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MINISTRY OF URBAN DEVELOPMENT

TRAFFIC MANAGEMENT AND INFORMATION CONTROL CENTRE (TMICC) OPERATIONS DOCUMENT



SUPPORTED BY:



NOVEMBER, 2016

OPERATIONS DOCUMENT FOR TRAFFIC MANAGEMENT AND INFORMATION CONTROL CENTRE (TMICC)

Ministry of Urban Development,
Government of India,
Nirman Bhawan, New Delhi - 110008

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सत्यमेव जयते

The Ministry of Urban Development (MoUD) is the apex authority of Government of India at the national level to formulate policies, sponsor and support programme coordinate the activities of various Central Ministries, State Governments and other nodal authorities and monitor the programmes concerning all the issues of urban development in the country. This operations document has been developed as part of GEF-Sustainable Urban Transport Project (GEF-SUTP) of MoUD.



Sustainable Urban Transport Project (SUTP), an initiative of Ministry of Urban Development, launched in May 2010, underlines the principles of National Urban Transport Policy (NUTP), 2006. SUTP aims at building capacity in Indian cities and undertake pilot projects with the concept of giving priority to moving people over moving vehicles. It is financed by Government of India, participating States & Cities and is aided by World Bank, GEF and UNDP. The project's funding, about INR 17.5 billion, is used for building capacity in urban transport planning pan India and for demonstration of six projects in different cities. Under the GEF-SUTP component of SUTP, a series of guidance documents is being developed to improve capacity at National, State and Local levels to implement NUTP, and this Operations Document is one of them.



Delhi Integrated Multi-Modal Transit System (DIMTS) Ltd. (Lead Consultant) along with Transport Research Laboratory (TRL) and Kimley Horn Consulting & Engineering India Private Limited has developed this document. DIMTS is an equal equity joint venture of Govt. of NCT of Delhi and IDFC Foundation with focus on urban transportation. DIMTS provides consultancy services that span from Concept to Commissioning, Intelligent Transport System solutions and Urban Transport asset management services.

Foreword

Indian cities have been witnessing a rapid increase in vehicular population, especially personal transport, in the recent past. Given the constraints in increasing roadway widths, this increase in vehicles has resulted in a drastic drop in levels of service on urban roads, with average speeds, in certain cities, dropping to below 10 kmph in peak traffic conditions. The problem is compounded owing to the fact that traffic control mechanisms are typically sub-optimal employing either fixed-time signal control or manual control. In today's context, a road user would also like to have real time information of traffic on alternate routes so that he/she could make an informed choice on the route to take. Urban traffic congestion has a number of adverse impacts, namely,

- Low road network speeds
- Higher travel times
- Increased cost of travel
- Increased energy consumption
- Increased pollution (both, noise and air)
- Decline in human productivity
- Decrease in competitiveness of the city
- Decline in quality of life.

Realising this, most developed cities across the world have adopted IT based traffic management systems to bring in efficiencies in managing traffic within their cities. In fact, given the longer term sustainability of IT based interventions; many countries have also consciously prioritised it over fresh roadway capacity creation (e.g. roadway widening/flyovers/underpasses etc.).

Typically, this is achieved through a centralised facility with which various systems of the transportation network (traffic signal, cameras, detectors etc.) are connected and is manned by operators who monitor the traffic conditions as well as the performance of the various traffic systems. These centralised facilities or Traffic Management and Information Control Centres (also called TMC - Transportation Management Centre in certain countries) are, therefore, the hub or nerve centre of a transportation management system.

There is clearly a need to establish such systems for various Indian cities. The aim of developing the TMICC Operations Document is to encourage cities towards planning and implementing the TMICC with a view to improve mobility. It is not only envisaged to provide a thorough insight to the concept but shall also assist in better understanding for future course of action. It would also assist various government organisations and public authorities in India embarking on the process of planning and establishing TMICC and be a reference guide for such organisations and their staff.

Armed with the knowledge related to the benefits of TMICC and various aspects pertaining to its planning and implementation, cities are expected to take earnest steps in implementing these systems.

November 2016

Preface

The Traffic Management and Information Control Centre (TMICC) Operations Document has been developed as a part of the GEF-Sustainable Urban Transport Project (GEF-SUTP) undertaken by the Ministry of Urban Development (MoUD), Government of India with support from Global Environment Facility (GEF) and World Bank (WB). The primary objective of GEF-SUTP is to apply National Urban Transport Policy principles to achieve a paradigm shift in India's urban transport system for more favourable sustainable developments and alternatives.

This document has been prepared under the guidance of Ministry of Urban Development (MoUD), Government of India with the primary objective to assist various government organisations and public authorities in India embarking on the process of establishing TMICCs. It is also intended to assist ITS practitioners towards proper implementation of TMICCs in Indian cities. It is developed as a reference guide for the various organisations and their staff working towards planning, designing, procuring, establishing, managing and monitoring the TMICCs. This document is also intended to be an essential reference for consulting organisations advising on planning and design of the TMICC facilities in various cities/towns in India.

This document relies upon the state-of-the-art review exercise undertaken by the consultants. As part of the review, several overseas and Indian cities were studied and the practices followed by them were examined. The outcome of the review was shared with various cities during the workshops and the feedback received has also shaped the development of this document.

It has also benefited considerably from the insights provided, feedback given and the reviews undertaken by the World Bank, Project Management Unit (PMU) and Project Management Consultants (PMC) engaged by Ministry of Urban Development (MoUD), GoI.

Chapter 3.0 and Chapter 4.0 are the core parts of the document which provide details regarding ITS architecture, standards and TMICC applications. Chapter 5.0 and Chapter 9.0 provide the details regarding TMICC planning and designing aspects, and responsibilities of various city agencies during implementation and operation of TMICC.

The Ministry and the consultancy team led by Delhi Integrated Multi Modal Transit System Limited and supported by Transport Research Laboratory, UK and Kimley Horn Consulting and Engineering India Pvt. Limited hope that this document will facilitate the city authorities in setting up and managing the TMICC.

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Acknowledgements

National Urban Transport Policy (NUTP) of the Government of India (GoI) has been framed with the objective to work towards sustainable urban transport in Indian cities. Ministry of Urban Development (MoUD), GoI is undertaking the GEF-Sustainable Urban Transport Project (GEF-SUTP) with the support of the Global Environment Facility (GEF), World Bank and UNDP to create a platform for working together with State/Local Governments towards implementation of the NUTP.

The Project Management Unit (PMU), Project Management Consultant (PMC) and the Consultants express their deep gratitude to MoUD for entrusting the responsibility for preparing operations document for development of TMICC in Indian cities as part of the GEF-SUTP.

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The Consultants are grateful to the National Project Manager (PMU team), Project Leader (PMC team), and the entire World Bank, PMU and PMC team for their unstinted support and untiring efforts in painstakingly reviewing the TMICC Operations Document and providing valuable suggestions and inputs during the course of development of the document.

The Consultants are also grateful to all the cities which participated in the workshops organised by MoUD as a part of this project. Their valuable suggestions have contributed immensely in the development of the document.

The Consultants also want to thank the four pilot cities (Delhi, Mumbai, Ahmedabad, and Guwahati) which were chosen by MoUD for preparing the city specific concept documents. Their reviews and suggestions were very critical and have led to refining of this document from the city perspective.

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Abbreviations

Acronym	Definition/Description
API	Application Programming Interface
ASN.1	Abstract Syntax Notation One
AVL/AVLS	Automatic Vehicle Location System
BOT	Build Operate Transfer
BSNL	Bharat Sanchar Nigam Limited
BRT	Bus Rapid Transit
CCTV	Closed Circuit TV
CEO	Chief Executive Officer
COI	Constitution of India
CORBA	Common Object Request Broker Architecture
DBFOT	Design Build Finance Operate Transfer
DIMTS	Delhi Integrated Multi Modal Transit System Ltd.
ETA	Estimated Time of Arrival
GEF	Global Environment Facility
GHG	Greenhouse Gas
GIS	Geographic Information System
Gol	Government of India
GPS	Global Positioning System
IEC	International Electro-technical Commission
ISO	International Organization for Standardization
ISP	Information Service Providers
ITS	Intelligent Transport Systems
kmph	Kilometers per hour
MoU	Memorandum of Understanding
MoUD	Ministry of Urban Development, Government of India
NHAI	National Highways Authority of India
NUTH	National Urban Transport Helpline
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
PP	Project Plan

Acronym	Definition/Description
PMU	Project Management Unit, SUTP India
PWD	Public Works Department
RFPs	Request for Proposals
SEMP	Systems Engineering Management Plan
SOP	Standard Operating Procedures
TMICC	Traffic Management and Information Control Centre
UK	United Kingdom
UMTA	Unified Metropolitan Transport Authority
UML	Unified Modelling Language
UNDP	United Nations Development Programme
USA	United States of America
UTF	Urban Transport Fund
VMS	Variable Message Signs
WB	World Bank

EXECUTIVE SUMMARY

Our cities have been witnessing a rapid increase in vehicular population, especially personal transport, in the recent past. Given the constraints in increasing roadway widths, traffic congestion in many cities in the country has reached alarming levels resulting in a drastic drop in levels of service on urban roads with average speeds, in certain cities dropping to below 10 kmph in peak traffic conditions. The problem is compounded owing to the fact that traffic control systems are typically sub-optimal employing either fixed-time signal control or manual control with no centralised command and control centre to effectively manage traffic congestion. In today's context, a road user would also like to have real time information of traffic on alternate routes so that he/she could make an informed choice on the route to take. Absence of such real-time information leads to clogging of few arterial routes and sub-optimal utilisation of the road network as a whole. Urban traffic congestion has a number of adverse impacts, namely,

- Low road network speeds
- Higher travel times
- Increased cost of travel
- Increased energy consumption
- Increased pollution (both, noise and air)
- Decline in human productivity
- Decrease in overall competitiveness of the city
- Decline in overall quality of life

Realising this, most developed countries across the world have adopted IT based traffic management systems to bring efficiencies in managing traffic in their cities. In fact, given the longer term sustainability of IT based interventions, many countries have also consciously prioritised it over fresh roadway capacity creation (e.g. roadway widening/flyovers/underpasses etc.). In order to cater to the increased demand for transportation and mobility, cities typically prepare mobility plans that identify various interventions that would be needed to support the projected transportation demand in the city. IT based interventions are required to be planned alongside in order to increase the efficiency of such transportation sector investments and to get the best out of the investments made in infrastructure creation.

Typically, traffic management using IT based systems is achieved through a network of field devices (traffic signal, cameras, detectors etc.) connected to a centralised facility which is manned by operators who monitor traffic conditions as well as performance of the various traffic systems. These centralised facilities called Traffic Management and Information Control Centres (TMICCs, also called TMC - Transportation Management Centre in certain countries) act as hub or nerve centre of the transportation management system and are typically involved with,

- Collection of data on traffic conditions in real-time (speed, traffic volume etc.);
- Analysis of data and control of traffic management systems (traffic signal systems etc.);
- Monitoring of traffic conditions and incidents;

- Timely interventions in response to traffic incidents, emergency conditions and/or system failures; and
- Real-time dissemination of information to travellers and other stakeholders (like media, emergency response teams etc.).

1. TMICC Objectives (Chapter 2.0)

The main objectives of the TMICC and important activities performed to meet these objectives are listed below:

- **Traffic Enforcement**
 - On-road checks
 - Speed violations
 - Red light violations
 - Parking violations
 - Entry restriction violations
 - Handheld Device Based e-Challan System
- **Monitoring and Management of Traffic**
 - Management and Monitoring of Traffic Junctions and Roadway Systems
 - Signal Timing and Operations
 - Road Network Surveillance
 - Active Traffic and Demand Management
 - Emergency Operations and Incident Management
 - Monitoring the functional status of various traffic equipment (field equipment) and taking steps towards restoration of defective equipment, including,
 - Traffic signals
 - Roadway sensors
 - Cameras
 - Variable message signs
 - Interfacing with various agencies to obtain information impacting traffic flows
 - Transit Operations
 - Parking Management and Operations
 - Weather Information
 - Toll Operations
 - Safe City Control Centres

- Support traffic management activities related to planned events in coordination and collaboration with other city agencies
- Detecting traffic incidents, emergencies and supporting authorities in responding to these by way of coordination, information sharing and dissemination
- Sharing of traffic data and information with various agencies such as transit, road construction and maintenance, Traffic Police etc. to help such agencies to monitor and control their respective operations more efficiently
- **Dissemination of Traffic Information to Public**
 - Dissemination of traffic information to public through variable message signs, website, helplines, mobile applications, social media etc.
- **Data Repository**
 - Storage of traffic data and sharing the same with planning agencies in order to support transport planning measures in the city.
- **Data Mining**
 - TMICC would collect vast amount of traffic and associated data through various devices and systems and would have a rich repository of data for the city. The data collected could be mined and insights derived could be used for planning and optimising the traffic related infrastructure.

Therefore, implementation of TMICCs leads to the following:

- Improvement in overall traffic flow by efficient traffic management thereby improving the efficiency of transportation network
- Reduction in travel time for commuters resulting from improved flow of traffic
- Increased road user satisfaction driven by access to real-time information of traffic
- Reduction in traffic congestion
- Capital expenditure on physical infrastructure build-up to cater to traffic requirements can be avoided or postponed
- Reduction in energy consumption for transportation
- Reduction in pollution and Green House Gas (GHG) emissions
- Improvement in coordination amongst various agencies enabling faster responses to incidents
- Improved planning for traffic management both, for short term measures as well as long term interventions based on data mining and analysis.
- Useful for accident data collection and analysis
- Collected data can be used for framing the traffic policy for the city

2. TMICC Applications (Chapter 4.0)

The Table below provides an overview of the TMICC related applications.

Table E1: TMICC Applications

Area	TMICC Applications
Traffic Enforcement	<ul style="list-style-type: none"> On-road checks Speed violations Red light violations Parking violations Entry restriction violations Handheld Device Based e-Challan System
Traffic Management and Monitoring of Roadway Systems and Traffic Junctions	<ul style="list-style-type: none"> Signal Timing and Operations Road Network Surveillance Active Traffic and Demand Management Emergency Operations and Incident Management
Interfaces with Transit Operations	<ul style="list-style-type: none"> Bus Operations Metro and Suburban Rail Operations (Urban Areas) IPT Operations
Interfaces with Other Agencies	<ul style="list-style-type: none"> Road Construction and Maintenance Weather Information Parking Management and Operations Safe City Control Centres Toll Operations
Information Dissemination	<ul style="list-style-type: none"> Congestion Incidents Construction Activities Website Mobile Phone Applications

3. TMICC Structures (Chapter 5.0)

TMICCs can operate with various levels of distributed or centralised configurations, ranging from the single unified centre to separate TMICCs working as a single virtual set up with the centres connected over communication networks. TMICCs can be configured to operate in accordance with the following options or their variants as listed below:

- Virtual set up wherein each entity manages its traffic centre but they share information with each other to facilitate cooperation
- A single unified set up where all traffic related entities are co-located and operate their respective systems from the facility. They share information with each other to facilitate cooperation.
- A central core TMICC set up with representation from each traffic related agency for coordination and information sharing purposes while each agency also having its own transit or traffic centre to manage its operations.
- TMICC operating in conjunction with National Urban Transport Helpline (NUTH).

Table E2: TMICC Structure Options

Options	Advantages	Disadvantages
Standalone (single) TMICC	<ul style="list-style-type: none"> • Ease of set up • Faster set up time • Lower costs • Simpler management structure 	<ul style="list-style-type: none"> • Lack of information sharing ability • Lack of coordination for critical management issues
Standalone (single) TMICC with data links to other Centres	<ul style="list-style-type: none"> • Ease of set up • Faster set up time • Lower costs 	<ul style="list-style-type: none"> • Complex coordination mechanism • Requires agreements for standard data and video exchange. • All agencies must adhere to the same platform/standards
Joint TMICC with multiple agencies dealing with traffic management	<ul style="list-style-type: none"> • Improves coordination • Faster response time • Reduction in conflicts in response • Reduction in duplicated costs 	<ul style="list-style-type: none"> • More elaborate and time consuming for set up and operation • Requires agreements for cost sharing and assignment of responsibility • More time required to set up

Options	Advantages	Disadvantages
Fusion Centres with multiple disparate agencies, such as traffic, transit and emergency management systems	<ul style="list-style-type: none"> • Greater improvement in coordination on a multi-modal and multi-agency level • Faster and more clear response time • Management of the network in an integrated manner • Better suited for major metropolitan areas 	<ul style="list-style-type: none"> • More elaborate and time consuming to set up • Complex management structure • Require agreements for cost sharing and assignment of responsibility • More time required to set up
Joint TMICC plus standalone agencies	<ul style="list-style-type: none"> • Better coordination • Redundancy in case of failure of one centre (backup provisions) 	<ul style="list-style-type: none"> • Additional costs of operating multiple centres • Duplication of effort and resources • Potential breakdown of communication

The choice of any particular structure would be a function of stakeholder preferences, existence of traffic and transit centres, number of entities managing the transit/traffic activities in the city, character of such entities (whether government or private, and if government entity: level of government controlling the entity).

4. TMICC Components (Chapter 5.0)

Components of a typical TMICC would depend on the functional design and requirements of each TMICC. Keeping in view that TMICCs typically operate on a 24x7 basis and have systems to monitor and manage traffic, the Essential and Optional components have been listed in the tables below:

Table E3: TMICC Essential Components

Essential Components	
Centre Application Software <ul style="list-style-type: none"> • Traffic Enforcement Systems • Traffic Management Software • Road Network Surveillance Software • Emergency and Incident Management Application • Traveller Information System Application • Interfaces with <ul style="list-style-type: none"> – Transit Systems – Incident and Emergency Management Systems – Road Construction & Maintenance Agencies' Systems Backend Standard Software <ul style="list-style-type: none"> • Operating system • Firewall/Intrusion Prevention System (IPS)/ Intrusion Detection System (IDS) • Anti-virus • Database 	Centre Hardware <ul style="list-style-type: none"> • Video walls • Computers/ Operators consoles • Servers for various applications and databases (application, communication, information dissemination, signals, CCTV etc.) • Storage Area Network (SAN) • Network and Communication Routers, Switches • Printers
Field Equipment <ul style="list-style-type: none"> • Traffic Management Equipment (signals, controllers, detectors, etc.) • Surveillance Equipment (CCTV) • Variable Message Signs • Communication equipment 	Utilities <ul style="list-style-type: none"> • Fire suppression • Air conditioning • Access control • Power and its backup Facilities <ul style="list-style-type: none"> • Management Offices • Conference Room and Assembly Areas • Cafeteria, eating areas and/or vending machines • Parking

Table E4: TMICC Optional Components

Optional Components	
Centre Application Software <ul style="list-style-type: none"> • Active traffic and demand management • Interfaces with <ul style="list-style-type: none"> – Parking management and operation systems – Safe City Control Centres – Toll operation systems 	Centre Hardware <ul style="list-style-type: none"> • -none

Optional Components	
<ul style="list-style-type: none"> – Congestion pricing systems – Integrated corridor management systems – Lighting Control Systems – Weather Monitoring Systems 	
Field Equipment <ul style="list-style-type: none"> • Field equipment linked to active traffic and demand management (barriers, gates etc.) 	Facilities <ul style="list-style-type: none"> • Viewing gallery • Locker Room, Showers, Sleeping Areas and Exercise Rooms for special centres including emergency management operations

5. TMICC Implementation Process (Chapter 6.0)

Since the complexity of the TMICC will depend on the size of the city, the number of agency interfaces and specific traffic applications, the total time for implementation would vary and could range between 17-25 months. The figure below outlines the typical steps for the TMICC development process.

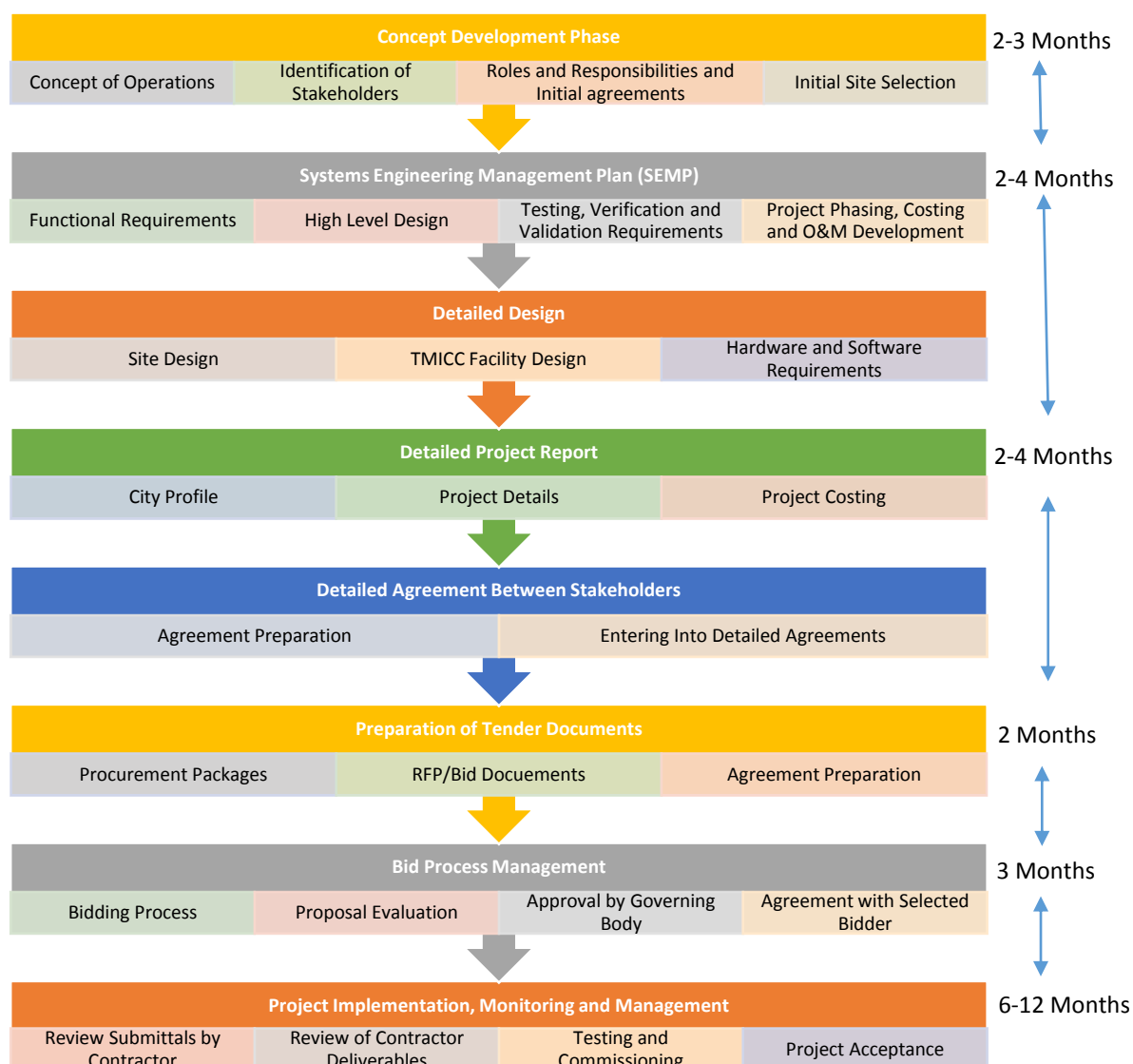


Figure E1: TMICC Implementation Process

As the concept of TMICC is new to the Indian cities and will require additional support from organisations having required expertise, Ministry of Urban Development, GoI has empanelled a set of consultants who may be engaged by the cities for seeking assistance in conceptualising, preparing detailed project report (DPR), designing, procuring and monitoring the implementation of the TMICC in the city. In line with the international best practices, it is recommended that the city adopts Systems Engineering Approach towards system design and implementation. The indicative scope of services for the city specific project consultancy is set out as Annexure 8.

6. Project Phasing (Chapter 11.0)

It may not be necessary or desirable to set up TMICC for the entire urban agglomeration or with full functionality from the beginning. TMICC could be implemented in a phased manner

with time period for phasing varying based on the scope of the project. A suggested phasing for TMICC is given below:

Table E5: TMICC Project Phasing

Parameter	Phase-1 (3-5 years)	Phase-2 (4-8 years)	Phase-3 (6-10 years)
TMICC Area of Coverage	<ul style="list-style-type: none"> City Corporation area –arterial roads, (only specific corridors to begin with) 	<ul style="list-style-type: none"> City Corporation area sub-arterial roads plus arterial roads of nearby municipalities in the city development authority area 	<ul style="list-style-type: none"> City development authority area / urban agglomeration
Focus Area	<ul style="list-style-type: none"> Signal control Traffic surveillance (CCTV) Basic traffic information dissemination using VMS 	<ul style="list-style-type: none"> Signal control Traffic surveillance (CCTV) Traffic information dissemination using VMS 	<ul style="list-style-type: none"> Signal control Traffic surveillance (CCTV) Traffic information dissemination using VMS
Traffic Equipment	<ul style="list-style-type: none"> Signals VMS CCTV cameras 	<ul style="list-style-type: none"> Signals VMS CCTV cameras 	<ul style="list-style-type: none"> Signals VMS CCTV Camera
Traffic Information Dissemination	<ul style="list-style-type: none"> Congestion Information (using coloured links on map) Road diversions / closures Accidents / Incidents Advisories and alerts Construction/ maintenance Weather Information 	<ul style="list-style-type: none"> Congestion Information Road diversions / closures Accidents / Incidents Advisories and alerts Parking Information Weather Information Construction/ maintenance Speed/Congestion Information CCTV Footage 	<ul style="list-style-type: none"> Congestion Information Road diversions / closures Accidents / Incidents Advisories and alerts Parking Information Weather Information Construction/ maintenance Speed/Congestion Information CCTV Footage

Parameter	Phase-1 (3-5 years)	Phase-2 (4-8 years)	Phase-3 (6-10 years)
Information Dissemination Modes	<ul style="list-style-type: none"> Website Phone helpline Mobile App Social Media VMS along roadways 	<ul style="list-style-type: none"> Website Phone helpline Mobile App Social Media VMS along roadways 	<ul style="list-style-type: none"> Website Phone helpline Mobile App Social Media VMS along roadways

7. Participating Agencies (Chapter 9.0)

In line with the objectives of the TMICC, agencies participating in them may also come from diverse set of backgrounds. TMICC facilities that are set up for monitoring road network and traffic facilities for a metropolitan region would have participating agencies having jurisdiction over the metropolitan region for performing such activities. The implementing agency for setting up of the TMICC could be any of the following:

- Unified Metropolitan Transport Authority (UMTA) or entity performing this role
- Municipal Corporations/ Urban local bodies
- Traffic Police

The agencies that would be required to share data with the TMICC would be as under:

- Transit Agencies: Bus operator, Metro operator, Suburban Rail operator (Indian Railways), operator of any other mode
- Road Construction & Maintenance Agencies: Municipal Corporations/ Urban local bodies, PWD, Development Authorities and other road owning agencies
- Event/ Incident Management Related Authorities: Police, Fire Department, State Transport Department
- Weather department
- Vendors and service providers

While planning and designing TMICC, the identification of agencies, their systems (both existing and the planned ones) and the data/information that would be provided by them must be taken into consideration. These aspects may have a bearing on the concept of operations, information receiving and processing mechanism, TMICC system requirements, resource deployment, time to deploy the system, cost of deployment and the expertise required.

In view of the role currently being performed by Traffic Police and Municipal Corporations by virtue of the existing legal framework in traffic management activities, these entities would be central to setting up and managing the TMICCs. Additionally, given the proposed structure of Unified Metropolitan Transport Authority (UMTA) and its constituent stakeholders, it should

also be made part of the core TMICC stakeholders together with Traffic Police and Municipal Corporation, wherever it has been established. UMTA would be in a good position to lead the effort in getting all the TMICC stakeholders on board most of which in any case are proposed to be part of UMTA organisation. UMTA would also be a good conduit to bring in the transit agencies into the mix of TMICC operations.

Entities Co-located in TMICC

The Traffic Police and Municipal Corporations are key entities involved in management of traffic related assets and activities. Municipal Corporations (in some cities such as Mumbai, Pune, and Ahmedabad) install and maintain signals and other traffic equipment while these are operated and controlled by the Traffic Police. In many cities, it is the Traffic Police that are responsible for installation, maintenance and operation of the signals and other traffic equipment. Given that traffic monitoring and management is a central function of TMICC, these entities would be part of the core set of stakeholders and would play an important role in designing, setting up and managing the TMICC together with Unified Metropolitan Transport Authority (UMTA), wherever it has been established.

Table below provides a list of suggested entities that may need to deploy personnel or be co-located at TMICC:

Table E6: Entities Co-located in TMICC

Area	Entities
Transport & Traffic	<ul style="list-style-type: none"> Unified Metropolitan Transport Authority or the entity playing this role
Traffic	<ul style="list-style-type: none"> Traffic Police Municipal Corporation (traffic signal team) Other agencies managing traffic signals

Entities Sharing Data with TMICC

The indicative list of entities and the requirements for data sharing is outlined in Table below. Depending on the specific requirements agreed by the city stakeholders, the final set of entities as well as data sharing requirements would need to be worked out for each TMICC.

Table E7: Entities Sharing Data with TMICC

Area	Entities	Data Sharing
Transport & Traffic	<ul style="list-style-type: none"> Unified Metropolitan Transport Authority or the entity playing this role 	<ul style="list-style-type: none"> Details of various public transit modes / operators in the region both current as well as planned Periodical updates to the aforesaid data Details of transport sector initiatives
Traffic	<ul style="list-style-type: none"> Municipal Corporation (traffic signal team) Other agencies managing traffic signals 	<ul style="list-style-type: none"> Location of various traffic related equipment: signalised junctions, cameras, variable messages signs etc. on map and as list Plans and schedules for construction & maintenance Updates on the construction & maintenance
	<ul style="list-style-type: none"> Municipal Corporation (roads team) State PWD Central PWD National Highways Authority of India (NHAI) State Road Development Corporations Cantonment Board Development Authorities Other Road owning agencies 	<ul style="list-style-type: none"> Road network details including Geographic Information System (GIS) maps Location of various traffic related equipment: signalised junctions, cameras, variable messages signs etc. on map and as list Road attributes: name, number of lanes, width, weight restrictions, height restrictions etc. Plans and schedules for construction & maintenance Updates on the construction & maintenance New roads planned
	<ul style="list-style-type: none"> Traffic Police 	<ul style="list-style-type: none"> Road attributes: name, number of lanes, whether one-way or two-way, speed limit, entry restrictions, weight restrictions, height restrictions etc. Location of various traffic related equipment: signalised junctions, cameras, variable messages signs etc. on map and as list Location of red light enforcement cameras, speed enforcement cameras Speed limit on various road sections

Area	Entities	Data Sharing
		<ul style="list-style-type: none"> Entry restrictions such as one way, no entry, time based entry, no U-turn etc. Incident information Event information Road closures, diversions Live traffic surveillance camera feeds and access to historical feeds, live messages being displayed on the variable messages signs, traffic volume data, details of public notices on traffic etc.
Transit	<ul style="list-style-type: none"> Bus including BRT (City Transport Corporations, State Transport Undertakings, city bus SPVs, Municipal Transport Undertakings) Rail Metro Monorail Other modes, if any 	<ul style="list-style-type: none"> Operators details: Name, modes operated, contact details, website details Modes: Bus, Metro, Monorail, Tram etc. Services: Express, Ordinary, AC, Non AC, Night services Routes: Details of the routes operated Schedule Data: Frequency during peak/off-peak hours, Timings Timing of operations: First and last service on various routes Fare structure: Normal fares, special fares, concessions for various category of commuters Pass Details: Pass charges for various category of commuters, validity rules Bus terminals, Bus Stops, Metro Stations details Details of parking facility: capacity, vehicle types that can be parked, operational hours, charges, mode of payment, operating agency, contact details Inter-modal transfer options: feeder services, connecting routes, interchange stations/terminals Transit trip planner: intra-modal as well as inter-modal based on static data Tourism related information with connecting transit options to tourist spots Running status

Area	Entities	Data Sharing
		<ul style="list-style-type: none"> • Departures scheduled at bus terminals, bus stops, metro stations • Estimated Time of Arrival (ETA) • Service delay, disruptions • Information on new services, discontinuation of any service etc. • Rerouting • Transit trip planner • GPS feed data • Incidents & Events • Schedules for construction & maintenance • Updates on the construction & maintenance • Parking availability status (real-time)
Para-transit / Intermediate Public Transport (IPT)	<ul style="list-style-type: none"> • State Transport Department 	<ul style="list-style-type: none"> • GPS feeds data such as speed, time taken on a road stretch • Planned strike, service disruptions
Parking	<ul style="list-style-type: none"> • Municipal Corporation • Other agencies managing parking facilities 	<ul style="list-style-type: none"> • Details of parking facility such as capacity, type of vehicles that can be parked, operational hours, charges, mode of payment, operating agency, contact details • Parking availability status (real-time) • Updates on construction/ maintenance activities • Updates on facility closure
Bus Terminus	<ul style="list-style-type: none"> • Department of Transport • State Transport Undertakings • Other entities managing such facilities 	<ul style="list-style-type: none"> • Details of services operated from the bus terminus • Details of parking facility such as capacity, type of vehicles that can be parked, operational hours, charges, mode of payment, operating agency, contact details • Updates on service delay /disruptions /facility closure • Updates on construction/ maintenance activities

Area	Entities	Data Sharing
Emergency Response	<ul style="list-style-type: none"> Fire Police 	<ul style="list-style-type: none"> Incident information Event information
Weather	<ul style="list-style-type: none"> Regional Meteorological Centre 	<ul style="list-style-type: none"> Weather updates Temperature, wind speed, fog, visibility details, humidity, rainfall etc.
Tourism	<ul style="list-style-type: none"> Tourism department or Tourism development corporation 	<ul style="list-style-type: none"> Details of tourist spots Information related to tourist spots such as locations, brief details, ticketing details, operational timings, contact details, transit connection, route map etc.
Pollution	<ul style="list-style-type: none"> Pollution Control Board 	<ul style="list-style-type: none"> Air quality data such as sulphur dioxide, nitrogen dioxide, particulate matter, ozone, lead, carbon monoxide

8. Organisation Structure (Chapter 9.0)

TMICC is typically a 24x7 operations centre and, therefore, needs to be staffed with personnel in shifts accordingly. The shifts would have varying personnel depending upon the peak and non-peak traffic patterns on the roads. It is expected that there would also be variations in staffing for weekdays as compared to weekends. The suggested organisation chart for the TMICC has been set out below:

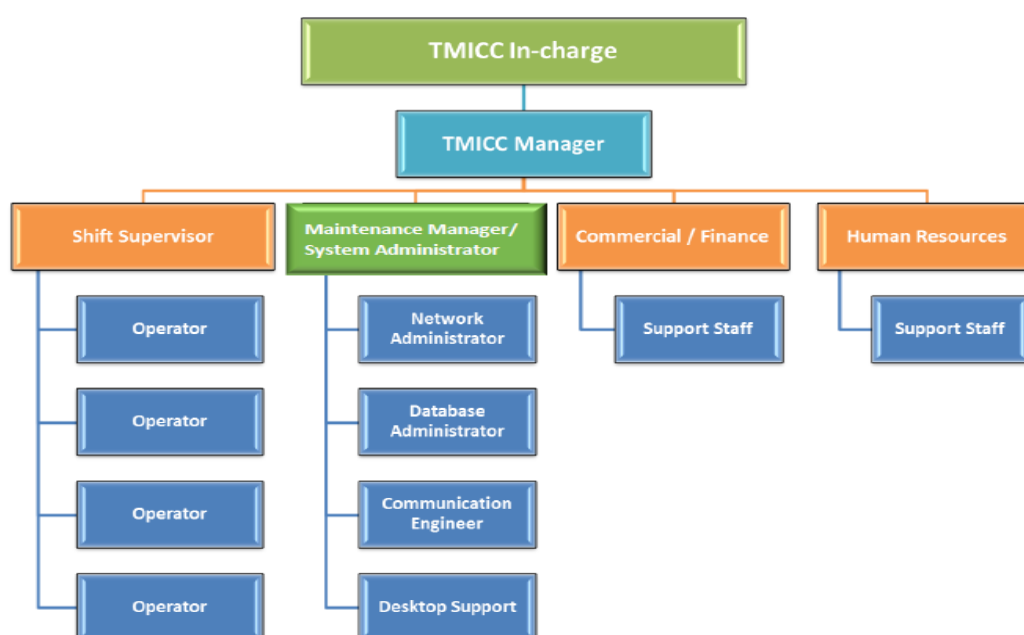


Figure E2: Typical TMICC Organisation Structure

Considering the importance of traffic engineering discipline in traffic management and its optimisation, it is recommended that personnel from traffic engineering discipline be entrusted with the responsibility of managing the TMICCs or they be assigned major responsibilities in TMICCs in the areas that deal with traffic engineering aspects. The implementing agency would need to hire resources under suitable arrangement if the skill sets required for effective and efficient management of TMICCs are not available with them. The manpower resource requirements and the training needs have been discussed in Chapter 9.0.

9. Revenue Streams (Chapter 11.0)

TMICC projects may not be able to generate any significant revenue by charging users. Worldwide also such services are provided by government entities free of cost to the users with users having to bear the cost of making calls to the transport helpline numbers providing information generated by the TMICCs. In the USA for example, the data being collected is shared with various entities (including the private sector) currently without any charges, even though an option to charge for the data has been retained by the government entities.

Some of the revenue streams that could be explored by TMICC to defray part of the O&M costs are as under:

- Fines collected by the Traffic Police through the enforcement measures.
- Parking charges collected from users.
- Receipts from private entities for sharing data.
- Receipts from media for sharing data.
- Receipts from users for providing personalised information sent through mailers, Short Message Service (SMS), mobile apps or providing personalised access to certain information.
- Receipts from advertisers against grant of right to display advertisements on website
- Receipts from advertisers against grant of right to display advertisements on mobile apps.
- Receipts from advertisers against grant of right to undertake advertisements on helpline.
- Receipts from sponsorship by corporates in lieu of exclusive right to co-brand.
- Receipts from mobile apps downloads.
- Receipts from subscription services offered on mobile apps..

10. Funding of TMICC (Chapter 11.0)

Central Government may use any of its programmes for supporting such initiatives. Funding for setting up of the TMICC may be secured with the support of the State Government under the centre's on-going or future schemes. Central Government has launched the Smart Cities

Mission¹/ Atal Mission for Rejuvenation and Urban Transformation (AMRUT)² and the cities may avail funding from one or both these schemes.

Multilateral or bilateral funding may also be secured at Central Government, State Government or City levels. Since these projects support environment management as well, national and international programmes providing funding support for undertaking environment related measures may also be accessed based on the requirements of such programmes.

Funding for Operations & Maintenance (O&M) activities are critical as these projects require operational systems and functional teams to manage the O&M activities. The O&M cost of TMICC may be shared by the respective State Government (Traffic Police are part of State set up except in Union Territories including Delhi) and the Urban Local Bodies / City Urban Transport Fund (UTF). Central government may also support the O&M of such initiatives on a need basis.

11. Overview of Implementation Models (Chapter 11.0)

The typical implementation models that may be examined for establishing and operating the TMICCs are listed in the Table below.

Table E8: Implementation Structure Options

Implementation Options	Investment	O&M Cost
Option 1	Public	Public
Option 2	Public	Private
Option 3	Private	Private

Considering the limited revenue potential from such projects, it is recommended that such projects are taken up in the government/public authority domain (Option 1).

The private sector players could be engaged by government agency /public authority for design, supply, installation, testing, commissioning, maintaining and operating such facilities.

¹ Smart Cities- Mission Statement & Guidelines, Ministry of Urban Development, Government of India (June 2015)

² Atal Mission for Rejuvenation and Urban Transformation (AMRUT) - Mission Statement & Guidelines, Ministry of Urban Development, Government of India (June 2015)

1.0 INTRODUCTION TO THE DOCUMENT

1.1 Purpose

This Traffic Management and Information Control Centre (TMICC) Operations Document has been developed to assist various government organisations and public authorities in urban areas of India embarking on the process of planning and establishing a TMICC.

This document is intended to be a reference guide for such organisations and their staff working towards planning, designing, procuring, establishing, managing and monitoring the TMICC.

It would also be a useful reference document for the consultants who would be advising for planning and design of the TMICC facilities in various cities/towns in India.

1.2 Intended Audience

The activities to be performed from the TMICC are typically dealt with by Traffic Police, Unified Transport Metropolitan Authorities (UMTA), Urban Local Bodies and other government departments related to transport and traffic. These are the primary targets for whom this Operations Document has been developed.

This document has been developed to assist these organisations as they will generally lead or participate in the initiatives for planning and establishing the TMICCs.

It would also be a useful reference guide for the Intelligent Transport Systems (ITS) practitioners and consultants who would be advising the UMTA, urban local bodies and traffic agencies in matters connected with the planning and design of the TMICCs.

1.3 Document Development Method

This document has been prepared under the guidance of Ministry of Urban Development (MoUD), Government of India and draws upon the experience in setting up similar facilities in the USA, Europe and Asia.

This document has been developed also based on the state-of-the-art review exercise undertaken by the consultants. As part of the review, several overseas and Indian cities were studied and the practices followed by them for such systems were reviewed. The outcome of the review was shared with various cities during the workshops conducted by MoUD and their feedbacks received during the workshops have also shaped the development of this document.

This document has also benefited considerably from the insights provided, feedback given and the reviews undertaken by the World Bank, Project Management Unit (PMU) and Project Management Consultants (PMC) engaged by MoUD.

1.4 Organisation of Operations Document

The overview and organisation of TMICC Operations Document content is as set out below:

- **Chapter 2.0** undertakes an overview of TMICC, the objectives and benefits of setting up of a TMICC and various aspects to be considered with respect to implementation and operations of a TMICC.
- **Chapter 3.0** deals with the concept of ITS architecture and standards including associated details such as Project Requirements, Functional Architecture, Physical Architecture, and Project Details.
- **Chapter 4.0** provides the details of the various TMICC applications/activities such as Traffic Enforcement, Traffic Management and Monitoring, Interfaces with Transit and other agencies, Information dissemination, data warehousing and analysis.
- **Chapter 5.0** covers the planning and design considerations to be kept in mind while setting up the TMICCs. It deals with various aspects such as TMICC Structures, various components that are part of TMICC, essential and optional components, capacity and resources required, need for ITS architecture and managing obsolescence.
- **Chapter 6.0** covers the topic of TMICC project management covering various aspects such as Project Planning, TMICC Implementation Process, Project Monitoring and Control, Risk Management, Configuration Management and application of Systems Engineering concepts.
- **Chapter 7.0** deals with system operational procedures and undertakes an overview of TMICC Activities, Daily Operations, Citizen Inputs and Requests, System Reports, Data Storage and System Documentation.
- **Chapter 8.0** covers TMICC maintenance procedures covering areas such as TMICC related assets maintenance, Types of maintenance, System Start-Up and Shut-Down Procedures, Spare/Backup Equipment, Emergency Operations, Maintenance contracting approaches such as Agency Maintenance and Contract Maintenance.
- **Chapter 9.0** provides an overview of institutional framework in the Indian context and provides details of Stakeholders, Potential Agencies in TMICC, TMICC Organisation structure, Training Requirements and agreements amongst project stakeholders.
- **Chapter 10.0** takes a look at performance monitoring aspects of TMICC.
- **Chapter 11.0** deals with the sizing, phasing and costing of TMICC.
- **Chapter 12.0** provides the details of resources and references used in preparing this document.

1.5 How to Use the Operations Document?

This document may be used as a reference manual by the project teams which are either contemplating setting up of the TMICCs or are in the process of establishing one. While the chapters have been arranged to provide a flow of understanding of the subject, each chapter of the document is designed to be a self-contained one and, therefore, chapters can be read on a need basis without the necessity to follow any particular order.

1.6 Relationship to Other Manuals, Policies and Procedures

This document is intended to serve as a guideline for agencies and ITS practitioners to apply good and reasonable measures to the planning, design and implementation of TMICC for urban or metropolitan areas. This guideline provides concept of some of the best practices in TMICC and Intelligent Transport Systems (ITS) standards and implementation.

TMICC and NUTH are both Intelligent Transport Systems with several interfaces for information exchange. While TMICC focuses on managing roadway traffic movement in an overall sense, the NUTH is focused on providing travellers information pertaining to journey planning – generally for public transport modes, but could also cover inter-mediate public transport and private modes. Therefore, TMICC focuses on Centre-to-Field and Centre-to-Centre interfaces while the NUTH focuses on Centre-to-Public interfaces. However, since both are ITS, some of the aspects are common, such as: application of Systems Engineering concepts, ITS architecture and standards, project management framework, maintenance procedures, operational procedures, stakeholders, institutional framework etc. These aspects have been covered in both, the TMICC Operations Document and the NUTH Operations Document, with modifications as relevant for each system.

2.0 OVERVIEW OF TMICC

2.1 Need for TMICC

Our cities have been witnessing a rapid increase in vehicular population, especially personal transport, in the recent past. Given the constraints in increasing roadway widths, traffic congestion in many cities in the country have reached alarming levels resulting in a drastic drop in levels of service on urban roads, with average speeds, in certain cities, dropping to below 10 kmph in peak traffic conditions. The problem is compounded owing to the fact that traffic control mechanisms are typically sub-optimal employing either fixed-time signal control or manual control and lack of a centralised command and control centre to effectively manage traffic congestion. In today's context, a road user would also like to have real time information of traffic on alternate routes so that he/she could make an informed choice on the route to take. Absence of such real-time information, again leads to clogging of few arterial routes and sub-optimal utilisation of the road network as a whole. Urban traffic congestion has a number of adverse impacts, namely,

- Low road network speeds
- Higher travel times
- Increased cost of travel
- Increased energy consumption
- Increased pollution (both, noise and air)
- Decline in human productivity
- Decrease in overall competitiveness of the city
- Decline in overall quality of life.

Realising this, most developed cities across the world have adopted IT based traffic management systems to bring in efficiencies in managing traffic within their cities. In fact, given the longer term sustainability of IT based interventions, many countries have also consciously prioritised it over fresh roadway capacity creation (e.g. roadway widening/flyovers/underpasses etc.). In order to cater to the increased demand for transportation and mobility, cities typically prepare mobility plans that identify various interventions that would be needed to support the projected transportation demand in the city. IT based interventions are required to be planned alongside to increase the efficiency of such transportation sector investments and to get the best out the investments made in infrastructure creation.

A city should consider setting up a TMICC when it is faced with the following challenges as identified in its mobility plan, master plan, other planning documents or surveys:

- **Traffic Enforcement:** The city has a high absolute number of traffic violations and/or an upward trend towards number of traffic violations indicating issues with traffic enforcement.
- **Road Network Congestion:** City is experiencing congestion on its road network evidenced by higher travel time, very low speed and growing trip rates. It could be due to available transport capacities being sub-optimally utilised or issues with traffic management approaches.
- **Population Growth:** The city is registering rapid growth in population leading to higher number of trips being observed on its road network causing congestion.
- **Growth in number of registered vehicles:** The city is observing a high rate of growth in number of vehicles registered which is deteriorating the traffic conditions on its road network.
- **Traffic Accidents:** The city has a high absolute number of accidents and/or an upward trend towards number of traffic accidents and related injuries.
- **Pollution Level:** The city has high level of vehicle related pollution in the form of suspended particulate matter (PM_{2.5}) and other pollutants (such as NO_x, CO) as compared to the permitted levels.
- **Lack of Traffic Data:** The city does not have traffic related data (historical or current) that it can use for planning transport related interventions and/or share with public to enable them to plan their trips using such information.
- **Physical Constraints:** The city is experiencing growth in number of transport trips but it cannot augment transport capacity owing to physical and/or geographical constraints.

