of image recognition sensor for both bounds detection will be basically put on a supporting steel pole at median except locations where the METRO will be constructed. In the METRO sections, the sensors will be separately installed at both sides of road shoulder.
- CCTV camera will be fixed on the top of supporting steel pole to monitor the actual traffic flow visually.
- The visible clearance must be kept in the detection area of image recognition sensor. The detection area would be around 15m width and 30m length along the road.
- The supporting pipe must be equipped with steel ladder to ease the maintenance work of ATCC detector.
- The communication unit, processing unit, power supply facilities and other devices installed at roadside will be housed in the cabinet. The cabinet would be hanging on the supporting pole.

Typical installation plan for the ATCC roadside equipment is illustrated as figure below.



Source: Prepared by JICA Study Team

Figure 237 Typical Installation Plan for ATCC Roadside Equipment

(6) Power Supply to ATCC Roadside Equipment

(a) Power Source

The electrical power supply system for roadside equipment is classified into:

- Solar power with back-up battery,
- AC commercial power,
- AC commercial power with UPS (Uninterruptible Power Supply), and
- AC commercial power with UPS and DEG (Diesel Engine Generator)

The solar power supply is normally applied to equipment with small power consumption located at remote area where the commercial power is not available from the power company because the back-up battery becomes huge capacity to compensate power supply even under non-sunshine condition. The comparison of power supply system is shown in table below.

Table 141 Comparison of Power Supply System

Item \ Power Supply	Solar Power Supply System	AC Commercial Power Supply System
1. Outline	Solar power supply system is composed of solar cell panel to convert solar energy into electrical power, battery & charger to compensate power supply in night time or non-sunshine period and power distribution panel to control power charge/discharge.	Power is fed from low voltage line of power company. Avoiding voltage fluctuation and the lightning serge from commercial line, the stabilizer or isolation transformer is provided in this system. UPS and/or DEG may be used as back-up power supply in case of commercial power interruption.
2. System Configuration	1) Solar cell panel 2) Power distribution panel (Controller) 3) Battery and battery charger with huge capacity	1) Stabilizer or isolation transformer 2) Power distribution panel 3) UPS and/or DEG as option
3. Advantages	- Power supply is possible even at the areas where the commercial power is not available. - Deterioration by lighting serge can be reduced due to independent power supply system. - Monthly charges to be paid to the power company are unnecessary.	- Stable power supply can be expected. - Capacity of UPS battery can be minimized since the compensation time is reduced comparing with solar power. - Initial cost is cheaper than solar power.
4. Disadvantages	- Large sized battery with enough capacity for supplying power for a certain period (normally 10 days or more) is needed. - It requires enough space for installing solar cell panel and battery. - Lifecycle of battery is short due to its discharge characteristics. - Constant power generation cannot be expected in case solar cell panel is masked by dust or other obstacles. - Initial cost is higher than solar power.	- Monthly charges are required. - There are possibilities to receive damages by lightning serge from commercial line.
5. Unsuitable Locations and/or Conditions	- Roadside equipment having high power consumption	- Remote area where the commercial power is not available

Source: Prepared by JICA Study Team

AC commercial power with UPS is selected as power source for the roadside equipment with following reasons:

- The solar power supply is normally applied to equipment with small power consumption located at remote area where the commercial power is not available from the power company because the back-up battery becomes huge capacity to compensate power supply even under non-sunshine condition. However, all of sites are located near commercial power pole and power can be easily fed from low voltage line of the power company. Also, estimated total amount of power consumption for the roadside equipment (continuously 0.7kVA - 3.0kVA) is not so little as to supply power by the solar system, and it is difficult to secure enough space for installation of solar cell panel since roadside equipment must be placed on the median or the road shoulder. Therefore, the solar power supply system is not suitable as power supply system for roadside equipment.
- In Hyderabad Metropolitan Area, there often observes commercial power interruptions. Thus, backup power supply system must be considered to compensate commercial power interruptions. Generally, three types of backup power supply system can be applicable; 1) UPS (Uninterruptible Power Supply), 2) DEG (Diesel Engine Generator) and 3) UPS + DEG combined. Among them, however, DEG is not suitable for backup power supply for the roadside equipment since DEG system requires starting-up time and the roadside equipment does not allow such short time power cut. Hence, UPS or UPS+DEG combined are acceptable.
- Utilization of UPS and DEG combined system to the roadside equipment is not recommendable because DEG cannot be mounted in the cabinet of roadside equipment and maintenance for fuel supply will be required.

(b) Estimated Power Consumption

The power demand load of traffic counter roadside equipment with CCTV camera is estimated as total of 0.9 KVA as shown in table below.

Table 142 Estimated Power Demand Load of ATCC Roadside Equipment

Power Demand / Equipment	Voltages	Unit Power Demand (kVA)	Number of Unit	Estimated Power Demand (kVA)	Remarks
Image Recognition Detector	1φ – 2W – 220V	0.1	2	0.2	
ATCC Processing Unit	1φ – 2W – 220V	0.5	1	0.5	
CCTV Camera	DC 12V	0.1	1	0.1	DC power is supplied from power unit in the controller.
Controller Unit	1φ – 2W – 220V	0.1	1	0.1	
Total				0.9	

Source: Prepared by JICA Study Team

(c) UPS

To compensate for a short time power cut off, Uninterruptible Power Supply (UPS) will be provided to the ATCC roadside equipment.

Roadside equipment other than VMS such as ATCC, MET, etc. are categorized into data

collection system and data collected from those roadside equipment will be utilized as not only for real time monitoring but also for statistics bases to feedback the future road planning. From this point of view, roadside equipment of data collection system shall not allow any power interruption period to avoid lack of data collection.

According to official statement of Central Power Distribution Company of Andhra Pradesh Limited (APCPDCL) which is a power distribution company in AP state, the targeted durations of scheduled power cut are less than 3 hours in GHMC area and actual operations of power distribution line including recovering the unexpected power cut are being implemented by following this policy. Under such circumstance, it is proposed that the compensation duration of UPS for roadside equipment shall be of 3 hours except VMS.

The required capacity of the UPS battery is given by formula below:

$C = K \times I / L$

Where,

C : Required capacity of battery [Ah]

K : Conversion factor depending on discharge time (T), minimum temperature and allowable minimum voltage [h] = 6.5

I : Discharge current = estimated power demand (VA) x power factor (0.9) / η / Ed

η : Inverter efficiency = 0.85

Ed: Battery voltage = allowable minimum voltage of battery (1.8) x number of battery cell (104) = 187.2 (V)

L : Maintenance Factor = 0.8

Hence, the required capacity of battery is estimated as:

$C = K \times I / L$

$= 4.0 \times (900 \times 0.9 / 0.85 / 187.2) / 0.8$

$= 25.5$ [Ah]

The capacity of UPS battery must be recalculated by the contractors in compliance with power requirements of their equipment.

10-2-2 Probe Car System

(1) System Objectives

The probe car system is a system to measure traffic data including traveling speed and time, to analyze congested area from traffic data and to provide such traffic information to the road users. The system shall be introduced in the Project with following objectives:

- To measure the traffic conditions such as travelling speed and travelling time on the road in Hyderabad Metropolitan Area
- To provide traffic information including congested area and travelling time at particular section generated by the probe car system to the road users and encourage detour from the congested areas:
- To utilize measured and analysing data as statistics for future road planning such as road widening or road expansion plan: and
- To share the traffic information with road planning agencies, road operators and traffic polices in the ITS Centre (ITSC) in order to enhance system objectives above.

The vehicle tracking devices, i.e. GPS On-Board Unit (OBU), to be used in this system will be mounted on the public buses owned by Andhra Pradesh Road State Transport Corporation (APSRTC) and provided under the scheme of other project. Once the vehicle tracking data is transmitted to the server in the APSRTC Data Centre, then, the data is transferred to probe server in the ITSC. The probe car system shall operate on a 24-hour a day 7-day a week basis.

(2) Probe Car System Requirements

System requirements of the probe car system are as follows.

- To measure the traffic conditions such as travelling speed and travelling time on the road in HMA.
- The vehicle tracking data generated at an interval of 10 seconds in each GPS OBU consists of followings:
  - ✓ Bus number,
  - ✓ Bus type,
  - ✓ Location (Longitude and Latitude),
  - ✓ Time stamp,
  - ✓ Bus route number,
  - ✓ Travel speed
- All of vehicle tracking data collected by APSRTC Bus Probe Server shall be received by the Probe Server in the ITSC at an interval of less than one (1) minute.
- The traffic data can be monitored in the ITSC on real-time basis and the data can be stored for a certain period in order to utilize for road planning, road operation and maintenance.
- The communication between Probe Server in the ITSC and the APSRTC Bus Probe Server shall use HTTPS or equivalent data transfer protocol.
- The traffic data collected and analysed by ITSC System shall be provided to road users through VMS System and other information provision systems such as E-mail, Internet and SMS.

(3) Selection of Probe Vehicle

The probe vehicles to be equipped with vehicle tracking device will be selected in accordance with following policies to meet the system objectives and requirements above.

- It is appropriate to apply the vehicles which are continuously running on the road such as bus, taxi and fleet vehicles as probe vehicles so that traffic data can be collected at regular intervals.
- One of the best candidates for the probe vehicle is the public buses operated by the APSRTC. Approximately 3,600 buses are under operation as of now and their service areas cover nearly entire city of the Hyderabad Metropolitan Area.
- The vehicle tracking devices, i.e. GPS On-Board Unit (OBU), will be mounted on 1347 buses owned by the APSRTC and provided under the scheme of other project implemented by the APSRTC. The APSRTC agreed to provide the probe data of the 1347 city buses to the ITSC.
- The vehicle tracking data generated by APSRTC bus location system can be easily available at ITSC by connecting network links between Central Data Centre of APSRTC and ITSC without any additional vehicle tracking devices.

Based on the above policies, the vehicle tracking data in this project will be obtained from the bus location system prepared by the APSRTC.

(4) Technical Specifications and Present Conditions on the APSRTC Bus Location System

(a) System Outline

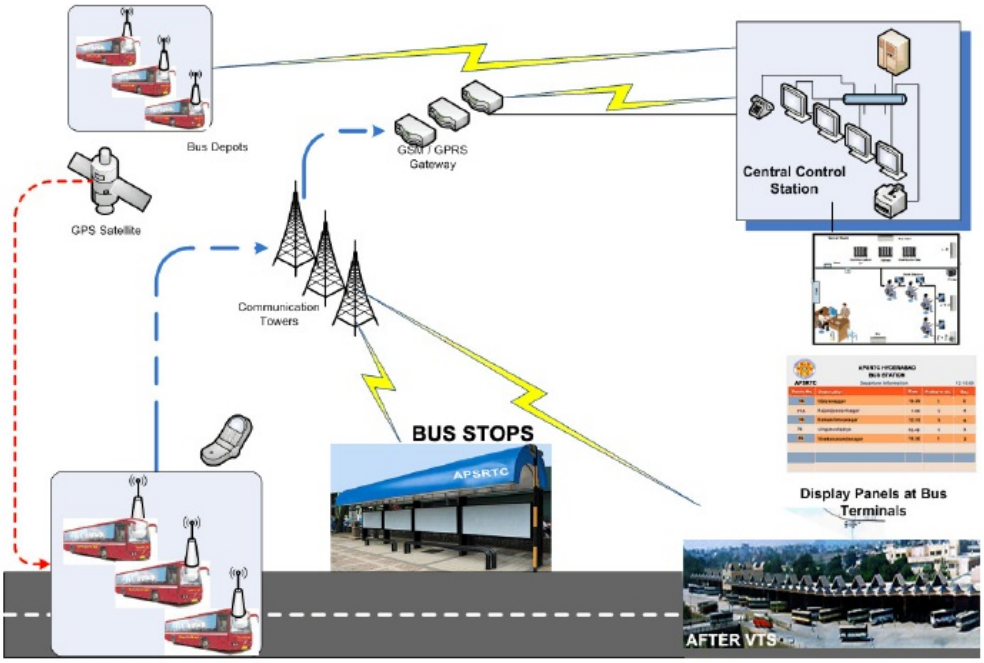
Andhra Pradesh Road State Transport Corporation (APSRTC) has planned to introduce Vehicle Tracking & Passenger Information System (VT & PIS) to overcome the critical issue of road congestion by adopting state-of-art technologies and attractive, convenient, comfortable, value added services to encourage the usage of bus services instead of individual personal vehicles. They expect a significant model shift with national and international sustainable development in affordable cost and overcome traffic problems.

VT & PIS incorporates various systems such as Vehicle Tracking System, Real Time Passenger Information System and Central Control Centers. Core technologies include GPRS, GSM, Geographical Positioning System (GPS), Display units and Information & Communication Technologies.

(b) System Configuration

The VT & PIS project will comprise with following subsystem:

- Vehicle Tracking System (VTS) with real time connectivity:
- Passenger Information System (PIS) with LCD/LED Display Boards:
- Central Control Rooms at APSRTC premises at locations identified by APSRTC:
- Data Centre (to be located in Hyderabad): and
- Depot Level Applications to support the above systems.



Source: Prepared by JICA Study Team based on RFP of APSRTC Project, 2012

Figure 238 Proposed System configuration of VT&PIS by APSRTC

A broad description of each subsystem is as follows:

(c) Vehicle Tracking System (VTS)

Global Positioning System (GPS) based Vehicle Tracking Unit (VTU) is the most important part of VTS. The Vehicle Tracking Unit records and transfer vehicle movement data (Latitude/Longitude coordinates) with time stamp to a central server through GSM/GPRS network in every 10 seconds or lower intervals. Fleet tracking application is hosted at the central server to monitor and manage the fleet with analytical tools (supporting a map, graph and text display.

(d) Passenger Information System (PIS)

PIS comprises of installing LCD/LED Display Boards with required controllers (at Bus Stations, Bus Shelters and other locations identified for the purpose) along with all required fittings, fixtures & UPS Systems for providing two hours backup power, displaying real time information of arrival and departure (including incident related information such as delay). The PIS includes an application to support and provide real time information of arrival and departure of buses through LCD/LED displays, Short Message Service, Internet. Real time information on SMS & internet will be provided on demand.

(e) Data center

Data Center receives transactional data from device applications into servers hosting VTS, and decision support applications respectively to generate alerts and reports on revenue and schedule parameters aiding in analyzing through a centralized web solution for different users at APSRTC (with a map, graphical and text display) at designated control stations.

(f) Control centers

Control Center will act as a live hub to manage and monitor service related data which will be viewable through a centralized web application on PC's and LCD Displays. Activities at the control centre will comprise at the minimum, tracking fleet for adherence to schedule through

alerts, immediate follow up action to non-adherence to 9 schedules, initiate a two way communication with the crew, incident management with defined escalation procedures, help desk activities to monitor health of VT&PIS project.

(g) Depot Level Applications

Depot level Application would include a software application that can be used for fleet management at bus depots. The application tracks the activities and location details of the vehicles. The data collected through the application could be used for further planning and managing the fleet in efficient way.

(5) Technical Specifications

(a) [VTS Device]

CPU	32 Bit Microcontroller
Storage (Program + Transactions)	Minimum 8MB flash (capable to store 2 hours data in case of communication failure)
GSM/GPRS Module	Incoming and outgoing GSM calls and GPRS data transfer
GPS Module	GPS Receiver, Tracking sensitivity -161 dBm
Power Supply	Primary: Vehicle Battery 12/24volts Backup: Internal battery for 8 hours backup
Environmental Specification	Temperature Operating: about 0 to +70º C Humidity: 5% to 95% RH non condensing at +40°C Sealing: IP65
Physical dimensions	116 X 76 X 28 mm
Weight	< 200 gms

(b) [GSM/GPRS Specifications]

GSM	Normal MS-SMS data
Frequency	900/1800 (dual band) Class 4 (2W) at 900 MHz (EGSM) Class 1 (1W) at 1800 MHz
GPRS	Type B class 10
SIM	1.8V/3V
Antenna	Built in Antenna
Provider	Airtel / Equivalent

(c) [GPS Specifications]

Frequency	L1 (1575.42 MHz) frequency
C/A code	Standard Positioning Service
Channels	Minimum 16-Channels
Sensitivity	Minimum –158 dBm Acquisition without external assistance
Accuracy	Horizontal: <10 meters Velocity: 10 m/sec
Antenna	Built In active antenna

(d) [System Availabilities]

VT & PIS Application Availability	> 99.00%
Computing accuracy	100%
Availability of systems at Data Centre	> 99.00%
Data availability	100%
Data accuracy	100%
Availability of agreed services over the internet	100%
Network availability	> 99%

(6) Present Situation of the Project

It was originally planned to implement Vehicle Tracking and Passenger Infrmation System for 12,000 buses of APSRTC. But later, it was decided to implement the the project for 3,502 buses only.Out of the total 3,052 buses for which the Vehicle Tracking and Passenger Infrmation System is being implemented, 1,616 buses are operating to long distances, 1,347 buses are operating in the Hyderabad city and the remaining are operating in other cities of the state.

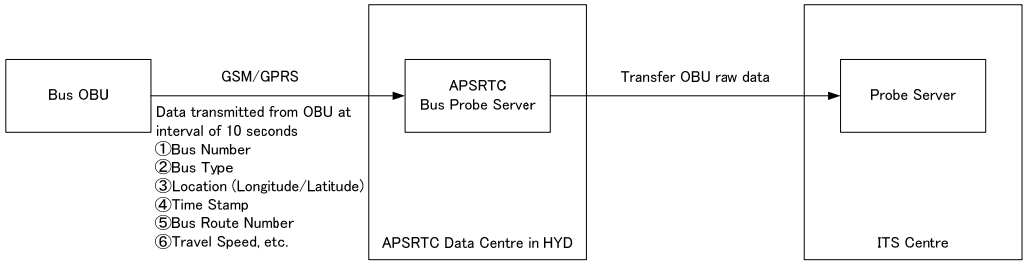
The APSRTC agreed to provide the vehicle tracking data of 1,347 city buses to ITSC. APSRTC incorporated the additional system requirements and specifications in the RFP which was prepared and submitted to APSRTC by the Study before the pre-bid meeting.

The project has been awarded to a private agency, CMC Ltd and the agency started the project related work.

(7) Proposed Vehicle Tracking Data Transferring Method

(a) Transferring Method

The data flow of vehicle tracking data transfer is outlined as figure below,



Source: Prepared by JICA Study Team

Figure 239 Outline of Vehicle Tracking Data Transfer

All of data transmitted from VTS devices in buses to the Central Data Centre shall be transferred to probe sever in ITSC less than one (1) minute interval.

The data transferred to probe server shall be a vehicle tracking raw data generated in each VTS device at interval of 10 seconds and consists of followings;

- Bus number,
- Bus type,
- Location (Longitude and Latitude),
- Time stamp,
- Bus route number,
- Travel speed, and
- Other available raw data.

The Central Data Centre will communicate with ITSC using HTTPS or equivalent. The communication network which will be provided by ITSC contractor shall have high speed internet connectivity over IP-VPN technology for security purpose. The VT & PIS system contractor shall provide interfaces to connect such broadband data communication network. The data transfer protocol must be coordinated with the ITSC contractor and approved by both APSRTC and HMDA.

The data structure and format shall be configured with xml (Extensible Markup Language) or equivalent. Details must be coordinated among the ITSC contractor and VT & PIS system

contractor and approved by both APSRTC and HMDA.

In case that any abnormal or malfunctioning communication is detected, the server in the Central Data Centre shall record a type of the failure and issue an alarm.

The service level requirements of the system including data availability and accuracy must meet the requirements specified in the original technical specifications of APSRTC contract.

(b) Work Demarcation

1) [The scope of VT & PIS system contractor]

- Supply, installation, testing and commissioning of required hardware in the Central Data Centre located in Hyderabad for facilitating vehicle tracking data transfer to ITSC.
- Development, installation and maintenance of the required application software for the data transfer.
- Coordination with the ITSC contractor about detailed data transfer protocols and specifications.

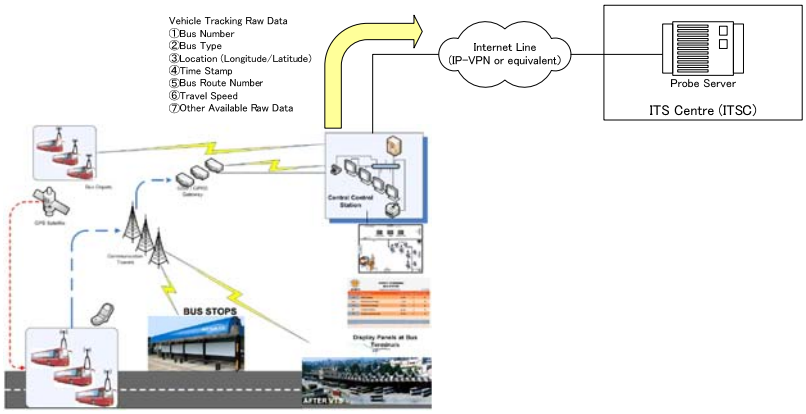
2) [The scope of ITSC contractor]

- Supply, installation, testing and commissioning of probe server for receiving vehicle tracking data in the ITSC.
- Providing high speed internet connectivity of the required bandwidth to the Central Data Centre and ITSC.

(c) System Configuration

The probe car system will consist of the following components:

- VTS devices installed on 1,347 city buses: APSRTC project components
- GSM/GPRS network between VTS devices and APSRTC Central Data Centre: APSRTC project components
- Servers and application software in APSRTC Central Data Centre: APSRTC project components,
- High speed internet connectivity over IP-VPN between APSRTC Central Data Centre and ITSC
- Probe server with analysis software in ITSC

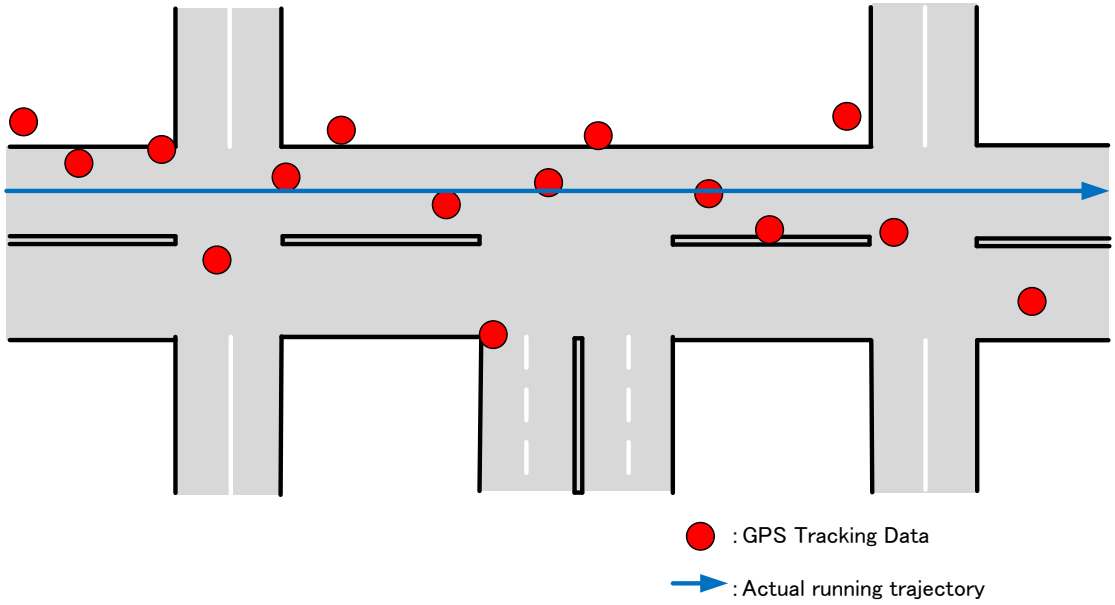


Source: Prepared by JICA Study Team

Figure 240 Proposed Probe Car System Configuration

(8) Digital Road Map

The coordinate data tracked by the OBU is not necessarily corresponding to actual vehicle location due to GPS accuracy. It is normally said that GPS data have 5 - 10 meters margin of error. In order to minimize the error range of GPS tracking data, the probe car system must have functions to compensate the measuring data and/or vehicle running trajectory data so as to match them with the coordinates of road.



Source: Prepared by JICA Study Team

Figure 241 Necessity of GPS Data Matching

Realizing such GPS tracking data corrective functions, the system must be equipped with digital data map specifying the coordinates of each road called Digital Road Map (DRM). In the DRM, the road is expressed as “link” connecting to “nodes” which are marked at junctions or any other points where the vehicle can change its pathway. The required road characteristics such as road width, regulatory speed, etc. are generally incorporated into the link data.

The DRM to be used in the project shall include following road characteristics.

Table 143 Required Road Characteristics in the DRM

Data Group	Type of Data	Data Item	Remark
Major Road Data	Node Data	Node number	
		Location coordinate	
		Number of connecting links	
		Connecting node number	
		Name of junction	
	Link Data	Link number (expressed by beginning and ending node number)	
		Code of road operator	
		Type of road	
		Number of road (E.G. NH7, SH1, etc.)	
		Particular information of road	
		Link distance	
		Traffic regulation in the link (threshold of regulation and type of regulation)	
		Number of lane	Future extension
		Lane width (width of carriage way)	Future extension
		Minimum lane width in the link	Future extension
		Median width	Future extension

Data Group	Type of Data	Data Item	Remark
		Maximum speed limit	Future extension
	Attribution Data in the Link	Location, name and length of bridge	
		Location, name and length of flyover	
		Location, name and length of tunnel	
		Location and name of railway crossing	
		Location, name and length of skywalk	
		Location, name and length of tollgate	Future extension
Minor Road Data	Node Data	Node number	
		Location coordinate	
		Number of connecting links	
		Connecting node number	
	Link Data	Link number (expressed by beginning and ending node number)	
		Code of road operator	
		Type of road	
		Link distance	
		Number of lane	Future extension
		Traffic regulation in the link	
		Link number of connecting major road	
		Name of junction	
	Attribution Data in the Link	Location and name of railway crossing	
Background Data	Riverine Data	Coastline	
		Lake	
		River (polyline or polygon data)	
		Municipality (polyline data)	
	Location of Railway	Railway	
	Location of Premise	Location, administrative district and name of prefectural government	
		Location, administrative district and name of municipal government	
		Location, administrative district and name of railway station	
		Location, administrative district and name of airport	

Source: Prepared by JICA Study Team

(9) Probe Car System Function in Probe Server

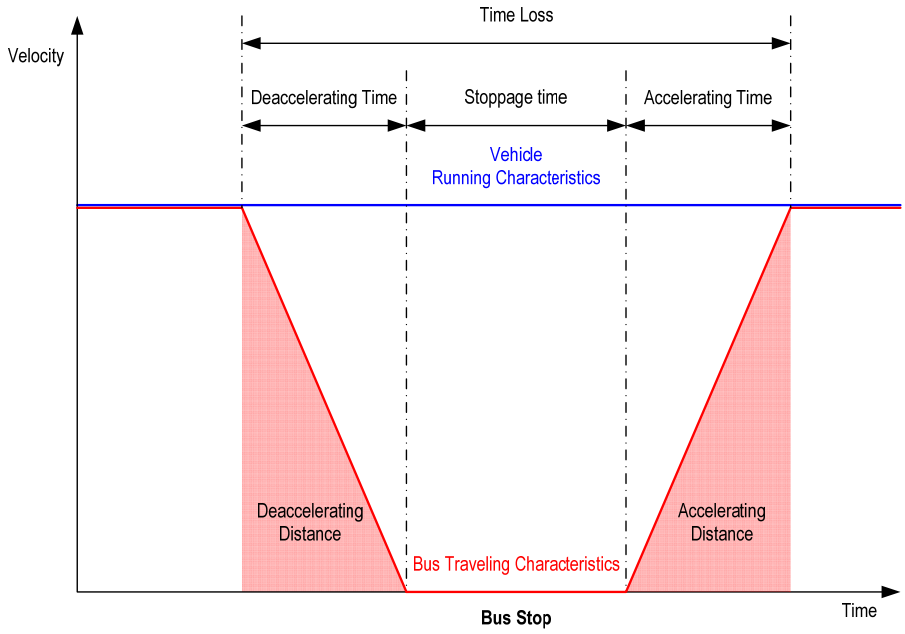
(a) Map matching function

The Probe Car System in the ITSC shall have vehicle tracking data corrective function named map matching to meet the tracking data with the coordinates of road. To realize the map matching function, the system shall be equipped with digital data map specifying the coordinates of each road called Digital Road Map (DRM).

(10) Data elimination function (in the vicinity of bus stop)

- The Probe Car System in the ITSC shall have function to omit abnormal data from data processing in case the tracking data is highly deviated from coordinates of bus routes.
- The Probe Car System in the ITSC shall have function to eliminate the bus tracking data in the vicinity of bust stop to minimize the differences with general vehicle traffic flows. In this system, bus tracking data within 50m front and back from bus stop shall be excluded from the processing except the case that bus goes through the bus stop.
- The system shall be capable of eliminating the tracking data of 100 km/h or faster speed.
- The APSRTC buses that are passing in different routes in the Hyderabad city are identified by bus numbers and bus shelter location in the route of each bus. This

information is available with the APSRTC. The Contractor shall obtain the bus number, bus shelter location data to perform the data elimination function as explained above



Source: Prepared by JICA Study Team

Figure 242 Bus Travelling Characteristics

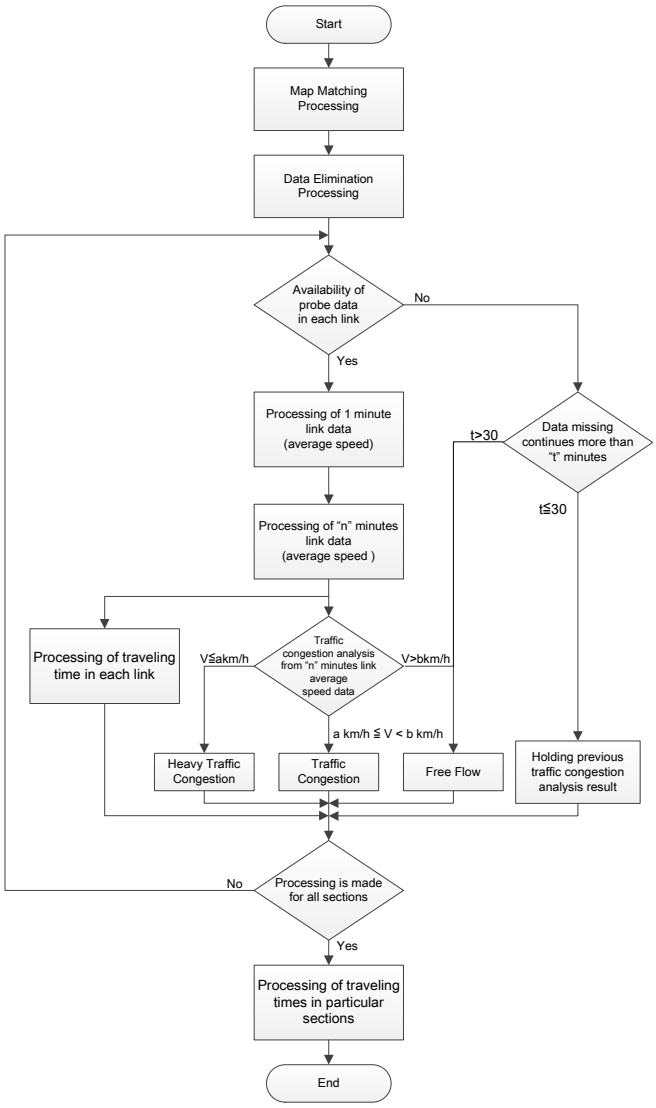
The bus trucking data in the vicinity of bust stop must be eliminated from the processing to avoid and minimize differences. In this system, bus tracking data within 50m front and back from bus stop will be excluded from the processing expect in case bus goes through the bus stop.

