

**REPUBLIC OF INDIA  
DIRECTORATE OF URBAN LAND TRANSPORT  
URBAN DEVELOPMENT DEPARTMENT  
GOVERNMENT OF KARNATAKA**

**THE MASTER PLAN STUDY  
ON  
THE INTRODUCTION OF  
INTELLIGENT TRANSPORT SYSTEM (ITS)  
IN  
BENGALURU AND MYSORE  
IN  
INDIA  
SUMMARY OF FINAL REPORT**

**June 2015**

**JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)**

**JICA STUDY TEAM Consisted by  
NIPPON KOEI CO., LTD.**

**EAST NIPPON EXPRESSWAY CO., LTD.  
CTI ENGINEERING INTERNATIONAL CO., LTD.**

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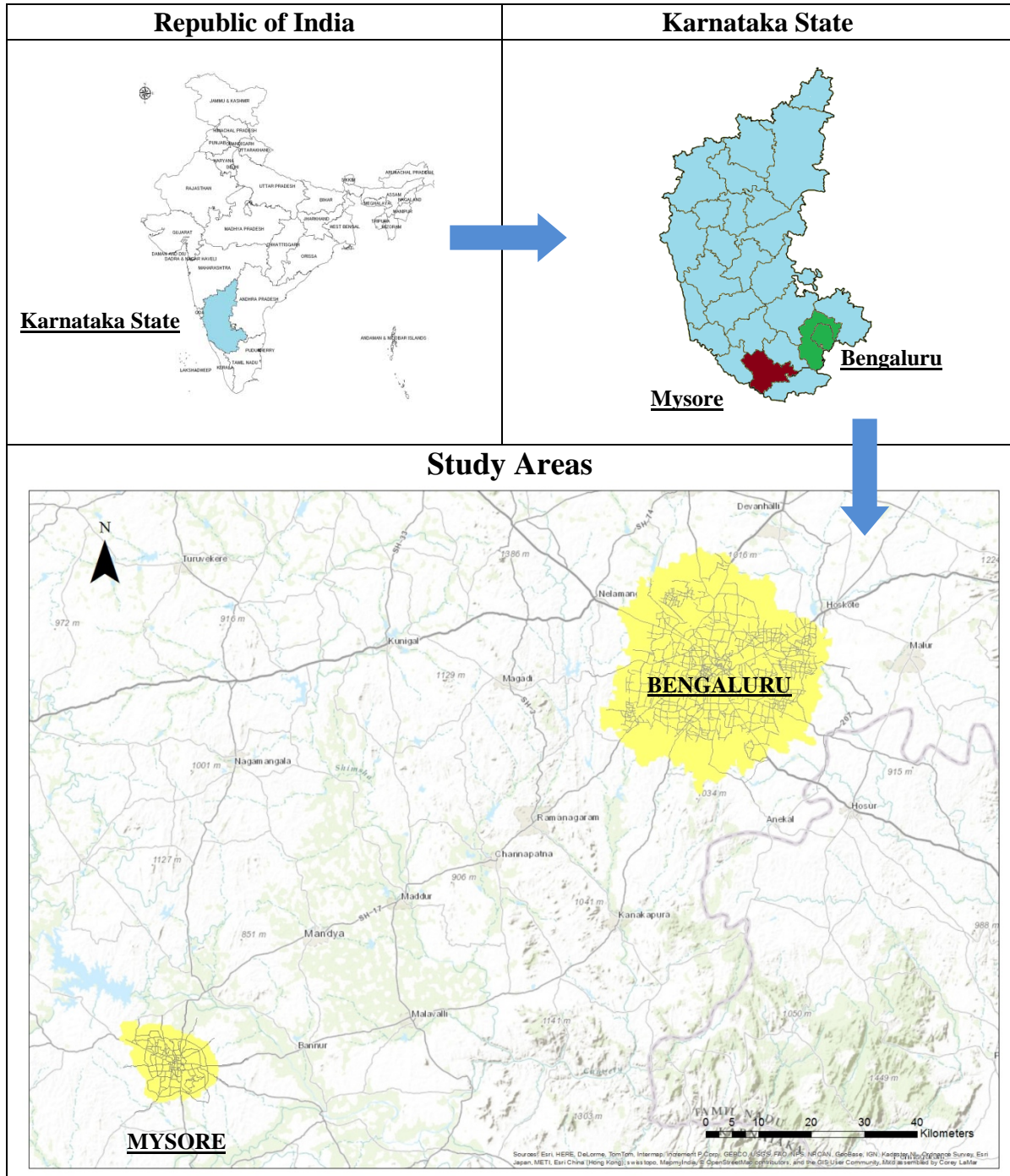
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### Location Map



(Source: Jointly prepared by DULT and JICA Study Team)

## **1 Introduction**

### **1.1 Study Background**

Bengaluru is a capital city of Karnataka state and the fifth largest metropolis in India. It is widely known as India's IT capital and an important industry hub in the region of south India with a number of leading Indian and foreign companies such as Microsoft, Toyota, and etc. Due to rapid urbanisation, severe traffic congestion is becoming a serious problem and causing a bottleneck for business activities in the region.

Hard measures of infrastructure development are underway. They include for example improvement of radial road, extension of the existing Metro, and etc. The development of the Peripheral Ring Road under Japanese Yen loan project is under consideration. Hence, it is also important to simultaneously take soft measures, represented by Intelligent Transport Systems (ITS), to contribute to effective use of infrastructure.

Mysore, the second largest city in Karnataka state, is located 140km southwest of Bengaluru and a major tourist destination in the state with a plenty of historical heritages. Having been a former capital of Kingdom of Mysore for decades, Mysore is still a home of people's heart in the state. A promotion of tourism preserving environment is the most important policy of Mysore. Under the situation that the population and vehicle are expected to become double in number in decade, urban transport measures achieving the policy of Mysore is increasingly important.

An ITS seminar co-hosted by India and Japan was held in Bengaluru in March 2012, and attended by a number of Indian stakeholders in the ITS field. The officials of Directorate of Urban Land Transport of Karnataka State Government (DULT) participated in the ITS training programme in Japan in 2013. Taking a cue from these events, ITS and related advanced technologies that Japan possess have drawn attention to comprehensively address the urban transport.

The Government of Karnataka requested the Government of Japan to carry out a study to prepare a comprehensive ITS Master Plan for this region. As a result, Urban Development Department, the Government of Karnataka State, and Japan International Cooperation Agency (JICA) agreed that both parties would cooperate sincerely with each other to formulate an ITS Master Plan for Bengaluru metropolitan area and Mysore.

### **1.2 Objectives of the Study**

The objectives of ITS Master Plan study are to formulate a long-term holistic plan of ITS to prioritise ITS components in accordance with local requirements and related plans so that the ITS will be smoothly implemented in a phased manner in Bengaluru metropolitan area and Mysore, thereby assisting the state Government of Karnataka and city authorities to tackle the traffic issues.



The deliverables of the study are:

- **ITS Master Plan for Bengaluru Metropolitan Area**
- **ITS Master Plan for Mysore**
- **Draft Specification for Proposed ITS Components for Bengaluru Metropolitan Area**

### **1.3 Expected Outcomes of the Study**

ITS is a soft measure for assisting the measures on urban transport. It supports to enable;

- Reduced traffic congestion and traffic flow on the road network including PRR
- Enhanced and improved usage of public transport
- Proper planning and implementation of road infrastructure development and traffic management by the utilisation of quantitative data on traffic made available by ITS

### **1.4 Stakeholders and Study Implementation Structure**

Joint Coordinating Committee (JCC) and Technical Advisory Group (TAG) were organised for smooth execution of the Study.

JCC was organised to facilitate execution of the Study. It functioned as a decision making body, assuring the study objectives and inter-organisational coordination. JCC was chaired by the commissioner of DULT and held whenever deemed necessary. The members of JCC include JICA, India office, BDA, BBMP and JICA study team.

TAG was organised to achieve consensus for the issues across related agencies. TAG meetings were convened as required. As per the issues to be discussed, the relevant members were invited for the meetings. TAGs for Bengaluru and Mysore were respectively organised and consisted by the relevant organisations in these regions.

### **1.5 Study Members and Study Team Structure**

The study members and structure of JICA Study Team are shown in Figure 1.1.

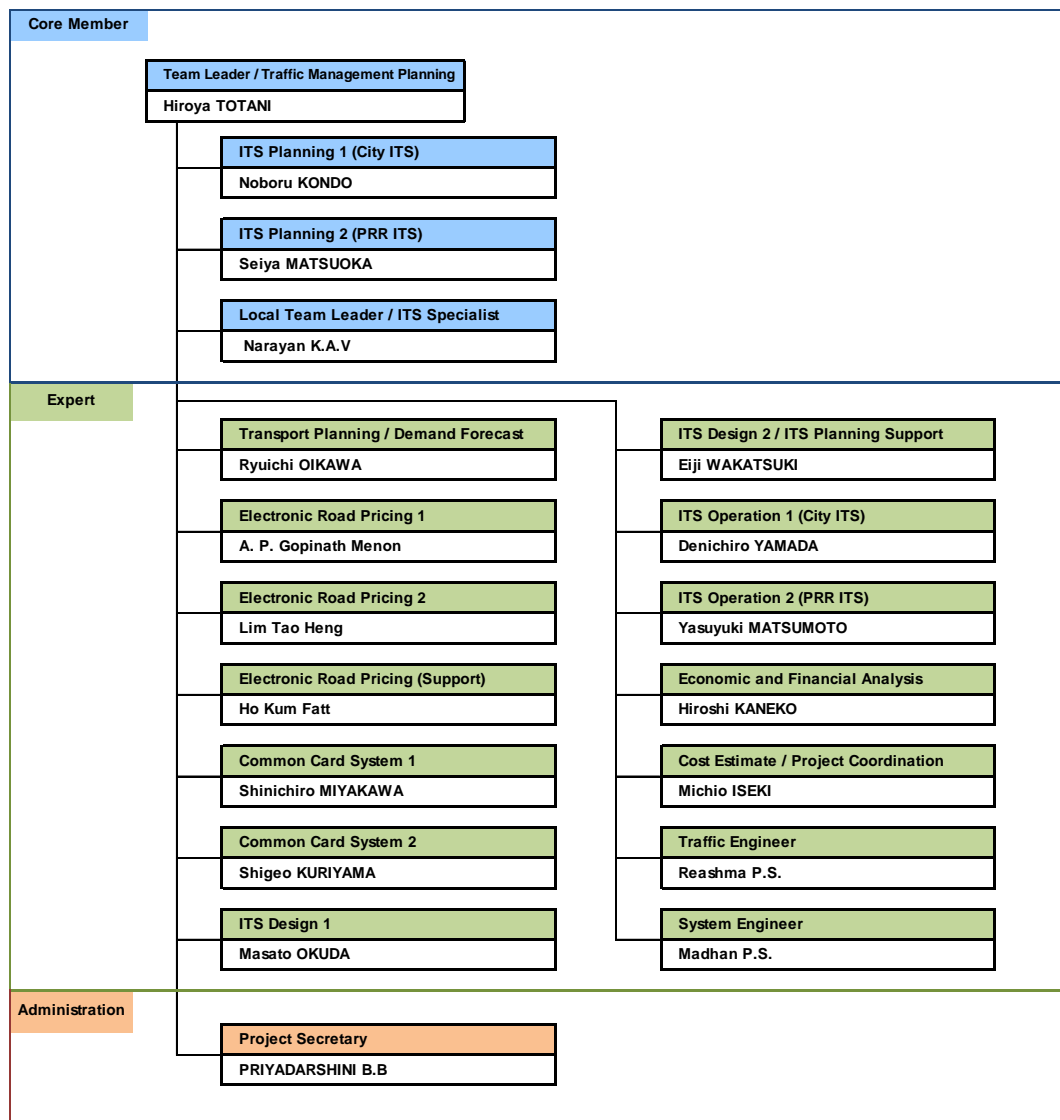


Figure 1.1 Members and Structure of JICA Study Team

(Source: JICA Study Team)

