NATIONAL HIGHWAY AUTHORITY OF INDIA

THE REPUBLIC OF INDIA

TECHNICAL SUPPORT
ON
DELHI EASTERN PERIPHERAL EXPRESSWAY CONSTRUCTION PROJECT
IN
THE REPUBLIC OF INDIA
(ITS SUPPLEMENTAL STUDY)

FINAL REPORT

JUNE 2018

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.

METROPOLITAN EXPRESSWAY CO., LTD.

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Summary

1. Outline of the Country

India, located in South Asia, has the largest land area (3.28746 million km^2) among other South Asian countries and is second-ranked in the highest population in the world with 1.21057 billion people (Census Population Record, 2011).

The Delhi National Capital Region, which is the capital of the India, is an industrial city having a population of around 21.7 million people (ranked 1st in India). It is referred to as largest city in India. The Delhi National Capital Region is an important economic hub in India where many Indian and overseas companies are starting to expand.

2. Background of the Project

The traffic issues surrounding Delhi city include heavy cargo traffic, noise deterioration, problems on traffic safety, moving delay, and cargo corruption due to bad status of substitute route condition, etc.

For these reasons, India requested the Japanese government to support the introduction of ITS (Intelligent Transport System) equipment by providing Loan for the eastern half section (total extension 135 km) of Ring Road in Delhi city suburbs, which NHAI (National Highway Authority of India) is currently planning. In response, basic information collection in "Support of Delhi Eastern Peripheral Expressway Construction work Compilation" (ITS Introduction Plan) was performed from January to April 2015 for the ITS equipment configuration and integration.

Moreover since the Loan Project was formed by picking up only the ITS part due to strong interest of Indian government, the suitability of technical aspect in this project as well as the study of materials required for the audit of Loan for project cost and management maintenance control system was to be performed.

Table1 Project overview

Item	Contents
Project name	Introduction project of Delhi Eastern Peripheral Expressway ITS equipment
Project purpose	By adopting the ITS equipment in Delhi Eastern Peripheral Expressway, efficiency of management maintenance control and smoothing of road traffic of the said expressway are to be improved.
Request overview	Adoption of the ITS equipment (automatic toll management system (ATMS), advanced traffic management system (ATMS), highway maintenance control system, etc.) in the Delhi Eastern Peripheral Expressway (EPE), total extension 135 km）. The Delhi EPE is an access controlled toll highway.

（Source: JICA Study Team）

3. Outline of the Study Result and the Project

Considering the request from the Government of India, JICA dispatched the JICA Study Team to Delhi three times from the 31st January 2016 to 18th Jun 2016. Activities done by the team during the survey in Delhi were: 1) discussion related to the Project among relevant agencies such as the NHAI(: National Highway Authority of India) and MoRTH(: Ministry of Road Transport and Highway), 2) Design of Toll Management System based on Demand forecasting, 3)Design of Advanced Traffic Management System.

(1) Study areas

Uttar Pradesh state, Haryana sate and Delhi Eastern Peripheral Expressway in India

(2) Partner related authorities

NHAI (National Highway Authority of India)
MoRTH (Ministry of Road Transport and Highway)

(3) Outline of ITS system

1) Advanced traffic management system

The information on traffic status and meteorological status for through traffic lane is collected from the information collectors installed on the roadside, and is transmitted to the advanced traffic management center by the fiber optic cable on the through traffic lane. In the advanced traffic management center, the information is processed and analyzed, and uniform management of the information is carried out as well as information supply to road users by information supply devices such as variable road information signs, internet, etc.

Table 2 Advanced traffic management system topics in EPE

Class.	Equipment	Purpose	Layout planning	Function
Inform. collect. equip.	Traffic monitor camera (CCTV)	Traffic status monitoring	1 camera between ICs	Vehicle shooting, video output
	Abnormality monitor camera (VIDS)	Abnormal event monitoring	Black spots where accidents frequently occur	Vehicle shooting, video output, abnormal detection, notice
	Traffic volume measuring device (ATCC)	Traffic situation monitoring	1 device between ICs	Traffic volume by vehicle type, vehicle speed, occupancy
	Meteorological Observation Station (MOS)	Meteorological. information collection	All ICs	Rainfall, precipitation and fog detection
	Environmental Observation Station (EOS)	Meteorological. information collection	All ICs	Rainfall, precipitation and fog detection
	Travel Time Measuring System (TTMS)	Meteorological. information collection	1 device between ICs	Rainfall, precipitation and fog detection
Inform. supply equip.	Variable road information sign (VMS)	Visual information supply to driver	Through line: 200m on this side of IC exit	Traffic status supply of through line front
			IC entrance (EPE outside)	EPE and Delhi city traffic
			IC entrance (EPE inside)	EPE traffic status supply
			Mobile information plate	Front traffic status supply
	Internet	Information supply to civilian by internet	(Exception)	EPE traffic information, EPE fare search
	Highway radio (HWR)	Information supply to driver by voice	To install transmission station and antenna tower on IC (20 – 30km distance)	Voice by 3 languages
Commun. system	Fiber optic cable	Connection of information collect and supply to advanced traffic management center	Up and down line of peripheral expressway	Information transmission between devices
	Transmission system device	Consisting of layer 3 switch, layer 2 switch and media converter	To install each device inside	Redundancy maintenance by loop function
Power supply equip.	Uninterruptable power supply, non-utility generator	Maintaining stable operation of each device	All ICs	Power supply to each device
Inform. process & analys	Advanced traffic management center device, server, firewall, network control, large display, call center	Integration of information collection device and information supply device	Advanced traffic management center to be installed on any IC	Redundancy maintenance by server duplication

（Source: JICA Study Team）

2) Toll Management System

The toll management system uses both manual collection and automatic electronic toll collection systems, and charges by distance-based pricing.

Table 3 Toll management system overview in EPE

Classification	Contents
Charge system	Distance-based pricing
Toll management sys.	Both usage of manual and ETC
ETC system	RFID（Radio Frequency IDentification）[1]

（Source: JICA Study Team）

[1] The technology which corresponds information by the radio communication from the RF tags which ID information was buried in (the plate which memory media used non-contact IC chip and antenna plate were buried)

4. Project Plan

The Project period shall be needed 18months for TMS, and 21months for ATMS. And completion of installation, O&M scheme will be procured for 4 years.