(11) Abnormal speed data elimination function

The tracking data with 100 km/h or much more speed can be considered as abnormal data since the system targets for the buses running through the ordinary road. The system shall be capable of eliminating such unexpected speed.

(12) Data processing and management function

After the processing of map matching and data elimination, the system shall generate average speed data in each section (link) and identify the traffic congested section from the average speed data as described in the below processing flow and algorithm.



Source: Prepared by JICA Study Team

Figure 243 Probe Data Processing and Congestion Analysis Flow

- The algorithm for traffic congestion analysis must be configured to handle the following factors and parameters.
- To avoid the fluctuation of analysis results, average speed data of specific time duration (n) must be utilized in the processing. The default of the time period duration is initially set for five (5) minutes and this value must be changeable.
- The analysis result is classified into three (3) traffic congestion levels, that is, "Heavy Traffic Congestion", "Traffic Congestion" and "Free Flow". The thresholds of traffic congestion level, "a" and "b" are tentatively set as 10km/h and 15km/h respectively in initial stage. Also, these thresholds must be variable and determinable for each location.
- In case of non-availability of data at any time, previous analysis result shall be considered till an extent of 30 minutes. If the data is continuously not available for more than 30 minutes, previous data is reset and the traffic is processed as "Free Flow".
- After the completion of congestion analysis processing in each link, travelling times of

particular sections shall be calculated to provide information to road users through VMS System and other information provision systems such as E-mail, website and SMS.

- If the average speed processed at a section is lower or higher than the pre-determined threshold, the server shall issue an alarm "abnormal traffic condition" to the Operator Console display.
- It shall be possible to monitor real-time traffic flow data on console operator display and also as printed report. Both numerical and graphical presentation of the data shall be provided. The data on the display shall be automatically updated at the pre-defined time interval.
- The congestion analysis shall be prepared for each link (defined as one road section)

(13) Data Storage function

All data transmitted from the APSRTC bus probe server and processed data in the ITSC shall be recorded and stored in the probe server for analysis and future usage. Data retrieval and presentation software shall be provided that can easily retrieve and show the traffic flow data and the operating condition of equipment at the specified time, hour or day. Graphical presentation of historical traffic flow data such as hourly variation and daily variation shall also be possible.

Status of each server and network equipment (normal or malfunctioned) shall be recorded in the probe server as operation log and for future reliability analysis together with error code and time stamp.

Table 144 Data Storage of Probe System

Sub-System	Storage Data		Type
Probe Car System	Bus Location data	Bus number	Raw data
		Bus type	
		Location (Longitude and Latitude)	
		Time stamp	
		Bus route number	
		Travel speed	
		Other available raw data	
	Equipment operational status		Raw data
	1 minute sectional (multiple lanes) data	Vehicle average speed	Processed data
	"n" minutes sectional average speed		Processed data
	Traffic congestion analysis results with parameters		Processed data
	Travelling time in each link		Processed data
	Travelling time in particular section with location parameters		Processed data

Source: Prepared by JICA Study Team

(14) Display and reporting functions

- The information display shall be schematic map based interface and as well in the form of a list.

- The schematic map based display shall cover the entire HMA and be able to enlarge individual locations on the map when selected. The enlarged view shall be able to display the details for each selected location. The details displayed shall cover the contents as described in the below table but not limited to.

Item	Contents on Schematic Map	Contents on list
Equipment status		• Server and network equipment status (normal / error)
Traffic conditions	• Current average speed Current traffic congested section • Current travelling time Hourly average speed variation	• Current average speed • Currently congested section • Current travelling time • Hourly average speed variation
Observation (raw) data		• Observation record in the form of list • Screen to edit or remove abnormal observation record
Processed data		• Processed data in the form of list
Parameter setting		• Parameters in the form of list • Screen form to edit all the parameters
Server status		• Server status (normal / error) in the form of list
Operation log		• List of Roadside Equipment those operational or non operational • Error record
Date and Time	• Current date and time	• Current date and time

The ITSC Probe Server shall publish/print the reports listed below, but not limited to these. The reports shall be produced as pre-scheduled or on-demand by system operator. It shall be possible to produce the reports in a portable file format:

Item	Contents
Traffic conditions	• Daily report containing hourly sectional average speed • Monthly report containing daily sectional average speed and that of the day of the week
Operation and error log	• List of Roadside Equipment those are operational or non operational • Error record

(15) Data Transmission Functions

Following data processed in the ITSC Probe Server shall be stored at an interval of 5 minutes in the database of ITSC System for total system management.

- 1 minutes sectional average speed
- “n” minutes sectional average speed (default “n” = 5 minutes)
- Traffic congestion analysis results with parameters
- Travelling time in each link
- Travelling speed in predetermined particular section with parameters
- Equipment operational status

10-2-3 CCTV Camera System

(1) System Objectives

This section describes CCTV Camera System to be installed as one of the Sub-Systems of Hyderabad City ITS. CCTV Camera System shall have the following objectives.

- To visually monitor road, traffic and weather conditions on major roads in HMA from the ITSC,
- To detect abnormal conditions on the roads within the coverage of CCTV camera in order to take necessary actions
- To view traffic flows on the major roads in the city using live camera footage to confirm the traffic condition at site.

The CCTV camera shall be installed at the same locations with the ATCC Roadside Equipment or the flood monitoring Roadside Equipment to monitor traffic conditions and water logging situations on the road. The images taken by camera shall be transmitted to the ITSC in real time and the images are selectively shown on the monitor display of CCTV console and large display panel. The footage/images from all camera shall be recorded on the storage device in the CCTV Server and the system shall operate on a 24-hour a day 7-day a week basis. The CCTV Camera System shall be IP based.

CCTV Camera System shall be capable of taking clear images of road, traffic and weather conditions under any brightness conditions during the daytime and night time.

It shall be the responsibility of the Contractor to furnish and install all necessary hardware, software, and database, integrate all system components and deliver a complete operational CCTV Camera System.

(2) CCTV Camera System Requirements

System requirements of the CCTV camera system are summarized as follows.

- The CCTV camera system shall collect real-time camera image from each CCTV camera located at roadside and can monitor and control the camera images in the ITSC.
- The CCTV camera shall be equipped with zoom and pan-tilt functions (PTZ functions) to secure wider area and longer distance coverage.
- The CCTV camera shall have functionality to take images in night time and connectivity with high-capacity communication network.
- The CCTV camera devices shall be easily available in India.
- The live camera images collected by the system can be shared among road operators and traffic polices, etc. in the ITSC and provided to the public through internet.
- The camera device with soft encoder shall be put on the top of supporting pole of ATCC or flood monitoring detector. The supporting structure with enough length must be provided to keep good visibility.
- The CCTV camera must be placed at the location where visibilities to both bounds on the road are kept as much as possible.

(3) CCTV Camera Location Plan

The CCTV camera will be located in accordance with following criteria to meet the system objectives and requirements above.

(a) [Phase-1]

- The CCTV cameras will be placed at same locations with ATCC roadside equipment to monitor actual traffic flows visually.
- The CCTV cameras will be located at flood monitoring sensor locations in order to confirm water logging situation by image.
- Currently, Hyderabad Traffic Police and Cyberabad Traffic Police have their CCTV monitoring system and total of 334 cameras have been renewed or newly implemented at the junctions in the city to monitor accident prone areas identified by Hyderabad Traffic Police and traffic congestion prone areas.
- In phase-1, the CCTV camera will be introduced at total of 49 locations in this project.

(b) [Phase-2]

- The CCTV cameras will be additionally located at traffic congestion prone areas in phase-2 after such areas are identified by the ATCC system and probe car system provided in Phase-1.
- Installation of CCTV cameras will be expanded to cover other critical points or sections on the road.

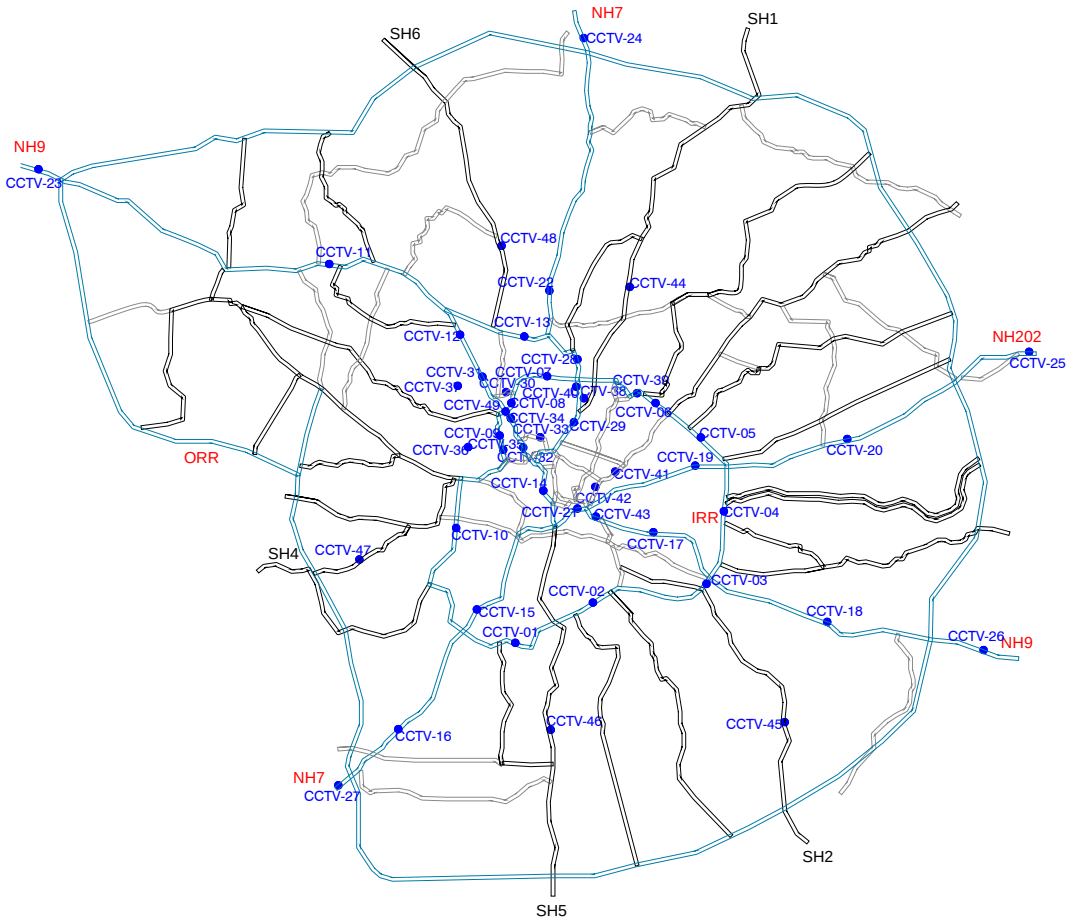
This report is prepared to be targeted for CCTV camera procured in Phase-1 and the proposed location plan of CCTV camera in Phase-1 is shown in Table and Figure below.

Table 145 Proposed Locations of CCTV Camera in Phase-1

CCTV No.	Road	Location/Landmark
CCTV-01	IRR	Chandrayanagutta,Near Palle Cheruvu road
CCTV-02	IRR	DRDL, Kanchanbagh
CCTV-03	IRR	LB Nagar Ring road
CCTV-04	IRR	Nagole Junction
CCTV-05	IRR	Genpact, Habsiguda (2 cameras)
CCTV-06	IRR	Railway Golf Course, Mettuguda (2 cameras)
CCTV-07	IRR	ACP Office, Begumpet (2 cameras)
CCTV-08	IRR	Green Lands,CM Office
CCTV-09	IRR	Taj Banjara, Banjara Hills
CCTV-10	IRR	Spencers Stores, Attapur (2 cameras)
CCTV-11	NH9	Miyapur, near Prajay City
CCTV-12	NH9	Hyderabad Industries Ltd, Moosapet (2 cameras)
CCTV-13	NH9	Air Force Station, Bowenpally Junction
CCTV-14	NH9	Nampally, near Gandhi Bhavan (2 cameras)
CCTV-15	NH7	National Police Academy,Shivarampalli
CCTV-16	NH7	Airport Road, near Shamshabad town
CCTV-17	NH9	Dilsukhnagar, near Chandnabrothers (2 cameras)
CCTV-18	NH9	Hayathnagar, near All India Radio Station
CCTV-19	NH202	Ramanthapur, near HPS & Cheruvu
CCTV-20	NH202	Boduppal, near Central Power Research Institute (CPRI)

CCTV-21	NH9	Esama Bazar Road, Near MGBS
CCTV-22	NH7	Medchal Road, near Dairy farm road turn
CCTV-23	NH9	Muthangi village after Patancheru
CCTV-24	NH7	Medchal, near CMR Engineering College
CCTV-25	NH202	HP Petroleum Tanks, Ghatkesar
CCTV-26	NH9	Inamguda near Ramoji Film City
CCTV-27	NH7	Thondapally village
CCTV-28	NH7	Tarbond near JBS
CCTV-29	NH7	Tankbund, at Makhdum Mohiuddin Statue
CCTV-30	Ameerpet Rd (City Road)	Greenland to Ameerpet Road, near LalBunglow
CCTV-31	NH9	Ameerpet Junction at Maitrivanam
CCTV-32	NH9	Erramanzil T Junction near RTA office
CCTV-33	Raj Bhavan Road (City Road)	TSR Towers, Somajiguda
CCTV-34	NH9	Panjagutta, near Model House
CCTV-35	IRR	Road No 1 Banjara Hills, near Masab Tank Flyover Rd
CCTV-36	Road No. 12 (City Road)	Road No 12, Banjara Hills Traffic Police
CCTV-37	Krishna Nagar Main Rd (City Road)	Yousufguda, Near KVBR Indoor Stadium
CCTV-38	NH7 (NH9)	Ministers Road Jn, near James Street Rly Station, Ranigunj
CCTV-39	IRR	Road Under RailBridge, near Railnilayam Secunderabad
CCTV-40	NH7 (NH9)	Ranigunj to Paradise road, near Park Lane Y Jn
CCTV-41	Tilak Nagar Rd (City Road)	Road Under Rail Bridge Nallakunta, near Fever Hospital,
CCTV-42	Barkatpura Rd (City Road)	Barkatpura Circle Road, near EPF Office
CCTV-43	NH9	Malakpet Road, Under Rail Bridge
CCTV-44	Siddipet Rd (SH1)	Military College, Siddipet Road, Alwal
CCTV-45	Nagarjuna Sagar Rd (SH2)	Nagarjuna Sagar Road, Turkayamjal
CCTV-46	Srisailam Highway (SH5)	Pahadisharif, near RCI
CCTV-47	Chevella Rd (SH20)	Chevella Road, near Shadan College
CCTV-48	HMT Rd (SH6)	Medak Road, near HMT
CCTV-49	IRR	Under Punjagutta Flyover

Source: Prepared by JICA Study Team



Source: Prepared by JICA Study Team

Figure 244 Proposed Location Map of CCTV Camera in Phase-1

The locations shown above are tentative. The Contractor shall examine each location and confirm the exact proper location at site for installation of each Roadside Equipment. The Contractor shall coordinate with the relevant authorities and obtain approval of the Employer's Representative.

(4) Site Reconnaissance for CCTV Camera Locations

The site reconnaissance at the locations of CCTV camera was carried out by the JICA Study Team to investigate following site conditions.

- Location of roadside equipment
- Installation space for CCTV camera equipment (foundation size is around 1.5m x 1.5m widths)
- Road conditions (road width, number of lanes, width of median)
- Visibility to both bounds on the road
- Power receiving point (identifying the nearest pole and its pole number)
- Network connecting point (Service provider's optic fibre connection point)
- Mobile cellular communication availability
- Other conditions

(5) CCTV Camera System Design

(a) Type of CCTV Camera

The CCTV camera is roughly classified into three types of camera, fixed camera, PTZ camera and network camera. The fixed camera is equipped with fixed lens and auto focus function, and to be used for monitoring the particular narrow area. The PTZ camera is having zoom lens and pan-tilt (PTZ) functions to secure wider area and longer distance coverage. The network camera is one of PTZ camera equipped with image encoding software to be easily connected to network system. Table below shows the comparison of CCTV camera.

Table 146 Type of CCTV Camera

Network / Item	Fixed Camera	PTZ Camera (Industrial TV Camera)	Network Camera
Image			
Outline	Camera device with fixed lens, auto focus function	Camera device with zoom lens, pan-tilt, auto focus functions	Camera device with zoom lens, pan-tilt, auto focus functions and encode software
Image sensor	1/4” - 1/2” sensor	1/4” - 2/3” sensor	1/4” - 1/2” sensor
Focal length of lens	3.8 mm	7.0 mm – 363 mm	3.8 mm – 114 mm
Resolution	640 x 480 pixel (VGA)	640 x 480 pixel (VGA)	640 x 480 pixel (VGA)
Minimum illuminance intensity	0.05 lx (day mode) 0.001 lx (night mode)	0.01 lx (day mode) 0.001 lx (night mode)	0.5 lx (day mode) 0.01 lx (night mode)
Ingress protection	IP66	IP67 or IP68	IP66
Advantages	- Cost is cheaper than industrial camera. - Once the camera is fixed, no operation for camera control is needed. Therefore, fixed cameras are installed in the tunnel where continuous and seamless monitoring is required and a lot of cameras are installed.	- Capable of using high spec. zoom lens. - CCTV monitoring can be realized under condition of darkness, since required minimum illuminance intensity is low.	- Cost is around 1/5 of industrial camera since network camera is basically provided for private sector. - No need to be equipped with hard encoder to connect network. - Wide-spreading in the world
Disadvantages	- Limited monitoring coverage - Necessary to have hard or soft encoder to connect network in addition to camera device	- Equipment cost is quite high. - Necessary to have hard or soft encoder to connect network in addition to camera device	- No compatibility on control commands among different manufactures due to lack of international standard.
Cost	Low	High	Low

Source: Prepared by JICA Study Team

Due to its big advantages such as wider and longer distance coverage, cost performance, and network connectivity, the network camera is utilized as CCTV camera device in this project.

(b) Monitoring Range

Monitoring range of CCTV camera is determined by width of image sensor, the focal length of zoom lens, size of monitor in the Control Centre and minimum dimension of target to be shown on the monitor as follows.

$$\text{Monitoring Range (L)} = f \times \frac{Wa}{0.9 \times w}$$

Where,

f: focal length of lens = 114mm (30 x zoom)

Wa: minimum width of target = 1.5 m (width of vehicle)

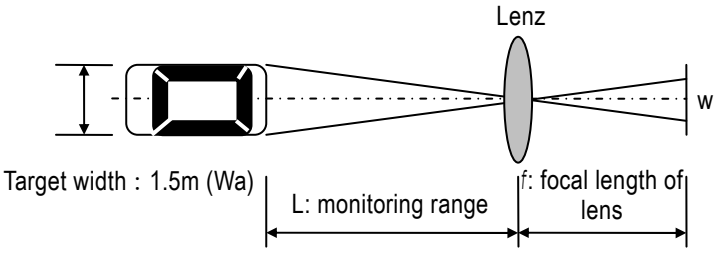
w: required size on monitor = $b \times \frac{s}{u}$

b: width of image sensor = 6.4 mm (1/2" sensor)

s: width of target on monitor = 15mm (normal human eye resolution in 5m distance from monitor)

u: monitor width = 531mm (24 inch wide LCD monitor)

0.9: Over-scanning ratio



Source: Prepared by JICA Study Team

Figure 245 Principle of CCTV monitoring range

Hence, when 1/2 inch CCTV camera with 30 x zoom lens, 24 inch wide LCD monitor and 1.5m wide target (vehicle width) are set for calculation, monitoring range of CCTV camera is estimated as follows,

$$L = f \times \frac{Wa}{0.9 \times w}$$

$$= 114 \times \frac{1.5}{0.9 \times (6.4 \times \frac{15}{531})}$$

$$= \underline{1050.9 \text{ m}}$$

The CCTV camera would take image around 1.0 km ahead from its location in case of keeping the line-of-sight.

(c) Image Compressing

To transmit image over IP (Internet Protocol) network, live-image taking by CCTV camera must be compressed into digital image format. Various types of image compressing

method are standardized by international telecommunication organizations.

Table 147 Image Compressing Method

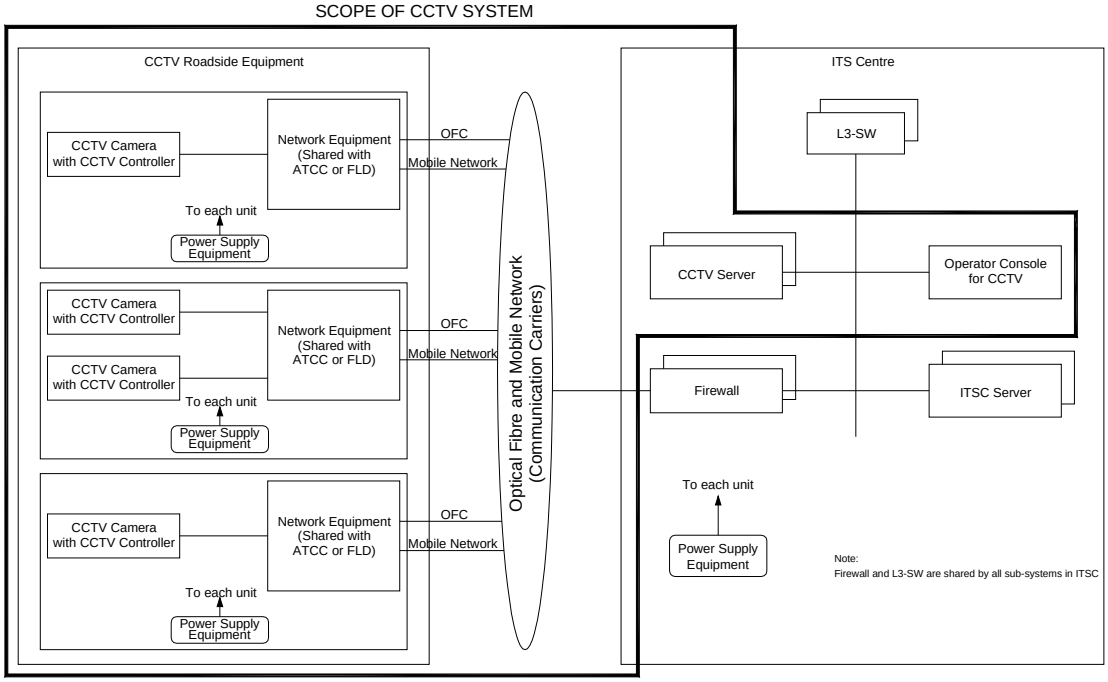
Item \ Network	M-JPEG	MPEG-2	H.264/MPEG-4
Outline	M-JPEG is a moving image compressing format by continuously transmitting a JPEG image which is one of still image encoding. The encoding efficiency of M-JEPG is not so high, but M-JPEG has advantages that can easily generate the still images from moving image.	MPEG-2 is used as the format of digital television signals that are broadcast by radio, cable and broadcast satellite TV systems.	MPEG4 was introduced in 1998 and designated a standard for a group of audio and video coding formats and related technology. Uses of H.264/MPEG-4 are wide and include compression of AV data for web (streaming media) and CD distribution, etc.
Main usages	Digital camera Network camera	TV Broadcast DVD	Network camera Internet streaming TV conference Blue-ray Disc, etc
Image compressing algorism	DCT	DCT Inter-frame prediction coding	DCT Inter-frame prediction coding intra-frame coding
Image size (Resolution)	320 x 240 (QVGA) 640 x 480 (VGA)	720 x 480 (SDTV) 1920 x 1080 (HDTV)	176 x 144 (QCIF) 352 x 288 (CIF) 720 x 480 (SDTV) 1920 x 1080 (HDTV)
Bit-rate	128 kbps – 20 Mbps	2Mbps – 30 Mbps	10 kbps – 240 Mbps
Application to network camera	Frequent	Not so many	Frequent
Advantages	- High compression ratio - Wide-range usage to network camera - Easiness to generate still images - Low Cost	- High definition video image - Interoperability can be strictly secured since the ISO/IEC 13818 defines the formats in detail.	- High compression ratio (to reduce network capacity) - Wide-range usage to network camera - High encoding efficiency - Low Cost
Disadvantages	- No compatibility among different manufactures. - Encoding efficiency is not so high.	- Large capacity network system will be required. - Expensive comparing with other compressed method - Not utilized as network camera encoding system.	- No compatibility among different manufactures.

Source: Prepared by JICA Study Team

(6) CCTV Camera System Configuration

The CCTV camera system will consist of the following components:

- CCTV Server at the ITSC;
- CCTV Console with camera control keyboard and display monitor at the ITSC
- CCTV Roadside Equipment consisting of camera, controller, network equipment, media converter , power supply equipment and peripheral,
- Communication Network between the ITSC and Roadside Equipment
- Supporting structure and foundation at roadside



Source: Prepared by JICA Study Team

Figure 246 Proposed CCTV Camera System Configuration

(7) Network Requirements for CCTV Camera

It is recommended that image transmission of the CCTV image be made either the optical fibre network or mobile network both provided by the communication carriers to enhance the network reliability. The optical fibre network will be utilized as main communication line while the mobile network will be used as backup. The live image taking by CCTV camera must be compressed into digital image format such as H.264/MPEG-4 and M-JPEG to transmit images over IP network. Should any communication failure occur in optical fibre network, the CCTV camera system will automatically change over the communication line to mobile network. In case where the optical fibre network is used, the live image compressed into H.264/MPEG-4 format will be transmitted to the ITSC. When the mobile network is utilized, the still images of JPEG format shall be generated at interval of 1 frame per second or less and transmitted to the ITSC.

(8) CCTV Camera System Functions

CCTV system will be provided with the functions described below.

(a) Monitoring Function

- The road and traffic images taken by CCTV cameras on the road shall be transmitted as video signal to the CCTV Server at the ITSC through the communication network. The CCTV Server shall be capable of selecting video signal from any CCTV camera to be displayed on the display monitor of the CCTV console and Video Wall.
- Sequential display function shall be provided for CCTV Camera System to display video images from the multiple cameras sequentially at a pre-set interval. It shall be possible to select the cameras for sequential display and to set the display time of the image from each camera.
- The CCTV display monitor on the console and Video Wall shall have multiple screen

capability and shall display either one image or multiple images at a time. The image on the Video Wall shall be controlled by the CCTV console.

(b) PTZ Control Function

CCTV camera system shall have a manual remote control function of pan, tilt and zoom of the camera. Each camera shall have a normal position of pre-set pan and tilt angles and a pre-set focal length to return and stay when the manual control of PTZ is released.

(c) Image Recording and Retrieval

All images shall be automatically recorded in the storage device of the CCTV server with camera ID and time stamp. Frame rate of the video signal can be reduced to one frame per minute to reduce the requirements for the storage capacity required. Images shall be stored for minimum three (3) days. The CCTV still image together with equipment operational status shall be also stored in the storage server of ITS centre system.

(d) Data Storage Function

- All data transmitted from the CCTV roadside equipment and processed data in the ITSC shall be recorded and stored in the CCTV server for analysis and future usage. Data retrieval and presentation software shall be provided that can easily retrieve and show the movie image and still image of the specified roadside equipment at the hour or day.
- Status of roadside equipment (normal or malfunctioned) shall be recorded in the CCTV server as operation log and for future reliability analysis.

Sub-System	Storage Data	Type
Sub-System	• Storage Data	Type
CCTV Camera System	• CCTV video image	Raw Data
	• CCTV still image	Raw data
	• Equipment operational status	Raw data

(e) Diagnosis

The CCTV camera system shall have a diagnosis function. The CCTV server shall inquire the connection with the CCTV camera and the status of CCTV camera by sending the diagnosis signal in every five (5) minute. If CCTV fault signal is received or there is no response from the CCTV camera, the CCTV server shall issue an alarm and the fault shall be recorded in the log.