## 1.6 Study Schedule

The study schedule is shown in Figure 1.2

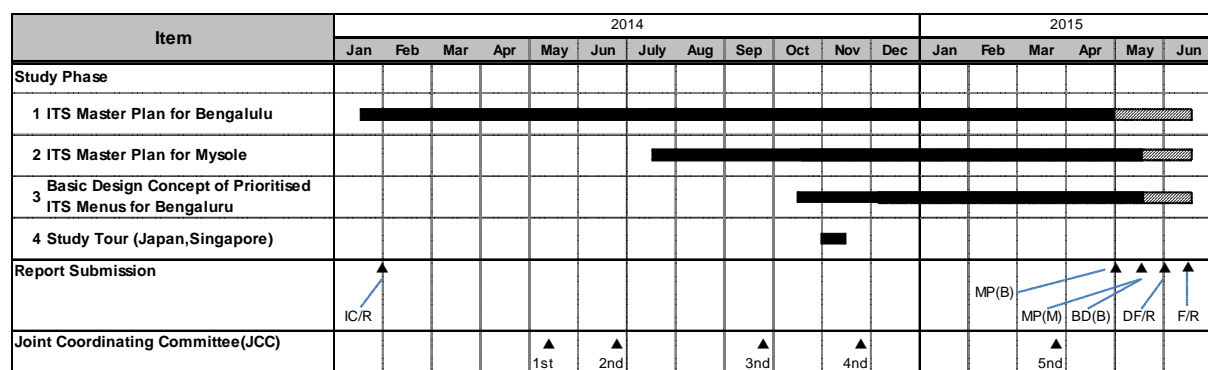


Figure 1.2 Study Schedule

(Source: JICA Study Team)

## **2 Current Condition and Required Measures by ITS**

The study described in this chapter was carried out for ITS Master Plan preparation. ITS Master Plan for Bengaluru Metropolitan Area and Mysore was formulated based on the study made in this chapter.

### **2.1 Current Condition**

#### **2.1.1 Outline**

Bengaluru is the capital and largest city in Karnataka state. With a population of over 9 million, it is the fifth largest metropolitan city in India and 27<sup>th</sup> largest city in the world. Bengaluru is one of the most ethnically diverse cities in India. More than 60% of the population is the immigrants from other places of India.

Bengaluru is located in southern India on the Deccan Plateau at 900 metres above mean sea level. The city is featured by a tropical monsoon climate which is moderate and pleasant throughout year.

Mysore was a former capital of the Kingdom of Mysore. It served as the capital city of princely kingdoms from 1399 to 1947. It spreads across an area of 128.42 km<sup>2</sup>. Mysore is noted for its palaces, including the Mysore Palace. During festival season (generally in the months of September to October every year), a large number of tourists visit Mysore.

Socio-economic conditions in Bengaluru and Mysore such as population, economy, industry, tourism, trade, etc. are reviewed and utilised as basic information for the study.

#### **2.1.2 Road Networks**

##### **(1) Bengaluru**

The road network in Bengaluru is formed in radial pattern and consisted of three existing ring roads connecting the radial roads. The major radial roads are consisted of parts of NH4 lying through the city in east-west direction, NH7 in north-south direction, NH209 to the south and other state highways.

The existing ring roads include Core Ring Road (CRR) , Inner Ring Road (IRR) and Outer Ring Road (ORR). A semi-circle peripheral ring road, called NICE Road, 45 km in length, lies south-west of the city. The construction of Peripheral Ring Road (PRR), 65 km in length, is planned to connect with NICE Road forming a full circle ring road around Bengaluru in the future. The total length of the existing road network in Bengaluru is approximately 4,000 km. The PRR is planned to develop by Japanese loan.

The road network in Bengaluru is shown in Figure 2.1

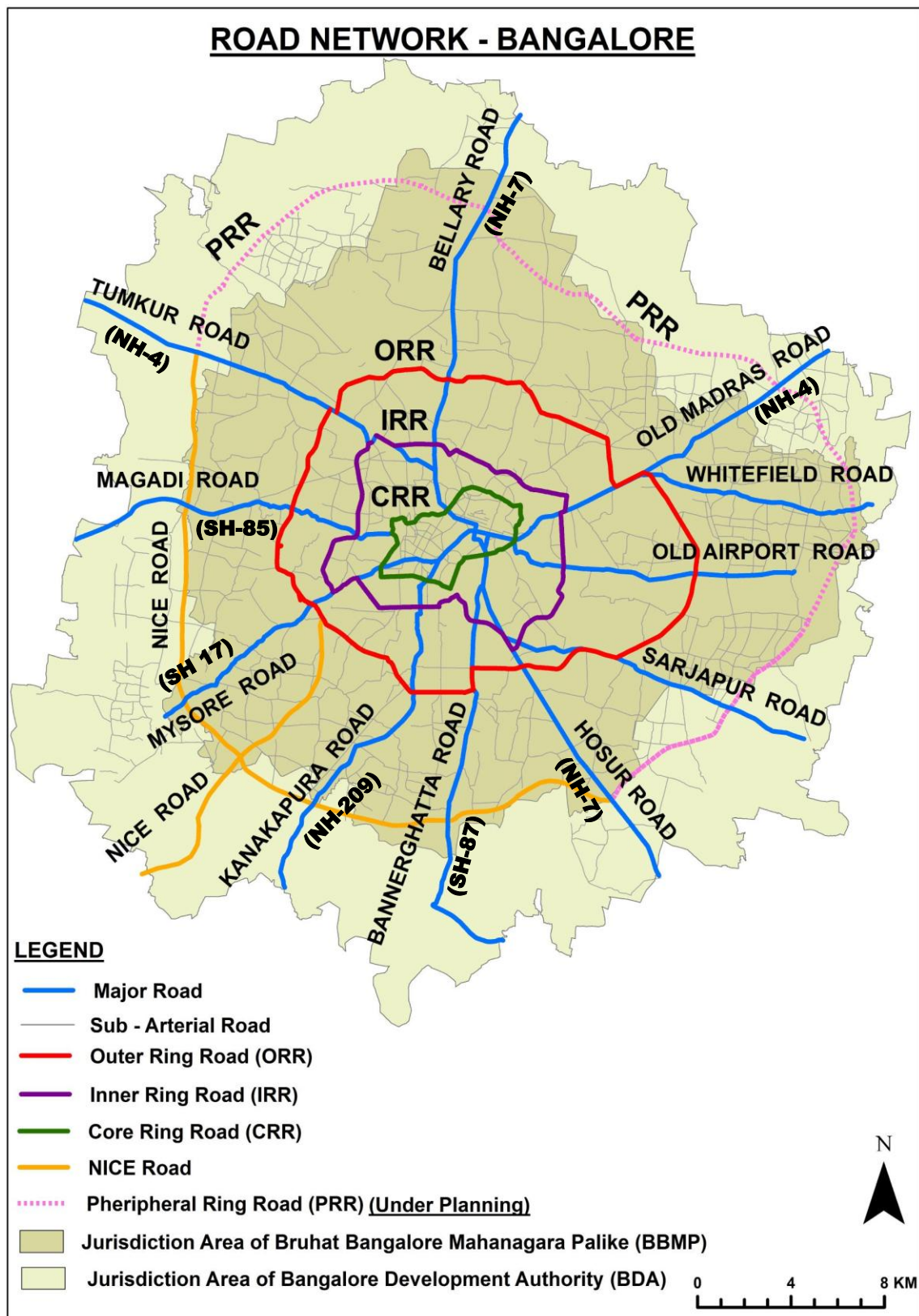


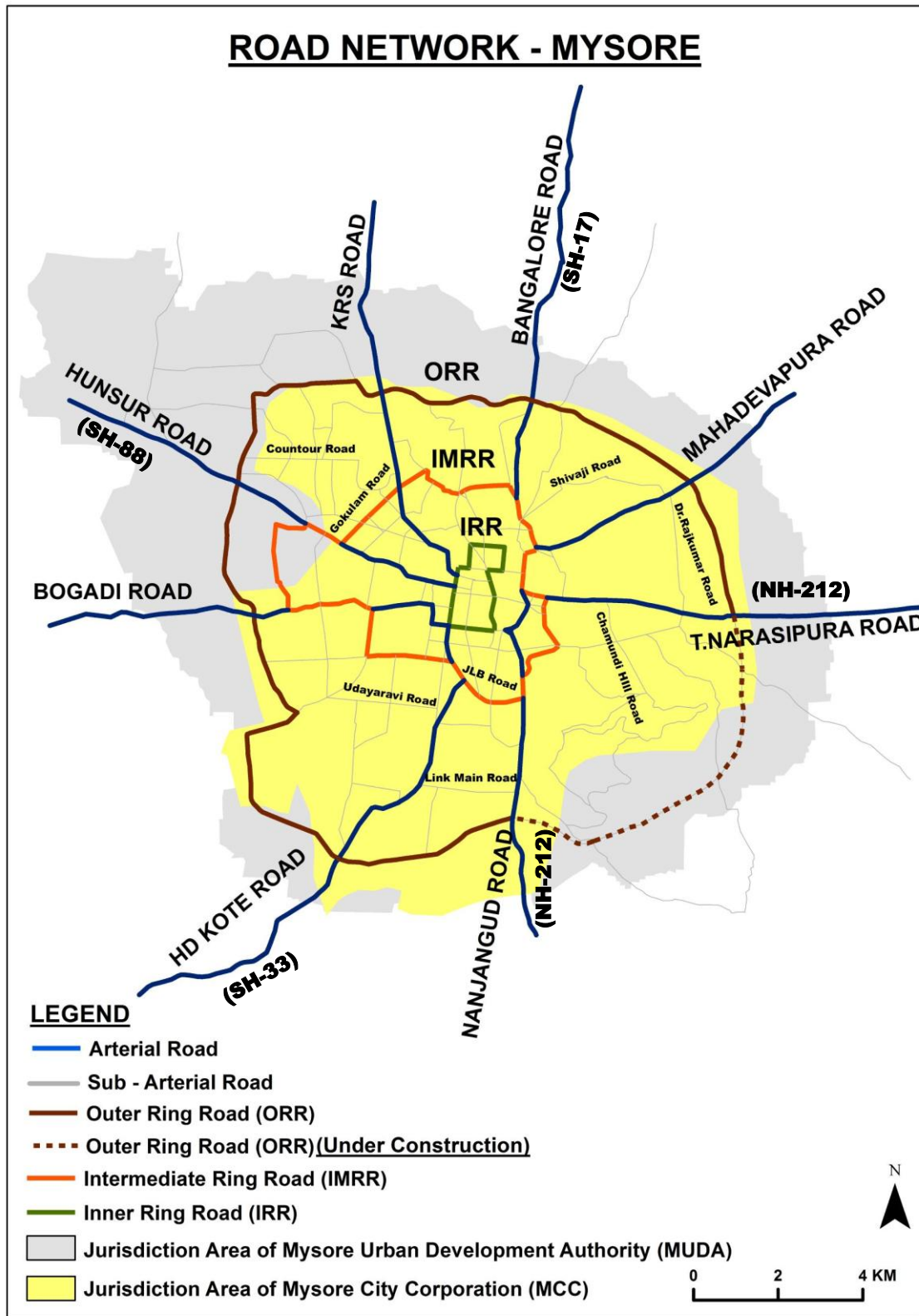
Figure 2.1 Road Network in Bengaluru

(Source: Jointly prepared by DULT and JICA Study Team)

## **(2) Mysore**

There are eight radial roads and three ring roads in Mysore. Amongst the eight radial roads, four of them are state highways and one of them is national highway. SH17, called Bangalore Road, connects Mysore and Bengaluru. Some sections of these roads are developed as four-lane road. However the remaining sections are mostly two-lane. The innermost ring is Inner Ring Road (IRR) and covers the core area which is the busiest area in Mysore. Intermediate Ring Road (IMRR) encircles the IRR. The outermost ring road in Mysore is Outer Ring Road (ORR) and constructed as six lane road. The south-east section is missing. Neither continuous grade separations nor flyover are developed on these ring roads.