Total cost for the Project is 11,738 million yen, of which 6,870 million yen is JICA Loan amount.

5. Project Evaluation

5-1. Relevance

In order to keep pace with the increase of the traffic demand at Delhi National Capital Region, the development of road infrastructure is underway as the structural measure. Therefore, the urgent non-structural measure is required.

The mitigation of the traffic condition in the area greatly contributes to the economic development of the India.

NHAI is now engaged in the reinforcement of its personnel capable of planning the future road transportation plan including the ITS. With these backgrounds, NHAI have enough personnel organizations and finance to operate and maintain the introduced system on the Project.

Considering the emergency of the Project, the effect to the economy and the operation and maintenance, the relevance of the Project is greatly expected.

5-2. Effectiveness

(1) Direct Effects

Following quantitative effects are expected by the Project.

Table-4 Outcome (Effect Index)

Index	Base Line (Measured Value in 2016*)	Target Value <2 years after the completion of the Project>
Traffic Accident Rate (Per 1,000 cars /km)	NA	0.018%
Average Time for Emergency Action (Mean time from notice to arrival)	NA	20 minutes
Que Length of waiting for payment at Toll lane (Average)	NA	0 m

(Source: JICA Study Team)

* Actual Values is not existed because EPE is under construction.

(2) Indirect Effects

Traffic jam improvement in the Delhi National Capital Region, improvement of advantage convenience by keeping a constant transit time and development of regional economic in this area are expected.

Moreover, cushion against global warming by reduction of greenhouse gas emissions is expected.

(3) Economic Internal Rate of Return

As the result of the economic analysis, Economic Internal Rate of Return (EIRR) is 9.0 percent.

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Abbreviations

ASST	Assistant
ATCC	Automatic Traffic Counters cum Classifier
ATMS	Advanced Traffic Management System
BFTL	Badarpur Faridabad Tollways Limited
BOQ	Bill of Quantity
CCH	Central Clearing House
CCTV	Closed Circuit Television
DATR	Delhi Agra Toll Road
DIMTS	Delhi Integrated Multimodal Transit System Ltd
DSC	Divisional Sub Centre
DWG	Drawing
EIRR	Economic Internal Rate of Return
EOS	Environmental observation System
EPE	Eastern Peripheral Expressway
ETC	Electric Toll Collection
FC	Foreign Currency
GM	General Manager
GOI	Government of India
GOJ	Government of Japan
HDPE	Hi Density Polyethylene
HH	Hand Hole
HR	Human Resources
HWR	Highway radio
IC	Inter Change
IHMCL	Indian Highway Management Company Limited
ITS	Intelligent Transport System
JH	Japan Highway Public Cooperation
LC	Local Currency
MCEPL	Millennium City Expressway Pvt. Limited
MH	Man Hole
MOS	Meteorological Observation System
MRCS	Mobile Radio Communication System
MRCS	Mobile Radio Communication System
MoRTH	Ministry of Road Transport & Highways
NH	National Highway
NHAI	National Highways Authority of India
O&M	Operation and Maintenance
OD	Origin Destination
PCU	Passenger Car Unit
PIU	Project Implementation Unit
POS	Point of Sale

PTZ	Pan Tilled Zoom
RFID	Radio Frequency Identification
ROW	Right of Way
SBD	Sample Bid Document
SH	State Highway
TMC	Traffic Management Centre
TMCS	Traffic Monitor Camera System
TMS	Toll Management System
TTMS	Travel Time Measurement System
UPS	Uninterrupted Power Supply
VAT	Value Added Tax
VIDS	Video Incident Detection System
VMS	Variable Message System
WMS	Weigh Monitoring System
WPE	Western Peripheral Expressway

1 Confirmation of Project Background and History

1.1 Background

Delhi is an important transport centre, large numbers of commercial vehicles are passing through the city as a transit point. However, the road infrastructure surrounding the city is not sufficient; a lot of vehicles have to enter the city to pass through. To avoid the traffic congestion in the city during daytime, traffic restriction system was introduced. However, due to insufficient surrounding roads and this traffic restriction system, more vehicles enter the city at night. It causes environmental problem such as noise, air pollution and traffic safety problems. In addition, vehicles that need to pass through the city in daytime have to use the alternative routes in the suburbs of Delhi because of the traffic restriction system in the city, however the alternative routes are in poor condition, therefore they need more time to pass through and the cargo is damaged by rough road.

Based on such back ground, GOI planned to construct an outer ring road around Delhi, and construction of Western Peripheral Expressway (hereinafter referred to as "WPE") has already started as a PPP Project, and also construction of Eastern Peripheral Expressway (hereinafter referred to as "EPE") has also started by National Highways Authority of India (hereinafter referred to as "NHAI"). EPE is a 135-km long tolled access-control highway that starts at Kundli which crosses National Highway (hereinafter referred to as "NH") 1, and ends at Palwal, which crosses NH 2.

And, GOI requested Government of Japan (hereinafter referred to as "GOJ") to provide loan assistance in carrying out the introduction of Integrated Traffic System (hereinafter referred to as "ITS") to the east half of the outer ring road around Delhi named Eastern Peripheral Expressway (EPE) planned to be completed by NHAI.

In response, basic information collection in "Support of Delhi Eastern Peripheral Expressway Construction work Compilation" (ITS Introduction Plan) was performed from January to April 2015 for the ITS equipment configuration and integration. Moreover since the Loan Project was formed by picking up only the ITS part due to strong interest of Indian government, the suitability of technical aspect in this project as well as the study of equpment required for the examinationt of Loan for project cost and management maintenance control system was to be performed.