2.2 What is TMICC

Typically, traffic management using IT based systems is achieved through a centralised facility with which various systems of the transportation network (traffic signal, cameras, detectors etc.) are connected and is manned by operators who monitor the traffic conditions as well as the performance of the various traffic management systems. These centralised facilities or Traffic Management and Information Control Centres (TMICCs, also called TMC - Transportation Management Centre in certain countries) are, therefore, the hubs or nerve centres of a transportation management system comprising,

- Collection of data on traffic conditions in real-time from field equipment (about the transportation network highways, state and local roads, traffic signal system);

- Analysis of data and control of traffic management systems (traffic signals, variable signs used for dynamic re-routing etc.);
- Monitoring of information on traffic conditions and incidents and emergencies by operators;
- Timely interventions to rectify traffic incidents and/or system failures, and
- Real-time dissemination of accurate information to travellers and other stakeholders (like media, emergency response teams etc.).

TMICCs receive data from equipment installed in the transportation network, process it and correlate the same with other control and operational parameters to generate useful information. Based on this information, actions are taken from the TMICC with a view to manage the traffic flow, support incident management, send commands to the connected systems or issue traffic advisories to road users.

The information is also used by various agencies to monitor and control their respective operations to bring about an improvement in system performance. TMICCs also help agencies to undertake coordinated responses to incidents and other situations. Often, many of the agencies are also co-located at TMICCs and work with each other in order to improve coordination.

TMICCs additionally act as a common interface for sharing and disseminating transport information to the public and other stakeholders.

2.3 TMICC Objectives

The main objectives of the TMICC and the activities performed to meet these objectives are as under:

1. Traffic Enforcement

- On-road checks
- Speed violations
- Red light violations
- Parking violations
- Entry restriction violations
- Handheld Device Based e-Challan System

2. Monitoring and management of traffic

- Management and Monitoring of Traffic Junctions and Roadway Systems
 - Signal Timing and Operations
 - Road Network Surveillance

- Active Traffic and Demand Management
- Monitoring the functional status of various traffic equipment and taking steps towards restoration of defective equipment, including,
 - Traffic signals
 - Roadway sensors
 - Cameras
 - Variable message signs
- Interfacing with various agencies to obtain information impacting traffic flows
 - Transit Operations
 - Parking Management and Operations
 - Weather Information
 - Toll Operations
 - Safe City Control Centres
- Support traffic management activities related to planned events and emergencies in coordination and collaboration with other city agencies
- Detecting traffic incidents and supporting authorities in responding to these by way of coordination, information sharing and dissemination
- Sharing of traffic data and information with various agencies such as transit, road construction and maintenance, Traffic Police etc. to help such agencies to monitor and control their respective operations more efficiently

3. Dissemination of Traffic Information to Public

- Dissemination of traffic information to public through NUTH, variable message signs, website, helplines, mobile applications, social media etc.

4. Data Repository and Analysis

- Storage of traffic data and sharing the same with planning agencies in order to support transport planning measures in the city
- Analysis of traffic related data and data mining to support infrastructure planning and design.
- Traffic flow analysis
- Providing inputs to road agencies in junction planning and layout design

5. Data Mining

- TMICC would collect vast amount of traffic and associated data through various devices and systems and would have a rich repository of data for the city. The data collected could be mined and insights derived could be used for planning and optimising the traffic related infrastructure.

Each TMICC would be set up within the context of city/regional requirements and is likely to have objectives that support the respective stakeholders' needs. Some may cater to the city requirements (Figure 2-1) while the others may have regional or even statewide mandates (Figure 2-2). This report deals with TMICC for urban or metropolitan areas in India.

The London Traffic Control Centre (LTCC)

- Refine traffic signal timings at 6,000 sites – nearly half are controlled centrally
- Actively manage the impact of incidents, with the Metropolitan Police Service
- Proactively manage traffic for major events in London with event sponsors and Metropolitan Police Service
- Enable the comprehensive network of bus priority at traffic signals
- Inform travelers of real-time and forecasted network disruption and congestion
- Improve safety at junctions and pedestrian crossings

Source: Transport for London, UK

Figure 2-1: The London Traffic Control Centre (LTCC)

Traffic Management Centers (Washington State Department of Transportation)

Traffic Management Centers are the nerve center of highway monitoring and operations. Engineers, radio operators and other staff:

- Monitor traffic and identify problems using hundreds of cameras located throughout the state on the highway system.
- Use data from traffic detectors on the highways to get a real-time picture of traffic conditions.
- Coordinate response with the Washington State Patrol and other law enforcement and emergency response crews when responding to incidents on the highway.
- Coordinate activities of WSDOT incident response teams who help stranded drivers, move disabled vehicles, and also help keep traffic moving safely while emergency responders help people involved in accidents.
- Operate reversible lane control systems and ramp meters to help manage traffic flow and reduce congestion.
- Provide up-to-the-minute information about what is happening on the roadway and mountain passes, including weather, incidents, construction, and some travel times, to drivers through highway advisory radios, electronic signs, the web, and the 511 traveler information phone system.
- Provide up-to-the-minute information to news reporters, particularly radio and television reporters.
- Are a critical component of our coordinated response to emergencies and disasters anywhere in the state.

Source: Washington State Department of Transportation

Figure 2-2: Traffic Management Centres (Washington State Department of Transportation)

TMICC Applications have been detailed in Chapter 4.0 of the report.

2.4 Benefits of TMICC

Setting up of Traffic Management and Information Control Centre and management of traffic through these centres have the following benefits:

- Improvement in overall traffic flow by efficient traffic management thereby improving the efficiency of transportation network
- Improved flow of traffic resulting in savings in time for commuters
- Increased road user satisfaction driven by access to real-time information of traffic
- Reduction in traffic congestion

- Capital expenditure on physical infrastructure build-up to cater to traffic requirements can be avoided or postponed
- Reduction in energy consumption for transportation
- Reduction in pollution and Green House Gas (GHG) emissions
- Improvement in coordination amongst various agencies and enabling faster responses to incidents
- Improved planning for traffic management both, for short term measures as well as long term interventions based on data mining and analysis.
- Useful for accident data collection and analysis
- Collected data can be used for framing the traffic policy for the city.

2.5 Standards and Protocols

Traffic Management and Information Control Centres (TMICCs) are hub of information exchange not just between the TMICC and field equipment connected to it but also with other TMICCs, NUTHs and with various other entities operating and managing separate systems which may have useful interfaces with the TMICC (e.g. transit operators, parking operators etc.). In view of this, it is critical that the agencies participating in TMICC follow various standards and protocols while setting up their respective systems in order that the interoperability among the various systems and sub-systems including that with TMICC could be ensured and data exchange could be affected between them.

A more in-depth discussion on the Standards and Protocols has been undertaken in Chapter 3.0.

2.6 TMICC Planning and Designing

Planning and designing of a TMICC must be carried out in a systematic manner adopting a Systems Engineering approach. A detailed description of the Systems Engineering approach has been provided in Annexure 5.

It is also important to sequence the development process in a systematic manner. A flow-chart setting out the various steps for implementation of the TMICC has been provided in Chapter 6.0.

Chapter 3.0 provides details about a number of TMICC applications. However, given the nascent status of development of traffic management systems in Indian cities, it is neither possible nor recommended to undertake the implementation of the full suite of systems. A phased roll-out and the estimated costing for setting up of various sizes of TMICCs have been provided in Chapter 11.0.

2.7 Institutional Considerations for Implementation of TMICCs

There are several considerations from institutional perspective when establishing the TMICCs:

- The agency that may set up and manage the TMICC.
- Agencies that would be responsible for maintenance of the TMICC related equipment and infrastructure.
- Agencies that need to be considered for possible association.
- The nature of association required such as data sharing, co-location, cost sharing, and the role to be played by the agency etc.
- Responsibilities being discharged by the agencies in accordance with the law, government directives or under any other contract / arrangement.
- Level of readiness of the agency such as ITS equipment deployment, automation of the systems (manual or electronic monitoring systems).

These and other related aspects have been discussed in Chapter 9.0 of the report.

2.8 Role of National, State and Local Governments

Various levels of governments play roles in the urban transport sector in India. The framework governing the responsibilities of various entities has been outlined in the Constitution of India (COI).

The division of role between various levels of government in India is governed and guided by the Constitution of India (COI). Article 246 of the COI deals with this matter and contains references to Seventh Schedule containing List I (Union List), List II (State List) and List III (Concurrent List). Article 243 (W) deals with provisions regarding power, functions and other incidental matters related to municipalities.

The roles currently being played by various levels of governments or agencies controlled by them and the suggested roles with respect to setting up and operation of the TMICC have been detailed in Chapter 9.0 of the report.

2.9 Personnel, Training and Capacity Building

TMICCs could either be managed by staff from the participating government agencies/authorities or they could alternatively be managed by staff deployed by the contractors engaged by such agencies. In case the government agencies/authorities chose to deploy their own staff, the staff would need to be recruited and trained since very limited capacity exists in these organisations for managing such systems. In case there is a limitation in hiring of staff by the government agencies/authorities or any preference for outsourcing exists, then contractors could be engaged to deploy manpower for operation

of the TMICC. The contractor staff in such case would work under the control and supervision of the government agencies/authorities.

The details of the organisation setting including the manpower required, the training and capacity building needs have been detailed in Chapter 9.0 of the report.

2.10 Consultants and Contractors

Considering the capacity limitations in government agencies/statutory authorities towards implementing such systems, it is recommended that help and assistance may be sought from professional consultants who have relevant expertise and experience while conceptualising, designing, developing, procuring and programme managing the implementation of such facilities.

As the concept is new to the Indian cities and will require additional support from organisations having required expertise, Ministry of Urban Development, GoI has identified and empanelled a set of consultants who may be engaged by the cities for seeking assistance in conceptualising, designing, procuring and monitoring the implementation of the TMICC in the city. The indicative scope of services for the city specific project consultancy is set out in Annexure 8.

In addition to the consultants, there will also be a need to engage a contractor whose role could entail detailed design, supply, installation, testing, commissioning, maintaining and operating the TMICC. The decision making role of government/public authority could be suitably embedded in such procurements. Table 6-6 of this report provides an overview of the role allocation amongst various project related entities (system owner, consultant and contractor).

A list of some of the potential contractors is provided in Annexure 1 at the end of report for various types of equipment. It is an illustrative list and is not an exhaustive one.

3.0 ITS ARCHITECTURE AND STANDARDS

3.1 Introduction

3.1.1 What is an ITS Architecture?

Intelligent Transport System (ITS) Architecture provides a framework for any type of technology related project in the transport sector. The system architecture is broadly a description of services, ITS components, interconnections and information flow mapping for various systems and sub-systems that encompass the ITS project. ITS Architecture is a strategic business analysis, focusing on users and user services, providing the big picture plan for current and future services, facilities and the functional linkages.

With a properly developed architecture, the owners and the stakeholders can identify both the services required by the end users, the data for these services and the interconnection among the different sub-systems. The architecture goal is to also describe how a system can be optimised, structured and coordinated among various systems and show how the data/information can be used for a common benefit of the end users.

ITS Architecture has the desired ability to improve and enhance system deployments. Specifically, it can:

- Promote compatibility
- Allow expandability
- Allow interoperability
- Improve and enhance systems integration
- Promote standardisation

Through proper sharing of data, information and services, the overall cost of system components can be reduced, enabling multiple systems to work together. This will also allow systems to communicate together, private sector to operate effectively and share information at lower costs than are required to build new systems to collect similar data and services. It reduces system inefficiencies and allows maximum collaboration and cooperation among public sector agencies and private entities. Through identification of services, data flows and interconnections, appropriate standards can also be identified to allow common platform for data and information sharing, which will support standardised systems planning and architecture.

The intent of this chapter is to provide guidance to the public agencies and consultants to understand the ITS Architecture concepts and use these concepts as a step by step process for development of a concept of operations, project requirements and definitions through the use of a Systems Engineering process as described in Annexure 5.

3.1.2 ITS Architecture in Other Countries

Typically an ITS Architecture is a set of frameworks developed at a national and a regional level to describe all of the ITS functionalities that encompass the ITS technology realm. Many countries have developed a national level architecture, typically through a multi-year process, to provide a comprehensive perspective to the ITS development in the country. An ITS Architecture at a national level needs to be supported by a national level ITS Master Plan that describes all existing as well as future ITS vision for the country and for particular regions.

The United States, European Union, Japan, South Korea, and certain other countries have all developed a national level ITS Architecture to support the development and realisation of ITS vision for their respective countries/region. These efforts are multi-year processes which involve all or most stakeholders, trade unions, and private stakeholder industry to become meaningful. Without a comprehensive public input into the process, the programme will have minimal impact and will not be followed by project sponsors.

Furthermore, ITS Architecture is supported by the concepts of standardisation and use of standard technologies and protocols. The use of standards and crucial enabling components of the ITS Architecture support effective use of technologies and allow interoperability and data/information sharing. Consequently, the participation of the private sector, technology vendors and the software/hardware/system integrator community is extremely important in formulating a national level ITS Architecture/Standards platform.

3.1.3 ITS Architecture in India

ITS planning and deployment is in its infancy in India. There are a number of noteworthy achievements in ITS applications in India, primarily in transport technology, traffic management, fare collection and toll collection systems. However, at the present time, there is no national ITS Plan or ITS Architecture that has been developed. Therefore, the burden of developing the ITS Architecture will fall on the project sponsors and proponents. The lack of a national ITS Architecture does not mean that this step is not required. In fact, it becomes more important to understand and apply the concept of ITS Architecture through a Systems Engineering approach, which has been described in more detail in this chapter.

For each project concept, it is critical that the project sponsor evaluates, describes and details out the Architecture requirements to ensure that all of the systems and sub-systems are properly identified, described and data/information flows are identified and described. In this respect, the project sponsor can rely on best approaches in planning, designing, and implementing a system that would consider the best industry practices in formulating the ITS project.

In fact, the World Bank recommends that for those nations and regions that have not yet developed a national or regional ITS Architecture, a project-level ITS Architecture is the recommended initial step to begin the process of formulation of a national ITS Architecture.

Development of ITS Architecture that follow this process, can lead to development of a national level ITS Architecture and a basis for initiating Standards development.

3.1.4 Benefits of ITS Architecture

The benefits of establishing sound ITS architecture include coherence in development process, added value in system identification and cost savings in proper implementation of solutions that benefit the end users.

Development of ITS architecture at logical and functional levels will include a comprehensive analysis of the data underlying each service, identification of commonalities and a sound technical approach to data flows, data sharing, integration and interface standards so that multiple agencies, including the private sector, can be assured that the ITS services and products are compatible and interoperable with other ITS products and services.

Once these elements are correctly identified, the systems integrators can leverage the ITS architecture to develop and create efficient system designs in which the services will avoid unnecessary redundancies and inherent incompatibilities. Compatible systems enable each technology to serve multiple functions as a common platform, providing cost savings and ease of use by multiple end users.

The use of ITS architecture will likely result in

- lower system development cost;
- lower operational and maintenance costs;
- ease of integration, upgrade and expansion;
- improved life-cycle costs; and
- greater end user benefits.

Some of the key benefits of ITS Architecture can be summarised as follows:

- Allows common understanding of assumptions (e.g. data formats, frequency of transfer, data size) by all parties across various system components;
- Provides a unified approach to planning, designing and implementing ITS projects at regional and national levels;
- Provides clarity to planning, design and implementation process;
- Permits evolution of technology and system component replacements and upgrades;
- Facilitates sharing of information across multiple platforms;
- Facilitates interoperability of hardware, software and system components;
- Facilitates more open marketplace so that multiple systems and vendors can compete for services and products, reducing overall costs;

- Allows collaboration among various vendors for services and products;
- Permits economies of scale for system implementation;
- Promotes investments by developers and vendors through a greater level of certainty in the future;
- Enables multiple vendors and sub-systems to be built by separate contractors;
- Allows for improved future operational costs planning;
- Reduces development time and costs;
- Reduces duplication of efforts, and
- Enables information sharing between sub-systems, enabling a regional, national, multi-modal and sustainable transport policy implementation.

3.1.5 ITS Architecture Components

Systems Architecture provides the framework for the ITS Architecture for any given project, system or sub-system. The ITS Architecture can be broadly described and categorised into the following components:

- **User Services:** User services describe the activities related to the ITS or sub-system and applications that support those services. Examples of User Services include TMICC, NUTH, Traveller Information Systems, Signal Control System, Fare Collection System, Electronic Toll Collection System, etc.
- **Functional Architecture:** Functional Architecture or Logical Architecture describes a system from a functional perspective. It focuses on the functional processes and information flows of a system. The functional architecture can also be described as entities where these functions exist, such as a traffic management centre, a public transport system, a parking management centre, etc. A functional architecture describes the specifications or functionalities of a system and how they should work and process the information. It defines the final product or deliverable. A functional description is different from the description of a technology, such as a Global Positioning System (GPS) unit. A GPS unit is a technology component, but providing the physical location of an asset is the functional description of this technology.
- **Physical Architecture:** Physical Architecture describes the physical view of the system. The physical architecture describes how the systems should provide the required functionalities. It defines the data flows that originate from one sub-system to another sub-system or group of systems. The physical architecture also describes the desired communications and interactions between different agencies and organisations. The movement of information is described as the data flows. These data flows also provide the basis for the standards identification.
- **Institutional Framework:** An ITS Architecture would not be complete, unless the institutional frameworks are also identified. As important as the functional or physical

layers or interactions are in the “technology” realm, a system would not be functional or operate at optimal level, if the “human” side of the equation is not considered. In fact, today, due to increased complexity of ITS technologies, multiple stakeholders, both from public agencies and private entities, are involved in developing a complete ITS solution. Identification, interaction and agreements between these entities are critical in developing complete ITS solutions, especially in the areas of traveller information and Traffic Management and Information Control systems. Figure 3-1 depicts the framework of the ITS Architecture from a project level perspective.

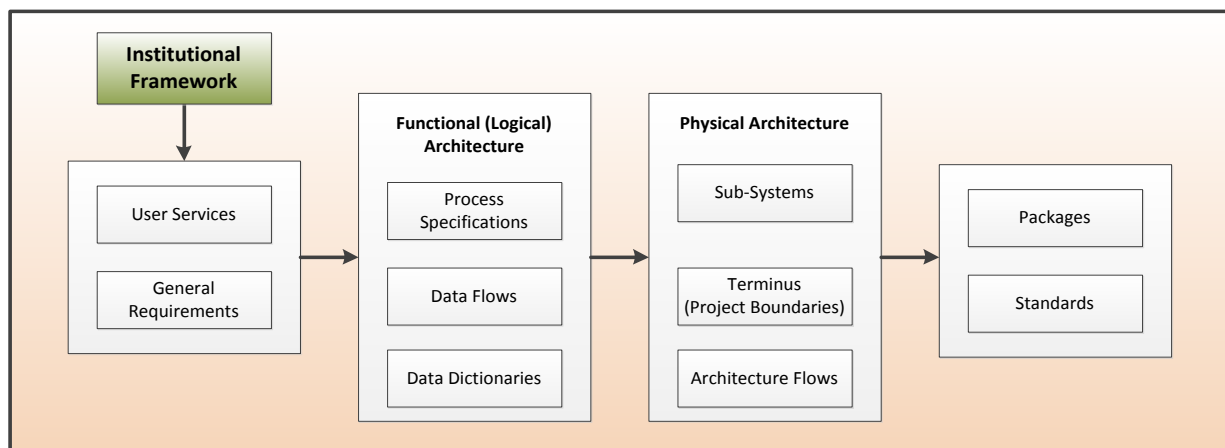


Figure 3-1: ITS Architecture Flow Diagram

3.2 Project Requirements

3.2.1 User Services

In the US National ITS Architecture, for example, there are eight groups of User Services. These eight services are as follows:

- Travel and Traffic Management
- Public Transportation Management
- Information Management
- Maintenance and Construction Operations
- Electronic Payment
- Commercial Vehicle Operations
- Emergency Management
- Advanced Vehicle Safety Systems

The goal of User Services is identification of what level of services are to be provided to the users or to the public. The user services attempt to address issues and needs

associated with the specific user services. These services are not static and can be modified if other types of services, technologies or needs are identified.

Once the User Services are identified, it is important to develop requirements for these services, so that the functionalities are correctly identified and then mapped to the Logical and Physical Architecture requirements. These will then allow a complete description of the Project Definition and the associated Standards that are required to allow interoperability and standardisation.

3.2.2 Requirements

The system requirements are based on the user needs. Requirements do not state how the system will be implemented, but defines what the system is to do; how well it is to do it; and under what conditions. These requirements are detailed and documented. The systems requirements are further refined at the high level design stages that defines the project level architecture for the system which is then further broken down and assigned to sub-systems of hardware, software, database and people.

Requirements for each sub-system element are documented the same way as for the system level requirements. The process is repeated until the system is fully defined and decomposed. Each layer will have its own set of interfaces defined. Each layer will require an integration step that is needed when the sub-system interfaces with the other sub-system. These steps are further defined in the Systems Engineering Section (Annexure 5) of this operations document.

The following is an example of Requirements for a Signal Control sub-system for a TMICC:

- The centre shall remotely control traffic signal controllers;
- The centre shall accept notifications of pedestrian calls;
- The centre shall collect traffic signal controller operational status and compare against the control information sent by the centre;
- The centre shall collect traffic signal controller fault data from the field;
- The centre shall manage (define, store and modify) control plans to coordinate signalised intersections, to be engaged at the direction of centre personnel or according to a pre-defined schedule;
- The centre shall implement control plans to coordinate signalised intersections based on data from sensors;
- The centre shall manage boundaries of the control sections used within the signal system;
- The centre shall maintain traffic signal coordination including synchronising clocks throughout the system.

3.3 Functional Architecture

The functional (logical) architecture defines the more detailed layers of the architecture in terms of setting out the physical sub-systems. The logical architecture aims to define and illustrate the configuration of services. The logical architecture starts with the functions specifications and takes the form of a series of data flow diagrams that depict the logical processes, the data flows and the definitions of the data requirements, or Data Dictionaries. It is a graphical tool to organise complex entities and relationships. It focuses on the functional processes and the information (data) flows of sub-systems and the system as a whole. A logical architecture helps to identify the system function and guides the development of the overall requirements of the system and/or upgrades. A logical architecture is independent of institutional framework and technology, but is supported by the institutional arrangements and goals.

Figure 3-2 is an example of a representative TMICC Functional Architecture. It depicts those services that are anticipated and required for the particular projects. Not all of these services are necessary for all TMICCs, and would need to be customised to the particular agency requirements and needs.

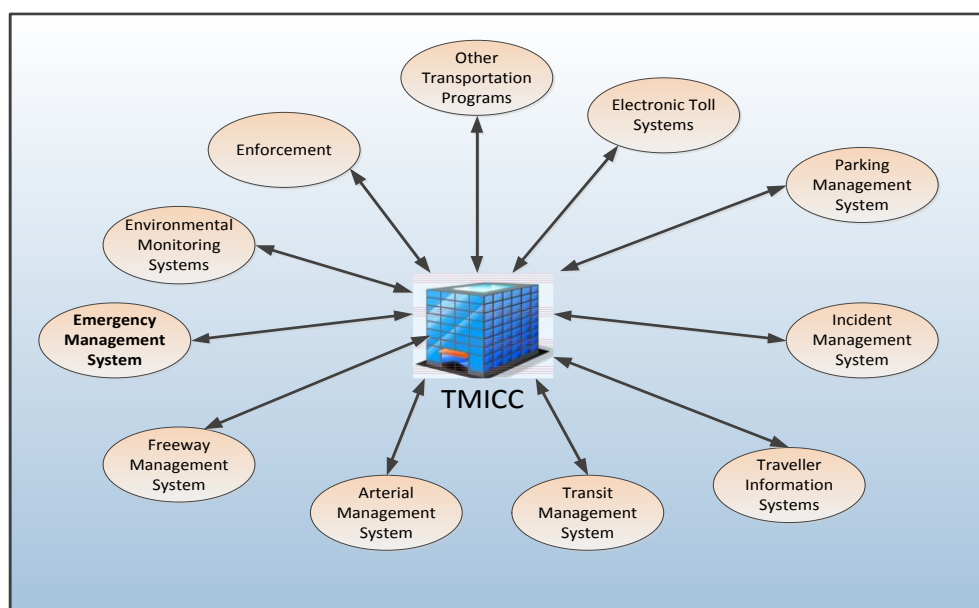


Figure 3-2: Representative TMICC Functional (Logical) Diagram

3.3.1 Process Specifications

Process Specifications are detailed description of the functionalities for all of the activities that will take place in the project. Table 3-1 shows examples of these functional descriptions for a typical TMICC project.

Table 3-1: Representative Process Descriptions for TMICC

Functional Areas	Description
Process Traffic Sensor Data	<p>This process is responsible for collecting traffic sensor data. This data includes traffic parameters such as speed, volume, and occupancy, as well as video images of the traffic. The process collects pedestrian images and pedestrian sensor data. The process collects reversible lane, multimodal crossing and special lane systems. Where any of the data is provided in analog form, the process is responsible for converting it into digital form and its calibration. The converted data should be sent to other processes for distribution, further analysis and storage. The process should accept inputs to control the sensors and return operational status (state of the sensor device, configuration, and fault data) to the controlling process.</p>
Exchange Data with Other Traffic Centres	<p>This process exchanges data with the other Traffic Management centres. This represents the exchange of data between peer 'Manage Traffic' functions (e.g. between peer and TMICCs). The other TMICC can be adjacent geographically, under control of a different jurisdiction, or part of a more complex hierarchy. The exchange of data may be triggered by a request to (or from) the other Traffic Management Centre or the exchange of data may be initiated without a specific request. This data includes both traffic information and traffic control data. Some examples of these exchanges are:</p> <ul style="list-style-type: none"> • traffic control pre-emption for vehicle routes which pass through the local network but have a destination in an area served by another remote TMICC; • data about an incident that has an impact on the traffic conditions in the network served by a remote TMICC; • control data for the Manage Traffic function to control video cameras or environmental sensors under the jurisdiction of another traffic management organisation; or • requests for control of the other centre's field equipment. <p>The data received from remote TMICCs could be used to vary the current traffic control strategy to give signal pre-emption to emergency vehicles or enable the passage of commercial vehicles with unusual loads, or as input to the local traffic predictive model estimation process.</p>
Review and Classify Possible Incidents	<p>This process would review input data about possible incidents and provide verification of the incident. The process should have the capability of using algorithms to automatically identify and verify an incident. The process should have the capability to classify an incident</p>

Functional Areas	Description
	as a current incident or a planned event (such as a multimodal crossing) and shall output that potential incident data to another process for storage. The process should report any incidents that it is unable to verify or classify to the traffic operations personnel for manual verification and classification. The process should allow the traffic operations personnel to request all possible incidents and carry out the verification and classification process manually. This process should provide feedback on proposed maintenance and construction work plans and proposed event plans.

3.3.2 Data Flows

Information exchanges between the processes and functional specifications are called data flows. Data flows follow all activities that exchange information in one or both directions. Data flows follow the Process Specifications. Data flows are aggregated together to form high-level architecture flows in the physical architecture as will be discussed later. Figure 3-3 shows a representative data flow of TMICC system. (Note that not all flows are shown).

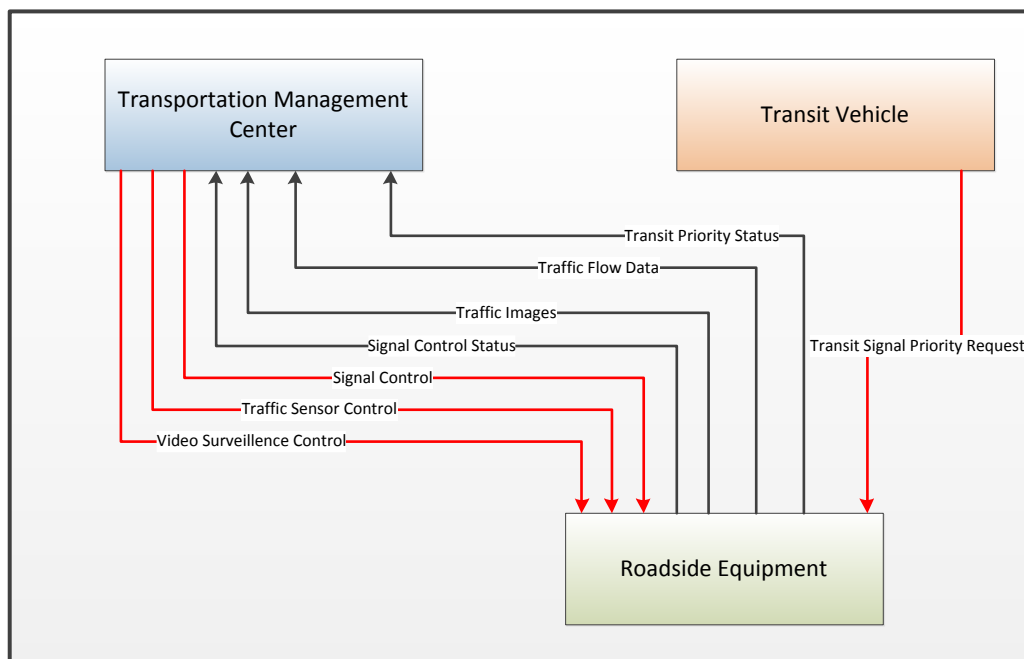


Figure 3-3: Representative Data Flow for a TMICC

3.3.3 Data Dictionaries

Every data flow included in the logical architecture should have a defined data dictionary. Each data dictionary entry should contain a description of the data flow and identify any

lower level data elements that make up the data flow. In this fashion, all data requirements can be identified.

3.4 Physical Architecture

The physical architecture is a physical representation of the important ITS interfaces and the major system components. This provides a physical representation of how the system should provide the required functionalities. This is a line drawing representation and should not be a detailed level design.

The physical architecture takes the processes identified in the functional architecture and assigns them to physical entities. The data flows that originate in the functional architecture are grouped together in the physical architecture flows. This architecture also identifies the communication requirements and the interfaces that are required between sub-systems. This would include preliminary identification of desired communications and interactions between different transportation systems and organisations.

3.4.1 Sub-Systems

Most of the National ITS Architectures have identified four major categories to represent physical entities for typical public transport systems. These include Centres, Field Equipment, Vehicles (Including automobile, transit vehicles and commercial vehicles) and Travellers or Human interface. From the communications perspective there are a number of options that can connect various sub-systems. These include both wire-line (hardwired) and wireless systems. Wire-line systems include all types of physical communications media, such as fibre optics, twisted wire-pair and coaxial cable. Wireless options include microwave, spread spectrum, mobile applications, dedicated short range communications, and other similar media. Figure 3-4 is a depiction of potential connection options between various sub-systems in the four areas of transport system and various communication media.

A physical architecture supports multiple sub-systems or functionalities from multiple sub-systems. This is particularly important for the centre sub-system, which is not in particular a physical building. A centre can represent any location that collects data, fuses data and disseminates the data to the end users. A centre can also function for multiple purposes. For example, a Traffic Management Centre can act both as a traffic management function as well as traveller information system. A centre can also function as a multi-agency system, housing both the traffic management as well as emergency incident management functions.

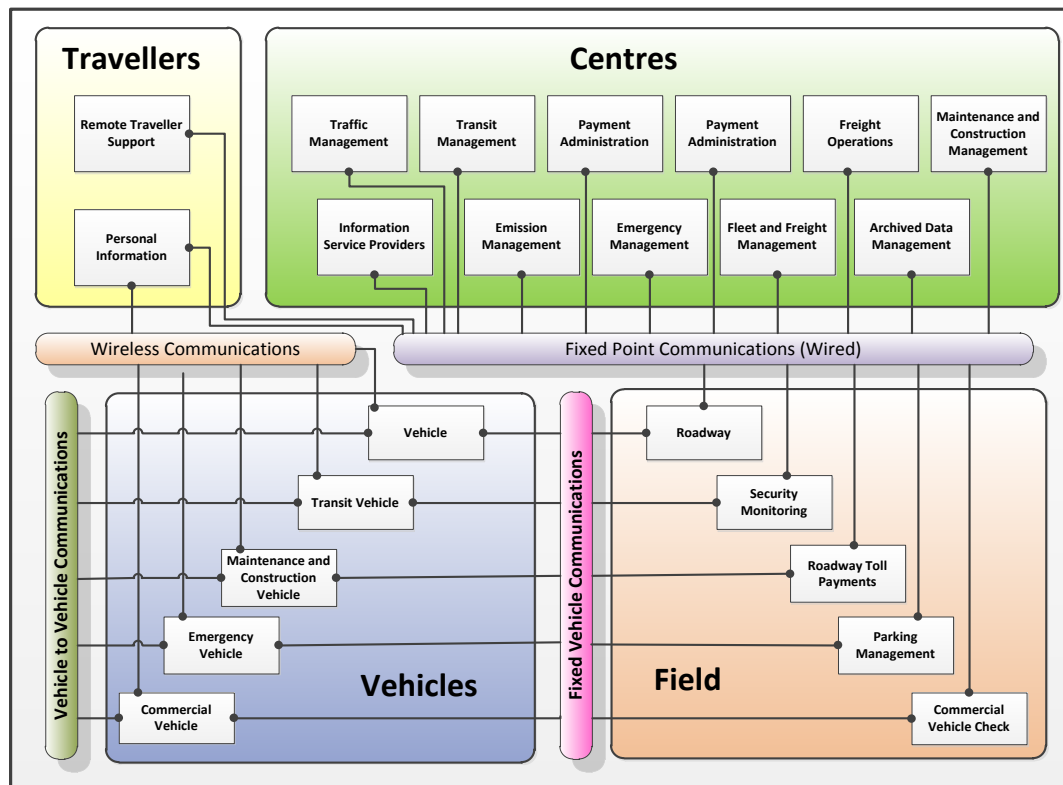


Figure 3-4: Physical ITS Architecture Sub-Systems and Communications

Figure 3-5 shows a representative TMICC application and the communication flow diagram.

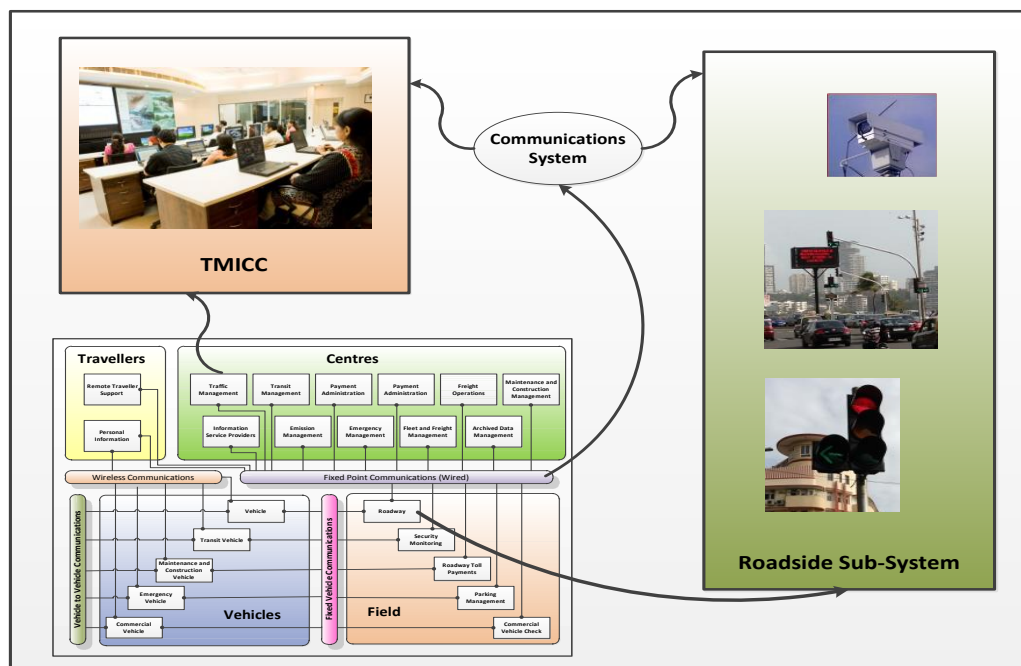


Figure 3-5: Representative TMICC Communications Diagram

3.4.2 Boundaries (Terminus)

Boundaries or Terminus are the interfaces to the real world and the end users. The physical architecture defines interfaces to the terminus, but does not define functionality for the terminators. Terminus can be humans, environments, and systems.

In a TMICC system, for example, the Traffic Operator is a terminus. This terminus represents the human entity that directly interfaces with traffic operations. These personnel interact with traffic control systems, traffic surveillance systems, incident management systems, work zone management systems, and travel demand management systems to accomplish ITS services. They provide operator data and command inputs to direct systems operations to varying degrees depending on the type of system and the deployment scenario. All functionality associated with these services that might be automated in the course of ITS deployment is modelled as internal to the architecture.

Annexure 2 provides examples of different boundaries (terminators) for human, environment and systems.

3.4.3 Architecture Flows

Information that is exchanged between sub-systems and terminus in the physical architecture are the architecture flows. Architecture flows and their communication requirements define the interfaces which form the basis for much of the standards that need to be defined. Data flows described earlier in the Logical Architecture are aggregated together to form architecture flows.

Figure 3-6 shows a typical architecture flow for a signal control sub-system in a TMICC system.

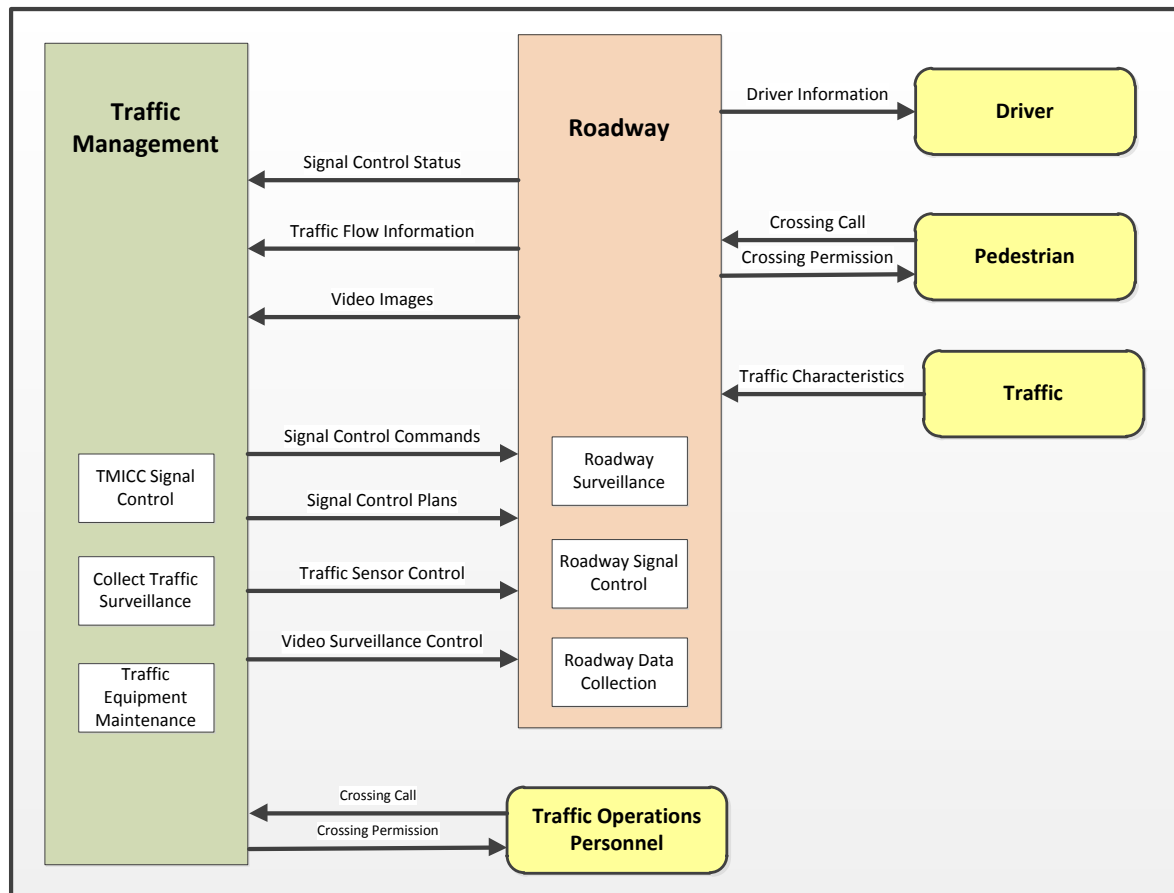


Figure 3-6: Architecture Flows for a Representative Signal Control Sub-System³

3.5 Project Definitions

Project Definitions are the outcome of the 4-step process described earlier. It will become a textual, graphical and description of the project components. In a fully developed national ITS Architecture, these are defined as Market or Service Packages or similar terminologies. However, the step by step process will result in a fully developed ITS Architecture framework.

3.5.1 Packages

Project packages are a group of sub-systems that work together to form an implementable package of hardware and software capabilities. The group of functions takes into account the user services and the need to accommodate various levels of functionalities.

³Adapted from US National ITS Architecture

These groups of functionalities or “packages” include a description of the following components:

- Functionalities
- Inputs and Outputs
- Security Considerations (information and data protection)
- Sub-Systems Interface Diagrams
- Boundaries (Terminus) Interface Diagrams

Packages can be a number of sub-systems or a complete sub-system, such as a Traffic Control system or Transit Traveller Information system. In a TMICC system, there will be several packages that would comprise the full scale of the proposed project. Project packages can be grouped together as a “Service Packages”

The following are examples of Service Packages related to TMICC:

1. Traffic Signal Control
2. Network Surveillance
3. Traffic Metering
4. Traffic Information Dissemination
5. Reversible Lane Management
6. Roadway Closure Management
7. Traffic Incident Management System
8. ITS Data Archives

This list is not an exhaustive set of service packages and depending on the project requirements, there can be other functions, such as interfaces with street light management systems, parking management systems, and emergency management system components.

3.5.2 ITS Standards

One of the primary functions of ITS Architecture is to help define ITS standards, particularly at the interfaces between major ITS components.

The ITS standards are important, because as of now in India, there are no mandatory standards in place when implementing advanced technologies into transportation implementations. There are currently, a number of initiatives in India towards formulation and adoption of standards, such as the initiative taken by Bureau of Indian Standards (BIS) towards setting of standards for Automatic Fare Collection System, Signalling and Vehicle Tracking Technologies. In addition, MoUD has also requested the National Association of Software and Services Companies (NASSCOM) to develop ICT architecture framework, GIS architecture framework and safe city architecture framework.

The use of standards is important, because the four main system types in the architecture classes: centre, field, vehicle, and traveller, must be able to communicate with each other and across many systems. The “centre” must be able to remotely access what is going on in the “field”; the “vehicles” and “travellers” must be able to understand the signs and directions implemented when traveling with the new Intelligent Transport Systems.

The current “most practical” source of ITS standards for application in India is the International Organization for Standardization (ISO) which is also being referred to by BIS for adoption in India. The list of potential ISO Standards that could be used is provided as Annexure 3. Specifically, ISO TC204 has developed an architecture that defines the ITS standards activities. Since this is a relatively simple architecture, it can serve as a base model for the ITS architecture activities.

ISO TC204 provides recommendations for standardisation of information, communication and control systems in the field of urban and rural surface transportation, including intermodal and multimodal systems, traveller information, traffic management, public transport, commercial transport, emergency services and commercial services. The table provided in Annexure 3 is a summary of applicable standards that are related to the TMICC applications. Since there are no mandates or requirements established by any of the Indian Government agencies, these standards are advisory and shall be treated as such. As and when standards are notified by BIS, the same may be adopted for designing and implementation of the TMICCs and its various components.

3.5.3 Use of Standards in Project Implementation

There are a number of activities that can be undertaken to enhance the use of ITS Architecture and Standards. These include the following:

- Developing a common data model
- Establishing communications standards
- General communication technologies

A. Common Data Model

ITS applications are dependent on the availability and use of many types of data, including traffic, transport, weather and other information. The data is often created by many organisations and without a common uniformity. Therefore, it would be important to establish uniformity in data formats to make the information consistent among various systems. One approach is to use ISO standards or use the XML (Extensible Mark-up Language), which has become a standard in IT for information exchange, especially in the Internet domain.

There is no common standard for data exchange used in India by traffic agencies and transit operators. Traffic agencies and transit operators in India are currently using data exchange protocols provided by their respective systems integrators. The National Transportation Communications for ITS Protocol (NTCIP) is widely used in USA as a

communications standard to ensure interchangeability and interoperability of Intelligent Transport System (ITS) devices including traffic signal controllers. Similarly, in the United Kingdom, Urban Traffic Management Control (UTMC) is used as a standard for communicating and sharing of information by ITS and traffic systems such as traffic signals, cameras, and Variable Messaging Signs (VMS).

In respect of transit information dissemination, General Transit Feed Specification (GTFS) is one of the exchange protocols that has been popularised by Google and has been used by many transit operators in India and internationally for disseminating transit schedule and operational details to general public on Google Maps. In India, Bangalore Metropolitan Transport Corporation (BMTCL), Namma Metro, Bengaluru and Metropolitan Transport Corporation (MTC), Chennai have used GTFS for disseminating their transit schedule through Google Maps. In the UK, TransXChange is used as nationwide standard for exchanging bus schedules and related data. JourneyWeb (UK) is the protocol used for Journey Planners to communicate. Network Exchange (NeTEx) and Service Interface for Real Time Information (SIRI) (Europe) and GTFS (USA and many other countries) are other standards used internationally. Open511.org has also developed the specification for sharing road events and traffic related data in open format. It has been done in collaboration with Metropolitan Transportation Commission; Canada, Ministry of Transportation of British Columbia; and Canada, Open North, Canada. Any other organisation can start implementing Open511 specification but it should be done in collaboration with MTC and Open North since some minor changes could still occur

B. Communications Standards

Communications standards include both the data dictionaries, message set specification and the protocols using which the packages of information is transmitted and received. Data dictionaries are an organised collection of data elements, which describe the meaning, format and the use of the data elements. Defining these elements will be extremely important in establishing a standard protocol of information exchange.

C. Communications Technologies

Using standardised communication technologies can benefit ITS deployment and ease of use. Almost all ITS applications can use existing communication infrastructure (e.g. mobile radio services, conventional and cellular telephones, internet, FM subcarriers, digital audio broadcast, etc.). Many traffic information service operations through the internet and cellular telephone technology is often used for communication between centres and field equipment. Initial capital costs, as well as on-going operational costs for leased telecommunication systems must be evaluated during the Systems Engineering process to address the life-cycle needs of the project.

4.0 TMICC APPLICATIONS & CONCEPTS

4.1 Introduction

This chapter provides an overview of the major operational areas and applications supported by the TMICC. The topics that have been covered in this chapter are TMICC applications covering traffic enforcement, traffic monitoring, interfaces with transit operations and other agencies, information dissemination and data warehousing.

4.2 TMICC Applications

Table 4-1 provides an overview of the TMICC related applications in the area of Traffic Enforcement, Traffic Monitoring, Transit Operations and Information Dissemination. These have been detailed in subsequent sub-sections.