The road network in Mysore is shown in Figure 2.2.



**Figure 2.2 Road Network in Mysore**

(Source: Jointly prepare by DULT and JICA Study Team)

### 2.1.3 Public Transportation

Public transportation currently available in Bengaluru and Mysore is summarised in Table 2.1.

**Table 2.1 Public Transportation in Bengaluru and Mysore**

City	Public Transport	Current Status
Bengaluru	Metro Rail	<ul style="list-style-type: none"> <li>Bengaluru Metro, called “Namma Metro”, is currently under development by Bengaluru Metro Rail Corporation Limited (BMRCL), a special purpose vehicle entrusted with implementation and operation of Bengaluru Metro.</li> <li>A total in length of 127.3km metro network is planned in three phases; 42.3km in Phase-I, 72km in Phase-II and 13km in Phase-III respectively.</li> <li>The construction of the metro corridor in Phase-I is underway and it is expected to complete in December 2015.</li> <li>The sections of 6.7km have been in operation since October 2011.</li> </ul>
	City Bus	<ul style="list-style-type: none"> <li>The bus transport in Bengaluru is operated by Bangalore Metropolitan Transport Corporation (BMTTC).</li> <li>It offers the bus services in urban, sub-urban and rural areas.</li> <li>BMTTC currently operates approximately 6,700 buses carrying about 4.95 million daily passengers.</li> </ul>
Mysore	City Bus	<ul style="list-style-type: none"> <li>The major public transport in Mysore is bus transport, operated by Karnataka State Road Transport Corporation (KSRTC).</li> <li>It operates 5,824 routes of 551,164 km in total.</li> <li>The city bus route network consists of 192 routes with average route length of 14.5km.</li> <li>There are 220 bus schedules on these routes with approximate 400 buses.</li> <li>Approximate daily passengers are 175,000, trip bases.</li> <li>Average daily service kilometre in Mysore is 226km.</li> </ul>

(Source: JICA Study Team)

## 2.1.4 Related Studies and Development Plans

The related studies and major development plans in Bengaluru are summarised in Table 2.2.

**Table 2.2 Related Studies and Development Plans**

National/Regional	Studies and Development Plans	Remark
National	National Urban Development Plan (NUTP)	It is a national policy for urban transport formulated under National Urban Renewal Mission (NURM) by Government of India
Bengaluru	Master Plan Bengaluru 2015	Master Plan Bengaluru 2015 was prepared by Bangalore Development Authority (BDA) under Karnataka Town and Country Planning Act. It serves as a foundation for developing strategic plans and local area plans.
	Comprehensive Traffic and Transportation Plan for Bengaluru (CTTP)	It was prepared in 2011 to develop transport network. It was formulated under the framework envisaged by NUTP.
	Comprehensive Traffic and Transportation Study for Bengaluru (CTTS)	It is currently under preparation by Bangalore Regional Development Authority (BMRDA). It sets out the policies and strategies and formulates a roadmap for improvement of transport in Bengaluru for the future under the framework of National Urban Transport Policy (NUTP)
Mysore	Master Plan Mysore 2031	The Master Plan Mysore 2031 has been prepared by Mysore Urban Development Authority (MUDA). The vision of Master Plan Mysore 2031 sets out framework and direction of urban development. Master Plan covers comprehensive sectors including land use, sewage, power supply and etc.
	Comprehensive Traffic and Transportation Plan for Mysore (CTTP)	The Comprehensive Traffic and Transportation Plan (CTTP) is a policy document and a basis for the development of Mysore addressing transportation issues and proposing a transportation plan in Mysore. The CTTP 2012 was prepared by DULT in line with the framework of National Urban Transport Policy (NUTP), 2006.

(Source: JICA Study Team)



## 2.1.5 Current Condition of ITS

### (1) Bengaluru

Some ITS components have been introduced and in operation in Bengaluru. Table 2.3 summarises ITS in Bengaluru.

**Table 2.3 Current Condition of ITS in Bengaluru**

Agency	Component	Description
ITS Components of Bangalore Traffic Police (B-TRAC)	Traffic Management Centre (TMC)	<ul style="list-style-type: none"> <li>• Located in a headquarters of Bangalore Traffic Police</li> <li>• A large-size video wall of 83' x 11' in size</li> <li>• 40 workstations for operators</li> <li>• TMC monitors 20 major corridors in Bengaluru</li> </ul>
	CCTV Camera	<ul style="list-style-type: none"> <li>• CCTV cameras installed at 179 intersections</li> <li>• CCTV cameras monitor traffic condition at intersection</li> </ul>
	Over-speed Enforcement Camera	<ul style="list-style-type: none"> <li>• 5 speed cameras installed in the city</li> <li>• It captures over-speeding vehicle and transmit the information to TMC</li> </ul>
	Variable Message Sign (VMS)	<ul style="list-style-type: none"> <li>• 20 VMS installed in the city</li> <li>• Static messages e.g. for safety are shown on VMS</li> </ul>
	Traffic Signal	<ul style="list-style-type: none"> <li>• 352 signals exist in the city</li> <li>• Signal phase timings are changed by operator from TMC</li> </ul>
	Traffic Violation Enforcement System	<ul style="list-style-type: none"> <li>• It is called "E-Challan" system</li> <li>• It takes pictures of vehicle violated traffic regulation</li> <li>• It generates penalty notice by identifying the vehicle number plate based on the captured pictures</li> </ul>
	Vehicle Database	<ul style="list-style-type: none"> <li>• Online connection from TCC to vehicle database of Department of Transport</li> </ul>
Bangalore Metropolitan Transport Corporation (BMTCL)	Vehicle Tracking System (VTS)	<ul style="list-style-type: none"> <li>• It monitors city bus location</li> <li>• GPS unit to be installed on 6,500 city buses</li> </ul>
	Electronic Ticketing System (ETS)	<ul style="list-style-type: none"> <li>• Electronic Ticketing Machine (ETM) to issue printed ticket</li> <li>• Smart card for electronic payment (planned)</li> </ul>
	Passenger Information System (PIS)	<ul style="list-style-type: none"> <li>• It provides bus arrival information at bust stop</li> <li>• Information is also provided through web site, SMS, and automated voice service</li> </ul>
	Data Centre	<ul style="list-style-type: none"> <li>• Centre servers of above sub systems</li> </ul>
	Command Control Centre	<ul style="list-style-type: none"> <li>• It monitors bus location</li> <li>• It manages administrative work for bus operation</li> <li>• It is equipped with video wall and workstations</li> </ul>
<b>BMRCCL (*1)</b>	Electronic Fare Collection	<ul style="list-style-type: none"> <li>• Smart token</li> <li>• Contactless smartcard</li> </ul>
<b>KSTD (*2)</b>	Taxi Tracking System	<ul style="list-style-type: none"> <li>• Taxis equipped with GPS devices</li> </ul>
Bangalore Elevated Tollway	Highway Traffic Management System	<ul style="list-style-type: none"> <li>• CCTV Surveillance System</li> <li>• Automatic Vehicle Counting and Classification System</li> <li>• Meteorological System</li> <li>• Variable Message Sign Boards (VMS)</li> <li>• Emergency Call Boxes (ECB) for emergency</li> <li>• Mobile route patrol</li> <li>• HTMS Control Room</li> </ul>
	Toll Management System	<ul style="list-style-type: none"> <li>• Electronic Toll Collection System (ETC) (to be replaced to RFID system)</li> <li>• Touch &amp; Go (TnG) system using smartcard</li> <li>• Manual Toll Collection</li> </ul>
<b>Department of Transport (DOT)</b>	Vehicle Database	<ul style="list-style-type: none"> <li>• Registration of Motor Vehicles</li> </ul>

Note (\*1): Bangalore Metro Rail Corporation Limited

Note (\*2): Karnataka State Tourism Development Corporation

(Source: JICA Study Team)

**(2) Mysore**

Some ITS components have been introduced and in operation in Mysore. Table 2.3 summarises ITS in Mysore.

**Table 2.4 Current Condition of ITS in Mysore**

Agency	Component	Description
<b>Mysore Traffic Police (M-TRAC)</b>	Command Centre	<ul style="list-style-type: none"> <li>• Located in headquarters of Mysore Traffic Police</li> <li>• LED video wall consisted by 4 units in size of 40 inches</li> <li>• 4 operator work stations</li> </ul>
	CCTV Camera	<ul style="list-style-type: none"> <li>• 42 CCTV cameras installed at intersections</li> <li>• CCTV cameras monitor traffic condition at intersection</li> </ul>
	Over-speed Enforcement Camera	<ul style="list-style-type: none"> <li>• 5 speed cameras installed in the city</li> <li>• It captures over-speeding vehicle and transmit the information to centre</li> </ul>
	Traffic Signal	<ul style="list-style-type: none"> <li>• 52 signals installed in the city</li> <li>• Signal timings are manually changed</li> </ul>
	Traffic Violation Enforcement System	<ul style="list-style-type: none"> <li>• It is called "E-Challan" system</li> <li>• It takes pictures of vehicle violated traffic regulation</li> <li>• It generates penalty notice by identifying the vehicle number plate based on the captured pictures.</li> </ul>
	Vehicle Database	<ul style="list-style-type: none"> <li>• Online connection from TCC to vehicle database of Department of Transport</li> </ul>
<b>Karnataka State Road Transport Corporation (KSRTC)</b>	Vehicle Tracking System (VTS)	<ul style="list-style-type: none"> <li>• It monitors city bus location</li> <li>• GPS units installed on 500 buses</li> </ul>
	Electronic Ticketing System (ETS)	<ul style="list-style-type: none"> <li>• Electronic Ticketing Machine (ETM) to issue printed ticket</li> </ul>
	Passenger Information System (PIS)	<ul style="list-style-type: none"> <li>• It provides bus arrival information at bus stop</li> <li>• Information is also provided through web site, SMS and etc.</li> </ul>
	Data Centre	<ul style="list-style-type: none"> <li>• Centre servers of above sub systems</li> </ul>
	Command Control Centre	<ul style="list-style-type: none"> <li>• It monitors bus location</li> <li>• It manages administrative work for bus operation</li> <li>• It is equipped with video wall and workstations</li> </ul>
<b>Department of Transport (DOT)</b>	Vehicle Database	<ul style="list-style-type: none"> <li>• Registration of Motor Vehicle</li> </ul>

(Source: Prepared by JICA Study Team based on interviews with the respective agencies)

## **2.2 Opinion Survey**

ITS Opinion Survey was carried out for the purpose of identifying potential needs. It was conducted in Bengaluru and Mysore. The surveyors randomly distributed the interview sheets and collected the responses on the spot in the vicinity of shopping malls, parking lots of government institutions and other places

The opinions were collected from the users of motorcycle, car, bus, metro, truck and ambulance.