(f) Display and Reporting Functions

- The information display shall be schematic map based interface and as well in the form of a list.
- The schematic map based display shall cover the entire HMA and be able to enlarge individual locations on the map when selected. The enlarged view shall be able to display the details for each selected location. The details displayed shall cover the contents as described in the below table but not limited to.
- The CCTV Server shall be capable of creating the following screen contents, but not limited to these:

Item	Contents on schematic Map	Contents as list
Equipment location and status	• Location of CCTV cameras and location of selected camera	• Location of CCTV cameras and location of selected camera

	• Status of CCTV cameras	• Status of CCTV cameras
CCTV video image	• Video image from the CCTV camera along with camera ID • CCTV video splitting shall support multiple images /videos on one single display screen • CCTV video automatically selected and sequentially played • Video image from the CCTV camera along with camera ID and event data such as traffic congestion and water logging that was received from the ITSC Server • Video image from the video recorder with camera ID, date and time	•
CCTV operation	• Monitoring CCTV video • CCTV operation to select CCTV camera and operation such as pan, tilt, zoom and return to preset position	•
Video operation	• Monitoring recording status • Operations as for recorded videos such as play back rewind and forward. • Management of recorded videos such as delete video and copy video to other media	•
Parameter setting	•	• Parameters in the form of list • Screen form to edit all the parameters
Server status	•	• Server status (normal / error) in the form of list
Operation log	•	• List of Roadside Equipment that are operational and non-operational • Error record
Date and Time	• Current date and time	• Current date and time

- The CCTV Server shall print the reports listed below, but not limited to these. The reports shall be produced as pre-scheduled or on-demand by the system operator. It shall be possible to publish the report as a portable file format:

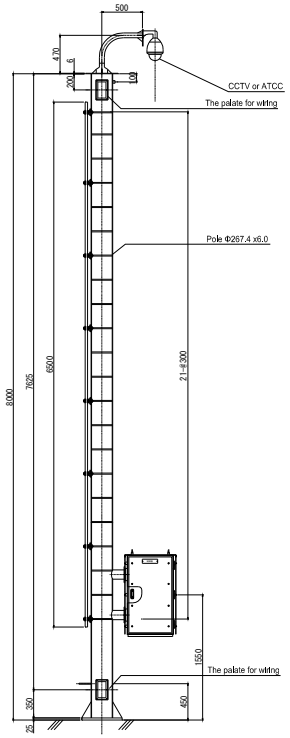
Item	Contents
Operation and error log	• List of **CCTV** camera that are operational and non operational • Error record

(9) Installation of CCTV Camera

The CCTV camera will be installed at roadside as follows:

- The camera device with soft encoder will be basically put on the top of supporting pole of ATCC or flood monitoring detector. The length of supporting structure would be of 8,000 mm or more to keep good visibility.
- The CCTV camera must be placed at the location where visibilities to both bounds on the road are kept as much as possible. In case any obstacles such as branches are identified at surrounding areas of CCTV location, such obstacles will be removed in advance of equipment installation.
- The supporting pipe must be equipped with steel ladder to ease the maintenance work of CCTV camera.
- The communication unit, camera control unit, power supply facilities and other devices installed at roadside will be housed in the cabinet. The cabinet would be hanging on the supporting pole.

Typical installation plan for CCTV camera is illustrated in the figure below.



Source: Prepared by JICA Study Team

Figure 247 Typical Installation Plan for CCTV Camera

(10) Power Supply to CCTV Camera

(a) Power Source

As described in Section above, AC commercial power with UPS is chosen as power source for the CCTV camera with following reasons:

- Since the CCTV camera will be installed together with ATCC or flood monitoring

detector, required power consumption of equipment is much higher than the consumption of CCTV camera itself. Therefore, it seems difficult to cover such high power consumption by solar power supply system.

- All of sites are located near commercial power pole and power can be easily fed from low voltage line of the power company.
- In Hyderabad Metropolitan Area, there often happens commercial power interruptions. In order to compensate power supply during short time power cut, it is recommended to provide UPS with minimum size of battery.

(b) Estimated Power Consumption

The power demand loads of CCTV camera are estimated as total of 0.9 KVA (with ATCC) and 0.7 KVA (with flood monitoring detector) respectively as shown in table below.

Table 148 Estimated Power Demand Loads of CCTV Camera

1) CCTV camera with ATCC

Power Demand / Equipment	Voltages	Unit Power Demand (kVA)	Number of Unit	Estimated Power Demand (kVA)	Remarks
Image Recognition Detector	1φ – 2W – 220V	0.1	2	0.2	
ATCC Processing Unit	1φ – 2W – 220V	0.5	1	0.5	
CCTV Camera	DC 12V	0.1	1	0.1	DC power is supplied from power unit in the controller.
Controller Unit	1φ – 2W – 220V	0.1	1	0.1	
Total				0.9	

2) CCTV camera with flood monitoring detector

Power Demand / Equipment	Voltages	Unit Power Demand (kVA)	Number of Unit	Estimated Power Demand (kVA)	Remarks
CCTV Camera	DC 12V	0.1	1	0.1	DC power is supplied from power unit in the controller.
Controller Unit	1φ – 2W – 220V	0.1	1	0.1	
Flood Monitoring Unit	1φ – 2W – 220V	0.5	1	0.5	
Flood Monitoring Detector	-	Including above	3	Including above	
Total				0.7	

Source: Prepared by JICA Study Team

(c) UPS

To compensate for a short time power cut off, Uninterruptible Power Supply (UPS) will be provided to the CCTV camera. The compensation time of UPS shall be of 3 hours.

The required capacity of UPS battery is estimated as follows;

1) CCTV camera with ATCC

C = K x I / L

= 4.0 x (900 x 0.9 / 0.85 /187.2) / 0.8

= 25.5 [Ah]

2) CCTV camera with flood monitoring detector

C = K x I / L

= 4.0 x (700 x 0.9 / 0.85 /187.2) / 0.8

= 19.8 [Ah]

The capacity of UPS battery must be recalculated by the contractors in compliance with power requirements of their equipment.

10-2-4 Meteorological Monitoring System

(1) System Objectives

This section states MET System to be installed as one of the components of Hyderabad City ITS. The MET System will be introduced in the Project with following objectives.

- To collect the data on weather conditions including rainfall, temperature, wind velocity/direction and etc on the roads in HMA from APSDPS
- To provide the weather information to the road users.
- To provide measured meteorological data and related alerting signals to road administrators and traffic police etc. in the ITSC.
- To store the data for a certain period in order to utilize for future weather statistics.
- To provide alert information to road users through VMS System and other information provision systems such as e-mail, website and SMS.

The meteorological measurement is carried out by APSDPS. It is measured by the MET measurement Equipment at approximately 63 locations in the HMA. The measured data is transmitted from the meteorological measurement equipment to the Meteorological Server in APSDPS. It has been agreed between HGCL and APSDPS that the meteorological data collected by the Meteorological Server in APSDPS will be provided to the MET Server of ITSC at 5 minute interval.

The scope of MET System of the Hyderabad City ITS project is;

- To read the meteorological data from the Meteorological Server in APSDPS,
- To transmit the meteorological data from APSDPS to the MET Server in ITSC,
- To process the meteorological data in ITSC, and
- To provide the meteorological data to the road users from the ITSC.

The meteorological data is measured by APSDPS currently at 63 locations in HMA. The number of locations is tentative. The Contractor shall obtain the location list from APSDPS where the APSDPS is measuring the meteorological data in the HMA and confirm with the Employer.

(2) MET System Requirements

System Requirements of the MET system are as follows.

- The system shall collect the following weather information. The collection shall be performed at every 5 minute interval.
- Rainfall (detection and level)
- Atmospheric Temperature
- Relative Humidity
- Wind Speed
- Atmospheric Pressure
- Wind Direction
- The collected meteorological data shall be processed to eliminate abnormal data by the MET Server in the ITSC.

(3) MET System Design

(a) General Measurement Items

Generally meteorological roadside equipment consists of various types of sensor to measure weather data required.

Table 149 Meteorological Observation Items and Sensors

Item	Purpose	Required Sensor	Necessity in the Project
Wind Velocity & Wind Direction	To measure and process instantaneous and average wind velocity and direction for alerting strong wind	Anemometer	Yes
Air Temperature	To measure air temperature for general purpose	Thermometer	Yes
Road Temperature	To mainly detect iced road	Road surface thermometer	No
Precipitation (Rainfall Level)	To measure and process hourly rain and accumulated rain for alerting heavy rain	Rain gauge	Yes
Rainfall detection	To detect start of rainfall	Rainfall detector	Yes
Visibility	To detect dense fog	Visibility meter	Yes
Earthquake	To detect large earthquake	Seismometer	No

Source: Prepared by JICA Study Team

It is considered road surface thermometer and seismometer are not necessary since average minimum temperature has been more than 20 degree Celsius and major earthquake has not occurred in this area in the past tens years.

(b) Traffic Control Criteria for Disaster Management

The meteorological monitoring system is to measure weather conditions on or near the road. A driving environment on the road is judged by the data from the meteorological roadside equipment. If hazardous weather condition is detected by the system, warning message will be announced road users through the information provision system. In case weather condition is too dangerous for driving, the road operators must take appropriate countermeasures such as maximum speed limit reduction and/or road closure.

Table below shows the example of typical traffic control criteria of Japanese highway.

Table 150 Traffic Control Criteria for Disaster Management on Japanese Highway

Cause of Disaster	Operation Criteria by Highway Operator	
	Alert Operation	Emergency Operation
	Alerting Information Issue	Roadway Closure, etc.
Heavy Rain	Accumulated Rain > 150mm, or Hourly Rain > 30mm	Accumulated Rain > 200mm, or Hourly Rain > 50mm
Strong Wind	Maximum Wind Speed between 25m/s and 25m/s	Maximum Wind Speed > 25m/s
Dense Fog	Visibility between 50m and 100m	Visibility less than 50m
Flooding	-	When Flooding is detected
Earthquake	between 20 gal and 80gal	Over 80 gal, or Actual damage confirmed
Others	Disasters probable	Closure judged to be necessary

Source: Prepared by JICA Study Team

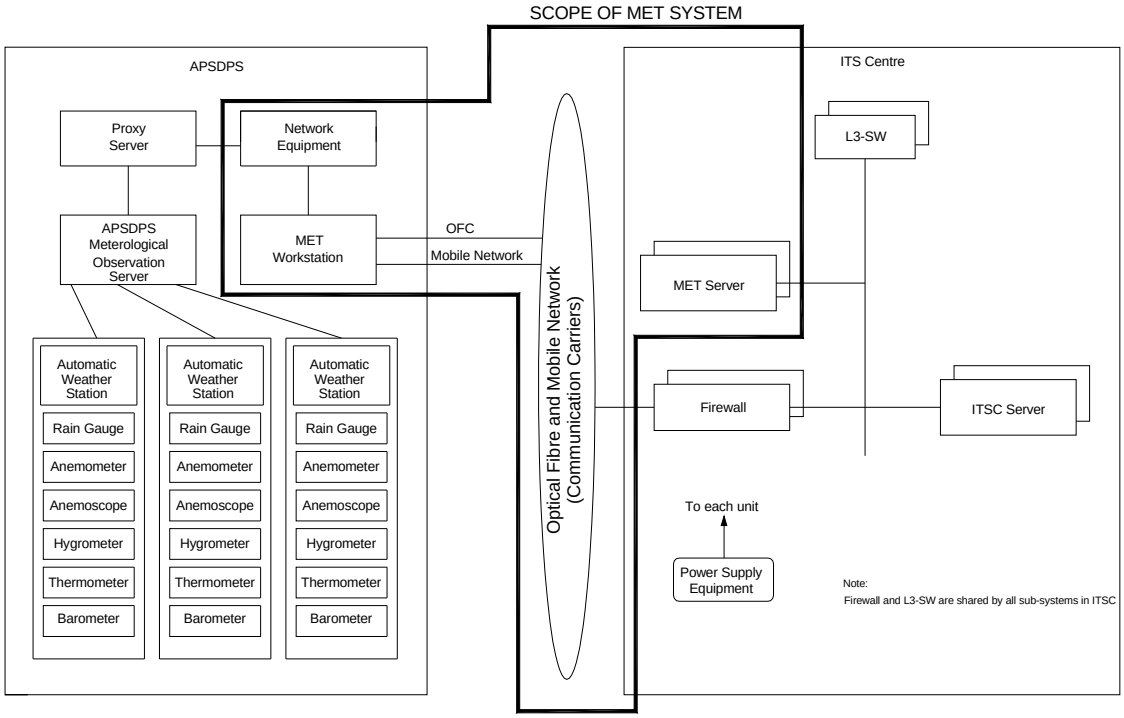
IRR and any other roads in Hyderabad Metropolitan Area do not have the traffic control criteria for disaster management like above at this moment. Such criteria must be set up on each road by the road operator and the meteorological monitoring system shall have functions to automatically issue weather alerting signals when the measuring and analyzed data are over the predetermined values.

(4) System Configuration

The MET System shall consist of the following components:

- MET Server at the ITSC,
- MET Workstation and Network Equipment in the APSDPS, and
- Communication network between the ITSC and Roadside MET Workstation in APSDPS

The proposed meteorological monitoring system would be configured in the Figure below.



Source: Prepared by JICA Study Team

Figure 248 Proposed MET System Configuration

(5) System Functions

MET system will be provided with the functions described below.

(a) Data Reading Function of MET Workstation in the APSDPS

The MET Workstation in the APSDPS shall read and obtain the meteorological data from Meteorological Server in the APSDPS at specified interval (default is 5 minutes). The meteorological data is stored in the CSV format at the Meteorological Server in the APSDPS.

The data reading interval and the specified location of the CSV file on the MET Server shall be modifiable parameters. The Contractor shall confirm the data reading interval with APSDPS and get approval of the Employer.

The Contractor shall obtain the CSV file structure from the APSDPS and confirm it.

(b) Data Transmitting Function of MET Workstation at APSDPS

The meteorological data read from the Meteorological Server in the APSDPS shall be transmitted by the MET Workstation at APSDPS to the MET Server in the ITSC.

The data transmission shall be in real time by instantaneous checking of data availability on the Meteorological Server in the APSDPS.

The data transmission loss between the MET Workstation at the APSDPS and the MET Server in the ITSC shall be identified. The data shall be re-transmitted in case that the data transmission loss is identified.

(c) Data Processing Function in the ITSC

- Data validity check
- Error checking shall be performed for the received data by comparing the data with the pre-defined threshold. Threshold may include upper limit, lower limit, and variation

from the previous data. The data that was identified as faulty shall not be used as observed data.

- Calculation of Hourly and Cumulative Precipitation
- Precipitation data shall be processed into hourly precipitation and cumulative precipitationData Processing Function in the ITSC.

(d) Data Processing Function by MET Server

The MET Server shall perform the data processing as listed in the table below for display and logging. Display shall be updated every 5 minute.

Data	Display	Logging
Precipitation		
Moving total for previous 1 hour	X	X
Total continuous precipitation	X	X
Rainfall detection		
Instantaneous (every 5 minute)	X	X
Temperature		
Instantaneous (every 5 minute)	X	X
Wind velocity		
Maximum during previous 15 minute	X	X
Wind direction		
Direction at maximum wind during previous 15 minute	X	X

A warning system shall be introduced where an alarm is issued to the system operator when the wind data or precipitation data exceeds the pre-defined threshold. Several types and values of threshold shall be provided and the threshold shall be alterable.

All meteorological observation data shall be recorded in the database in the form of 5-minute, daily and monthly data and data retrieval software shall be provided for easy access to the recorded data. It shall be possible to show graphically the retrieved data from the database.

(e) Data Storage Function

All data transmitted from the APSDPS and processed data in the ITSC shall be recorded and stored in the MET Server for analysis and future usage. Data retrieval and presentation software shall be provided that shall show the meteorological data received from APSDPS at the specified time, hour or day. Graphical presentation of historical meteorological data such as hourly variation and daily variation shall also be possible.

Sub-System	Storage Data	Type
MET System	• Instantaneous value of ambient temperature at 5 minute interval	Raw Data
	• Hourly cumulative value of rainfall	Raw Data
	• Cumulative value of rainfall from the start of rainfall	Raw Data
	• Instantaneous rainfall detection at 5 minute interval	Raw Data
	• Maximum and minimum value of wind speed during previous 15 minutes	Raw Data
	• Wind direction at the maximum and minimum velocity	Raw Data

	during previous 15 minutes	
	• Instantaneous temperature (5minutes)	Processed data
	• Moving total precipitation for previous 1hour	Processed data
	• Total continuous precipitation	Processed data
	• Instantaneous rainfall detection (5 minute)	Processed data
	• Maximum value of wind velocity for previous 15 minute	Processed data
	• Direction at maximum wind during previous 15 minute	Processed data
	• Heavy rain analysis results with parameters	Processed data
	• Strong wind analysis results with parameters	Processed data

Source: Prepared by JICA Study Team

(f) Display and Reporting Function

The information display shall be schematic map based interface and as well in the form of a list.

The schematic map based display shall cover the entire HMA and be able to enlarge individual locations on the map when selected. The enlarged view shall be able to display the details for each selected location. The details displayed shall cover the contents as described in the below table but not limited to.

The MET Server shall be capable of creating the following screen contents, but not limited to these:

Item	Contents displayed on schematic map	Contents displayed as list
Weather conditions	• Current weather condition (rainfall detection, precipitation, air temperature, wind velocity, wind direction) as graphical display similar to the one displayed on APSDPS website.	• Current weather condition (rainfall detection, precipitation, air temperature, wind velocity, wind direction) • Historical variation of weather conditions in the form of list
Observation (raw) data	• Screen to edit or remove abnormal observation record	• Observation record in the form of list • Screen to edit or remove abnormal observation record
Processed data	•	• Processed data in the form of list
Parameter setting	•	• Screen form to edit all the parameters
Server status	•	• Server status (normal / error)
Date and Time	• Current date and time	• Current date and time

Source: Prepared by JICA Study Team

The MET Server shall print the reports listed below, but not limited to these. The reports shall be published as pre-scheduled or on-demand by system operator. It shall be possible to publish the report in a portable file format.

Item	Contents
Meteorological data	• Daily report containing hourly precipitation and rainfall detection • Daily report containing hourly maximum and minimum wind velocity, its

	direction and time • Monthly report containing daily precipitation and rainfall time • Monthly report containing daily maximum and minimum wind velocity, wind direction, and time

Source: Prepared by JICA Study Team

10-2-5 Flood Monitoring System

(1) System Objectives

This section states Flood Monitoring (FLD) System to be installed as one of the components of Hyderabad City ITS. FLD System shall be installed with following objectives:

- To detect and measure flood situation on the roads in HMA.
- To provide the waterlogged information and alerting signals to the road users so that drivers can avoid the flooding area.
- To utilize measured data for road facility improvement planning such as road drainage rehabilitation etc.
- To provide the water logging information to road planning agencies (HGCL, HMDA), road administrators and traffic polices.

FLD System shall collect at the flood observation stations the waterlogged level data continuously. The data collected shall be transmitted to the FLD Server at the ITSC for data processing and logging. In case water logging is detected, the system shall automatically issue an alarm to the system operator. They shall operate on a 24-hour a day 7-day a week base.

It shall be the responsibility of the Contractor to furnish all necessary hardware and software, install Equipment at the specified location, provide necessary cabling, integrate all system components, and deliver a complete operational FLD System.

(2) System Requirements

System Requirements of the FLD system are as follows.

- FLD System shall detect and measure the following flooding information at Roadside. The flooding information shall be monitored in the ITSC on real-time basis. The detection and measurement shall be performed at one (1) minute time interval.
  - ✓ Flooding point
  - ✓ Flooding depth
- The measured flooding data shall be stored for a certain period in order to utilize for road facility improvement planning.
- The flooding and alerting information detected and measured by the system shall be provided to road users through VMS System and other information provision systems such as e-mail, website and SMS.
- Flood monitoring detectors shall be easily installable at Roadside with simple operation and maintenance. The electrode contact type detectors shall be installed.
- The flood monitoring detectors shall be placed on the road shoulder in order to avoid traffic interruption.

(3) Location Plan of Flood Monitoring Detector

The flood monitoring detectors will be located at water logging areas in Hyderabad

Metropolitan Area identified by Hyderabad Traffic Police.

(a) Phase-1

According to the website of Hyderabad Traffic Police, around 125 flooding prone spots in the city are identified. In the newspaper on 29th May 2011, 14 areas among them are listed as major areas to be addressed immediatly.

[Newspaper on 29th May, 2011]
Of the 125 potential water-logging spots, 14 areas have been shortlisted as the most troublesome. The shortlisted regions are:
(1) Lai Bungalow & Mythrivanam in Ameerpet, (2) KCP Junction on Somajiguda,
(3) Villa Marie College on Raj Bhavan Road, (4) Model House in Punjagutta,
(5) Pension Office at Banjara Hills No. 1/12 Junction, (6) Road No. 12,
(7)Banjara Hills in Kaman, (8) Yousufguda Checkpost,
(9) Ranigunj &(10) Alugaddabavi in Secunderabad, (11) Karbala Madian in Lower Tank Bund,
(12) Feber Hospital in Kacheguda, (13) Ganabowli in Barkatpura, and
(14) Lalazar Railiway Bridge in Chaderghat.

In phase-1, flood monitoring detectors will be installed at 14 water logging spots mentioned above.

(b) [Phase-2]

In phase-2, installation of flood monitoring detectors will be expanded to all of 125 water logging spots identified by Hyderabad Traffic Police.

This design report is prepared for flood monitoring system proposed under Phase-1. The proposed location plan of flood monitoring detectors in Phase-1 is shown in the Table and Figure below.

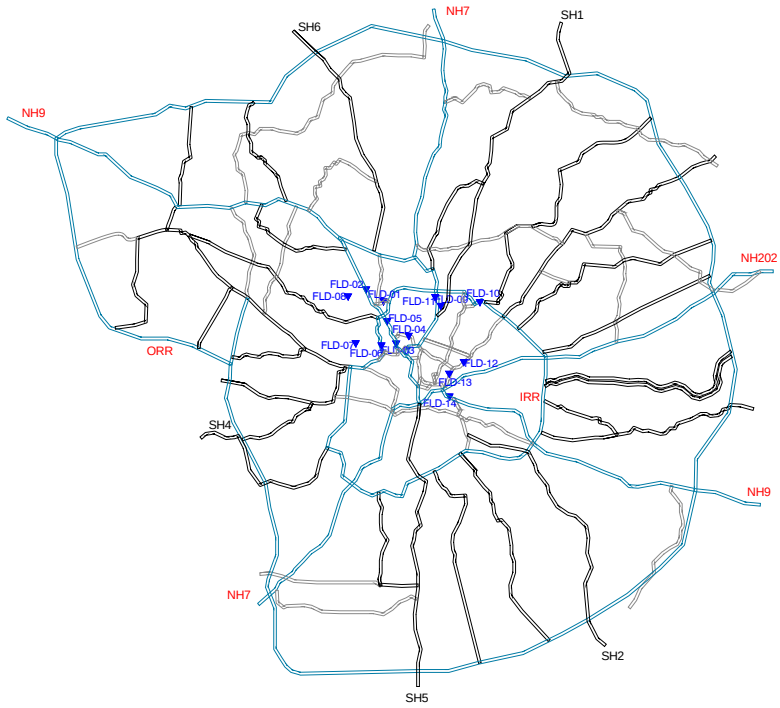
The locations shown below are tentative. The Contractor shall examine each location and confirm the exact proper location at site for installation of each Roadside Equipment. The Contractor shall coordinate with the relevant authorities and obtain approval of the Employer's Representative

Table 151 Proposed Locations of Flood Monitoring Detectors in Phase-1

FLD No.	Road	Location/Landmark
FLD-01	Ameerpet Rd. (City Road)	Greenland to Ameerpet Road, near LalBunglow
FLD-02	NH9	Ameerpet Junction at Maitrivanam
FLD-03	NH9	Erramanzil T Junction, near RTA office
FLD-04	Raj Bhavan Rd (City Road)	TSR Towers, Somajiguda
FLD-05	NH9	Panjagutta, near Model House
FLD-06	IRR	Road No 1 Banjara Hills, near Masab Tank Flyover Road
FLD-07	Road No. 12 (City Road)	Road No 12, Banjara Hills Traffic Police
FLD-08	Krishna Nagar Main Rd.	Yousufguda, near KVBR Indoor Stadium

FLD No.	Road	Location/Landmark
	(City Road)	
FLD-09	NH7 (NH9)	Ministers Road Junction, near James Street Rly Station,Ranigunj
FLD-10	IRR	Road Under RailBridge, near Railnilayam Secunderabad
FLD-11	NH7 (NH9)	Ranigunj to Paradise rd, near Park Lane Y Junction
FLD-12	Tilak Nagar Rd (City Road)	Road Under Rail Bridge Nallakunta, near Fever Hospital,
FLD-13	Barkatpura Rd (City Road)	Barkatpura Circle Road, near EPF Office
FLD-14	NH9	Malakpet Road, Under Rail Bridge

Source: Prepared by JICA Study Team



Source: Prepared by JICA Study Team

Figure 249 Proposed Location Map of Flood Monitoring Detector in Phase-1

(4) Site Reconnaissance for Flood Monitoring Detector Locations

Site reconnaissance at the locations of flood monitoring detector has been carried out by the Study Team to check following site conditions.

- Location of roadside equipment
- Installation space for flood monitoring sensor (foundation size is around 1.0m x 1.0m widths)
- Road conditions (road width, number of lanes, width of median)
- Installation level (level of installation point must be same as or lower level than road surface)
- Power receiving point (identifying the nearest pole and its pole number)
- Network connecting point (Service provider's optic fibre connection point)

- Mobile cellular communication availability

(5) Flood Monitoring System Design

(a) Type of Sensors

It is considered that three (3) types of sensor can be applied to flood monitoring detector for sensing water logging level on the road.

(b) Electrode contact type

Electrode contact type detects water logging level by turning on electrode contact sensor when the water level reaches the pre-determined sensor level. Even this type of sensor has disadvantage that only two (2) or three (3) water levels where the sensors are setup can be measured, the sensor configuration is quite simple comparing with other types of sensor and has advantages such as high accurate detection and cost merits.

(c) Water level sensor (pressure type)

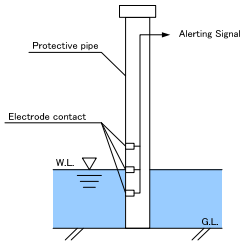
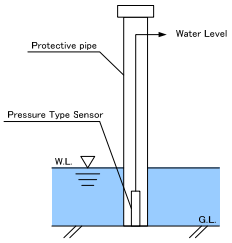
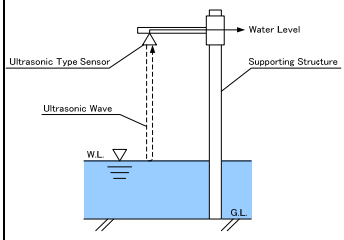
Pressure type water level sensor can detect any water levels by measuring the changes of water pressure depending on water depth. Water levels can be measured with relatively high accuracy (0.05% of full scale) by the sensor. The pressure type sensor needs much equipment cost than the electrode contact type detector though the sensor is widely used in the world as water level sensor (not as a water logging detector).

(d) Water level sensor (ultrasonic type)

Ultrasonic type water level sensor can detect any water levels by using arrival time difference of ultrasonic waves reflected from water on the road and from the road with measurement accuracy of ± 1cm. The sensor can be easily installed on the road by fixing on the supporting pole. However, in case that vehicle passing or other obstacles under the sensor be existed, it is difficult to measure the accurate water level.

The flood monitoring sensor is necessary to detect whether the water logging level reaches over the pre-determined threshold level or not and measurement of detail water level is not required. Therefore, the electrode contact type detector is chosen as flood monitoring sensor for this project considering its advantages such as high accuracy of measurement and cost merits.

Table 152 Comparison of Automatic Water Logging Detector

Item \ Type	Electrode Contact Type Detector	Water Level Sensor Pressure Type	Water Level Sensor Ultrasonic Type
Outline			
Principle	When water logging level reaches pre-determined water level, the signal is generated by turning on the electrode contact sensor.	Pressure type water level sensor can measure water levels by detecting the changes of water pressure depending on water depth.	Ultrasonic type water level sensor can measure water levels by using arrival time difference of ultrasonic waves reflected from water on the road and from the road .
Measurement Item	Water Level (2 or 3 levels only) Flooding Alert	Water Level (any levels) Flooding Alert	Water Level (any levels) Flooding Alert
Measuring Accuracy	-	0.05% of full scale (F.S.)	± 1cm + α
Installation	Fixed with protective pipe. The sensor must be fixed at same level or lower than road surface.	Fixed with protective pipe. The sensor must be fixed at same level or lower than road surface.	Fixed on supporting structure securing sight path
Maintenance	Routine inspection (clean up, etc.) is not necessary, basically.	Routine inspection (clean up, etc.) is not necessary, basically.	Routine inspection of transmitter / receiver and thermometer is necessary.
Unsuitable Location	None	None	Places where vehicles passing or other obstacles under the sensor is existed
Implementation Cost	1.0	2.0	2.5
Evaluation	Recommended	Average	Not Suitable

Source: Prepared by JICA Study Team

(6) Setting-up of Alerting Water Level

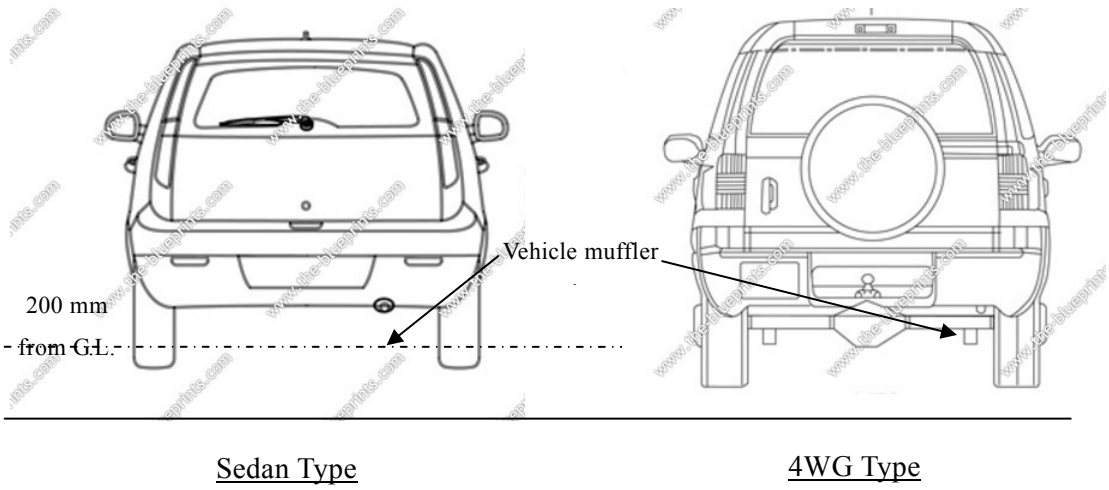
The alerting water levels must be set up before the equipment installation because the electrode contact detector must be put at such height levels. At least, three (3) alerting levels, i.e. warning level I: pre-alerting level to take notice for starting of flood, warning level II: to provide alerting signal to the road users, warning level III: to take necessary actions including road closures by road operators are set as follows:

(a) Warning Level I: 100 mm

Half level of warning level II

(b) Warning Level II: 200 mm

Warning level II is set up as normal height of vehicle muffler pipe as shown in figure below. This water level may cause some troubles of vehicle running operation.