1.2 Existing ITS in India

To study existing ITS in India, site surveys have been conducted of toll plazas and control rooms of the highways/expressways connecting EPE and Delhi to understand the current structure and requirement of similar project under operations. Following projects were visited by the team:

- Badarpur Faridabad Tollways Limited (BFTL) Toll Plaza, NH-2 (Concessionaire – Hindustan Construction Company (HCC))

- Delhi Agra Toll Road (DATR) Project, Palwal Toll Plaza – Dedicated ETC Lane, NH-2 (Concessionaire – Reliance Infra)

- Millennium City Expressway Pvt. Limited(MCEPL) Project, Km 24 Traffic Control Room, NH-8 (Concessionaire – MCEPL)

- Yamuna Expressway Project, Km 38 (Jewar Toll Plaza) Control Room (Concessionaire – Jaiprakash Infrastructure Limited

The equipment is installed by the concessionaires at the toll plazas for following reasons:

- To meet the minimum requirement concession agreement

- Management prospective is ensure that the toll collection/revenue is recorded properly and pilferage at the toll plazas (by operations staff) can be minimized and company gets all the money collected at toll plaza.

Therefore, almost all of the concessionaire is not concerned about the user. They mainly want the minimum requirement for O&M at the least possible price. That is why the system installed even 2-3 years back is quite old (as per the current international standards)

The ETC system being installed is strictly as per the NHAI and Indian Highway Management Company Limited (IHMCL) guidelines and is same at all the Toll Plazas (both NHAI plazas and Concessionaire plazas) The new ETC system is independent of the existing TMS system at the toll plazas.

The description of equipment installed at each of the project is as follows:

1.2.1 Badarpur Faridabad Tollways Limited (BFTL) Toll Plaza

	Item	Description	Make	Country
1	Plaza area camera	10X OPTICAL P/T/Z CAMERA, WIII DSP Chip (Model: SPD-1000P)	Samsung	China (Purchased locally in India)
2	DVR	MPEG4, 480 X 120, High Resolution Image(704*576, 704*288, 352*288), MAX 4HDD, 3 USB, PC Mouse, User Friendly GUI, DVD-RW, N/W, 320GB HDD (Model: SVR-1645NWH250)	Samsung	China (Purchased locally in India)
3	Fixed view cameras for Highway	1/3—inch, Advanced WDR, 540 TVL, PAL,2X DSP, 230 VAC, 50 Hz (Model: LTC 0498/51) LTC 3674/20 Varifocal Lens IR corrected	Bosch	Germany
4	Camera outdoor housing IP 67	Camera Outdoor Housing for Fixed Camera with IP67	Bosch	Germany
5	1 KVA UPS with 30 min backup	Liebert Emerson Make 1 KVA MTLB UPS Battery for 30 minutes Backup Time	Emerson	India
6	DVR	MPEG4, 480 X 120, High Resolution Image(704*576,	Samsung	China (Purchased

		704*288, 352*288), MAX 4HDD, 3 USB, PC Mouse, User Friendly GUI, DVD-RW, N/W, 250GB HDD (Model: SVR-1645NWH250)		locally in India)
7	Keyboard with Joystick for plaza area cameras	PTZ Controller (Model: STCSCC1000)	Samsung,	China (Purchased locally in India)
8	Monitors in control room	19" TFT	Samsung	China (Purchased locally in India)
9	Projector for highway cameras			China (Purchased locally in India)
10	Desktops in Control room	Intel® Pentium® Dual-Core E5300 Processor (2.60GHz 800MHz 2MB) 2 GB PC3-8500 DDR3 SDRAM 1066MHz Hard drive device 250GB 19" TFT monitor , Windows XP	IBM / HCL	India
11	VMS 2 line, 12 char, picto			India
12	VMS 1 line, 12 char		Envoys	India
13	Base station, antenna etc	Motorola GM338 base station WITH ANTENNA setup along with the accessories	Motorola	India
14	Vehicle mounted sets	Motorola GP 338 portable hanheld sets along with the accessories	Motorola	India
15	Handheld units	Motorola GP 328 portable hanheld sets along with the accessories	Motorola	India
16	Charger unit for hand held	6/1 rapid chargers	Motorola	India
17	Wire for Loop	1 Core 1.5 sqmm 22 strand flexible cable	Finolex/polycab	India
18	Booth camera	W-IV DSP, 580 TV LINES, 0.15LUX, ICR D&N FUNCTION, SSNRII, HLC, DIS, OSD, M/D, Privacy Masking, 3.6x(2.8~10mm) Varifocal Lens, DC12V (Model: SID-460WP)	Samsung	China (Purchased locally in India)
19	Lane Controller		Efkon Custom Built	India
20	AVC Analyser (Classax with Loop Detector)	Classax Assembly single component + loop detector:MD-220 v2.CLX0	Sensorline	Germany
21	Height Sensors	Height Sensors	Sunwave	India
22	Customozied Key Board USB Type	G86-63400EUADAA (Grey Colour)	Cherry	India
23	Operator Monitor	15" TFT		
24	Traffic Light	LED based,2 aspects - red / green, controller by - By LC , Diameter 200 mm, Visibility - 30 meters	Envoys	India
25	User Fare Display 2 Line 12 Character - NO BOLD FEATURE	12 character Normal, 60mm, 2 line, Size ~ 870L x 180H x 130W mm ,Visibility - 30 meters	Envoys	India
26	Overhead Lane Signal	450 mmx450 display, canopy mounting, Red cross, Green arrow,, Visibility - 300 meters	Envoys	India
27	FOG Light	200mm Dia, Visibility - 200 meter minimun, Plastic cabinet	Envoys	India
28	Lane Intercom Unit	NA-A Sub station: NA-A	Aiphone	Japan
29	Siren	DC (24V operated) Horizontal	Paramount	India