The results of the survey are summarised in the Table 2.5 and Table 2.6.

Table 2.5 Summary of ITS Opinion Survey Results for Bengaluru Metropolitan Area

Target	Required Information and ITS Facilities	Traffic and Transportation Problems	Solutions	Congestion Pricing	Other Problems
Motorcycle User	<ul style="list-style-type: none"> <li>Travel Time to Destination</li> <li>Congestion Length</li> <li>Information Provision to Mobile Phone and VMS</li> </ul>	<ul style="list-style-type: none"> <li>Insufficient Road Capacity</li> <li>Too Many Vehicles</li> </ul>	<ul style="list-style-type: none"> <li>Strict Enforcement of Traffic Rules</li> <li>Improvement of Public Transport Service</li> <li>Real time Traffic Information</li> <li>Congestion and Route Guidance Information</li> </ul>	<ul style="list-style-type: none"> <li>46% Agreed</li> </ul>	<ul style="list-style-type: none"> <li>Inconvenient Public Transport</li> </ul>
Car User	<ul style="list-style-type: none"> <li>Congestion Location</li> <li>Travel Time to Destination</li> <li>Congestion Length</li> <li>Alternative Route</li> <li>Traffic Incident</li> </ul>	<ul style="list-style-type: none"> <li>Insufficient Road Capacity</li> <li>Too Many Vehicles</li> </ul>	<ul style="list-style-type: none"> <li>Strict Enforcement of Traffic Rules</li> <li>Improvement of Public Transport Service</li> <li>Realtime Traffic Information</li> </ul>	<ul style="list-style-type: none"> <li>46% Agreed</li> </ul>	<ul style="list-style-type: none"> <li>Inconvenient Public Transport</li> </ul>
Bus User	<ul style="list-style-type: none"> <li>Smartcard</li> <li>Information at Bus Stop and on Board Bus</li> <li>Realtime traffic Information</li> </ul>	<ul style="list-style-type: none"> <li>Insufficient Road Capacity</li> <li>Too Many Vehicles</li> </ul>	<ul style="list-style-type: none"> <li>Strict Enforcement of Traffic Rules</li> <li>Improvement of Public Transport Service</li> <li>Realtime Traffic Information</li> </ul>	<ul style="list-style-type: none"> <li>65% Agreed (for private vehicles only)</li> </ul>	<ul style="list-style-type: none"> <li>Congested Bus</li> <li>Long Waiting Time at Bus Stop</li> <li>Expensive Fare</li> <li>Absence of Route, Time and Fare Information at Bus Stop</li> </ul>
Metro User	<ul style="list-style-type: none"> <li>Common Prepaid Card</li> <li>Transfer Facility</li> </ul>	<ul style="list-style-type: none"> <li>Insufficient Road Capacity</li> <li>Too Many Vehicles</li> <li>Bad Driving Manners</li> </ul>	<ul style="list-style-type: none"> <li>Strict Enforcement of Traffic Rules</li> <li>Improvement of Public Transport Service</li> <li>Realtime Traffic Information</li> </ul>	<ul style="list-style-type: none"> <li>79% Agreed (for private vehicles only)</li> </ul>	
Truck Driver	<ul style="list-style-type: none"> <li>Traffic incident</li> <li>Alternative Route</li> <li>Car Navigation System</li> </ul>	<ul style="list-style-type: none"> <li>Insufficient Road Capacity</li> <li>Too Many Vehicles</li> </ul>	<ul style="list-style-type: none"> <li>Strict Enforcement of Traffic Rules</li> <li>Improvement of Public Transport Service</li> </ul>	<ul style="list-style-type: none"> <li>1% Agreed</li> <li>99% Disagreed</li> </ul>	<ul style="list-style-type: none"> <li>Current Traffic Information System</li> </ul>
Ambulance Driver	<ul style="list-style-type: none"> <li>Congested Location</li> <li>Alternative Route</li> <li>Travel Time to Destination</li> <li>Car Navigation System</li> </ul>		<ul style="list-style-type: none"> <li>Awareness to Public</li> <li>Improvement of Driving Manners</li> <li>Clearance of Traffic on the Road</li> <li>Command Control Room for Ambulance</li> </ul>	<ul style="list-style-type: none"> <li>100% Agreed (for private vehicles only)</li> </ul>	<ul style="list-style-type: none"> <li>Current Traffic Information System</li> </ul>

(Source: JICA Study Team)

**Table 2.6 Summary of ITS Opinion Survey Results for Mysore**

Target	Required Information and ITS Facilities	Traffic and Transportation Problems	Solutions	Congestion Pricing	Others
Motorcycle User	<ul style="list-style-type: none"> <li>Congested location information</li> <li>Alternative Route Information</li> <li>Traffic Incident</li> </ul>	<ul style="list-style-type: none"> <li>Increasing vehicle</li> </ul>	<ul style="list-style-type: none"> <li>Strict enforcement of traffic rules</li> <li>Improvement of public transport</li> </ul>	Not required	<ul style="list-style-type: none"> <li>Traffic condition is generally good, but increasing vehicle is emerging issue</li> </ul>
Car User	<ul style="list-style-type: none"> <li>Congested location information</li> <li>Alternative Route Information</li> <li>Traffic Incident</li> </ul>		<ul style="list-style-type: none"> <li>Strict enforcement of traffic rules</li> </ul>	Not required	
Bus User	<ul style="list-style-type: none"> <li>Smartcard</li> <li>Information display board at bus stops</li> </ul>		<ul style="list-style-type: none"> <li>Strict enforcement of traffic rules</li> </ul>	Not required	
Truck Driver	<ul style="list-style-type: none"> <li>Congested location information</li> <li>Alternative Route Information</li> <li>Traffic Incident</li> </ul>		<ul style="list-style-type: none"> <li>Strict enforcement of traffic rules</li> </ul>	Not required	
Domestic Tourist	<ul style="list-style-type: none"> <li>Sight visit information</li> <li>Route guidance information</li> </ul>	<ul style="list-style-type: none"> <li>Lack of tourist spot guidance information</li> <li>Insufficient tourism information</li> </ul>	<ul style="list-style-type: none"> <li>Improvement of basic pedestrian infrastructure</li> </ul>	-	<ul style="list-style-type: none"> <li>Introducing eco-friendly vehicle</li> <li>Improvement of clearness and hygiene</li> </ul>
International Tourist				-	

(Source: JICA Study Team)

## 2.3 Summary of Identified Issues

### (1) Bengaluru

According to the studies so far, the issues in Bengaluru are identified and summarised in the Table 2.7.

**Table 2.7 Identified Issues in Bengaluru**

Category	Issues	Sources	CTTP	CTTS	Opinion Survey	Other Sources *1	Observed by JICA Study Team *2
Road Traffic	High proportion of motorcycle and auto rickshaw		●	●			
	Chronic traffic congestion		●	●	●	●	
	A large number of accidents			●		●	
	Increasing air pollution and noise		●			●	
Road Infrastructure	Complex road network due to many roads converted for one-way driving						●
	Insufficient road infrastructure to accommodate traffic demand		●		●		
	Deteriorated road surface conditions such as Ill-paved , speed breakers, unclear lane markings			●		●	
	On road parking occupying road spaces		●	●			
	Limited off road parking facilities		●	●			
	Water logging when it rains					●	
	Absence of vulnerable-friendly spaces such as separate sidewalks, crash barriers, slopes, narrow space of footpath etc		●	●		●	
	Limited bicycle ways		●				
Public Transport	Inefficient connectivity between different transport modes				●		
	Many ground-level railway crossings blocking road traffic					●	
	Insufficient information of the public transport				●		
	Improper location of bus stops						●
	Poor condition of public bus					●	
	Inconvenience to purchase ticket due to lack of efficient ticketing system						●
	Consequently high demand of road traffic		●				
Traffic Manner	Lack of traffic discipline				●	●	
	Lack of awareness of importance of traffic discipline			●	●	●	
Facilities	Number of broken roadside facilities					●	
	Absence of systems and data to support traffic and road management						●
	Absence of asset management						●
	Absence of sufficient traffic information				●		
	Inefficient toll payment system resulting in frequent long queue of vehicles						●

Category	Issues	S o u r c e s	CTTP	CTTS	Opinion Survey	Other Sources ※1	Observed by JICA Study Team ※2
Management and Coordination	Uncoordinated manner amongst concerned agencies for infrastructure planning, traffic management and road management			●			
	Haphazard road works and planning due to above			●			
	Complex administrative structure of facility management through procurement, installation, operation and management			●			
	Unclear responsibility amongst involved agencies due to above			●			
	Inconsistent operation and maintenance due to above			●			
	Lack of sufficient engineering expertise and knowledge and capacity building opportunities				●		

※1 : Information and materials that have been obtained by JICA Study Team, other than sources listed above. News articles are also included.

※2 : Observations by JICA Study Team on the items which are not covered by above listed sources.

(Source: JICA Study Team)

(2) Mysore

The issues in Mysore are identified and summarised in the Table 2.8.

**Table 2.8 Identified Issues in Mysore**

Category	Source of Issues Issues	CTTP	Master Plan	Opinion Survey	Others (*1)	Observed by JICA Team (*2)
Road Traffic	Heterogeneous traffic condition	●				
	Rapid increase of vehicles		●	●		
	Traffic congestion in core area	●				
	Increasing number of accidents	●			●	
Road Infrastructure	Insufficient road infrastructure to accommodate traffic demand	●	●			
	Insufficient road surface conditions such as Ill-paved, speed breakers, unclear lane markings	●		●		
	On road parking occupying road spaces	●				
	Limited off road parking facilities	●				
	Improper road and interchange structure					●
	Absence of vulnerable-friendly spaces such as separate sidewalks, crash barriers, slopes, narrow space of footpath etc	●		●		
Public Transport	Inefficient connectivity between different transport modes	●				
	Absence of facilities for pedestrians and passengers to avoid conflict between pedestrian and vehicles	●				
	Inconvenience to purchase ticket due to lack of efficient ticketing system			●		
	Consequently high demand of road traffic	●				
Traffic Manner	Lack of traffic discipline	●				
	Lack of awareness of importance of traffic discipline	●				
Facilities	Number of broken roadside facilities					●
	Improper cycle of traffic signal at major interchanges					●
	Absence of systems and data to support traffic and road management					●
	Absence of dynamic traffic information					●
	Lack of parking facility	●				
Tourism	Lack of tourist spot guidance information			●		
	Insufficient tourism information			●		
	Lack of route guidance information			●		
Administration	Uncoordinated manner amongst concerned agencies for infrastructure planning, traffic management and road management	●				
	Haphazard road works and planning due to above	●				
	Lack of sufficient engineering expertise and knowledge and capacity	●				

\*1: Others means other materials collected by JICA Study Team including new paper article and interview to Indian authority.

\*2: Observations by JICA Study Team on the items which are not covered by above listed sources.

(Source: JICA Study Team)



### 3 Policy for ITS

The study described in this chapter was carried out for ITS Master Plan preparation. ITS Master Plan for Bengaluru Metropolitan Area and Mysore was formulated based on the study made in this chapter.

#### 3.1 Bengaluru Metropolitan Area

##### (1) Vision

Based on the studies so far, ITS Master Plan for Bengaluru Metropolitan Area sets out its vision as stated below.