Table 4-1: TMICC Applications

Area	TMICC Applications
Traffic Enforcement (Section 4.2.1)	<ul style="list-style-type: none"> On-road checks Speed violations Red light violations Parking violations Entry restriction violations Handheld Device Based e-Challan System
Traffic Management and Monitoring of Roadway Systems and Traffic Junctions (Section 4.2.2)	<ul style="list-style-type: none"> Signal Timing and Operations Road Network Surveillance Active Traffic and Demand Management Emergency Operations and Incident Management
Interfaces with Transit Operations (Section 4.2.3)	<ul style="list-style-type: none"> Bus Operations Metro and Suburban Rail Operations (Urban Areas) IPT Operations
Interfaces with Other Agencies (Section 4.2.4)	<ul style="list-style-type: none"> Parking Management and Operations Safe City Control Centres Toll Operations Congestion Pricing Integrated Corridor Management Lighting System Control Weather Information Air quality monitoring system
Information Dissemination	<ul style="list-style-type: none"> Congestion

Area	TMICC Applications
(Section 4.2.5)	<ul style="list-style-type: none"> • Incidents • Construction Activities • Website • Mobile Phone Applications

4.2.1 Traffic Enforcement

Traffic Enforcement is generally carried out by the Traffic Police in Indian cities. Typical traffic enforcement related activities would include the following activities (Figure 4-1):

- On-road checks
- Speed violations
- Red light violations
- Parking violations
- Entry restriction violations
- Handheld Device Based e-Challan System

TMICC should either contain systems for the above activities or interface with Traffic Enforcement Centre to obtain and to share relevant information pertaining to the above. Typical applications of information sharing for the above components are listed below:

- A. On-road Security Checks:** In India, on-road checks as a security measure are a common phenomenon. While the information cannot be published for general public, it could be used by the TMICC for re-routing emergency vehicles (like registered ambulances etc.)
- B. Speed Violation Detection System:** Although the Speed Violation Detection System would be hosted by the traffic enforcement wing, it should share data pertaining to speed violations with the TMICC. This data could be used for planning purposes. Also, in instances of erratic driver behavior the data could be used by the TMICC to regulate traffic and prevent accidents. Since Speed Violation Detection field equipment are expensive and would be deployed selectively, in case the TMICC captures any speed violation event, the details of the same could be transmitted to the enforcement authorities for appropriate action.
- C. Red Light Violation Detection System (RLVDS):** The RLVDS would also be hosted by the traffic enforcement wing. However, information of violations should be shared with the TMICC for analyses (e.g. correlation with accidents, vehicle category wise violations etc.) and planning corrective actions, if any. In case the TMICC captures any red light violation event, the details of the same could be transmitted to the enforcement authorities for appropriate action.
- D. Parking Violations:** While parking areas are managed by the urban local bodies or transit agencies (metro, bus terminal agencies, railways etc.), the enforcement of

parking rules is typically carried out by the Traffic Police. The information of violations should be shared with the TMICC for analyses and planning corrective actions, if any (e.g.: planning for additional parking, changes in parking rates etc.). In case the TMICC captures any parking violation event, the details of the same could be transmitted to the enforcement authorities for appropriate action.

- E. Entry Restriction Violations:** Most large and medium sized cities in India have entry restrictions pertaining to certain classes of vehicles or pertaining to specified zones. These rules should be shared with the TMICC so that it can disseminate the information through various channels. Also, in case the TMICC captures any violation event, the details of the same could be transmitted to the enforcement authorities for appropriate action.
- F. Handheld Device Based e-Challan System:** These systems are used by Traffic Police for traffic and transport related enforcement. Data from the e-Challan system should interface with TMICC and can be used by TMICC for analysis.

In certain instances, TMICC may also use the video feeds available through the enforcement system to cross-check or validate traffic related issues which have been reported to the TMICC.

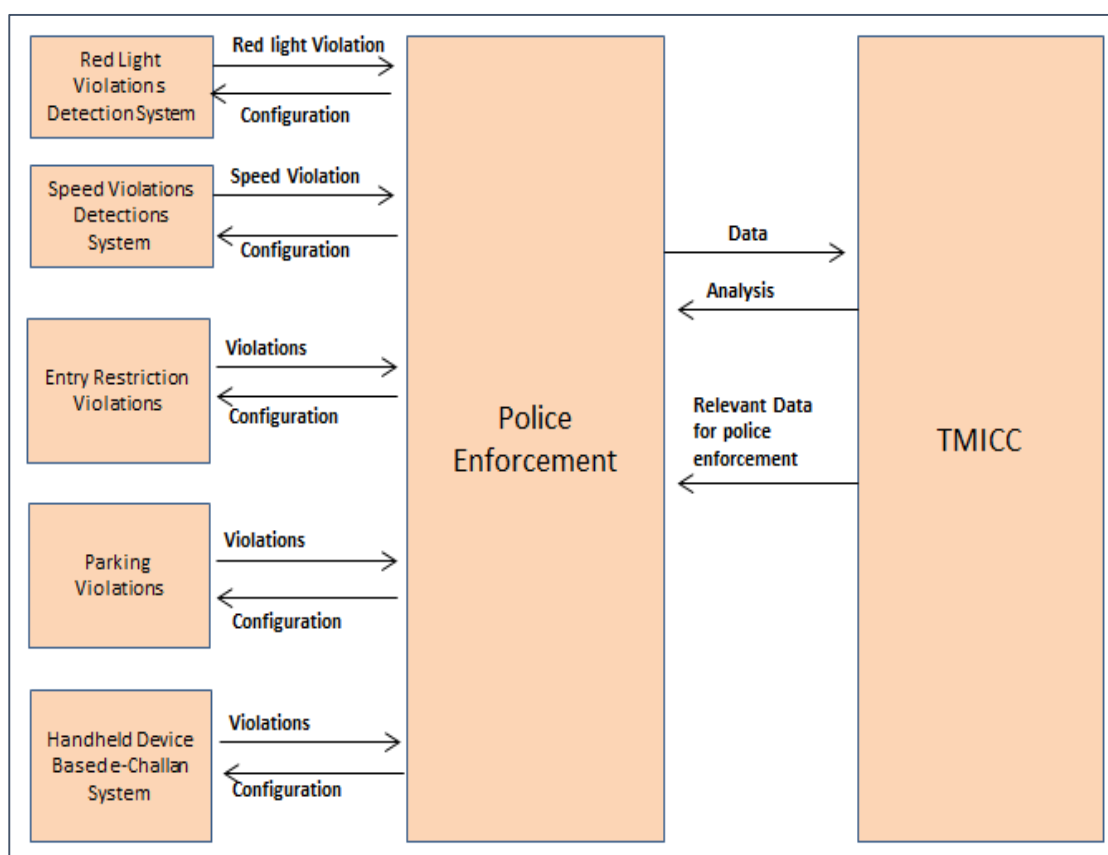


Figure 4-1: Traffic Enforcement

4.2.2 Traffic Management and Monitoring of Roadway Systems and Traffic Junctions

The Roadway systems cover all the field equipment and sensors that are installed on the roads to support management of road network and traffic movements on the same. These provide critical inputs covering aspects such as traffic volume, signal status, street images, etc. that helps in taking appropriate traffic management measures.

TMICCs receive data and information from several field equipment sources and based on the analysis of data received, various activities are performed by the TMICC such as signal control, surveillance, incident support, supporting traffic rule enforcement, data dissemination etc. Figure 4-2 provides an overview of some of the important TMICC interfaces.

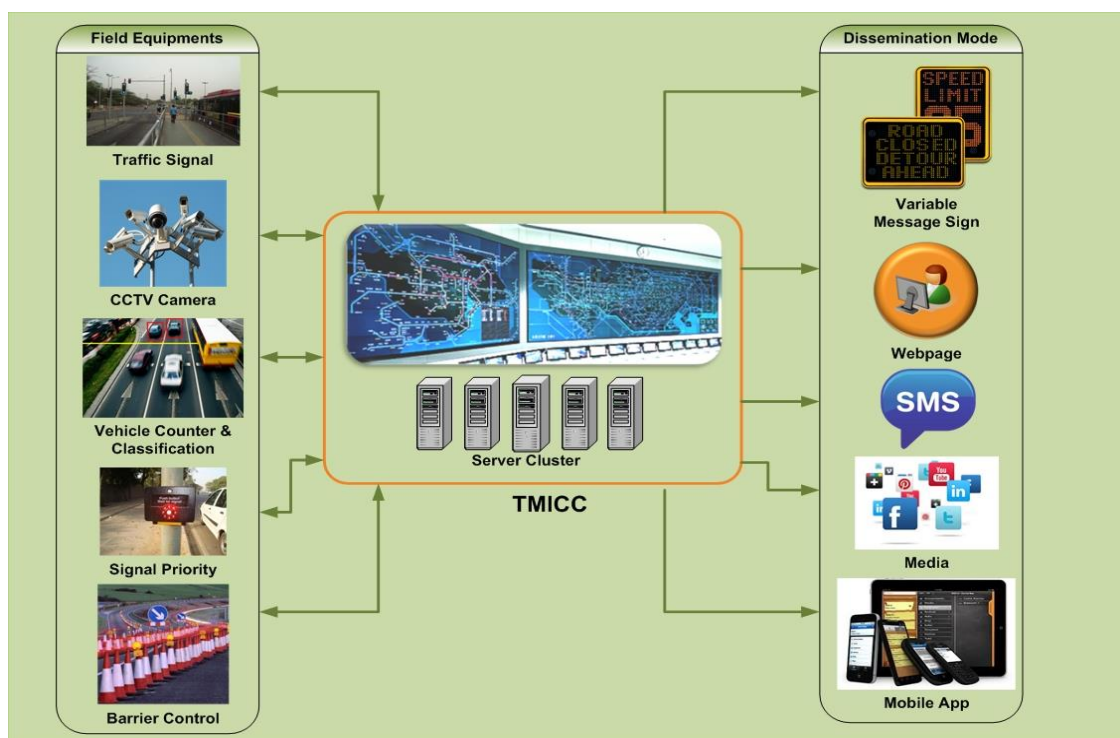


Figure 4-2: TMICC Field Equipment Interface (Centre to Field)

The components covered under this system include the following:

- Signal Timing and Operations
- Road Network Surveillance
- Active Traffic and Demand Management
- Emergency Operations and Incident Management

These have been described in the following sub-sections.

4.2.2.1 Signal Timing and Operations

The traffic signals are operated through controllers where signal plans are loaded. In case of adaptive signals, detectors and/or cameras could also form part of the signal system. Worldwide, signals are typically connected to the TMICCs (or control rooms) over communication networks. Two way communication is required to manage the signals through TMICC. TMICC transmits signal plans to the controller and the controller in turn provides the operational and functional status to the TMICC.

Another critical function is to provide for signal priority for specified categories of vehicles. These signal priority systems provide the capability to support signal priority and pre-emption policies at signalised junctions for special category of vehicles viz. transit vehicles, emergency support vehicles etc. The signal operation is adjusted to turn green upon acceptance of request. Signal pre-emption is given generally to the emergency support vehicles. Upon receiving request from these vehicles, the signal operation is adjusted by the signal controller to turn green in order to provide priority passage to such vehicles. TMICC Backend would be used to configure the parameters related to vehicle priority application. On ground, the vehicle priority would be handled locally by way of interaction between controllers and specified vehicles approaching the junction.

Signal timing and operations management is a very critical activity carried out as part of traffic monitoring and control in order to optimise the traffic flow. This activity is supported by specialised software at the TMICC, communication links between TMICC and the signal controllers located at junctions and equipment installed on emergency vehicles to communicate with signal controllers (Figure 4-3).

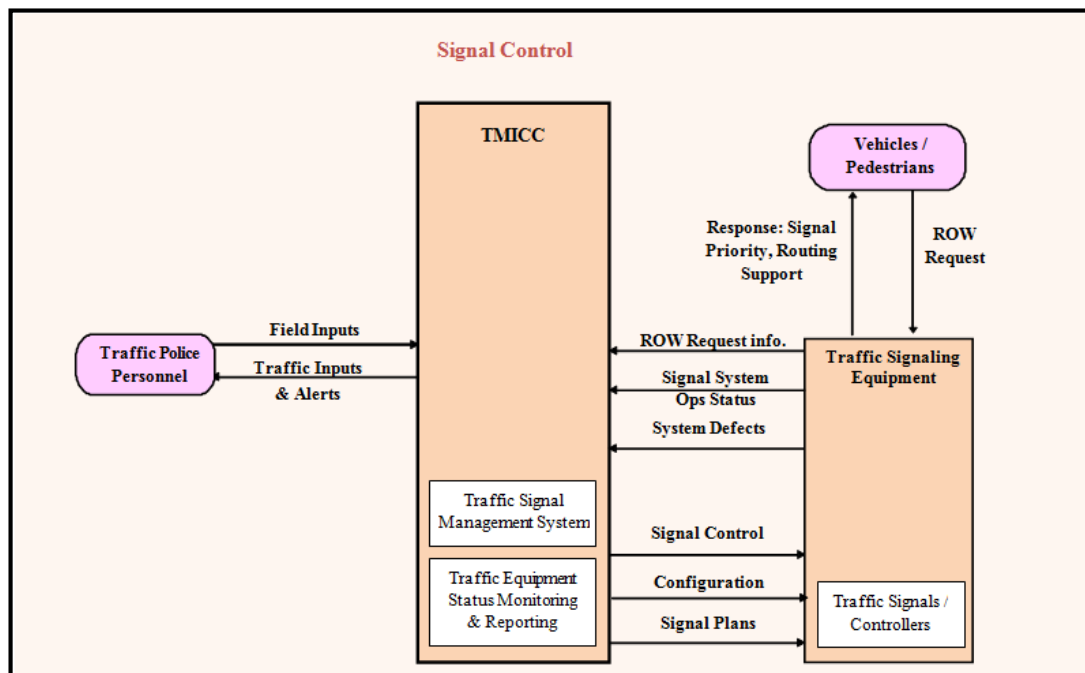


Figure 4-3: Signal Control

As part of signal timing and operations activity undertaken by the TMICC, inputs from a variety of sources are received and processed at the TMICC. The activities that the TMICC performs as part of this are listed below:

- Controlling signals from TMICC that are connected to it through communication links
- Signal control plans creation based on surveillance and other inputs and its implementation. The plan could be based on fixed time, adaptive or local operations.
- Coordinate with other signalised junctions while creating, modifying and implementing the signal control plans
- Configure signal controllers to operate in various modes such as adaptive, fixed time based etc.
- Collect signal LOS (level of service) or similar congestion data
- Collect and monitor status update from signal controller such as fault data
- Clock synchronisation of signal controllers

4.2.2.2 Road Network Surveillance

Road Network Surveillance would be carried out through vehicle detectors, sensors and surveillance cameras that monitor the traffic conditions on the road network, capture visuals and traffic characteristics from the field and transmit data to the TMICC for review and analysis. The data collected by detectors is speed, volume, classification and occupancy whereas the cameras collect images and videos.

TMICC transmits command and configuration details to these equipment and they send the captured data (speed, volume, classification, occupancy, images, videos), operational and functional status of the equipment to the TMICC (Figure 4-4). Signal timing can be adjusted based on the data feed for the surveillance equipment.

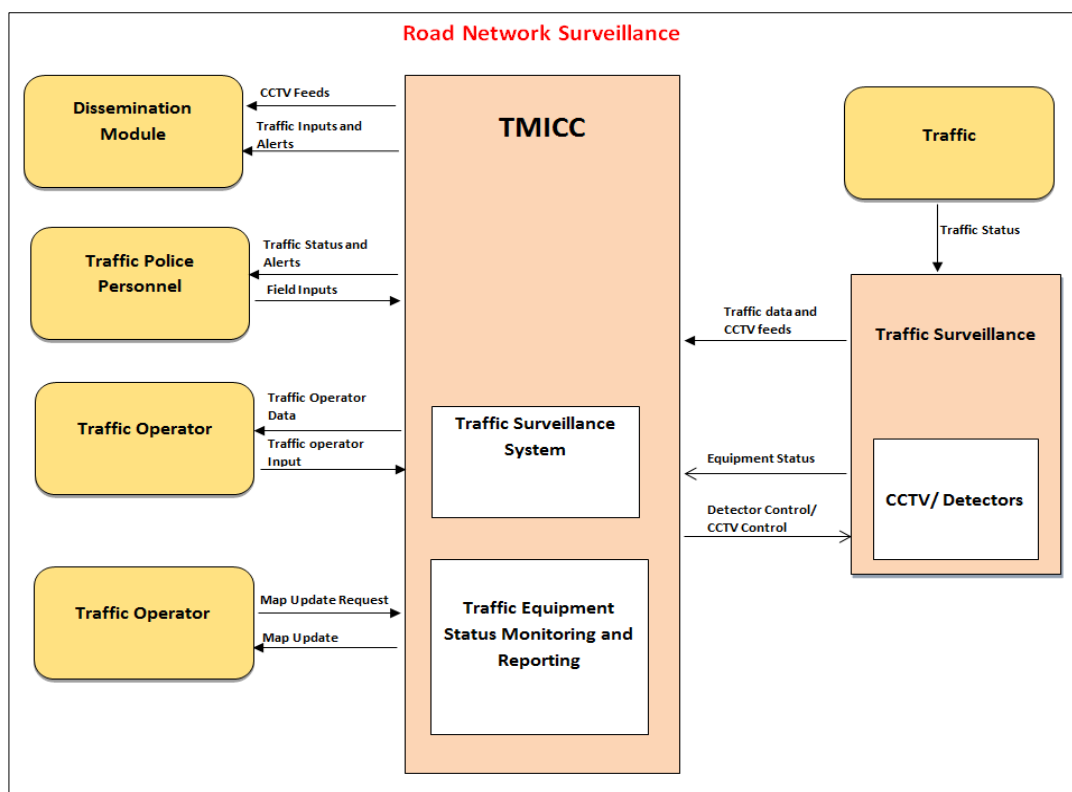


Figure 4-4: Road Network Surveillance

4.2.2.3 Active Traffic and Demand Management

The Active Traffic and Demand Management (ATDM) approach seeks to work towards efficient utilisation of the existing transportation network and to achieve a balance between demand and supply on a dynamic basis based on the prevailing and projected situations. This approach relies on extensive use of ITS, data collection and data mining tools. TMICCs could be used to support many of these initiatives.

Some of the examples of Active Traffic and Demand Management approaches are provided below:

- A. Dynamic speed limits:** Speed limits for any section do not remain fixed but change dynamically based on the real time assessment of traffic situation, weather and environmental conditions, road conditions etc. This has been applied extensively in Europe (U.K. Germany, Netherlands, etc.) and in USA.
- B. Adaptive signals:** Signal timing is dynamically adjusted based on current traffic on the arms of the junction to improve traffic throughput. Several cities have this system worldwide including London.
- C. Queue Alert:** Informing travellers through variable message signs regarding congestion or queues ahead.

- D. Dynamic rerouting:** Informing travellers through variable message signs to take alternate routes to avoid congestion on a route.
- E. Real time Ride sharing:** Facilitating ridesharing at very short notice using GPS locations of the driver and passenger. This has been implemented in USA (San Francisco Bay Area and other agencies).
- F. Dynamic parking management:** Parking charges vary in real time based on the current demand-supply situation. This has been used by San Francisco Municipal Transportation Authority (SFMTA) in the downtown area.
- G. Barrier Control:** This system provides the capability to remotely control barriers on road network. TMICC sends command and configuration details to the equipment and they send the operational and functional status of the equipment back to the TMICC.

4.2.2.4 Emergency Operations / Incident Management

Emergency response and its management is the responsibility of designated agencies and authorities through the emergency centre. Incident response requires several city agencies to come together, participate and discharge their respective roles. The need for information sharing and dissemination becomes very critical in such situations. TMICCs typically have a supporting role in emergency management as listed below:

A. Detecting Incidents

- Receive alerts and inputs on incidents/events from various sources including from public by telephone, e-mails etc.
- Verify incidents based on feeds received from surveillance systems and also provide the feed to emergency centres.
- Exchange incident related information with the emergency centres.
- Allow emergency centres to control sensor and field surveillance equipment.

B. Coordination for Emergency Vehicles Dispatch

- Coordination with emergency centres towards planning for incidents response and recovery.
- Providing special routing and signal pre-emption for emergency vehicles responding to incidents.
- Exchange incident information (such as details, spot, impact on traffic, current status, likely duration, and response details) with emergency centres, maintenance and construction agency, transit agencies, transport helplines, and the media.

- Exchange status of road network with emergency and maintenance agency including location, damage suffered, residual capacity, closures, alternate route, and expected time for repair.
- Receive details from transit agencies and emergency agency to develop an overall status of the transportation system including emergency transit schedules and current status of the transport facilities.

C. Support During Evacuation

- Coordinate planning for evacuation with emergency centres such as establishing routes, areas to be evacuated, timing, etc.
- Support requests from emergency centres to pre-empt the current traffic control strategy, activate traffic control and closure systems such as gates and barriers, to support evacuation traffic control plans.
- Coordinate execution of evacuation strategies with emergency centres such as setting closures and detours, establishing routes etc.

Depending upon the nature of the event, TMICC would analyse the situation and undertake required action as listed in Table 4-2.

Table 4-2: TMICC Analysis and Action Taken

	Issues	Analysis	Action
Foreseen Events	Climate/ Weather/ Vagaries	<ul style="list-style-type: none"> • Information regarding this would be provided by meteorological department to TMICC • TMICC will analyse the potential impact of the predicted weather condition on the traffic. 	<ul style="list-style-type: none"> • TMICC would disseminate this information to the public through various channels • TMICC would take necessary steps regarding traffic diversion and issue advisory based on its assessment of the impact on traffic.
	Ambulance	<ul style="list-style-type: none"> • The signalling system would be able to detect when the ambulance approaches the junction. 	<ul style="list-style-type: none"> • Signal priority would be given to the ambulance based on the policy followed by TMICC
	Festivals/Rallies/ Events	<ul style="list-style-type: none"> • Information regarding this would be provided by department concerned to the TMICC • TMICC will analyse the potential impact of the planned event on the traffic. 	<ul style="list-style-type: none"> • TMICC with the help of Traffic Police would make the traffic circulation plans for the events • TMICC would disseminate this information to the public through various channels

	Issues	Analysis	Action
Unforeseen Events	Breakdown of street furniture such as signal not working or any other issues	<ul style="list-style-type: none"> • TMICC would detect the breakdown • TMICC would also analyse the street furniture through its systems like cameras and other mechanism 	<ul style="list-style-type: none"> • TMICC would take necessary steps regarding traffic diversion and issue advisory based on its assessment of the impact on traffic.
	Accident	<ul style="list-style-type: none"> • TMICC would analyse the traffic data and detect the accidents based on the traffic pattern. • Concerned authorities may also provide accident related information to TMICC. 	<ul style="list-style-type: none"> • TMICC would disseminate this information to the public through various channels • TMICC would help in diverting the traffic • TMICC would inform the agencies for action on road • Coordination for emergency vehicle dispatch. • Support to authorities concerned during evacuation.
	Vehicle breakdown on roads	<ul style="list-style-type: none"> • TMICC would analyse the traffic data and detect the vehicle breakdown based on the traffic pattern. • Concerned authorities may also provide vehicle breakdown related information to TMICC. 	<ul style="list-style-type: none"> • TMICC would disseminate this information to the public through various channels • TMICC would help in diverting the traffic • TMICC would inform the agencies for action on road • Coordination for emergency / towing vehicle dispatch. • Support to authorities concerned during traffic restoration.
	Landslide	<ul style="list-style-type: none"> • TMICC would analyse the situation with the system cameras. • Concerned authorities may also provide information to TMICC. 	<ul style="list-style-type: none"> • TMICC would disseminate this information to the public through various channels • TMICC would divert the traffic. • TMICC would inform the agencies for required action on the road.

	Issues	Analysis	Action
Disaster	Disasters such as fire/ flood/ earthquakes	<ul style="list-style-type: none"> Management of disasters and other calamities are dealt with by the disaster management authorities. TMICC would analyse the situation in consultation with authorities in case of disaster and would recommend the necessary steps to be taken by authorities to regulate traffic flows. 	<ul style="list-style-type: none"> TMICC would disseminate this information to the public through various channels Disaster Management authorities would communicate with TMICC through interface about the disaster. Disaster Management authorities would guide the TMICC for the action to be taken. TMICC would also make traffic plans in coordination with the Traffic Police.

Traffic Incident Management Support system enables TMICC to detect incidents as well as provide incident management support to the authorities concerned (Figure 4-5). The system primarily analyses data captured by the detectors and surveillance cameras using algorithms to detect the patterns indicating potential incident. This is then verified by using feeds from surveillance cameras and/or field personnel. TMICC sends command and configuration details to these equipment and they send the captured data (speed, volume, occupancy, images, videos), operational and functional status of the equipment back to the TMICC.

The activities undertaken by the TMICC also include coordination with authorities managing incident response, providing routing support to emergency vehicles, signal priority / pre-emption for vehicles responding to incidents, exchanging the incident information with authorities concerned, and maintenance and construction agencies, disseminating incident information (such as details, spot, impact on traffic, current status, likely duration, and response details) to transit agencies, transport helplines, NUTH and the media.

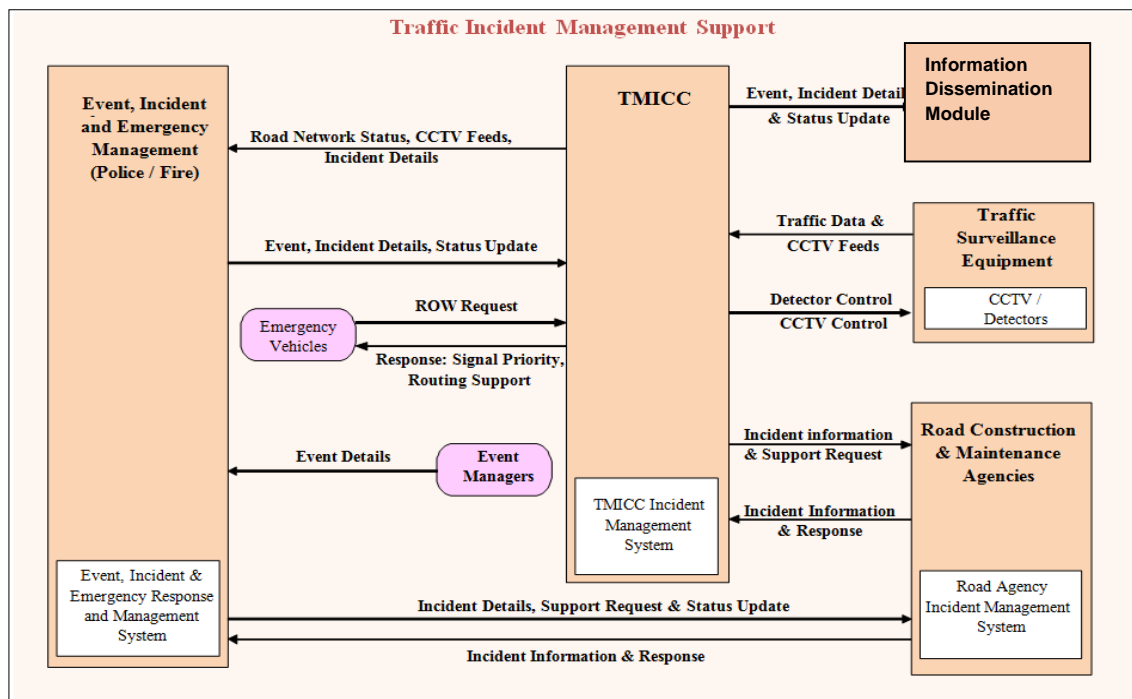


Figure 4-5: Traffic Incident Management Support system

4.2.3 Interfaces with Transit Operations

4.2.3.1 Bus Operations

The bus operations are managed by the bus operators through their respective control rooms. Bus operations utilise road network and infrastructure and they are, therefore, affected by the signal plans at signalised junctions, incidents/events affecting traffic, road closures/diversions, construction/maintenance work on the roads, congestion levels on the road, current and predicted traffic. They may need signal priority on certain predetermined corridors, to ensure schedule adherence or signal pre-emption while supporting emergencies.

All of the above matters pertaining to traffic control are typically the responsibility of TMICC. In view of this, there is a need to have close interaction between the TMICC and the bus operations covering the following:

- Managing the request from bus operations for signal priority on specific junctions / route and giving priority in accordance with the policy. This would require system to be configured from the TMICC so that as the vehicle approaches the junction, the signal controllers installed at the junction give priority to such vehicles for the configured policy. The transit ITS equipment on the bus should support such a system.

- Information exchange.
 - Bus operations to share details of bus routes, vehicles deployed, their locations both during normal operation as well as while supporting emergencies.
 - Bus operations to share any service changes such as changes in route schedule or frequency.
 - Bus operations to share any service delay or disruption information.
 - Bus operations to share details of any break-downs/ accidents of their buses along with likely time for clearing the affected buses.
 - Bus operations to share probe data captured through bus tracking such as speed, time taken on a road stretch.
 - TMICC to share incident/event, construction information with details such as location, nature, impact on traffic, road closures, diversions. Incident updates also need to be shared.
 - TMICC to share details such as weather, congestion, traffic jams/queues, traffic forecast, road condition, diversions, closures, any restrictions, road details (width, number of lanes, one way, no entry, speed limit etc.).
 - TMICC to share surveillance system feed such as images, videos related to bus routes.

4.2.3.2 Metro and Suburban Rail Operations (Urban Areas)

Metro and suburban rail operations in India are carried out on their dedicated and exclusive right of ways. Since there are no at grade crossing in urban areas with respect to metro operations in India, their interface with road network on account of rail operation activity is not there. However, there are still a number of at-grade rail crossings which impact road traffic. The information of level-crossing closures should be shared by the railways with the TMICC so that travel route decisions could be taken accordingly.

Metro and suburban rail stations also attract and generate traffic, require parking and depend upon road network for providing accessibility to these facilities. Additionally in some cases they may have their own feeder buses that facilitate access to the stations.

The information exchange between Metro /suburban rail operations and the TMICCs could cover the following:

- Metro /suburban rail operations to share data related to any construction activity (whether planned/current) on the road network, the nature of access and the period for which access is required.
- Metro /suburban rail operations to share parking related data.

- Metro /suburban rail operations to share any service delay or disruption information.
- TMICC to share incident/event, construction information (whether planned/current) with details such as location, nature, impact on traffic, road closures, diversions. Incident updates also need to be shared.
- TMICC to share details such as weather, congestion, traffic jams/queues, traffic forecast, road condition, diversions, closures, any restrictions, road details (width, number of lanes, one way, no entry, speed limit etc.).
- TMICC to share surveillance system feed such as images, videos related to feeder bus routes.

4.2.3.3 IPT Operations

IPT operations cover modes such as auto rickshaws, taxis, radio taxis and other similar modes. In case of unorganised IPT operations, the regulatory authority may coordinate for information exchange with the TMICC.

The information exchange between such modes and the TMICCs could cover the following:

- IPT operations to share probe data captured through vehicle tracking such as speed, time taken on a road stretch.
- IPT operations to share event details such as planned strike, service disruptions etc.
- TMICC to share incident/event information, construction with details such as location, nature, impact on traffic, road closures, diversions. Incident updates also need to be shared.
- TMICC to share details such as weather, congestion, traffic jams/queues, traffic forecast, road condition, diversions, closures, any restrictions, road details (width, number of lanes, one way, no entry, speed limit etc.).

4.2.4 Interfaces with Other Agencies or System Applications

TMICCs receive data and information from other centres which manage transit and other sub-systems that are processed by the TMICC system to assess the impact on traffic management and also to arrive at actions to be taken. Figure 4-6 provides an overview of some of the major TMICC interfaces. Centre to Centre interfaces will occur when separate centres are interconnected.

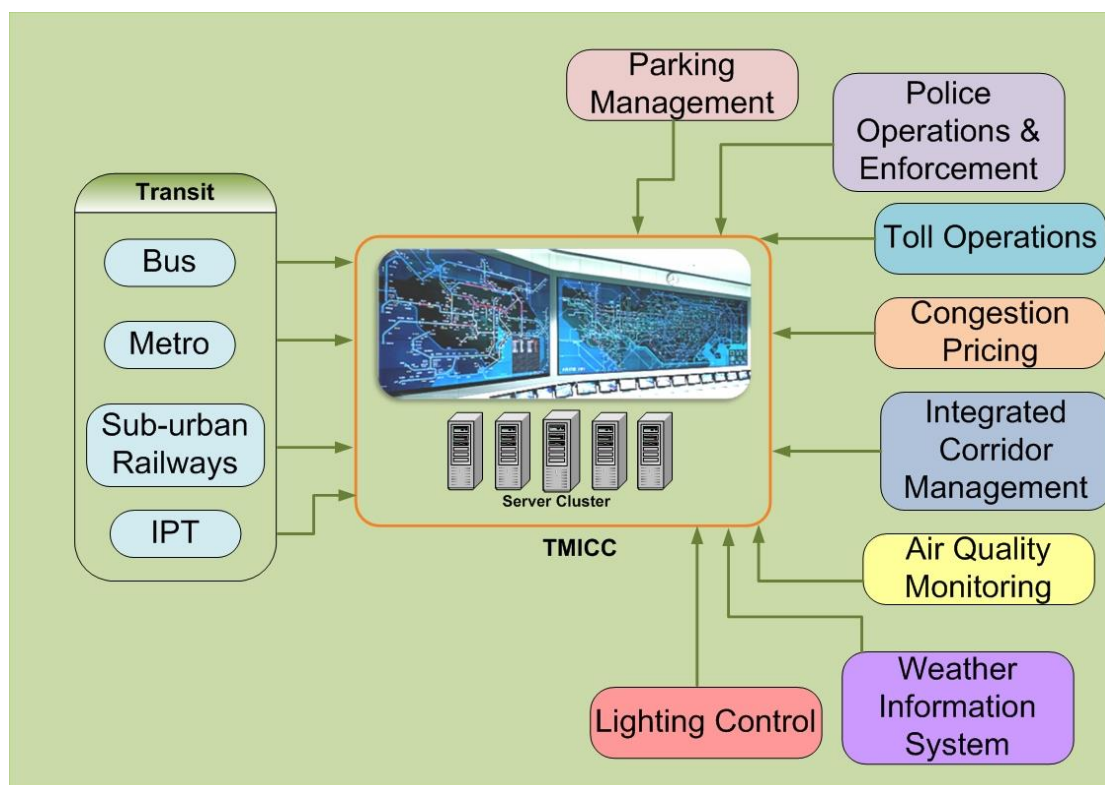


Figure 4-6: TMICC – Interfaces with other Operations Control Centres

4.2.4.1 Parking Management

TMICC shall interface with and collect data from the Parking Management System of parking operators. This system provides capability to manage and monitor the parking facilities. They interface with TMICC and share information that could be disseminated by TMICC to public. The system typically supports the following capabilities in relation to parking management:

- Interface with the TMICC / local traffic centre for coordination with respect to traffic around the parking facility
- Provide information to TMICC and drivers about facility, operational timings, capacity, parking rates, directions to entrances and exits
- Provide real time parking availability details to TMICC and users.

Parking agencies should be required to share live parking availability information with TMICC. This would lead to reduction in avoidable movement of vehicles searching for parking on the streets.

4.2.4.2 Safe City Control Centres

Some cities have implemented Safe City Control Centres (e.g. Surat) which have access to CCTV camera feeds from various locations in the city. It might be useful to

develop an interface between Safe City Control Centre and TMICC in order to have access to the CCTV feeds and also to initiate appropriate actions from TMICC on the Road/Transport network in response to any incident having security implications by way of signal control, VMS messages etc.

4.2.4.3 Toll Operations

These systems support management of the toll collection system. They support registration of vehicles, charging for using the toll road (including based on dynamic pricing policies), reconciliation of toll collected as against those reported by the banks/financial institutions, reporting violations to the regulatory authorities and other incidental matters related to toll collection and management.

Typical Electronic Toll Collection (ETC) systems are comprised of four sub-systems: Automatic Vehicle Classification (AVC), Violation Enforcement System (VES), Automatic Vehicle Identification (AVI), and Transaction Processing, which include a back office and customer service centre.

In the TMICC context, information pertaining to aspects that impact traffic flows or travel route decisions should be shared with the TMICC. These would include:

- Toll charges
- Lane closures
- Real-time queue lengths (if available)
- Incidents
- CCTV feeds
- Traffic flows

4.2.4.4 Congestion Pricing

It is a travel demand management strategy whereby the user is required to pay charges for using a road or for entering in the designated zone/area, including based on the time of the day, where the congestion pricing applies. It is implemented with the expectation that congestion pricing would lead many people (who can) to change the time of their travel (when the charge is not applicable or is less) or the mode of travel (to which the charge is not applicable or is less) or use alternate road (on which the charge is not applicable or is less). In all cases, the congestion on that road or in the charging zone is likely to reduce leading to improved throughput. The experience with this also supports that it is so. The funds so collected can be utilised to promote public transit use or other green measures.

Congestion pricing schemes require use of technology in large measure to administer the scheme especially in a barrier free environment with free flow of traffic. The vehicles entering the zone/road which are subject to congestion pricing need to be tracked either through GPS or through cameras. Tags could be used for making payments on the go

that require overhead antennas to be installed. For enforcement, often, more than one means of vehicle identification is adopted. TMICCs could be used to administer such scheme from technology view point. Backend of such systems could be hosted at the TMICC from where the system could be implemented and operated. Alternately, the authority managing the congestion pricing system should share the following data with the TMICC:

- Zones/roads which are covered under the scheme
- Pricing regime (real-time in case it is dynamic)
- Specific no-entry vehicle categories and associated timings

4.2.4.5 Road Construction & Maintenance

Any maintenance activity carried out either by the road owning agency (in terms of maintenance of carriageway, footpath, median etc.) or maintenance activity carried by any other utilities/services provider (for example, water supply, sewerage, power supply/street lighting) usually results in either full or partial closure of the roadway leading to traffic congestion. It is, therefore, necessary for the TMICC to interface with all agencies which have a role to play in road construction and maintenance and obtain information of both, planned and unplanned construction/maintenance activities.

4.2.4.6 Integrated Corridor Management (ICM)

By virtue of administrative, institutional and jurisdiction related issues, management of transportation assets has largely remained localised with each agency trying to optimise the system and traffic flows at the level of its own network. While this approach may have led to some optimisation at local network level, inefficiencies still persist at corridor level which spans multiple jurisdictions.

Integrated Corridor Management is an approach that goes beyond agency jurisdictions and efforts are accordingly directed towards planning and management of transport infrastructure at corridor level. The planning related to the corridor as well as operation of the corridor assets is coordinated amongst the entities that are part of the corridor.

This approach requires exchange of information on a real time basis amongst these entities following the agreed standards and protocols.

Construction and maintenance efforts also would need to be coordinated at the corridor level to ensure that undue capacity constraints are not created due to these efforts.

4.2.4.7 Lighting System Control

These systems are used for monitoring and controlling the lighting and illumination system of the road network and other transport facilities. The lighting is typically controlled by the road owning agencies. The control is exercised based on a combination of pre-programmed schedule and/or using sensors to detect ambient

conditions. The agency managing the lighting control system should share the information pertaining to outages in street lighting with the TMICC.

4.2.4.8 Weather Information

In India, the weather conditions are typically monitored by the Meteorological Department. This weather information system collects weather related data such as wind speed, temperature, humidity, rainfall, fog, visibility etc. The collected data should be shared with the TMICC for review, analysis, use and dissemination. Travellers may use the information to plan their travel accordingly.

4.2.4.9 Air Quality Monitoring

In India air quality is typically monitored by the State Pollution Control Boards. The Air Quality Monitoring System collects air quality data such as presence and level of pollutants (Sulphur-dioxide, nitrogen dioxide, particulate matter, ozone, lead, carbon monoxide etc.). It is envisaged that this data would be shared with the TMICC for review, analysis, use and dissemination.

4.2.5 Information Dissemination

4.2.5.1 Introduction

The objective of information dissemination is to provide the travellers with comprehensive, relevant, reliable, accurate and updated traffic information which is useful for them to plan their travel.

The idea is not to flood travellers with a barrage of information but to provide only that information which could affect travel choices. Such information includes the factors that affect road network capacity, lead to congestion, affect travel times, require road closure or diversions. It is, therefore, necessary that information about such factors is captured promptly and disseminated through suitable channels so that travellers can accordingly make/change their travel plans.

The information could be disseminated through various channels: web, mobile apps, social network, variable message signs, radio channels and/or TV channels.

Traffic Information Dissemination System comprises elements that are used by TMICC for dissemination of traffic and related information and includes variable message signs, fixed format displays, blinkers, helpline, NUTH etc. TMICC sends traffic messages, commands and configuration details to the field equipment (variable message signs, fixed format displays, blinkers etc.) and they send the operational and functional status of the equipment back to the TMICC (Figure 4-7).

The data captured by TMICC may also be shared in open data format with public. This would enable third party software developers and/or Value Added Service (VAS) providers to develop mobile applications and other tools to disseminate useful

information to the public. The data could be shared on an open-data format (GTFS, XML, SIRI, Open511 Specification etc. as given in Section 3.5.3) so that it could be used by multiple agencies/information service providers.

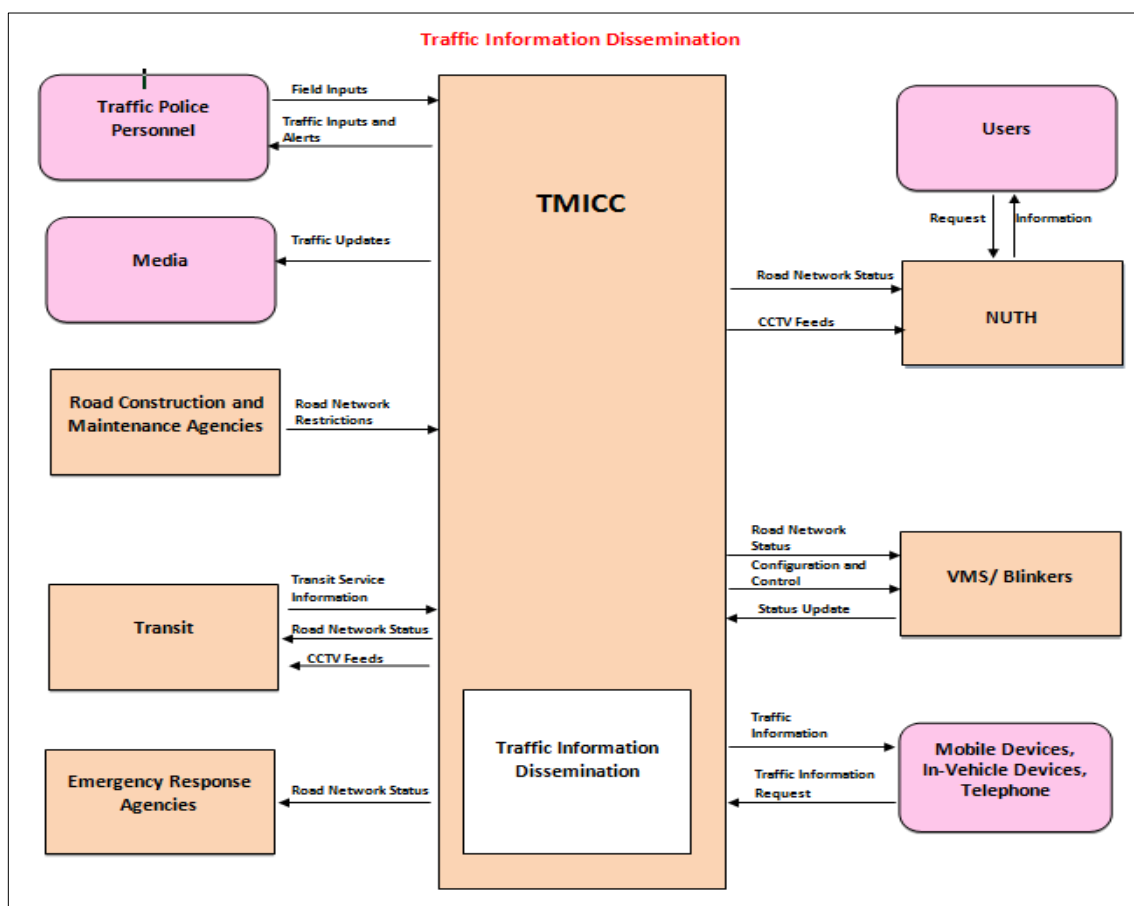


Figure 4-7: Traffic Information Dissemination System

4.2.5.2 Typical Information Disseminated

A. Congestion

Road network congestion is an important piece of information that is considered by travellers while planning their travel. This information could be provided on the variable messages signs, on a map with suitable color coding indicating various speed ranges and through phone helpline where speed details could be provided for the selected road segment. If the capability exists, both current as well predicted congestion levels may be provided. Congestion information can be obtained from the signalised intersection sensors, roadway sensors/detectors, CCTV Surveillance cameras or from intelligent processing of GPS probe provided by transit agencies. Bluetooth technology based sensors can also be used to determine travel times and speed on road network. In addition, such information

can also be provided by or sourced from travellers by providing suitable interfaces on the website/ mobile applications.

B. Incidents

It is one of the most important elements of traffic information that affects travel planning. Incidents may lead to congestion, require road diversions or closure. It is, therefore, necessary that information about incidents is captured promptly and disseminated. The information that could be provided to travellers in relation to incidents is listed below:

- Incident/event details (e.g.: Road accidents, collisions, events, Auto/taxi strikes etc., transit service disruptions, political rallies, religious or social processions, State ceremonies etc.)
- Location: road, section, spot
- Direction of travel affected
- Impact: lane closure, diversion, congestion
- Alternate routes
- Time stamp
- Time during which traffic would be affected
- Expected time to restore normal traffic

Information in respect of planned events could be provided in the form of calendar so that travel planning for future could take these into account.

In order to get such data, interfaces must be built by TMICC with the systems of the agencies which participate in managing and responding to the incidents or are required to be intimated prior to conducting any event. Media could be another source of providing information related to any planned events, strikes, rallies etc. In addition, incident related information can also be provided by or sourced from travellers by providing suitable interfaces on the website/ mobile applications.

C. Construction / Maintenance Activities

Construction and maintenance activities also affect road network capacity or even access to the network. The information that could be provided to travellers in relation to construction and maintenance activities is listed below:

- Brief details
- Location: road, section, spot
- Direction of travel affected
- Impact: lane closure, diversion, congestion

- Alternate routes
- Expected time to restore normal traffic

Information in respect of planned construction and maintenance activities could be provided in the form of calendar so that travel planning for future could take these into account.

In order to get such data, interfaces must be built by TMICC with the systems of the agencies which are responsible for construction and maintenance activities and/or the authorities who are required to be intimated prior to undertaking construction and maintenance activities.

4.2.5.3 Modes of Dissemination

A. Variable Message Signs (VMS) or Dynamic Message Signs (DMS)

VMSs are typically large sized LED/LCD Boards which are placed along arterial corridors and are used by TMICC for dissemination of traffic and related information. TMICC sends traffic messages, commands and configuration details to these equipment and they send the operational and functional status of the equipment back to the TMICC. An example of VMS installation has been provided in Figure 4-8.



Figure 4-8 : Variable Message Sign on roadway

B. Website

Websites have emerged as a popular channel for accessing information. In view of this, the TMICC could either have its own website or based on availability, NUTH

and its accompanying websites (regular as well as mobile version) could be used for dissemination of information in the most appropriate form and manner.