		siren 100 mts range		
30	Amber Light	Revolving Light 24DC	Kheraj	India
31	Panic Alarm Switch	Simens make mushroom actuator red with 02 NO contact	Indian Electro Trade	India
32	Receipt Printer	Epson Thermal TM 88 IV	Epson	China (Purchased locally in India)
33	Incident Camera	Built-In SSNR, 1/3" Colour, 530TVL(Color), 550TVL(B/W), 50dB, Internal, Line Lock, 0.002Lux (F 1.2 Sense Up), 0.3Lux(F1.2), Motion Detect, Privacy Image Masking, C/CS mount , DC12V: SDC-313BPD	Samsung	China (Purchased locally in India)
34	Automatic Barrier	High Speed Barriers for normal lanes - Boom – Aluminium, Dia 75x1.4mm , Length 3000mm	Magnetic (MIB 20)	Germany
35	Smart Card Reader	Outdoor Smart Card Reader without Adapter, reading range 8 to 10 cm	TRACK RF LINK	China
36	Bar Code Readers - USB type	Barcode scanner - USB type : LS2208	Symbol	China (Purchased locally in India)
37	Manual Booth Controller-external switches	Custom Built	Madhura	India
38	Handheld Terminal		Coromandal	China (Purchased locally in India)
39	Transceiver (IR based)	IS TR P10-A	Efkon AG	Austria
40	Automatic Barrier (0.6 sec)	High Speed Barriers for normal lanes - Boom – Aluminium, Dia 75x1.4mm , Length 3000mm, Automatic Barrier RAL 2000 color housing, Logic Controller + Software for two loops suitable for normal lane.	Magnetic	Germany
41	Plaza Equipment			
42	Toll Plaza Server	IBM X3200M2 Server - 4367xxx /4368xxx Quad-Core Intel Xeon E3310 Processor 3.0 GHz	IBM	India
43	Workstation	Intel® Pentium® Dual-Core E5300 Processor, 2 GB PC3-8500 DDR3 SDRAM 1066MHz Hard drive device 250GB 19" TFT monitor, Windows XP	IBM	India
44				
45	POS Printer – Laser	HP1008	HP	India
46	Master Intercom Unit	NEM -20A/C (Master station) with Power supply adapter: PS -2420S		Japan
47	ORACLE 10G		Oracle	India
48	Antivirus with Firewall	For all workstations & server & lanes - SYMC antivirus with in built firewall	SYMANTEC	India
49	TOLL SOFTWARE			
50	Lane Software		EFKON	India
51	ETC Software		Efkon	India
52	Toll Management		Efkon	India
53	UPS with Battery			India
54	6kVA UPS with 30 mins backup for Lane	Power Bank 6KVA (6KVA UPS) + Battery 26 AH - 16 nos	Emerson	India

Source: JICA Study Team

1.2.2 Delhi Agra Toll Road (DATR) Project, Palwal Toll Plaza

S. No.	Item	Description	Make	Country
1	RFID ETC transceiver (entry) – over lane entrance (AVI)	Procyon - UHF RFID integrated Reader, 12dbi, ETSI, EPC, Class1 Gen2/ ISO18000-6C with mounting bracket	Star	Hong Kong
2	RFID ETC transceiver (exit) – for transaction – over lane Canopy near AVC	Procyon - UHF RFID integrated Reader, 12dbi, ETSI, EPC, Class1 Gen2/ ISO18000-6C with mounting bracket	Star	Hong Kong
3	Electronics Enclosure	Electronics enclosure with Twedo PLC	Teknocrat	India
4	Lane Controller with Industrial PC	ARK-3360L	Advantech	China
5	AVC Sensor Set	Emitter Sensing range-20m with Cable 2m (QS186E) & Receiver Sensing range-20m with Cable 2m (QS18VN6R) i.e (1Emitter+1Receiver) one set	Banner	China (Purchased locally in India)
6	Height Sensor Set	Emitter Sensing range-20m with Cable 2m (QS186E) & Receiver Sensing range-20m with Cable 2m (QS18VN6R) i.e (1Emitter+1Receiver) one set	Banner	China (Purchased locally in India)
7	User Fare Display	EE - UFD - 2 - FM - R - ML - L - P	Envoys	India
8	Automatic Barrier Gate	MAUT 30	Elka	Germany
9	Overhead Lane Status light (OHLS)	EE - OHLS - PC - 300	Envoys	India
10	Vehicle Guidance Signal – Traffic light	Traffic light (200mm Dia Amber Arrow + Green Ball)	Envoys	India
11	Single Channel Loop Detector	LDP1SA1BM24 (Relay SPDT)	Carlo Gavazzi or equivalent	China (Purchased locally in India)
12	Dual Channel Loop Detector	LDP2TA2BM24 (Relay SPST)	Carlo Gavazzi or equivalent	China (Purchased locally in India)
13	11 Pin Socket	11 Pin Socket	Paramount or equivalent	India
14	Sensor set for light curtains	Emitter Sensing range-20m with Cable 2m (QS186E) & Receiver Sensing range-20m with Cable 2m (QS18VN6R) i.e (1Emitter+1Receiver) one set	Banner	China (Purchased locally in India)
15	Incident Capture Camera	DS-2CD2010-I (with 6 mm lense)	Hikvision	China (Purchased locally in India)
16	License Plate Image Capture Camera	DS-2CD2010-I (with 12 mm lense)	Hikvision	China (Purchased locally in India)
17	Hand-held RFID Reader	Platino UHF Handheld Reader (CE/ETSI Region frequencies) with WIFI, including USB cables and carry case	Star	Hong Kong
18	Local ETC Plaza Server in a hot-	HP ML350P Gen8 E5-2609V2 P/N- G7U06A	HP	India

	standby configuration	HP 512 FBWC P- Series Smart Array P/n- 661069-B21 3 nos. HP 300 GB 6G SAS 10K 2.5 HDD P/N- 652564-B21 19.5 TFT Monitor Acer HP WIN12 R2 Std ROK P/n- 748921-371		
19	Incident Management Workstation	Acer Desktop with 18.5"TFT Acer, MS Win 8.1SL 32 Bit OEM	Acer	China (Purchased locally in India)
20	Network Printer	HP Laserjet 1020+ Printer	HP	India
21	8 port switch	Netgare 8 Port Switch	Dlink/Netgare	China (Purchased locally in India)
22	8 port switch with POE	TP Link TLSF-1008P 8 Port POE	TP Link	China (Purchased locally in India)
23	POE Injector	TP Link POE 150S	TP Link	China (Purchased locally in India)
24	WLAN switch	D-Link DWR-111-3G Router with WAN	Dlink	China (Purchased locally in India)
25	Set of maintenance tools including Laptop computer	Acer E-511 Laptop with MS Win 8.1SL 32 Bit OEM and carry bag	Acer	China (Purchased locally in India)