Source: Prepared by JICA Study Team

Figure 250 Typical Vehicle Dimension

(c) Warning Level III: 500 mm

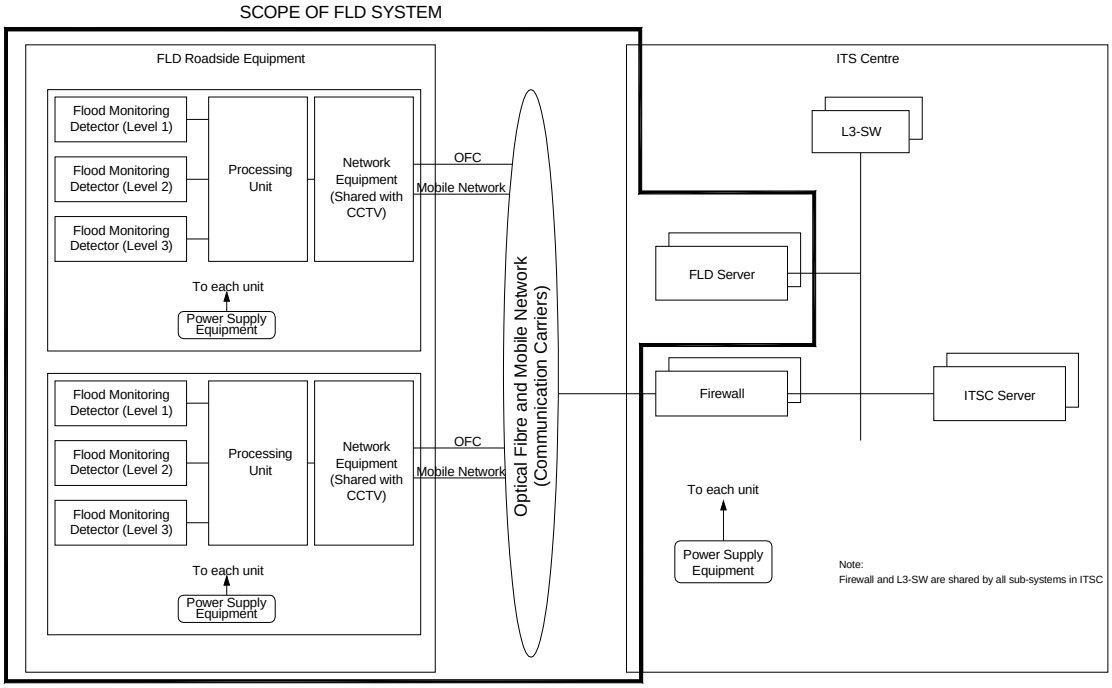
In addition to 2 warning levels above, warning level III is set up as above-the-knee level that has possibilities to arise serious human suffering.

(7) System Configuration

FLD System shall consist of the following components:

- FLD Server at the ITSC,
- FLD Roadside Equipment consisting of flood monitoring detectors with processing unit, network equipment, power supply equipment and peripheral,
- Communication network between the ITSC and Roadside Equipment and
- Supporting structure or station house and foundation at Roadside.

The proposed flood monitoring system would be configured in the Figure



Source: Prepared by JICA Study Team

Figure 251 Proposed Flood Monitoring System Configuration

The ITSC shall have the FLD Server for receiving all FLD Roadside Equipment data. IP based network equipment shall be provided to connect the FLD Roadside Equipment with the FLD Server at the ITSC.

(8) Network Requirements for FLD System

The data transmission of the FLD system shall be made either through the optical fibre network or through mobile network both provided by the communication carriers. The flood monitoring system only handles flood alerting signals whether water level reach predetermined flood alerting levels or not. Also, frequencies of data transmission are quite few, only limited under situation that flood occur. However, CCTV camera will be installed at same location of flood monitoring sensor to monitor the water logging situations visually. Therefore, total network traffic will be getting much bigger and high speed network will be required.

The optical fibre network shall be utilized as main communication line while the mobile network shall be used as backup. Should any communication failure occur in optical fibre network, the FLD system shall automatically change over the communication line to mobile network.

(9) FLD System Functions

The flood monitoring system will be provided with the functions described below.

(a) Flood measuring and processing functions

- The FLD roadside equipment shall detect following three (3) levels of water logging condition at each location.
- Warning Level I: 100 mm
- Warning Level II: 200 mm

- Warning Level III: 500 mm
- Unit duration of detection and measurement shall be on real-time basis.
- Error checking shall be performed for the measuring data by comparing them with the previous data. The data judged faulty shall not be used as observed data.
- The FLD system must have an overall detection accuracy of 99 % or better in each water logging level detection.

(b) Data Transmission Function

- Following measurement data shall be periodically transmitted to the FLD server installed in the ITSC through the communication networks provided by the communication carriers.
- Water logging level
- Equipment failure
- Other necessary data
- Unit time period of data transmitting shall be within one (1) minutes.

(c) Data processing and management functions

- The FLD server shall gather the observed flood logging data and monitor signals from the FLD roadside equipment at a regular interval.
- A warning system shall be introduced in the system. When any levels of water logging are detected at roadside, an alarm must be issued to the system operator and automatically indicated on the large display panel and/or operator consoles.
- All observed flood logging data shall be recorded in the FLD server in the form of 5-minute. Daily and monthly data and data retrieval software shall be provided for easy access to the recorded data.

(d) Data storage function

- All data transmitted from the FLD roadside equipment and processed data in the ITSC shall be recorded and stored in the FLD server for analysis and future usage. Data retrieval and presentation software shall be provided that can easily retrieve and show the flooding information of the specified roadside equipment at the hour or day.
- Status of roadside equipment (normal or malfunctioned) shall be recorded in the FLD server as operation log and for future reliability analysis together with error code and time stamp.

Data / Subsystem	Storage Data	Type
FLD system	Flood warning level I: 100 mm	Raw data
	Flood warning level II: 200 mm	Raw data
	Flood warning level III: 500 mm	Raw data
	Equipment operational status	Raw data

(e) Diagnosis function

- The FLD system shall have a diagnosis function. The FLD server shall inquire the connection with the roadside equipment and the status of equipment by sending the diagnosis signal in every one (1) minute. If equipment fault signal is received or there is no response from roadside equipment, the FLD server shall issue a warning and the fault shall be recorded in the log.

(f) Display and reporting functions

- The information display shall be schematic map based interface and as well in the form

of a list. The schematic map based display shall cover the entire HMA and be able to enlarge individual locations on the map when selected. The enlarged view shall be able to display the details for each selected location. The details displayed shall cover the contents as described in the below table but not limited to.

- The FLD Server shall be capable of creating the following screen contents, but not limited to these:

Item	Contents to be displayed on Map	Contents as List
Equipment location and status	• Location of FLD Roadside Equipment and its status (normal / error)	• Location of FLD Roadside Equipment and its status (normal / error)
Flood condition	• Current flood conditions (warning level I, II and III)	• Current flood conditions (warning level I, II and III)
Observation (raw) data	•	• Observation record in the form of list • Screen to edit or remove abnormal observation record
Processed data	•	• Processed data in the form of list
Parameter setting	•	• Screen form to edit all the parameters
Server status	•	• Server status (normal / error) in the form of list
Operation log	•	• List of Roadside Equipment that are operational and non operational • Error record
Date and Time	• Current date and time	• Current date and time

The **FLD Server** shall publish/print the reports listed below, but not limited to these. The reports shall be published as pre-scheduled or on-demand by system operator. It shall be possible to publish the report in a portable file format.

Item	Contents
Flood data	• Daily report containing water logging level and its time • Monthly report containing water logging level and its time
Error log	• List of FLD equipment currently not in operation • Error record

(g) Data transferring function

The following data received and/or processed in the FLD server shall be stored in the database of ITS centre system for total system management on the real time basis.

- Water logging levels (level 1, 2 and 3) at each FLD roadside equipment
- Equipment operational status

The alerting signals of waterlogged conditions stored in the database shall be utilized to judge which VMS must indicate the warning information to the drivers.

(10) Installation of Flood Monitoring Roadside Equipment

Flood monitoring detector will be installed at roadside as follows:

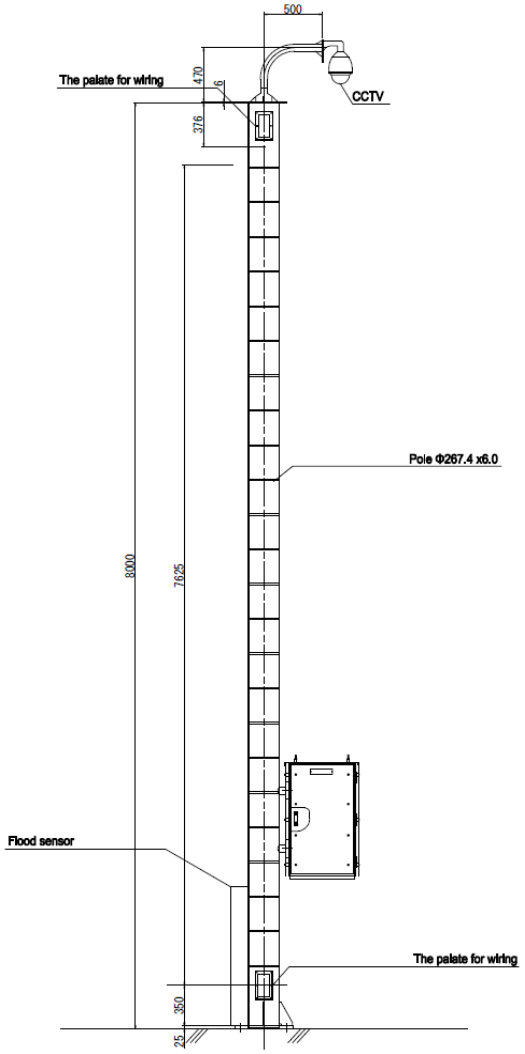
The electrode contact type detectors will be fixed into steel protective pipe of which diameter is around 100mm.

The bottom of protective pipe must meet the same level of road surface to detect accurate flood conditions. The protective pipe would be placed on the road shoulder in order to avoid traffic interruption.

The protective pipe would be sustained by the supporting pole.

The GSM/GPRS communication unit, processor unit, power supply facilities and other devices installed at roadside will be housed in the cabinet. The cabinet will be hanging on the supporting pole.

Typical installation plan for flood monitoring roadside equipment is illustrated as figure below.



Source: Prepared by JICA Study Team

Figure 252 Typical Installation Plan for FLD Roadside Equipment

(11) Power Supply to Flood Monitoring Roadside Equipment

(a) Power Source

As described in Section above, AC commercial power with UPS is chosen as power source for flood roadside equipment with following reasons:

All of sites are located near commercial power pole and power can be easily fed from low voltage lines of the power company.

The flood monitoring system must be surely functioning during heavy rains in view of its objectives. The solar power supply system may stop power supply in bad weather conditions since the power cannot be generated under such conditions.

In Hyderabad Metropolitan Area, there often observes commercial power interruptions. However, almost all of power interruptions are recovered within a few minutes. In order to compensate power supply during short time power cut, it is recommended to provide UPS with minimum size of battery.

(b) Estimated Power Consumption

As mentioned in previous Section of CCTV Camera System, The power demand load of FLD roadside equipment is estimated a total of 0.7 KVA.

(c) UPS

The compensation time of UPS shall be of 3 hours. The required capacity of UPS battery is estimated around 19.8 [Ah].

10-2-6 Variable Message Sign System

(1) System Objectives

This section states VMS System to be installed as one of the Sub-Systems of Hyderabad City ITS. VMS System shall be installed with following objectives;

- To provide road users with real time information of traffic status, incident, and weather conditions on the major roads in HMA;
- To provide option of route selection to driver in the case of congestion, incidents and adverse weather,
- The messages displayed on VMS are controlled and processed from the ITSC Centre (the ITSC) where all the information is collected.

The VMS shall be located at major junctions and intersections on the Inner Ring Road (IRR). The VMS shall be placed upstream of major junctions and intersections on national highways and state highways to provide the information to drivers travelling towards the city. VMS System shall be capable of creating, managing and displaying messages in three languages (English, Hindi and Telugu) separately and alternately, or simultaneously in case of simple message. The system shall operate on a 24-hour a day 7-day a week basis.

It shall be the responsibility of the Contractor to furnish all necessary hardware and software, provide gantry or cantilever support depending on the width of road, install the Equipment at the specified location, provide necessary cabling, setup database and parameters, integrate all system components, and deliver a complete operational VMS System.

The following standards shall apply for the requirements not specifically stated in The Employer’s Requirements:

- IRC SP 85-2010
- EN 12966-1
- NEMA TS4

(2) VMS System Requirements

System requirements of the VMS system are as follows.

- VMS System shall display on real time basis the following message components on the VMS boards located at Roadside;
- Location
- Incident (accident, traffic congestion, bad weather condition, etc.)
- Action to be taken by road user (Slow-down, be careful, diverting to alternative route, etc.)
- VMS System shall provide traffic information such as travelling time on the roads in HMA so that the drivers select their travelling route.
- Character including symbol mark indicated on the VMS board shall be visible under the natural environmental conditions in India, and the character height shall be enough size for recognition by driver passing through the road.
- VMS board(s) shall be properly installed at locations so that the road users can read and understand information on the board and safely change the lane, take turn at junctions and/or intersections.
- The VMS board shall be fixed on either gantry type supporting structure or F-shaped cantilever structure. The type of supporting structure shall be determined by considering the message visibility to the drivers.
- VMS System shall be capable of creating, managing and displaying messages locally or remotely from the ITSC

(3) VMS Location Plan

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

(a) Phase-1

- The VMS will be placed beside major junctions and intersections on National Highways and State Highways to provide traffic status, incidents and weather information to drivers entering towards the city.
- The VMS will be located at major junctions and intersections on the IRR, as well.
- The VMS will be located at all junctions and intersections on existing radial roads connecting the IRR to provide the information to drivers upstream of IRR
- Installation of VMS on the ORR will be excluded from this project since the VMS board on the ORR will be prepared within the scope of ORR project. However, road, traffic and weather data exchange between ITSCC and Highway Traffic Control Center established by ORR project shall exchange the necessary information frequently and interactive VMS information provisions each other.
- The VMS will be placed beside junctions and intersections on major roads inside Hyderabad Metropolitan Area including road No.2 connecting with IRR and High-tech city.
- The VMS will be located at junctions and intersections in front of flooding prone areas so that drivers can divert to alternative traveling route when flooding occurs.
- Apart from VMS being planned by this project and ORR project, traffic police will install 17 VMS under the H-TRIMS project. Exact locations and directions of those

VMSs implemented by traffic police are not currently clarified. After identifying the location of VMSs provided by the H-TRIMS project, the VMS may be canceled from this project in case the locations are overlapping with H-TRIMS project.

(b) Phase-2

- The VMS will be located beside all junctions and intersections on the radial roads crossing the ORR to provide road, traffic and weather information on the ORR to drivers.
- The VMS will be basically placed at all junctions and intersections on the radial roads crossing the ORR. However, the VMS to be installed at junctions and intersections on the National Highways crossing the ORR has being implemented by the ORR project. Thus, those VMSs are excluded from the scope of this project.

(c) Phase-3

- The VMS may be further located inside the city for the purpose of information provisions related to parking area information, detailed traffic information or other objectives.

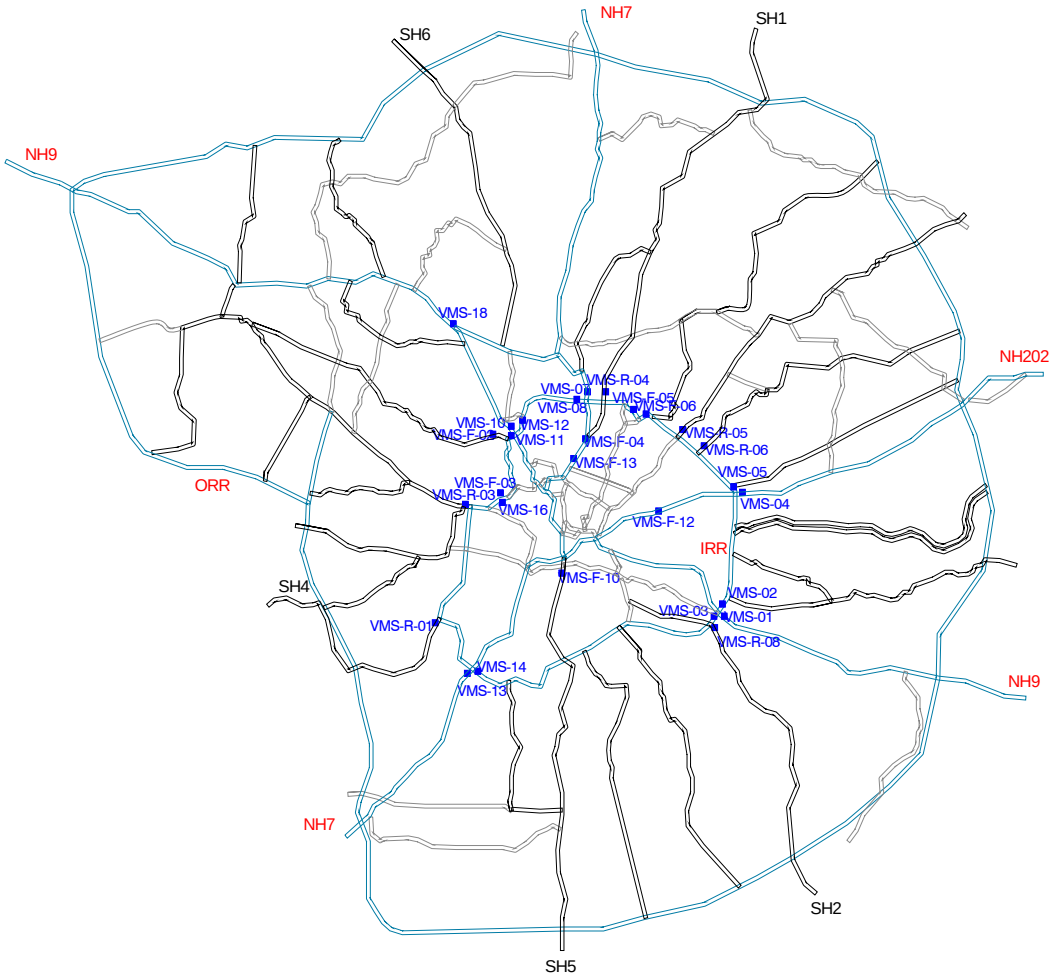
This design report is prepared for the VMS system to be nstalled in Phase-1.The proposed location plan of VSM board in Phase-1 is shown in Table and Figure below.

Table 153 Proposed Locations of VMS in Phase-1

VMS No.	Road	Location/Landmark
VMS-01	NH9	LB Nagar Ring Road
VMS-02	IRR	LB Nagar Ring Road
VMS-03	IRR	Uppal Ring Road
VMS-04	NH202	Uppal Ring Road
VMS-05	IRR	Uppal Ring Road
VMS-07	NH7 (NH9)	Secunderabad, MG Road Flyover Junction
VMS-08	IRR	MG Road Sec'bad, near Anand Theatre
VMS-10	NH9	Khairatabad road near Panjagutta Flyover
VMS-11	IRR	Nagarjuna Circle Road, near Brisah, Flyover Towards Greenlands
VMS-12	IRR	ITC Kakatiya Sheraton, Greenlands
VMS-13	NH7	Rajendra Nagar, near PVNR Expressway entry
VMS-14	IRR	Sivarampalli Junction, towards Mehdipatnam
VMS-16	IRR	Mehdipatnam Road, near Sarojinidevi Eye Hospital
VMS-18	NH9	IDA Kukatpally, near Metro Mall
VMS-F-02	Road No.2 (City Road)	Road No 2, Banjara Hills, near Sultan-Ul-Uloom College
VMS-F-03	IRR	Mehdipatnam Road, near Sarojinidevi Eye Hospital & Entry to PVNR Expressway
VMS-F-04	NH7 (NH9)	Tank Bund, near Secunderabad Sailing Club-Marriott Hotel
VMS-F-05	IRR	Railnilayam, Secunderabad
VMS-F-06	IRR	Secunderabad-Tarnaka Main Road, near Alugadda Bavi

VMS No.	Road	Location/Landmark
VMS-F-10	NH7	Charminar Road near Madhina Circle
VMS-F-12	NH202	Moosram bagh Junction
VMS-F-13	NH7 (NH9)	Tank Bund, near Vemana Statue
VMS-R-1	Himayat Sagar Rd (Radial Road 2)	Himayat Sagar Road, near Sri Venkateswara Veterinary College
VMS-R-3	Mumbai Road (Radial Road 5)	Nanalnagar Junction, near Mehdipatnam
VMS-R-4	Club Rd (SH1)	Secunderabad Club Road, near Gymkhana Grounds
VMS-R-5	Tarnaka Main Rd	Osmania University road, at Lalapet Flyover
VMS-R-6	Nacharam Mallapur Rd	Nacharam Mallapur Road, near IICT Colony (Habsiguda)
VMS-R-8	Nagarjina Sagar Rd	Bairamalguda Bypass Road, near Mallikarjuna Nagar Colony

Source: Prepared by JICA Study Team



Source: Prepared by JICA Study Team

Figure 253 Proposed Location Map of VMS in Phase-1

(4) Site Reconnaissance for VMS Locations

Site reconnaissance at the locations of VMS board has been carried out by the Study Team to check following site conditions.

- Location of roadside equipment
- Installation space for flood monitoring sensor (foundation size is around 1.5m x 3.0m widths)
- Road conditions (road width, number of lanes, width of median)
- Visibility to the direction showing messages to the drivers
- Power receiving point (identifying the nearest pole and its pole number)
- Network connecting point (Service provider's optic fiber connection point)
- Mobile cellular communication availability

(5) VMS System Design

(a) Type of VMS

The variable message sign (VMS) system will be introduced to provide road users with road and traffic information such as weather condition, congestion and other incidents in order to assist road users. Following are the types of variable message sign boards:.

Table 154 Type of Variable Message Signboard

Type	Image	Function
VMS (Text-based)		To inform the road, traffic and weather conditions on the roads to drivers by using text information and/or symbol mark.
Travel Time Display		To provide travel time information from VMS location to major destinations.
Graphic Information Signboard		To inform congested sections to make drivers select most suitable traveling route by using graphic information.

Source: Prepared by JICA Study Team

The VMS introduced in the project will support text and graphic display to provide not only information for travel time and congested area but also weather condition and any other incident information on the roads.

(b) Display Indication

The VMS signboard shall indicate the following information obtained from other subsystem components on real time basis.

- Location
- Incident
- Action to be taken by road user

Table below shows the example of the messages indicating on the signboard.

Table 155 Example of Message on VMS Board

Location	Incident	Action
From here	Accident	Slow down
_____km ahead	Construction work	Be careful
_____ junction	Congested area	Keep right / left lane
Right / Left lane	Road paving	Keep distance
Bridge	Stalled vehicle	Turn on light
Tarnaka	Slow moving vehicle	
Hightech City	Fallen object	
NH 9	Heavy rain	
IRR	Strong wind	
	Heavy fog	
	Poor Visibility	
	Flooded road	
	Lane closure	

Source: Prepared by JICA Study Team

Considering the necessary information to be shown on the VMS board, the display panel shall indicate three (3) lines, i.e. “location”, “incident” and “action”, and each line shall be capable of displaying 20 characters or more.

Apart from text-based message indication, VMS shall have capability of symbol mark indication or combined indication of characters and symbol marks to allow drivers easily understand and quickly respond to messages. The figure below shows the sample of symbol mark.

Source: Prepared by JICA Study Team

Figure 254 Sample of Symbol Mark

(c) Size of Character on Signboard

According to the IRC (Indian Road Congress) VMS Guideline, minimum character height of VMS is defined as 300 mm. However, it does not describe the reasons for deciding the minimum character height as 300 mm. In general, character size must be determined depending on the vehicle travelling speed, decipher distance, etc. Hence, the minimum character height specified in the VMS Guideline is validated in accordance with the formula defined by Japanese Standard as below.

(d) Possible deciphering distance

The possible deciphering distance of VMS message is given by formula below.

$L = f \times h^*$

Where

L: Possible deciphering distance

f: Factor = 5.67

h*: Effective character height = k1 x k2 x k3 x h

k1: Coefficient defined by type of character (alphabet) = 1.2

k2: Coefficient defined by complexity of character = 1.0

k3: Traveling speed coefficient (see table below)

Travelling Speed (km/h)	pedestrian	40	50	60	80	100
coefficient	1.00	0.91	0.89	0.87	0.82	0.77

h: Character height (cm)

Hence, in case of traveling speed set at 50 km/h (because design speed of national highways inside city and IRR where VMS are installed is not clearly defined, traveling speed is considered at 50 km/h for purpose of this calculation) and character height at 30 cm (300 mm), possible deciphering distance of VMS message is calculated as:

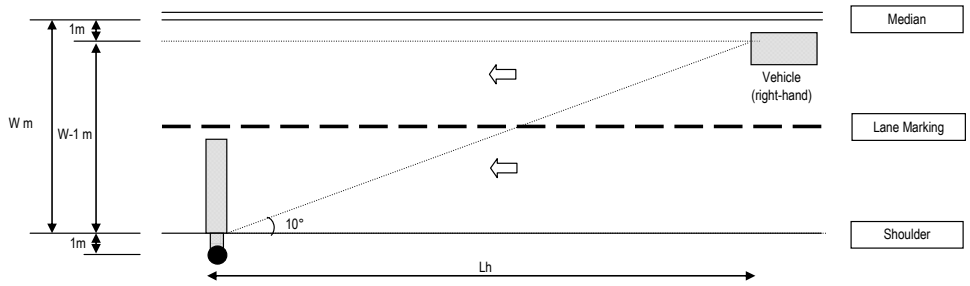
$L = f \times h^*$

$= 5.67 \times (1.2 \times 1.0 \times 0.89 \times 30)$

$= \underline{181.7 \text{ (m)}}$

(e) Message disappearance point

On the other hand, message disappearance point of VMS from vehicle driver (Ld) can be illustrated as figure below:



Source: Prepared by JICA Study Team

Figure 255 VMS Message Disappearance Point from Driver (Vertical)

When the upper edge of VMS (Hv) is set at 7,000 mm (road clearance 5.5 m + height of VMS 1.5m), vertical visual limit (α) equal to be set at 7° and driver's eye-level (He) is 1,200mm respectively. The message disappearance point of VMS from vehicle driver (Ld) is calculated as:

Ld = (Hv – He) / tan α°

= (7.0 – 1.2) / tan 7°

= 47.2 (m)

(f) Required deciphering distance

Required deciphering distance of VMS message (Lv) is varied based on the travelling speed and number of characters displayed on VMS as shown in table below.

Table 156 Required Deciphering Distance (Lv)

Speed (km/h) / Number of Characters	50	60	70	80	90	100
10 Characters	21	25	30	34	38	42
15 Characters	27	32	37	43	48	53
20 Characters	35	42	49	56	63	70

Source: Prepared by JICA Study Team

When 3 lines VMS with 20 characters/line is selected, required deciphering distance is calculated as 105.0 m.

(g) Validity of Character Height

Validity of character height is proven as follows:

L – Ld > Lv

Hence,

Possible deciphering distance of VMS message (L) = 181.7 m

Message disappearance point (Ld) = 47.2

Required deciphering distance (Lv) = 105.0 m

L – Ld = 181.7 – 47.2

= 134.5 m > 105.0 m

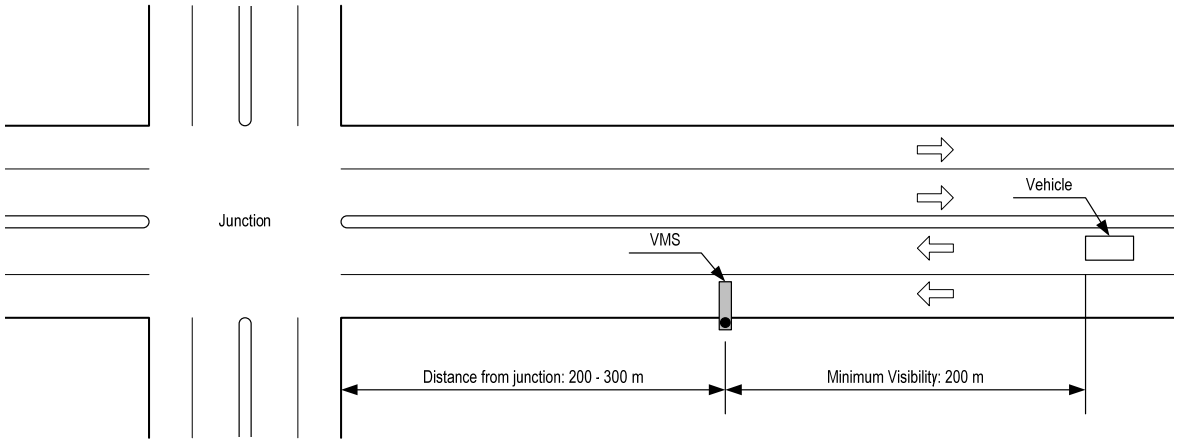
Thus, the character height of VMS is chosen as 30 cm (300 mm) in this project.

(6) Location of VMS Signboard

As mentioned earlier, the VMS board will be placed upstream of major junctions and

intersections on national highways and state highways to provide road, traffic and weather information to drivers entering into the city. The VMS board will be located at major junctions and intersections on the IRR, as well.