- **Enhance quality of life by utilising latest technologies to deliver convenience and comfort of mobility**
- **Optimize efficiency to achieve sustainable urban growth and greater productivity**
- **Achieve greater travel efficiency and safety in harmony with environment**

##### (2) Goals and Objectives of ITS

Under the visions of ITS for Bengaluru, the goals are set out to be achieved. They are accessibility, efficiency, safety and reduced environmental impact as shown in Table 3.1.

**Table 3.1 Goals of ITS**

<b>Goal</b>	<b>Description</b>
Accessibility	To reduce travel time and cost To provide travel/traffic information To support vulnerable people
Efficiency	To enhance road/traffic management To enhance intermodal connectivity To enhance efficiency of road use
Safety	To reduce traffic accidents To enhance response for emergency To enhance pedestrian facilities
Environment and Energy	To reduce air pollution To reduce CO <sub>2</sub> emissions To reduce energy consumption

(Source: JICA Study Team)

## 3.2 Mysore

### (1) Vision

ITS Master Plan for Mysore sets out its vision as stated below.

- **Enhance quality of life and convenience of tourists by utilising latest technologies**
- **Achieve better environmental friendly mobility through integrated manner for urban transport**
- **Optimize efficiency to achieve sustainable urban growth by protecting heritage value of the city**

### (2) Goals and Objectives of ITS

Under the visions of ITS for Mysore, the goals are further set out to be achieved. They are accessibility, efficiency, safety and reduced environmental impact. The goals and their descriptions are as shown in Table 3.1.

**Table 3.2 Goals of ITS**

<b>Goal</b>	<b>Description</b>
Accessibility	To reduce travel time and cost To provide travel/traffic information To provide tourist information
Efficiency	To enhance road management To enhance Pedestrian and NMT connectivity To enhance efficiency of road use
Safety	To reduce traffic accidents To enhance response for emergency
Environment and Energy	To reduce air pollution To reduce CO <sub>2</sub> emissions To reduce energy consumption

(Source: JICA Study Team)

### **3.3 Strategies and ITS Components**

#### **3.3.1 Strategies**

In order to achieve the goals, the following 9 strategies shall be executed.

- (1) Quantitative Data Collection, Analysis, Storage and Provision**
- (2) Integration and Utilisation of Data and Information Available in Various Sources**
- (3) Centrally Coordinated Administrative Structure to Realise Proper Coordination**
- (4) Proper Decision Making on Urban Transport**
- (5) Proper Traffic Control and Management**
- (6) Proper Road Management**
- (7) Traffic Demand Management**
- (8) Efficient Public Transport Connectivity**
- (9) ITS Promotion and Coordination with ITS National Policy**

#### **3.4 ITS Focus Area and ITS Component for Strategies**

For the strategies set out in the previous clause, ITS measures and administrative measures such as setting up required organisations need to be taken together with. This clause considers in viewpoint of ITS measures.

In order to execute the strategies, ITS focus areas are defined. ITS Components to realise the ITS focus areas are then identified as shown in Table 3.3 and Table 3.4.

**Table 3.3 ITS Components by ITS Focus Areas for Bengaluru Metropolitan Area**

ITS Focus Area	ITS Component (*1)
1) Collecting Quantitative and Effective Information for Traffic	Traffic Data Collection System Highway Traffic Management System
2) Assisting Implementation of Traffic Management	Traffic Data Collection System Traffic Condition Monitoring System Traffic Information Provision System Traffic Accident Management System Parking Management System Area Traffic Signal Control System Electronic Road Pricing System Highway Traffic Management System
3) Assisting Urban Transport and Road Planning	Traffic Data Collection System Traffic Condition Monitoring System Traffic Accident Management System Highway Traffic Management System
4) Assisting Parking Efficiency and Planning	Traffic Data Collection System Parking Management System
5) Assisting Measures on Traffic Accident and Safety	Traffic Condition Monitoring System Traffic Accident Management System Highway Traffic Management System Overloaded Vehicle Monitoring System
6) Assisting Smooth Traffic Flow	Parking Management System Traffic Information Provision System Area Traffic Signal Control System Electronic Road Pricing System Toll Management System
7) Assisting Traffic Enforcement	Traffic Regulation Violation Enforcement System Overloaded Vehicle Monitoring System
8) Assisting Road Management Work	Road Inventory System
9) Providing Pre-Trip and En-Route Road Traffic Information to Road Users	Parking Management System Traffic Information Provision System
10) Assisting Inter-modal Connectivity	Common Smartcard System Passenger Information Provision System
11) Providing Information on Public Transport	Passenger Information Provision System
12) Assisting Vulnerable Road Users	Safety Assistance System for Vulnerable Road Users
13) Assisting Commercial Activities	Traffic Information Provision System Area Traffic Signal Control System Commercial Vehicle Management System
14) Assisting Emergency Vehicle Activities	Area Traffic Signal Control System
15) Assisting Efficiency in Public Transport Operation	Public Transport Operation Management System Public Transport Fare Payment System Common Smartcard System

Note (\*1): There are a number of ITS components to realise ITS focus area other than listed above. The ITS components which can contribute more directly to the ITS focus are listed.

(Source: JICA Study Team)

**Table 3.4 ITS Components by ITS Focus Areas for Mysore**

ITS Focus Area	ITS Component (*1)
1) Collecting Quantitative and Effective Information for Traffic	Traffic Data Collection System
2) Assisting Implementation of Traffic Management	Traffic Data Collection System Traffic Condition Monitoring System Traffic Information Provision System Traffic Accident Management System Parking Management System Area Traffic Signal Control System
3) Assisting Urban Transport Road Planning	Traffic Data Collection System Traffic Condition Monitoring System Traffic Accident Management System
4) Assisting Parking Efficiency and Planning	Traffic Data Collection System Parking Management System
5) Assisting Measures on Traffic Accident and Safety	Traffic Condition Monitoring System Traffic Accident Management System Overloaded Vehicle Monitoring System
6) Assisting Smooth Traffic Flow	Parking Management System Traffic Information Provision System Area Traffic Signal Control System
7) Assisting Traffic Enforcement	Traffic Regulation Violation Enforcement System Overloaded Vehicle Monitoring System
8) Assisting Road Management Work	Road Inventory System
9) Provision Pre-trip and En-route Road Traffic Information to Road Users	Parking Management System Traffic Information Provision System
10) Assisting Inter-modal Connectivity	Common Smartcard System Passenger Information Provision System
11) Providing Information on Public Transport	Passenger Information Provision System
12) Assisting Vulnerable Road Users	Safety Assistance System for Vulnerable Road Users
13) Assisting Commercial Activities	Traffic Information Provision System Area Traffic Signal Control System Commercial Vehicle Management System
14) Assisting Emergency Vehicle Activities	Area Traffic Signal Control System
15) Assisting Efficiency in Public Transport Operation	Public Transport Operation Management System Public Transport Fare Payment System Common Smartcard System

Note (\*1): There are a number of ITS components to realise ITS focus area other than listed above. The ITS components which can contribute more directly to the ITS focus are listed.

(Source: JICA Study Team)

### **3.5 Proposed ITS Component for ITS Master Plan for Bengaluru Metropolitan Area and Mysore**

Based on the consideration of current situation in Bengaluru and Mysore, and other aspects, ITS components are selected and proposed for Bengaluru Metropolitan Area and Mysore amongst the ITS components shown in the tables on the previous clause.

Other aspects considered for selection of ITS include systems that collect quantitative traffic data, systems that improve traffic flow, systems that generate and provide dynamic traffic information, systems that assist to enhance convenience and travel reliability for users and tourists.

The proposed ITS components for Bengaluru and Mysore are :

- (1) Proposed ITS Components for Bengaluru**
  - (a) Traffic Data Collection System**
  - (b) Traffic Information Provision System**
  - (c) Electronic Road Pricing System**
  - (d) Area Traffic Signal Control System**
  - (e) Highway Traffic Management System for PRR**
  - (f) Toll Management System for PRR**
  - (g) Common Smartcard System**
  
- (2) Proposed ITS Components for Mysore**
  - (a) Traffic Data Collection System**
  - (b) Traffic Information Provision System**
  - (c) Parking Management System**
  - (d) Area Traffic Signal Control System**
  - (e) Common Smartcard System**

These ITS components are prioritised based on the phasing policy described on the next clause.

The details for process of selection of ITS components can be found in the Final Report.

### 3.6 Phasing Policy of ITS

Amongst the selected ITS components, some of them can be implemented in short period. Others require longer period for development. In addition, advancement of information technology is significantly rapid in nature.

In consideration of such aspects, phased development policies are set out in three phases respectively as shown in the Table 3.5.

**Table 3.5 Phased Development Policy**

Phases		Year	Policies
Phase-1	Bengaluru	2015 - 2019 (1-5 Years)	<ul style="list-style-type: none"> <li>To develop ITS components which can be implemented in short period</li> <li>To start operation of above ITS components</li> <li>To start preparation of ITS components which require a relatively long period for development</li> </ul>
	Mysore	2015 - 2017 (1-3 Years)	
Phase-2	Bengaluru	2020 - 2024 (6-10 Years)	<ul style="list-style-type: none"> <li>To expand and upgrade ITS components which are implemented in Phase-1</li> <li>To start operation of ITS components which started preparation in Phase-1</li> </ul>
	Mysore	2018 - 2022 (4-8 Years)	
Phase-3	Bengaluru	2025 - (After 10 years)	<ul style="list-style-type: none"> <li>To upgrade functions, adopting new technologies</li> </ul>
	Mysore	2023 - (After 8 years)	

(Source: JICA Study Team)

### 3.7 Proposed ITS Component and Implementation Schedule

Based on considerations so far, ITS components are proposed and implementation schedule is set out as shown in the Table 3.6 and Table 3.7.

**Table 3.6 Proposed ITS Component and Implementation Schedule for Bengaluru Metropolitan Area**

Technical Prerequisite for ITS and Major Event		Phase-1					Phase-2					Phase-3	Remark	
		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025		
Technical Recommendation	Improvement of Vehicle Registration													Recommended for vehicle registration implementation by mid of 2018
	Standardisation of Vehicle Number Plate													Recommended for vehicle number plate implementation by mid of 2018
Major Event Related to ITS	Peripheral Ring Road (PRR)													Preparation process includes land acquisition, civil work, and etc.
	Bengaluru Metro													
	ITS Master Plan													Revising ITS Master Plan is recommended.
Selected ITS Components		Phase-1					Phase-2					Phase-3	Remark	
		2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025		
Bengaluru Traffic Information System	Traffic Data Collection System													- It will be prepared as a component of Bengaluru Traffic Information System. - The coverage area will be expanded in expansion stage.
	Traffic Information Provision System													- It will be prepared as a component of Bengaluru Traffic Information System. - The coverage area will be expanded in expansion stage.
Traffic Management System (Existing)	Area Traffic Signal Control System													- The area control signals will be installed in 3 stages. - They will be prepared under existing Traffic Management System of Bengaluru Traffic Police.
ITS for Peripheral Ring Road	Highway Traffic Management System (HTMS)													- HTMS will be prepared for Peripheral Ring Road. - The operation of HTMS will start at the time of commencement of service of Peripheral Ring Road.
	Toll Management System (TMS)													- TMS will be prepared for Peripheral Ring Road. - The operation of TMS will start at the time of commencement of service of Peripheral Ring Road.
Electronic Road Pricing System														- ERP will be prepared for CBD area. - The operation of ERP will start at the time of commencement of area charging at CBD.
Parking Management System														The development of parking lots are required before system installation.
Common Smartcard System														The service of Common Smartcard System will start before completion of Metro phase-2.