1.2.3 Millennium City Expressway Pvt. Limited(MCEPL) Project CCTV system

S. No.	Item	Description	Make	Country
1	CCTV Camera	SD8363E , 20x High HD 2.0mega pixel with mount	Vivotek	Tiawan
2	Roadside Cabinets	Standard IP 65 pole mounted cabinet for putting LIU, patch cord and UPS with battery	Standard	India
3	Industrial Media Converter		Kyland	China
4	UPS	Eton 500VA with 1 hours backup	Eton	India
5	LCD 42 inches	42” LCD display	LG	India
6	Frame for 4 LCD 42 inches each	Customized frame for covering LCD displays	Customised	India
7	Switch and LIU in Control room	8 port Network Switch and LIU	Kyland	China
8	CCTV Client Workstation	Desktop with 18.5"TFT, MS Win 8.1SL 32 Bit OEM	HP	India
9	Keyboard with Joystick		Vivotek	Taiwan
10	Video Management Software	NUUO VMS	Nuuo	India
11	Projector	with 2200 Luminious	BenQ	China
12	Server Rack 42U	Standard server rack with accessories to install 1 sever	D-Link	India
13	Link for Wireless	RF P2P 2.4 GHz wireless link	Altai	China

Source: JICA Study Team

1.2.4 Yamuna Expressway Project, Km 38 (Jewar Toll Plaza)

S. No.	Item	Description	Make	Country
Indigenous Items				
1	**Toll Booth**			
1.01	Ticket Issuer Enclosure	Rittal Enclosure with Cooling arrangement to accommodate on ramp booth eqipmemts	Rittal, Custom Built	India
1.02	Toll Lane Computer	AIMB-567 (VGA, DVI-I, Audio Codec Realtek ALC892, GbE LAN1: Intel 82578DM, GbE LAN2: Intel 82583V), Intel Core 2 duo, HDD-500 GB, RAM-4GB, Surge Suppressor unit	Efkon, Custom Built	India
1.03	Screen	E1720NR (17" TFT)	Samsung	India
1.04	Keyboard	G86-63400EUADAA 142 programmable keys	Cherry	India
1.05	Receipt Printer	TM-T88IV , High-speed printing of upto 7.9"/sec	Epson	
1.06	Outdoor Touch & Go (CSC) Reader	Contact less Smart Card Reader (ISO 14443 Type A) Read Range upto 10cm, -10 °C to +70 °C	Mifare	China
1.07	Bar Code Reader (Internal)	AS - 8250	Argox	India
1.08	Lane Intercom Unit (Unmanned Booth, External Weather Proof)	NE - JA weather resistant	AI – Phone	Japan
2	**Toll Lane**			
2.01	Manual Lane Entry Barrier with Switch, including Boom Arm	EE-MLB-35, Manual barrier with Switch and boom arm as per the lane width	Envoys	India
2.02	User Fare Display (other than motorcycle lanes) incld. Poles	3 Lines, 12 chararacters per line, 75 mm character height, mounted on pole of Dia 110mm (3m high, 110mm dia, 2mm thk)	Envoys UFD/75-2-18-R-E-L-P	India
2.03	User Fare Display (for Motorcycle Lanes) w/o Pole	1 Line, 16 characters per line, character height 45mmm, mounted on booth	Envoys, UFD/45-1-25-R-ML-L	India
2.04	Traffic Light and Aspects (Red and Green)	200 mm dia. with 2 aspects (red & green)	Envoys, EE-TTL-200PC	India
2.05	Overhead Lane Sign	450 mm x 450mm with 2 aspects (red cross & green arrow)	Envoys, EE-OHLS-450	India
2.06	Violation Siren	100 Meter Audio Range	Iota, Cap 123	India
2.07	Violation Alarm Light	Amber Light	Kheraj	India
2.08	Incident CCTV Camera, Lens, Pole & Housing	---	Samsung, SDC-313BPD	India
2.09	SSWIM CCTV Camera, Lens together with Weather Proof Enclosure for CCTV System	---	Samsung SDC-313BPD	India
2.1	SSWIM Optical Separators & Housings with mounting poles	IR based vehicle separator with 3 beams	Efkon	India
2.11	Load Gauge Sensors (4 Nos. per Set)	IR Based Load Gauge Sensors	Sunwave – Efkon	India
2.12	Fog Light (SSWIM Lanes = 2Each Lane)	300mm dia with four rings of White LED on	Envoys	India

		inner side and two rings of Amber LED on outer side		
2.13	Fog Light Controller	Custom Built to interface above FOG lights	Envoys	India
2.14	Camera Booth with Enclosure	---	Axis	China
3	**AVC Lane**			
3.01	AVC Processor and Enclosure with UPS (1.5 Kva)	1) AIMB-567 (VGA, DVI-I, Audio Codec Realtek ALC892, GbE LAN1: Intel 82578DM, GbE LAN2: Intel 82583V), Intel Core 2 duo,HDD-500 GB, RAM - 4GB, Surge Suppressor unit	1) AVC Cumtomized Computer - Efkon	India
		2) **2** KVA UPS	2) UPS - Libert - Emerson	India
3.02	Loop Detector - AVC L1 and L2	PD234	Nortech	Austria
3.03	Profile Scanner (2 per Set)	IR based - Custom Built	Efkon	India
4	Queue Length Monitoring System			
4.01	Portable Storage Device	8 GB, USM-N Series	Sony	India
4.02	Manual Booth Controller	Customized Keys (as required) for manual operation	Efkon	India
5	**Plaza Computer System**			
5.01	TMIS Server and Monitor	Processor - Intel® Xeon® X5672 3.20GHz/ 4-core, RAM - 32GB, 'HDD- 6 x 146GB, 17" TFT,Windows 2008 server- Enterprise edition, Oracle -EE + SE1 Combination	HP DL380 G7	India
5.02	TMS Server (M&A)	Processor - Intel® Xeon® E7520 ,1.86GHz/ 4-core, RAM - 64 GB, 6 x 600GB (or higher) hot plug 3.5” or 2.5” SAS/SCSI HDD ,17" TFT,'Windows 2008 server- Enterprise edition, Oracle -EE + SE1 Combination	HP DL980	India
5.03	TMIS Server and Monitor (RTP)	Processor-Intel® Xeon® Processor E5645 2.4 Ghz (1 * Hex Core), RAM - 8GB, 'HDD- 2 x 300GB, 17" TFT,Windows 2008 server- Enterprise edition, Oracle -EE + SE1 Combination	HP DL180 G6	India
5.04	PCS Server & Monitor	Processor - Intel® Xeon® X5672 3.20GHz/ 4-core, RAM 32GB, HDD- 6 x 146GB, 17" TFT,'Windows 2008 server- Enterprise edition, Oracle -EE + SE1 Combination	HP DL380 G7	India
5.05	AVC Server (DMS)	Processor-Intel® Xeon® Processor E5645 2.4 Ghz (1 * Hex Core), RAM - 8GB, 'HDD- 2 x 300GB, 17"	HP DL180 G6	India