The exact location of VMS board and distance from targeted junctions and intersections must be sufficient for road users to read and understand information on the signboard and to safely change lane and/or take turn at junctions and intersections. Thus, the VMS board will be located approximately 200m – 300m upstream of targeted junctions and intersections. Also, minimum visibility to the direction showing message to the driver must be kept for 200m as specified by the VMS Guideline.



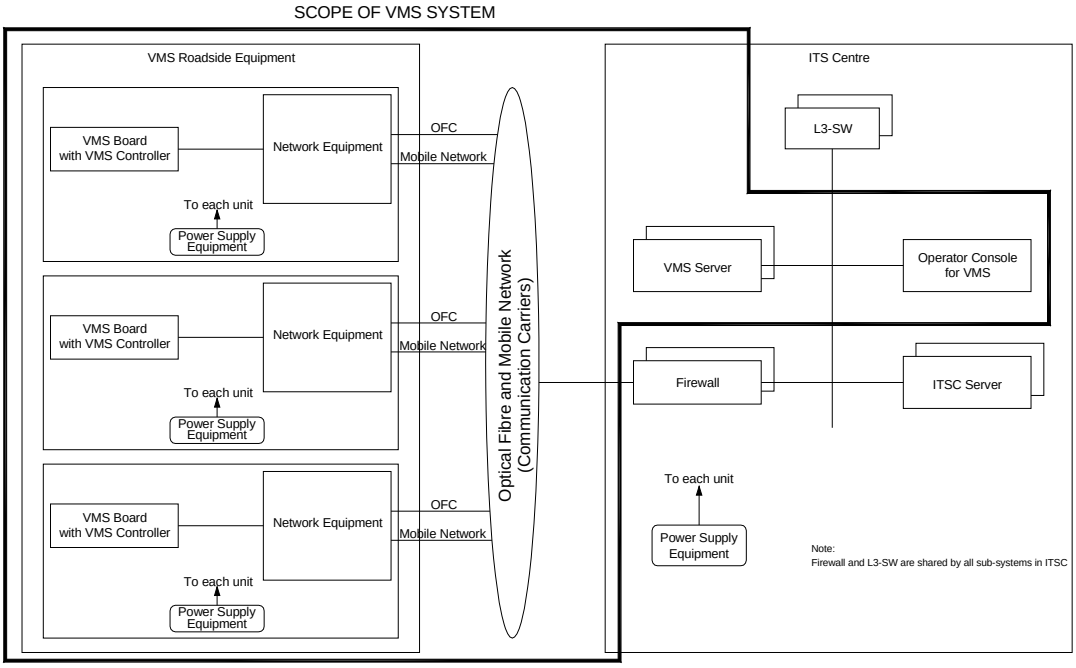
Source: Prepared by JICA Study Team

Figure 256 Requirements for VMS Board Location

(7) VMS System Configuration

The variable message sign system shall consist of the following components:

- VMS Server and Operator Console for VMS at the ITSC,
- VMS Roadside Equipment consisting of VMS board with VMS controller, network Equipment, power supply equipment and peripheral,
- Communication network between the ITSC and Roadside Equipment and
- Supporting structure and foundation at Roadside.



Source: Prepared by JICA Study Team

Figure 257 Proposed VMS System Configuration

- The VMS controller will be accommodated in a separate cabinet or in the VMS board housing.
- A dedicated Operator Console for VMS shall be provided in the ITSC for message preparation, monitoring and control of the variable message signs. IP based network equipment shall be provided to connect the VMS Roadside Equipment with the VMS Server at the ITSC.

(8) Network Requirements for VMS System

The data transmission of the VMS system shall be made either through the optical fibre network or through mobile network both provided by the communication carriers. The optical fibre network shall be utilized as main communication line while the mobile network shall be used as backup. Should any communication failure occur in optical fibre network, the VMS system shall automatically change over the communication line to mobile network.

(9) VMS System Functions

(a) Message indication functions

Message to be displayed on the VMS shall be concise and clear as the road users have to read and understand the message in a short time. Messages shall have uniform structure and simple words shall be used. Messages on the VMS board shall be expressed in English, Hindi and Telugu. In principle, a message to be displayed on the VMS board shall be composed of three parts, “location”, “event”, and “action” to be taken by the road users.

1) Location

Location indicates the relationship between the **VMS** location and the incident location. They can be expressed as section (between junction A to junction B), distance (ahead, xx km ahead), or specific location (near junction A).

2) Event

Event is a thing that has happened or taken place on the road. It includes traffic conditions (accident, congestion), traffic regulation (lane closure, road maintenance work), road condition (wet road surface, damaged pavement), and weather condition (fog, rain, strong wind and flood).

3) Action

The action is to be taken by the road users such as “slow down”, “cautious” and “use right/left lane”.

All the three components are not necessarily required all the time. Messages consisting of one or two components described above or simple message shall also be displayed.

The variable message sign system shall be capable of displaying the graphic symbol marks. The sample symbol marks are listed below for reference. **The Contractor** shall design and propose graphic symbol marks to be used on the variable message sign for approval by **The Employer’s Representative**. The system shall be capable of having a maximum of twenty (20) graphic symbol marks. The graphic symbol marks shall be defined as dot matrix and editing of the symbol mark shall be possible. It shall be possible to combine text and graphic symbol marks in a message.

(b) Message creation and editing functions

Three message composition methods shall be provided; (1) manual input, (2) combination of pre-defined phrases, and (3) selection of ready-made message. The functions specified herein shall be possible in three languages i.e. in English, Hindi and Telugu. In addition, a set of graphic symbol marks shall be provided to complement the text message.

Manual composition

In the manual input, it shall be possible to display on the VMS any text message input by the system operator through the keyboard of the operator console in ITSC. There shall be no restriction as to the contents of message but the length of message is limited to the display capacity of the VMS board. If manual composition mode is selected, the operator console shall show the image of the VMS board and the message as it is input by the system operator.

Combination of Pre-Defined Phrase

In the case of combination of pre-defined phrase, frequently used words or phrases such as “accident”, “congestion”, “construction work”, “slow down” and so on are used to compose a message. It shall be possible to insert a word into the message composed by combination method. There shall be sets of pre-defined words. They shall contain words indicating location, incident and action. Each set shall have a capacity of 100 words in each language. In this mode, the operator console shall show the categories and the words or phrases in each category for the system operator to select. It shall be possible to alter the pre-defined words by the system operator.

Ready-made message

Ready-made message selection method shall allow the system operator to choose one of the ready-made messages. If the ready-made message mode is selected, the operator console shall indicate the list of ready-made messages grouped into categories for the system operator to select. Message set shall have the capacity of 100 messages in each language.

Graphic symbol marks

Graphic symbol marks that show typical incidents such as construction work and heavy rain shall be provided to complement the text message. The sample graphic symbol marks are provided in The Employer's Requirements for reference. The design of graphic symbol marks shall be subject to the Employer's approval.

Dot matrix pattern

The VMS system shall be provided with a function to create a display pattern by specifying the on/off status and colour of each pixel comprising the display area of the VMS board. It shall be possible to mix the dot matrix pattern and character message on the board.

Automatic message creation from incident information

- If a water logging is detected by the flood monitoring system or an adverse weather condition is detected by the meteorological monitoring system or any incidents are manually inputted at console by system operator, the systems shall send an alarm to VMS System. VMS System shall then create a warning message indicating the location, type of incident and action to be taken. The message created shall not be displayed automatically on the VMS board. Instead, a recommendation shall be displayed on the Operator Console indicating the contents of the message and the location of VMS for which message is recommended. Upon confirmation of the recommendation, the message shall be displayed.
- The Operator Console shall be provided with updating and editing function of pre-defined word, phrase, message and symbol mark. Editing of symbol mark shall be possible on a pixel basis.
- Graphic user interface shall be adopted in the interface as much as possible for user friendly operation and fail safe mechanism shall be incorporated to prevent VMS System from showing inadequate message. The system shall be equipped with a text input method in Telugu and Hindi languages commonly used in Hyderabad through the standard keyboard.
- VMS System shall be provided with an automatic message selection function based on the priority or severity of the events and coefficient that represents the importance of event. The function shall select and recommend the message to be shown for each VMS when there are two or more incidents to be informed to the road users.
- Each message being displayed on the VMS shall be assigned with a time-to-live (TTL) value and upon expiration of TTL, message shall be automatically extinguished. A warning shall be issued to the Operator Console before TTL expires for operator to choose extension of TTL or termination of the display as scheduled.
- VMS System shall have an alternative display function, in which a maximum of two sets of message shall be displayed alternatively. The function is intended to display a message in three different languages (English, Hindi and Telugu) but not necessarily limited to the same message.

(c) Data transmitting function

- Text and symbol mark message to be displayed shall be converted to pixel image data to control display unit before transmitting to the variable message sign.
- The VMS server shall communicate with the VMS controller at roadside through the

networks provided by the communication carriers. It shall send out message converted to dot pattern for display. It shall also send out command data to control the VMS controller and to confirm normal operation of the VMS board. In return, the server shall receive status data from the controller.

(d) Operation monitoring and logging functions

- Operating status of the variable message sign shall be checked periodically. Status (message on, no message, fault, local control, test and switch off) shall be collected from the VMS controller at roadside. If any abnormality is reported, an alarm shall be issued. The collected operation monitoring data shall be recorded as part of operation log. It shall be possible for the operator console to send a command to the controller and collect the dot pattern data being displayed on the VMS board upon system operator's initiative.
- Displayed message along with the starting and ending time shall be recorded as operation log. Status or malfunction of the VMS and the controller shall also be recorded. Data retrieval software shall be provided and operation log can be retrieved for display on monitor and as printed report.

(e) Data storage function

- All data transmitted from the VMS roadside equipment and processed data in the ITSC shall be recorded and stored in the VMS server for analysis and future usage. Data retrieval and presentation software shall be provided that can easily retrieve and show the recommended message automatically generated against event and message indicating on each VMS of the specified roadside equipment location at the hour or day.
- Status of roadside equipment (normal or malfunctioned) shall be recorded in the VMS server as operation log and for future reliability analysis together with error code and time stamp.

Sub-System	Storage Data	Type
VMS System	• Recommended message automatically • generated against event	• Raw data
	• Manual input operation record	• Raw data
	• Equipment operational status	• Raw data
	• Current message indicating on each VMS	• Processed data

(f) Display and reporting functions

- The information display shall be schematic map based interface and as well in the form of a list.
- The schematic map based display shall cover the entire HMA and be able to enlarge individual locations on the map when selected. The enlarged view shall be able to display the details for each selected location. The details displayed shall cover the contents as described in the below table but not limited to.
- The VMS Server shall be capable of creating the following screen contents, but not limited to these:

Item	Contents to be displayed on the Map	Contents as List
Equipment location and status	• Location of VMS and their condition (message / no message and normal / error)	• Location of VMS and their condition (message / no message and normal / error)
Server status	•	• Server status (normal / error) in the form of list
VMS Message	• Message displayed currently on a VMS • Graphic symbol marks	• Message displayed currently in the form • Message displayed at past (historical messages displayed) in the form of list • Message being displayed at selected VMS with starting time and scheduled end time in the form of list • Pre-defined words and phrases in the form of list • Pre-defined messages in the form of list • Graphic symbol marks
Parameter setting		• Parameters in the form of list • Screen form to edit all the parameters
Operation		• List of Roadside Equipment in operation or not • Operation log and error record
Date and Time	• Current date and time	• Current date and time

The server shall print the reports listed below, but not limited to these. The reports shall be published as pre-scheduled or on-demand by system operator. It shall be possible to publish the report in a portable file format

Item	Contents
VMS operation	• Daily report summarizing VMS location, message displayed, start time, end time
Operation and error log	• List of Roadside Equipment in operation or not • Error record

(10) VMS Installation Method

The VMS board will be installed at roadside as follows:

- VMS control unit and LED panel modules will be put in VMS board together.
- VMS board will be fixed on the supporting structure (gantry type or F-shaped cantilever type). The type of supporting structure will be determined by considering the necessary visibility to the driver as follows

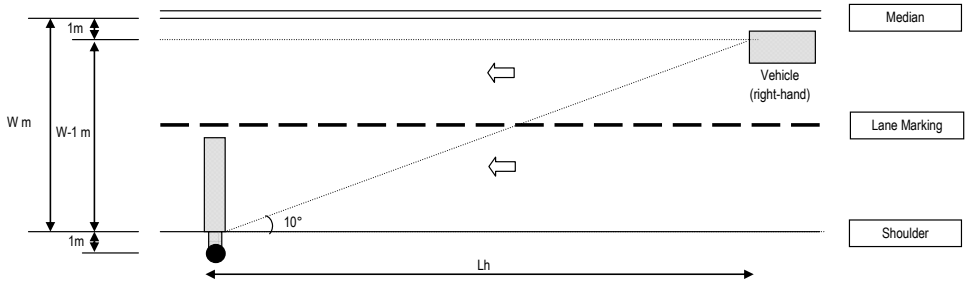
As described above, possible deciphering distance and required deciphering distance of VMS message are estimated as:

Possible deciphering distance: L = 181. 7m

Required deciphering distance: Lv = 105.0 m

Hence, the VMS must be legible 76.7 m upstream of VMS location.

On the other hand, message disappearance point of VMS to horizontal direction (Lh) can be illustrated as figure below



Source: Prepared by JICA Study Team

Figure 258 VMS Message Disappearance Point from Driver (Horizontal)

When the horizontal visual limit of LED display is set as 10°, message disappearance point of VMS with F-shaped cantilever structure (Lh) is calculated as:

Ld = (W – 1 / tan 10°) m < 76.7 m

If the road width (W) is assumed as 14.5 m,

Ld = (14.5 – 1 / tan 10°) m

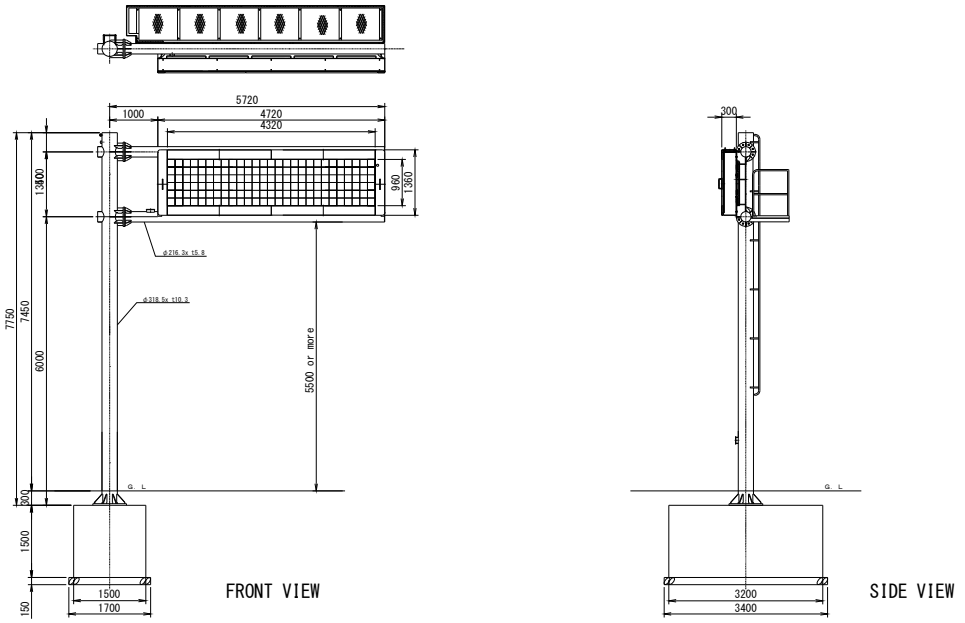
= 13.5/ tan 10°

= 76.6 m

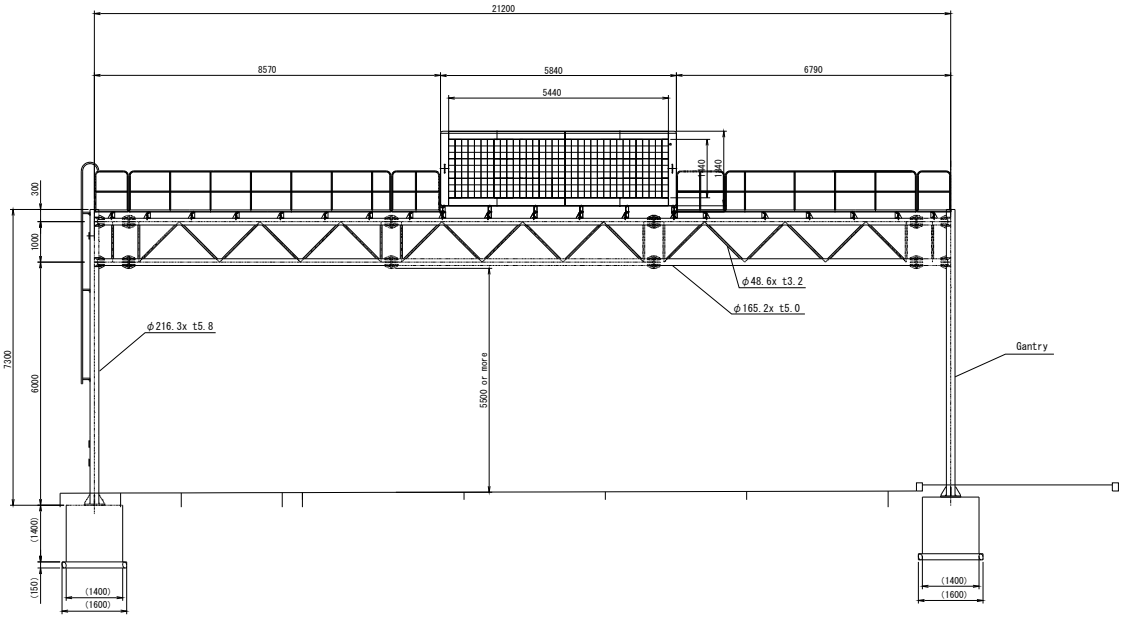
Thus, F-shaped cantilever would be provided in case the road width is 14.5m or less and gantry type is applied to the VMS location where the road width is wider than 14.5 m.

- The VMS board must be installed at the location having minimum visibility of 200 m to the direction showing message to the driver.
- 5.5m or more clearance from road surface must be kept under the bottom of VMS board.
- Both of gantry type and F-shaped cantilever type supporting structure require enough spaces for constructing foundation. They are estimated as 1.4 m (W) x 3.5 m (D) x 1.4 m (H) on both sides of road shoulder and median for gantry type, and 1.5 m (W) x 3.2 m (D) x 1.5 m (H) on road shoulder and median for F-shaped cantilever type, respectively.
- The communication unit, processor unit, power supply facilities and other devices installed at roadside would be housed in the VMS board.

Typical installation plan for VMS board is illustrated as figure below.



F-shaped cantilever type supporting structure



Gantry type supporting structure

Source: Prepared by JICA Study Team

Figure 259 Typical Installation Plan for VMS Board

(11) Power Supply to VMS

(a) Power Source

As described in the previous Section, AC commercial power with UPS is chosen as power source for flood roadside equipment with following reasons:

- All of sites are located near commercial power pole and power can be easily fed from low voltage lines of the power company.

- The VMS board requires large power consumption and it is difficult to supply power from solar cell panel. Also in case of applying the solar power supply system, battery with huge capacity will be required to compensate power supply for non-sunshine period. It causes high initial costs.
- In Hyderabad Metropolitan Area, there often observes commercial power interruptions. Thus, backup power supply system must be considered to compensate commercial power supply interruptions. Generally, three types of backup power supply system can be applicable; 1) UPS (Uninterruptible Power Supply), 2) DEG (Diesel Engine Generator) and 3) UPS + DEG combined. Among them, however, 2) DEG is not suitable for backup power supply for the roadside equipment since DEG system requires starting-up time and the roadside equipment does not allow such short time power cut. Hence, UPS or UPS+DEG combined are acceptable.
- Utilization of UPS and DEG combined system to the roadside equipment is not recommendable because DEG cannot be mounted in the cabinet of roadside equipment and maintenance for fuel supply will be required.

(b) Estimated Power Consumption

The power demand load of meteorological roadside equipment is estimated as total of 3.0 KVA as shown in table below.

Table 157 Estimated Power Demand Load of VMS Board

Power Demand / Equipment	Voltages	Unit Power Demand (kVA)	Number of Unit	Estimated Power Demand (kVA)	Remarks
VMS board	1φ – 2W – 220V	2.0	1	2.0	
VMS LED Panel	-	Including above	1	Including above	
VMS Control Unit	1φ – 2W – 220V	1.0	1	1.0	
Total				3.0	

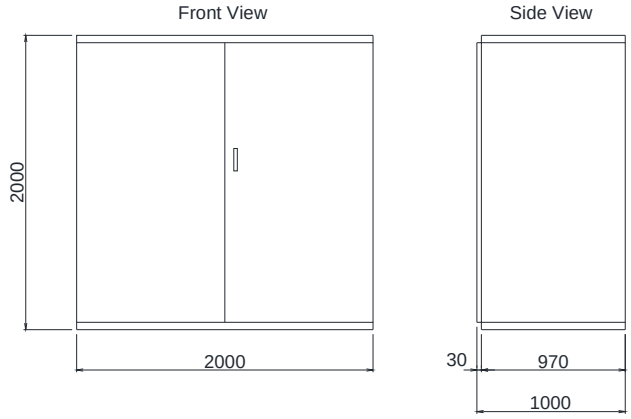
Source: Prepared by JICA Study Team

Unit power demand for VMS board is an average power demand that only 35 % of the pixels are on.

(c) UPS

According to the guidelines of variable message signs (IRC:SP:85-2010) published by Indian Road Congress, inverter of adequate power capacity must have six (6) hours backup in case of power failure. However, the Consultant supposes that 6 hours backup power supply for VMS is too long and proposes to minimize the compensation time with following reason.

Power consumption of VMS is 3.0 KVA or more and quite huge comparing with other roadside equipment. From the Consultant's rough calculation of UPS and battery, expected size and weight of UPS for 3 hours backup is of 2,000mm width x 1,000mm depth x 2,000mm height and 1.2 tons as shown in figure below. It seems not feasible for keeping enough space at median or roadside on the road.



Source: Prepared by JICA Study Team

Figure 260 Reference Dimension of UPS for VMS

Thus, the Consultant proposes to provide UPS with 10 minutes backup capacity for VMS to shut down the roadside equipment safely in case power interruption occurs.

Hence, the required capacity of battery is estimated as

C = K x I / L
= 0.78 x (3000 x 0.9 / 0.85 /187.2) / 0.8
= 16.5 [Ah]

The capacity of UPS battery must be recalculated by the contractors in accordance with power requirements of their equipment.

10-2-7 ITS Centre System

(1) System Objectives

This section states ITSC System to be installed as a central monitoring and control system of Hyderabad City ITS. Hyderabad City ITS is composed of several Sub-Systems. ITSC System is one of Sub-System, and it manages the total system with the exchange of data between Sub-systems in order to achieve the overall objectives of the Hyderabad City ITS as described below;

- To collect all real time data related to road and traffic conditions, incidents, weather conditions and any other necessary data;
- To process and store the collected data for effective road planning, operation and maintenance;
- To disseminate the processed information to road users in order to take notice of road conditions and/or detour drivers' from travelling to the congested area or the hazardous area;
- To monitor the collected and processed information on real-time basis
- To provide the information to the road planning agency, road administrator and traffic police personal in the ITSC;
- To manage the Hyderabad City ITS operation in the ITSC.

(2) ITS Centre System Requirements

The system requirements of the ITS centre system are as follows.

- The ITS centre system shall collect all necessary information from following each

sub-system component on real-time basis.

- ✓ Automatic Traffic Counters-cum-Classifier (ATCC) System
- ✓ Probe Car System
- ✓ Closed Circuit Television (CCTV) Camera System
- ✓ Meteorological Monitoring (MET) System
- ✓ Pollution Monitoring (POL) System
- ✓ Flood Monitoring (FLD) System
- ✓ Variable Message Sign (VMS) System

- The system shall automatically process the collected data into usable road traffic information including traffic flow data, weather alerting data, etc. Also, the system must have capability of event data management such as traffic accident.
- The processed data shall be stored into database of the system for necessary period so that each data can be utilized for future statistical analysis.
- The system shall have function to provide the information collected and processed through VMS system to the road users, and internet, e-mail and/or SMS to the public.
- The collected and processed data shall be monitored on operator console and video wall in the ITSC.
- The system shall receive the data from relevant stakeholders such as TCC of ORR, APSDPS for meteorological data and APSRTC for probe data.
- The system shall have functions to monitor and manage the operational status of all ITS Sub-System.
- The system shall have a reporting function in which various reports can be printed.
- The display and reporting function shall be scalable with the capability to include a unified view across concerned transportation agencies – HMDA, Traffic Police, Traffic Control Centre of ORR, Control Centre of APSRTC, road planning agencies and GHMC. The purpose is to enable real-time communication and collaboration necessary to coordinate actions and resolve issues in an efficient manner
- The system shall have built-in fault tolerance and high availability and operate continuously 24 hours a day and 7days a week with a redundant system configuration.

(3) ITS Centre System Configuration

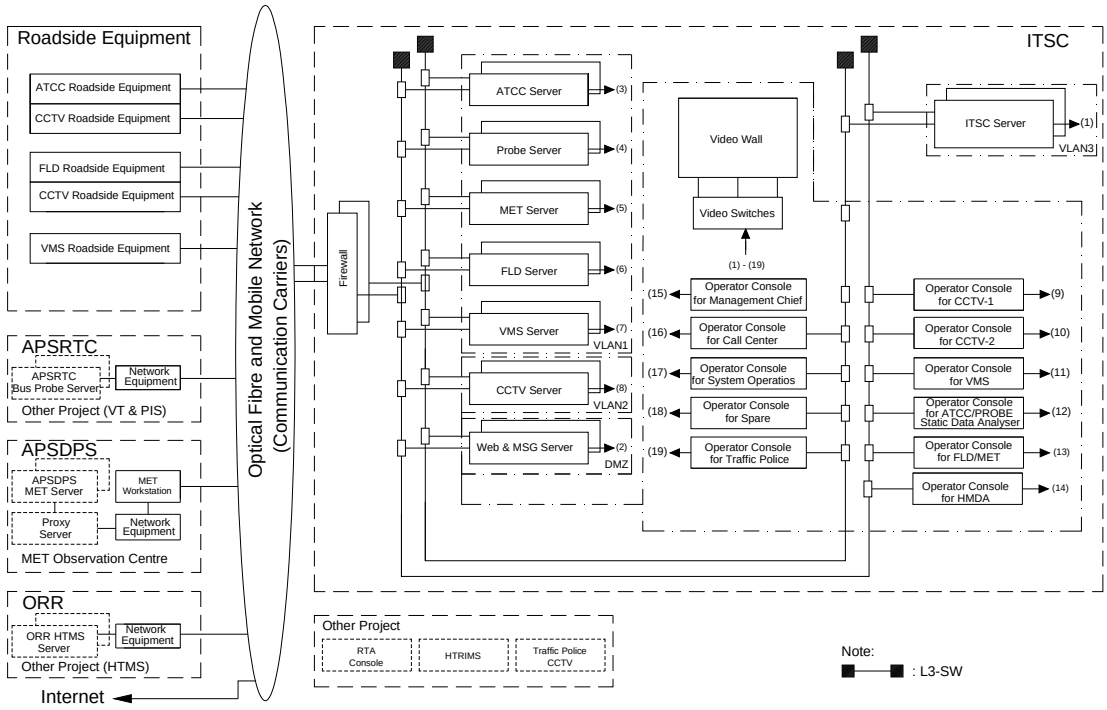
The ITSC System in the ITSC shall consist of the following component;

- ITSC Server,
- WEB & MSG Server
- Video Wall with Video Switches,
- Operator Consoles stated below:
  - ✓ Operator Console for Traffic Management Chief
  - ✓ Operator Consoles for Call Centre
  - ✓ Operator Console for Video Wall and CCTV
  - ✓ Operator Console for CCTV
  - ✓ Operator Console for VMS
  - ✓ Operator Console for ATCC / Probe / Static Data Analyzer
  - ✓ Operator Console for System operation
  - ✓ Operator Console for FLD and MET

- ✓ Operator Console for Traffic Police
- ✓ Operator Console for HMDA
- ✓ Operator Console for backup operator
- ✓ Operator Console for Spare

- Internet Connection with sufficient bandwidth
- Printers
- Firewall and network Equipment
- Power Supply Equipment

Proposed ITS Centre system would be configured in the Figure below.



Source: Prepared by JICA Study Team

Figure 261 Proposed ITC Centre System Configuration

The ITS centre server and Web & MSG server will consist of an operating server and a standby server. In the event of a failure of the operating server, the standby server shall take over the operation automatically and there shall be no loss of data and abnormal operation of the system.

The ITS centre system will consist of a centre server and several operator consoles as illustrated in figure above. Each operator console will have its own functions and perform the tasks assigned to it under normal conditions. In the event of unavailability of an operator console due to malfunction or maintenance, however, it shall be possible to use any other operator consoles as substitution to perform the same functions. Access privilege control shall be applied in the same manner when the operator console is being replaced.

The assignment of the functions to each operator console is as shown table below.