- C. Regular websites provide flexibility to offer rich content on maps that are suitable for viewing on a large screen but may require higher bandwidth. The mobile versions of websites allow for accessing information over low band width and smaller displays. The content, however, would need to be customised and tailored to suit the regular and mobile versions of websites. The website could also have capability to provide personalised version of the web pages displaying content based on user preferences. Alerts through automatic e-mails could also be provided to those subscribing for the same. The traffic web page for San Francisco Bay Area has been provided as Figure 4-9

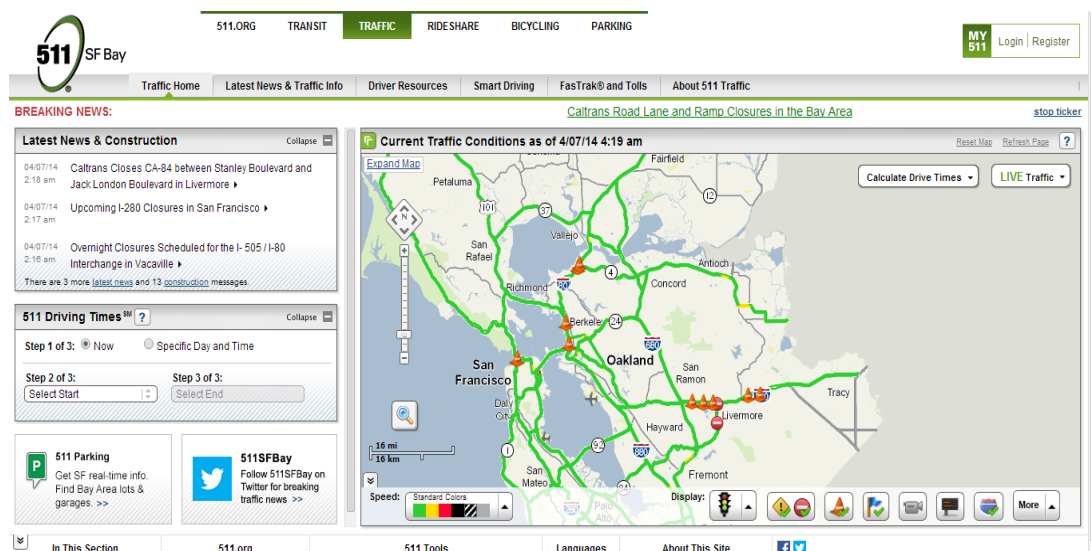


Figure 4-9 : Traffic web page, 511, San Francisco Bay Area

D. Mobile Phone Applications

Adoption of mobile devices in India, as elsewhere, is on the rise with urban areas already reaching saturation levels. The types of mobile devices being used are conventional mobile phones, smart phones, phablets, tablets etc. Most of such devices support mobile internet and such services are being widely used by various sections of the public. It is, therefore, important that the traffic content is made accessible from such devices.

Mobile apps have become quite popular with wider availability and adoption of mobile devices. The mobile apps provide user interfaces that support easy access of information on the mobile devices. There are various types and sizes of mobile devices in the market working on different operating systems such as iOS, Android, Windows; hence mobile app would need to be developed to support multiple device

OSs/ sizes. Screen shots of a mobile application that accesses information for Utah roadways from the Utah Department of Transportation's Intelligent Transport System (ITS) has been provided as Figure 4-10.

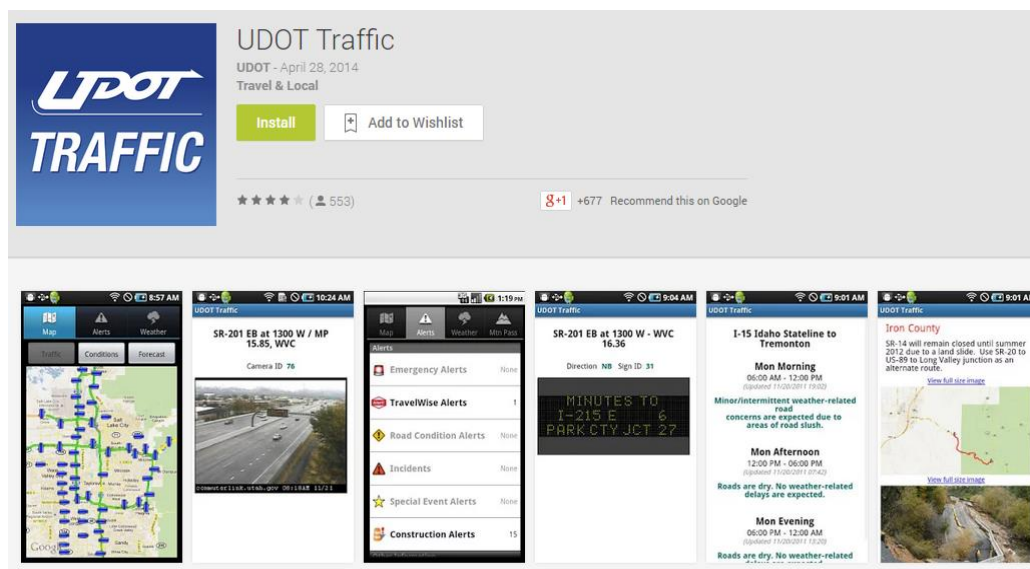


Figure 4-10: UDOT Mobile Application for Traffic Information Dissemination

In India, there have been examples of traffic information applications on mobile phones. Some of these are the BTP, Bangalore Traffic Info App (by the Bangalore Traffic Police), Delhi Traffic Police mobile application and Poochh-O (by DIMTS).

Android users are increasingly using traffic information provided by Google through its navigation application Google Maps which has over 1 billion downloads till date. Some screenshots of the Google Maps app have been provided in Figure 4-11.

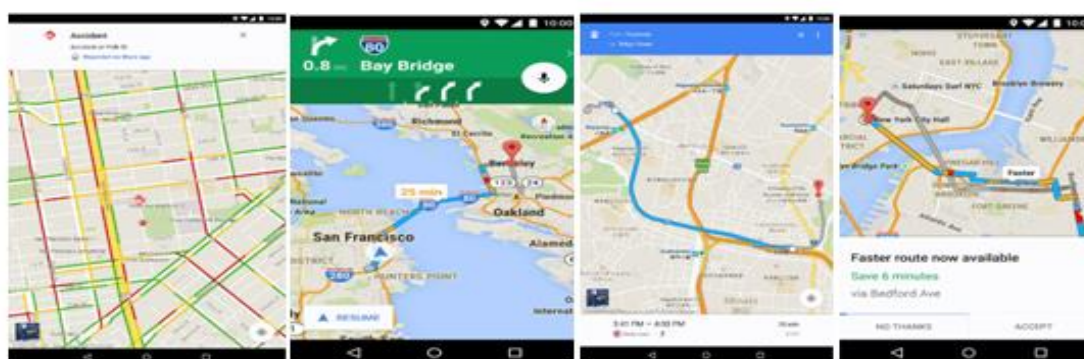


Figure 4-11: Screen Shots of Google Maps Mobile Application

The mobile apps are an area where a public-private partnership could be beneficial. Public agencies that collect information can provide their data and information to third party software developers and/or Value Added Service (VAS) providers to allow the open market to provide useful information to the public. The data could be

shared on an open-data format so that it could be used by multiple agencies/information service providers. Typically, an agreement is executed with information service providers which sets out the terms and conditions for providing the data. Most often this is provided free of charge, with restricted use for the information and data with an option to charge for data in future with notice.

E. Media

FM Radio has been a popular means of dissemination of traffic updates across the world. In India, while FM Radio does provide traffic updates it is largely based on dial-in traveller updates and not on IT based data analysis. It is recommended that select media representatives be co-located in the TMICC, since it not only provides a medium for mass outreach but also keeps an independent check on the functioning of the TMICC.

4.2.6 Data Warehousing and Analysis

- A. Data Warehousing:** Data Warehousing deals with collection of data from multiple stakeholders, its storage, archival, management and retrieval for review and analysis in future. It supports query, report generation and data mining using archived data. It is a vital element that must be planned for as data mining activities would ride on the availability of and access to the archived data. Transportation planning efforts in a city needs to be supported by TMICC by way of sharing of information collected by it. The information collected and maintained by the TMICC could be accessed by other agencies in their planning exercise.

For example, the data could be used to carry out analysis leading to identification of black spots/accident zones. TMICC staff could carry out a more detailed analysis of these spots and recommend design interventions to reduce accidents. Several State level transport agencies in India have either implemented or are in the process of deploying their own Road Accident Data Management System (RADMS). TMICC should coordinate and align with such agencies in relation to accident data.

TMICC should also use the data collected to carry out impact analysis, such as,

- Micro-level impact of junction design
- Impact of TMICC initiatives on overall traffic flow
- Reduction in energy consumption
- Reduction in GHG emissions

It is recommended that the TMICC should also have a software module to compute the energy savings that have accrued owing to initiatives taken by the TMICC, which could be further extrapolated to compute the reductions in GHG emissions.

- B. Big Data Analysis:** TMICC will collect vast amount of data which is termed as Big Data. Such data stream would include traffic data, configuration data, images, videos etc. through various devices and systems. In order to harvest this data for useful

information, the TMICC organisation should include staff specialising in Big Data Analytics. The data mined from TMICC should be used for planning and optimising the system parameters and in addition, shared periodically and regularly with relevant stakeholders at the City, State, and National levels, as required.

The Table 4-3 provides an overview of the data collected, analysis carried out and output provided by the TMICC.

Table 4-3: Data Collection, Analysis & Output

Area	Data Collected	Data Analysis and Output
Traffic Management	<ul style="list-style-type: none"> Current signal timing and operations Road network surveillance Signal phasing Traffic volume Traffic speeds 	<ul style="list-style-type: none"> Changes in signal timing and signal phasing based on traffic conditions observed
Incident Management	<ul style="list-style-type: none"> Detection of incidents 	<ul style="list-style-type: none"> Route diversions Information dissemination
Weather	<ul style="list-style-type: none"> Rains Waterlogging Fog Storm Natural calamities 	<ul style="list-style-type: none"> Route diversion s Information dissemination
Congestion	<ul style="list-style-type: none"> Traffic volume Traffic speeds 	<ul style="list-style-type: none"> Changes in signal timing and signal phasing based on traffic conditions observed
Accident	<ul style="list-style-type: none"> Accidents spots Accident history Casualty details Junctions details 	<ul style="list-style-type: none"> Inputs for junction design Warning messages Speed limit adjustments
Energy Saving	<ul style="list-style-type: none"> Speeds on corridor Number of vehicles 	<ul style="list-style-type: none"> Energy saving due to reduced congestion
Pollution Control	Pollution data such as SPM2.5, SPM10, NOx, CO levels	<ul style="list-style-type: none"> Trend analysis on the level of pollution indicators
Traffic Engineering	<ul style="list-style-type: none"> Accidents data Observed speeds Traffic volume Congestion details 	<ul style="list-style-type: none"> Inputs for Junctions/road network design Signal timing adjustments
Enforcement	<ul style="list-style-type: none"> Data on traffic violations such as speed, red light, no entry, pollution. 	<ul style="list-style-type: none"> Inputs for policy Inputs for junction /road network design

Area	Data Collected	Data Analysis and Output
	<ul style="list-style-type: none"> Entry restriction violations Handheld device based e-challan system 	
Emergency Vehicles	<ul style="list-style-type: none"> Identification of emergency vehicles at junction Route plans 	<ul style="list-style-type: none"> Signal priority Inputs for emergency vehicles routing
Transit Vehicles	<ul style="list-style-type: none"> Identification of transit vehicle at junction Route plan 	<ul style="list-style-type: none"> Signal priority Inputs for transit vehicles routing
Traffic Equipment monitoring and control	Equipment health status	<ul style="list-style-type: none"> Actions for maintenance/repair replacement

Table 4-4 provides the relationship between data collected and data output and its use.

Table 4-4: Relationship between Data Collected and Data Output

Data Collected	Data Output and Use											
	Changes in signal timing	Route diversions	Information dissemination	Inputs for junction/ road network design	Warning messages	Speed limit adjustments	Energy saving	Trend analysis on pollution indicators	Inputs for policy	Signal priority	Inputs for emergency vehicle routing	Actions for maintenance
Signal timing & phasing	✓											
Road network surveillance	✓								✓			
Traffic volume	✓			✓			✓		✓			
Traffic speed	✓						✓		✓			
Detection of incidents		✓	✓									
Rains, Waterlogging, Fog, Storms		✓	✓									
Pollution data								✓				
Accidents data	✓			✓	✓	✓			✓			
Congestion details	✓			✓								
Data on traffic violations				✓					✓			

Data Collected	Data Output and Use											
	Changes in signal timing	Route diversions	Information dissemination	Inputs for junction/ road network design	Warning messages	Speed limit adjustments	Energy saving	Trend analysis on pollution indicators	Inputs for policy	Signal priority	Inputs for emergency vehicle routing	Actions for maintenance
Identification of emergency vehicles at junctions										✓	✓	
Identification of transit vehicles at junctions										✓	✓	
Equipment health status												✓

5.0 PLANNING AND DESIGN CONSIDERATIONS

5.1 Introduction

This chapter covers the planning and design considerations to be kept in mind while setting up the TMICCs. It deals with various aspects such as TMICC Structures, various components that are part of TMICC, essential and optional components, capacity and resource required, need for ITS architecture and managing obsolescence.

5.2 TMICC Structures

TMICCs can operate with various levels of distributed or centralised configurations, ranging from the single unified centre to separate TMICCs working as a single virtual set up with the centres connected over communication networks. TMICC can be configured to operate in accordance with the following options or their variants as listed in Table 5-1:

- Virtual set up wherein each entity manages its own traffic centre but they share information with each other to facilitate cooperation
- A single unified set up where all traffic entities are co-located and operate their respective systems from the facility. They share information with each other to facilitate cooperation.
- A central core TMICC set up with representation from each traffic agency for coordination and information sharing purposes while each agency also having its own transit or traffic centre to manage its operations.
- TMICC operating in conjunction with National Urban Transport Helpline (NUTH).

Table 5-1: TMICC Structure Options

Options	Advantages	Disadvantages
Standalone (single) TMICC	<ul style="list-style-type: none"> • Ease of set up • Faster set up time • Lower costs • Simpler management structure 	<ul style="list-style-type: none"> • Lack of information sharing ability • Lack of coordination for critical management issues
Standalone (single) TMICC with data links other Centres	<ul style="list-style-type: none"> • Ease of set up • Faster set up time • Lower costs 	<ul style="list-style-type: none"> • Complex coordination mechanism • Requires agreements for standard data and video exchange. • All agencies must adhere to the same platform/standards

Options	Advantages	Disadvantages
Joint TMICC with multiple agencies	<ul style="list-style-type: none"> Improves coordination Faster response time Reduction in conflicts in response Reduction in duplicated costs 	<ul style="list-style-type: none"> More elaborate and time consuming for set up and operation Requires agreements for cost sharing and assignment of responsibility More time required to set up
Fusion Centres with multiple disparate agencies, such as traffic, transit and emergency management systems	<ul style="list-style-type: none"> Greater improvement in coordination on a multi-modal and multi-agency level Faster and more clear response time Management of the network in an integrated manner Better suited for major metropolitan areas 	<ul style="list-style-type: none"> More elaborate and time consuming to set up Complex management structure Require agreements for cost sharing and assignment of responsibility More time required to set up
Joint TMICC plus standalone agencies	<ul style="list-style-type: none"> Better coordination Redundancy in case of failure of one centre (backup provisions) 	<ul style="list-style-type: none"> Additional costs of operating multiple centres Duplication of effort and resources Potential breakdown of communication

The choice of any particular structure would be a function of stakeholder preferences, existence of traffic and transit centres, number of entities managing the transit/traffic activities in the city, character of such entities (whether government or private, and if government entity: level of government controlling the entity). These aspects have been dealt with below.

Stakeholder Preferences: Based on the operational requirements and/or infrastructure created, agencies may decide to operate from their respective facility or to relocate to any common facility.

Existence of Traffic Centres: If the traffic centres (control rooms) have already been set up and are functional, agencies may wish to continue to operate from these centres. In such cases, data sharing and communication arrangements could be established between the centres so that these facilities work as a virtual integrated facility. As part of this, video conferencing facilities should also be established to facilitate effective communication and coordination between various centres. If a city has not yet established a traffic centre of some scale, or it would not lead to any undue inconvenience to the agencies concerned, the city may consider co-locating agencies in the TMICC.

Number of Entities Managing Transit/Traffic Activities: Co-locating agencies at TMICC would be relatively easier both from physical as well as administrative view-point when the number of agencies involved is less.

Character of the Entities: It would be relatively less cumbersome administratively to co-locate entities that are under the control of any particular level of government, be it Central Government, State Government or urban local body. In the event, entities are from different levels of government, co-ordination issues may limit the flexibility to co-locate various entities in TMICC. In case any private sector players are involved, it may lead to further difficulties in co-locating them with government entities.

5.3 TMICC Components

5.3.1 TMICC Components: General

Each TMICC would have system components that would be driven by its design and operational needs. TMICC will house all the necessary equipment for the monitoring, operation, control and archiving of data for the purpose of transport infrastructure. Equipment requirements for each TMICC will depend on the functional requirements and a Systems Engineering study. The typical major equipment and systems in a TMICC will include, but not limited to, the equipment and systems listed in Table 5-2 and

Table 5-3

Table 5-2: TMICC Components: Backend Centre

BACKEND CENTRE COMPONENTS	
Centre Application Software <ul style="list-style-type: none"> • Traffic Management Software • Road Network Surveillance Software • Emergency and Incident Management Application • Traveller Information System Application • Interfaces with Transit, Traffic Enforcement Systems and other Specialised Applications 	Centre Hardware <ul style="list-style-type: none"> • Computers/ Operators consoles • Servers (application, communication, information dissemination, signals, CCTV, enforcement system etc.) • Video Wall • Storage Area Network (SAN) • Network and Communication Routers, Switches • Printers
Backend Standard Software <ul style="list-style-type: none"> • Operating system • Firewall/ Intrusion Prevention System (IPS)/ Intrusion Detection System (IDS) • Anti-virus • Database 	Utilities <ul style="list-style-type: none"> • Fire suppression • Air conditioning • Access control • Power and its backup

Table 5-3: TMICC Components: Field

FIELD COMPONENTS	
Field Equipment <ul style="list-style-type: none"> • Traffic Management Equipment (signals, controllers, detectors, etc.) • Surveillance Equipment (CCTV) • Variable Message Signs 	Communication <ul style="list-style-type: none"> • Hardwired, such as fibre optic, twisted pair, coax cable, etc. • Wireless, such as microwave, spread spectrum, cellular, Wi-Fi, etc. • Leased options, including both wireless (cellular) and wireline. • Plain Old Telephone System (POTS)

5.3.2 Essential and Optional TMICC Components

Components of a typical TMICC will be dependent on the functional design and requirements of each TMICC. These requirements are developed through the Concept of Operations study to examine the needs of the agencies, the number of agencies that will be working in the TMICC, the functional requirements of the TMICC, and the number of personnel working in the TMICC. However, keeping in view that TMICCs would need to operate on a 24x7 basis and have systems to monitor and manage traffic, the Essential and Optional components have been listed in Table 5-4 and Table 5-5:

Table 5-4: TMICC Essential Components

Essential Components	
Centre Application Software <ul style="list-style-type: none"> • Traffic Enforcement Systems • Traffic Management Software • Road Network Surveillance Software • Emergency and Incident Management Application • Traveller Information System Application • Interfaces with <ul style="list-style-type: none"> – Transit Systems – Incident and Emergency Management Systems – Road Construction & Maintenance Agencies' Systems Backend Standard Software <ul style="list-style-type: none"> • Operating system • Firewall/ Intrusion Prevention System (IPS)/ Intrusion Detection System (IDS) • Anti-virus • Database 	Centre Hardware <ul style="list-style-type: none"> • Video walls • Computers/ Operators consoles • Servers for various applications and databases (application, communication, information dissemination, signals, CCTV etc.) • Storage Area Network (SAN) • Network and Communication Routers, Switches • Printers

Essential Components	
Field Equipment <ul style="list-style-type: none"> • Traffic Management Equipment (signals, controllers, detectors, etc.) • Surveillance Equipment (CCTV) • Variable Message Signs • Communication equipment 	Utilities <ul style="list-style-type: none"> • Fire suppression • Air conditioning • Access control • Power and its backup Facilities <ul style="list-style-type: none"> • Management Offices • Conference Room and Assembly Areas • Cafeteria, eating areas and/or vending machines • Parking

Table 5-5: TMICC Optional Components

Optional Components	
Centre Application Software <ul style="list-style-type: none"> • Active traffic and demand management • Interfaces with <ul style="list-style-type: none"> – Parking management and operation systems – Safe City Control Centres – Toll operation systems – Congestion pricing systems – Integrated corridor management systems – Lighting Control Systems – Weather Monitoring Systems 	Centre Hardware <ul style="list-style-type: none"> -none
Field Equipment <ul style="list-style-type: none"> • Field equipment linked to active traffic and demand management (barriers, gates etc.) 	Facilities <ul style="list-style-type: none"> • Viewing gallery • Locker Room, Showers, Sleeping Areas and Exercise Rooms for special centres including emergency management operations

TMICC would require data centre facility to host backend system comprising hardware, software, storage and associated facilities. TMICC implementing agencies may either set up a dedicated data centre for TMICC or they may alternatively explore the possibility of hosting the backend system at a data centre facility owned by (i) State Government (ii) Central Government, or (iii) any government owned or controlled organisation. In order to utilise and harness the benefits of cloud computing, Government of India has embarked

upon an ambitious initiative - "GI Cloud" which has been named as 'MeghRaj'⁴. There are several government agencies such as National Informatics Centre (NIC), RailTel, Bharat Sanchar Nigam Limited (BSNL) that offer cloud based hosting services. Any of these cloud based hosting option may also be considered by the TMICC implementing agencies, in case they decide not to set up dedicated data centres.

5.4 Resources and Resource Constraints

TMICCs are a new concept in India and as such limited capacity exists in India for planning, designing, operating and managing such facilities.

Setting up the TMICC would require personnel with skills in the area of information technology, networking, data communications, telecom, traffic engineering, administration, intelligent transport system, and transport planning. Considering the importance of traffic engineering discipline in traffic management and its optimisation, it is recommended that personnel from traffic engineering discipline be entrusted with the responsibility of managing the TMICCs or they be assigned critical responsibilities in TMICCs in the areas that deal with traffic engineering aspects. The implementing agency would need to hire resources under suitable arrangement if the skill sets required for effective and efficient management of TMICCs are not available with them.

TMICCs rely on interfacing and feeds from extensive set of field equipment such as cameras, signals, sensors, actuators, detectors, communication equipment and the like in order to work effectively, most of which are currently non-existent in Indian cities. It is only now that the cities have started implementing the ITS-based projects for traffic monitoring and management. Some of the traffic and transit agencies have set up their individual control rooms with limited functionality.

Both technical as well as financial resources would be required to set up and manage a TMICC facility for a city / region and, therefore, planning for these must also be undertaken as part of resource planning. Good financial planning and allocation of funds are necessary to maintain an effective TMICC programme. Without adequate Operations and Maintenance (O&M) funding, the system cannot be sustained.

Any agency embarking on the exercise for setting up TMICC would need to carefully assess not just the initial cost of setting up such facilities but also the ongoing costs of operating, maintaining and managing these facilities. The manpower requirements have been discussed in greater detail in Chapter 9.0 and the approximate cost for implementation and subsequent O&M has been detailed in Chapter 11.0.

5.5 Technology Evolution and Integration

TMICCs work and interface with a variety of systems deployed by the participating agencies in many diverse areas. Moreover the technologies and standards in many of

⁴ <https://cloud.gov.in/about.php>

these areas are still evolving thereby creating challenges towards system integration as well as for the personnel managing these systems.

Since TMICC is designed to be a long term facility, over its life, it may be exposed to many generations of technologies and systems all of which need to be integrated with the TMICC for sharing of data. Moreover, as and when any participating traffic, transit or other agencies update their systems, the interfaces with TMICC would need to be updated as well. Further, as additional traffic equipment gets deployed and newer data sources become available, they also need to be integrated with TMICC to enhance its utility.

The technology evolution road map and integration aspects must be kept in mind while designing and establishing the TMICC.

5.6 ITS Architecture Needs

USA, Europe, Japan, and several other countries have their own national/regional ITS architectures that provide a framework for defining the services, systems, system elements and information exchanges among a variety of systems, centres, vehicles and stakeholders in the transportation system. Various cities and regions are expected to follow the ITS architecture while planning ITS deployments in the transportation sector in order to become eligible for seeking government funding. The availability of ITS architecture has also led to usage of phased but scalable deployments, common terminologies, data dictionaries and adoption of information exchange protocols. Users of such systems, in turn, are able to experience some degree of uniformity from the systems developed using the ITS architecture and this, in turn, has led to wider support from the user community.

In India, there is no such national ITS architecture in place currently and as such ITS projects in India as of now do not need to follow any such requirements. There are some specific guidelines though such as the guidelines issued by the MoUD on urban bus specifications which have ITS elements also covered. The Ministry of Road Transport and Highways (MoRTH), GoI has also issued certain guidelines on the Electronic Toll Collection System that the concessionaires managing the National Highways are required to adhere to.

As and when national ITS architecture in India is put in place, which is expected to be a long term process, considering the international experience, TMICC project proponents would be advised to understand its implications on such projects and plan and design the projects based on the same.

A more in-depth discussion on the ITS Architecture has been undertaken in Chapter 3.0.

5.7 Obsolescence Management

Obsolescence of the systems needs to be managed in a structured manner. Based on the current approach being followed in similar projects, it is seen that during the contract period, the contractor has the responsibility to support and maintain the systems supplied and to ensure that spares are available for providing such support. In such cases,

responsibility to manage the obsolescence of the system is that of the contractor over the contract duration.

Post expiry of the initial contract, the procurement process for support services is undertaken by the implementing agencies. In such cases agencies often end up selecting a contractor which is different from the one who supplied the system. In such cases, responsibility to manage the obsolescence of the system is that of the new contractor. In some cases, agencies are either not able to find contractors willing to undertake support of the system or the same turns out to be too expensive or sub-optimal.

Some of the ways in which agencies can deal with obsolescence are listed below:

- Undertaking selection of technology keeping in mind the stage at which the technology is, it's projected phase-out, ecosystem to support the same (suppliers, support agencies etc.)
- Incorporating contractual provisions placing obligation on the contractors to ensure continued support over the expected life of the equipment
- Making contractual provisions to ensure availability of spares over the expected life of equipment
- As a part of procurement, requiring the bidders to obtain undertaking from the Original Equipment Manufacturer (OEM) to ensure continued support and availability of spares over the expected life of equipment
- Plan phasing out of the system in advance based on discussions with the OEM of the system regarding their planned time frame to phase out the system/technology.

6.0 TMICC PROJECT MANAGEMENT

6.1 Introduction

TMICCs are typically conceptualised and designed to interface with a number of systems that are operated and maintained by various traffic, transit and other agencies of the city/region. These facilities often additionally act as an information exchange mechanism supporting collaboration and information sharing among various participating agencies and law enforcement departments.

TMICC projects are complex ITS initiatives and, therefore, these projects would need to be developed using a blend of traditional and the Systems Engineering approach.

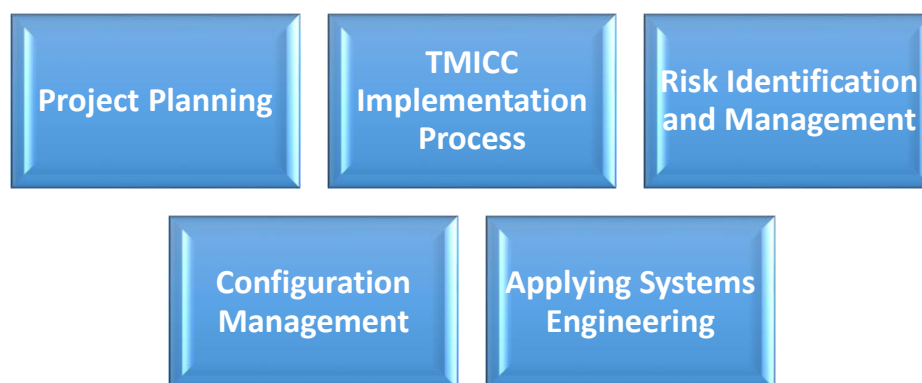


Figure 6-1: Project Management Activities

Figure 6-1 provides an overview of the Project Management Activities which have been detailed in later sections of this chapter.

6.2 Project Planning

The process of project planning deals with creation of activity schedule, working out interdependencies, preparing timelines, undertaking budgeting, drawing up responsibility matrix and planning for resources. It begins in the early phase of the project and leads to creation of Project Plan (PP) and Systems Engineering Management Plan (SEMP).

These documents need to be written in a manner such that they provide a clear view of the project scope, major stakeholders, division of responsibilities among various project stakeholders, the project team, the timelines being pursued and budgeting.

Depending upon the nature and size of the project, some other documents may get attached to the PP or SEMP or will need to be created separately.

6.2.1 Project Plan

The Project Plan (PP) details the various project related aspects from the view point of project management and control covering the following elements:

- Project overview
- Project milestones and deliverables
- Project schedule
- Project organisation chart along with roles and responsibilities.
- Detailed work plans covering technical and administrative activities with dependencies
- Budgeting covering the monthly / quarterly /annual funds inflow and outflow and sources of funding
- Schedule and periodicity for holding review meetings
- Important performance parameters that will be monitored and tracked to review the schedule, physical and financial performance.
- Relevant project documents

The PP will be prepared either by the project owner or will be prepared by the contractor at the project commencement stage. The PP needs to be approved by all major stakeholders before the commencement of the project.

6.2.2 Systems Engineering Management Plan

The Systems Engineering Management Plan (SEMP) is a high level plan document dealing with the Systems Engineering side of the project and covers the implementation and monitoring aspects related to Systems Engineering steps and tasks.

The SEMP could be incorporated in the Project Plan (PP) itself for smaller projects but the same should be developed as a separate document for bigger and complex projects. It must be ensured, however, that the SEMP and PP are in consonance with each other.

The SEMP would typically contain the following:

- Project introduction (System description, Project schedule)
- Technical plan and control method
 - Engineering team, organisation chart, role and responsibilities
 - Plans for technical review, project monitoring reviews
 - Approach for system testing

- Approach for performance measurements
 - Risk management (see Section 6.4 for details)
 - Configuration management (see Section 6.5 for details)
- Systems engineering processes
 - Systems engineering steps to be followed for the project
 - Definition of all high-risk areas, including critical technologies that might pose some challenge for the system.
 - Details of the tools proposed to be used during the course of development activity (such as configuration management tool)
- Inputs from various engineering disciplines
 - Tasks requiring inputs from various engineering disciplines
 - Details of inputs required
 - Timing when the inputs would be required
 - Coordination mechanism
- Other Plans (either included in SEMP or created as separate documents and referred in the SEMP)
 - Interface Management and Control Plan
 - System Integration Plan
 - System, Sub-system and Components Verification Plan
 - Hardware and Software Development Plans
 - System Installation Plan
 - Training Plan
 - Operations and Maintenance (O&M) Plan
 - System Validation Plan
- Relevant project documents

Table 6-1 provides a general description of a typical SEMP document as a guiding outline for ITS practitioners. Again, the degree of detailing of the report needs to be mapped to the complexity of the project and not all chapters or sections may be required for every project. For a simple Variable Message Sign (VMS) installation, the SEMP document may be only a few pages, but for a complex TMICC project, the SEMP document will have to be a detailed document considering various aspects of the project.

Table 6-1: Systems Engineering Management Plan Guidebook⁵

Section	Suggested Content
Title Page	<p>Typically, the title page follows the Agency's procedures or style guide. At a minimum, it contains the following information:</p> <ul style="list-style-type: none"> • Date the document was approved • The organisation responsible for preparing the document • Internal document control number, if available • Revision version and date issued
1.0 Purpose of Document	<p>This section is a brief statement of the purpose of this document and the plan for the Systems Engineering activities with special emphasis on the engineering challenges of the system to be built.</p>
2.0 Scope of Project	<p>This section gives a brief description of the planned project and the purpose of the system to be built. Emphasis is placed on the project's complexities and challenges that must be addressed by the Systems Engineering efforts.</p> <p>This section also describes the environment in which the project will operate. It identifies the organisation structures that encompass all stakeholders. It gives a brief description of the role to be played by each stakeholder. This includes ad hoc and existing management work groups and multi-disciplinary technical teams that should be formed or used to support the project. Such teams are critical to reaching successful system deployment.</p> <p>This section defines the general process for developing the SEMP, including the draft framework version prepared by the implementing agency or their Systems Engineer and the complete version prepared in conjunction with the Systems Engineer and Development Teams.</p>
3.0 Technical Planning and Control	<p>This section lays out the plan for the Systems Engineering activities. It must be written in close synchronisation with the project's Project Plan. However, it is often necessary to put further expansion of the Systems Engineering effort into the SEMP even if they are already described at a higher level in the Project Plan. Even within the SEMP, an effort may need to be described at a higher level in the draft SEMP framework. Then it may need to be expanded further in the final version of the SEMP. An example would be the Configuration Management Plan, to be described below.</p> <p>The purpose of the section is to describe the activities and plans that will act as controls on the project's Systems Engineering activities. For instance, this section identifies the products of each Systems Engineering activity, such as, documentation, meetings, and reviews. This list of required products will control the activities of the team performing the activity and will control the satisfactory completion of the activity. Some of these plans may be defined in the SEMP. For</p>

⁵ Adopted from Systems Engineering Guidebook For ITS by California Department of Transportation

Section	Suggested Content
	<p>other plans, the SEMP may only define the requirements for a particular plan. The plan itself is to be prepared as one of the subsequent Systems Engineering activities, such as may be the case with a Verification Plan or a Deployment Plan. Almost any of the plans described below may fall into either category. It all depends on the complexity of the particular plan and the amount of up-front Systems Engineering that can be done at the time the SEMP is prepared.</p> <p>The first set of required activities/plans relates primarily to the successful management of the project. These activities are likely to have already been included in the Project Plan, but may need to be expanded here in the SEMP. Generally, they are incorporated into the SEMP; but, on occasion, may be developed as separate documents.</p> <ul style="list-style-type: none"> • Work Breakdown Structure (WBS), a list of all tasks to be performed on a project, usually broken down to the level of individually budgeted items • Task Inputs is a list of all inputs required for each task in the WBS, such as source requirements documents, interface descriptions, and standards • Task Deliverables is a list of the required products of each task in the WBS, including documents, software, and hardware • Task Decision Gates is a list of critical activities that must be satisfactorily completed before a task is considered completed • Reviews and Meetings is a list of all meetings and reviews of each task in the WBS • Task Resources is identification of resources needed for each task in the WBS, including for example, personnel, facilities, and support equipment • Task Procurement Plan is a list of the procurement activities associated with each task of the WBS, including hardware and software procurement and, most importantly, any contracted services, such as Systems Engineering services or development services • Critical Technical Objectives is a summary of the plans for achieving any critical technical objectives that may require special Systems Engineering activities. It may be that a new software algorithm needs to be developed and its performance verified before it can be used. Or a prototyping effort is needed to develop a user-friendly operator interface. Or a number of real-time operating systems need to be evaluated before a procurement selection is made. This type of effort is not needed for all projects • Systems Engineering Schedule shows the sequencing and duration of the Systems Engineering activities. The schedule should show tasks [at least to the level of the WBS], deliverable

Section	Suggested Content
	<p>products, important meetings, reviews, and other details needed to control and direct the project. An important management tool is the schedule. It is used to measure the progress of the various teams working on the project and to highlight work areas that need management intervention.</p> <p>The second set of plans is designed to address specific areas of the Systems Engineering activities. They may be included entirely in the SEMP or the SEMP may give guidance for their preparation as separate documents. The plans included in the first set listed above are generally universally applicable to any project. On the other hand, some of the plans included in this second set are only rarely required. The unique characteristics of a project will dictate their need.</p> <ul style="list-style-type: none"> • Software Development Plan describes the organisation structure, facilities, tools, and processes to be used to produce the project's software. Describes the plan to produce custom software and procure commercial software products • Hardware Development Plan describes the organisation structure, facilities, tools, and processes to be used to produce the project's hardware. It describes the plan to produce custom hardware (if any) and to procure commercial hardware products • Technology Plan if needed, describes the technical and management process to apply new or untried technology to an ITS use. Generally, it addresses performance criteria, assessment of multiple technology solutions, and fall-back options to existing technology • Interface Control Plan identifies the physical, functional, and content characteristics of external interfaces to a system and identifies the responsibilities of the organisations on both sides of the interface • Technical Review Plan identifies the purpose, timing, place, presenters & attendees, subject, entrance criteria, [a draft specification completed] and the exit criteria [resolution of all action items] for each technical review to be held for the project • System Integration Plan defines the sequence of activities that will integrate software components into sub-systems and sub-system into entire systems. This plan is especially important if there are many sub-systems produced by a different development team • Verification Plan is almost always required. This plan is written along with the requirements specifications. However, the parts on tests to be conducted can be written earlier • Verification Procedures are developed by the Development Team and this defines the step by step procedure to conduct verification and must be traceable to the verification plan

Section	Suggested Content
	<ul style="list-style-type: none"> • Installation Plan or Deployment Plan describes the sequence in which the parts of the system are installed [deployed]. This plan is especially important if there are multiple different installations at multiple sites. A critical part of the deployment strategy is to create and maintain a viable operational capability at each site as the deployment progresses • Operations & Maintenance Plan defines the actions to be taken to ensure that the system remains operational for its expected lifetime. It defines the maintenance organisation and the role of each participant. This plan must cover both hardware and software maintenance • Training Plan describes the training to be provided for both maintenance and operation • Configuration Management Plan describes the development team's approach and methods to manage the configuration of the system's products and processes. It will also describe the change control procedures and management of the system's baselines as they evolve • Data Management Plan describes how and which data will be controlled, the methods of documentation, and where the responsibilities for these processes reside • Risk Management Plan addresses the processes for identifying, assessing, mitigating, and monitoring the risks expected or encountered during a project's life cycle. It identifies the roles & responsibilities of all participating organisations for risk management • Other plans that might be included are for example, a Safety Plan, a Security Plan, a Resource Management Plan, and/or a Validation Plan <p>This list is extensive and by no means exhaustive. These plans should be prepared when they are clearly needed. In general, the need for these plans become more important as the number of stakeholders involved in the project increases.</p>
4.0 Systems Engineering Process	<p>This section describes the intended execution of the Systems Engineering processes used to develop the system. These processes are generically identified in the "V" life technical development model. The SEMP describes the processes specifically needed for a project. It defines them in sufficient detail to guide the work of the Systems Engineering and development teams.</p> <p>The following factors should be discussed in the SEMP:</p> <ul style="list-style-type: none"> • Identification of portions of the ITS • Identification of participating agencies and their roles & responsibilities

Section	Suggested Content
	<ul style="list-style-type: none"> • Requirements definitions • Analysis of alternative system configurations and technology options to meet requirements • Procurement options • Identification of applicable ITS standards and testing procedures • Procedures and resources necessary for operations & maintenance of the system <p>This section will contain a description of the Systems Engineering procedures tailored to the specific project. There are four areas of analysis that need to be described:</p> <ul style="list-style-type: none"> • System Requirements Analysis describes the methods to be used to prepare the Concept of Operations and the top-level system requirements documents. The analysis techniques that may be used include: peer reviews, working groups, scenario studies, simulation, and prototyping. The amount of analysis required increases with the risk of the specific requirements. The process for approving the resulting documents will be described, including who is involved, whether technical reviews are necessary, and how issues and comments are resolved so the baseline can be defined • Sub-system (Functional) Analysis describes the methods to be used to identify sub-systems and to allocate the system [top-level] requirements to the sub-systems. It is often necessary, at this step, to expand the top-level requirements into a complete description of the functions of the system, for instance, details of an operator interface. It also may be necessary, at this time, to define internal interfaces [sub-system to sub-system] to the same level of detail as the external interfaces [interfaces to other systems]. The SEMP should describe the methods for analysis and the tools required. Budget and schedule constraints, as well as completion criteria, should be included • Design Synthesis describes the methods to be used by the development teams to translate the functional requirements into a hardware and software design. A number of tools and methodologies exist for this. The specific ones to be used by the development team should be identified, along with the necessary resources. Describe the products to be produced as this process unfolds and the design review steps to be taken • System Analysis describes the methods to be used for any required technical trade-off studies, cost/benefit decisions, and risk mitigation alternative analysis. The methodologies used should provide a rigorous basis for selecting an alternative, a quantifiable basis for comparing the technical, cost, and schedule

Section	Suggested Content
	<p>impacts of each alternative, and comprehensive description of the risks involved with each alternative.</p>
5.0 Transitioning Critical Technologies	<p>This section will describe the methods and processes to be used to identify, evaluate, select, and incorporate critical technologies into the system design. Since this may represent an area of considerable impact to the project, this is one of the major efforts of risk management.</p> <p>The need for a critical technology may be based on a performance objective. It may also be based on other factors; the desire to reduce acquisition or maintenance costs; the need to introduce standard compliance; or the need to meet an operational objective. In some cases, the need may move away from a technology that is obsolete and no longer supported by industry.</p> <p>Identification of candidate technologies hinges on a broad knowledge of the technologies and knowledge of each technology's status and maturity. In other words, build on a thorough understanding of the pros and cons of each available technology. Obtaining the resource[s] capable of performing this step is one of the major risks encountered by project management.</p> <p>Sufficient analysis of the risks and benefits of a particular technology may become a major effort involving acquiring the technologies, modifying the technology to meet system requirements, and developing methods to test and evaluate the various technologies that need to be considered. Each of these steps can introduce considerable risk.</p> <p>Finally, incorporation of a technology into an operational system may involve considerable work, especially establishing the support and maintenance environment for the technology.</p> <p>All of these aspects of technology introduction, especially introduction of novel technology, need to be carefully and fully addressed in the SEMP.</p>
6.0 Integration of the System	<p>This section describes the methods to be used to integrate the developed components into a functional system that meets the system requirements and is operationally supportable. The Systems Engineering process steps to be detailed here include: integration, verification, deployment, and the training necessary to support operations & maintenance. Plans for validation of the system should also be covered. For each step, the resources [tools and personnel] are identified and products and criteria for each step defined.</p>
7.0 Integration of the Systems Engineering Effort	<p>This section addresses the integration of the multi-disciplinary organisations or teams that will be performing the Systems Engineering activities. Obviously, the larger the number of such organisational teams, the more important the integration of their efforts</p>

Section	Suggested Content
	is. Each team will have both primary and support tasks from the WBS. Each team will have to be aware of the activities of other teams, especially those activities that immediately precede or follow their own primary tasks. Representatives of most teams will have to be involved in critical technical reviews, and in the review of baseline documentation. Likewise, up-front teams (e.g. requirements and design) must be available to support the ending activities, such as, integration, verification, deployment, and training.
8.0 Applicable Documents	This section lists the applicable documents which are inputs to the project [i.e., needed but not produced by the project]. Such documents may include: the regional ITS architecture description, planning documents describing the project, agency procedures to be followed, standards & specifications, and other descriptions of interfacing external systems. Other applicable documents may be required by a specific project.

6.3 TMICC Implementation Process

Figure 6-2 outlines the steps involved during the TMICC development process. The process steps have been explained in detail in the sub-sections below. In line with the international best practices, it is recommended that the cities adopt Systems Engineering approach towards system design and implementation.

The implementation process for the system would broadly include Concept Development phase (2-3 months); Systems Engineering Management Plan (2-4 months); Detailed Design, Detailed Project Report and Detailed Agreement between Stakeholders (2-4 months); Preparation of Tender Document (2 months); Bid Process Management (3 months); and Project Implementation, Monitoring and Management (6-9 months).

A total of 17-25 months period is projected for TMICC planning, procurement and implementation.

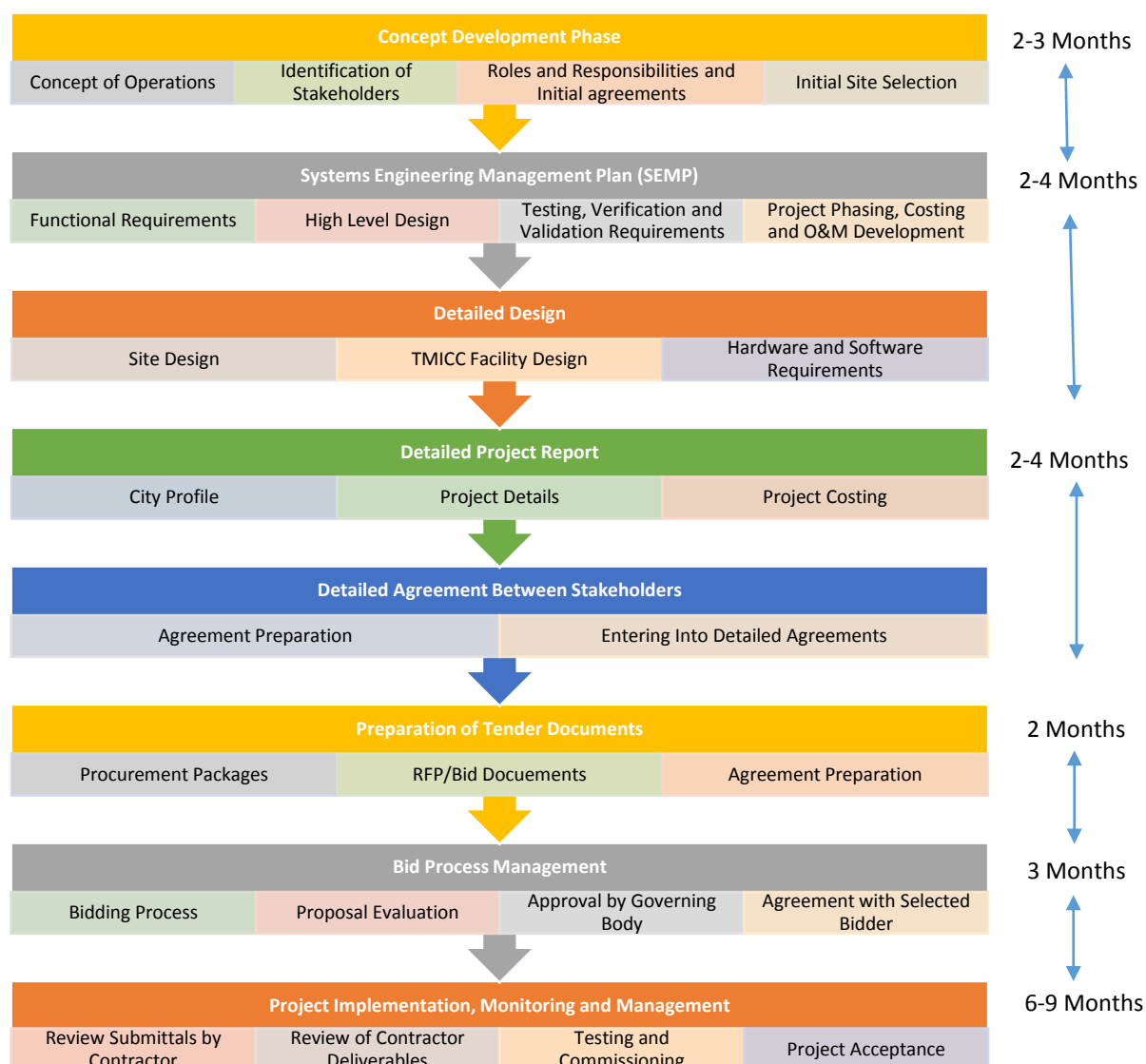


Figure 6-2: TMICC Implementation Process and Estimated Time Schedule

As the concept is new to the Indian cities and will require additional support from organisations having required expertise, Ministry of Urban Development, GoI has identified and empanelled a set of consultants who may be engaged by the cities for seeking assistance in conceptualising, designing, procuring and monitoring the implementation of the TMICC in the city. The indicative scope of services for the city specific project consultancy is set out as Annexure 8.