: Prepration (Design, Procurement, Installation, etc.)  
 : Operation

(Source: JICA Study Team)



**Table 3.7 Proposed ITS Component and Implementation for Mysore**

Technical Prerequisite for ITS and Major Event		Phase-1			Phase-2					Phase-3	Remark	
		2015	2016	2017	2018	2019	2020	2021	2022	2023-		
Technical Recommendation	Improvement of Vehicle Registration	■			■						Recommended for Vehicle Registration implementation by mid of 2018	
	Standardisation of Vehicle Number Plate	■			■						Recommended for vehicle number plate implementation by mid of 2018	
Major Event in Mysore	Public Bicycle Sharing	■	■									It is planned to start from middle of 2016 (WB grants project)
	Completion of ORR, BRTS, and improvement of major radial roads	- - - - -										Concrete schedules are not clear, thus expressed in dotted-line.
	ITS Master Plan	▲ Approval of ITS Master Plan			▲ Revising ITS Master Plan ▲						Revising ITS Master Plan is recommended.	
Selected ITS Components		Phase-1			Phase-2					Phase-3	Remark	
		2015	2016	2017	2018	2019	2020	2021	2022	2023-		
Mysore Traffic Information System	Traffic Data Collection System (ATCC)	■	■									- It will be prepared as a component of Mysore Traffic Information System. - The coverage area/function will be expanded as necessary.
	Traffic Data Collection System (Probe)	■	■									- It will be prepared as a component of Mysore Traffic Information System. - The coverage area/function will be expanded as necessary.
	Traffic Information Provision System (Internet & Mobile Application)	■	■									- It will be prepared as a component of Mysore Traffic Information System. - The coverage area/function will be expanded as necessary.
	Traffic Information Provision System (VMS)				■	■					- It will be prepared as a component of Mysore Traffic Information System. - The coverage area/function will be expanded as necessary.	
Traffic Management System (Existing)	Area Traffic Signal Control System	■	■		■						- The area control signals will be installed in core area. - They will be prepared under existing Traffic Management System of Mysore Traffic Police. - The coverage area will be expanded in expansion stage as necessary.	
Common Smartcard System		■	■									The service of common smartcard system in Mysore will participate in the clearinhouse scheme to be developed in Bengaluru.

■ : Prepration (Design, Procurement, Installation, etc.)

■ : Operation

(Source: JICA Study Team)

## 4 Conceptual Design for Proposed ITS Components

The study described in this chapter was carried out for ITS Master Plan preparation. ITS Master Plan for Bengaluru Metropolitan Area and Mysore was formulated based on the study made in this chapter.

Conceptual Design proposed for Bengaluru Metropolitan Area and Mysore was carried out for the proposed ITS component as described in Table 4.1 and Table 4.2.

**Table 4.1 Conceptual Design for Proposed ITS Components in Bengaluru Metropolitan Area**

System	Sub-system	Purpose/Function	Development Plan
Bengaluru Traffic Information System (B-TIC)	Probe Car System	<ul style="list-style-type: none"> <li>To generate dynamic traffic congestion information from probe data</li> <li>GPS unit installed on vehicle sends probe data to centre and the probe data is processed at centre</li> </ul>	<ul style="list-style-type: none"> <li>City bus agency plans to install GPS units on 6,700 city buses</li> <li>Their bus probe data will be used in early stage and other probe data will be used in later stage</li> </ul>
	Queue Length Measurement System	<ul style="list-style-type: none"> <li>To measure occupancy rate</li> <li>To supplement probe data</li> </ul>	<ul style="list-style-type: none"> <li>A total of 81 locations at heavily congested intersections are proposed</li> </ul>
	Automatic Traffic Counter-Cum-Classifier (ATCC) System	<ul style="list-style-type: none"> <li>To measure traffic volume by vehicle size at cross sections</li> </ul>	<ul style="list-style-type: none"> <li>A total of 136 locations at major road section are proposed</li> </ul>
	Variable Message Signboard (VMS) System	<ul style="list-style-type: none"> <li>To provide information on the road and traffic conditions to road users</li> </ul>	<ul style="list-style-type: none"> <li>A total of 20 locations in the city are proposed</li> </ul>
	Centre System (B-TIC)	<ul style="list-style-type: none"> <li>To process the data collected by sub-systems</li> <li>To provide traffic information to road users through various information media</li> <li>To utilise cumulated data for urban transport measures</li> <li>To monitor traffic condition</li> </ul>	<ul style="list-style-type: none"> <li>The centre is proposed to prepare in DULT building</li> </ul>
Traffic Management System	Area Traffic Control System (ATCS)	<ul style="list-style-type: none"> <li>To improve traffic flow by automatic coordination amongst signals according to traffic condition</li> </ul>	<ul style="list-style-type: none"> <li>100 signals in stage 1 and 180 signals in stage 2 and 120 signals in stage 3 are proposed</li> <li>It is proposed to prepare under existing traffic control centre of Bangalore Traffic Police</li> </ul>
ITS for Peripheral Ring Road	Toll Management System (TMS)	<ul style="list-style-type: none"> <li>To collect toll on Peripheral Ring Road</li> <li>Three types of toll collection methods (Manual, Touch And Go (TnG), and Electronic Toll Collection (ETC)) are proposed</li> </ul>	They will be developed as part of PRR construction project
	Highway Traffic Management System (HTMS)	<ul style="list-style-type: none"> <li>To monitor and manage traffic on Peripheral Ring Road</li> </ul>	
Electronic Road Pricing System	Electronic Road Pricing (ERP)	<ul style="list-style-type: none"> <li>To charge congestion pricing in the CBD area to alleviate congestion and encourage public transport usage</li> </ul>	<ul style="list-style-type: none"> <li>ERP is proposed in CBD area</li> <li>Eighteen (18) entry points for charging in CBD area is proposed</li> </ul>
Common Smart Card System	Common Smartcard	<ul style="list-style-type: none"> <li>To introduce inter-modal fare payment using common smartcard to enhance convenience</li> </ul>	<ul style="list-style-type: none"> <li>A central state level clearinghouse for settlement amongst different transport operators is proposed</li> </ul>

(Source: JICA Study Team)

**Table 4.2 Conceptual Design for Proposed ITS Components in Mysore**

System	Sub-system	Purpose/Function	Development Plan
Mysore Traffic Information System (M-TIC)	Probe Car System	<ul style="list-style-type: none"> <li>To generate dynamic traffic congestion information from probe data</li> <li>GPS unit installed on vehicle sends probe data to centre and the probe data is processed at centre</li> </ul>	<ul style="list-style-type: none"> <li>Bus agency installed GPS units on 400 city buses</li> <li>Probe data will be collected from their control centre</li> </ul>
	Automatic Traffic Counter-Cum-Classifier (ATCC) System	<ul style="list-style-type: none"> <li>To measure traffic volume by vehicle size at cross sections</li> </ul>	<ul style="list-style-type: none"> <li>A total of 22 locations are proposed</li> </ul>
	Variable Message Signboard (VMS) System	<ul style="list-style-type: none"> <li>To provide information on the road and traffic conditions to road users</li> </ul>	<ul style="list-style-type: none"> <li>A total of 6 locations in the city are proposed</li> </ul>
	Parking Availability Information System	<ul style="list-style-type: none"> <li>To provide parking availability information through VMS and Internet</li> </ul>	<ul style="list-style-type: none"> <li>VMS are proposed at three tourist locations: Mysore Palace, Chamundi Hills and Mysore zoo</li> </ul>
	Centre System (M-TIC)	<ul style="list-style-type: none"> <li>To process the data collected by sub-systems</li> <li>To provide traffic information to road users through various information media</li> <li>To utilise cumulated data for urban transport measures</li> <li>To monitor traffic condition</li> </ul>	<ul style="list-style-type: none"> <li>The centre is proposed to prepare at the same location of B-TIC at initial stage</li> </ul>
Traffic Management System	Area Traffic Control System (ATCS)	<ul style="list-style-type: none"> <li>To improve traffic flow by automatic coordination amongst signals according to traffic condition</li> </ul>	<ul style="list-style-type: none"> <li>10 signals in phase-1 and 14 additional signals in phase-2 are proposed</li> <li>It is proposed to prepare under existing traffic control centre of Mysore Traffic Police</li> </ul>

(Source: JICA Study Team)

## 5 Organisation Setup

The study described in this chapter was carried out for ITS Master Plan preparation. ITS Master Plan for Bengaluru Metropolitan Area and Mysore was formulated based on the study made in this chapter.

### (1) Proposed Institutional Framework

The steps towards implementing the proposed ITS require establishing institutional framework. The existing ITS facilities are implemented under the respective organisations. Likewise, the responsible organisations need to be designated or newly set up for the ITS components proposed by ITS Master Plan.

It is then recommended that an “ITS Society” \*<sup>1</sup> is formed by government to oversee all activities of ITS. ITS will require planning, developing, operating/maintaining, enforcing, evaluating effect, updating and assuring necessary budget. It is suggested that the ITS Society be organised by senior official of stakeholder organisations, headed by DULT, and it functions as a body for monitoring, coordinating and proposing decisions to take care of these matters.

### (2) Proposed Structure of Organisation for Operation and Maintenance: B-TIC

Bengaluru Traffic Information Centre (B-TIC) will be established to function as a single central body for collection of data on traffic, processing and provision of dynamic traffic information to road users. The collected and cumulated quantitative data on traffic is aimed to utilise for planning and evaluation of measures on urban transport as well. The information and data will be shared with the concerned agencies as necessary.

It is proposed that B-TIC is operated and maintained under supervision of government agency in charge of B-TIC. Actual operation and maintenance would be outsourced to contractor. Therefore the structure of organisation of B-TIC comprises the in-house members of the government agency and operation and maintenance teams organised by the contractor under them.

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<sup>1</sup> The ‘Society’ is a body which is entitled with legal authority and responsibility to achieve the objectives of the society. It is to be formed under Indian Society Act 1860 and registered in the Register of Society. A memorandum of association is signed by the constituent members of the society. The memorandum of association contains the name of the society, its objectives, details of the constituent members, and etc. Once registered, the society will be legally responsible for making decisions and implementing as per the objectives.

**(3) Proposed Structure of Organisation for Operation and Maintenance: ATCS in Bengaluru**

The area traffic control signal system (ATCS) aims to improve traffic flow by optimising signal timing parameters according to traffic volume and coordinating amongst signals.

The existing traffic signal is operated by the traffic management centre, B-TRAC, of Bangalore Traffic Police. ATCS is proposed to prepare under B-TRAC.

The operation of traffic signal is a part of traffic control which is a jurisdiction of traffic police. Therefore the actual operation is also recommended to carry out by the in-house member of Bangalore Traffic Police. The maintenance work would be undertaken by maintenance contractor. But supervision of their work is required as part of duty of Bangalore Traffic Police.

**(4) Proposed Structure of Organisation for Operation and Maintenance: HTMS of PRR in Bengaluru**

“Traffic Control Centre for PRR” (“TCC”) will be established to manage the traffic on PRR by monitoring traffic status and disseminating necessary information to users for 24 hours a day and 7 days a week.

It is proposed that HTMS is operated and maintained under supervision of government agency in charge of PRR. Actual operation and maintenance would be outsourced to contractor. Therefore the structure of organisation of HTMS comprises the in-house members of the government agency and operation and maintenance teams organised by the contractor under them.

**(5) Proposed Structure of Organisation for Operation and Maintenance: TMS of PRR in Bengaluru**

It is proposed that TMS is operated and maintained under supervision of government agency in charge of PRR. Actual operation and maintenance would be outsourced to contractor. Therefore the structure of organisation of TMS comprises the in-house members of the government agency and operation and maintenance teams organised by the contractor under them.