Table 158 Functions of Each Operator Console

Source: Prepared by JICA Study Team

No.	Position	Main functions
1	Traffic Management Chief	• Responsible for overall management of ITSC • Monitoring all contents of sub-systems • Instruct operators whenever it require
2	VMS Operator (VMS)	• Leader of each shift • Create and editing of VMS message to be displayed • Select the information as per priority and display selected VMS • Input and record of events
3	Call Center Operator	• Receiving phone call information/data from public and other agencies • Record the call information/data • Providing necessary information/data to related agencies if necessary • Collect and reply any necessary information/data to answer enquiry for caller from public and other agencies • Collect necessary information from related agencies such as VIP movement, work zone
4	CCTV Operator 1 (CCTV / Video Wall)	• Monitor the CCTV images • Utilize PTZ function and understand the situation whenever CCTV sends the serious incident image and inform Manager and VMS operator. • Manipulate Video Wall console if necessary
5	CCTV Operator 2	• Monitor the CCTV images which cannot be covered by operator 1 • Utilize PTZ function and understand the situation whenever CCTV sends the serious incident image and inform Manager and VMS operator.
6	Flood Operator (Flood / MET)	• When alarm issues, inform CCTV operator to check the water logging spot. • When alarm issues since MET data send by APSDPS beyond the threshold, operator inform the Manager and VMS operator
7	ATCC Operator (ATCC / Probe / Static Data Analyzer)	• Collect the information regarding traffic speed and congestion from ATCC • Whenever heavy traffic congestion is found, find the time to destination. • Analyze the traffic data and make a report periodically and whenever manager request.
8	System Operator	• Monitor functionality of FLD, ATCC, MET and Probe equipment/communication • Maintain all network system in ITSC including Security & Incident Management Service • Up-gradation of systems
9	Back-up Operator	• Back-up staff for the above operators except system operator
10	Others	• Necessary number of administrator staff, security guard, cleaning

		helper, peon and other staff

(4) ITS Centre System Function

- ITSC Server
- Data collection from and exchange with all Sub-Systems
- Traffic data analysis
- Event data management
- Database management
- Sub-System management
- Network management and control
- Display and monitoring
- Parameter monitoring and management
- Data collection from stakeholders
- Information dissemination through VMS System
- Human-machine interface
- Report printing
- WEB & MSG Server
- Information dissemination
- Report printing

(5) Data collection

The ITSC System shall collect the road and traffic conditions, incidents, weather conditions and any other data from the respective Sub-System in specified periods as listed below..

Table 159 Data Collecting Functions

Sub-system	Types of Data	Interval	Remarks
ATCC System	• Traffic volume	5 minutes	• Data collection at every 1 minute interval for spot (multiple lanes) and sectional (single lane and multiple lanes) data
	• Vehicle classification (at least large and small sized vehicle)		
	• Time occupancy rate		
	• Vehicle average speed		
	• "n" minutes sectional average speed		• Default "n" = 5 minutes
	• Traffic congestion analysis results		
	• Equipment operational status		
Probe Car System	• 1 minute sectional average speed	5 minutes	
	• "n" minutes sectional average speed		• Default "n" = 5 minutes
	• Traffic congestion analysis results		
	• Travelling time in each link		
	• Travelling time in particular section		

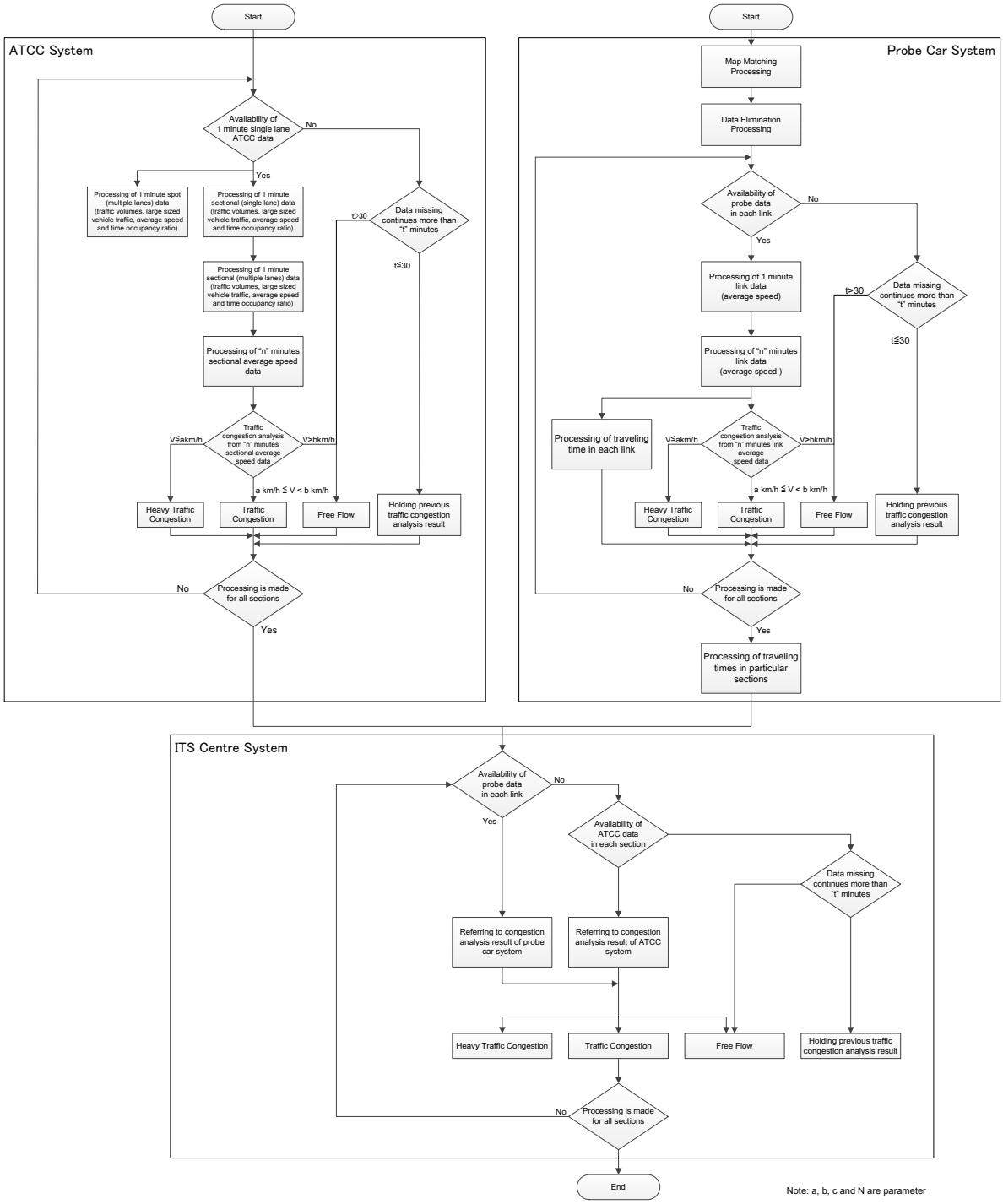
CCTV Camera System	• CCTV still image	On real-time	
	• Equipment operational status		
MET System	• Instantaneous value of ambient temperature	5 minute	
	• Hourly cumulative value of rainfall in last hour		
	• Instantaneous rainfall detection		
	• Maximum value of wind speed		
	• Wind direction		
FLD System	• Flood warning level I: 100 mm	1 minute	
	• Flood warning level II: 200 mm		
	• Flood warning level III: 500 mm		
	• Equipment operational status		
VMS System	• Manual input operation record	On real-time	
	• Current message showing on each VMS		
	• Equipment operational status		

Source: Prepared by JICA Study Team

The ITS centre system will gather the road, traffic and weather data and equipment operational status from sub-system terminal equipment and their processed data via servers provided in each sub-system component. It will also receive the still image data taken by CCTV camera.

(6) Traffic Data Analysis

The traffic data analysis is the process of analysing the traffic data collected from ATCC System and Probe Car System to calculate the average traffic speed and travel time, judge congestion section and aggregate traffic data. The traffic data is collected from Roadside Equipment.



Source: Prepared by JICA Study Team

Figure 262 Traffic Analysis Flow and Algorithm

ATCC shall be installed in the middle of each section of the Principal Roads such as IRR, National Highway within HMA (NH-7, NH-9 and NH-202), and State Highways within HMA (SH-1, SH-2, SH-4, SH-5 and SH-6).

Probe data is collected by the Andhra Pradesh Public Transport Corporation (hereinafter referred as APSRTC) from the vehicle tracking devices i.e. GPS devices mounted on their city buses. The probe data is transmitted from APSRTC data centre to the ITSC.

The traffic data analysis shall be calculated in real time for both the ATCC System and the

Probe Car System separately. ATCC System data shall be used as supplement data to Probe Car System's vehicle tracking data while calculating the congestion section analysis in the ITSC Server.

The above flow diagram describes the process of traffic data analysis for ATCC System and Probe Car System separately. The processed probe car data shall be prioritized over the processed ATCC System data while calculating the congestion section analysis.

(7) Event data management

The ITSC System shall have event data management functions for the events that are automatically generated in each Sub-System component such as water logging, traffic congestion, and incidents or traffic regulations that may be reported by road administrators, traffic police and road users thorough verbal communication and manual input in to the system. The event data management functions shall be implemented with manual data input, editing, monitoring and printing, and these shall be easy to understand and easy to use.

The event data management system shall have the ability to collect data from multiple device types through a range of generic data collectors (probes) including SOA, SNMP, log, and socket. The probe should acquire data from any stable data source, including devices, databases, and log files.

The system shall handle the following event data.

Table 160 Proposed Event Data Management Items

Event	Types of Data	Expected Source	Remarks
Incident	Fire Accident	Call Centre, Traffic Police, Fire Station, CCTV	Manual
	Traffic Accident	Call Centre, Traffic Police, Fire Station, CCTV	Manual
	Obstacle	Call Centre, Traffic Police, CCTV	Manual
	Broken-down Vehicle	Call Centre, Traffic Police, CCTV	Manual
	Natural Disaster	Call Centre, Traffic Police, CCTV	Manual
	Demonstration	Call Centre, Traffic Police, CCTV	Manual
	Festival	Call Centre	Manual
Traffic Congestion	Heavy Congestion	Sub-System	Automatic
	Congestion	Sub-System	Automatic
Adverse Weather	Heavy Rain	Sub-System	Automatic
	Strong Wind	Sub-System	Automatic
	Water Logging	Sub-System	Automatic
Construction Work	Construction Work	Road Operator	Manual
Traffic Regulation	Closure	Traffic Police	Manual
	Lane Closure	Traffic Police	Manual
	Speed Limitation	Traffic Police	Manual

Source: Prepared by JICA Study Team

(8) Database management

The ITSC Server shall store the processed data in an industry-standard SQL based Database Management System (DBMS) for future statistical usage in road planning. The system shall have one centralized database for managing the entire Hyderabad City ITS. Parameters such as type, quantity and time period of data to be stored in the database shall be configurable.

The Contractor shall provide the latest version of SQL based Relational Database Management System (RDBMS) such as Oracle, SQL Server, DB2 and/or equivalent as part of the Contract.

Table 161 Proposed Database Items and Storage Periods

Sub-System	Storage Data		Type
ATCC System	Equipment operational status		Raw data
	1 minute spot multiple lanes) data	Traffic volume by vehicle classification	Processed data
		Large-sized vehicle traffic	
		Time occupancy rate	
		Vehicle average speed	
	1 minute sectional (single lane) data	Traffic volume by vehicle classification	Processed data
		Large-sized vehicle traffic	
		Time occupancy rate	
		Vehicle average speed	
	1 minute sectional (multiple lanes) data	Traffic volume by vehicle classification	Processed data
		Large-sized vehicle traffic	
		Time occupancy rate	
		Vehicle average speed	
	"n" minutes sectional average speed		Processed data
	Traffic congestion analysis results with Parameters		Processed data
Probe Car System			
	1 minute sectional (multiple lanes) data	Vehicle average speed	Processed data
	"n" minutes sectional average speed		Processed data
	Traffic congestion analysis results with Parameters		Processed data
	Travelling time in each link		Processed data
	Travelling time in particular section with location parameters		Processed data
CCTV Camera System	**CCTV** still image		Raw data
	Equipment operational status		Raw data
MET System	Instantaneous temperature (5minutes)		Processed data
	Moving total precipitation for previous 1hour		Processed data
	Total continuous precipitation		Processed data

	Instantaneous rainfall detection (5minutes)		Processed data
	Maximum value of wind velocity for previous 5 minute		Processed data
	Direction at maximum wind during previous 5 minute		Processed data
	Heavy rain analysis results with parameters		Processed data
	Strong wind analysis results with parameters		Processed data
FLD System	Flood warning level I: 100 mm		Raw data
	Flood warning level II: 200 mm		Raw data
	Flood warning level III: 500 mm		Raw data
	Equipment operational status		Raw data
VMS System	Recommended message automatically generated against event		Raw data
	Manual input operation record		Raw data
	Equipment operational status		Raw data
	Current message indicating on each **VMS**		Processed data
ITSC System	Input event data	Incident	Raw data
		Construction work	
		Traffic regulation	
	Received data from **ORR** project	Traffic congestion	Raw data
		meteorological data	
		Incident	
		Construction work	
		Traffic regulation	
	Equipment operational status		Raw data
	Traffic congestion analysis results in the system		Processed data
WEB & MSG Server	E-mail and SMS subscriber information		Raw data
	Access history of Web		Processed data
	Transmitting history of e-mail and SMS		Processed data

Source: Prepared by JICA Study Team

(9) Sub-system management

The ITSC System shall have a system management function to monitor the operational condition of Roadside Equipment and ITSC System Equipment. The system management function shall monitor the operation status of all the Sub-System components.

This function shall consolidate the status monitoring of each Sub-System component, present the status to operators and record the system operation. When any abnormality or malfunction is detected, the ITSC Server shall issue an alarm providing the type and location of the failure so that remedial action can be taken and shall store the record in a log.

(10) Network management and control

The network management function shall be provided at the **ITSC System** and the function shall continuously monitor the Layer 2 switch and Layer 3 switch using Simple Network Management Protocol (SNMP). In case of identification of a malfunction, network management system shall issue an alarm to the **Operator Console** and shall store the record in a log.

(11) Display and monitoring

The ITSC Server shall have display and monitoring functions of schematic road map in the HMA (HMA) with various kinds of static and dynamic information. This helps the system operator understand the current condition through display devices such as Operator Consoles and Video Wall and take necessary action.

The information display shall be schematic map based interface and as well in the form of a list.

A schematic map based display interface shall display a consolidated view of the city traffic condition including the traffic status, Roadside Equipment, events and weather conditions, etc. It shall provide the ability to monitor and manage services and respond to events. The map based interface shall be an easy-to-use interface that is designed for multiple types of users, such as operators, managers and other authorized users of the system.

The schematic map based display shall cover the entire HMA and be able to enlarge individual locations on the map when selected. The enlarged view shall be able to display the details for each selected location. The details displayed shall cover the contents as described in the below table but not limited to.

The information to be displayed on the schematic map, the enlarged view and in the list shall include the following but not limited to.

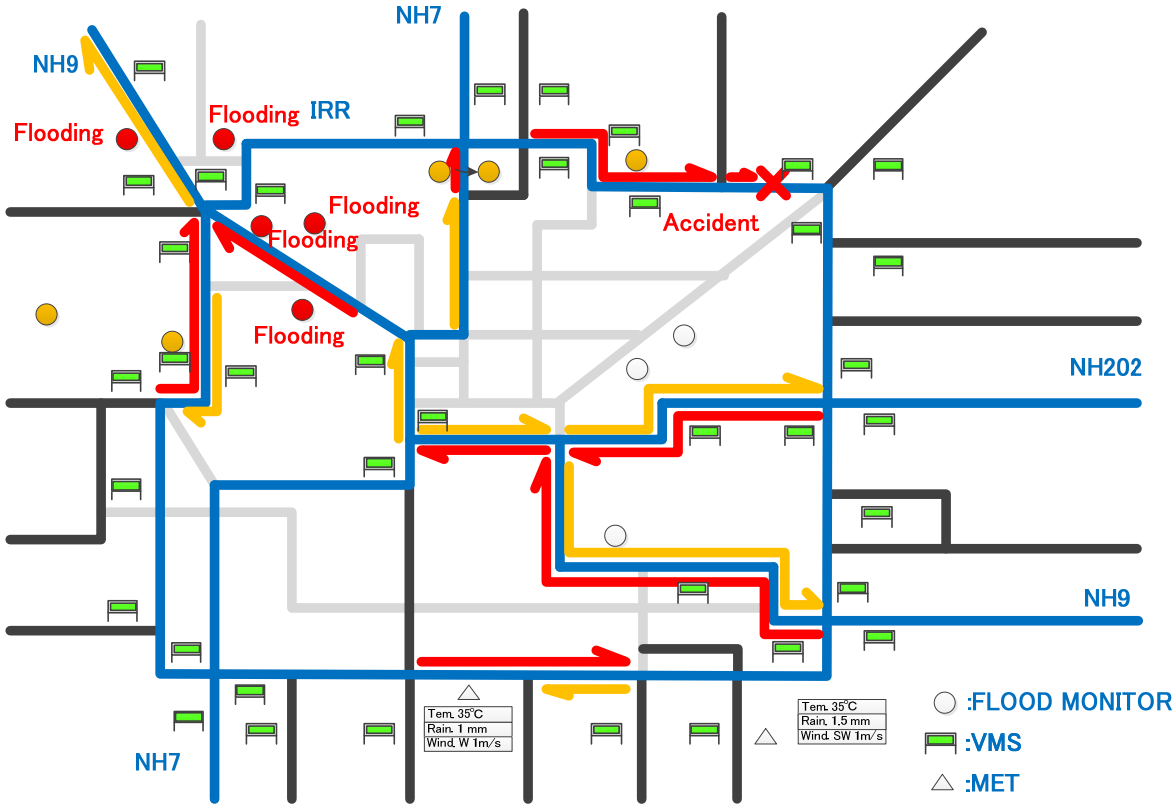
Table 162 Proposed Display Contents

Item	Contents on Schematic Map based Interface	Contents as a List
Equipment location and status	• Location and status of ATCC Roadside Equipment • Location and status of CCTV camera • Location and status of FLD Roadside Equipment • Location of VMS • Status of VMS (working or not working) • Status of the Message (Message Displayed or not) • Message being displayed	• Location and status of ATCC Roadside Equipment • Location and status of CCTV camera • Location and status of FLD Roadside Equipment • Location of VMS • Status of VMS (working or not working) • Status of the Message (Message Displayed or not) • Message being displayed
Road, traffic and weather condition	• Traffic congestion • Weather condition (rain, wind velocity, wind direction, precipitation) • Waterlogged condition • Incident (traffic accident, broken-down vehicle, left obstacle, natural disaster) • Regulation (lane closure, road closure)	• List of traffic congested road • List of adverse weather area • List of waterlogged area • List of incident • List of regulation • Event List for VMS operation
CCTV video	• Static and video image from the	•

image	CCTV camera selected • Static and video image from the video recorder selected	
Event management	• Unplanned event and planned event	• Unplanned event and planned event • Screen form to edit all the parameters
HTMS data monitoring	• Meteorology data • Congestion data	• Events list for VMS operation
Server status of **Sub-System**	•	• Status of server of Sub-System (normal / error) in the form of list
Parameter setting	• •	• Parameters in the form of list • Screen form to edit all the parameters
Operation log	•	• List of Roadside Equipment - those in operation and those not in operation • Error record
Date and Time	• Current date and time	• Current date and time

Source: Prepared by JICA Study Team

Figure below shows the example of schematic road map within the IRR.



Source: Prepared by JICA Study Team

Figure 263 Display Image of Schematic Road Map in IRR

(12) Parameter monitoring and management

Some of Sub-System components have warning system to detect the traffic congestion or adverse weather condition based on the pre-defined threshold. The ITSC System shall monitor and manage such parameters. The parameters to be monitored and that are changeable in the ITSC

System shall include at least followings;

- ATCC System: Two parameters of average speed recognition for “heavy congestion” and “congestion”;
- Probe Car System: Two parameters of average speed judging for “heavy congestion” and “congestion”, and locations for calculating the travel time in particular section;
- MET System: Parameters detecting heavy rain, strong wind.

(13) Data Collection from Stakeholders

Hyderabad City ITS shall collect data from HTMS of ORR, APSDPS and the APSRTC The data collection from HTMS of ORR is at five minute interval to collect the following data;

- Traffic Data (traffic congestion and travelling speed in each section)
- Weather and waterlogged conditions (rain, wind velocity, wind direction, precipitation, visibility, waterlogged)
- Event and incident information (traffic accident, broken-down vehicle, left obstacle, natural disaster)
- Regulation (lane closure, road or section closure)
- Bus probe data collection from APSRTC is as specified in the Probe Car System.
- Meteorological data collection from the APSDPS is as specified in the MET Sub-System.

The ITSC shall interface with various data collection Equipment using the Institute of Transportation Engineers (ITE) Traffic Management Data Dictionary (TMDD) Version 3.0 & above standard.

The data collection mechanism shall be robust, reliable and ensure the following objectives but not limited to:

- Shall provide support for industry standard Secure Sockets Layer (SSL)
- Shall support data encryption and compression.
- Shall be capable of handling failures without losing mission-critical information

(14) Information dissemination

The road, traffic and weather condition information collected and processed in the ITSC will be provided to the road users through variable message sign, Internet, e-mail or SMS in the Project.

(a) Information dissemination through VMS

The road, traffic and weather condition information collected and processed in the **ITSC** shall be provided to the road users through **VMS** under **the Contract**.

VMS System provides road users with processed road, traffic and weather information through variable message sign boards. The **VMS** boards shall be controlled by console operator of **VMS Sub-System**. The **ITSC System** shall provide automatic message selection function based on the priority or severity of the events and coefficients that represent the importance of event. This function shall include;

- Automatic generation of the recommended message to be displayed on the **VMS** when an event occurs
- Zoning functionality that selects particular **VMS** boards for showing message when an event occurs at a particular location

- Information screening functionality that selects the prior message to be displayed on the **VMS** when several events occur at the same time.

Table 163 Proposed Priority Schedule in VMS Message Selection

Event Type	Event
Incident	Fire Accident
	Traffic Accident
	Obstacle
	Broken-down Vehicle
	Natural Disaster
	Demonstration
	Festival
Traffic Congestion	Heavy Congestion
	Congestion
	Travelling time
Adverse Weather	Heavy Rain
	Strong Wind
	Water Logging
Construction Work	Construction Work
Traffic Regulation	Closure
	Lane Closure
	Speed Limitation
Other events input by operator	Other Events

Source: Prepared by JICA Study Team

(b) Information dissemination through Internet and e-mail/SMS

Information dissemination system through Internet and e-mail/SMS will consist of a Web & MSG server and a firewall and an application software. The basic information to be provided to the road users through those media shall include but not limited to the following:

1) Internet

- Traffic information on map
- Weather and waterlogged conditions on map
- Event and incident information on map
- Traffic regulation on map
- Overall schematic map indicating all information above

2) e-mail/SMS

- Weather and waterlogged conditions in text
- Event and incident in text
- Traffic regulation in text

The system will have subscriber management function to register and deregister the e-mail and SMS users. Firewall shall be provided to protect the Internet server against the possible attack.

(15) Human-machine interface

Two kinds of display devices shall be provided as human-machine interface; Operator Console's display monitor and Video Wall.

The Video Wall shall have multiple screen display function where each display area shall be capable of displaying images from different sources. The Video Wall shall be capable of displaying image from any CCTV Camera System and any Operator Console. The operation of Video Wall, such as selecting Video Wall layout pattern and assigning screen source to display area, shall be conducted from Operator Console of Video Wall.

(16) System clock

The ITS centre system shall have a real-time clock that shall be used for the timing of monitoring, data transfer, device control, reports, and print-outs. The clock shall have an automatic adjustment function using GPS, Internet, mobile phone or any other references and the clock shall remain accurate within one second all the time. The real-time clock shall have an internal battery and shall maintain the correct time for at least 48 hours. All sub-systems, equipment and devices comprising the city intelligent transport system shall synchronize with the real-time clock.

(17) Operating log

All operations by the system operator through the operator console shall be recorded as operation log with the operator's ID and time. All malfunctions of the equipment comprising the system shall be recorded with time of occurrence, time of recovery and type of error.

(18) Report function

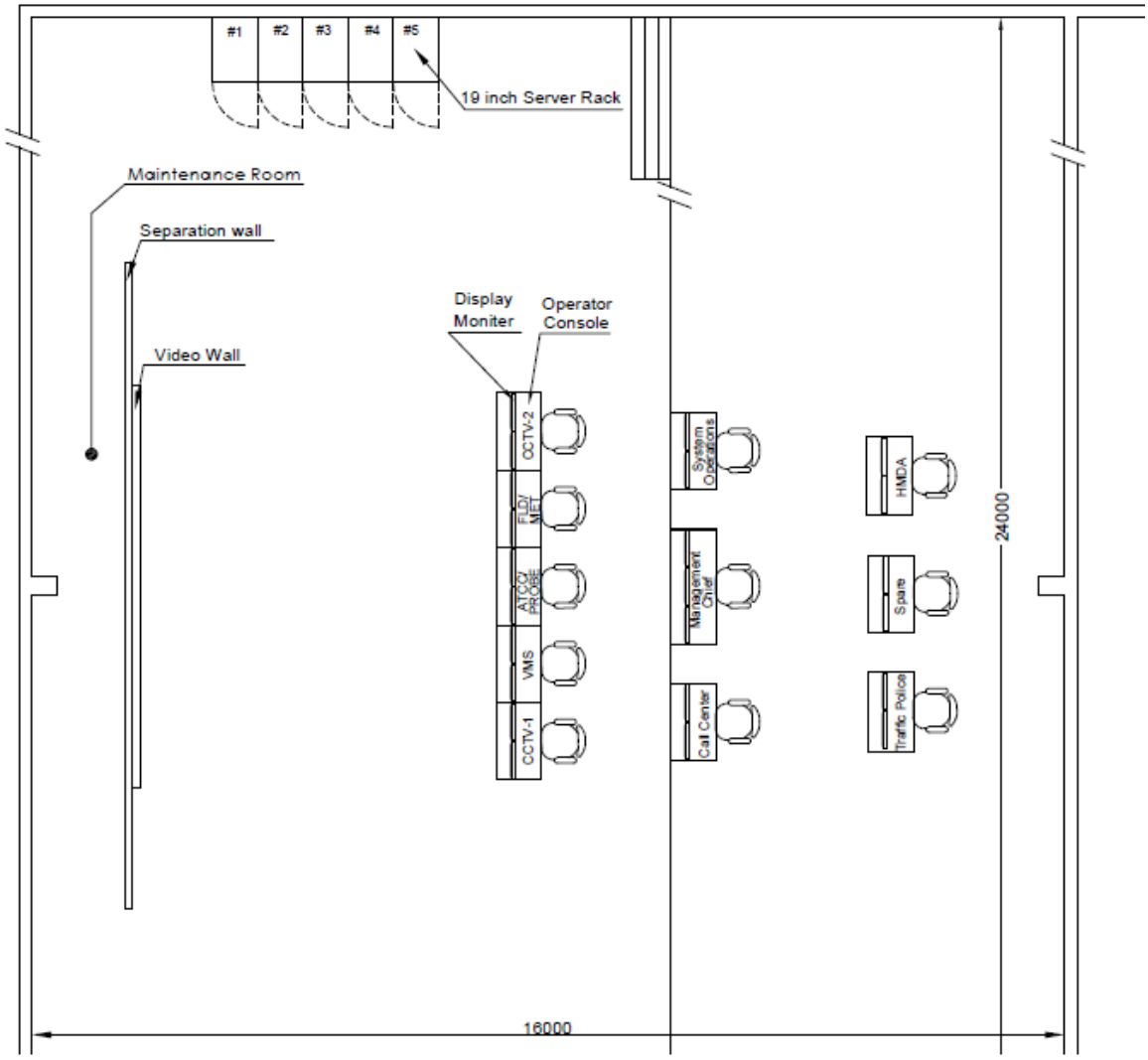
The ITS centre system shall have a reporting function in which various daily, monthly and annual reports can be prepared with printer. The types of report shall include but not limited to the followings:

- Traffic conditions and traffic analysis results
- Weather conditions (MET)
- Air pollution condition
- Waterlogged condition
- Variable message sign operation
- Equipment malfunction and recovery

The report will be produced in two modes. In automatic mode, reports will be printed automatically at the timing specified for each report. In manual mode, report is printed when the operator requests it. All reports will be in English.

(19) ITS Centre Layout Plan

It has been committed that the ITS Centre will be established in the building owned by **HGCL** at Nanakramaguda. The **ITSC** will be accommodated on the first floor. Traffic Control Centre of Outer Ring Road project will be accommodated on the second floor of the building. The proposed layout plan of ITS centre system equipment is illustrated as figure below.



Source: Prepared by JICA Study Team

Figure 264 Proposed ITS Centre Layout Plan

(20) Power Supply System

Power supply system in the ITS Centre is proposed in accordance with following policies.

- Existing AC commercial power fed to the building of Hyderabad Traffic Police will be used as power source in normal condition.
- Diesel Engine Generator (DEG) will be used as backup power supply system for long time power failure.
- To compensate short time power interruption, UPS will be provided to continuously supply power during starting-up time of the DEG.

Since the DEG with a capacity of 40kVA will be provided by the HTRIMS project and it seems no enough space to install other DEG in the yard of traffic police, JICA Study Team recommends shared use of DEG provided by the HTRIMS project. The power supply facilities other than DEG such as power distribution board and UPS will be provided in this Project. Table below shows estimated power demand load of DEG for this project.

Table 164 Estimated Power Demand Load of ITS Centre System

Power Demand Equipment	Voltages	Unit Power Demand (kVA)	Number of Unit	Estimated Power Demand (kVA)	DEG	Remarks
ITSCC Server	1φ – 2W – 220V	0.9	2	1.8	X	
Storage Server	1φ – 2W – 220V	0.9	2	1.8	X	
ATCC Server	1φ – 2W – 220V	0.9	2	1.8	X	
Probe Receiving Server	1φ – 2W – 220V	0.9	2	1.8	X	
MET Server	1φ – 2W – 220V	0.9	2	1.8	X	
POL Server	1φ – 2W – 220V	0.9	2	1.8	X	
FMS Server	1φ – 2W – 220V	0.9	2	1.8	X	
CCTV Server	1φ – 2W – 220V	0.9	2	1.8	X	
VMS Server	1φ – 2W – 220V	0.9	2	1.8	X	
Web & SMS Server	1φ – 2W – 220V	0.9	2	1.8	X	
Firewall	1φ – 2W – 220V	0.45	2	0.9	X	
L3SW	1φ – 2W – 220V	0.3	2	0.6	X	
Network Equipment	1φ – 2W – 220V	2.4	1	2.4	X	
Large Size Monitor (LCD)	1φ – 2W – 220V	0.36	6	2.16		
CCTV Console	1φ – 2W – 220V	0.5	1	0.5	X	
VMS Console	1φ – 2W – 220V	0.5	1	0.5	X	
Data Input Console	1φ – 2W – 220V	0.5	1	0.5	X	
Manager Console	1φ – 2W – 220V	0.5	1	0.5	X	
Large Size Monitor Console	1φ – 2W – 220V	0.5	1	0.5	X	
System Status Monitoring Console	1φ – 2W – 220V	0.5	1	0.5	X	
Offline Working Console	1φ – 2W – 220V	0.5	1	0.5	X	
Call Centre Console	1φ – 2W – 220V	0.5	3	1.5		
Total				29.06		

Source: Prepared by JICA Study Team

The maximum demand load of ITS Centre system is estimated as total of 29.06 KVA as shown in table below.