6.3.1 Development of City Specific Concept of Operations Report

City Specific Concept Report or Concept of Operations should cover the following aspects:

- TMICC Concept Plan covering:
 - Review existing ITS facilities for the city
 - Identification of ITS & TMICC needs for the city based on data analysis and collection
 - Identification of stakeholders
 - Drawing up of implementation role of various stakeholders
 - Identification of ITS application and TMICC system design to support the applications
 - Plan for administration and management of the system
 - Broad costing for setting up of the TMICC – upfront and ongoing
 - Sources of revenue

- Site selection and preliminary design of TMICC facility

This activity would require identification and evaluation of suitable site(s) for housing the TMICC facility. Preliminary site design should consider functions within the TMICC, number of staff and space requirements, and future expansion and growth. Once the site is finalised, high level design of the TMICC facility, including building design and/or modifications, would be carried out based on site conditions.

- Project Structuring
 - Phasing of the build-out of the TMICC system
 - Prepare business plan including financing details for the TMICC system
 - Examine possibility of implementing the project/sub-projects on PPP format and draw up the broad structure for the same
 - Consideration for Operations and Maintenance budget

- Identification of Stakeholders and Preliminary Agreements

This activity would deal with identification of major stakeholders and drawing up of the preliminary set of agreements between the various stakeholders related to the TMICC.

The city implementing agency and the consultant engaged by it may refer to the TMICC Operations Document and City Specific Operations Documents available with MoUD while preparing city specific concept reports.

6.3.2 Systems Engineering Management Plan

Systems Engineering Management Plan (SEMP) is a high level plan dealing with the Systems Engineering side of the project and covers the implementation and monitoring aspects related to the Systems Engineering steps and tasks. The activities related to SEMP have been covered in Section 6.2.2.

6.3.3 Detailed Design

The detailed design would cover the following for the TMICC:

- Detailed technical requirements of the system (including hardware requirements)
- Detailed design of the centre (sizing, floor plan, data centre design, utilities design etc.)
- TMICC facility design
- Hardware design
- Software design

The design life of the system should be at least 10 years after the system has been substantially installed. It must be noted that the design life of all equipment depends upon the availability and reliability of spare parts. It is worthwhile to adopt value engineering technique to ensure cost effectiveness and undertake a detailed analysis when detailed technical specifications are developed by the city.

6.3.4 Detailed Project Report

Prior to TMICC implementation, city will need to develop Detailed Project Report (DPR). An indicative template for DPR is provided in Annexure 6. The DPR would cover both technical as well as cost related details for the TMICC in accordance with the following structure:

- Project Background
- City Profile
- TMICC Concept Overview
- Review of ITS Initiatives in the City
- Project Concept
- Project Implementation, Operation and Maintenance
- Project Stakeholders and Organisation
- Project Sizing, Costs, Revenue and Funding
- Resources, References and Contact Details
- Annexure

6.3.5 Detailed Agreements Between Stakeholders

This activity would deal with drawing up and entering into the detailed agreements between the various stakeholders related to the TMICC. The agreement would clearly set out the roles and responsibilities of each stakeholder and funding allocation and responsibilities based on the project requirements. Guidance regarding agreements between stakeholders for TMICC has been provided in Section 9.10.

6.3.6 Preparation of Tender Documents

Tender documents would need to be prepared in order to carry out the bidding process for selection of contractors for various items of work. This would cover the following:

- Parceling of work packages.
- Preparation of bid documents, setting out the scope of work, qualification and evaluation criteria of proposals in consultation with city specific government entity. It is recommended that some minimum quality certifications (e.g. ISO 9001, ISO 27001, and CMMI Level 3) be specified as part of the qualification criteria, so that quality conscious vendors are considered.
- Preparation of formats for bid submission.
- Preparation of Request for Proposal (RFP) comprising the eligibility criteria, qualification criteria and evaluation methodology for selection of contractor(s) for the development/procurement of the TMICC.
- Preparation of bid documents for construction work
- Preparation agreement for various procurements in consultation with the TMICC implementing agency. The agreement would cover roles and responsibilities of the stakeholder, payment terms, events of defaults, termination conditions, termination payments, design and construction requirements, O&M requirements (if any) etc.

Based on the project structure and implementation plan finalised, the project may require multiple bid processes and corresponding tender documents.

6.3.7 Bid Process Management

The various tasks involved in the bid process management activity would include the following:

- Conducting pre-bid conference, formulating and communicating responses to the potential bidders.
- Responding to questions from bidders and issuing clarifications and addenda, as necessary
- Evaluating the proposals submitted by the bidders in response to the tender process:
 - Scrutiny of Key Submissions

- Evaluation of Qualification Information
- Evaluation of Technical Proposal
- Evaluation of the Financial Proposal

6.3.8 Project Implementation, Monitoring and Management

After successful completion of the bidding process, project monitoring and management would be required to ensure that contracted deliverables are submitted and obligations are discharged by the selected contractors in accordance with their respective agreements. This would entail the following

- Finalisation of Functional Requirements and System Requirements Specification
- Reviewing and finalising the Implementation Plan, Quality Assurance Plan, Testing Plan and schedule submitted by the contractors
- Monitoring the progress of implementation and variations from the plans
- Monitoring and testing of various deliverables
- Reviewing and finalising the Change Requests
- Scrutiny of invoices and releasing payments to contractors
- Final project review and preparation of “punch list” (deficiency list)
- Review and acceptance of all corrective measures
- Testing and commissioning of the system components
- Final testing, verification and validation acceptance
- Final Project Acceptance

6.3.9 Project Monitoring and Control

Project monitoring and control is performed through project tracking and reviews which have been described in the subsections below:

6.3.9.1 Project Tracking

The project tracking can be undertaken by way of measuring the parameters that are indicative of project progress. The parameters could relate to project management aspects or deal with the progress of the project on technical front. The PP and SEMP contain details of the performance measures that would be used for project monitoring and tracking. Table 6-2 provides some examples of performance measures.

Table 6-2: Performance Measures Examples

Area	Parameters	Performance Measures
Project Management	Physical Progress	<ul style="list-style-type: none"> Number of activities planned vs. Number of activities completed Number of sub-systems planned for completion vs. Actual number of sub-systems completed
	Financial	<ul style="list-style-type: none"> Budgeted spending during the period vs. actual spending during the period Budgeted cost vs. actual cost
	Schedule	<ul style="list-style-type: none"> Planned start for an activity vs. Actual start for the activity Planned date for achieving a milestone vs. Actual schedule for achieving the milestone Planned duration for a task vs. Actual duration for the task Planned completion date for an activity vs. Actual completion date for the activity
Technical Aspects	System Development	<ul style="list-style-type: none"> Number of requirements captured vs. predicted number of requirements Number of software elements designed vs. total number of software elements to be designed Number of software elements finished vs. total number of software elements Number of acceptance test cleared vs. Number of acceptance test conducted
	System Performance	<ul style="list-style-type: none"> Predicted vs. Actual failure rate Number of faults reported by system component vs. Total number of system component faults Actual Data base storage usage vs. space allocated Actual average response time vs. target response time

The performance measures needs to be tracked periodically or at specific stages. This will lead to any potential issues being discovered in time so that corrective actions could

be planned and taken. The project management related measures may lead to taking course correction steps on the project schedule, resource augmentation, task re-assignment and other process related aspects. Technical measures may lead to design review, test plan review, resource deployment and allocation and engineering process related aspects.

6.3.9.2 Project Reviews

The project reviews provide a forum where stakeholders take stock of project progress, discuss the feedback provided based on review of the various outputs, take decision on moving to the next steps and plan for any interventions that may be required to address any specific issue discovered pursuant to the review. The project reviews must have participation from all the key people associated with the aspects being reviewed. Where contractors are engaged, they also need to participate in the project reviews.

The project review can be carried out from the perspective of project management or from a technical standpoint. The project management review would cover aspects such as progress, schedule, milestone achievements, resource deployment, budget and other related aspects.

From Systems Engineering point of view, the reviews are required upon completing a "V" process step leading to decision points which needs to be successfully cleared for moving on to the next "V" process step. In line with the "V" process steps, the reviews which could be conducted for a project would include:

- Project Planning Review
- Concept of Operations review
- Requirements review
- High-Level Design review
- Detailed Design review
- Implementation reviews
- Test Readiness review
- Operational Readiness review

Beyond the specific "V" process decision-point reviews, other reviews may also be undertaken on a need basis with participation from team members concerned on any specific matters or issues identified.

6.4 Risk Identification and Management

The objective of risk management exercise is to put in place a framework for dealing with any potential issues that could adversely impact the project progress or performance.

Figure 6-3 provides an overview of the Risk Management Processes which have been detailed in subsequent sections.



Figure 6-3: Risk Management Process

6.4.1 Identifying Risks

In this step, potential risks to the project progress and performance are identified by the project stakeholders in the early stage of the project.

Risks can be categorised into the several areas such as Technical, Institutional, Schedule, Cost, Quality, Funding, Personnel, Commercial, Security, Communication etc. (Table 6-3).

Table 6-3: Risk Identification

Area	Nature of Risk
Technical	• Requirements not properly worked out leading to project not achieving the desired outcome
	• Obsolescence
Institutional	• All institutions whose support is critical for project success are not on board, or if on board, not fully supportive
Schedule	• Delay in any phase of project or overall completion
Cost	• Project cost overrun
Quality	• Quality of project assets / processes not up to the mark
Funding	• Funding for the project activities not forthcoming in a timely manner leading to delay
Personnel	• Availability of personnel is an issue
	• Training of personnel is an issue

Area	Nature of Risk
Commercial	<ul style="list-style-type: none"> Funding of the gap between project cost and likely revenues
Security	<ul style="list-style-type: none"> Physical security of project assets
	<ul style="list-style-type: none"> Data security
Communication	<ul style="list-style-type: none"> Availability and adequacy of means of communication between various personnel and other stakeholders

Toolkit for Public Private Partnership in Urban Transport, Ministry of Urban Development, Government of India (July 2008) provides a framework for identifying various risks under different type of contracts and method of allocating these between different entities.

6.4.2 Analysing Risks

In this step, the risks identified are analysed with respect to the probability of their occurrence and the impact if they occur as depicted in Figure 6-4.



Figure 6-4: Risk Prioritisation Matrix

Risks falling under the category 1, 2, and 3 are very important and need to be managed on priority. Subsequently, based on resource availability, management of risks falling under the category 4, 5, and 6, can also be considered. Table 6-4 provides a sample of prioritisation matrix. The project risk prioritisation matrix would differ from project to project based on specific situation.

Table 6-4: Risk Prioritisation Example

Area	Nature of Risk	Risk Category
Technical	• Requirements not properly worked out leading to project not achieving the desired outcome	1
	• Obsolescence	3
Institutional	• All institutions whose support is critical for project success are not on board, or if on board, not fully supportive	1
Schedule	• Delay in any phase of project or overall completion	3
Cost	• Project cost overrun	3
Quality	• Quality of project assets / processes not up to the mark	4
Funding	• Funding for the project activities not forthcoming in a timely manner leading to delay	5
Personnel	• Availability of personnel is an issue	3
	• Training of personnel is an issue	5
Commercial	• Funding of the gap between project cost and likely revenues	2
Security	• Physical security of project assets	2
	• Data security	2
Communication	• Availability and adequacy of means of communication between various equipment, personnel and other stakeholders	5

6.4.3 Risk Mitigation

The next important task in risk management is to find ways to deal with risks identified and their analysis carried out earlier.

There are several ways in which the risk could be dealt with as set out below:

- Avoiding the risk completely by changing any of the project related aspects such as change in design, technology, location, stakeholder, scope, requirements etc.
- Taking measures to bring down the probability or severity such as building a prototype or proof of concept, resource management etc.
- Accepting the risk without taking any action for low probability/severity risks.

Table 6-5 provides a sample of the mitigation measures. These would differ from project to project based on specific situation.

Table 6-5: Risk Mitigation Example

Area	Nature of Risk	Risk Category	Mitigation Measures
Technical	<ul style="list-style-type: none"> Requirements not properly worked out leading to project not achieving the desired outcome 	1	<ul style="list-style-type: none"> Professional consultants could be engaged Systems Engineering approach to be adopted Key project stakeholders to be involved during system planning and design stage
	<ul style="list-style-type: none"> Obsolescence 	3	<ul style="list-style-type: none"> Suitable provisions in the procurement documents to ensure that the system support and spares are available over the system lifecycle
Institutional	<ul style="list-style-type: none"> All institutions whose support is critical for project success are not on board, or if on board, not fully supportive 	1	<ul style="list-style-type: none"> Understanding be established among the participating institutions as regards their role and support
Schedule	<ul style="list-style-type: none"> Delay in any phase of project or overall completion 	3	<ul style="list-style-type: none"> Close and continuous monitoring, timely inputs and approvals, timely payments to vendors
Cost	<ul style="list-style-type: none"> Project cost overrun 	3	<ul style="list-style-type: none"> Project planning with professional help, clarity and stability in project scope
Quality	<ul style="list-style-type: none"> Quality of project assets / processes not up to the mark 	4	<ul style="list-style-type: none"> Suitable vendor selection process with appropriate qualification criteria containing quality certification requirements, appropriate warranty and support requirements
Funding	<ul style="list-style-type: none"> Funding for the project activities not forthcoming in a timely manner leading to delay 	5	<ul style="list-style-type: none"> Funding to be tied up prior to procurement
Personnel	<ul style="list-style-type: none"> Availability of personnel is an issue 	3	<ul style="list-style-type: none"> Identify the personnel / positions that would be involved in various stages of the project

Area	Nature of Risk	Risk Category	Mitigation Measures
	<ul style="list-style-type: none"> Training of personnel is an issue 	5	<ul style="list-style-type: none"> Identify the training needs of the personnel that would be involved in various stages of the project and subject these personnel to training
Commercial	<ul style="list-style-type: none"> Funding of the gap between project cost and likely revenues 	2	<ul style="list-style-type: none"> Funding for any likely deficit to be tied up
Security	<ul style="list-style-type: none"> Physical security of project assets 	2	<ul style="list-style-type: none"> Appropriate security measures to control physical access to project assets, CCTV surveillance
	<ul style="list-style-type: none"> Data security 	2	<ul style="list-style-type: none"> Appropriate security measures to control access to project systems such as role based access to the system through password, monitoring the access to the system, firewall, Intrusion Prevention System (IPS), Intrusion Detection System (IDS), antivirus, disaster recovery centre. A brief note on data security is added as Annexure 7
Communication	<ul style="list-style-type: none"> Availability and adequacy of means of communication between various equipment, personnel and other stakeholders 	5	<ul style="list-style-type: none"> Identify the most suitable means of communication for various project requirements: data, voice, wired, wireless etc. Check for their availability and reliability and plans for backup arrangements

6.4.4 Risk Monitoring

In a dynamic project environment, the character of risk in terms of its probability and/or impact may change during the course of project progress. It is also possible that the project may now be subjected to any new risk which was not affecting the project earlier. It is, therefore, important to keep track of the risks on a periodical basis during the project review meetings so that action could be initiated in order to deal with the changing situation.

6.5 Configuration Management

Systems are composed of specific versions of sub-systems and components. Configuration Management (CM) process helps in ensuring system integrity by establishing the baseline and managing any changes made to the baseline.

The typical activities that form part of CM process are as under:

- **Planning:** This activity deals with preparing a CM Plan covering aspects such as the system elements that are to be controlled to define the system configuration, changing a configuration parameter, approvals required, keeping track of the changes made, audit and verification
- **Identification:** Hardware, software, tools and documents to be tracked and the physical and functional aspects thereof that needs to be tracked
- **Managing Changes:** Controlling change to the items and their characteristics that are subject to configuration management
- **Keeping Track:** Keeping record of the current configuration and also the details of changes completed, approved or proposed
- **Auditing:** To verify that the CM requirements are being adhered to by all concerned and that the documents reflect the system status correctly

6.6 Applying Systems Engineering

6.6.1 Procurement and Systems Engineering

Based on the procurement approach adopted for project, different entities (System Owner, Consultant or Contractor) could be responsible for carrying out various Systems Engineering steps. Table 6-6 provides an overview of role allocation options. The Owner typically decides on the requirements, and may even do preliminary and detailed design, if they have qualified staff for the work. Typically, this work is done by a qualified consultant team. The Owner can also do development work, but typically this work is done by an outside contractor.

Table 6-6: Options for Role Allocation

Activity	Options for Role Allocation
Requirements	System owner, consultant
Preliminary Design	System owner, consultant
Detailed Design	System owner, consultant
Development/Construction	System owner, contractor
Testing	System owner, consultant, contractor

Activity	Options for Role Allocation
Deployment	contractor
Operation	System owner, contractor
Maintenance	System owner, contractor

A typical allocation of responsibility among various entities followed by government is provided in

Table 6-7. The owner will always have oversight responsibility for all phases of the project.

Table 6-7: Distribution of Responsibilities

Activity	System Owner	Consultant	Contractor (Systems Integrator)
Requirements	S	Y	
Preliminary Design		Y	
Detailed Design		Y	Y (1)
Development/Construction			Y
Testing		S	Y
Deployment			Y
Operation	O		O
Maintenance	O		O

Y: The entity concerned is primarily responsible for the activity

S: The entity concerned would support the entity having primary responsibility for the activity

O: Either of the entity could take on the responsibility for the activity

1: For Design-Build or Public-Private Partnership projects, the Contractor can also do final design, provided appropriate preliminary design documents have been developed.

The system owner is required to be involved in each activity irrespective of the responsibility allocation among the various entities and will have some specific role to play in each activity such as giving inputs, monitoring, approvals, reviews etc.

6.6.2 Selecting a Development Strategy

There are several different strategies for implementing a system driven by the factors such as clarity of requirements, budget constraints and evolving system requirements based on user feedback. Given these factors, there are three broad approaches that the system owner could follow:

- **Implement the entire system at one go:** This approach could be followed if the requirements are known and they are not likely to undergo any major changes; and funding for undertaking full scale deployment is available.
- **Implement the system incrementally:** This approach could be followed when the requirements are known but the system is to be designed and deployed in phases due to funding or other constraints.
- **Implement the system with initial capability and then build additional capabilities based on user feedback:** This approach could be followed when there is limited understanding of the user needs and it is expected that user needs would evolve based on their experience in using the system built with initial set of capabilities. The system is developed and released with initial set of requirements. Based on user experience with the system and their feedbacks, their needs are captured, requirements are worked out, system design is undertaken and the system is rolled out.

6.6.3 Customising the Systems Engineering Approach for the Project

The “V” model of Systems Engineering process and the steps comprising the model have been described in Annexure 5 of this document. The manner in which these processes are followed, the degree of detailing, the documentation created and the requirement to follow formal processes vary from project to project depending on its size and complexity.

Irrespective of the project size, all the steps must be followed in the manner assessed most suitable by the project team. It is, however, useful to have the requirements that are documented and to put in place formal design and verification related processes.

7.0 TMICC OPERATIONS

7.1 Introduction

In complex systems such as TMICC where not just several systems and sub-systems belonging to different agencies interface but there are personnel from these agencies that work together to operate and manage the facility, it would be useful to have well-documented procedures that would lay down detailed guidelines for handling various identified activities and events. Such procedures would cover the role to be discharged by the various personnel, agencies and other stakeholders, the timelines to be adhered to, reporting requirements, escalation matrix, communication and other related aspects. In the case of multiple agencies, protocols and standards for information exchange must be developed in the Systems Engineering process and adopted by all agencies, especially as they upgrade or modify their systems to ensure continuous compatibility with all other affected systems.

7.2 TMICC Activities

TMICC's focus areas of operations are data collection, data processing, fusion, validation and information dissemination. TMICC operations, therefore, revolve around these central themes.

7.2.1 Data Collection from Stakeholders and Equipment

Data collection from various participating entities and connected equipment is one of the most important operational activities undertaken by TMICC. TMICCs work with and rely upon several data inputs from variety of sources. The data inputs and their sources need to be planned for at the design stage itself based on the then available data sources and those planned to be implemented. Such data could be of static nature or dynamic nature. Examples of static data are road network, signal locations, terminal locations, transit routes, parking facility details etc. Dynamic data could be location of transit vehicle, departures scheduled at various terminals/bus stops, traffic volume, incidents, feed from cameras etc. The data would also be captured from the field devices installed on the roads and junctions.

The actual data elements that would need to be received and processed by any TMICC would be driven by the services to be provided from the TMICC and the participating agencies.

Some of the activities that relate to this function are listed below:

- Establishing and maintaining connectivity with the traffic and road network equipment
- Review of the relevant systems being managed by the agencies and the data collected/generated that may be useful for TMICC
- Finalising the data exchange protocols between TMICC, traffic/road network equipment and agency systems
- Deciding on the data format to be provided by such agencies
- Deciding on the method of transmission of data
- Deciding the periodicity of transmission of data and its update
- Receiving and storing the data
- Managing, operating and maintaining the data receiving and storage infrastructure and system
- Collection of incident data, including updates from agencies responsible for incident response

Coordinating with participating agencies for ensuring that the data is provided by them to TMICC in accordance with the understanding as set out in the MoU among the participating agencies (sample of MoU is provided as Annexure 4 of this report).

Availability of information in electronic format from the control centres of various participating agencies is a key pre-requisite of TMICC. It must, therefore, be ensured that the participating agencies provide information to TMICC in a digital mode using appropriate standards and protocols.

7.2.2 Data Processing & Fusion

As part of this activity, the data collected from various participating entities is analysed, correlated and fused with other data and information. Some of the key activities that are undertaken as part of this exercise are listed below:

- Data massaging to suitably format the data received
- Data sorting in some required order or sequence and/or data classification
- Data validation based on various rules to ensure that data received is valid, useful, meaningful, clean and correct
- Data aggregation by way of combining data received from multiple sources
- Preparing data summaries
- Data analysis to derive meaning out of data using software tools

- Data fusion by integrating of multiple data, information and knowledge to provide a single unified view using software tools
- Setting up, managing, operating and maintaining the data processing infrastructure and system

7.2.3 Other Operational Aspects

Other operational aspects of TMICC are as set out below:

- Hosting of TMICC systems
- Relationship management with traffic, transit and other participating agencies covering aspects such as entering into agreements (as desired), coordinating for data exchange etc.
- Contractors and consultants hiring and management
- Licensing of data to private sector entities to enable data dissemination by such entities
- Branding & promotion of the helpline to create awareness and catalyse its regular use by public
- Financial management
- Human resource management
- Managing relations with media
- Training on TMICC System

7.3 Daily Operations

TMICC is a 24x7 operations centre and, therefore, needs to be staffed with personnel in shifts accordingly. The shifts would have varying personnel depending upon the peak and non-peak traffic patterns. It is expected that there would also be variations in staffing for weekdays as compared to weekends. The suggested organisation chart for the TMICC has been discussed in Chapter 9.0.

There is a need to have clearly defined and documented procedures governing the daily operational activities to be carried out in relation to the TMICC. It is recommended that standard operating procedures are laid down for the same, covering the following:

- Jurisdiction of the TMICC with maps
- Organisation structure and reporting relationships
- Hours of operation, shift details, staff deployment during various shifts
- Emergency and other contact numbers
- Details regarding capturing log of various operational activities

- Responsibilities of various agencies
- Role description of various positions
- Coordination mechanism with various agencies
- Facility and building management aspects such as utilities, services etc.
- Procedures for notifications
- Data backup and archival policies
- Asset custody and maintenance related procedures
- Access control mechanism
- Data and asset security
- Communication with Media
- Communication infrastructure
- Procedure for bypassing any policy requirements
- Handling visitors
- Office Administration
- Training requirements
- Other TMICC manuals

The Standard Operating Procedures (SOP) would evolve with time and experience and also based on inputs from various stakeholders. Therefore, the SOP document would have to be updated in line with evolving procedures on a periodic basis. Training must be provided to the responsible staff on an annual basis or as needed. .

7.4 Citizen Inputs and Requests

Since citizens are one of the most important stakeholders of TMICC, being the key recipient of the services being provided by the TMICC, it is critical that a mechanism is created for receiving their request for services, feedbacks, inputs, suggestions, complaints and event & incident reporting etc. in a suitable manner.

Such inputs from citizens must be recorded and processed in a structured manner with carrying out activities such as logging, review, action taken thereon and response to citizen.

Based on the feedbacks received from the citizens, new services could be introduced, existing services could be modified / enhanced and the activities of the TMICC could be tailored to meet the citizen expectations. Logs of all citizens' requests must be maintained to allow an effective management and troubleshooting procedures.

7.5 System Reports

TMICC system should be designed in such manner that it is capable of supporting report generation of various types and their dissemination. System should support for automatic generation and distribution of various identified reports. Additionally, it should have a reporting tool that can support generation of customised reports as well.

Such reports would capture the performance of various system elements as set out below:

- TMICC Key Result Areas: Average speed on various sections, average incident response time, customer satisfaction, data dissemination quality and coverage etc.
- Operational Activities: Number of incidents handled, road network coverage, number of signals being managed, interfaces with field equipment being handled, traffic volume, number of events handled etc.
- Maintenance & System Performance: Uptime, downtime, mean time between failure, response time etc.
- Statistical Analysis: Traffic volume and trends, incidents volume and trends, analysis of data on feedbacks etc.

7.6 Data Storage

The data storage policy of the TMICC would need to be defined based on utility of data points, entity owning the data, storage space requirements, need to access data, legal and statutory aspects etc.

7.7 System Documentation

Documentation for the TMICC system, including the system design, operations and management must be developed and maintained during the life of the project. These documentation are often a part of the original contract documents with the design and implementation of the system. The agencies must ensure that proper documentation are developed and updated on an annual basis for staff use.

Details of all documents, policies, plans and programmes as well as the documents themselves must be readily accessible to responsible staff and other stakeholders on an as needed basis. The indicative list of various types of documents that may be associated with any TMICC is:

- City Development Plans
- Mobility Plan of the City
- Agreements among participating agencies
- Agreements with Suppliers and Contractors
- TMICC Operations Document

- TMICC Concept of Operation document
- TMICC Operations Manual
- TMICC Maintenance Manual
- System Requirements
- Systems Engineering Management Plan
- System design documents
- Project ITS Architecture
- Business Continuity & Disaster Recovery Plan
- Standard Operating Procedures
- Relevant Laws and Statutes
- TMICC Equipment specifications
- Manual provided by Suppliers

8.0 TMICC MAINTENANCE PROCEDURES

8.1 Introduction

There are various systems that would interface with or reside within TMICC. Some, such as field equipment, would provide data feed to the TMICC which would be processed by the TMICC application software for managing traffic, incidents etc. and also pushed to NUTH for dissemination. Some others would be used to host the TMICC application software and other standard software and support networking and communication. Then there would be remaining systems that manage the environment, power back up or are part of utilities and services supporting the TMICC. Each of these must be maintained in proper state of upkeep and repair to the acceptable standards so as to support the TMICC related activities.

8.2 TMICC Related Assets Maintenance

8.2.1 TMICC Backend System

TMICC backend system would consist of the following:

- A. Hardware:** TMICC backend hardware would include servers, switches, storage, desktops UPS, network and communication equipment that support TMICC operations. Such equipment would include those deployed in production as well as the ones maintained at the Disaster Recovery site. Such hardware would be maintained by the respective Original Equipment Manufacturer (OEM) or their authorised resellers, as the case may be. The maintenance should be subject to agreed service levels in terms of response and resolution times.
- B. Standard Software:** TMICC Backend Standard software would comprise database, operating systems, firewalls, office suite etc. that support TMICC operations. Such software would include those deployed in production as well as the ones maintained at the Disaster Recovery site. Such software would be maintained by the respective software owner or their authorised resellers, as the case may be. The maintenance should be subject to agreed service levels in terms of response and resolution times. The O&M costs for software maintenance need to be considered in the life-cycle costs for the project.
- C. Application Software:** TMICC Application software would comprise the application software that supports TMICC operations. Such software would include those deployed in production as well as the ones maintained at the Disaster Recovery site. Such software can be maintained by the respective software developer or the agency who has commissioned the development of the software. The maintenance should be subject to agreed service levels in terms of uptime, response and resolution times.

The O&M costs for software maintenance need to be considered in the life-cycle costs for the project. In case of the agency maintained system, the agency needs to have qualified and dedicated staff in order to properly maintain the system. In both situations, the O&M costs for software maintenance needs to be considered in the life-cycle costs for the project

- D. Communication Links:** Communication links would be maintained by the respective telecom service providers to agreed service levels in terms of uptime, response and resolution times. The O&M costs for software maintenance need to be considered in the life-cycle costs for the project, especially if the communication links are based on leased solutions instead of agency owned options. Leased costs, such as cellular service can be expensive in the long run. If an agency owned communication system is selected in the Systems Engineering analysis, appropriate trained staff is required for system maintenance.
- E. Other Facilities:** Facilities such as fire-fighting equipment, air conditioning, power back up, false flooring & ceiling, furniture & fixture and civil structure pertaining to the TMICC facilities, where applicable, could be maintained by the respective OEMs/suppliers/contractors. The maintenance should be subject to agreed service levels in terms of response and resolution times.

8.2.2 Field Equipment

- A. TMICC Systems:** Such systems and associated equipment will be maintained by the TMICC. TMICC may, in turn, maintain these either directly or through the contractor(s) engaged for the purpose. TMICC system would generate alert as and when any of the requisite data feed for which TMICC is responsible, is not reaching TMICC system so that TMICC staff or its contractor may get the equipment inspected and take corrective action.
- B. Systems of Participating Agencies:** Such systems and associated equipment will be maintained by the agency to which they belong. The Agency may in turn maintain these systems and associated equipment either directly or through their contractor(s). TMICC system would generate alert as and when any of the requisite data feed from these systems is not reaching TMICC system and would report the same to the agency concerned so that the agency may get the check the reasons for breaks in data feeds and take corrective action within a reasonable time frame. For example, TMICC would alert the parking operator/agency in case of break in the parking availability data or the transit agencies in case of break in transit ETA data.

8.3 Types of Maintenance

8.3.1 Routine Maintenance

Routine maintenance are activities of periodic nature required to be carried out for the general upkeep of any system, hardware, software and equipment against normal wear

and tear during its usage. The maintenance activities and their frequency (daily, weekly, monthly etc.) are typically based on the equipment manufacturer's recommendations as provided in the equipment maintenance manual.

Depending upon the arrangement with the contractor, such activity would either be undertaken by the contractor or by the agency personnel.

Such activities may include equipment cleaning, lens cleaning, adjustment/calibration, battery replacement, bulb replacement, minor component replacement etc.

8.3.2 Preventive Maintenance

Preventive maintenance is carried out in order to pre-empt any equipment failure by proactively and systematically examining various equipment based on recommendations of the respective equipment manufacturer.

Preventive maintenance is defined set of activities that are typically carried out by skilled personnel at pre-specified schedules. Depending upon the arrangement with the contractor, such activity could either be undertaken by the contractor or by the agency personnel who are generally trained by the equipment manufacturer to carry out such tasks.

Such activities may include detailed inspection of the equipment, replacement of major/minor components etc.

8.4 System Start-Up and Shut-Down Procedures

Since the TMICC related systems, sub-systems and equipment support several processes and provision of various services, all such processes and services would get affected whenever there is any change in status of any of these elements.

As and when any system, sub-system or equipment is to be shut down for maintenance or other requirements, a well laid down process must be followed covering the following:

- To the extent possible shut-down must be planned in advance in accordance with the agreed schedules preferably during lean hours
- Communication must be sent to all the stakeholders concerned who would get affected by such shut-down. Such communication must contain all the relevant details:
 - Nature of issue being addressed
 - Commencement time
 - Completion time
 - The services and the processes that would be affected
 - Period of time the equipment is not expected to be available
 - Contact details of the key personnel responsible for maintenance / shut down activities

- Any other relevant information, in accordance with the agreed procedure
- Start-up communication must be sent to all the stakeholders concerned and their confirmation must be obtained regarding proper functioning of the systems, sub-systems or equipment concerned.

8.5 Spare/Backup Equipment

Spares and back up equipment may be required to be provided for in order to support desired service levels based on recommendations of the equipment manufacturer.

Depending upon the critical nature of the service, spares and back up equipment must be stored close to their location of usage.

The spares and back up equipment would be maintained by the agency to which the equipment belongs directly through its personnel or through respective equipment manufacturer. In addition, the vendors/suppliers would also need to be contractually bound to ensure availability of spares over the life of the system (for example, in case a system is being procured with a design life of 10 years, then the system vendor/supplier must be contractually bound to provide all spares for the duration of the contract with a pre-determined price/pricing formula). This will insulate the TMICC against technology obsolescence over the design life of the equipment.

8.6 Emergency Operations

In case any equipment or any other component of the system fails leading to an unplanned shut-down, several processes and services may get affected.

For dealing with such situations emergency operations procedures must be established, covering the following:

- Alternate arrangement to fully /partially support the affected services to the extent possible.
- Communication must be sent to all the stakeholders concerned who would get affected by such shut-down containing the relevant details.
- Start-up communication must be sent to all the stakeholders concerned post restoration and their confirmation must be obtained regarding proper functioning of the systems, sub-systems or equipment concerned.

8.7 Maintenance Contracting

8.7.1 Agency Maintenance

Based on availability of trained personnel and capacity within the various agencies, they may decide to undertake different levels of maintenance on their own. Routine maintenance activities may be undertaken by the agency personnel with minimal training

but for carrying out any major maintenance, the agency personnel would need to be trained by the equipment manufacturer. Continuous and periodic training should be planned and carried out to maintain a high level of expertise for the staff. It is suggested that, to begin with, the TMICC should have a small maintenance team which is responsible for routine Level One maintenance of the backend systems (hardware and 3rd party software). Depending upon capability build-up within the TMICC, responsibility of carrying out routine maintenance of additional systems (both, backend and field) may be considered in the longer term.

8.7.2 Contract Maintenance

In case the agency does not have trained personnel or in-house capacity or it otherwise decides to outsource the maintenance activities, it may do so under suitable arrangement with the contractor or equipment supplier or their authorised service partners.

The agreement with such entities must cover the detailed scope of maintenance activities, its coverage including exclusions (if any), contract period, payment terms, performance standards, response and resolution times, penalties and reward structure, as mutually agreed. The agencies must include provisions in the contract to ensure the third party providers provide continuous and on-going training for the staff. Maintenance manuals should be prepared for all aspects of the project and be available to the agency staff, as well as the contract employees.

9.0 INSTITUTIONAL CONSIDERATIONS AND ORGANISATIONAL SETTING

9.1 Introduction

As the Traffic Management and Information Control Centre (TMICC) functions involve roles to be played by various agencies having their respective mandates and jurisdictions, the establishment, operation and management of a TMICC involve interplay, collaboration and cooperation among several agencies.

In order to work towards meeting the objectives of TMICC, the relevant agencies working in the area of transportation, transit and traffic need to come together and cooperate at several levels ranging from its planning, to be a part of its operational set up.

The agencies concerned must get involved in establishment of TMICC right from the beginning and evolve concept of operations jointly so that the services and associated facilities are developed keeping in mind their expectations from TMICC in terms of the TMICC's objectives, operational and managerial role of various entities, the nature and extent of information & data sharing, space requirements, the entities that need to be co-located and the like.

In order to give the arrangements among various agencies an institutional shape, agencies may need to enter into suitable agreements, contracts or Memorandums of Understanding (MoUs) outlining their roles, responsibilities and other related aspects of their cooperation.

9.2 Applicable Laws and Regulations

Development and operation of the TMICC would in any case need to be within the legal framework governing such activities in India. Some of the specific laws, regulations or government orders that would have bearing on the TMICC activities are as follows:

- Information Technology Act, 2000 with regard to matters such as privacy, theft, legal admissibility of electronic communication etc.
- Copyright Act, 1957 with regard to protection of intellectual property
- Motor Vehicles Act, 1988 with regard to the traffic violations
- Acts or executive orders governing setting up of Unified Metropolitan Transport Authority participating in the project
- Police Act with regard to the role of State police in traffic activities
- Municipal Acts governing the municipal body of the city
- Fire Services Act governing the fire agency of the city
- The Road Transport Corporation Act, 1950

- The Metro Railways (Construction of Works) Act, 1978
- The Delhi Metro Railway (Operation & Maintenance) Act, 2002
- The Railways Act, 1989
- The Persons with Disabilities Act, 1995
- Government guidelines in setting up TMICC facilities, if any

The list above is not intended to be an exhaustive one and the agency implementing the project must take into account the extant legal regime that would apply to their projects and specific situations.

9.3 Role of National, State and Local Governments

Various levels of governments play roles in the urban transport sector in India. The framework governing the responsibilities of various entities has been outlined in the Constitution of India (COI).

9.3.1 Constitutional Provisions

The division of role between various levels of government in India is governed and guided by the Constitution of India (COI). Article 246 of the COI deals with this matter and contains references to Seventh Schedule containing List I (Union List), List II (State List) and List III (Concurrent List). Article 243 (W) deals with provisions regarding power, functions and other incidental matters related to municipalities.

Indian Parliament has exclusive power to make laws with respect to any of the matters enumerated in Union List. The Legislature of any State has exclusive power to make laws for such State or any part thereof with respect to any of the matters enumerated in State List. Indian Parliament and the Legislature of any State also have power to make laws with respect to any of the matters enumerated in Concurrent List. According to Article 248 of COI, Indian Parliament has exclusive power to make any law with respect to any matter not enumerated in the Concurrent List or State List.

Union List entries that have relevance in relation to TMICC:

- Delimitation of cantonment areas, local self-government in such areas, the constitution and powers within such areas of cantonment authorities and the regulation of house accommodation (including the control of rents) in such areas.
- Railways.
- Highways declared by or under law made by Parliament to be national highways.
- Shipping and navigation on inland waterways, declared by Parliament by law to be national waterways, as regards mechanically propelled vessels; the rule of the road on such waterways

- Airways; aircraft and air navigation; provision of aerodromes; regulation and organisation of air traffic and of aerodromes; provision for aeronautical education and training and regulation of such education and training provided by States and other agencies
- Carriage of passengers and goods by railway, sea or air, or by national waterways in mechanically propelled vessels.
- Posts and telegraphs; telephones, wireless, broadcasting and other like forms of communication
- The Survey of India, the Geological, Botanical, Zoological and Anthropological Surveys of India; Meteorological organisations.
- Extension of the powers and jurisdiction of members of a police force belonging to any State to any area outside that State, but not so as to enable the police of one State to exercise powers and jurisdiction in any area outside that State without the consent of the Government of the State in which such area is situated; extension of the powers and jurisdiction of members of a police force belonging to any State to railway areas outside that State

State List entries that have relevance in relation to TMICC:

- Police (including railway and village police) subject to the provisions of entry 2A of List I.
- Communications, that is to say, roads, bridges, ferries, and other means of communication not specified in List I; municipal tramways; ropeways; inland waterways and traffic thereon subject to the provisions of List I and List III with regard to such waterways; vehicles other than mechanically propelled vehicles
- Local Government, that is to say, the constitution and powers of Municipal Corporations, improvement trusts, districts boards, mining settlement authorities and other local authorities for the purpose of local self-government or village administration
- Taxes on goods and passengers carried by road or on inland waterways
- Taxes on vehicles, whether mechanically propelled or not, suitable for use on roads, including tramcars subject to the provisions of entry 35 of List III.

Concurrent List entries that have relevance in relation to TMICC:

- Shipping and navigation on inland waterways as regards mechanically propelled vessels, and the rule of the road on such waterways, and the carriage of passengers and goods on inland waterways subject to the provisions of List I with respect to national waterways
- Mechanically propelled vehicles including the principles on which taxes on such vehicles are to be levied

The aforesaid provisions deal with division of power between central and State Governments only. Provisions relating to Municipalities dealing with their formation, power, functions and other matters were incorporated in the Seventy-fourth Amendment of the COI which came into force on 1st June, 1993. According to Article 243 (W) of the COI, the Legislature of a State may, by law, endow the Municipalities with such powers and authority as may be necessary to enable them to function as institutions of self-government and such law may contain provisions for the devolution of powers and responsibilities upon Municipalities, subject to such conditions as may be specified therein with respect to, *inter alia* the performance of functions and the implementation of schemes as may be entrusted to them including those in relation to the matters listed in the Twelfth Schedule. The matters related to TMICC listed in the said Schedule are:

- Urban planning including town planning.
- Planning for economic and social development.
- Roads and bridges.
- Fire services.
- Protection of the environment and promotion of ecological aspects.
- Public amenities including street lighting, parking lots, bus stops and public conveniences.

9.3.2 Existing Roles of Various Levels of Governments in Transportation

In line with the constitutional mandate, various levels of governments or agencies controlled by them have participation in provision of transportation services. Table 9-1 provides a brief overview of the roles currently being played by various levels of governments or agencies controlled by them.

Table 9-1: Roles of Various Levels of Governments in Transportation

Government Level	Entity	Current Roles in Transportation
National	Indian Railways	Inter-city rail services, suburban rail services, Metro rail services
	Metro Rail Corporations under JV with State Government	Metro Rail Services in metropolitan areas
	National Highways Authority of India	Developing and managing the entrusted National Highways in India
	Inland Waterway Authority of India	Developing and managing National Waterways in India
	Airport Authority of India	Developing and managing Airports in India

Government Level	Entity	Current Roles in Transportation
	Ministry of Road Transport and Highways	Developing and managing National Highways in India, Motor Vehicle legislation, administration of Motor Vehicles Act, 1988
	Ministry of Urban Development	National Urban Transport Policy formulation, supporting its implementation by various States and Local Governments through various funding schemes
State	State Transport Corporations	Inter-city and urban bus services
	City Bus Companies (shareholding through development authorities, infrastructure board and other parastatals)	Urban bus services
	Metro Rail Corporations including those under JV with Central Government	Metro Rail services in metropolitan areas of the State
	Public Works Department	Developing and managing State Highways in the State
	Transport Department	Vehicle registration, licensing, permits, stage carriage permits, city bus routes, river ferry services (where applicable)
	State / Development Authorities	Concessions for Metro Rail / Mono Rail
	Police, including Traffic Police	Management of traffic signals, regulation of traffic, traffic rules enforcement, accident management and law & order issues connected with traffic/transport.
	State Fire Services (most States)	Fire services, incident response due to road traffic accidents, flood, rescue etc.
Local	Municipal Corporations / their Undertakings	Urban bus services
	City Bus Companies (shareholding by Municipal Corporations)	Urban bus services
	Municipal Corporations	City roads, bus stops, signal installation and maintenance, Fire services (in some States)

9.3.3 Augmented Roles for National, State and Local Governments

Notwithstanding the constitutional provisions mentioned in Section 9.3.1, the Central Government can and does influence various transport sector initiatives taken up by the State and Local Governments through various funding schemes by requiring them to undertake certain reforms including by making these reforms as pre-condition for seeking funding. In addition, as detailed in Section 9.3.2, Central Government has set up joint venture companies with State Governments to provide metro rail services in a few cities (Delhi, Bengaluru, Chennai, Jaipur, Kochi) and through Indian Railways, it also provides suburban rail services in some cities (Mumbai, Chennai, Delhi etc.).

Given the constitutional provisions, transport entities managed or controlled by the various levels of Governments and the persuasive role of the Central Government. Table 9-2 contains the suggested roles of the Central, State and Local Governments in matters connected with setting up of the TMICCs in India:

Table 9-2: Augmented Roles of National, State and Local Governments

Level	Suggested Roles
National	<ul style="list-style-type: none"> Guiding ITS Architecture development for India with respect to the urban transport, traffic and related matters Setting standard protocols for data exchange related matters between various TMICCs, NUTHs, traffic and transportation agencies Standardising the data dissemination parameters through TMICC/NUTH on a nationwide basis Facilitating institutional development (such as UMTA) Ensuring participation and support of Central Government departments and agencies as well as private entities working under contract with Central Government/ its agencies in TMICC in accordance with the requirements by way of data sharing, content updates and other matters Launching scheme for funding TMICC initiatives on a nationwide basis with applicable guidelines Provide capital as well as Operation & Maintenance (O&M) funding support for TMICC initiatives either directly or through the agencies controlled by Central Government Capacity building of the various stakeholders connected with TMICC in coordination with State and Local Governments
State	<ul style="list-style-type: none"> Establish institutions or facilitate institutional development Following the standards, protocol, architecture and guidelines developed by Central Government with respect to the TMICC and other urban transport, traffic and related matters Ensuring participation and support of State Government departments and agencies as well private entities working under contract with State

Level	Suggested Roles
	<p>Government/ its agencies in the TMICC in accordance with the requirements by way of data sharing, content updates and other matters</p> <ul style="list-style-type: none"> • Provide capital as well as Operation & Maintenance (O&M) funding support for TMICC initiatives either directly or through the agencies controlled by State Government • Capacity building of the various stakeholders connected with TMICC in coordination with central and Local Governments
Local Government	<ul style="list-style-type: none"> • Facilitating inter-agency coordination and resolving issues, if any • Following the standards, protocol, architecture and guidelines developed by Central Government with respect to the TMICC and other urban transport, traffic and related matters • Ensuring participation and support of Local Government departments and agencies as well private entities working under contract with Local Government / its agencies in the TMICC in accordance with the requirements by way of data exchange, co-location, content updates and other matters • Provide capital as well as Operation & Maintenance (O&M) funding support for TMICC initiatives either directly or through the agencies controlled by Local Government • Capacity building of the various stakeholders connected with TMICC in coordination with central and State Governments

9.4 Stakeholders/Joint Operations

In line with the objectives of the TMICC, agencies participating in them may also come from diverse set of backgrounds. TMICC facilities that are set up for monitoring road network and traffic facilities for a metropolitan region would have participating agencies having jurisdiction over the metropolitan region for performing such activities. The implementing agency for setting up of the TMICC could be any of the following:

- Unified Metropolitan Transport Authority (UMTA) or entity performing this role
- Municipal Corporations/ Urban local bodies
- Traffic Police

For a TMICC, the participating agencies could be as under:

- Road Construction & Maintenance Agencies: Municipal Corporations/ Urban local bodies, PWD, Development Authorities and other road owning agencies
- Event/ Incident Management Related Authorities: Police, Fire Department, State Transport Department

- Transit Agencies: Bus operator, Metro operator, Suburban Rail operator (Indian Railways), operator of any other mode
- Weather department
- Any other relevant agency

Depending upon the jurisdiction, the traffic agencies, road owning agencies and other agencies from the contiguous areas could also participate in the TMICC.

While planning and designing TMICC, the identification of agencies, their systems (both existing and the planned ones) and the data/information that would be provided by them must be taken into consideration. These aspects may have a bearing on the concept of operations, information receiving and processing mechanism, TMICC system requirements, resource deployment, time to deploy the system, cost of deployment and the expertise required.

9.5 Service Providers and Stakeholders

Considering the diverse nature of activities and the scope of TMICC functions, a very wide set of stakeholders and entities may have interest in or emerge as potential candidates that TMICC may need to get associated with in order to make it efficient and effective. Such entities could be from any level of government (Central, State or Local) or could be from private sector or even Non-Government Organisations (NGOs) as long as they have some meaningful role to play and their association supports the objectives set for the TMICC.

Potential agencies that need to get associated with TMICC would be driven by the objectives of the TMICC. For any city specific TMICC, representation from the city related stakeholders would suffice. However, when the geographical coverage of TMICC extends beyond the city and includes adjoining areas/cities as well, a much broader set of stakeholders may need to get involved. Table 9-3 provides a list of entities that could be considered for possible association with TMICC.