**(6) Proposed Structure of Organisation for Operation and Maintenance: ERP in Bengaluru**

Electric Road Pricing (ERP) centre will function as a single central body for collection of congestion fee and RFID data.

It is proposed that ERP is operated and maintained under supervision of government agency in charge of ERP. Some operation and maintenance would be outsourced to contractor. Therefore the structure of organisation of ERP comprises the in-house members of the government agency and operation teams and maintenance teams organised by the contractor under them.

**(7) Proposed Structure of Organisation for Operation and Maintenance: Clearinghouse in Bengaluru**

The clearinghouse settles the payment of different transport and services used by a single smart card. It is proposed that the clearinghouse is operated and maintained under supervision of government agency in charge of the clearinghouse. The settlement of fare payment is a major activity and it entails a financial responsibility. Therefore it is recommended that the operation team consists of the in-house members of the government agency. Actual maintenance would be undertaken by contractor.

**(8) Proposed Structure of Organisation for Operation and Maintenance for M-TIC**

It is proposed that M-TIC is operated and maintained under supervision of government agency in charge of M-TIC. Actual operation and maintenance would be outsourced to contractor. Therefore the structure of organisation of M-TIC comprises the in-house members of the government agency and operation and maintenance teams organised by the contractor under them.

**(9) Proposed Structure of Organisation for Operation and Maintenance: ATCS in Mysore**

The existing traffic signal is operated by the traffic management centre, M-TRAC, of Mysore Traffic Police. ATCS and centre system are proposed to prepare under M-TRAC

The operation of traffic signal is a part of traffic control under the jurisdiction of traffic police. Therefore the actual operation is also recommended to carry out by the in-house member of Mysore Traffic Police. The maintenance work would be undertaken by maintenance contractor. But supervision of their work is required as part of duty of Mysore Traffic Police.

## 6 Rough Cost Estimate

The rough costs of the proposed ITS components for Bengaluru and Mysore are estimated as shown in Table 6.1 and Table 6.2

**Table 6.1 Rough Cost Estimate of ITS Component for Bengaluru Metropolitan Area**

ITS Component		Equipment			O&M (Annual)
		Phase-1	Phase-2	Total	
Bengaluru Traffic Information System (B-TIC)	Centre System (including Probe Car System)	691,778,188	44,523,400	736,301,588	50,281,440
	Queue Length Measurement System	138,934,950		138,934,950	
	Automatic Traffic Counter-Cum Classifier (ATCC) System	197,324,820		197,324,820	
	Variable Message Sign (VMS) System	161,475,353	161,475,353	322,950,705	
	Internet System	66,792,000	1,265,000	68,057,000	
<b>Subtotal</b>		<b>1,256,305,310</b>	<b>207,263,753</b>	<b>1,463,569,063</b>	
ITS for Peripheral Ring Road	Highway Traffic Management System (HTMS)	703,752,149		703,752,149	39,551,318
	Toll Management System (TMS)	676,745,031		676,745,031	798,905,184
<b>Subtotal</b>		<b>1,380,497,180</b>		<b>1,380,497,180</b>	<b>838,456,502</b>
Area Traffic Signal Control System (ATCS)		848,880,665	2,309,515,215	3,158,395,880	133,660,208
Electronic Road Pricing (ERP) System		1,100,002,931		1,100,002,931	72,822,288
Clearinghouse for Common Smartcard		475,663,920		475,663,920	10,890,000
<b>Grand Total</b>		<b>5,061,350,006</b>	<b>2,516,778,968</b>	<b>7,578,128,973</b>	<b>1,106,110,438</b>

(Source: JICA Study Team)

**Table 6.2 Rough Cost Estimate of ITS Component for Mysore**

Unit=INR

ITS Component		Equipment			O&M (Annual)
		Phase-1	Phase-2	Total	
Mysore Traffic Information System (M-TIC)	Centre System (including Probe Car System)	604,443,853	0	604,443,853	40,954,232
	Automatic Traffic Counter-Cum Classifier (ATCC) System	54,264,326	0	54,264,326	
	Variable Message Sign (VMS) System	96,885,212	0	96,885,212	
	Parking Availability Information Provision System	120,373,985	0	120,373,985	
	Internet System	66,792,000	0	66,792,000	
<b>Subtotal</b>		<b>942,759,374</b>	<b>0</b>	<b>942,759,374</b>	
Area Traffic Signal Control System (ATCS)		310,169,536	0	310,169,536	28,346,736
<b>Grand Total</b>		<b>1,252,928,910</b>	<b>0</b>	<b>1,252,928,910</b>	<b>69,300,968</b>

(Source: JICA Study Team)

Based on the considerations described so far, ITS Master Plan for Bengaluru Metropolitan Area and Mysore were prepared.

The ITS Master Plans are included in the Final Report.



## 7 Pilot Project: Technical Study on Probe System

### 7.1 Objectives

ITS Master Plan proposes providing dynamic traffic congestion information generated from available probe data as one of the major ITS components. It proposes to utilise the probe data obtained from city bus as an immediate measure in early stage and other vehicles in the next step as necessary. The technologies for generating congestion information from probe data are widely available in the developed countries. However the conditions of communication and road infrastructures and traffic conditions are different in India. Thus it is important to examine usability of probe data. The technical survey called as Pilot Project was carried out to examine the usability of probe data currently available in Bengaluru, find technical issues and propose measures. The outcome of the survey aims to be used and referred as basic information for designing the system.

### 7.2 Technical Points and Sample Probe Data

The usability of probe data in Bengaluru was examined on the following technical points.

- Temporal continuity and variation tendency of probe data in a day
- Time delay characteristics of probe data
- Area coverage condition
- Comparison with actual traffic situation

The technical survey used sample probe data obtained from bus and other vehicles and compared. The probe data used for the survey is shown in Table 7.1. The probe data of taxi cab and other fleet was shared by business partner of the contractor who carried out this survey. The probe data of city bus was shared by city bus agency. All of the probe data is being used for their vehicle monitoring system. The analysis of this survey was carried out on off-line basis using the shared probe data.

**Table 7.1 Outline of Sample Probe Data**

Probe Vehicle	Probe Vehicle Number	Remarks
Taxi Cabs	600	Treated as taxi probe data in this survey
Other Fleets	1,200	
City Bus	200	Limited to 200 vehicle because the city bus monitoring system is currently under trial
Total	2,000	-

(Source: JICA Study Team)

### 7.3 What Has Been Found by Survey

- Temporal continuity and variation tendency of probe data in a day

The difference in volume of bus probe data between mid-night hours and other hours was almost 10 times mostly due to operation hours of bus service. It was approximately two times in the case of taxi probe. The volume of bus probe data significantly fluctuates throughout a day even during day-time hours. Relatively stable volume of taxi probe data was collected for 24 hours. It was confirmed that all probe data was collected through same mobile communication carrier. Thus the fluctuation of bus probe data during day-time hours could be attributed to the existing system of city bus. Much larger volume of data was collected from city bus (mostly due to transmission interval of every 10 second of bus probe data whereas one minute of taxi probe).

- Time delay characteristics of probe data

The probe data contains two times: (i) time recorded by GPS and (ii) time recorded on server. The difference between these times is defined as 'Time Delay'.

The probe data with a time delay within 30 seconds was almost 20% of total volume of probe data and less than one minute was more than 90%. The reason of 30 seconds delay could be attributed to communication situation typical in developing country. The overall time delay of probe data can be judged as acceptable range. This was evaluated together with bus and taxi probe.

- Area Coverage Condition

The bus probe data was limited on the major road understandably due to bus operating route. The taxi probe data was distributed in the entire city and almost constantly available for 24 hours. However it was not always available on the major road.

- Comparison with actual traffic situation

The location of large time delay was generally observed at the locations of slower travel speed. However it was not always the case. Rather, insufficient communication capacity on cell phone network or insufficient base stations due to large communication volume in such locations are assumed. Such locations were found mainly in the suburb in south east of the city. It was also found that small amount of probe data was available in some locations of heavily congested.

### 7.4 Conclusion of Pilot Project: Technical Study on Probe System

It can be judged that the bus probe data itself in Bengaluru is useful data for generation of real time congestion information as long as the following points are taken care of:

- Sufficient number of probe bus vehicle and stable availability of probe data need to be assured

- The communication capacity of cell phone network in Bengaluru needs to be improved. Duplicating communication network for the system is important. Such measures as using several different high quality communication carriers by comparing/confirming the communication quality of each carrier instead of depending on a single communication carrier are highly recommended. It is also important to consider duplicating communication network including Internet as much as possible because the quality of system is largely affected by the speed and stability of communication.
- Using roadside sensors at the locations of frequent congestion is recommended to cover the absence of probe data.
- The target road and time for information provision can be confined to the major road and during bus operation hour in the city in early stage and to cover others in later stage by using other sources of probe vehicle. Such service level and policy which are practicable considering restrictions and various aspects need to be defined.
- The capability of vendors for system development shall be thoroughly evaluated. Their capabilities for designing and operation need to be carefully checked. It shall be evaluated not only on superficial level, but also by such measures as specifying measures on the occasion of trouble on the contract, obtaining the detail report which describes configuration of their systems and operation status, etc.

The details of pilot project: technical study on probe system can be found in the Final Report.

## **8 Draft Specification for Proposed ITS Services for Bengaluru Metropolitan Area**

The draft specifications of prioritised ITS components in Bengaluru Metropolitan Area were prepared. It aims to assist the Indian authority to smoothly implement ITS projects by utilising them as basic technical requirements at the design stage of the project. They were prepared according to the basic concepts of the ITS components proposed by ITS Master Plan.

The draft specifications include the following systems:

- **Bengaluru Traffic Information System (B-TIC)**
- **Area Traffic Signal Control System (ATCS)**
- **Highway Traffic Management System for Peripheral Ring Road (HTMS)**
- **Toll Management System for Peripheral Ring Road (TMS)**
- **Electronic Road Pricing System (ERP)**

A standard structure of tender documents is as follows:

- (1) **Invitation for Tender**
- (2) **Instruction to Tenderers**
- (3) **Form of Tender**
- (4) **Pricing Documents**
- (5) **General Condition of Contract**
- (6) **Conditions of Particular Specifications**
- (7) **Employers Requirements Part A: General Technical Specifications**
- (8) **Employers Requirements Part B: Particular Technical Specifications**
- (9) **Employers Requirements Part C: Maintenance Specifications**
- (10) **Employers Requirements Part D: Drawings**

The draft specifications prepared by this study cover (8) “Employers Requirements Part B: Particular Technical Specifications” shown above. The Indian authority requires preparing all other documents listed above at the time of implementation before initiating tender process. It is also noted that the draft specifications need to be modified as necessary at the design stage.