11 Operation and Maintenance for Pilot Project

The requirement of operation and maintenance for pilot project was studied and prepared in the form of specification for operation and maintenance as part of tender document, 'The Employer's Requirements Part C: Operation & Maintenance Specifications'. The following clauses describe the requirements for operation and maintenance for pilot project.

The details are provided in the tender document, 'The Employer's Requirements Part C: Operation & Maintenance Specifications'.

11-1 Purpose of Operation and Maintenance

The purpose of operation and maintenance for pilot project, referred as 'the City ITS', is to operate and maintain the City ITS and related facilities in the intended manner. That is to collectthe traffic data on real-time bases, process, analyse and disseminate information to road users. The purpose also includes assuring continuous operation for 24 hours a day and 7 days a year without interruption, taking necessary measures in a timely manner and sustaining the life of the system and equipment by meating the prescribed service level.

11-2 Scope of Works

The works for operation and maintenance prescribed in the tender document, 'The Employer's Requirements Part C: Operation & Maintenance Specifications', are listed below:

(1) Monitoring of traffic on the Hyderabad metropolitan road network through CCTV and ATCC system

(2) Monitoring of weather condition on road using Flood System and Meteorological System

(3) Detection of incidents

(4) Information dissemination through VMS and Internet

(5) Monitoring and maintenance of equipment operation

(6) Identification of the roles of operation and maintenance staff

(7) Information exchange with other organizations concerned

(8) Keeping operation and maintenance log

11-3 Organisation Setup

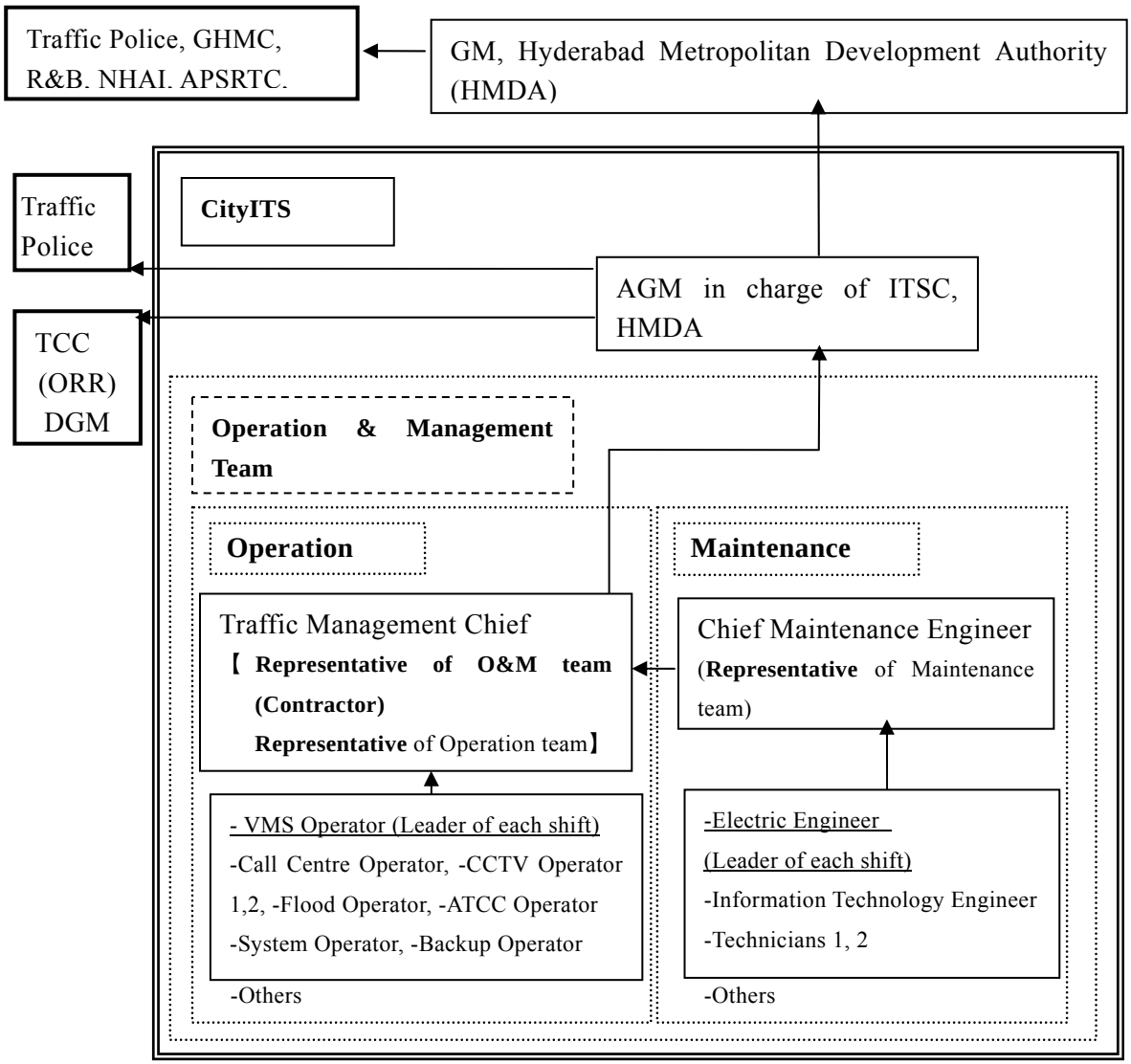
In order to achieve the objective of the City ITS, proper organisation needs to be set up. Based on the discussion with HMDA, the organisation is proposed as shown in the figure below. The figure shows the proposed organisation structure of the City ITS for the pilot project. The arrows in the figure indicate the information flow.

The basic concepts are:

- The operation and maintenance works are carried out by contractor under General Manager (GM) of HMDA.
- The operation and maintenance team for the City ITS is formulated by the members of the contractor under GM of HMDA.
- GM of HMDA/HGCL, is responsible for traffic management in Hyderabad

metropolitan area and making related policy coordinating with the relevant organisations such as Traffic Police, GHMC, R&B, NHAI, APSRTC, APSDPS and others.

- Assistant General Manager (AGM) of HMDA is responsible for supervising the operation and maintenance team under GM of HMDA.
- AGM of HMDA directly communicates with the personnel of Traffic Police for taking necessary measures in timely manner for the events such as traffic accident.
- AGM of HMDA also directly communicates, as necessary, with Deputy General Manager (DGM) in the Traffic Contrl Centre (TCC) for Outer Ring Road (ORR).
- Traffic Management Chief, a member of the contractor, controls the operation team and is responsible for management of both operation and management teams. He is responsible for reporting on the events such as traffic accidents to AGM without delay.
- Chief Maintenance Engineer, a member of the contractor, controls the maintenance team under the Traffic Management Chief.



Source: Prepared by JICA Study Team

Figure 265 Organisation Setup

11-4 Coordination with Other Agencies

The operation of the City ITS needs be conducted with close coordination and cooperation with related agencies such as traffic police, ambulance, fire brigades, etc. The liaison and coordination with these agencies needs to be maintained all time.

11-5 Proposed Organisation and Workshifts

According to the policy of HMDA, the operation and maintenance works for the City ITS will be outsourced to the contractor which will be procured by competitive tendering. The contractor needs to establish the organisation consisting of traffic management chief, chief management engineer, operators, administrative and supporting staff, as detailed below.

(1) ITS Centre Operation Staff

Traffic Management Chief is responsible for traffic information management of the roads in Hyderabad metropolitan area on realtime basis. He supervises overall management of ITS Centre

The operation team consists of nine (9) persons, including one (1) Traffic Management Chief and eight (8) operators.

Traffic Management Chief supervises on daytime basis.

The work shift of other operators is divided into three (3) shifts. One party consists of 9 members (from No. 2 to No.9 in the table below) and total 4 parties including backup. VMS operator acts as a leader of each shift, in addition to his own duty for VMS.

In the night time shift, which is the time when Traffic Management Chief is off-duty in ITSC, VMS Operator acts as a substitute for Traffic Management Chief.

Table 165 Positions and Main Functions

No.	Designation	Tasks and Responsibility
1	Traffic Management Chief	Responsible for overall management of ITSC, representing operation and maintenance team Monitoring all contents of sub-systems Instructing operators whenever it is required
2	VMS Operator (VMS) / Shift Leader	Act as a leader of each shift of operation team Creating and editing VMS message to be displayed Selecting information as per priority and displaying the selected VMS Inputing and recording the events
3	CCTV Operator 1 (CCTV / Video Wall)	Monitoring CCTV images Manipulating PTZ functions and identifiying the traffic events such as accident by CCTV, and informing to Manager and VMS operator Manipulating Video Wall console if necessary
4	CCTV Operator 2	Monitoring CCTV images which are not covered by CCTV Operator 1 Manipulating PTZ functions and identifiying the traffic

		events such as accident by CCTV, and informing to Manager and VMS operator
5	Call Centre Operator	Receiving phone call information/data from public and other agencies Recording the call information/data Providing necessary information/data to related agencies if necessary Collecting and replying necessary information/data to answer enquiry for caller from public and other agencies Collecting necessary information from related agencies such as VIP movement, road works, etc.
6	Flood Operator (Flood / MET)	Informing CCTV Operator to check the water logging spot, when alarm is issued Informing Manager and VMS Operator, when alarm is issued on the occasion that MET data send by APSDPS exceeds the threshold
7	ATCC Operator (ATCC / Probe / Static Data Analyzer)	Collecting data on traffic speed and congestion from ATCC Identifying the time to destination whenever heavy traffic congestion is found Analyzing the traffic data and making reports periodically and whenever manager requests
8	System Operator	Monitoring functions of FLD, ATCC, MET and Probe equipment and communication Maintaining all network systems in ITSC including security and incident management service Upgrading systems
9	Backup Operator	Backup staff for the above operators except system operator
10	Others	Administration, Security, Cleaning, and Others (Necessary number as required for above)

(2) Maintenance Staff

Necessary number of maintenance staff needs to be arranged to undertake the maintenance work in shift on a 24/7 basis. The team shall consist of the number of persons of suitable expertise. Under normal conditions, they engage in the preventive maintenance work. In the event of malfunction or damage to the equipment or operational problem of server system and network, the team is dispatched to the site immediately to attend to the incident.

Chief Maintenance Engineer supervises on daytime basis.

The work shift of other engineers is divided into three (3) shifts. One party consists of 4 members (from No. 2 to No.4 in the table below) and total 4 parties including backup.

In the night time shift, which is the time when Chief Maintenance Engineer is off-duty in ITSC, Electric Engineer acts as a substitute for Chief Maintenance Engineer.

Table 166 Designation and Responsibility

No	Designation	Task and Responsibility
1.	Chief Maintenance Engineer	• Responsible for overall maintenance of City ITS
2.	Electric Engineer	• -Act as a leader of each shift of maintenance team • -Responsible for maintenance of all equipment comprising the City ITS.
3.	Information Technology Engineer	• Responsible for maintenance of all network, software and database used for the City ITS.
4.	Two (2) numbers of Technicians	• Technical works for the above engineers
5.	Others	• Administration, Security, Cleaning, and Others (Necessary number as required for above)

11-6 Change in Workshifts

(1) ITS Centre Operation Team

The shifting needs to be arranged in such a way that there is an overlapping period for at least 15 minutes. During the overlapping period, next operation team is briefed by the previous operation team as to the following:

- General traffic conditions
- Weather conditions
- Existing and cleared incidents and accident
- On-going and scheduled work and event in Hyderabad metropolitan area
- Messages being displayed on VMS
- Malfunctioned equipment the status of maintenance work
- Other issues that need attention of the operation team

The leader of each shift handovers all reports to the leader of the next shift. When the last shift of the day complets his duty, Traffic Management Chief checks all the reports and file them. He submits the reports to HMDA.

(2) Maintenance Team

The shifting needs to be arranged in such a way that there will be relevant overlapping period. During the overlapping period, next maintenance team is briefed by the previous maintenance team as to the following:

- General condition of equipment and software
- Malfunctioned equipment and the status of maintenance work
- On-going and scheduled maintenance work in Hyderabad metropolitan area
- Other issues that need attention of the maintenace team

The leader of each shift handovers all reports to the leader of the next shift. When the last shift of the day completes his duty, Chief Maintenance Engineer checks all the reports and file them. He submits the reports to HMDA.

11-7 City ITS Operation

The operation of the City ITS is executed in accordance with the procedures as set forth and instructions given by HMDA. The system needs to be in operation 24/7 without interruption.

The detail procedures for the following items are are specified in the tender document, 'The Employer's Requirements Part C: Operation & Maintenance Specifications', and Operation and Maintenance Mannual.

- ITS Center System
- Automatic Traffic Counter-cum-Classifier (ATCC) System
- Probe System
- CCTV System
- Flood (FLD) System
- Meteorological (MET) System
- Variable Message Sign
- Security and Incident Management

11-8 City ITS Maintenance

The maintenance of the City ITS is executed in accordance with the procedures as set forth and instructions given by HMDA. The system needs to be in operation 24/7 without interruption.

The detail procedures for the following items are are specified in the tender document, 'The Employer's Requirements Part C: Operation & Maintenance Specifications', and Operation and Maintenance Mannual.

- Preventive Maintenance
- Corrective Maintenance and Accident Repair
- Service Level Requirements

12 Contract Document

12-1 Preaparation of Contract Documents

The following documents along with Pre-Qualification document were prepared for tender of the ITS pilot project.

Table 167 Tender Documents

Volume	Description
I	Section I - Invitation for Tender (IFT)
	Section II - Instructions to Tenderers (ITT)
	Section III - Form of Tender
	Section IV - Pricing Documents
	Section V - Conditions of Contract Part I General Conditions (COC-GC)
	Section VI - Conditions of Contract Part II Conditions of Particular Applications (COC-PA)
II	Section VII - Employer's Requirements Part A General Technical Specification (GTS)
	Section VII - Employer's Requirements Part B Particular Technical Specification (PTS)
	Section VII- Employer's Requirements Part C Operation & Maintenance Specification (OMS).
III	Section VIII - Employer's Requirement - Drawings

12-1-1 Steps for Preparation of Tender Document

The following major steps were taken for preparing the tender documents:

- October in 2012:
  The first version of draft tender documents was submitted to HMDA/HGCL by JICA study team.
- November in 2012:
  Technical Advisory Committee (TAC) was formulated for the purpose of discussion/examination/provision of advices on the proposed ITS components for the pilot project.
- December in 2012 – May in 2013
  Technical Advisory Committee (TAC) meetings were held three times. The correspondence between the members of TAC and JICA study team through HMDA/HGCL were carried out.
- April in 2013
  The first set of comments was officially provided by HMDA/HGCL.
- July in 2013
  The second set of comments was officially provided by HMDA/HGCL.
- August in 2013
  It was agreed between HMDA/HGLC and JICA to include preparation of tender document for the portion of procurement of contractor for operation and maintenance.
- November in 2013
  The revised version of draft tender documents, including operation and maintenance and reflecting the comments provided from above period, was prepared and submitted

to HMDA/HGCL by JICA study team.

- January in 2014
  The further revised version of draft tender documents, together with draft final report, was prepared and submitted to HMDA/HGCL by JICA study team.

12-1-2 Basic Policy for Preparation of Tender Document

(1) Referred Tender Document and FIDIC

It was agreed between HMDA/HGCL and JICA and confirmed with JICA study team that the tender document for the pilot project of this project, the City ITS, would be prepared based on the tender document for Toll Management System (TMS) and Hihgway Traffic Management System (HTMS) of Outer Ring Road (ORR) because of the following reasons;

- The City ITS is closely linked to TMS and HTMS of ORR
- HGCL is the employer of the City ITS, TMS and HTMS of ORR
- Procurement of equipment of the City ITS, TMS and HTMS of ORR will be funded by the same JICA loan agreement

The tender document of TMS and HTMS of ORR was prepared based on FIDIC Orange Book which was published in 1995.

(2) Applied Desing Method

'Design Build' was applied to the design method for the pilot project, in consideration of the nature of ITS. Being different from the conventional project represented by civil construction, the system design and development constitute large proportion in the ITS project. The ITS project is generally characterised by i) information technology which rapidly advances on day-to-day basis, ii) many different methods to realise the required functions in terms of detail design.

In order for the employer, HMDA/HGCL, to avoid losing the opportunity to adopt the latest technology at the time of installation and to assure flexibility to adopt the most optimum method to realise the required functions, the consultant's design shall specify the required functions which need to be realised, by applying the method of the design build, instead of preparing the detailed design.

(3) Operation and Maintenance

Based on the request of HMDA/HGCL for inclusion of preparation of tender document for procurement of contractor for operation and maintenance, it was agreed between HMDA/HGCL and JICA and confirmed with JICA study team that the procurement of the contractor for operation and maintenance for a period of 5 years would be included in the same package of the City ITS. Thus the tender document of the City ITS was prepared including the portion of operatin and maintenance.

The cost for the equipment of the City ITS will be funded by JICA loan, 'Hyderabad Outer Ring Road Project (Phase 2), ID-P198'. The cost for the operation and maintenance for a period of 5 years will be funded by HGCL.

(4) Scope of Contract for Contractor

In regard of all above, the scope of contract for contractor of this project was set out as 'Design, Supply, Installation, Testing, Commissioning, Training, Warranty and Remedying Defects

of Equipments and Related Facilities of Hyderabad City Intelligent Transport System (Hyderabad City ITS) in the state of Andhra Pradesh, India being taken up with the loan of assistance of Japan International Cooperation Agency under Phase-2 program and Operation and Maintenance of Hyderabad City ITS and Related Facilities a separate fund provided by Hyderabad Growth Corridor Limited for a period of five years'.

12-1-3 Tender Document Volume I – Contract Document

The contract documents were prepared based on the policies described above. The 'Section V – Condition of Contract Part I General Conditions (CoC-GC)' is based on FIDIC Orange Book.

12-1-4 Tender Document Volume II - Technical Specification

The technical specifications were prepared based on the design of the pilot project. The requirements which are commonly applicable to the technical specification are described in the 'Section VII - Employer's Requirements Part A General Technical Specification (GTS)'. The technical specification of each ITS sub-system are described in the 'Section VII - Employer's Requirements Part B Particular Technical Specification (PTS)'.

12-1-5 Tender Document Volume II – Operation and Maintenance Specification

The requirements and specifications for operation and maintenance for a period of 5 years are described in the Volume II – Operation and Maintenance Specification. The requirement of service level to meet, Service Level Agreement (SLA), is one of the most important aspects for HGCL. Thus, the requirements and specifications for operation and maintenance were prepared on the basis of SLA.

12-1-6 Tender Document Volume III - Drawings

The drawings were prepared for reference purpose.

12-2 Pre-Qualification Document

The pre-qualification documents were prepared based on the following criteria described.

12-2-1 Qualification Criteria

(1) Financial Capability

The bidder shall meet the following criteria and must prove by either commissioning or completion certificate provided by their clients.

- The bidder shall prove the current soundness of the financial condition and prospective long term profitability by submitting audited financial statement or audited balance sheets acceptable to the Employer, for the last five (5)years.
- As a minimum requirement, the bidder's net worth calculated as the difference between total assets and total liabilities shall be positive for three (3) years within last five (5) years.
- The bidder shall have average annual turnover of US$ 37Million as system integrator

in transportation sector, calculated as total certified payments received for contracts in progress or completed within last five (5) years.

(2) Technical Experience

- The bidder shall have experience under the contract of transport and traffic management system project in the role of prime contractor for at least one project for the last five (5) years prior to the application submission deadline.
- The bidder shall have experience exclusively in the role of prime contractor, in at least one contract within last ten (10) years, that have been successfully and substantially 90% of value of work completed and that are similar to the following key activities:
  - ✓ The similarity shall be based on the physical size, complexity, methods/technology or other characteristics as described in scope of works described in the prequalification document.
  - ✓ The experience shall be evidenced by a signed certificate from the client or the owner of the system or the prime contractor.
- The bidder shall have experience in operation and maintenance of traffic control centre of City ITS/ Highway ITS comprising data collection, processing and dissemination functions and human machine interface through video wall map display, and monitoring and control through roadside equipment comprising of ATCC, CCTV, VMS, FLD etc. in the role of prime contractor/sub contractor for at least 2 years in the last ten years that have been successfully completed or 75% value of work was completed.
- The bidder shall have minimum experience, as prime contractor or partner in joint venture or subcontractor, in the following key activities:
  - ✓ System integration of traffic control centre system comprising information gathering, processing and dissemination functions and human machine interface through wall map display, and monitoring and control console
  - ✓ Integration of traffic surveillance system using minimum of 35 automated traffic counter-cum-classifier by image processing camera
  - ✓ Integration of traffic surveillance system consisting of minimum 28 CCTV cameras
  - ✓ Integration of variable message sign system consisting of minimum 15 units of signboard and central control system
  - ✓ Integration of probe car system collecting minimum 1200 GPS units
  - ✓ Integration of flood monitoring system consisting of minimum 7 flood monitoring stations
  - ✓ Establishing web-site of traffic information provision system

(3) Personal Capability

The bidder shall meet the requirememts of the experience as specified below.

Table 168 Personal Capability

Position	Total Experience in Electrical, Electronics and IT Industries	In Similar Works	As Manager of Similar Works
Project Manager	20	5	3
ITS Chief Engineer	15	5	2
Project Manager for	15	5	5

Operation and Maintenance			
Traffic Management Chief	10	5	5
Engineer in Information Technology	10	5	-
Accident Prevention Officer	10	5	-

12-3 Cost Estimation of Pilot Project

The project cost was estimated based on the configulation of the Pilot Project. The result of the cost estimation is as shown in the following table. Detail cost estimation is attached in Apendix.

Table 169 Estimation of the Pilot Project

Total Estimation Cost (INR)
1,62,00,00,000

12-4 Tender Assistance for Pilot Project

The tender assistance is not included in this project.

13 Road Inventory Survey

13-1 Purpose of Road Inventory Survey

The purpose of the road inventory survey is to prepare a road inventory application which visually shows the inventory information of the major roads in Hyderabad.

One of the major issues in transport sector in Hyderabad is that neither HMDA, which is a planning agency, nor GHMC, which is a road administrator, hold basic information on the road such as road structures, facilities, etc. The drawings of the roads are not available, either. Such situation is causing difficulties in carrying out a proper road maintenance and management. Futher, the situation is not limited to Hyderabad and many cities across India are in a similar condition.

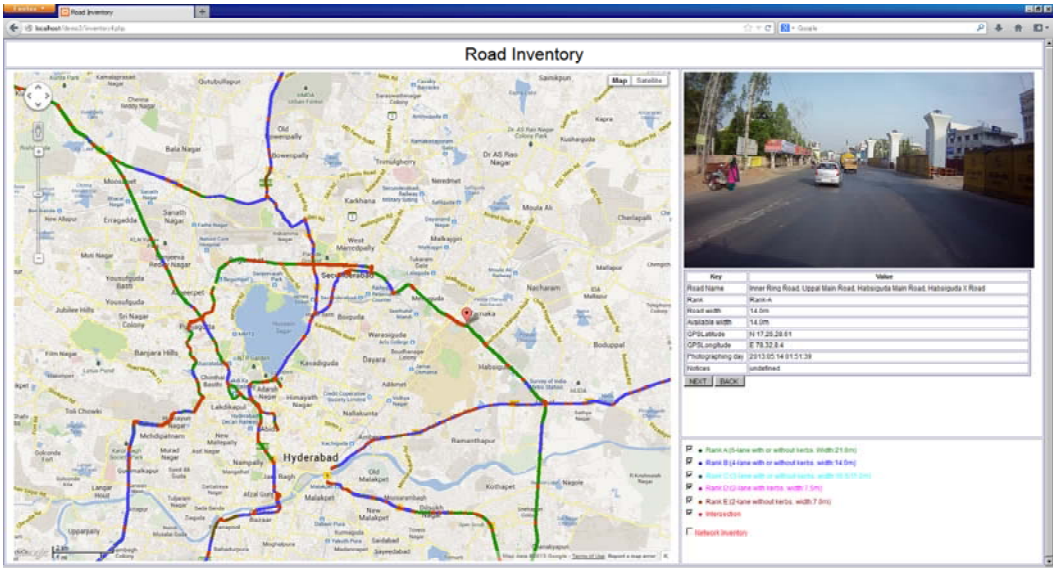
In Japan, the road inventory is maintained by road operators/administrators and utilised for road maintenance and management. It is also used as important source for planning of road improvement. Concerning this, a road inventory application for Hyderabad was prepared by this project, as a pilot bases, to contribute to improvement of management and planning of the road.

13-2 Prepared Road Inventory Application

The road inventory application provides basic inventory information such as road name, road class, width, etc. together with the picture of site condition and map of road network in Hyderabad. A sample image of the application is shown below. The map on left shows the road network. The road classification on the road network is indicated by different colour in accordance with Indian Road Congress (IRC) guideline.

The picture on upper-right shows the image of site condition which was captured by driving recorder. It provides both static pictures and moving images along with the corresponding locations of the road on the map of the road network. The table on middle-right provides basic inventory information pertaining to the corresponding road section.

The user can select the road section to show the inventory information and image of the site condition by clicking the location on the map. The pane on buttom-right allows the user to select the road class to show on the road network on the map.

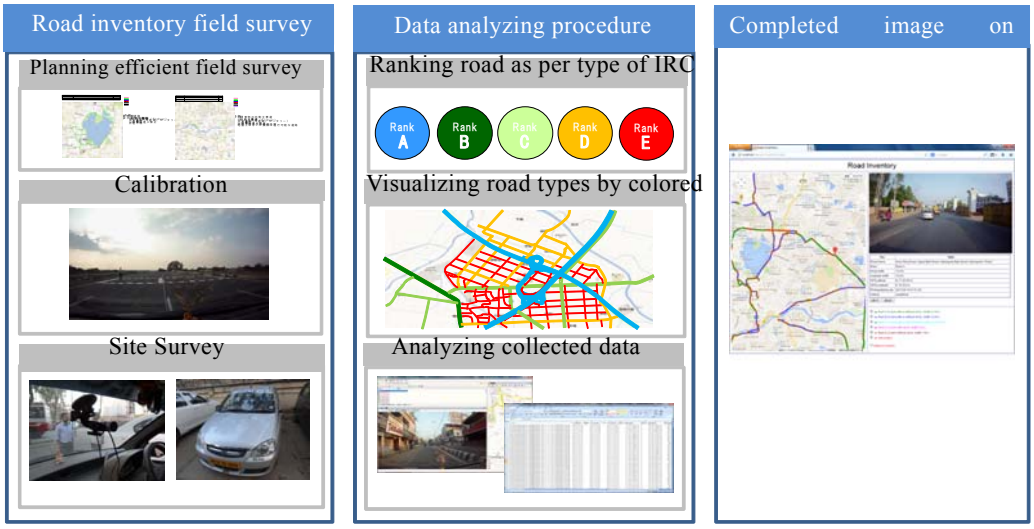


Source: Prepared by JICA Study Team

Figure 266 Visualising Road Inventory Image (Road Inventory Tool)

13-3 Survey Methodology

In this study, The road inventory visualization tool which visually presents inventory information was prepared as shown in the figure below. It includes road condition, width-of-street change, etc., on a digital map.



Source: Prepared by JICA Study Team

Figure 267 Outline of Road Inventory Study

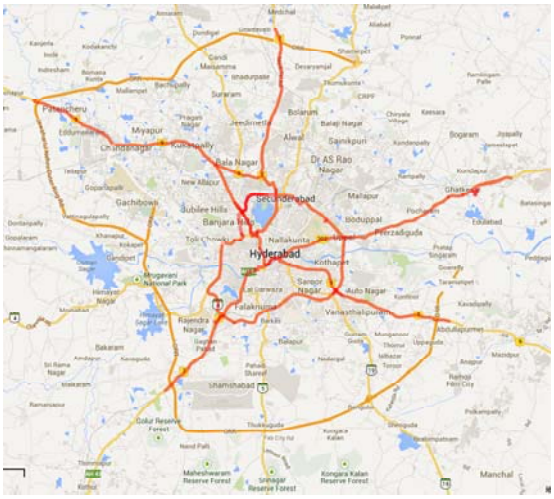
(1) Selection of Target Road and Data Collection

Firstly, the target roads were selected by the following conditions:

- Inside of Outer Ring Road
- All National Highways and Inner Ring Road

(2) Data Collection by Field Survey

Secondly, the field data collection was carried out. The moving picture was recorded by camera installed on the windshield of vehicle with GPS unit. The location information by GPS was recorded every 1 second.



Source: Prepared by JICA Study Team

Figure 268 Surveyed Road (NH7, NH9, NH202 and IRR)

(3) Calibration for Road Width

Thirdly, the captured image and actual scales were caliburated to decide the road width by first, second and third lanes based on the obtained images. The grid lines were plotted on each image. These grids and captured images from site survey make it possible to figure out the road width within the range of +-50cm.