Table 9-3: Entities for Possible Association with TMICC

Area	Entities
Transport & Traffic	<ul style="list-style-type: none"> • Unified Metropolitan Transport Authority (UMTA) or the entity playing this role
Traffic	<ul style="list-style-type: none"> • Municipal Corporations • Cantonment Board (as needed) • Traffic Police • Other agencies managing traffic signals
Transit	<ul style="list-style-type: none"> • Bus including Bus Rapid Transit (BRT)- City Transport Corporations, State Transport Undertakings, city bus Special

Area	Entities
	Purpose Vehicles (SPVs), Municipal Transport Undertakings, PPP Operators <ul style="list-style-type: none"> • Rail • Metro • Monorail • Other modes, if any
Roads	<ul style="list-style-type: none"> • State PWD • Central PWD • National Highways Authority of India (NHAI) • State Road Development Corporations • Municipal Corporations • Cantonment Board • Development Authorities • Other Road owning agencies
Parking	<ul style="list-style-type: none"> • Municipal Corporations • Other Parking facility management entities
Para-transit	<ul style="list-style-type: none"> • State Department of Transport
Bus Terminus	<ul style="list-style-type: none"> • State Department of Transport • State Transport Undertakings
Emergency Response	<ul style="list-style-type: none"> • Fire • Ambulance • Police
Weather	<ul style="list-style-type: none"> • Regional Meteorological Centre
Pollution	<ul style="list-style-type: none"> • Pollution Control Board
Service Providers	<ul style="list-style-type: none"> • Contractors implementing and maintaining ITS equipment that are connected to TMICC • Concessionaires / O&M operators managing roads under agreement with road owning entities (to the extent relevant for the TMICC) • Concessionaires of parking, bus terminus, transit operation or other relevant transport assets(to the extent relevant for the TMICC) • Entities having probe data that are of interest to TMICC • Entities providing traffic or transit data feeds to public

Area	Entities
Media	<ul style="list-style-type: none"> • Newspapers • FM Radio Channels • TV Channels • Social Media
Other Organisations	<ul style="list-style-type: none"> • Hospital • Towing services

The nature of association of various entities would differ depending on the role envisaged for an entity. Some agencies would need to work at the TMICC premises and, therefore, they need to deploy personnel at the TMICC. Others need not be co-located and they may participate in the TMICC related activities while functioning from their respective set-ups. Some agencies may only be required to share information without there being any need for their physical presence in the TMICC.

9.6 Potential Agencies in TMICC

In view of the role currently being performed by Traffic Police and Municipal Corporations by virtue of the existing legal framework in traffic management activities, these entities would be central to setting up and managing the TMICCs. Additionally, given the proposed structure of Unified Metropolitan Transport Authority (UMTA) and its constituent stakeholders, it should also be made part of the core TMICC stakeholders together with Traffic Police and Municipal Corporation, wherever it has been established. UMTA would be in a good position to lead the effort in getting all the TMICC stakeholders on board most of which in any case would be part of UMTA organisation. UMTA would also be a good conduit to bring in the transit agencies into interfacing with the TMICC. However, since the UMTA is yet to become fully operational in many cities/States, it is suggested that this role of bringing the stake-holders together and setting up of the TMICC could be undertaken by the Municipal Corporation/ULB or the Traffic Police. State/City may finally choose an implementing agency based on the roles assigned to the various agencies in the city and their capacity.

There are several agencies identified in Section 9.5 above that may have a role to play or interest in the activities to be undertaken by the TMICC and that may even be considered for possible association with TMICC. It may, however, be noted that not all of them need to deploy personnel at or be co-located within TMICC. Only a limited set of these may need to deploy personnel at or be co-located within TMICC as provided in Section 9.6.1. The remaining may share requisite data with TMICC in the form and manner agreed as detailed in Section 9.6.2.

9.6.1 Entities Co-located in TMICC

The Traffic Police and Municipal Corporations are key entities involved in the management of traffic related assets and activities. Municipal Corporations (in some cities such as Mumbai, Pune, and Ahmedabad) install and maintain the signals and other traffic equipment while these are operated and controlled by the Traffic Police. In many cities, it is the Traffic Police that are responsible for installation, maintenance and operation of the signals and other traffic equipment. Given that traffic monitoring and management is a central function of TMICCs, these entities would be part of the core set of stakeholders and play key role in designing, setting up and managing the TMICCs together with Unified Metropolitan Transport Authority (UMTA), wherever it has been established. Table 9-4 provides a list of suggested entities that may need to deploy personnel or be co-located at TMICC:

Table 9-4: Entities Co-located in TMICC

Area	Entities
Transport & Traffic	<ul style="list-style-type: none"> Unified Metropolitan Transport Authority or the entity playing this role
Traffic	<ul style="list-style-type: none"> Traffic Police
	<ul style="list-style-type: none"> Municipal Corporation (traffic signal team)
	<ul style="list-style-type: none"> Other agencies managing traffic signals

The list of entities above that may need to deploy personnel or be co-located is indicative and, depending upon the objectives of the TMICC and the role it is expected to play, the final set of entities could be worked out.

9.6.2 Entities Sharing Data with TMICC

The indicative list of entities and the requirement for data sharing is outlined in Table 9-5. Depending upon the specific requirements agreed by the city stakeholders, the final set of entities as well as data sharing requirements would need to be worked out for each TMICC. Some of the data may be shared directly with TMICC while the remaining could be provided through NUTH. TMICC in turn would provide these entities with the information that may be relevant for their respective operations and other activities.

Table 9-5: Entities Sharing Data with TMICC

Area	Entities	Data Sharing
Transport & Traffic	<ul style="list-style-type: none"> Unified Metropolitan Transport Authority or the entity playing this role 	<ul style="list-style-type: none"> Details of various public transit modes / operators in the region both current as well as planned Periodical updates to the aforesaid data

Area	Entities	Data Sharing
		<ul style="list-style-type: none"> Details of transport sector initiatives
Traffic	<ul style="list-style-type: none"> Municipal Corporation (traffic signal team) Other agencies managing traffic signals 	<ul style="list-style-type: none"> Location of various traffic related equipment: signalised junctions, cameras, variable messages signs etc. on map and as list Plans and schedules for construction & maintenance Updates on the construction & maintenance
	<ul style="list-style-type: none"> Municipal Corporations (roads team) State PWD Central PWD National Highways Authority of India (NHAI) State Road Development Corporations Cantonment Board Development Authorities Other Road owning agencies 	<ul style="list-style-type: none"> Road network details including Geographic Information System (GIS) maps Location of various traffic related equipment: signalised junctions, cameras, variable messages signs etc. on map and as list Road attributes: name, number of lanes, width, weight restrictions, height restrictions etc. Plans and schedules for construction & maintenance Updates on the construction & maintenance New roads planned
	<ul style="list-style-type: none"> Traffic Police 	<ul style="list-style-type: none"> Road attributes: name, number of lanes, whether one-way or two-way, speed limit, entry restrictions, weight restrictions, height restrictions etc. Location of various traffic related equipment: signalised junctions, cameras, variable messages signs etc. on map and as list Location of red light enforcement cameras, speed enforcement cameras Speed limit on various road sections Entry restrictions such as one way, no entry, time based entry, no U-Turn etc. Incident information Event information Road closures, diversions

Area	Entities	Data Sharing
		<ul style="list-style-type: none"> Live traffic surveillance camera feeds and access to historical feeds, live messages being displayed on the variable messages signs, traffic volume data, details of public notices on traffic etc.
Transit	<ul style="list-style-type: none"> Bus including BRT (City Transport Corporations, State Transport Undertakings, city bus SPVs, Municipal Transport Undertakings) Rail Metro Monorail Ferry Other modes, if any 	<ul style="list-style-type: none"> Operators details: Name, modes operated, contact details, website details Modes: Bus, Metro, Monorail, Tram, Ferry etc. Services: Express, Ordinary, AC, Non AC, Night services Routes: Details of the routes operated Schedule Data: Frequency during peak/off-peak hours, Timings Timing of operations: First and last service on various routes Fare structure: Normal fares, special fares, concessions for various category of commuters Pass Details: Pass charges for various category of commuters, validity rules Bus Terminals, Bus Stops, Metro Stations details Details of parking facility: capacity, vehicle types that can be parked, operational hours, charges, mode of payment, operating agency, contact details Inter-modal transfer options: feeder services, connecting routes, interchange stations/terminals Transit trip planner: intra-modal as well as inter-modal based on static data Tourism related information with connecting transit options to tourist spots Running status Departures scheduled at bus terminals, bus stops, metro stations Estimated Time of Arrival (ETA) Service delay, disruptions

Area	Entities	Data Sharing
		<ul style="list-style-type: none"> Information on new services, discontinuation of any service etc. Rerouting Transit trip planner GPS feed data Incidents & Events Schedules for construction & maintenance Updates on the construction & maintenance Parking availability status (real-time)
Para-transit / Intermediate Public Transport (IPT)	<ul style="list-style-type: none"> State Transport Department 	<ul style="list-style-type: none"> GPS feeds data such as speed, time taken on a road stretch Planned strike, service disruptions
Parking	<ul style="list-style-type: none"> Municipal Corporations Other agencies managing parking facilities 	<ul style="list-style-type: none"> Details of parking facility such as capacity, type of vehicles that can be parked, operational hours, charges, mode of payment, operating agency, contact details Parking availability status (real-time) Updates on construction/ maintenance activities Updates on facility closure
Bus Terminus	<ul style="list-style-type: none"> Department of Transport State Transport Undertakings Other entities managing such facilities 	<ul style="list-style-type: none"> Details of services operated from the bus terminus Details of parking facility such as capacity, type of vehicles that can be parked, operational hours, charges, mode of payment, operating agency, contact details Updates on service delay /disruptions / facility closure Updates on construction/ maintenance activities
Emergency Response	<ul style="list-style-type: none"> Fire Police 	<ul style="list-style-type: none"> Incident information Event information

Area	Entities	Data Sharing
Weather	<ul style="list-style-type: none"> Regional Meteorological Centre 	<ul style="list-style-type: none"> Weather updates Temperature, wind speed, fog, visibility details, humidity, rainfall etc.
Tourism	<ul style="list-style-type: none"> Tourism department or Tourism development corporation 	<ul style="list-style-type: none"> Details of tourist spots Information related to tourist spots such as locations, brief details, ticketing details, operational timings, contact details, transit connection, route map etc.
Pollution	<ul style="list-style-type: none"> Pollution control board 	<ul style="list-style-type: none"> Air quality data such as Sulphur dioxide, nitrogen dioxide, particulate matter, ozone, lead, carbon monoxide

9.6.3 Roles and Responsibilities

The roles and responsibilities of the agencies associated with TMICC need to be allocated in such a manner that each participating agency continues to discharge its functions mandated by law, its charter or the governing contracts. This is important in order to preserve and ensure institutional integrity and to avoid any legal, constitutional and contractual issues that may arise if the roles assigned to an entity do not conform to the underlying contracts, established order or the statutes, as applicable.

The role allocation amongst various parties needs to be agreed upon early in the planning phase of the project, typically at the Concept of Operations and Systems Engineering Management Plan (SEMP) stage. This will ensure that each party is aware of its roles and discharges these in the agreed manner. Keeping this in mind, Table 9-6 shows the examples of suggested roles and responsibilities of the key TMICC stakeholders. It may be noted that only a few of these entities would be co-located at the TMICC and the rest would operate from their respective set-ups. These roles could be different for the agencies based on specific circumstances.

Table 9-6: Examples of Roles and Responsibilities of Entities Associated with TMICC

Area	Agencies	Role and Responsibilities
Transport & Traffic	<ul style="list-style-type: none"> Unified Metropolitan Transport Authority (UMTA) or the entity playing this role 	<ul style="list-style-type: none"> To set up TMICC with other core stakeholders: Traffic Police & Municipal Corporation To depute its personnel at TMICC To enter into agreement/MoUs with various agencies associated with TMICC

Area	Agencies	Role and Responsibilities
		<ul style="list-style-type: none"> To coordinate with various agencies associated with TMICC To share data and updates
Traffic	<ul style="list-style-type: none"> Traffic Police 	<ul style="list-style-type: none"> To set up TMICC with other core stakeholders: UMTA & Municipal Corporation To depute its personnel at TMICC to monitor and manage traffic Managing and optimising signal cycle Monitoring surveillance cameras Taking lead role in managing traffic incidents including coordinating with other internal and external stakeholders such as Fire, Police, Ambulance etc. Traffic enforcement Traffic related information dissemination to public, media and other internal and external stakeholders Managing the contracts and relationships with the contractors responsible for installation, maintenance and upkeep of the traffic related ITS equipment deployed by the Traffic Police Impact on traffic flow and fuel saving based on data analysis To share data and updates
	<ul style="list-style-type: none"> Municipal Corporation (traffic signal team) Other agencies managing traffic signals 	<ul style="list-style-type: none"> To set up TMICC with other core stakeholders: UMTA & Traffic Police To depute its personnel at TMICC Signals and other traffic equipment installation and maintenance Managing the contracts and relationships with the contractors responsible for installation, maintenance and upkeep of the signalling system, and other traffic related ITS equipment deployed by the agency

Area	Agencies	Role and Responsibilities
	<ul style="list-style-type: none"> • Municipal Corporations (roads team) • State PWD • Central PWD • National Highways Authority of India (NHAI) • State Road Development Corporations • Cantonment Board • Development Authorities • Other Road owning agencies 	<ul style="list-style-type: none"> • To share data and updates • Road construction and maintenance • Managing the contracts and relationships with the contractors responsible for construction & maintenance of road network • Junction design based on data analysis • To share data and updates
Transit	<ul style="list-style-type: none"> • Transit Operators 	<ul style="list-style-type: none"> • To manage and monitor transit operation • To provide agreed data / information in desired form and frequency
Parking	<ul style="list-style-type: none"> • Municipal Corporations • Other Parking facility management entities 	<ul style="list-style-type: none"> • Manage the parking facility • To provide agreed data / information in desired form and frequency
Bus Terminus	<ul style="list-style-type: none"> • Department of Transport • State Transport Undertakings • Other entities managing such facilities 	<ul style="list-style-type: none"> • Manage the parking facility • To provide agreed data / information in desired form and frequency
Emergency Response	<ul style="list-style-type: none"> • Fire • Police 	<ul style="list-style-type: none"> • To provide agreed data / information in desired form and frequency
Weather	<ul style="list-style-type: none"> • Regional Meteorological Centre 	<ul style="list-style-type: none"> • To provide agreed data / information in desired form and frequency
Pollution	<ul style="list-style-type: none"> • Pollution control board 	<ul style="list-style-type: none"> • To provide agreed data / information in desired form and frequency

Area	Agencies	Role and Responsibilities
		<ul style="list-style-type: none"> Estimating fuel saving based on data analysis
Tourism	<ul style="list-style-type: none"> Tourism department or Tourism development corporation 	<ul style="list-style-type: none"> To provide agreed data / information in desired form and frequency
Media	<ul style="list-style-type: none"> Newspapers FM Radio Channels TV Channels 	<ul style="list-style-type: none"> Disseminating traffic related information and advisories to general public based on feeds from TMICC Providing inputs on any unscheduled road blockage, accidents, incidents noticed by media personnel to TMICC

9.7 TMICC Organisation

As with any operating entity, organisational structure of the TMICC directly impacts its ability to operate effectively, and should be recognised and developed explicitly in the Concept of Operations report, including any multi-agency provisions. In particular, in TMICCs where the level of automation is relatively low, and where accountability dictates that decisions are based on judgements of highly experienced professionals and supervisors, the levels and accessibility of management are an important component of the Concept of Operations.

Figure 9-1 shows a typical TMICC operations management structure.

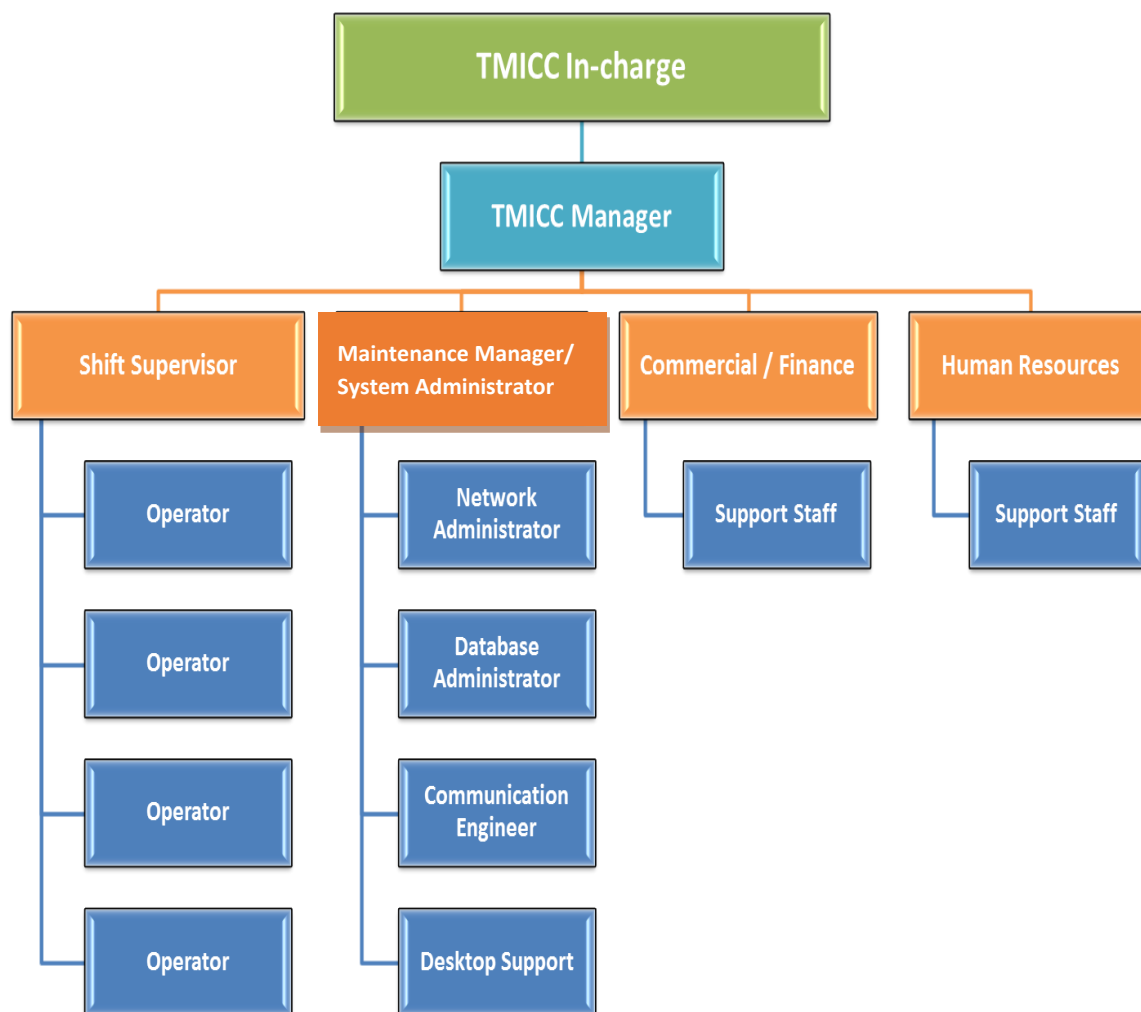


Figure 9-1: Typical TMICC Organisational Structure

The general structure of a TMICC can be described as follows:

- **Decision-Making Authority:** The level of decision-making authority for the TMICC operations is driven by the agency policies. These are typically approved by the competent authorities and defined in the Standard Operating Procedures (SOP).
- **Supervision:** The number of levels of supervision and the reporting relationships can strongly influence both the quality of TMICC activity and its ability to respond rapidly to changing conditions. Typically, there is a single supervisor responsible for control room operations to whom the operators report directly.
- **Staffing:** The number of staff required is one of the most important elements of the TMICC operations. This must reflect all elements of the workload, including how the team is organised and deployed. There are no absolutes regarding the number of personnel per number of signalised junctions, or centreline kilometre of roadway. The

primary determining factor is the set of functions which the staff are employed to deliver. In roadway and highway management, for example, the responsibilities may include only incident management (detection, verification, action, monitoring, closure), or may also include various traveller information functions, interaction with a motorist assistance patrol, control of planned lane closures, and other functions (such as some forms of enforcement) which are not directly related to highway management. Since the TMICC is a 24x7 operations centre, the staffing would vary across peak and off-peak hours. In the off-peak hours (especially night shift), the staffing could be reduced substantially since the traffic intensity would be low. While it would be impractical to have prescriptive ratio of personnel in peak-to-off peak, in order to enable such reduction in manpower, the control room application should be flexible to allow for varying the elements being monitored by each operator console.

Table 9-7 provides the details of key positions in a typical TMICC organisation together with associated role description. The actual position and role description may vary for a TMICC depending on its size and the nature of activities being discharged by the TMICC.

Table 9-7: TMICC: Typical Positions and Role Description

Positions		Role Description
TMICC In-charge	In-	<ul style="list-style-type: none"> Responsible for overall management, monitoring and operation of the TMICC Should ideally be a Traffic Engineer with an additional degree in Management Formulation of procedures governing TMICC operations Point of contact for authorities, media and other external agencies
TMICC Manager		<ul style="list-style-type: none"> Reports to TMICC In-charge Should be a Traffic Engineer Responsible for day to day operation of the TMICC Responsible for assigning and deployment of the operators in shifts Coordinates with field and data centre team Provide support and inputs during procurement of TMICC equipment, their location and specifications of VMS, CCTV equipment Creation and updating of signal plans Preparing route diversion plans Plans for the scheduled maintenance of the field and back office system components in coordination with suppliers, shift supervisor and the system administrator Monitoring and analysing the traffic volume and conditions Training and guidance of Shift Supervisors

Positions	Role Description
Shift Supervisor	<ul style="list-style-type: none"> • Reports to TMICC Manager • Should be a Traffic Engineer • Responsible for day to day operation of the TMICC during a shift • Responsible for supervision of the operators deployed in a shift • Coordinates with field and data centre team • Creation and updating of signal plans • Preparing route diversion plans • Plans for the scheduled maintenance of the field and back office system components in coordination with suppliers, shift supervisor and the system administrator • Monitoring and analysing the traffic volume and conditions • Training of operators
Operator	<ul style="list-style-type: none"> • Reports to Shift Supervisor • Operates and manages the system through operator console • Configures and controls field devices • Reports any downtime in field devices and backend system. Separate operators would need to be deployed for monitoring and managing different ITS sub-systems. Therefore, separate operator teams would be deployed for the following: <ul style="list-style-type: none"> ○ Signalling system ○ CCTV surveillance system ○ VMSs ○ Coordination for incident management • Coordinates with other agencies which are part of workflow being managed by the operator • Shares information and reports events with agencies/entities concerned in accordance with the policies and procedures • Data analytics
System Administrator (also responsible for routine maintenance of the backend systems)	<ul style="list-style-type: none"> • Reports to TMICC Manager • Responsible to manage the data centre and associated IT environment such as network, communication, security, firewall, desktop support etc. • To monitor and supervise the team comprising network administrator, database administrator, desktop support personnel, communication engineer etc. • Responsible to configure the computing and other IT systems • To implement policy giving role based access to various personnel to the IT systems • To manage and monitor security of the IT systems

Positions	Role Description
	<ul style="list-style-type: none"> Coordinates with vendors and suppliers for maintenance and support of the hardware and software deployed in TMICC
Commercial / Finance Manager	<ul style="list-style-type: none"> Contract management Invoicing and payments
Human Resources Manager	<ul style="list-style-type: none"> Recruitment Training General administration and facilities maintenance

9.8 Training and Capacity Building

There would be a need for extensive training initially in the areas of planning and designing of the TMICC and later progressively in the area of operating and managing such facilities. As technologies evolve, these may also drive the need for imparting training to the personnel working on TMICC and related initiatives.

While some of the consultants that have been empanelled by MoUD, GoI, as part of this assignment have received some exposure to the TMICC concepts and would, in turn, disseminate the learning as part of their advisory engagements with the cities, the need for such training would be there on an ongoing basis.

The personnel to be trained and the topics to be covered during training would be as set out in Table 9-8:

Table 9-8: Coverage of Training

Positions	Coverage of Training
City Managers	<ul style="list-style-type: none"> Background of TMICC and purpose of the system
TMICC In-charge	<ul style="list-style-type: none"> Background of TMICC and purpose of the system Operational procedures Non-standard operations (special events, emergency conditions) Use of the TMICC Backend Applications Capabilities of the field equipment Contract management Financial management
TMICC Manager	<ul style="list-style-type: none"> Background of TMICC and purpose of the system Operational procedures Non-standard operations (special events, emergency conditions) Use of the TMICC Backend Applications

Positions	Coverage of Training
	<ul style="list-style-type: none"> Capabilities of the field equipment Equipment maintenance, testing, debugging, and repair Contract management
Shift Supervisor	<ul style="list-style-type: none"> Background of TMICC and purpose of the system Operational procedures Non-standard operations (special events, emergency conditions) Use of the TMICC Backend Applications Traffic control and management. Traffic flow analysis
Operator	<ul style="list-style-type: none"> Background of TMICC and purpose of the system Operational procedures for the application designated to the operator Non-standard operations (special events, emergency conditions) for the application designated to the operator Use of the TMICC Backend Application designated to the operator Field equipment installation and functioning Traffic Control and Management. Traffic flow analysis Data analytics
System Administrator	<ul style="list-style-type: none"> System management training by OEM supplier Technical SLA Management

Training can be categorised as either initial training or on-going training as detailed below.

A. Initial Training: The initial training should be carried out for at least one-week, or any other suitable duration depending on the TMICC function, and should be repeated semi-annually during the first two years of the TMICC operations. New hires are given tours of the project area to gain familiarity with the road network and device locations during the "new hire" training period.

Since training and documentation are critical for operations, it is important to create user-friendly documentation that is consistent and complete, which will improve the quality of operator performance, and will enhance training of personnel. While undertaking procurement of system and field equipment, agencies should specify the training requirements as part of scope of the supplier in the respective procurement documents.

B. On-Going Training: The agency should plan for on-going training on an annual basis, after the two-year initial period. Few systems are implemented completely in a single programme. Instead, most systems both grow and evolve, reflecting the success of

their operation, the lessons learned during system stabilisation, and the changes in technology that become available overtime. Thus, training materials will require periodic updates. An element of the organisation should be identified who will be tasked with this upkeep as a primary level duty.

The Ministry of Urban Development (MoUD) can be a facilitator for on-going TMICC training in India. These can be accomplished by retaining a combination of international and Indian university experts to provide on-going and periodic training to the governmental agencies in India, including relevant topics on best practices and new technologies. Typical topics for training can include, but not be limited to, the following major areas:

- Development and updates of Concept of Operations
- Traffic control and management.
- Junction design and traffic flow analysis
- Applying Systems Engineering Principals
- Incident and Emergency Management Procedures
- Hardware and Software Maintenance
- Document Maintenance
- Organisational Management
- Data Archival Systems
- ITS Architecture Maintenance and Update
- ITS Standards and Protocols

9.9 Operating Agreements

The agreements and MoUs entered into between the agencies set the stage and context within the confines of which detailed operating agreements need to be evolved that provide for the specifics of cooperation.

The operating agreements would cover in detail the information and data that need to be exchanged, the manner and frequency in which the same would be exchanged, the format, protocol and other technical details relating to such exchange. It would also deal with the requirement for personnel to be deployed by the agency at the TMICC and the role of such personnel. Financial aspects of cooperation are typically detailed in the agreement, including on-going operations, management and maintenance of system and functionalities. Other issues, such as performance measurements, enhancements, growth, and replacement and retiring of system, i.e. the entire life-cycle of the programme needs to be stipulated in the agreements. legal issues, liabilities and indemnification for each party may also need to be suitably addressed in the agreements based on agency policies.

9.10 Agreements, Contracts, and Memoranda of Understanding

Many of the arrangements and cooperation envisaged in the TMICC may not be mandated by law or the charter of the participating agencies involved. In view of this and in order to reach a long term understanding on the nature, extent and specifics of cooperation, it is recommended that the agencies enter into suitable agreement or Memorandum of Understanding (MoU) that would not just capture these but also result in deepening the commitment of the agencies involved and lead to stable and long term relationship in the context of TMICC. Typically, the MoU can be an initial step in establishing relationships among agencies to define the overall goals and objectives of association. Once an association and goals of the cooperation has been established, the agencies can move towards a contract or a binding agreement to formalise their association. Binding agreements would entail detailed roles and responsibilities, financing and other contractual nature of cooperation.

Many cities and States have taken up initiatives in setting up the Unified Metropolitan Transport Authority (UMTA) with the coordinating role, among others, during planning and implementation of urban transport initiatives of all modes in the cities. Since UMTA would have participation from all the key agencies/stakeholders from the transportation sector of the respective cities, it could also be used as forum for establishing the relationship and details relating to cooperation among various agencies.

The agreements and MoUs entered into would be high level cooperation documents that would outline the nature, extent and principles of co-operation. From these would flow the detailed operating agreements that would deal with various subsidiary matters in a more granular fashion. A sample of the MoU is provided as Annexure 4 at the end of the report.

The agreements and MoUs entered into may get reviewed periodically and changes, as required, may be carried out to reflect the emerging environment and evolving objectives of the TMICC.

9.11 Advisory Functions of Other Related Organisations

In order for a multiple agency system to operate, there may be a need for other adjunct parties to participate in the decision making and collaboration process. As most transit and traffic system operating agencies engage contractors and solution providers to deploy and maintain their ITS equipment, it would be useful to take their feedback and inputs at the TMICC planning stage itself so that the interfaces to such systems are suitably provided for in the TMICC, including on-going coordination needs.

10.0 PERFORMANCE MONITORING

10.1 Introduction

TMICCs need to be developed with clearly defined set of objectives. From the objectives various performance measures could be derived in order to assess the success of the TMICC over a period of time.

The performance measures and their target levels should be set keeping in mind the following:

- They should support and be consistent with the goals and objectives of the TMICC
- They should be easy to understand and be meaningful to the relevant stakeholders
- They should be easily and economically measurable
- They should be measured over an appropriate time frame
- The performance thresholds targeted should be realistic and achievable

10.2 Performance Measures

Performance measures could be classified broadly as an outcome, output or an input measure. While outcome based measures are mostly qualitative, the output and input based measures could be quantified.

Some of the outcome/ output based measures that could be used to monitor the performance of TMICC are as under:

- Efficiently manage the movement of people and goods on streets and highways
- Efficient utilisation of assets and resources
- Reduce congestion
- Reduce travel times
- Encourage public transport usage
- Enhancing compliance with traffic rules
- Reducing incident impact including response time
- Reducing number of accidents
- Improving coordination among various agencies
- Adoption of modern means and technologies
- Dissemination of Information: quality, coverage, reach, modes

- Reducing negative environmental impacts of traffic and travel
- Citizen satisfaction

Some of the input based measures that could be used to assess the performance of TMICC are as under:

- Number of junctions monitored by TMICC
- Number of junctions with adaptive signal control
- Coverage of roads under TMICC as proportion of total major roads in the area
- Coverage of transit agencies under TMICC as proportion of total number of transit agencies in the area
- Number of incidents handled by the TMICC
- Budget of the TMICC
- Number of Traffic Equipment connected to TMICC
- Number of agencies associated with TMICC
- Number of Messages displayed on Variable Message Signs
- Uptime, downtime, mean time between failure of the field equipment

10.3 Data for Performance Measurements

The data for capturing performance measures would come from the following sources:

- Data collected from field equipment/other systems by the TMICC system
- Data captured and logs created by the TMICC system
- Data collected from various agencies by TMICC
- TMICC budget documents
- User feedbacks
- Surveys carried out to receive feedbacks
- Other city planning documents

10.4 Presenting and Reporting Performance Data

The performance reports related to TMICC would largely be system generated. The system is typically designed to support generation of a variety of performance reports. Their presentation and formats are also generally finalised during the system design stage. The frequency of report generation could be configurable and the same could be decided by the user at the time of report generation.

The performance reports need to be displayed in the most appropriate manner based on the channel/device used to access the same. The information needs to be displayed in a manner that is easy to understand and could be in the form of tables, graphs, charts, maps, dash boards, line diagram etc.

In addition to the above, performance of the TMICC could also be captured by way of user feedback elicited through surveys.

The agencies must evaluate the performance reports on a periodic basis and plan improvements and corrections to the system to continuously enhance and maintain a proper system. A system that consistently provides wrong information or inaccurate data will soon be abandoned by the public and the investments will be lost as the public will lose trust and faith the system. Therefore, it is critical that the performance reports are reviewed periodically in order to ensure that the system continues to meet the user expectations.

11.0 SIZING, PHASING AND COST ESTIMATION

11.1 Factors Influencing TMICC Solution and Area Sizing

11.1.1 Factors Influencing TMICC Solution Sizing

Some of the important factors that would drive the TMICC solution sizing are detailed below:

- Number of signals connected to the TMICC.
- Number of CCTV cameras feeds being monitored from the TMICC.
- Number of operators and other staff in the TMICC.
- Number and type of external/internal interfaces to the TMICC system as data volume and number of transactions hitting the servers would be driven by these.
- Quantum of analytical work being carried out through the TMICC system.
- Data storage policy of the agency as to the period for which the data is to be stored.
- Transit management interface requirements.
- Design of TMICC related applications.

The above parameters would influence physical space requirements, storage capacity, processing power (number and types of servers), number of operators, number of operator consoles, size of video wall, leased line bandwidth required, power including its back up etc.

11.1.2 Factors Influencing TMICC Operations Centre Space Requirements

Space requirements for TMICC will depend on the functional design and requirements of the TMICC. Human factors and ergonomics also need to be considered in planning and design of a TMICC for a functional and comfortable working environment. This is typically developed through the Concept of Operations study to examine the needs of the agencies, the number of agencies that will be working in the TMICC, the functional requirements of the TMICC, and the number of personnel working in the TMICC. Considering the activities proposed to be undertaken by the TMICCs, instead of combining it with any of the existing traffic control room in the cities, it may be helpful to create a new and modern facility that could house the TMICC.

Typically, the TMICC space requirements can be categorised into the following functional areas:

- Main floor area, including the operations consoles.
- Management offices.
- Conference room and assembly areas.
- Data Centre.
- Equipment area, including HVAC, fire suppression and other equipment
- Storage area.
- Cafeteria, eating areas and/or vending machines.
- Backup power generation area.
- Vehicle parking areas or maintenance area.
- Locker room, showers, sleeping areas and emergency management operations.

Some of the design considerations for a TMICC would include the following:

Size: TMICC should be designed to meet the requirements of the agency and the number of staff that will be stationed in the centre. Based on a study conducted in 1999 of major Transportation Management Centres in US, the average space allowance for the control room is approximately 24 square meters per operator. The median (50%) is approximately 19 sq. m. per operator for the main control room area. These do not include general areas, amenities, or other facilities.

Table 11-1: Examples of TMICC Sizing

Function	Boston	Toronto	Long Island	Detroit	Milwaukee	Atlanta	Phoenix	Houston	AVG	MEDIAN
TMC Area	460	230	280	1300	600	6830	1670	5020		
Coverage (KM)	12	100	265	290	965	355	410	200		
Control Room (SQ M)	220	170	58	335	55	120	220	335		
No of Operators	10	9	5	6	3	12	6	18		
Total Staff	10	12	12	9	5	18	8	19		
Area per Operator (SQ M) (Control Area)	22	19	12	56	18	10	37	19	24	19
Area per Total Staff (SQ M) (Total Area)	46	19	23	144	120	379	209	264	151	132
Coverage Per Operator (KM)	1.2	11.1	53.0	48.3	321.7	29.6	68.3	11.1	68	39

Source: Transportation Management Center Concept of Operations Implementation Guide, 1999

Connectivity: Physical connections (i.e. wiring, cabling) between the operator console(s) and equipment room is typically done under the floor. This can be accomplished in a few ways; one method is conduits under the floor between the consoles and equipment room. This method requires conduits to each console group. The second method is a raised floor, which is more flexible. The equipment room needs to have communication

entrances. These can be shared with the building resources or stand-alone entrances. The communication media, including agency owned fibre, twisted pair or coax should have a separate conduit out of the building. Radio communications may involve a conduit or path to the antenna on the roof.

Observation/Visitor Area: TMICC design needs to account for visitors and senior staff. The observation/visitor area can also be used by the executive staff for emergency events and conditions management. Typical TMICC will get groups of visitors at a time as well as individual visitors on a regular basis. These visitors vary greatly and there may be other agencies, and executives who need to be in a centre during disaster or emergency conditions. TMICC should accommodate these groups. A viewing area outside the TMICC can be provided to see the operation in action without disturbing the operators. The visitor's area outside of the TMICC can be combined with a conference room with windows into the control room. The observation area should include audio visual systems and presentation boards.



Figure 11-1: Florida and Idaho Department of Transportation TMICC Layouts

Flooring: Raised flooring gives the most flexibility for the future by providing a large raceway for any cabling. Some sensitive cabling may be run through inner duct under this floor to provide additional protection. The raised floor method requires additional work, if utilising open equipment racks which will require bolting to the floor. The display systems cannot be placed on the raised flooring and should have the stability of being mounted directly on the sub-flooring. One disadvantage of the raised floor is that there is an elevation difference from the remainder of the floor in the building. There can be a step up into the

TMICC or the slab floor can be depressed (new construction) to achieve a uniform elevation. This will eliminate mitigation involving the stepping up onto the raised flooring. This applies to both the TMICC and the equipment room. The equipment room is typically a tiled surface. TMICC is typically a carpeted surface, with anti-static carpets.

Ceiling: TMICC ceilings are typically higher than the normal ceilings due to the equipment in the TMICC. The display systems can dictate the height of the ceiling in both the TMICC and the equipment rooms.

Lighting: TMICC lighting within the control room should consider the general lighting effects on the display system(s), as well as task lighting for operators. For general lighting, indirect and dimmable is the most common type which is preferred. The control for dimming this lighting should be placed in reach of an operator station. Secondary controls (usually only on/off) should be placed at the room entrances. Task lighting should be dimmable and direct to the task area with consideration to potential glare on the display system and monitors. If the TMICC is equipped with overhead cabinets then under cabinet task lighting should be considered. For the equipment room, standard fluorescent/LED lighting will be sufficient. The placement should account for the equipment racks, which typically are seven feet high, as it can create shadowing. The work surface in the equipment room typically will need some supplemental lighting. The lighting can be one of the most creative and dramatic effects within the TMICC and should be given proper consideration.

Sound-proofing: TMICC control room should have sound damping materials on the floor and walls. The control room will have a great deal of communications occurring at any point in time. These will include operator to operator, radio dispatching, telephonic, and in coming media sources. Soundproofing in the walls of equipment room can help to eliminate equipment noise into the TMICC.

Storage Space: Storage space is needed both in the TMICC and in the equipment room. Equipment room storage requirements include storage for spare parts and test equipment. TMICC storage shall include enough space for any needed operational manuals, operating supplies (paper, toner, etc.), reference books, files on field equipment configuration settings and maintenance records.

Sound System: TMICC should be equipped with a quality sound system. The sound system should be controlled from an operator station. The sound system should be able to deliver sound to a visitor area located outside of the control room. This sound system would be separate from the radio systems used by the operators. The radio systems used by the operator should utilise headsets as not to interfere with the other operators.

Security System and Access Control: TMICC should have adequate security in place. Access to the main floor area, equipment room and data centre should be through an access control system. If there are a windows into the TMICC, blinds should be considered. The security system should provide an operator the ability to grant access without leaving their workstation.

Power Consideration: Since TMICCs are 24x7 operations centres, the power supply to the TMICC needs to be robust with multiple failover systems. Ideally, the TMICC should have grid supply from two independent sub-stations with an automatic switch-over generator back-up. The data-centre, operator consoles and critical lighting and ventilation should have a further UPS backup of at least 1 hour.

TMICC Backup Systems: Consideration should be given to set up a Backup TMICC, in case of critical failure of one facility. The Backup TMICC will have similar set-up, but smaller in size, to allow emergency use in case the main TMICC is out of function due to natural disasters or terrorist actions. More critical is the backup data centres to allow continuous back up of data and critical software. These systems would mirror the main systems and will be available for immediate function, in case of the main system failure. A cloud-based backup system can also be used.

Media Area or Information Service Provider (ISP) Area: Consideration should be given to a media station or room, so that the media can have access to the relevant information. Typically, a representative of media can work with the TMICC management to disseminate information that is useful and relevant to the public. An ISP is typically a private information service provider that provides relevant information to the public about transport conditions. Usually, ISPs have access to the transport agency data and ISPs typically provide value-added information that is useful to the public. Both ISPs and media will function in the TMICC based on written agreements as to the conduct and the type of information they can disseminate to the public.

11.2 Project Phasing

It may not be necessary or desirable to set up TMICC for the entire urban agglomeration or with full functionality from the beginning. TMICC could be implemented in a phased manner with time period for phasing varying based on the scope of project. An example of the project phasing for TMICC is provided below (Table 11-2):

Table 11-2: TMICC Indicative Project Phasing

Parameter	Phase-1 (3-5 years)	Phase-2 (4-8 years)	Phase-3 (6-10 years)
TMICC Area of Coverage	<ul style="list-style-type: none"> City Municipal Corporation area – arterial roads 	<ul style="list-style-type: none"> City Municipal Corporation area sub-arterial roads plus arterial roads of nearby municipalities in the city development authority area 	<ul style="list-style-type: none"> City Development Authority area / urban agglomeration

Parameter	Phase-1 (3-5 years)	Phase-2 (4-8 years)	Phase-3 (6-10 years)
Focus Areas	<ul style="list-style-type: none"> • Traffic Enforcement • Signal control • Traffic surveillance • Basic traffic information dissemination 	<ul style="list-style-type: none"> • Traffic Enforcement • Signal control • Traffic surveillance • Traffic information dissemination 	<ul style="list-style-type: none"> • Traffic Enforcement • Signal control • Traffic surveillance • Traffic information dissemination
Traffic Equipment	<ul style="list-style-type: none"> • Signals • VMSs • CCTV cameras 	<ul style="list-style-type: none"> • Signals • VMSs • CCTV cameras 	<ul style="list-style-type: none"> • Signals • VMSs • CCTV Camera
Traffic Information Dissemination	<ul style="list-style-type: none"> • Road diversions / closures • Accidents / Incidents • Advisories and alerts • Construction/ maintenance • Weather Information 	<ul style="list-style-type: none"> • Road diversions / closures • Accidents / Incidents • Advisories and alerts • Parking Information • Weather Information • Construction/ maintenance • Speed/Congestion Information • CCTV footage 	<ul style="list-style-type: none"> • Road diversions / closures • Accidents / Incidents • Advisories and alerts • Parking Information • Weather Information • Construction/ maintenance • Speed/Congestion Information • CCTV footage
Information Dissemination Modes	<ul style="list-style-type: none"> • Website • Phone helpline • Mobile App • Social Media • VMS along roadways 	<ul style="list-style-type: none"> • Website • Phone helpline • Mobile App • Social Media • VMS along roadways 	<ul style="list-style-type: none"> • Website • Phone helpline • Mobile App • Social Media • VMS along roadways

11.3 Indicative Cost of TMICC Implementation and O&M

Apart from the implementation cost, TMICCs also have on-going Operations and Maintenance (O&M) costs, which need to be budgeted for. In the absence of budgetary provisions for O&M, maintenance of equipment (both, field side and in the centre) may be compromised leading to sub-optimal performance of the overall system, and, in some cases, complete failure of the system. Therefore, in order to ensure long term sustainability of the TMICC, it is extremely critical that traffic management be treated at par with other

essential services (like water supply, power supply etc.) and adequate funds are allocated for its O&M.

Indicative costs for implementing, operating and maintaining TMICCs of various sizes is provided in Table 11-3. Case-1 pertains to small size city (population < 1 million), Case-2 for a medium size city (population 1-5 million) and Case-3 for a large city (population > 5 million).

The quantity and costs indicated in Table 11-3 are for illustration purposes only. Actual costs may vary depending on project scope and infrastructure needs. The cost of red-light violation detections /ANPR systems have not been considered. The indicative implementation cost of each of these systems will be about Rs.9 Million (per junction with four arms) and O&M cost will be about Rs. 3 Million (per junction per annum)

Table 11-3: TMICC Basic Implementation and O&M - Indicative Cost

				Case 1		Case 2		Case 3	
S.No.	Items	Unit Rate (Rs.)	UOM	Qty.	Amount (Rs.)	Qty.	Amount (Rs.)	Qty.	Amount (Rs.)
A.	Implementation Cost								
1	Signalised Junctions Upgrade	6,00,000	per Jn.	60	3,60,00,000	200	12,00,00,000	600	36,00,00,000
2	VMSs	18,00,000	per unit	6	1,08,00,000	15	2,70,00,000	50	9,00,00,000
3	Surveillance Cameras at junctions and midblock locations	3,00,000	per unit	120	3,60,00,000	400	12,00,00,000	1,200	36,00,00,000
4	Vehicle Detections Cameras	1,50,000	per unit	240	3,60,00,000	800	12,00,00,000	2,400	36,00,00,000
5	Data Centre Civil Works	1,00,000	per sq. m.	150	1,50,00,000	400	4,00,00,000	1,000	10,00,00,000
6	Video wall	75,00,000	per unit	2	1,50,00,000	4	3,00,00,000	6	4,50,00,000
7	Operator consoles	80,000	per unit	8	6,40,000	12	9,60,000	24	19,20,000
8	Systems for TMICC staffs	70,000	per unit	14	9,80,000	14	9,80,000	14	9,80,000
9	Servers	4,00,000	per unit	4	16,00,000	10	40,00,000	18	72,00,000
10	TMICC Software Applications (including development of interfaces)		L.S.	1	5,00,00,000	1	10,00,00,000	1	15,00,00,000
	Sub Total - A				20,20,20,000		56,29,40,000		1,47,51,00,000
B.	Systems Engineering and Programme Management Cost								
1	Systems Engineering & Design	10%	of A		2,02,02,000		5,62,94,000		14,75,10,000

S.No.	Items	Unit Rate (Rs.)	UOM	Case 1		Case 2		Case 3	
				Qty.	Amount (Rs.)	Qty.	Amount (Rs.)	Qty.	Amount (Rs.)
2	Programme/ Construction Management, System Integration	15%	of A		3,03,03,000		8,44,41,000		22,12,65,000
3	Training and Capacity Building	1.25%	of A		25,25,250		70,36,750		1,84,38,750
	Sub Total - B				5,30,30,250		14,77,71,750		38,72,13,750
	Grand Total (A+B)				25,50,50,250		71,07,11,750		1,86,23,13,750
C.	Operations & Maintenance Cost								
1	Operation Cost	15%	of A						
1(a)	Manpower Cost	refer staffing cost in Section 11.3.1			1,94,40,000		2,30,40,000		2,84,40,000
1(b)	Other Operations Cost		residual of 15%		1,08,63,000		6,14,01,000		19,28,25,000
2	Lease line for control room			1	11,00,000	1	11,00,000	1	20,00,000
3	2mbps annual leased line cost	1,50,000	per junction	120	1,80,00,000	400	6,00,00,000	1,200	18,00,00,000
4	Maintenance Cost (per annum)	10%	of A		2,02,02,000		5,62,94,000		14,75,10,000
	Total O&M Cost				6,96,05,000		20,18,35,000		55,07,75,000

11.3.1 Staffing Cost

Indicative staffing cost for TMICC is provided in Table 11-4.

Table 11-4: Staffing Cost

S.No.	Position	Shifts		Case 1		Case 2		Case 3	
1	TMICC In charge	1	85,000	1	10,20,000	1	10,20,000	1	10,20,000
2	TMICC/Traffic Manager	3	70,000	1	25,20,000	1	25,20,000	1	25,20,000
3	Maintenance Engineer/System Administrator	2	50,000	1	12,00,000	1	12,00,000	1	12,00,000
4	Network Administrator/Communication Engineer	2	50,000	1	12,00,000	1	12,00,000	1	12,00,000
5	Database Administrator	2	40,000	1	9,60,000	1	9,60,000	1	9,60,000
6	Desktop Support	2	30,000	1	7,20,000	1	7,20,000	1	7,20,000
7	Commercial	1	50,000	3	18,00,000	3	18,00,000	3	18,00,000
8	HR	1	50,000	2	12,00,000	2	12,00,000	2	12,00,000
9	Shift Supervisor	3	45,000	1	16,20,000	1	16,20,000	1	16,20,000
10	TMICC Operator	3	25,000	8	72,00,000	12	1,08,00,000	18	1,62,00,000
	Total Cost				1,94,40,000		2,30,40,000		2,84,40,000

11.4 Funding and Revenue

11.4.1 Funding of TMICC

TMICC projects are platforms where various government agencies discharging their statutory / mandated functions come together and collaborate in order to efficiently and effectively perform their activities. It does lead to generation of information which is disseminated to public. However, considering the worldwide experience, it is not expected that users of the TMICC related services would be inclined to pay for the same. In view of this, TMICC projects would need to be funded by the government agencies.