## 9 Technical Tour

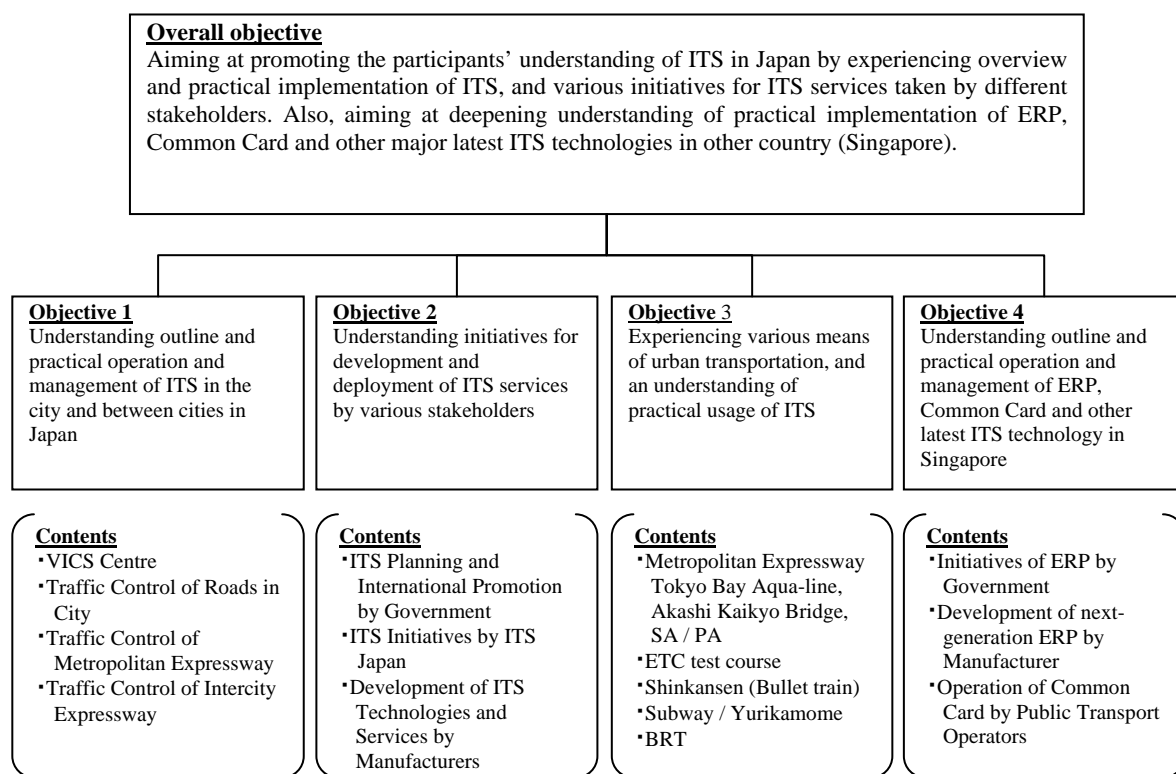
The technical tour described in this chapter was carried out for capacity building of the stakeholders as part of ITS Master Plan preparation. ITS Master Plan for Bengaluru Metropolitan Area and Mysore was formulated based on observations provided by participants of the technical tour.

### 9.1 Purpose

The technical tour to Japan and Singapore was conducted for the purpose of capacity building of ITS and also aiming to contribute building close relationship between India and Japan. It was carried out in the beginning of November 2014 to provide the important key officials in India with an opportunity to experience the practices of ITS implemented in Japan and Singapore and broaden knowledge on the technologies and operations of ITS.

### 9.2 Objectives of ITS Study Tour

Figure 9.1 shows objectives of the ITS Study Tour.



**Figure 9.1 Objectives of ITS Study Tour**

(Source: JICA Study Team)

### 9.3 Participants

A total of 12 members from stakeholder agencies in the sector of urban transport in Bengaluru and Mysore participated in ITS technical tour. The participant list is shown in Table 9.1.

**Table 9.1 Members of ITS Technical Tour to Japan/Singapore**

Region	No.	Organisation		Participants	
		Abbrev.	Full Name	Position	Name
Bangalore	1	DULT	Directorate of Urban Land Transport	Head of Traffic Engineering and Transportation Cell	Shamanth P Kuchangi (Mr.)
	2	DULT	Directorate of Urban Land Transport	Transport Planning Group Leader	Sivasubramaniam J (Mr.)
	3	BDA	Bangalore Development Authority	Engineer Member	P.N.Nayak (Mr.)
	4	BBMP	Bruhat Bengaluru Mahanagara Palike	Executive Engineer	Umashankar (Mr.)
	5	BBMP	Bruhat Bengaluru Mahanagara Palike	Executive Engineer	Basavaraj R Kabade (Mr.)
	6	BTP	Bangalore Traffic Police	Assistant Commissioner of Police	Syad Afsar Pasha (Mr.)
	7	BMTC	Bangalore Metropolitan Transport Corporation	Divisional Traffic Officer	Nagendra (Mr.)
	8	DOT	Department of Transport	Managing Director, D .Deveraj Urs Truck Terminals Ltd	Hemantha Kumar L (Mr.)
	9	BMRCL	Bangalore Metro Rail Corporation Limited	Dy. Chief Engineer (Planning, Procurement & Contracts)	Shivananda K R (Mr.)
	10	KSRTC	Karnataka State Road Transport Corporation	Divisional Traffic Officer	S. Rajesh (Mr.)
Mysore	11	MCP	Mysore City Police	Police Inspector	R.P. Ashok (Mr.)
Others	12	C-DAC	Centre for Development of Advanced Computing	Joint Director	Ravi Kunar P (Mr.)

(Source: JICA Study Team)

## 9.4 Purposes of Visit by Place

The visiting places were arranged by the following purposes as shown in Table 9.2.

**Table 9.2 Purposes of Visit by Place**

Training No.	Place	Purpose
1	Mitsubishi Heavy Industries Engine System Asia PTE LTD (MHI)	To deepen understanding practices of ERP and common smart card in Singapore.
2	Land Transport Authority (LTA)	To deepen understanding practices of ERP in Singapore.
3	ITS-Japan and other private companies	To deepen understanding available ITS technology in the world and Japan
4	Traffic Police Control Centre	To deepen understanding traffic control in the metropolitan area, utilisation of quantitative data and signal control practices
5	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
6	Hitachi Collaboration Square	To deepen understanding clearing house mechanism, ETC, Smart Card and number plate recognition technology
7	Nagoya Electric Works	To deepen understanding ITS technologies developed by manufacture
8	Nagoya Guide-way Bus	To deepen understanding practices of Bus Rapid Transit
9	Mitsubishi Heavy Futami Factory	To deepen understanding ERP and ETC technology
10	The University of Tokyo	To deepen understanding ITS overview in Japan and the world
11	Japan Traffic Management Technology Association	To deepen understanding practices of traffic signal operated by Police in Japan
12	Public Transportation Network	To deepen understanding how it functions and planned for transferring amongst different mode of transport, single IC card for multipurpose usage

(Source: JICA Study Team)

## 10 Study Trip

The study trip for ITS master plan was carried out as shown in Table 10.1.

**Table 10.1 Results of Study Trip**

<b>Date</b>	<b>Visited</b>	<b>Participant</b>	<b>Contents</b>	<b>Purpose</b>
10/Feb/2014 - 10/Feb/2014	<b><u>PUNE</u></b> KENT Intelligent Transportation Systems (India) Pvt, Ltd	Matsuoka, Wakatsuki, Yamada, Matsumoto	<b><u>Site Visit &amp; Lecture</u></b> <ul style="list-style-type: none"> <li>• VMS manufacturing factory</li> <li>• ETC facilities</li> </ul>	<ul style="list-style-type: none"> <li>• To deepen understanding ITS technology in India</li> </ul>
11/Feb/2014 - 13/Feb/2014	<b><u>SINGAPORE</u></b> Mitsubishi Heavy Industries Engine System Asia PTE LTD (MHI), Land Transport Authority (LTA), TOYOTA, OMRON	Kondo, Matsuoka, Wakatsuki, Yamada, Matsumoto	<b><u>Site Visit &amp; Lecture</u></b> <ul style="list-style-type: none"> <li>• ERP facility</li> <li>• EPS system</li> <li>• LTA Traffic Centre</li> <li>• Signal Control</li> </ul>	<ul style="list-style-type: none"> <li>• To deepen understanding ERP, EPS, Traffic Control Centre and Signal Control technology</li> </ul>
19/Mar/2014 - 19/Mar/2014	<b><u>CHENNAI</u></b> Seminar venue (MLIT, JICA, MoUD, etc..)	Kondo, Oikawa	<b><u>Lecture</u></b> <ul style="list-style-type: none"> <li>• Participation in the Seminar On Highway Development And Intelligent Transport System (ITS)</li> </ul>	<ul style="list-style-type: none"> <li>• To deepen understanding available ITS technology in India and Japan</li> </ul>
30/May/2014 - 31/May/2014	<b><u>SINGAPORE</u></b> Land Transport Authority (LTA)	Kondo, Miyakawa	<b><u>Site Visit &amp; Interview</u></b> <ul style="list-style-type: none"> <li>• Related to Common smart card</li> </ul>	<ul style="list-style-type: none"> <li>• To deepen understanding clearing house mechanism and Common Smartcard and technology</li> </ul>
1/Apr/2015 - 3/Apr/2015	<b><u>TAIPEI</u></b> Far Eastern Electronic Toll Collection Co., Ltd.	Okuda	<b><u>Site Visit &amp; Interview</u></b> <ul style="list-style-type: none"> <li>• Related to radio frequency identifier (RFID)</li> </ul>	<ul style="list-style-type: none"> <li>• To deepen understanding RFID technology for ERP</li> </ul>

(Source: JICA Study Team)



## **11 Conclusions and Recommendation**

### **1. Firm Commitment of Government of Karnataka for Implementing ITS Envisaged by Master Plan**

A strong commitment of the policy makers and relevant authorities is important for implementation of ITS. The implementation of ITS requires close coordination and collaboration amongst stakeholders. The firm commitment of the government makes it possible.

### **2. Development and Improvement of Transport Infrastructure Together with ITS**

ITS is one of soft measures to alleviate traffic congestion. The road and transport infrastructure need to be sufficiently and properly developed in order for ITS to exert effectiveness. It is important that the development and improvement of road transport infrastructures be carried out together with ITS.

### **3. Incorporating ITS Master Plan into Transport Plan**

ITS is one of the soft measures in the transport sector. It is important that ITS be planned and developed under the framework of transport planning. It would be appropriate to incorporate ITS Master Plan into the urban transport master plan in Bengaluru and Mysore.

### **4. Adopting New Technologies**

Innovation and advancement of information and communication technology are rapidly progressing. ITS Master Plan was prepared based on currently available technologies. It is important that attention always be paid to explore the latest technologies to apply at the time of implementation of ITS.

### **5. Revising ITS Master Plan**

The traffic characteristics will become different in the near future in accordance with further urbanisation, development of road transport infrastructures. Also information and communication technology are rapidly progressing. Therefore, the ITS Master Plan shall be continuously reviewed and revised at every 4 – 5 years.

### **6. Continuous Promotion of ITS and Harmonising with ITS National Policy**

It is ideal that ITS be developed in the individual cities under the framework of the national policies. However established national policies have yet to be prepared in India. The Ministry of Urban Development, a Government of India, is currently working on developing a national ITS policy. It is recommended that the regional ITS in Bengaluru and Mysore be harmonised with the framework of national ITS policy when it is ready.

## **7. Capacity Development**

Capacity building is one of the most important factors to assure sustainable operation, maintenance, reviewing, planning and upgrading of ITS over a long period. It is important to draw plans for training and carry out them to enable continuous improvement of their skills.

## **8. Establishment of Strong Central Body**

Establishing a central body for continuous initiatives is important. A central body shall be formed with participation of the related agencies to take strong and continuous initiative for ITS and urban transport in a coordinated manner. The establishment of ITS Society described in the previous chapter in early stage is strongly recommended.

## **9. Standardising Motor Vehicle Number Plate and Improvement of Vehicle Registration**

Standardised number plates and properly registered motor vehicle information are indispensable factors for ITS. Proper enforcement by ITS cannot be realised without these. Therefore, it is important to implement standardisation of number plates at regional and national levels for the success of ITS measures.