		TFT,Windows 2008 server- Enterprise edition, Oracle -EE + SE1 Combination		
5.06	SSWIM Server	Processor-Intel® Xeon® Processor E5645 2.4 Ghz (1 * Hex Core), RAM - 8GB, 'HDD- 2 x 600GB, 17" TFT,Windows 2008 server- Enterprise edition, Oracle -EE + SE1 Combination	HP DL180 G6	India
5.07	LSDU Workstation & Monitor For MTP	Intel Core 2 duo E7500 Speed- 2.93 GHz, RAM - 4GB, HDD- 500 GB,ATI Radeon HD 4550 (512) DH x16 1st Card,23" LCD,MS Office Standard & Windows-7 preloaded	HP3090	India
5.08	LSDU Workstation & Monitor for RTP	Intel Core 2 duo E7500 Speed- 2.93 GHz, RAM - 4GB, HDD- 500 GB,ATI Radeon HD 4550 (512) DH x16 1st Card,23" LCD,MS Office Standard & Windows-7 preloaded	HP3090	India
5.09	Incident Workstation & Monitor	Intel Core 2 duo E7500 Speed- 2.93 GHz, RAM - 4GB, HDD- 500 GB,18.5" LCD,MS Office Standard & Windows-7 preloaded	HP4000SFF	India
5.1	Validation Workstation & Monitor	Intel Core 2 duo E7500 Speed- 2.93 GHz, RAM - 4GB, HDD- 500 GB,18.5" LCD,MS Office Standard & Windows-7 preloaded	HP4000SFF	India
5.11	Plaza Report Printer	Up to 30 ppm, RAM - 16 MB	HP 2035n	India
5.12	Time Server	LANTIME M300/TCR	Meinberg	India
6	**Network Equipment**			
6.01	Network Router - 24 Port	24 Ethernet 10/100 and two small form factor pluggable(SFP) Based gigabit ethernet ports 1RU	Cisco catalyst 3560G - 24TS	India
6.02	Server Rack together with Cooling Fans and Power Strips with lockable doors	Floor Mounted - Custom Built as per design requirements	Dhananjay Ind	India
6.03	Lane Switch Rack Wall Mount to Accommodate 6 Switches and Fiber Splicing Box	Wall Mounted - Custom Built as per design requirements	Dhananjay Ind	India
6.04	Cisco Firewall to accommodate 50 Users	ASA5505-50-BUN	Cisco	India -K9
6.05	In Rack UPS for Servers 6Kva for MTP	with 4 battery modules (20 minutes backup) Adapt series 6 kVA	Emerson	India
6.06	In Rack UPS for Servers 6Kva for RTP	with 4 battery modules (20 minutes backup) Adapt series 6 kVA	Emerson	India
6.07	Rack for UPS @ MTP and RTP	for Adapt series 6 kVA with 4 battery modules	Dhananjay Ind	India

6.08	Suitable 19 Rack Frames with Cooling Fans and power strip with lockable door (POS)	Floor Mounted - Custom Built as per design requirements	Dhananjay Ind	India
7	**Intercom Supply and Installation**			
7.01	VOIP Telephony System (Ramp to Mainline Plaza)	IP Master Station	Aiphone IS - IPMV	Japan
7.02	Master Station Power Supply	PS-2420S.E	Aiphone	Japan
7.03	GSM Modem	82GM	Visiontek	India
8	**Plaza DVR**			
8.01	NVR / 6TB Storage	Processor-Intel® Xeon® Processor E5645 2.4 Ghz (1 * Hex Core),RAM- 8 GB, HDD 8x1TB,RAID 5, 17" LCD,Windows 2008 server, Enterprise edition	HP DL180 G6	India
8.02	NVR / 1TB Storage	Processor-Intel® Xeon® Processor E5645 2.4 Ghz (1 * Hex Core),RAM- 8 GB, HDD 8x1TB,RAID 5, 17" LCD,Windows 2008 server, Enterprise edition	HP DL180 G6	India
8.03	DVR PC	Processor-Intel® Xeon® Processor E5620 2.4 Ghz (1 * Quad Core), RAM- 8 GB, HDD- 2x500GB, NVIDIA Quadro 600 1 GB Dedicated Graphics, 24" TFT,	HP Z800	India
9	**Plaza Camera**			
9.01	Camera Pole for outdoor camera	5 Meter Height, 4 mm thickness, Painted with an epoxy paint, Suitable Additional Mounting for “W”	Customized	India
10	**POS Computer System**			
10.01	POS Server & Monitor	Processor-Intel® Xeon® Processor E5645 2.4 Ghz (1 * Hex Core), RAM- 8 GB, HDD- 2 x 300GB, 17" TFT,Windows 2008 server- Enterprise edition, Oracle -EE + SE1 Combination	HP DL180 G6	India
10.02	POS Workstation & Monitor	Intel Core 2 duo E7500 Speed- 2.93 GHz, RAM - 4GB, HDD- 500 GB,18.5" LCD,MS Office Standard & Windows-7 preloaded	HP4000SFF P	India
10.03	POS Smart Card Reader	Read Range upto 3cm Contact less Smart Card Reader (ISO 14443 Type A)	Mifare	China
10.04	POS Bar Card Reader	AS - 8250	Argox	India
10.05	Printer POS Receipt Printer (Same as Lanes)	High-speed printing of upto 7.9"/sec	Epson TM-T88IV	India
10.06	POS Printer (All in One)	Up to 27 ppm, RAM - 64 MB	HP 2727NF	India
10.07	D2D Backup Server	Processor-Intel® Xeon® Processor E5645 2.4	HP D2D4112	India