Funding for setting up of the TMICC may be shared by the Central Government and the respective State Governments. In case of Union Territories, Central Government may fund the entire project implementation cost. Table 11-5 lists some of the options for meeting the funding requirements of the TMICC.

Table 11-5: Funding Options for TMICCs

Project Element	Central Govt.	State Govt./ UTF	State Transit Agencies/ Urban Local Bodies / City UTF
Funding for Setting Up			
Option 1	✓	✓	✓
Option 2	✓	✓	
Option 3	✓		
Funding for O&M			
Option 1	✓	✓	✓
Option 2		✓	✓
Option 3			✓

Central Government may use any of its programmes for supporting such initiatives. Funding for setting up of the TMICC may also be secured with the support of the State Government under the centre's on-going or future schemes. Central Government has recently launched the Smart Cities Mission⁶/ Atal Mission for Rejuvenation and Urban Transformation (AMRUT)⁷ and the cities may avail funding from one or both these schemes.

Multilateral or bilateral funding may also be secured at Central Government, State Government or City levels. Since these projects support environment management as well,

⁶ Smart Cities- Mission Statement & Guidelines, Ministry of Urban Development, Government of India (June 2015)

⁷ Atal Mission for Rejuvenation and Urban Transformation (AMRUT) - Mission Statement & Guidelines, Ministry of Urban Development, Government of India (June 2015)

national and international programmes providing funding support for undertaking environment related measures may also be accessed based on the requirements of such programmes.

Funding for Operations & Maintenance (O&M) activities are critical as these projects require operational systems and functional teams to manage the O&M activities. The O&M cost of TMICC may be shared by the respective State Government (Traffic Police are part of State setup except in Union Territories including Delhi) and the Urban Local Bodies / City Urban Transport Fund (UTF). Central government may also support the O&M of such initiatives on a need basis.

11.4.2 Revenue Streams

As mentioned earlier, TMICC projects may not be able to generate any significant revenue by charging users. Worldwide also such services are provided by government entities free of cost to the users with users having to bear the cost of data plans for accessing the system or making calls to the transport helpline numbers providing information generated by the TMICCs. It is recommended that a similar model may be adopted in India with users bearing the cost of data plans for accessing the system or making calls while the services are provided to users without any charges. In the USA for example, the data being collected is shared with various entities (including the private sector) currently without any charges, even though an option to charge for the data has been retained by the government entities. The idea behind this approach is that wider dissemination of information would support public good.

Some of the revenue streams that could be assigned to TMICC or explored from TMICC related activities to defray part of the O&M costs are as under:

- Fines collected by the Traffic Police through the enforcement measures.
- Parking charges collected from users.
- Receipts from private entities for sharing data.
- Receipts from media for sharing data.
- Receipts from users for providing personalised information sent through mailers, Short Message Service (SMS), mobile apps or providing personalised access to certain information.
- Receipts from advertisers against grant of right to display advertisements on website
- Receipts from advertisers against grant of right to display advertisements on mobile apps.
- Receipts from advertisers against grant of right to undertake advertisements on helpline.
- Receipts from sponsorship by corporates in lieu of exclusive right to co-brand.
- Receipts from mobile apps downloads.
- Receipts from subscription services offered on mobile apps.

One of the pre-requisites to the possibility of realisation of revenue from data is the utility, popularity and marketability of the data. Similarly, number of users accessing any particular channel (website, mobile app, helpline) would determine its appeal to advertisers. Content quality, brand perception and popularity of service would, therefore, be the key determinants of revenue realisation potential from data marketing/ information dissemination activities.

It may be noted that the quantum of funding available from the fines collected by through enforcement measures may go down progressively as the compliance to the traffic rules improves which, in any case, is the end objective of implementing the enforcement measures.

It may also be noted that there may be an overlap between the revenue streams identified for TMICC as above and the revenue streams identified for NUTH in the NUTH Operations Document. The common revenue streams should, therefore, need to be accounted for in any one system but not in both.

11.5 Implementation Structure

11.5.1 Overview of Implementation Models

The typical implementation models that may be examined for establishing and operating the TMICCs are listed in Table 11-6.

Table 11-6: Implementation Structure Options

Implementation Options	Investment	O&M Cost
Option 1	Public	Public
Option 2	Public	Private
Option 3	Private	Private

Revenue potential of the project is a key determinant in choosing an implementation structure for the project. In case the project is not expected to generate adequate revenue from user fees, the implementing agency would need to bear the cost of providing services and investments. Considering the limited revenue potential from such projects, it is recommended that such projects are taken up in the government/public authority domain (Option 1). Within this broader framework, Public-Private Partnership (PPP) models could be explored as outlined in Section 11.5.2.

The private sector players could be engaged by government agency /public authority for design, supply, installation, testing, commissioning, maintaining and operating such facilities.

In view of the role currently being performed by Traffic Police and Municipal Corporations by virtue of the existing legal framework in traffic management activities, these entities

would be central to setting up and managing the TMICCs. Additionally, given the proposed structure of Unified Metropolitan Transport Authority (UMTA) and its constituent stakeholders, it should also be made part of the core TMICC stakeholders together with Traffic Police and Municipal Corporation, wherever it has been established. UMTA in such case would have to lead the effort in getting all the TMICC stakeholders on board, most of which in any case would be part of UMTA organisation.

11.5.2 PPP Options

Some of the commonly used Public-Private Partnership (PPP) models and the typical role of private partner and public entity are as set out in Table 11-7.

Table 11-7: Key PPP Models

PPP Model	Typical Role of Private Partner	Typical Role of Public Entity
Build Operate Transfer (BOT)/ (Design Build Finance Operate Transfer) DBFOT	<ul style="list-style-type: none"> Design, supply and implementation Investment in the project Operation, maintenance and management of the project Recovery against cost and investment through revenues realised by charging users against the services availed Project assets transferred to public entity at the end of contract period 	<ul style="list-style-type: none"> Grant right and authority to the private partner to implement the project, levy user charges, provide right of way Define the user charges Monitor the performance of the private partner
BOT Annuity	<ul style="list-style-type: none"> Design, supply and implementation Investment in the project Operation, maintenance and management of the project Recovery against cost and investment through periodical payments (monthly, quarterly or annual) from the public entity Project assets transferred to public entity at the end of contract period 	<ul style="list-style-type: none"> Grant right and authority to the private partner to implement the project, provide right of way Monitor the performance of the private partner Make periodical payments to the private partner
Supply and/or Service Contract	<ul style="list-style-type: none"> Could be one or more from among design, supply, build, operate, maintain and manage the project or any part thereof Recovery against the cost incurred through periodical (monthly, quarterly 	<ul style="list-style-type: none"> Investment in the project Monitor the performance of the private partner Make periodical and/or milestone linked payments to the private partner

PPP Model	Typical Role of Private Partner	Typical Role of Public Entity
	or annual) and/or milestone linked payments from the public entity	<ul style="list-style-type: none"> Project assets ownership is with public entity

While PPP models such as BOT/DBFOT/BOT-Annuity have their advantages in setting up large infrastructure facilities, these arrangements are complex to set up and cumbersome to administer and manage considering the large number of stakeholders involved such as concessionaire, financiers, public authority, public etc. BOT/DBFOT/BOT Annuity models may often turn out to be not the most appropriate models for TMICC implementations due to the following:

- There is relatively small revenue stream that can be generated from a traffic- focused TMICC to satisfy the concessionaire or financiers, except for a toll operations, parking operations or transit operations that can generate revenues to satisfy the financier's requirements.
- The nature of activities being discharged through TMICC is regulatory and highly sensitive in nature viz. surveillance, enforcement, signal operation etc.
- TMICC facilities are not in the nature of services being provided to public where-under they can be made to pay while they avail services.
- Administration of such arrangements is likely to be cumbersome in terms of the contract administration and management

In view of the above, the Supply and/or Service Contract could be the models of choice while undertaking TMICC implementations in India, as it is the case abroad, where such facilities have been set up.

12.0 RESOURCES AND REFERENCES

The following is a list of documents that have been used and referenced in the preparation of this document. These documents provide additional information to the readers if more in-depth information is needed for any specific topic.

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- US National ITS Architecture, USDOT, version 7.0, prepared by Iteris, Information from website: <http://www.iteris.com/itsarch/>
- Toolkit for Public Private Partnership in Urban Transport, Ministry of Urban Development, Government of India (July 2008)
- Transportation Management Center, Concepts of Operation, Implementation Guide, U.S. Department of Transportation (December 1999)
- U.S. Department of Transportation (US DOT) (<http://www.itslessons.its.dot.gov/>)

Annexure 1: List of Contractors

The list of contractors provided below for various types of equipment is an illustrative one and is not intended to be an exhaustive list. The reference to any contractors, vendor systems integrators, technology providers or suppliers in the table below does not constitute or imply their endorsement or recommendation by the consultants or MoUD or Government of India.

Equipment	Systems Integrators /Technology Providers
Fixed Time/Vehicle Actuated Traffic Signal Controller	<ul style="list-style-type: none"> Delhi Integrated Multi Modal Transit System Limited Kerala State Electronics Development Corporation Limited (KELTRON) Bharat Electronics Limited (BEL) CMS Traffic Systems Limited Schneider Electric India Private Limited Nucleonics Traffic Solutions Private Limited Traffitronics Onyx Components & Systems Electro Ads Envoys Electronics Private Limited.
Adaptive Traffic Signal Controller with Remote Command Control Centre	<ul style="list-style-type: none"> Delhi Integrated Multi Modal Transit System Limited Siemens Limited CMS in association with Peek Traffic Systems Kerala State Electronics Development Corporation Limited (KELTRON) Bharat Electronics Limited (BEL) Schneider Electric India Private Limited (TELVENT earlier)
CCTV Surveillance System	<ul style="list-style-type: none"> Delhi Integrated Multi Modal Transit System Limited Indigo Vision Limited Turbo Consultancy Services Private Limited Almighty Techserv Private Limited Polixel Security Systems Private Limited Tyco Fire & Security India Private Limited (Tyco) Himachal Futuristic Communications Limited (HFCL) Indra Sistemas India Private Limited Vayam Technologies Limited (VAYAMTECH) Videonetics Technology Private Limited

Equipment	Systems Integrators /Technology Providers
Video Wall (LCD/LED/Rear Projection)	<ul style="list-style-type: none"> • Samsung Electronics Private Limited • Barco Electronic Systems Private Limited • Delta India Electronics Private Limited • Panasonic India Private Limited
Handheld Device based Challaning System	<ul style="list-style-type: none"> • USoft Technologies (I) Pvt. Ltd • Analogics Tech India Ltd. • Linkwell Telesystems Pvt. Ltd. (VISIONTEK) • Delhi Integrated Multi Modal Transit System Limited (DIMTS) • Geodesic Limited • Bharti Airtel Limited
Red Light Violation Detection Camera System	<ul style="list-style-type: none"> • Delhi Integrated Multi Modal Transit System Limited • Indra Sistemas India Private Limited • ARS Traffic and Transport Technology India Private Limited • Turbo Consultancy Services Private Limited • Kritikal Solutions Pvt. Ltd • Redflex Traffic Systems Private Limited • Almighty Techserv Private Limited
Speed Violation Detection Camera System	<ul style="list-style-type: none"> • Delhi Integrated Multi Modal Transit System Limited • Indra Sistemas India Private Limited • ARS Traffic and Transport Technology India Private Limited • Turbo Consultancy Services Private Limited • Kritikal Solutions Pvt. Ltd • Redflex Traffic Systems Private Limited • Almighty Techserv Private Limited
Variable Message Signs	<ul style="list-style-type: none"> • ORTANA/Trafitek Solutions Private Limited • Swarco Traffic Limited • Delhi Integrated Multi Modal Transit System Limited • CMS Traffic Systems Limited • Envoys Electronics Private Limited MIC Electronics Limited (MICELE) • SA Traffic • Micromax Instruments Private Limited
Communication/Leased Line	<ul style="list-style-type: none"> • Tata Communications Limited • Reliance Communications Limited

Equipment	Systems Integrators /Technology Providers
	<ul style="list-style-type: none"> • Tulip Telecom Limited • Bharat Sanchar Nigam Limited (BSNL) • Mahanagar Telephone Nigam Limited (MTNL) • Bharti Airtel Limited (Airtel)
Control Room Server/Workstation & Other Computing Hardware	<ul style="list-style-type: none"> • Hewlett Packard India Sales Private Limited (HP) • Dell India Private Limited (Dell) • IBM India Private Limited (IBM)

Annexure 2: List of Boundaries

Annexure 2(A): Boundaries (Human Interface) Definitions

Title	Description ⁸
Archived Data Administrator	The operator who provides overall data management, administration, and monitoring duties for the ITS data archive.
Driver	Human entity that operates a vehicle on the roadway. Included are operators of private and transit, vehicles where the data being sent or received is not particular to the type of vehicle.
Maintenance and Construction Centre Personnel	The people that directly interface with the systems in the Maintenance and Construction Management sub-system. These personnel interact with fleet dispatch and management systems, road maintenance systems, incident management systems, work plan scheduling systems, and work zone management systems.
Maintenance and Construction Field Personnel	The people that perform maintenance and construction field activities including vehicle and equipment operators, field supervisory personnel, field crews, and work zone safety personnel.
Parking Operator	Human entity that may be physically present at the parking lot facility to monitor the operational status of the facility.
Pedestrians	Provides input (e.g. a request for right of way at an intersection) from a specialised form of the Traveller who is not using any type of vehicle (including bicycles) as a form of transport. Pedestrians may comprise those on foot and those in wheelchairs.
Traffic Operations Personnel	The human entity that directly interfaces with vehicle traffic operations. These personnel interact with traffic control systems, traffic surveillance systems, incident management systems, work zone management systems, and travel demand management systems to accomplish ITS services.
Transit Operations Personnel	The human entities are responsible for fleet management, maintenance operations, and scheduling activities of the transit system. These different roles represent a variety of individuals in the transit industry.
Transit Vehicle Operator	The human entity that receives and provides additional information that is specific to operating the ITS functions in all types of transit vehicles.
Traveller	Any individual who uses transportation services. The interfaces to the traveller provide general pre-trip and en-route information supporting trip planning, personal guidance, and requests for assistance in an emergency that are relevant to all transportation system users.

⁸ Source: Adapted from US National ITS Architecture.

Annexure 2(B): Boundaries (Environment Interface) Definitions

Title	Description ⁹
Environment	The natural surroundings in which the ITS operates. These surroundings include conditions such as snow, rain, fog, pollution, dust, temperature, humidity, solar radiation, and man-made electromagnetic (RF) effects
Obstacles	Any object that possesses the potential of being sensed and struck and thus also possesses physical attributes.
Roadway Environment	The physical condition and geometry of the road surface and the conditions surrounding the roadway. The geometry of the roadway and the road surface characteristics must be sensed and interpreted to support automated vehicle control services.
Secure Area Environment	The environment around any area that is monitored by surveillance or sensor equipment. These areas include public areas frequented by transit users or travellers as well as transportation facilities and infrastructure.
Traffic	The collective body of vehicles that travel on surface streets, arterials, highways, expressways, or any other vehicle travel surface. Traffic depicts the vehicle population from which traffic flow surveillance information is collected (average occupancy, average speed, total volume, average delay, etc.), and to which traffic control indicators are applied (intersection signals, stop signs, ramp meters, lane control barriers, variable speed limit indicators, etc).
Vehicle Characteristics	The external view of an individual vehicle. It includes vehicle characteristics such as height, width, length, weight, and other properties (e.g., magnetic properties, number of axles) that allow an individual vehicle to be detected and measured or classified.

⁹ Source: Adapted from US National ITS Architecture.

Annexure 2(C): Boundaries (Systems Interface) Definitions

Title	Description ¹⁰
Alerting and Advisory Systems	The alerting and advisory systems that provide alerts, advisories, and other potential threat information that is relevant to surface transportation systems. It provides intelligence about potential, imminent, or actual attacks on the transportation infrastructure or its supporting information systems, including all types of emergencies including natural hazards (floods, hurricanes, tornados, earthquakes), accidents (chemical spills, nuclear power plant emergencies) and other civil emergencies such as child abduction alerts that impact transportation system operation and/or require immediate public notification.
Archived Data User Systems	The systems users employ to access archived data.
Archives	Distributed archived data systems or centres whose data can be accessed and shared with a local archive. The interface between the Other Archives Terminator and the Archived Data Management Sub-system allows data from multiple archives to be accessed on demand or imported and consolidated into a single repository.
Asset Management	The systems that support decision-making for maintenance, upgrade, and operation of physical transportation assets. Asset management integrates and includes the pavement management systems, bridge management systems, and other systems that inventory and manage the infrastructure and other transportation-related assets.
Driver Identification Card	The portable entity (e.g., a smart card) that enables the transfer of electronic identification information about a driver. This may include license information, biometrics, and other data to identify the driver.
Emergency Telecommunications System	These systems transparently support priority wire-line and wireless caller access to the emergency information system.
Equipment Repair Facility	The facilities that configure, service, and repair vehicles and other support equipment used in roadway infrastructure construction and maintenance.
Event Promoters	Special Event Sponsors that have knowledge of events that may impact travel on roadways or other modal means. Examples of special event sponsors include sporting events, conventions, motorcades/parades, and public/political events.
Financial Institution	The organisation that handles all electronic fund transfer requests to enable the transfer of funds from the user of the service to the provider of the service.

¹⁰ Source: Adapted from US National ITS Architecture.

Title	Description ¹⁰
Government Reporting Systems	The system and associated personnel that prepare the inputs to support government transportation data reporting requirements (e.g. Performance Monitoring System, Fatality Analysis Reporting System) using data collected by ITS.
Information Service Providers (ISP)	Representing other distinct Information Service Providers, this terminus is intended to provide a source and destination for ITS data flows between peer information and service provider functions.
Location Data Source	Systems which use GPS, terrestrial trilateration, or driver inputs are all potential examples of Location Data Sources.
Maintenance and Construction Administrative Systems	Various administrative systems that support the operation of ITS for maintenance and construction operations.
Maintenance and Construction Vehicle	A specialised form of the Basic Vehicle used by maintenance fleets.
Maintenance and Construction Management Centre	Maintenance and Construction Management centre or sub-system, this terminus is intended to provide a source and destination for ITS information flows between maintenance and construction management functions.
Map Update Provider	A provider of map databases used to support ITS services. It supports the provision of the databases that are used by travellers (e.g., navigable maps used for route guidance and display maps used at traveller information points) as well as those that are used by system operators (e.g., map data used by Traffic Operators to monitor and manage the road network, map data used by Fleet Managers to manage a vehicle fleet).
Media	The information systems that provide traffic reports, travel conditions, and other transportation-related news services to the traveling public through radio, TV, and other media.
Motor Vehicle Department	A specific public organisation responsible for registering vehicles.
Multimodal Transportation Service Provider	The interface through which Transportation Service Providers can exchange data with ITS. They are the operators of non-roadway transportation systems (e.g. airlines, ferry services, passenger carrying heavy rail) and providers of non-motorised transportation facilities.
Other Data Sources	Represents the myriad systems and databases containing data not generated from sub-systems that can provide predefined data sets to the ITS archive. The terminator can provide economic, cost, demographic, land use, law enforcement, and other data that is not collected by ITS and would otherwise be unavailable within an ITS data archive.

Title	Description ¹⁰
Parking	Representing another parking facility, system or sub-system, this terminus provides a source and destination for information that may be exchanged between peer parking systems.
Police (Enforcement Agency)	The systems that receive reports of violations detected by various ITS facilities including individual vehicle emissions, toll violations, excessive speed, etc.
Rail Operations	Centralised control point for a substantial segment of a freight railroad's operations and maintenance activities. It is roughly the railroad equivalent to a highway Traffic Management Centre.
Railroad Crossings	The control equipment that interfaces to a non-road based transportation system at an interference crossing with the roadway.
Roadway	Representing another roadway system or sub-system, this terminus supports 'field device' to 'field device' communication and coordination, and provides a source and destination for information that may be exchanged between roadway sub-systems.
Storage Facility	Facilities that provide storage and forward staging for equipment and materials used in maintenance and construction operations. It provides status information on the types and quantities of materials and equipment that are available at the facility.
Surface Transportation Weather Service	Providers of value-added sector specific meteorological services. These providers utilise Weather Service data and predictions, road condition information and local environmental data provided by the traffic management or maintenance organisations, and their own models to provide surface transportation related weather observations and forecasts including pavement temperature and conditions.
Telecommunications System for Traveller Information	The caller interface and voice processing (voice recognition/ synthesis) that supports voice-enabled traveller telephone information systems. It provides wire-line and wireless caller access to NUTH systems.
Traffic Management Centre	Representing another Traffic Management centre, system or sub-system, this terminus is intended to provide a source and destination for ITS data flows between peer (e.g. inter-regional) traffic management functions.
Transit Management Centre	Representing another Transit Management centre, system or sub-system, this terminus is intended to provide a source and destination for ITS data flows between peer (e.g. inter-regional) transit management functions. It enables transit management activities to be coordinated across geographic boundaries or different jurisdictional areas.
Transit Vehicle	A specialised form of the Basic Vehicle that interfaces with and hosts ITS electronics. The Basic Transit Vehicle may be a bus, light rail vehicle, or other vehicle designed to carry passengers.

Title	Description ¹⁰
Travel Services Provider	Individual organisations that provide any service oriented towards the Traveller. Example services that could be included are petrol, food, lodging, vehicle repair, points of interest, and recreation areas. It also includes services specifically directed toward bicyclists and pedestrians such as bicycle shops and parking locations and bicycle and pedestrian rest areas.
Traveller Card	The entity that enables the actual transfer of electronic information from the user of a service (i.e. a traveller) to the provider of the service. This may include the transfer of funds through means of an electronic payment instrument. The device, like a smart card, may also hold and update the traveller's information such as personal profiles or trip histories.
Vehicle	The basic vehicle platform that interfaces with and hosts ITS electronics. It provides an interface to drive train, driver convenience and entertainment systems, and other non-ITS electronics on-board the vehicle. This interface allows general vehicle systems (e.g., the stereo speaker system) to be shared by ITS and non-ITS systems. It also allows monitoring and control of the vehicle platform for advanced vehicle control system applications.
Wayside Equipment	Train interface equipment (usually) maintained and operated by the railroad and (usually) physically located at or near a grade crossing.
Weather Service	Weather, hydrologic, and climate information and warnings of hazardous weather including thunderstorms, flooding, hurricanes, tornadoes, winter weather, tsunamis, and climate events.

Annexure 3: List of Potential ISO Standards

Standard No: Year of Adoption	Description ¹¹
ISO 10711:2012	<p>Defines protocols and message sets between traffic detectors and traffic signal controllers. It is applicable to the various types of traffic detector technologies currently in use for real-time traffic signal controls.</p> <p>It defines message sets that contain data collection and control protocol for three different types of detectors of traffic signal control systems:</p> <ul style="list-style-type: none"> • detectors that deal with occupancy information; • detectors that deal with image information; and • detectors that deal with vehicle identification. <p>ISO 10711:2012 is limited to parameter generation to be used for traffic signal controls and for the interface between traffic signal controllers and detectors.</p>
ISO 14813-5:2010	<p>Requirements for the description and documentation of the architecture of Intelligent Transport Systems (ITS) in standards dealing with ITS. It also gives the definitions of terms to be used when documenting or referencing aspects of architecture description in those standards</p>
ISO 14813-6:2009	<p>Provides a formal means to enact the ISO/TC 204 decision by resolution to use Abstract Syntax Notation One (ASN.1) for data definitions within ITS International Standards. This provides a common message form to enable interoperability and reuse. It provides consistency of use so that where other aspects of ASN.1 (defined within ISO/IEC 8824 and ISO/IEC 8825), such as transfer rules, are selected to be used, they are used in a common and consistent way in order to maximise interoperability and reuse.</p> <p>ISO 14813-6:2009 also provides a means where particular ITS sector requirements, or existent International Standards, that require particular message forms and procedures that are expressed in other notations (EDIFACT, XML, etc.), may be referenced and reused by other ITS applications. Thus it presents an unambiguous system for identifying all the different data types and describing them in ITS International Standards in a common way.</p>
ISO 14817:2002	<p>Specifies the framework, formats, and procedures used to define information exchanges within the Intelligent Transport System/Transport Information and Control Systems (ITS/TICS) sector. It defines the content of the ITS/TICS central Data Registry and Data Dictionaries, the registration process to enter data concepts into the Data Registry. Throughout the text, the Data Registry should be taken to mean the ITS/TICS central Data Registry.</p> <p>Specifically, ISO 14817:2002 specifies:</p>

¹¹ Source: Adapted from US National ITS Architecture.

Standard No: Year of Adoption	Description ¹¹
	<ul style="list-style-type: none"> • framework used to identify and define all information exchanges; • framework used to extend standardised information exchanges to support local customisations and combinations; • information modelling method for defining ITS/TICS data concepts, when used; • meta attributes used to describe, standardise and manage each of the data concepts defined within this framework; • requirements used to record these definitions; and • formal procedures used to register these definitions within the Data Registry. <p>The Data Registry described herein supports, and is designed to include, data concepts using alternative International, Regional or National System Architecture methodologies or techniques. A common Data Registry will ease migration and interoperability between such approaches.</p>
ISO 14819-Part 1 to 6:2003-2008	Specifies the coding protocol for Radio Data System - Traffic Message Channel (RDS-TMC) - RDS-TMC using the ALERT-C protocol that is designed to provide mostly event-orientated road driver information messages.
ISO 14825:2011	<p>Specifies the conceptual and logical data model and physical encoding formats for geographic databases for Intelligent Transport Systems (ITS) applications and services. It includes a specification of potential contents of such databases (data dictionaries for Features, Attributes and Relationships), a specification of how these contents shall be represented, and of how relevant information about the database itself can be specified (metadata).</p> <p>The focus of ISO 14825:2011 is on ITS applications and services and it emphasises road and road-related information. ITS applications and services, however, also require information in addition to road and road-related information. Typical ITS applications and services targeted by ISO 14825:2011 are in-vehicle or portable navigation systems, traffic management centres, or services linked with road management systems, including the public transport systems.</p>
ISO 14827-1:2005	<p>Defines the format that should be used to document those end-application messages that are to be exchanged between/among central systems. The format is protocol-independent to the extent practical. For example, this one format can be used to define data exchanges that may apply to DATEX-ASN, Common Object Request Broker Architecture (CORBA), or other Application Protocols.</p> <p>In general, each system can be viewed as consisting of the following interfaces:</p>

Standard No: Year of Adoption	Description ¹¹
	<ol style="list-style-type: none"> 1. Application Interface 2. Operator Interface 3. Communication Interface 4. Database Interface
ISO 14827-1:2005	<p>Allows different systems to exchange relevant data. The relevant data will be contained in end-application messages. Each end-application message will be formally defined as either a "subscription" or a "publication", according to the format as specified in ISO 14827-1:2005. DATEX-ASN defines how these end-application messages are packaged to form a complete data packet and also defines the rules and procedures for exchanging these data packets. Systems using DATEX-ASN are free to implement additional end-application functionalities according to the user requirements.</p>
ISO 15628:2007	<p>Road transport and traffic telematics, Dedicated Short Range Communication (DSRC) application layer</p>
ISO 15628:2007	<p>Specifies the application layer core which provides communication tools for applications based on DSRC. These tools consist of kernels that can be used by application processes via service primitives. The application processes, including application data and application-specific functions, are outside the scope of ISO 15628:2007.</p>
ISO 15662:2006	<p>Provides information as a checklist to consider handling messages that are defined by the application working groups of ISO/TC204, installing systems and selecting suitable wide area communication systems for providing ITS application services.</p>
ISO 15784-1 to 3:2008	<p>Provides principles and documentation rules of application profiles used for exchange data and messages between a traffic management centre and roadside modules used for traffic management.</p> <p>The application profiles it specifies are used to exchange data and messages between a traffic management centre and roadside modules for traffic management and between roadside modules used for traffic management.</p>
ISO 17267:2009	<p>Specifies an Application Programming Interface (API) for navigation systems. It specifies the data that may be retrieved from the map database and defines the interface for access. This International Standard specifies a set of function calls. It also specifies the design of the API and gives examples of its intended use. Furthermore, it gives the criteria to determine whether a data access library is in accordance with this International Standard. ISO 17267:2009 is applicable to the following functional categories of navigation applications:</p>

Standard No: Year of Adoption	Description ¹¹
	<ul style="list-style-type: none"> • positioning; • route planning; • route guidance; • map display; • address location; • services and Point of Interest (POI) information access.
ISO 17572, Parts 1 to 3:2008	<p>Specifies Location Referencing Methods (LRM) that describes locations in the context of geographic databases and will be used to locate transport-related phenomena in an encoder system as well as in the decoder side. It defines what is meant by such objects, and describes the reference in detail, including whether or not components of the reference are mandatory or optional, and their characteristics. It specifies two different LRMs:</p> <ul style="list-style-type: none"> • pre-coded location references (pre-coded profile); • dynamic location references (dynamic profile). <p>It does not define details of the Location Referencing System (LRS), i.e. how the LRMs are to be implemented in software, hardware, or processes. ISO 17572-1:2008 specifies the following general LRM related sections:</p> <ul style="list-style-type: none"> • requirements to a Location Referencing Method; • conceptual Data Model for Location Referencing Methods; • inventory of Location Referencing Methods; • examples of Conceptual Data Model Use; • description of selected UML Elements; • comparison of Definitions with ISO/TC211 • introduction to the TPEG Physical Format
ISO 22837:2009	<p>Relates to vehicle probe data for wide area communications. It specifies the following.</p> <ul style="list-style-type: none"> • Reference architecture for probe vehicle systems and probe data, which provides a general structure for probe vehicle systems within which a wide range of actual probe vehicle systems can be built whose physical characteristics may differ (e.g., in their choice of communications medium). The reference architecture is used to: <ul style="list-style-type: none"> – clarify the major building blocks and logical interconnections of probe vehicle systems for which this standard will be used; – categorise probe data in accordance with the information model described below. • Basic data framework for probe data elements and probe data, which defines probe data elements and probe messages, and specifically provides:

Standard No: Year of Adoption	Description ¹¹
	<ul style="list-style-type: none"> – rules for mapping information models (as defined in ISO 14817) of probe data to probe data elements/messages. The information models show the logical structure of entities and concepts involved in probe data; – the required characteristics of probe data elements and probe data messages; – the notation for probe data elements/messages (in XML); – rules for using core data elements and basic data elements (see below), and extensions of data elements in each application domain. <ul style="list-style-type: none"> • Core data element definitions, which are basic descriptive elements, intended to appear in every probe message, i.e. the location and the time at which the probe data was sensed. • Initial set of probe data elements, which are commonly used in typical probe data, enabled application domains, such as traffic, weather, and safety. • Example probe messages, which define how probe data elements are combined to convey information to probe processing centres.
ISO 22951:2009	<p>Relates to systems that use priority signal control functions to help emergency vehicles operate. This type of system is composed of a traffic management centre, in-vehicle units, roadside communication units, and roadside units. Public transport vehicles such as buses are also targeted to receive priority signal control service.</p> <p>The scope of standardisation includes message sets and data dictionary related to the communications as follows:</p> <ul style="list-style-type: none"> • between a roadside communication unit and each in-vehicle unit, • between a roadside communication unit and other roadside units, • between in-vehicle units and roadside units. <p>ISO 22951:2009 concerns only information related to priority signal control and does not deal with information provision such as that of the situations at scenes. Since it is necessary to handle public transport vehicles in accordance with the conditions of individual cities and regions, the section in the messages and the data dictionary that are concerned with priority signal control for the vehicles are treated as an option. Furthermore, the standardisation does not depend on the type of communication medium used.</p>
ISO 24097-1:2009	<p>Establishes a Service-Oriented Architecture (SOA) for the realisation of interoperable ITS Web Services (WS). Web service behaviour is described at the metadata level (i.e. a higher level of abstraction) to enable auto-</p>

Standard No: Year of Adoption	Description ¹¹
	generation of both a "Service requestor" programme, as well as a "Service provider" programme.
ISO 24099:2011	<p>Defines the data structures and protocol(s) used in Intelligent Transport System (ITS) applications for the delivery and update of map-related data from Service Centre (SC) to users [(In-vehicle Systems (IVS)].</p> <p>The map centre specified in ISO 24099:2011 represents the supplier of map data and the Service Centre provides data and services to user devices.</p> <p>The term protocol as used in ISO 24099:2011 is a temporal sequence of map-related data interactions between system components that implement map-related data delivery and update. The delivery and update of map-related data rely on existing communication technology.</p>
ISO 24100:2010	States the basic rules to be observed by service providers who handle personal data in probe vehicle information services. This International Standard is aimed at protecting the personal data as well as the intrinsic rights and interests of probe data senders, i.e., owners and drivers of vehicles fitted with in-vehicle probe systems.
ISO 24531:2013	Assists ITS standards developers and users of ITS standards who wish to use XML, by providing a consistent definition of the rules and rule references for the use of XML within ITS. ISO 24531:2013 defines consistent rules and rule references to provide a framework to be used when implementing XML-based applications in ITS, and particularly in specifying XML in ITS standards, ITS data registries and ITS data dictionaries. ISO 24531:2013 also provides guidance and examples in respect of the use of XML in ITS, and the elaboration of XML within the ASN.1 data definitions required by ISO 14813-6 and ISO 14817.
ISO 24978:2009	Provides a standardised set of protocols, parameters, and a method of management of an updateable "Data Registry" to provide application layers for "ITS Safety messages" using any available wireless media.
ISO TR 24532:2006	Clarifies the purpose of CORBA and its role in ITS. It provides some broad guidance on usage, and prepares the way for further ISO deliverables on the use of CORBA in ITS.
ISO TR 25100:2012	<p>Provides guidance on the harmonisation of data concepts that are being managed by data registry and data dictionaries such as those described in ISO 14817:2002.</p> <p>ISO TR 25100:2012 describes processes for harmonisation of such data concepts to arrive at preferred definitions for use in formal standards, specifications, technical reports and information models. It is based on consideration of a harmonisation process used by international groups</p>

Standard No: Year of Adoption	Description ¹¹
	involved in the ITS sector and in the wider sector of transport and logistics information and control systems.
ISO TS 18234-1 to 12:2006 to 2013	Provides set of TPEG applications and specifications. It allows the indexing of new applications as they are added to the TPEG applications family, by defining their Application Identification (AID).
ISO/TR 13184-1:2013	<p>Specifies guidance information protocol to provide real-time decision support system to drivers or pedestrians using personal ITS stations:</p> <ol style="list-style-type: none"> 1. Reference architecture for real-time decision support systems This reference architecture provides a general structure for real-time decision support systems and the method of message exchange between the personal ITS station and the roadside ITS station. This reference architecture is used to build the interconnections between personal ITS stations and roadside ITS stations. 2. Design method of application protocols for light-weighted devices. This method is a flexible application protocol for safety warning and parking guidance services. Unlike many other application protocols in the ITS and Telematics domains, this protocol makes the client part independent of use cases for supporting light-weighted devices. 3. Use cases at the road and parking bays for warning and parking guide <p>ISO/TR 13184-1:2013 describes the use cases applicable to the communication services between personal ITS stations and roadside ITS stations for the purposes of providing safety warning and parking guidance.</p>
ISO/TR 13185-1:2012	Specifies the communications architecture and generic protocol to provide and maintain ITS services to travellers (including drivers, passengers and pedestrians), using nomadic and portable devices.
ISO/TR 17452: 2007	Gives guidelines for using the Unified Modelling Language (UML) for defining and documenting interfaces between Intelligent Transport Systems (ITS) and Transport Information and Control Systems (TICS). It presents these guidelines in the context of a case study for the creation of an ITS/TICS data dictionary and submissions to the ITS/TICS data registry.
ISO/TR 21707: 2008	<p>Specifies a set of standard terminology for defining the quality of data being exchanged between data suppliers and data consumers in the ITS domain. This applies to Traffic and Travel Information Services and Traffic Management and Control Systems, specifically where open interfaces exist between systems. It may of course be applicable for other types of interfaces, including internal interfaces, but this Technical Report is aimed solely at open interfaces between systems.</p> <p>ISO/TR 21707:2008 identifies a set of parameters or meta-data such as accuracy, precision and timeliness etc. which can give a measure of the quality of the data exchanged and the overall service on an interface. Data</p>

Standard No: Year of Adoption	Description ¹¹
	<p>quality is applicable to interfaces between any data supplier and data consumer, but is vitally important on open interfaces. It includes the quality of the service as a whole or any component part of the service that a supplying or publishing system can provide. For instance this may give a measure of the availability and reliability of the data service in terms of uptime against downtime and the responsiveness of the service or it may give a measure of the precision and accuracy of individual attributes in the published data.</p> <p>ISO/TR 21707:2008 is suitable for application to all open ITS interfaces in the Traffic and Travel Information Services domain and the Traffic Management and Control Systems domain.</p>
ISO/TR 24529:2008	<p>Deals with the use of UML within International Standards, Technical Specifications and Technical Reports and related documents.</p> <p>It discusses the application of the Unified Modelling Language (UML) to the development of standards within the context of ITS.</p>
ISO/TS 14823:2008	<p>Presents a system of standardised codes for existing signs and pictograms used to deliver Traffic and Traveller Information (TTI). The coding system can be used to form messages to be handled by respective media systems, graphic messages on on-board units, and media system information on TTI dissemination systems [Variable Message Signs (VMS), Personal Computers (PC), Public Access Terminals (PAT), etc.] (Including graphic data).</p>
ISO/TS 15624:2001	<p>Transport information and control systems -- Traffic Impediment Warning Systems (TIWS) System requirements</p>
ISO/TS 15624:2001	<p>Transport information and control systems -- Traffic Impediment Warning Systems (TIWS) System requirements.</p>
ISO/TS 20452:2007	<p>Describes the functional requirements and Logical Data Model for PSF and API and the Logical Data Organisation for PSF that were completed under ISO/NP 14826. It does not specify a Physical Data Organisation.</p>
ISO/TS 24530-1 to 4:2006	<p>Establishes the top-level "containers" for TPEG messages in XML and the common data types that are used by tpegML applications (e.g. tpeg-ptiML). Inherently, tpegML is designed to "map" the TPEG binary (ISO/TS 18234 series), however, additional tags are provided to create a message and message set structure to facilitate internet file delivery.</p>
ISO/TS 25114:2010	<p>Provides a common framework for defining Probe Data Reporting Management (PDRM) messages to facilitate the specification and design of probe vehicle systems and gives concrete definitions of PDRM messages.</p>

Standard No: Year of Adoption	Description ¹¹
	ISO/TS 25114:2010 also specifies reference architecture for probe vehicle systems and probe data which incorporates PDRM, based on the reference architecture for ISO 22837, and basic data framework for PDRM instructions, which defines specifically necessary conditions for PDRM instructions, and notations of these instructions (in XML).

Annexure 4: Memorandum of Understanding

DRAFT SAMPLE MoU

This Memorandum of Understanding (“**MoU**”) is entered into on _____ day of _____, 201X amongst:

City Municipal Corporation {AGENCY}, being a statutory body constituted under the _____ having its office at _____, represented by **Commissioner** (hereinafter referred as “**CMC**”, which expression unless repugnant to the context or meaning thereof includes its successors and permitted assigns) of the First Part;

And

City Traffic Police {AGENCY OR DEPARTMENT} a department of _____ State Government having its office at _____, represented by **DCP/ACP, Traffic**, _____ **City** (hereinafter referred as “**CTP**”, which expression unless repugnant to the context or meaning thereof includes its successors and permitted assigns) of the Second Part;

And

City Metro Rail Corporation {AGENCY} [a statutory corporation constituted under the _____] **OR** [a company incorporated under the Companies Act, 1956] having its office at _____ represented by **Managing Director/CEO**, (hereinafter referred as “**CMRC**”, which expression unless repugnant to the context or meaning thereof includes its successors and permitted assigns) of the Third Part.

And

City Transport Corporation {AGENCY} [a statutory corporation constituted under the _____] **OR** [a company incorporated under the Companies Act, 1956] having its office at _____ represented by **Managing Director/CEO**, (hereinafter referred as “**CTC**”, which expression unless repugnant to the context or meaning thereof includes its successors and permitted assigns) of the Fourth Part.

[Change the names, designation and other details as required. Add details if any other entity is also party to the MoU such as UMTA]

CMC, CTP, CMRC and CTC are hereinafter collectively referred to as “**Parties**” and individually as “**Party**”.

WHEREAS

- A. There are several departments, authorities and corporations that are providing services to the citizens in the area of transportation, transit and traffic;

- B. It has been agreed by the Parties that service delivery to public at large could be substantially augmented and provided in a more effective and efficient manner if the Parties collaborate, work together, share and disseminate information that are of interest to public;
- C. In order to give effect to the above, it has been decided by the Parties to collaborate with each other in order to set up, operate, manage and maintain a Traffic Management and Information Control Centre (TMICC) for the _____city;
- D. TMICC would collect data/information from various participating entities and disseminate the same to public through various channels;
- E. Parties have accordingly agreed to enter into this MoU in order to record their understanding on the extent and nature of their cooperation.

NOW THEREFORE, IT IS AGREED AS FOLLOWS:**1.0 PURPOSE**

- 1.1 The objective of establishing Traffic Management and Information Control Centre (TMICC) is to be able to collect, synthesise and disseminate travel, traffic and transit related information to public that would optimise the travel behaviour on the cities and lead to efficient utilisation of city transport assets.
- 1.2 The purpose of this MoU is to document the understanding reached amongst the Parties for setting up, operating, managing and maintaining a TMICC for the _____city and matters connected therewith and incidental thereto.
- 1.3 Based on the requirements as ascertained by High Level Committee (refer clause 3.0 of the MoU) more entities could be added to this MoU that support the objectives of the TMICC.

2.0 ROLES & RESPONSIBILITIES OF PARTIES

- 2.1 Subject to clause 2.6 hereunder, Parties agree to work together and discharge various responsibilities as outlined in clauses 2.2 to 2.5 hereunder for and in relation to supporting the city TMICC.
- 2.2 CMC agrees to discharge the following responsibilities {modify as required}:
 - (a) To set up TMICC (if it is to be located at their premises)
 - (b) To depute its personnel at the TMICC
 - (c) Signalling system installation, maintenance and upkeep
 - (d) Monitoring the uptime of signalling system
 - (e) To provide updates on construction/ maintenance activities of the roads
 - (f) To provide updates on installation/ maintenance of the equipment relating to TMICC

- (g) Managing the contracts and relationships with the contractors responsible for installation, maintenance and upkeep of the signalling system and other ITS equipment deployed by the CMC
- (h) Managing the contracts and relationships with the contractors responsible for construction, maintenance and upkeep of the road network of the CMC
- (i) Cooperate and work with Parties both at strategic and operational levels in order to ensure that the TMICC achieves its objectives
- (j) Cooperating with each other in responding to incidents, accidents and other emergency situations
- (k) Any other responsibility as mutually agreed

2.3 CTP agrees to discharge the following responsibilities {modify as required}:

- (a) To set up TMICC (if it is to be located at their premises)
- (b) To depute its personnel at the TMICC
- (c) Managing and optimising signal cycle
- (d) Monitoring surveillance cameras
- (e) Taking lead role in managing incidents including coordinating with other internal and external stakeholders such as Fire, Police etc.
- (f) Traffic enforcement
- (g) Traffic related information dissemination to public, media and other internal and external stakeholders
- (h) Managing the contracts and relationships with the contractors responsible for installation, maintenance and upkeep of the ITS equipment deployed by the CTP
- (i) Cooperate and work with Parties both at strategic and operational levels in order to ensure that the TMICC achieves its objectives
- (j) Cooperating with each other in responding to incidents, accidents and other emergency situations
- (k) Any other responsibility as mutually agreed

2.4 CMRC agrees to discharge the following responsibilities {modify as required}:

- (a) To deploy ITS equipment on its fleet such as Passenger Information System, CCTV cameras etc.
- (b) To manage and monitor its transit operation
- (c) To develop the transit related infrastructure for which it is responsible
- (d) To deploy, operate and maintain various equipment and associated systems that provide data feeds to TMICC

- (e) To provide agreed data / information in desired form and frequency
- (f) To provide updates on construction/ maintenance activities
- (g) To provide updates on service delay /disruptions /facility closure
- (h) To depute its personnel at the TMICC, as required
- (i) Cooperate and work with Parties both at strategic and operational levels in order to ensure that the TMICC achieves its objectives
- (j) Cooperating with each other in responding to incidents, accidents and other emergency situations
- (k) Any other responsibility as mutually agreed

2.5 CTC agrees to discharge the following responsibilities {modify as required}:

- (a) To deploy ITS equipment on its fleet such as Automatic Vehicle Location System, Passenger Information System, CCTV cameras etc.
- (b) To manage and monitor its transit operation
- (c) To develop the transit related infrastructure for which it is responsible
- (d) To deploy, operate and maintain various equipment and associated systems that provide data feeds to TMICC
- (e) To provide agreed data / information in desired form and frequency
- (f) To provide updates on construction/ maintenance activities
- (g) To provide updates on service delay /disruptions /facility closure
- (h) To depute its personnel at the TMICC, as required
- (i) Cooperate and work with Parties both at strategic and operational levels in order to ensure that the TMICC achieves its objectives
- (j) Cooperating with each other in responding to incidents, accidents and other emergency situations
- (k) Any other responsibility as mutually agreed

2.6 The roles and responsibilities of the Parties shall be subject to periodical review and amendment as may be discussed and mutually agreed.

3.0 ADMINISTRATIVE ARRANGEMENT

3.1 High Level Committee

3.1.1 High Level Committee (HLC) shall have representation from the senior most officer heading the administration of the Party as under:

Party	Representative
City Municipal Corporation	Commissioner
City Traffic Police	DCP/JCP (Traffic)
City Metro Rail Corporation	MD/CEO
City Transport Corporation	MD/CEO

3.1.2 HLC shall meet as and when needed (at least once every quarter) and shall be responsible for the following:

- (a) To act as high level decision making body on the matters connected with TMICC
- (b) Provide advice to Unified Metropolitan Transport Authority (UMTA) having jurisdiction over the city on various aspects related to the TMICC
- (c) Resolving any administrative issues that are faced at the TMICC
- (d) Decision regarding associating with other entities in relation to TMICC
- (e) Finalising the cost sharing mechanism and ratio amongst the Parties regarding setting up, managing, operating and maintaining the TMICC
- (f) Any other role assigned to the HLC by the UMTA.

3.2 Technical Committee

3.2.1 Technical Committee (TC) shall report to the HLC and shall have representation from the Parties as under:

Party	Representative
City Municipal Corporation	Nominee of the HLC Member of the Party
City Metro Rail Corporation	--- do----
City Transport Corporation	--- do----
City Traffic Police	--- do----

3.2.2 Technical Committee shall meet as and when needed (at least once every month or as necessary) and shall be responsible for the following:

- (a) To act as technical body supporting the decision making role to be played by the HLC
- (b) Providing advice to HLC on various aspects such as conceptualising, planning, designing, roll out, operation, maintenance and management of the TMICC
- (c) Resolving any technical issues that are faced at the TMICC

(d) Any other role assigned to the TC by the HLC.