Source: Prepared by JICA Study Team

Figure 269 Calibrating Images and Actual Scales from Left Lane, Middle Lane and Left Lanes

Step 1. Preparing image from calibration

Step 2. Plotting gridline on the image from calibration

Step 3. Applying gridline over the capture images

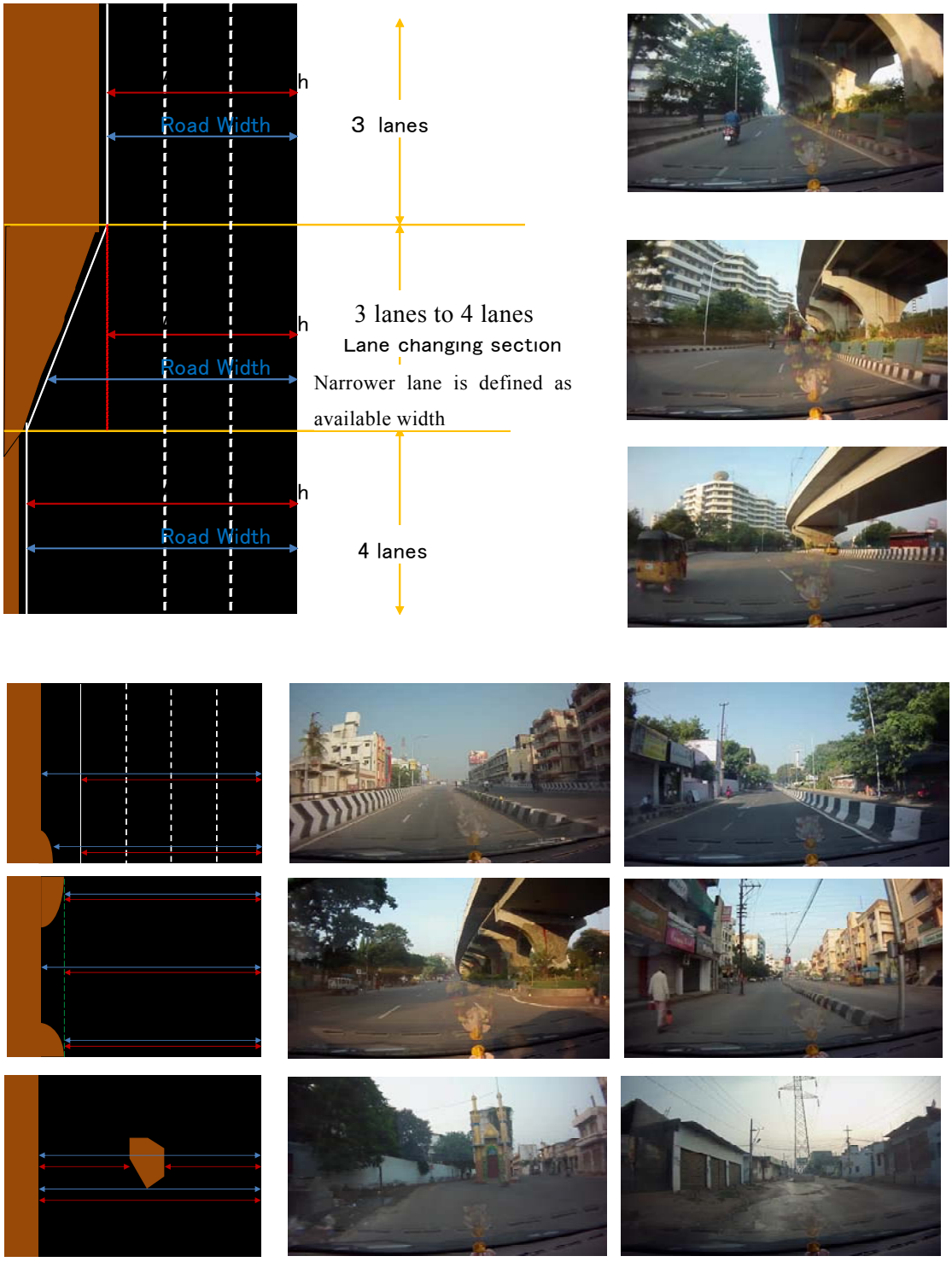
Source: Prepared by JICA Study Team

Figure 270 Methodology of Figuring out Road Width

(4) Defining Road Width

The width of roads in HMA frequently changes due to a number of factors such as religious structures, indistinct road boundary, incompletion of widening work, etc. Therefore, defining the road width in every possible case was considered.

To understand clearly, both actual road width and available width were defined. “Actual road width” means width of road from roadside edge to median, and “available width” means width which vehicle is able to drive. Each case of the actual width and available width is described below.



Source: Prepared by JICA Study Team

Figure 271 Available Width and Road Width on Each Case

(5) Development of Road Inventory Application

Based on the obtained data, the road inventory application was developed by linking image, location and information. Then inventory data pertaining to the section was registered. Input data is shown below.

Table 170 Input Data of Road Inventory

Data Item	Method for Data Acquisition
Image Data File	Acquired from image file name.
Road Name	Acquired from map.
Road Width	Acquired from image data which plotted grid line.
Available Width	Acquired from image data which plotted grid line.
Road Rank	Determined in accordance with road standard defined by Indian Road Congress ・Rank A: (6-lane with or without curbs. Width:21.0m) ・Rank B: (4-lane with or without curbs. width:14.0m) ・Rank C: (3-lane with or without curbs. width:10.5/11.0m) ・Rank D: (2-lane with curbs. width:7.5m) ・Rank E: (2-lane without curbs. width:7.0m) ・Rank F: (2-lane without curbs. width:3.5m)
Other Information	Additional information such as one-way traffic, no left turn, etc. acquired from the captured image

(6) Road Inventory Manual Preparation

A road inventory manual which describes how to manipulate the visualization tool was prepared.

14 Capacity Building Programme

14-1 ITS World Congress in Vienna

(1) Purpose

The study includes capacity building for HMDA officials through workshops, study tours and the on-the-job training to gain knowledge and experience of ITS. The participation in the 19th ITS World Congress in Vienna in 2012 was carried out as a part of the capacity building programme. It was intended to gain and reinforce the knowledge on ITS through preparation of a paper, making presentation on the Congress and extending knowledge through the opportunities of being exposed to the worldwide ITS practices, and meeting the practitioners of ITS in the World. The paper was prepared jointly by the officials of HMDA and JICA Study Team members and awarded by the committee of the ITS World Congress for presentation.

(2) Outline of ITS World Congress

The ITS World Congress is an annual event which showcases the latest ITS solutions in the world. It provides an excellent platform to exchange information and sharing knowledge of international best practices of ITS amongst stakeholders, and decision & policy makers in the world. The theme of 2012 ITS World Congress was “Smarter on the way” with “the goal that all citizens and businesses have at all times access to, and can benefit from, the most reliable, efficient and widespread intelligent mobility solutions”. The ITS Congress was attended by more than 10,000 participants from 91 countries including 3,000 delegates and 2,500 visitors. The ITS exhibitions included 304 companies from 33 countries with 23 technical demonstrations.

(3) Participants

Two officials from HMDA participated by JICA’s sponsorship. They were:

(1) Mr. Neerabh Kumar Prasad: Metropolitan Commissioner

(2) Mr. V. Madhwa Raja: HMDA Chief Engineer.

The Government of Andhra Pradesh, General Administration Department accorded the permission of participation of Sri. Neerabh Kumar Prasa, IAS, Metropolitan Commissioner of HMDA in the 19th ITS World Congress in Vienna, Austria from 22nd to 26th October 2012 for presenting the paper on ITS Technology in Hyderabad Metropolitan Area, vide G.O. Rt.No. 4763, dated on 12th October 2012.

The Government of Andhra Pradesh, MA&UD (A2 Department) accorded the permission of participation of Sri. V. Madhwa Raja, Chief Engineer (I/C) of HMDA during the same period above, vide G.O. Rt. No. 1361, dated on 13th October 2012.

Mr. Hiroya Totani, Team Leader of JICA Study, and Mr. Noboru Kondo, ITS Design Expert accompanied and participated in the ITS World Congress in Vienna.

(4) ITS World Congress Programme and Itinerary

The delegation, headed by Mr. Mr. Neerabh Kumar Prasad, departed from Hyderabad at 4:20 a.m. on the 21st October 2012 and arrived at 13:45p.m on the same day. They attended at the Opening Ceremony and the Plenary Session on the 22nd October 2012. Mr. Neerabh Kumar Prasad made the presentation of the technical paper AP-00273, titled ‘Introduction of ITS Technology to Hyderabad Metropolitan Area’ in the session of Policy and Strategy on the 23rd

October 2012. The delegate participated in the various sessions of the Congress on the 24th, 25th and 26th including executive sessions, plenary sessions, interactive sessions, technical, scientific sessions and exhibitions of the Congress. The delegation visited the National Traffic Control Centre in Vienna, Inzersdorf operated by ASFINAG on the 25th October. They made site visits in Vienna city using various public transport systems of the city. They departed from Vienna at 15:30 p.m. on the 27th October 2012 and arrived in Hyderabad at 8:50 on the 28th October 2012. The itinerary and programme of the delegation for the ITS World Congress are shown below.

Table 171 Itinerary at ITS World Congress

Oct. 2012	Flight		Activities
	Departure	Arrival	
21 (Sun)	EK525 Hyderabad 4:20	Dubai 6:20	Site Visit
	EK 127 Dubai 9:55	Vienna 13:45	
22 (Mon)			AM Site Visit
			Opening Ceremony & Plenary Session 1 (Smater on the way) 16:30-18:30
23 (Tue)			Plenary Session 2 (Converging Technologies) Policy & Strategy, Presentation is 5th, 14:00-15:30, AP-00273, Session No.TS008
24 (Wed)			Audition of sessions
25 (Thr)			Visit to Traffic Information Centre, 9:00-12:00
			Site Visit
26 (Fri)			Audition of sessions
27 (Fri)	EK 128 Vienna 15:30	Dubai 22:55	
28 (Sun)	EK527 Dubai 3:46	Hyderabad 8:56	

(5) Presentation Made by Hyderabad City ITS Project

The paper entitled “Introduction of ITS Technology to Hyderabad Metropolitan Area” consisted of the following components:

- Current traffic status of Hyderabad
- Study object
- Methodology of study
- Required measure by ITS
- Selection of ITS services
- Pilot project

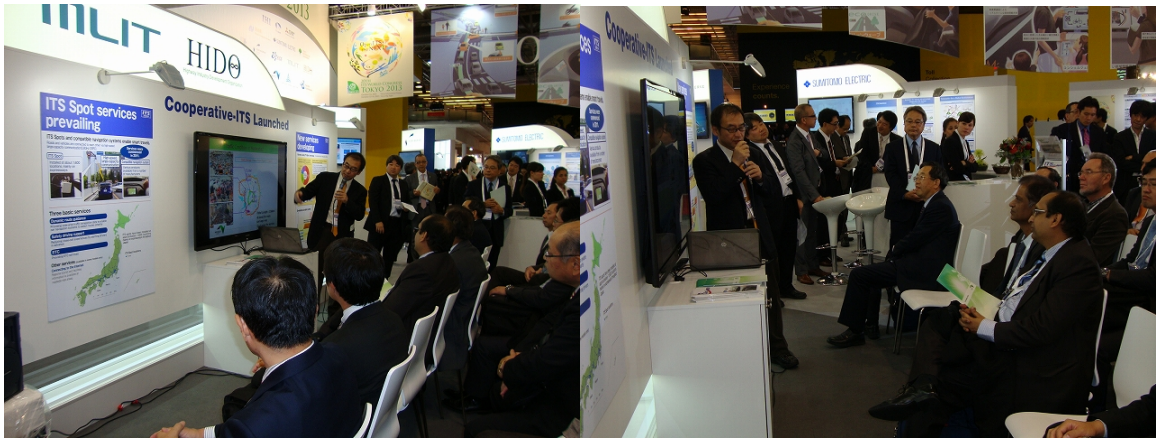
HMDA Commissioner Mr. Prasad presented on 23rd at “Policy & Strategy” session (TS008). In this session, totally 4 papers were presented as follows.

- EU-00147: ITS Manuals and Training with in Sweden, Norway and Denmark, by Lillia Halsen Bidar, Sweco AB, Sweden
- EU-00198: Use of position paper regarding ITS for Industry, by Roberto Bauducco, Swedish Transport Administration – STA, Sweden
- AP-00273: Introduction of ITS Technology to Hyderabad Metropolitan Area, by Neerabh Kumar Prasad, Hyderabad Metropolitan Development Authority, India
- EU-00745: A guide for pre-commercial procurement actors in ITS, by Sebastien Mure, ERTICO – ITS Europe

Source: JICA Study Team

Figure 272 Presentation Session

After above session, the delegation participated in the opening ceremony of Japan's Pavilion and Mr. Kondo presented JICA's achievement for ITS carried out in Hyderabad.



Source: JICA Study Team

Figure 273 Participation in Japan Pavilion

(6) Technical Visit

The participants of HMDA visited the Austrian National Traffic Management and Traffic Control Centre situated in Vienna, Inzersdorf where ASFINAG, the Austrian Motorway operator looks after the nationwide traffic management measures and provides traffic information to road

users. ASFINAG plans, finances, maintains and tolls across the Austria motorway and network covering 2,178 km including about 300 km in both directions of tunnels. The participants had a detailed discussion with Mr. Thomas Greineron the Traffic Information System, for VMS on the Gantry, and its maintenance and operations, etc.

Source: JICA Study Team

Figure 274 Technical Visit to ASFINAG

14-2 ITS Technical Tour in Japan

(1) Purpose

The technical tour to Japan was another capacity building programme, aiming to contribute building close relationship between Indian and Japan. It was carried out in the middle of February 2013 to provide the important key officials in India with an opportunity to experience the practices of ITS implemented in Japan and broaden knowledge on the technologies and operations of ITS.

(2) Participants

The members of the technical tour included officials from 2 different JICA studies: Hyderabad SAPI (this study), and some key personnel from 9 cities study, 'Data Collection Survey on the Introduction of Intelligent Transport Systems to Urban Transportation of Major Cities in India'.

The participants include 4 members from Hyderabad and 4 members from Bangalore, Mumbai, Ahmedabad and NHAI as shown below.

Table 172 Members of ITS Technical Tour to Japan

No	City	Organisation	Designation	Name
Hyderabad				
1	Hyderabad	Hyderabad Metropolitan Development Authority (HMDA)	Commissioner	Neerabh Kumar Prasad (Mr)
2	Hyderabad	Hyderabad Growth Corridor Limited	General Manager	Anamd Mohan (Mr)
3	Hyderabad	Hyderabad Traffic Police	Additional Commissioner	C.V. Anand (Mr)
4	Hyderabad	Andhra Pradesh State Road Transport Corporation.(APSRTC)	Vice Chairman & Managing Director	A. K. Khan (Mr)
Other Cities				
5	Delhi	National Highway Authority of India (NHAI)	Chief General Manager (Technical)	JINDAL Subhash Chand (Mr)
6	Bangalore	Ministry of Urban Development (MoUD)	Principal Secretary	V. Manjula(Ms)
7	Mumbai	Mumbai Metropolitan Regional Development Authority (MMRDA)	Additional Chief	K. Vijaya Lakshmi (Ms.)
8	Ahmedabad	Ahmedabad Urban Development Authority (AUDA)	Chief Executive Authority	DAYALAN Thara (Ms.)

(3) Technical Tour Programme and Itinerary

The programme was prepared with particular consideration of improvement of knowledge and experience of ITS as shown below.

Table 173 Itinerary of ITS Technical Tour to Japan

Date & Time			Programme / Place to Visit	Hotel
Day 1	2/16 (Sat)	AM		
		PM	Depart from India	Flight
Day 2	2/17 (Sun)	AM	Arrive in Japan (1st Group and 2nd Group)	
		PM	Site Visit to Metropolitan Expressway Network	Tokyo
Day 3	2/18 (Mon)	AM	Tour Briefing / JICA Arrive in Japan (3rd Group)	
		PM	Introduction of World and Japanese ITS Technologies Presented by ITS-Japan, Japanese Companies, and Discussions Toshiba Science Museum	Tokyo
Day 4	2/19 (Tue)	AM	VICS Center MLIT	
		PM	Police Traffic Control Centre Hitachi (Cyber Government Square) Shimbashi Station - Odaiba (Yurikamome Line)	Tokyo
Day 5	2/20 (Wed)	AM	Move to Kobe	
		PM	Mitsubishi Heavy Industry Akashi Kaikyo Ohashi	Kyoto
Day 6	2/21 (Thu)	AM	Experience of Metropolitan Public Network, Bus Terminal in Kyoto	
		PM	Experience of Inner City Expressway Network in Kyoto	Kyoto
Day 7	2/22 (Fri)	AM	Move to Tokyo	
		PM	Joint Wrap Up Meeting by Indian Delegate, MLIT and JICA	Tokyo
Day 8	2/23 (Sat)	AM	Site Visit at Service Areas, Facilities and Road Side ITS Equipment along Inter-City Expressway	
		PM	Site Visit in Tokyo Metropolitan Area	Tokyo
Day 9	2/24 (Sun)	AM	Site Visit in Tokyo Metropolitan Area	
		PM	Same as above	Tokyo
Day 10	2/25 (Mon)	AM	Depart from Japan	
		PM	Arrive in India	

(4) Major Places and Purposes to Visit

The programme was prepared with particular consideration of gaining knowledge and experience of ITS as shown below.

Table 174 Places and Purposes to Visit

Places	Purpose
VICS Centre	To deepen understanding roles and functions of VICS, and key technologies e.g. digital road map and road/traffic information on entire nation
Traffic Police Control Centre	To deepen understanding traffic control in the metropolitan area, utilisation of quantitative data and signal control practices
Metropolitan Expressway in Tokyo Area	To deepen understanding the facilities such as service areas, roadside ITS equipment and their management
Public Transportation Network in Tokyo	To deepen understanding how it functions and planned for transferring amongst different mode of transport, single IC card for multipurpose usage
Public Transportation Network in Kyoto	To experience bus location system and its services including information provision by variable message sign board
Hitachi Exhibition Hall	To deepen understanding clearing house mechanism, ETC, Smart Card and number place recognition technology
Toshiba Scientific Museum	To deepen understanding smart city concept, image processing based vehicle detection technology, number plate recognition
Mitsubishi Heavy Industry Factory	To deepen understanding ERP and ETC technology
ITS-Japan and other private companies	To deepen understanding available ITS technology in the world and Japan
Joint Discussion Session by MLIT and JICA	To deepen understanding the policy on metropolitan and road network development in Japan, share the challenges in each city in India and exchange opinions for the way forward

15 Conclution and Recomendation

(1) Outline

Memorandum of Understanding (MOU) for the Project was exchanged between Huderabad Growth Corridor Limited (HGCL) under Hyderabad Metropolitan Development Authority (HMDA) and Japan International Cooperation Agency (JICA) on the 28th April in 2011.

Consultancy services for the Project were provided, through grant support of JICA, for the purpose of contributing to alleviate congestion in Hyderabad Metropolitan Area.

The Project aims to assist the Andhra Pradesh State Government and Hyderabad city authorities to improve the traffic through formulating ITS Master Plan for Hyderabad Metropolitan Area and implementing the prioritied ITS services in a phased manner. Thereby, the traffic will be properly controlled and diverted, leveraging the road and transport network including radial roads and Hyderabad Outer Ring Road (ORR) which are under construction by JICA loan project.

JICA procured the consultant, a joint venture consisted of Nippon Koei Co., Ltd., East Nippon Expressway Co., Ltd. and Metropolitan Expressway Co., Ltd. in July 2011. The consultant commenced the project in August 2011 and officially submitted the Final Reaport together with ITS Master Plan for Hyderabad Metropolitan Area and a whole set of the tender document of the pilot project for the prioritied ITS services in February 2014.

HGCL/HMDA, the counterpart of the Project, continuously provided sincere support and cooperation throughout the Project, formulating Technical Advisory Committee consisted of a number of Indian stakeholders concerned.

We hope that the ITS Master Plan will contribute to improvement of urban traffic, thereby development of Hyderabad and the pilot project be smoothly implemented as the first ITS in India.

(2) Basic Concept of Master Plan in Regard of Current Condition in Hyderabad

The major issue in Hyderabad is that the traffic is not objectively comprehended. For example, the junction names and areas that are chronically congested are known to people. But these are based on people's general experiences. The traffic in the city is monitored by CCTV in the existing traffic control centre by traffic police. However the objective of CCTV is visual confirmation of site condition. It is important that the traffic condition is quantitatively perceived as to where, when and how much it is congested. The cumulated historical data and information needs to be utilised for the measures of improvement of road transport infrastructure and traffic management.

In consideration of such situation, the basic policy of ITS Master Plan was set out to prepare a basic environment to quantitatively measure the traffic condition and cumulate the data in ITS Centre. The data to be collected includes travel speed, spot traffic volume, flood condition and weather information because these are considered as basic important information that the road and traffic authorities need to have. It aims realtime monitoring on traffic and utilisation for proper planning and evaluation of measures for road transport infrastructure and traffic management, by cumulating the collected data in ITS Centre. It also aims to properly regulate the traffic flow by providing realtime traffic information through VMS installed at the critical locations. Moreover, the traffic information generated by ITS Centre is aimed to be used as one of the revenue sorces by selling to the interested parites in public and private sectors.

(3) Probe Data of Andhra Pradesh State Road Transport Corporation

Utilisation of probe data obtained from Andhra Pradesh State Road Transport Corporation (APSRTC) is proposed as the major data collection method in phase-1 of ITS Master Plan. APSRTC is planning to develop bus location system. The vehicle location data measured by GPS installed on bus will be transmitted and utilised for measurement of vehicle speed in ITS Centre. The reason is that sufficient number of other modes of road transport is not available. For example, there are many auto-rickshaws in the city. However they are not appropriate for measurement of vehicle speed due to lower speed than other vehicles. The private taxies are equipped with GPS. However they are not sufficient in number, and realtime transmission to ITS Centre would be difficult because of various reasons such as their policies of confidentialily, etc.

Data collection is most important factor for ITS. The data collection of ITS Centre will be heavily dependant on the probe data from APSRTC due to above reasons. Therefore, assuring that the probe data be shared by APSRTC is critical for the ITS project. It was agreed with APSRTC by the letter that the probe data would be shared by APSRTC. It is emphasized that continuous close coordination with APSRTC needs to be ensured and memorandum of understanding be exchanged between HMDA and APSRTC for smooth implementation of ITS.

(4) Meteorological Data of Andhra Pradesh State Development Society

Utilisation of meteorological data obtained from Andhra Pradesh State Development Society (APSDPS) is proposed for weather monitoring in phase-1 of ITS Master Plan. It was originally considered to install the meteorological measurement sensors in the city by this project for monitoring weather conditions such as precipitation. However it was confirmed that APSDPS was measuring the weather by their existing facilities and that APSDPS would share their data. The weather data will be transmitted on-line from their servers to the ITS Centre..

It was agreed with APSDPS by the letter that the space for equipment for data transmission in their premise would be provided and necessary software modifications of their system would be taken care by APSDPS. It is emphasized that continuous close coordination with APSDPS needs to be ensured and memorandum of understanding be exchanged between HMDA and APSDPS for smooth implementation of ITS.

(5) Data Collection from Highway Traffic Management System of Hyderabad Outer Ring Road

Highway Traffic Management System (HTMS) for Hyderabad Outer Ring Road (ORR) will be developed and the tender was called in December 2013. It was concluded that the ITS Centre proposed by ITS Master Plan will be developed in the same building of Traffic Control Centre (TCC) of HTMS. The ITS Centre will monitor the traffic in the city, and HTMS will monitor the traffic on ORR. The traffic information will be provided to the users by combining the information of HTMS and ITS Centre. The ITS Centre will obtain the traffic information from HTMS such as traffic regulation, road closure, road works, VMS information being provided, etc.

Necessary arrangement is required for both sides of TCC of HTMS and ITS Centre to realise this. For example, the different contractors will be procured for HTMS and ITS Centre. The contractor of HTMS can not make software arrangement of ITS Centre. The employer for both projects is Hyderabad Growth Corridor Limited (HGCL). Thus, proper arrangement needs to be made by the initiative of HGCL for smooth implementation of the projects.

(6) Necessity of Efficient Implementation of Pilot Project

ITS services proposed by ITS Master plan in phase-1 will be implemented as a pilot project. The basic design and tender documents were prepared by this project. The major issues for implementing the pilot project are i) limited period for installation which is eighteen (18) months, ii) many installation locations for various equipment in the city and iii) a number of involved parties such as Hyderabad Metro Rail Corporation (HMR), traffic police, Greater Hydeabad Municipal Corporation (GHMC), etc. In order to ensure timely implementation of the pilot project, a) submission of the detail desing by the contractor and approval of the employer in timely manner, b) assuring site acquisition for installation of equipment, c) coordination amongst involved parties are critical. A strong initiative of HGCL as an employer is necessary.

(7) Traffic Signals

The traffic signal is important for city traffic. The improvement of the traffic signals is proposed in phase-2 in the ITS Master Plan. The reason is that replacement of the existing signals and installation of new signals are underway by traffic police under the project called HTRIMS. However the intersection improvement is not included in HTRIMS. In addition, the spaces for the pedestrian are not properly developed in the city, and there are not sufficient signals for pedestrian. Considering the current condition in the city, signal replacement needs to be implemented along with the improvement of the intersection and the signals for pedestrian.

(8) Involvement of Traffic Police

Involvement of traffic police is important for ITS operation. The traffic control centre of traffic police is currently in operation. Thus, ITS Master Plan proposes that the ITS Centre will be developed at the different location from the existing traffic control centre. The ITS Centre will be attended by personnel of traffic police in phase-1, and the operation and systems will be integrated with traffic police in later stage. The traffic police raised concerns that confidentiality of the collected data on traffic by the ITS Centre needs to be ensured and provision of traffic information be controlled by the traffic police in regard of security.

The data to be collected and information to be provided by the ITS Centre in phase-1 is limited to the traffic. However when integrated with the traffic police in the later stage, the issues such as handling of VIP movement need to be dealt together with the traffic police. Thus, the policy for involvement of the traffic police and coordination with them towards integration for later stage needs to be set out. It is recommended that such policy be formulated and agreed at state level such as Unified Metropolitan Transport Authority (UMTA).

(9) Operation of ITS Centre

ITS Centre will be operated by the contractor under HMDA in phase-1. However, the long-term concept of the ITS Centre proposed by ITS Master Plan is to have holistic functions as a single agency including planning, promoting and managing ITS. A variety of related agencies such as Greater Hyderabad Municipal Corporation (GHMC), Hyderabad Growth Corridor Limited (HGCL), HMDA (Hyderabad Metropolitan Development Authority), AndhraPradesh State Road Transport Corporaion (APSRTC), National Highway Authority of India (NHAI), Transport Department, etc will have to be inevitably involved. It is strongly recommended that continuous efforts in coordinated, integrated and holistic manner be made towards establishment of full-fledged ITS Centre for Hyderabad, together with all involved parties.

(10) Coordination with Traffic Police for VMS Installation

VMS on the road side is proposed by the pilot project. Meanwhile, VMS is also planned by traffic police under HTRIMS project. The study team tried to confirm the locations of the VMS planned by HTRIMS during the basic design stage. However these locations were not confirmed because that these locations had not been identified yet. Thus, some of the locations of VMS planned by both projects may be duplicated. It is necessary to make adjustment of the numbers and locations of VMS to be installed by this project once the contractor is procured.

(11) Coordination with Other Departments for Installation of Roadside Equipment

The proposed roadside equipment by the pilot project are automatic traffic counter-cum (ATCC), flood sensors (FLD), CCTV and VMS. CCTV will be installed at the same locations of ATCC and FLD. FLD will be installed on the flood-prone locations based on the information published by the traffic police. The numbers and locations of the roadside equipment were confirmed by HGCL with the relevant authorities such as Hyderabad Metro, GHMC, NHAI, etc. However it is expected that procurement of consultant and contractor for the pilot project may take certain time. Further, tt may take more time for installation of the roadside equipment considering the required time for other activities such as detail desing by the contractor, approvals by the employer, etc. It is assumed that the surrounding road conditions will have changed by the time of installation. Therefore, final confirmation in regard of the locations and number of the roadside equipment is required again by the initiatives of HGCL with all related authorities.

(12) Incorporation of ITS Master Plan into Comprehensive Transport Plan in Hyderabad

A comprehensive transport plan, called CTS, is underway in Hyderabad. Meanwhile, ITS Master Plan was prepared by this project. The factors considered by CTS were reflected in ITS Master Plan. However, as ITS is one of soft measures in transportation sector, it would deserve to consider incorporating ITS Master Plan into the comprehensive transport plan in Hyderabad.

(13) Traffic Information of Google and New Technology

The Google Co., Ltd. is offering the congestion information in Hyderabad. The information is provided based on the location data collected through Android smartphone users. It is assumed that such congestion is judged by the travel speed based on the data which is identified as vehicle movement amongst different modes of traffic such as walking, cycling, etc. The study team requested them to utilise the data collected and cumulated by the Google for the ITS Centre. However their reply could not be obtained, presumably due to their policy of confidentiality. This implies that vast amount of traffic data that they hold can not be utilised. It is possible to simply show the congestion information offered by the Google on the map in ITS Centre, for example. But it is not possible to process and analyse their raw data. This is the situation as of February in 2014. However their current policy may not be necessarily remain the same forever. Furthermore, advancement of information technology is very fast. The new technology which is not available now may appear in the near future. Thus, the attention always needs to be paid to the prospect of availability of Google data and other new technologies for ITS in Hyderabad.

(14) Necessity of Revise of ITS Master Plan

ITS Master Plan was prepared by phase-1 for 5 years, phase-2 for 10 years and phase-3 after 10 years, and it shows the ITS services to be introduced by phase. However information

technology advances very rapidly. It can be assumed that new ITS services which do not exist now may become available after 5 years. Furthermore, ITS needs to be planned and developed in accordance with situation of traffic and road/transport infrastructures. The condition of traffic and the development status of road/transport infrastructures will be changed in the near future. Therefore, ITS Master Plan shall be continuously revised.

(15) Necessity of Infrastructure Improvement

ITS is one of soft measures and traffic congestion can not be alleviated only by ITS. The investment for infrastructure is necessary. For example, there are not sufficient alternative routes in Hyderabad. Even though the realtime traffic information is provided by ITS, there are not enough options for the road users to detour in the current situation. Currently, Outer Ring Road is under development and some radial roads are being improved. In addition to these roads, it is important that the road infrastructures be more improved. The examples include, development of more alternative routs in the city, grade separation of major junction, parking facilities, pedestrian footpaths, widening of Inner Ring Road, etc. Hyderabad metro is under construction. Development of area in front of/near station is also required such as parking bay for smooth transition between different traffic modes. Then, the movement of people will become different once such infrastructures are developed. ITS needs to be re-considered along with planning of transport and infrastructure.

End of Report.