		Ghz (1 * Hex Core), RAM- 16GB, HDD- 2 x 300GB (for DL180 G6) 12X1TB (D2D4112),17" LCD, Windows 2008 server Enterprise edition,HP Smart Array P212/ZM 1-ports Int/1-ports Ext PCIe x8 SAS Controller, Transfer rate1 TB/hr, Buffer size 256 MB, Host interface 6 Gb/sec SAS, Encryption capability AES 256 - bit, WORM capability , NO - Data Protector Latest Version as "Functionality is taken care through Efkon Application Software"	Backup System	
10.08	Rack for Servers and UPS	Floor Mounted - custom built	Dhananjay Ind	India
11	**Cashup System**			
11.01	Cashup Printer High Speed/Volume	Up to 35 ppm, RAM - 512 MB	HP 5200n	India
11.02	Cashup Workstations	Intel Core 2 duo E7500 Speed- 2.93 GHz, RAM - 4GB, HDD- 500 GB,18.5" LCD,MS Office Standard & Windows-7 preloaded	HP4000SFF	India
12	**Administration System**			
12.01	Admin Workstations	Intel Core 2 duo E7500 Speed- 2.93 GHz, RAM - 4GB, HDD- 500 GB,18.5" LCD,MS Office Standard & Windows-7 preloaded	HP4000SFF	India
12.02	Admin Printers (All in One Same as POS)	Up to 27 ppm, RAM - 64 MB	HP 2727NF	IOndia
13	**Network Equipment**			
13.01	200m MultiMode F/O Cable (16 core)	200m long, 16 Cores	Aksh / Finolex	India
13.02	Server Rack	Floor Mounted - Custom Built as per design requirements	Dhananjay Ind	India
14	**Media Supply**			
14.01	T&G Contactless Smart Cards	1k MF1 IC S50	Mifare	China
14.02	Smart Card For Toll Collector Access To Lanes	1k MF1 IC S50	Mifare	China
15	**Toll Booth - Test Rig**			
15.01	Lane Technical Cabinet	AIMB-567 (VGA, DVI-I, Audio Codec Realtek ALC892, GbE LAN1: Intel 82578DM, GbE LAN2: Intel 82583V), Intel Core 2 duo,HDD-500 GB, RAM - 4GB, Surge Suppressor unit	Efkon	India
15.02	Video Display Unit	17" TFT E1720NR	Samsung	India
15.03	Keyboard & cover	142 programmable keys G86-63400EUADAA	Cherry	India
15.04	Receipt Printer	High-speed printing of upto 7.9"/sec	Epson TM-T88IV	India
15.05	Outdoor Touch & Go (CSC) Reader	Read Range upto 10cm, -10 °C to +70 °C	Mifare	China

		Contact less Smart Card Reader (ISO 14443 Type A)		
16	**Toll Lane - Test Rig**			
16.01	User Fare Display & Lane Traffic Light (LTL)	1) 3 Lines, 12 chararacters per line, 75 mm character height, mounted on pole of Dia 110mm (3m high, 110mm dia, 2mm thk)	Envoys	India
		2) 200 mm dia. with 2 aspects (red & green)		India
16.02	Overhead Lane Sign	450 mm x 450mm with 2 aspects (red cross & green arrow)	Envoys	India
16.03	Siren	100 Meter Audio Range	Iota	India
16.04	Violation Alarm Light	Amber Light	Kheraj	India
16.05	Incident CCTV Camera, Lens & Housing	SDC-313BPD	Samsung	India
17	**ETC Lane - Test Rig**			
17.01	ETC Pole	5.5 meter pole	Custom built	India
18	**AVC Lane - Test Rig**			
18.01	AVC Processor	AIMB-567 (VGA, DVI-I, Audio Codec Realtek ALC892, GbE LAN1: Intel 82578DM, GbE LAN2: Intel 82583V), Intel Core 2 duo,HDD-500 GB, RAM - 4GB, Surge Suppressor unit	Ekon	India
18.02	AVC Simulator and Laptop	Sony VAIO Y Series YB, 11.6 (29.5 cms) wide (WXGA: 1366x768) TFT colour display , AMD Dual-Core Processor E-350 with AMD Radeon HD 6310 Discrete-Class Graphics ,Windows 7 Starter 32-bit , 2 GB RAM, 320 GB HDD	AVC Simulator (Ekon) & Laptop (Sony)	India
19	**Plaza Intercom System**			
19.01	Plaza Control Room (left and Right)	MNEM - 40 A / C	Aiphone	Japan
19.02	Toll Booth (Including Non Stop Lanes)	NA - A.E.	Aiphone	
19.03	Generator Room	NA - A.E.	Aiphone	
19.04	UPS Room	NA - A.E.	Aiphone	
19.05	Tunnel Entry/Exit/Non Stop Lanes	NE - JA with 2 SSB	Aiphone	
19.06	Cash up Room	NA - A.E.	Aiphone	
19.07	Plaza Managers Office	NA - A.E.	Aiphone	
19.08	Front Door/CIT to Plaza Building	NE - JA with 2 SSB	Aiphone	
19.09	Engineers Offices	NA - A.E.	Aiphone	
19.1	POS	NA - A.E.	Aiphone	
19.11	Corridor Control Room	NA - A.E.	Aiphone	
19.12	Spares	NA - A.E.	Aiphone	
19.13	Cable and Installation			
20	**Test Equipment & Tools**			
20.01	Electronic Tool case	Custom Built	---	India
20.02	Fluke 179 multimeter	Fluke 179	Fluke	India
20.03	Fluke 1587	Fluke 1587	Fluke	India
20.04	Fluke Mega Ohm Meter	FLUKE, 1507	Fluke	India
20.05	EA PS303205B 0-32V 5A Bench Power Supply	PS303205B	EA	India
21	**Software/ Licences**			
21.01	Lane Module for Manual and Dynamic Lanes	as per the design requirements	Efkon	India
21.02	Point of Sale Module	as per the design	Efkon	India