3.3 High Level Committee (HLC) shall, right at the project commencement stage, evolve decision making policy to be followed by HLC as well as Technical Committee (TC). The method of arriving at decisions by these committees could be based on voting, consensus, capital/operational cost sharing etc. as may be decided by HLC. The HLC may also frame policy regarding entry of new members, exit of members, methods of budget determination and apportionment of capital and operational costs to members.

4.0 RELATIONSHIP BETWEEN THE PARTIES

4.1 This MoU reflects the general understanding reached between the Parties for working together on the matters related to TMICC and does not authorise a Party to represent any other Party/Parties.

4.2 Except as otherwise agreed, the Parties shall bear their costs and expenses in relation to discharging their respective roles under the MoU.

5.0 VALIDITY AND TERMINATION

5.1 Unless terminated earlier or extended by the Parties, this MoU shall remain valid for a period of Ten (10) years from the date of execution of the MoU.

6.0 GENERAL

6.1 This MoU shall not affect any existing agreement or any other arrangements that the Parties may have relating to the matters covered under the MoU.

6.2 Any amendments to this MoU shall be in writing and signed by the authorised representatives of the Parties.

6.3 The official and binding language of this MoU, as well as the official and binding language between the Parties in connection with the MoU will be the English language.

IN WITNESS WHEREOF, the Parties, by their duly authorised officers, have executed this MoU as given above.

Party	For CMC	For CTP
Signature		
Name		
Designation		

Party	For CMRC	For CTC
Signature		
Name		
Designation		

Annexure 5: Systems Engineering For ITS Projects

1. Introduction

TMICCs are typically conceptualised and designed to interface and operate with a number of information technology & communication systems, equipment and processes that are managed, operated and maintained by various agencies of the city/region. TMICCs are complex ITS projects having very large technological element comprising information and communications technologies supporting collaboration and information exchange among various traffic, transit, other participating agencies and law enforcement bodies. The exchange of information happens both within the system, its sub-systems and components as well as with systems of other organisations.

In order to follow a structured process in planning and delivering complex ITS initiatives, Systems Engineering approach has been widely used and adopted by various organisations worldwide. All government funded ITS initiatives in the USA, for example, are now required to follow the Systems Engineering approach.

It is recommended that the TMICC projects also follow the Systems Engineering approach. This chapter provides a brief overview of the Systems Engineering approach for undertaking system development.

The agencies developing these projects could take assistance from professional consulting organisations on a need basis to secure support from them. Further, as the agencies would typically engage one or more contractors for designing and delivering the systems, it is important that the Request for Proposals (RFPs) created for such procurement includes the requirement for the contractors to follow the Systems Engineering approach.

2. Systems Engineering

The Systems Engineering is an interdisciplinary approach and means to enable the realisation of successful systems. It focuses on defining customer needs and required functionality early in the development cycle, documenting requirements, and then proceeding with design synthesis and system validation while considering the complete problem:

- Operations
- Cost & Schedule
- Performance
- Training & Support
- Test
- Manufacturing
- Disposal

“Systems engineering integrates all the disciplines and specialty groups into a team effort forming a structured development process that proceeds from concept to production to

operation. Systems engineering considers both the business and the technical needs of all customers with the goal of providing a quality product that meets the user needs". [As defined by The International Council on Systems Engineering (INCOSE)]

3. Benefits of Systems Engineering Approach

The primary benefits of following Systems Engineering is that its structured approach would reduce the risk of project schedule and cost overruns and support development of system of higher integrity. There are several advantages of following this approach:

- It is a structured and disciplined approach to implement complex ITS projects such as TMICC or other ITS projects.
- This approach leads to creation of various project related documents covering details such as concept of operations, system requirements, design, test plans, operational plans. These not just help in designing, testing, implementing and operating the projects but also ensure traceability between outputs and inputs encompassing all stages.
- The process by design requires stakeholders to participate at various phases of the project thereby ensuring that system is created based on their participation and inputs meeting their expectations.
- Since the IT systems evolve with time and change based on stakeholder expectations, and availability of new generation technologies, among others, following this approach would support easier upgrade of system
- It would help in ensuring continued system operation and support in case of any change in a contractor
- Leads to lesser rework and, therefore, lesser delivery times as each stage requires acceptance/approval from the relevant stakeholders before the project moves on to the next stage.

4. Systems Engineering: Key Principles

Some of the important principles of the Systems Engineering approach in undertaking any project development exercise are listed below:

- Stakeholder participation
- Defining the project objectives in the beginning
- Decomposing the system into manageable sub-systems and components
- Keeping the end objectives in mind
- Ensuring traceability

A. Stakeholder Participation

TMICC projects would require participation from various agencies such as those managing bus services, metro rail services, Municipal Corporations, PWD, development

authorities, Traffic Police etc. Further, officers from various departments, levels and with varying expected roles are going to participate at various stages of implementation of the project.

Success of such initiatives would largely be driven by the active participation by such stakeholders in the project development. Systems engineering provides a structured framework and ensures that each of the stakeholder participates and provides relevant inputs, feedbacks and/or approvals during various stages of the project development exercise.

B. Defining the Project Objectives in the Beginning

The project objectives should drive the solution. Any preconceived solution should not drive project definition and objectives. The Systems Engineering process starts with defining first the objectives that are sought to be achieved by the solution and thereafter identification and evaluation of various solution options is carried out to determine the most appropriate solution.

C. Decomposing the System into Manageable Sub-systems and Components

Systems have varying levels of complexities, scope and sizes. For large and complex projects, Systems Engineering approach is to break the system into smaller sub-systems and components. Such smaller sub-systems and components are easier to comprehend, visualise, define, design, develop and test. Further, following this approach also supports managing and monitoring the project more effectively.

D. Keeping the End Objectives in Mind

The success of any system could be measured in a number of ways. It is critical that the end objectives and the associated performance measures are clearly defined and understood by all the stakeholders in the beginning. This will ensure that there is an agreed measure to assess the project performance once the same is delivered and implemented.

E. Ensuring Traceability

It is necessary that the project is developed in accordance with defined and agreed set of objectives and requirements. In order to ensure this it is important that at each stage of the project there is a proper correlation between outputs (products/components) and inputs (requirements). Systems engineering provides a framework to ensure traceability or correlation.

5. The “V” Systems Engineering Model

A. The "V" Model Overview

Several models have been developed by the experts that provide an overview of the Systems Engineering steps in implementing projects. The "V" model, shown in Figure 1 is a widely used one and has been adopted and recommended by transport authorities.

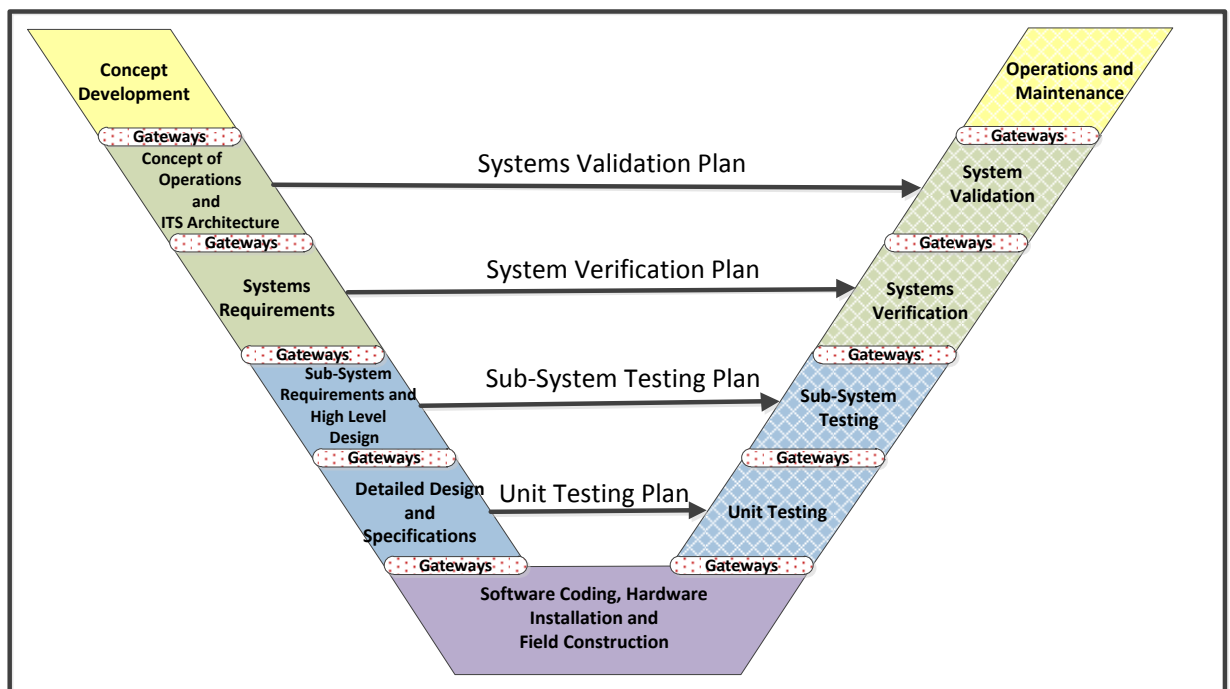


Figure 1: The “V” Model in Systems Engineering

B. Interfacing between the Left and Right Arms

Systems engineering process outlined in the model is a framework for ensuring that the requirements generated in following the processes represented by the left arm are verified by following processes represented on the right. Concept of Operations, for example, on the left that is used to capture the user needs and agreed system performance parameters is validated for delivery through the system validation exercise on the right. The connecting arrow between these two arms similarly provide for verification of the requirements created in the left part with the system delivery on the right.

C. Decision Points

The process provides for decision points or gateways between various stages. The project moves to the next stage only when the outputs from the earlier stage have been approved based on the agreed parameters.

D. Traditional Approach to ITS Deployment

Without a Systems Engineering process, traditionally an approach to ITS began with a Feasibility Study, proceeding to Detailed Project Report (DPR) and traditional implementation phase. This process may be adequate for traditional roadway and traffic projects; however, with complex TMICC or ITS projects, appropriate system checks and requirements would need to be taken into account and these projects typically fail if implemented with the traditional approaches. Figure-2 shows the traditional process and each phase of project development correspond with the Systems Engineering process.

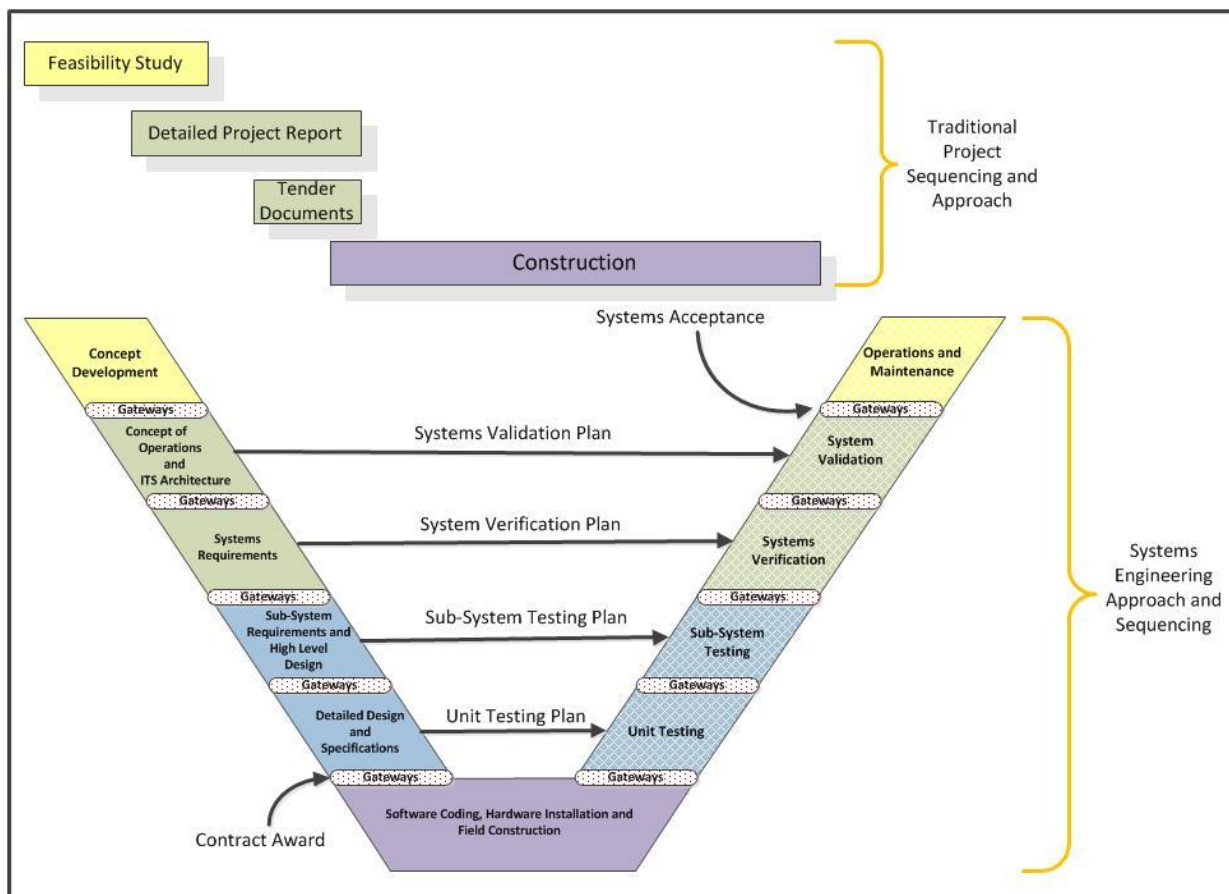


Figure 2: Traditional vs. the Systems Engineering Approach

6. ITS Technical Process

A. Regional ITS Architecture

ITS projects often work as part of network which has many other systems connected. If available, the regional ITS architecture provides the context within which an ITS project is to be developed, the positioning of the project in the transportation system for the city /region and the nature and degree of integration that is required to be considered. It is a framework that outlines the institutional agreement reached on the framework for implementation of ITS projects in the city/region, their functions, their inter-linkages and information exchange among them. USA has national ITS architecture in place which has gone through several iterations. Various States in the USA are following the national ITS architecture in developing regional ITS architecture for the State.

The ITS projects must be planned keeping in mind the requirements outlined in the regional ITS architecture, if one exists. In India, the national as well as regional ITS architectures are not yet in place. Chapter 5.0 provides guidance in developing a project level architecture, in the absence of a regional architecture.

B. Feasibility Study and Concept Development

The project, under this step, is evaluated for its technical, operational and economic/ financial feasibility. Various options for implementing the project are examined and evaluated at a high level. This step is distinct from the Concept of Operations step lined up next in the “V” model which needs to be developed for a chosen option.

A feasibility study typically covers the following aspects:

- Brief overview and objectives for taking up the project
- Options considered, details of evaluation and the chosen option
- Brief description of the chosen option with high level technical and operational details
- Implementation structure
- Financial model and proposed sources of funding

C. Concept of Operations

In this stage, the Concept of Operations document is created for the chosen project implementation option covering the following details:

- Objectives of the project
- Details of the project stakeholders together with their needs
- Role of the project stakeholders during various stages
- Memoranda of Understanding and/or Agreements amongst parties

- Project description and features at high level
- Project coverage in terms of geographical area, cities covered, modes covered, exclusions etc.
- High level project plan containing details and sequence of activities and their inter-dependencies
- Implementation structure covering the approach for design, development, operation, maintenance and procurement

D. System Requirements

In this step of the “V” model, system requirements are defined and documented. The objective in this step is to define what the system would do and not how it would do it which is the scope of system design step coming up next. System requirements govern the way the system would eventually be designed and developed. The requirements worked out and documented in this step are used by the system developer while designing and developing the system.

The stakeholder’s needs documented as part of Concept of Operations stage is used as a point of reference for developing the system requirements. The requirements need to be captured in a structured way, analysed, prioritised, validated (for completeness, accuracy and consistency), and documented.

Together with capturing and documenting the requirements, a plan for system verification vis-à-vis the requirements is also prepared capturing the method of verification for each requirement. The verification methods typically used are system review and analysis, inspection, testing and/or demonstration by the system developer.

E. System Design

The earlier steps in the “V” model had the objective of defining what the system is required to do. In this step, the objective is to create design of the system that would meet the requirements outlined pursuant to and in accordance with which the system would be developed and implemented in the next step of the “V” model.

Design is typically carried out in two stages: System architecture definition or high level design and detailed design.

The high level design defines the system architecture covering hardware, software, equipment, systems, other project components and their interfaces over the communication network. Detailed design contains detailed specification for project hardware, software, equipment, systems, other components and communication network so that these project elements could be developed, manufactured or provided in compliance with the system requirements.

F. Software and Hardware Development and Testing

This stage follows the design stage and is preceded by integration, verification and validation steps that follow it. The project elements identified in the design stage are developed/procured meeting the specifications outlined in the design. The system hardware, software and other elements that are standard commercial-off-the-shelf in nature are procured and combined with the custom built elements to deliver the system in accordance with the design.

Major steps involved in this process are as set out below:

- Create plan for hardware and software development
- Create development set-up with required tools and resources
- Undertake development of hardware and software
- Undertake unit and/or device testing

The outputs of this stage are hardware and software that have been subjected to unit and/ or device testing and are now ready for the next stage: integration and verification. The documents generated during this process would typically include the Hardware and Software development plans, development environment and unit test plan and results.

G. Integration and Verification

This is an iterative process under which the various system components are progressively integrated into sub-systems and then subjected to verification vis-à-vis the requirements. First, the individual system components are subjected to verification to assess their compliance with the requirements. Subsequently these components are integrated and assembled into sub-systems which are then subjected to verification against the requirements. This process of integration continues till it reaches the overall system level by the end of which the entire system would have been subjected to verification against the requirements.

This process is the inverse of the process followed during the requirements study and design stages earlier where the system was broken down into various sub-systems and components.

This process entails integrating components and sub-systems each of which typically may have associated configuration and versions. It is important to monitor and manage this and the configuration of each component/ test-case version should be duly verified and noted in the verification documents.

H. Initial Deployment

The system has so far been tested and verified in the controlled environment. In this stage, the system is deployed and installed at the deployment site and checked. The system is transferred by the development team for the operations and maintenance

(O&M). The transfer also entails handing over the applicable documents, imparting training and supporting the deployment.

The system is subjected to acceptance tests to confirm that the system is performing as intended in the field environment.

The output of this stage is a deployed, installed and operational system at the operations site.

The following documents are generally created under this stage:

- Final system documentation
- O&M Plan
- Inventory of hardware and software with version details
- Transition Plan and associated checklists
- Training materials
- Delivery and installation plan
- Test plan and procedures, duly updated

I. System Testing and Validation

The system owner in this stage conducts tests to determine if the deployed system is meeting the needs during the Concept of Operations stage.

In Systems Engineering, a distinction is drawn between verification and validation processes. Verification is to check if the system meets the stipulated requirements. Validation on the other hand is carried out to see whether the system meets the identified needs. It would be evident that majority of the system verification could be performed prior to system deployment. Validation, however, can be performed only post system deployment when the system is operational and it is being used by the intended users.

Any system owner would be uncomfortable on discovering that it built a system that does not meet user needs. In order to avoid this, the Systems Engineering approach framework validates each of the intermediate outputs leading up to the final system to minimise the chances of system failing the validation test in the end.

The system validation should be carried out throughout the lifecycle of the system and not just post initial deployment and operation phase. Some of the ways in which validation is carried out, are listed below:

- Stakeholder feedbacks to assess whether their needs are being met or not
- Status of important outcome parameters pre and post system deployment whether collected by the system or captured through surveys
- User satisfaction surveys to find out if they are satisfied with the system
- Measures collected as a part of normal system operation

The desired performance measures need to be properly documented in the system requirements in order to ensure that the measures, to the extent possible, are captured by the system in the normal course as a part of system operation.

As an output of this process, a validation report document is prepared based on the analysis of data gathered from the exercise to ascertain system performance vis-à-vis the user needs, the feedbacks received and the issues that are needed to be addressed. These are then used as input while updating or upgrading the system.

J. Operations and Maintenance (O&M)

During the O&M phase, the system is being operated and maintained by the system owner. The phase lasts till the time the system is replaced or is retired from service. Based on review and feedbacks, the system is periodically updated and upgraded. The activities that are performed during the O&M phase are:

- O&M of the system
- Collection of operational data
- Feedback to the development/support team
- Updates and upgrades
- System support
- Configuration control

K. Retirement and Replacement

Systems engineering requires planning for the entire lifecycle of the system. As part of this, the planning for system retirement and/or replacement is also carried out. The system could be retired or replaced due to several reasons:

- The system is no longer required and/or the user needs have either changed or are being supported in some other manner
- The system no longer meets the user needs
- It is no longer cost effective to operate and maintain the system
- Newer version of system supports the current user needs better and/or is more cost effective

The system is periodically reviewed with respect to its continued utility in supporting the then current user needs and its cost effectiveness as compared to other options. Based on the analysis, a decision is taken either for continuation of the system or for retiring it from service.

Once a decision is taken to retire the system, a retirement plan is developed containing the following details:

- An inventory of all hardware, software and other system elements
- Asset ownership details
- Alternative use of the system components elsewhere
- Details regarding the system operational status
- System and documentation and configuration details
- Disposal of system documentation
- Erasing the data from storage media subject to any need to retain data
- Applicable contracts and mechanism for their closure, as needed

Annexure 6: Model DPR Template

Model Template for Detailed Project Report for Traffic Management and Information Control Centre (TMICC)

Organisation Name

Date

EXECUTIVE SUMMARY

Provide the executive summary highlighting important aspects covered in various chapters of the report.

1. PROJECT BACKGROUND

1.1. Overview of the Project

A brief description on the project background covering the details like, size of city, transport infrastructure, population, expectation & horizon year etc.

1.2. Purpose

A brief description of the purpose/use of the document, guiding on the parameter like capacity required to be built, tangible and intangible benefits.

1.3. Approach

Brief discussion regarding the approach and methodology adopted while developing the detailed project report covering the requirements of primary data, secondary data, information sources and dissemination.

1.4. Chapters Outline

Brief outline of each of the chapter detailing the topics covered in the respective chapter.

2. CITY PROFILE

2.1. Background

A city background shall cover brief history of city, ranking of city, any specific information, spatial growth and regional setting, Climate, Linkages & Connectivity, Economy and profile.

2.2. Demographic Trends

This section illustrates the population, population growth rate and population density in the city.

2.2.1. Population

This section shall covers the population in the city and related facts and figures.

2.2.2. Population growth rate

This section shall covers yearly data of populations, yearly growth rate, analysis, trend, with table/figure/graph.

2.2.3. Population density

This section shall covers the brief details of yearly population density, analysis, with related table/figure/graph.

2.3. Registered Motor Vehicles

A details of vehicle registration data in the city for last 5 years, available space for parking/ parking facilities, residence on street & off street or any conclusion and relevance for TMICC.

2.4. Environmental Parameters

An overview of the environment quality parameters like temp., humidity, facts and data for the last 5 years, conclusion and relevance to TMICC.

2.5. Traffic Safety

Traffic safety shall covers accident data in the city for last 5 years and analysis of the data.

2.6. Travel Demand Forecast

2.6.1. Travel and Traffic Characteristics

This section shall provide Travel and Traffic Characteristics of the city.

2.6.2. Per Capita Trip Rate

Details of per capita trip rate, analysis of data, with relevant table and figure.

2.6.3. Average Speed

Details of average speed in the city, analysis of data and relevant table and figure, how average speed may be impacted, factors which may impact the average speed.

2.6.4. Average Trip Length

Details of average trip length, analysis of data, relevant table and figure, how average trip length may be impacted, factor which may impact average trip length.

2.6.5. Modal Shares

Details of modal shares, analysis of data, relevant table and figure.

2.6.6. Summary

This section shall provide summary of the above analysis and justification.

2.7. Transport Network Characteristics

Details of transport network characteristics, road network details, major intersections, traffic safety.

2.7.1. Road Network Characteristics

Details of road network characteristics, provide table/figure/maps, volume/ capacity ratio of road network, services and utilisations over the roads and under the roads, Analysis and justification for TMICC.

2.7.2. Major Intersections

This section shall include the names of major intersections, number of signalised and non-signalised intersections, capacity of intersections and any other specific information for the same.

2.8. Public Transport Characteristics

This section shall provide details of the available/proposed public transportation facilities in the city. (Note: Information on Mass Rapid Transit Systems (MRTS) such as Metro Rail system, BRTS, Light Rail, Monorail, Tram, PRT, existing/proposed city bus system and Intermediate Para-Transit system to be covered in the given sub-sections below.), Mass Rapid Transit System (Metro/Mono/Light Rail, if any), Bus Rapid Transit System (if any), Bus System (if any), Intermediate Public Transport and other modes, Ridership for PT and secondary viable options to be accommodated.

2.9. Proposed Transport Sector Interventions

Review of the comprehensive mobility plan, infrastructure plan and master plan etc.

2.10. Key Stakeholders

Details of List out stakeholders in the city and their roles and responsibilities.

2.11. Project Need Analysis

This section shall include the assessment/ need for TMICC in the city with relevant table/figures etc., as required. Refer Chapter 4.0 and Chapter 5.0 of the TMICC Operations Document for guidance.

3. TMICC CONCEPT OVERVIEW

3.1. TMICC Overview

An overview of TMICC. For detailed content, refer TMICC Operations Document.

3.2. TMICC Objectives

Define objectives of the TMICC for the city.

3.3. TMICC Benefits

List tangible and intangible benefits that can be realised from implementing the TMICC.

4. REVIEW OF ITS INITIATIVES IN THE CITY

4.1. ITS Background and Initiatives

This chapter explains the present ITS scenario and major ITS initiatives taken in the city and provides a context within which the TMICC for the city is proposed with relevant Table/ Figures/ Graph/Charts/Images.

4.2. ITS Initiatives in Traffic

Provide brief regarding traffic related ITS initiatives undertaken in the city, brief analysis of each initiative, sources of its funding, implementing agency, and usefulness of the initiative for TMICC with Table/Figures/Graph/Charts, as required.

4.3. ITS Initiatives in Transit

Provide brief regarding transit related ITS initiatives undertaken in the city, brief analysis of each initiative, sources of its funding, implementing agency, and usefulness of the initiative for TMICC with Table/Figures/Graph/Charts, as required.

4.4. Stakeholders Inputs

Details of user interactions, data collections from various stakeholders in the city with Table/ Figures/ Graph/ Charts, as required.

4.5. Summary and Conclusions

This section shall provide summary of all the earlier sections giving an overall analysis of the present scenario, Requirements of the proposed TMICC based on city characteristics and review of ITS initiatives in the city, Insert conclusion, systems to be interfaced with TMICC and define the need for the city, with Table/Figures/Graph/Charts, as required.

5. PROJECT CONCEPT

5.1. Introduction

This section shall provide the concept of TMICC

5.2. Goals and Objectives

This section shall provide the goals and objectives set out for TMICC in the city with Table/Figures/Graph/Charts, as required. Refer Chapter 2.0 of the TMICC Operations Document for more details.

5.3. Project Area

This section shall provide the details of the geographical/ planning area that would be addressed by the TMICC with Table/Figures/Graph/Charts, as required.

5.4. Project Phasing

This section provides the details of phasing of TMICC applications for the coverage area(s). Refer Chapter 11.0 of the TMICC Operations Document for more details.

5.5. Project Components and Specifications

This section shall provide the project component and specification with Table / Figures / Graph / Charts, as required. Refer Chapter 4.0 of the TMICC Operations Document for more details.

5.6. Location of TMICC Facility

This section shall provide the details of the location where the TMICC for the city would be set up. In addition, also provide size, location etc. with Table/Figures/Graph/Charts, as required.

5.7. Project Level Architecture

This section shall include a project level logical architecture diagram for city with Table/Figures/Graph/Charts, as required. Refer Chapter 3.0 and Chapter 4.0 of the TMICC Operations Document for guidance.

5.7.1. Traffic Signal Control

This section shall define the system, Signal technology, Operation of the signals with TMICC, Insert logical flow concept diagram with Table/Figures/Graph/Charts, as required. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

5.7.2. Road Network Surveillance

This section shall define the system, Road Network Surveillance technology, Operation of this component with TMICC, Insert logical flow concept diagram with Table/Figures/Graph/Charts, as required. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

5.7.3. Interfaces with Traffic Enforcement System

This section shall define the system, specify the system technology (as required), Interfaces with TMICC operations, Agency responsible for the system. Insert logical flow concept diagram (as

required), Table/Figures/Graph/Charts, as required. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

5.7.4. Interfaces with Parking Systems

This section shall define the system, Specify the system technology (as required), Interfaces with TMICC operations, Agency responsible for the system, Insert logical flow concept diagram (as required) with Table/Figures/Graph/Charts, as required. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

5.7.5. Interfaces with Transit agencies

This section define the system, Specify the system technology (as required), Interfaces of the system with TMICC, Agency responsible for the system(s), Specify the system technology, Insert logical flow concept diagram (as required) with Table/Figures/Graph/Charts, as required. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

5.7.6. Interfaces with Weather System

This section define the system, Operations of this component with TMICC, Interfaces with TMICC operations, Agency responsible for the system, Specify the system technology (as required), Insert logical flow concept diagram (as required) with Table/Figures/Graph/Charts. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

5.7.7. Interfaces with Incident/Disaster Management Agencies

This section define the system, Operations of this component with TMICC, Interfaces with TMICC operations, Agency responsible for the system, Specify the system technology (as required), Insert logical flow concept diagram (as required) with Table/Figures/Graph/Charts. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

5.7.8. Traffic Information Dissemination System

This section define the system, Specify the system technology (as required), Operations of this component with TMICC, Interfaces with TMICC, Agency responsible for the system, Insert logical flow concept diagram with Table/Figures/Graph/Charts, as required. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

5.8. Data Warehousing and Analysis

This section define the system, Specify the system technology, as required, Operations of this component with TMICC, Interfaces with TMICC, Insert logical flow concept diagram with Table/Figures/Graph/Charts, as required. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

5.9. Standards and Protocols

Details of different standards and protocols applicable for the TMICC in the city with Table/Figures/Graph/Charts, as required. Refer Chapter 3.0 of the TMICC Operations Document for guidance.

5.10. System Requirements

5.10.1. Traffic Signal Control

This section shall include the requirements for the system. Detail out the component, subcomponent based on the requirements of the system, Comparison of various technology options. Refer Chapter 4.0 of the Generic Operations Document for guidance.

5.10.2. Road Network Surveillance

This section shall include the requirements for the system. Detail out the component, subcomponent based on the requirements of the system. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

5.10.3. Interface with Other Systems

This section shall include the requirements for the system. Detail out the component, subcomponent based on the requirements of the system. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

5.10.4. Traffic Information Dissemination

This section shall include the requirements for the system. Detail out the component, subcomponent based on the requirements of the system. Refer Chapter 4.0 of the TMICC Operations Document for guidance.

6. PROJECT IMPLEMENTATION, OPERATION AND MAINTENANCE

6.1. Project Implementation Process and Timelines

This section shall provide brief description on Project Implementation and Timelines.

6.1.1. Detailed Project Report

This section shall include brief description on the DPR.

6.1.2. Agreements Between Stakeholders

This section shall include Approach for drawing up and entering into the detailed agreements between the various stakeholders related to TMICC. The idea is to clearly set out the roles and

responsibilities of each stakeholder and funding allocation and responsibilities based on the project requirements finalised with Table/figures/flow chart etc., as required. Refer Chapter 9.0 of TMICC Operations Document for guidance including sample draft of agreement.

6.1.3. Preparation for Bid Process Management

This section shall include Approach for Tender document preparation to carry out the bidding process for selection of contractors for various items of work with Table/figures/flow chart etc., as required. Refer Chapter 6.0 of TMICC Operations Document for guidance.

6.1.4. Bid Process Management

This section shall include details regarding the bid packages. Based on the project structure and implementation plan finalised by the city authority, the project may involve multiple bid process with Table/figures/flow chart etc., as required. Refer Chapter 6.0 of the TMICC Operations Document for guidance.

6.1.5. Project Implementation, Monitoring and Management

This section shall include approach for project monitoring and management. After successful completion of the bidding process, project monitoring and management would be required to ensure that contracted deliverable are completed and obligations are discharged by the selected contractors in accordance with their respective agreements. Refer Chapter 6.0 of the TMICC Operations Document for guidance.

6.2. Procurement Approach

6.2.1. Procurement Options and the Recommended Option

This section shall include procurement approach adopted for project, Rationale for the approach adopted with Table/figures/flow chart etc., as required. Refer Chapter 6.0 of the TMICC Operations Document for guidance.

6.2.2. Risk Identification and Allocation

This section shall include the objective of risk management process, Risk Identification and Allocation. Refer Chapter 6.0 of the TMICC Operations Document for guidance.

6.3. Project Implementation, Operations and Maintenance

6.3.1. Project Implementation

This section shall include the brief about the project implementation.

6.3.2. Project Operation

This section shall include the details of project operation. Refer Chapter 7.0 of TMICC Operations Document for guidance.

6.3.3. Project Assets Maintenance

This section shall include approach for assets management. Refer Chapter 8.0 of TMICC Operations Document for guidance.

6.3.4. Standard Operating Procedures

This section shall include Standard Operating Procedure. Refer Chapter 7.0 of TMICC Operations Document for guidance.

6.4. Awareness Campaign and Outreach

This section shall define the approach for branding and promotion of TMICC related activities and to create awareness.

6.5. Obsolescence Management

This includes a brief explanation of the issues related with obsolescence, Outline the approach to deal with obsolescence management. Refer Chapter 5.0 of TMICC Operations Document for guidance.

6.6. Retirement and Replacement

This section shall include approach for planning for system retirement and/or replacement. Refer Annexure 5 of TMICC Operations Document for guidance.

7. PROJECT STAKEHOLDERS AND ORGANISATION

7.1. Introduction

This section shall include brief Introduction to the chapter.

7.2. Role of Various Agencies in Transportation

Details of Identification of agencies in transportation sector in the city, Roles of various agencies in transportation. Refer Chapter 9.0 of TMICC Operations Document for guidance.

7.3. Project Implementing Agency

Details of Identification of implementing agency based on institutional structure in the city. Refer Chapter 9.0 of TMICC Operations Document for guidance.

7.4. Project O&M Agency

This section shall identify the O&M agency based on institutional structure in the city. Refer Chapter 8.0 and Chapter 9.0 of the TMICC Operations Document for guidance.

7.5. Stakeholders, Roles and Responsibilities

This section shall include Identification of stakeholders in transportation, defining Roles and responsibility of the various stakeholders in TMICC. Refer Chapter 9.0 of the TMICC Operations Document for guidance.

7.6. Data Sharing by Project Stakeholders

This section shall include the identification of data to be shared by various stakeholders with the TMICC. Refer Chapter 9.0 of the TMICC Operations Document for guidance.

7.7. Project Organisation

This section shall include the details of Identification of staff for the TMICC, Organogram etc. Refer Chapter 9.0 of the TMICC Operations Document for guidance.

7.8. Agreements between Stakeholders

This section shall include the details of the agreements between TMICC and various stakeholders for data sharing, operations, roles and responsibility, Sample agreement provided in the TMICC Operations Document. Refer Chapter 9.0 of the TMICC Operations Document for guidance.

7.9. Training and Capacity Building

This section shall outline the training and capacity building programme for TMICC staff and associated stakeholders. There would be a need for extensive training initially in the areas of planning and designing of the TMICC and later progressively. Refer Chapter 9.0 of the TMICC Operations Document for guidance.

8. PROJECT SIZING, COSTS, REVENUE AND FUNDING

8.1. Introduction

This section shall include the brief description on financial outlay.

8.2. Details of Project components in the city including sizing/quantity

This section shall provide Phasing of the components of TMICC along with rationale for the adopted phasing. Refer Chapter 11.0 of the TMICC Operations Document for guidance.

8.3. TMICC Facility

This section details out the location and size of the facility for TMICC, Give table, pictures, layout etc., as applicable. Refer chapter 11.0 of the TMICC Operations Document for guidance.

8.3.1. Equipment at TMICC Facility

This section shall detail out the equipment required at the TMICC, Insert table, picture, layout etc., as required. Refer Chapter 11.0 of the TMICC Operations Document for guidance.

8.3.2. Field Equipment

This section shall detail out the equipment to be required at field for TMICC, Insert table, picture, layout etc., as required. Refer Chapter 11.0 of the TMICC Operations Document for guidance.

8.4. Project Cost Estimates

Brief explanation regarding the approach adopted for cost assessment.

8.4.1. Capital Cost

This section shall include detailed estimates of components with relevant table. Refer Chapter 11.0 of the TMICC Operations Document for guidance.

8.4.2. O&M Cost

This section shall include detailed costing of each component with relevant table. Refer Chapter 11.0 of the TMICC Operations Document for guidance.

8.4.3. Summary

This section shall summarise the cost.

8.5. Revenue Streams

This section shall detail out the revenue sources for TMICC, Rationale of suggestions, relevant table, figures etc., as required. Refer Chapter 11.0 of the TMICC Operations Document for guidance.

8.6. Implementation Structure

8.6.1. Implementation Options

This section shall include the available options for implementation, PPP options. Detail out the feature of the various options. Refer Chapter 11.0 of the TMICC Operations Document for guidance.

8.6.2. Recommended Implementation Option

This section shall include adopted implementation structure. Refer Chapter 11.0 of the TMICC Operations Document for guidance.

8.7. Sources of Funding Project Implementation and O&M

This section shall include the options available for adopted funding structure. Refer Chapter 11.0 of the TMICC Operations Document for guidance.

9. RESOURCES, REFERENCES AND CONTACT DETAILS

9.1. Resources & References

This section shall include details of resources and references, reference heading, publication number, if any, author /organisation, place, month YYYY etc.

9.2. Contact Details

Provide contact details with name, contact details, organisation, and position held etc. who were consulted during the preparation of the DPR

10. Annexure

10.1. Annexure 1: Minutes of Meetings with City Stakeholders

Insert minutes of meeting(s) with attendance details

10.2. Annexure 2: Data Collected from City Stakeholders

Insert data collected from stakeholders

Insert table etc.

10.3. Annexure 3: List of Applicable Standards

Insert list of applicable standards for TMICC

10.4. Annexure 4: Draft Memorandum of Understanding

Provide draft of MoU with the agencies.

Annexure 7: Data Security

1. Security Architecture

Security can be characterised as a system's ability to resist unauthorised access while still providing its services to legitimate users. An attempt to breach security may be an unauthorised attempt to access data or services or to deny services to legitimate users. Security Management is the process of protecting and maintaining the Confidentiality, Integrity and Availability of data.

As part of security management, following security issues will be addressed for system:

- Services must only be available to authorised staff
- Data must be available only to authorised staff and only at agreed times
- Services must be recoverable within the agreed confidentiality and integrity parameters
- Services must be designed and operated within IT security policies
- Controlled access to hardware or software

Security management in the system will be implemented by providing non-repudiation, confidentiality, integrity, availability, and auditing. Security will address various type of threats such as unauthorised access to the application, network, data and virus etc.

The solution will address security areas such as:

- A. Application Security:** Including user authentication, authorisation, audit trails and DB security.
- B. Network Security:** The Data Centre network security design will be multi-tier architecture and it will be divided in multiple zones. For securing the Data Centre, DDoS protection will take care of denial of services attacks for Network as well as Application level. Next Generation firewall will control and inspect the all inbound and outbound traffic, the Intrusion prevention systems will carry out state inspection and multiple layers of Firewalls will manage the access control.

Security zones will be defined at the Data Centre with security levels defined for each zone to minimise the impact in case of an attack. The access between zones will be controlled with firewalls and routers. Further application and database tiers will be secured by limiting the user access to web servers only.

Specific content level scanning products like Anti-Spam, proxy servers & network anti-virus gateways will be provisioned at appropriate points to ensure content level scanning, blocking and access.

- C. Storage Security:** The master and transactional data stored will be secured by controlling access through application and network security measures such as securing the storage from internal threats by controlling access through proper authorisations, isolating each storage environment from other storage environment etc.
- D. OS Hardening and Vulnerabilities security:** Appropriate Enterprise Security software will be deployed for OS hardening policies. The software shall protect specific operating

system platforms from security vulnerabilities that could compromise the confidentiality, integrity, and/or availability of data that is stored and transmitted network.

Appropriate security policies and third party audits will be put in place to ensure and guarantee security of the data and the system.

2. Backup and Archiving Strategy

A. Backup Strategy

A well-defined backup strategy facilitates minimum loss of information in case of an accidental deletion, corruption of data, system failure etc. Data back-up on secondary media is done in addition to the replication of the data on DR site. Backup strategy depends on size of database and rate of growth of database.

The backup strategy will include a sequence of incremental and full back up of data on object store, as described in Table below:

Data Backup Strategy

S. No	Backup Type	Description of Backup
1	Onsite Backup	<ul style="list-style-type: none"> • Daily Incremental Backup – 6 copies • Weekly Incremental Backup – 4 copies • Monthly Full Backup – 3 copies • Quarterly Full Backup – 4 copies
2	Archive Backup	<ul style="list-style-type: none"> • Monthly Full Backup 5 years

B. Archival Strategy

Considering the large data size and data's importance, archival strategy will support offline storage of data for meeting legal requirements, fulfilling long-term regulatory compliances and for business continuity.

Considering the volume of the data which will be generated as part of the system, it will not be possible to store all the data for a long period in database in the National Backend Data Centre. As such, transactional data after a specified period will be archived in accordance to the archival strategy. In order to effectively manage archival and retrieval of data, the archival strategy could include the following:

- Data of all vehicles belonging to one city may be kept together.
- Data of specified category of vehicles of a city (say auto-rickshaws, taxi, buses, etc.), can be grouped together.
- CCTV images can be stored separately.

Annexure 8: Indicative Terms of Reference

The Consultant shall follow the Generic Operations Document for TMICC & NUTH prepared by the MoUD for preparing city specific documents. The generic Operations Documents shall be made available on the MoUD's website. These Terms of Reference (TOR) cover scope of work for both TMICC as well as NUTH. In case the city is planning to implement only one of the systems, the TOR may be amended.

The indicative scope of the empanelled consultants is as follows:

1. Development of City Specific Concept Reports

Task 1a: Prepare TMICC Concept Plan, inclusive of:

- i. Identification of ITS & TMICC needs for the city based on data analysis and collection
- ii. Identification of stakeholders
- iii. Drawing up of implementation role of various stakeholders
- iv. Identification of ITS application and TMICC system design to support the applications
- v. Plan for administration and management of the system
- vi. Broad Costing for setting up of the TMICC – upfront and on going
- vii. Sources of revenue

Task 1b: Prepare NUTH Concept Plan, inclusive of:

- i. A city-wide vision for transit as a multimodal resource
- ii. Type of information to be disseminated to the users
- iii. User friendly technologies for interactive voice response and web based systems
- iv. Plan for administration and management of the system
- v. Broad Costing for setting up of the NUTH – upfront and on going
- vi. Marketing to the users
- vii. Sources of revenue

Task 1c: Site selection and design of TMICC-NUTH facility

The Consultant would be expected to evaluate and suggest a suitable site(s) for housing the TMICC-NUTH. Once the site is finalised by the authority, the Consultant would be required to carry out detailed design of the facility.

Task 1d: Project Structuring

- i. Phasing of the build-out of the TMICC-NUTH facility
- ii. Prepare Business Plan for the TMICC-NUTH facility
- iii. Examine possibility of implementing the project/sub-projects on PPP format and draw up the broad structure for the same

2. Development of Detailed Technical Reports

The Consultant shall draw up the following for the TMICC and the NUTH:

- i. Detailed functional requirements of the system in line with the respective Generic Operations Documents
- ii. Based on the above, compare different technical requirements and draw up the detailed technical requirements of the systems (including hardware specifications)
- iii. Detailed design of the facility (sizing, floor plan, data centre design, utilities design etc.)
- iv. Detailing of operating procedures and processes
- v. Cost-benefit analysis and implementation phasing, if necessary
- vi. Detailed cost estimates, for the purpose of the Tender Documents

The Consultant shall adopt a Systems Engineering approach towards delivery of scope listed under Items 1 and 2 above. The consultant shall also include a chapter in the Detailed Technical Report, detailing the plan on how to expand and/or upgrade the TMICC and/or NUTH in the future.

3. Agreements between Stakeholders

The consultant shall be responsible for drawing up of the agreements between the various stakeholders of the traffic management centre. The agreement would clearly set out the roles and responsibilities of each stakeholder.

4. Preparation of Tender Documents

The Consultant would be responsible for assisting the implementing agency nominated for setting up of the TMICC in carrying out a transparent bidding process for appointment of vendors. The Consultant would be responsible for:

- i. Parceling of work packages and
- ii. Preparation of bid documents, setting out the scope of work, qualification and evaluation criteria of proposals in consultation with city specific government entity.
- iii. Preparation of formats for bid submission.

- iv. Preparation of and Request for Proposal (RFP) comprising the eligibility criteria, qualification criteria and evaluation methodology for selection of Successful Bidder for the development/procurement of the TMICC/NUTH.
- v. Preparation Draft Agreement for any procurement in consultation with city specific government entity. The Draft Agreement would comprise roles and responsibilities of the stakeholder, payment terms, events of defaults, termination conditions, termination payments, design and construction requirements, O&M requirements (if any) etc.

5. Bid Process Management

The consultant shall assist the implementing agency in bid process management and contract management for _____ (*item of work*).

The various tasks involved in Bid Process Management may include the following:

Task 5a: Assistance in Pre-bid conference

The consultant shall provide the following assistance in the pre-bid conference,

- a. Participate in the pre-bid conference
- b. Prepare minutes of the pre-bid meeting and assist implementing agency in preparation of responses to the queries received.

Task 5b: The Consultant shall carry out the following on behalf of the implementing agency as a part of evaluation of proposals:

Stage 1: Scrutiny of “Key Submissions”

Stage 2: Evaluation of “Qualification Information”

Stage 3: Evaluation of “Technical Proposal” and

Stage 4: Evaluation of the “Financial Proposal”.

Stage 1: Scrutiny of “Key Submissions”

The Bidders would be required to submit documents as listed in the RFP document along with supporting documents validating their eligibility, technical experience and financial capability. The proposals submitted by Bidders would have to be checked for key submissions and responsiveness to ascertain that the documents required in accordance with the RFP are submitted. The key submissions could include the following.

- Covering Letter for submission of proposal
- Details of Bidder
- Power of Attorney
- Memorandum of Understanding in case of Consortium

- Anti-Collusion Certificate
- Bid Security

Stage 2: Evaluation of “Qualification Information”

The responsive proposals would then be evaluated on the basis of the Qualification Information, Technical Proposal and Financial Proposal criteria.

Stage 3: Evaluation of “Technical Proposal”

The Technical Proposals of the Bidders, who pass Stage 2 evaluation, as described above, would then be evaluated on various parameters according to the RFP.

Stage 4: Evaluation of “Financial Proposal”

The Bidder quoting the lowest Financial Proposal would be the Successful Bidder for development of the Project.

Based on the project structure and implementation plan finalised by the implementing agency, the project may involve multiple bid processes.

6. Project Monitoring and Management

After successful completion of the bidding process, the Consultant would be required to carry out the project monitoring and management on behalf of the implementing agency. This would include the following:

- i. Finalisation of Functional Requirements and System Requirements Specification in consultation with the implementing agency
- ii. Vetting of the Implementation Plan submitted by the Vendor
- iii. Monitoring the progress of implementation and variations from the plan
- iv. Monitoring, testing and certifying quality of implementation
- v. Examining the impact of Change Requests and providing recommendations on the same

SUSTAINABLE URBAN TRANSPORT PROJECT (SUTP)

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