		requirements		
21.03	Lane Status Display Unit Module	as per the design requirements	Efkon	India
21.04	SSWIM Integration Module	as per the design requirements	Efkon	India
21.05	Administration Module License	as per the design requirements	Efkon	
21.06	Cashup Module License	as per the design requirements	Efkon	
21.07	Audit Module License	as per the design requirements	Efkon	
21.08	Report Generation Module License	as per the design requirements	Efkon	
21.09	Data Transfer Module	as per the design requirements	Efkon	
21.1	Head Quarter Monitoring System License	as per the design requirements	Efkon	
21.11	Backup Module	as per the design requirements	Efkon	
21.12	AVC Module	as per the design requirements	Efkon	
21.13	Banking Module	as per the design requirements	Efkon	
22	**Third Party Software**			
22.01	Operating System for Server	Windows 2008 server, Enterprise edition	Windows	
22.02	Oracle Database	Oracle (EE + SE1 Combination)	Oracle	
22.03	Antivirus	as per the design requirements	Symentec	
Imported Items				
1	**Toll Booth**			
1.01	Ticket Issuer	Model TD-6030	SysParc	Austria
2	**Toll Lane**			
2.01	Automatic Lane Exit Barrier (0.6 Sec)	0.6 sec opening and closing time, effective length : 3m , diameter of boom : 75 mm	Magnetic MIB 10	Germany
3	**ETC Lane**			
3.01	ETC Antenna	Sirit IDentity 4100 ETSI	Sirit	USA
3.02	Vehicle Separator	PD134	Nortech	Austria
4	**AVC Lane**			
4.01	Loop Detector - AVC L1 and L2	PD234	Nortech	Austria
	(for Motorcycle Lanes)			
4.02	Axle Sensor Counting	Fiber optic based	Sensorline	Germany
4.03	Network Switch	AMG 9242M H	AMG	UK
4.04	Multimode Fibre Converter	S18058	AMG	UK
5	**Lane Communications**			
5.01	Network Switch	AMG 9242M H	AMG	UK
5.02	Multimode Fibre Converter	S18058	AMG	UL
6	**Queue Length Monitoring System**			
6.01	Queue Length Monitoring System	PD234	Nortech	Austria
7	**Plaza Cameras**			
7.01	POS Area and Parking Areas (Outdoor)	VG4-514-ECE2W	BOSCH	Germany
7.02	POS Area (Indoor)	NDN-498V03-11P	BOSCH	
7.03	Main Entrances to the Building (Indoor)	NDN-498V03-11P	BOSCH	
7.04	Tunnel Cameras (Indoor)	NDN-498V03-11P	BOSCH	
7.05	Tunnel / Cashup Junction (Indoor)	NDN-498V03-11P	BOSCH	
7.06	Lane Area Cameras (Outdoor)	VG4-514-ECE2W	BOSCH	
7.07	Plaza Building Internal (Indoor)	NDN-498V03-11P	BOSCH	
7.08	Cashup Room (Indoor)	NDN-498V03-11P	BOSCH	
7.09	CIT Area (Indoor)	NDN-498V03-11P	BOSCH	
7.1	Internal Mounting Brackets Wall Mount	VDA-WMT-DOME	BOSCH	
7.11	Joystick & Keyboard	KBD - Digital	BOSCH	

7.12	Video Viewing & Archieving Software	VVAS	BOSCH	
7.13	Network Video Management	NVM	BOSCH	
8	**Media Supply**			
8.01	RFID On Board Units (4 wheelers)	ID-WMT-NT-L3S	Sirit	USA
8.02	RFID On Board Units (2 wheelers)	ID-HMT-NT-L3S	Sirit	

Source: JICA Study Team

1.2.5 ETC in India

The complete introduction on the status and process of ETC implementation including the functioning of Central Clearance House was provided by the IHMCL team to JICA study team. IHMCL informed that an apex committee was formed by the government of India to study the technology to be used on PAN India basis for ETC. This committee proposed the passive RFID system for PAN India ETC system which is now being implemented and monitored by IHMCL.

The standards and typical drawings were provided by IHMCL; accordingly, JICA study team will prepare the specifications for EPE ETC system.

The ETC system was started with one CCH bank in July 2015 and currently two CCH banks are operating in India.

Now IHMCL have introduced NPCI as CCH and more banks will be added as acquirers and issuers from April 2016. Till date the total ETC tags issued are only 3000 and it is expected that the penetration of ETC will be 10% by end of 2016 and 20% by 2017 with an annual increase of 10% per annum.

Capacity of per ETC lane is 1200 vehicles per hour which is almost 4 times the capacity of cash (manual) lane and more than 3 times the capacity of Touch & Go lanes (Smart Card lane) in India.

The RFID tags can be purchased and recharged at the toll plaza POS, banks and other counters to be opened by the issuer banks in near future. The users can also recharge the tags online (issuer bank website) and also link the ETC tag to a pre-paid card, credit card, wallet and bank account. The cost of tag is expected to be INR 250 and an additional security deposit of INR 200 will be taken from the user. The security deposit may vary for different vehicle class as the security deposit amount shall be more or similar to toll fare of 100 Kms.

1.3 Civil Design

1.3.1 ITS/Civil Demarcation

(1) Work Demarcation

1) The basic policy of the ITS project/Civil project is shown in Table 1-1.

Table 1-1 Basic policy of ITS Project/ Civil Project

<Expressway> 1/3

No.	Item	ITS Project	Civil Project
1.	Power Cable to VMS, VIDS, MET	Cable, Conduit and Chamber (Handhole or Manhole) at Toll Plaza/ Equipment location	Conduit across the expressway to Toll Plaza
2.	OF Cable	Cable and Conduit to equipment from Chamber	Conduit and Chamber along with Expressway Conduit across the expressway at I.C
3.	Equipment	Foundation	-

<Interchange> 2/3

No.	Item	ITS Project	Civil Project
1.	Toll Booth	-	Toll Booth
		-	Air conditioner in Booth
		Cable from Power distribution board to Equipment	Power distribution board
		-	Power socket and Lighting
2.	Toll Island	-	Toll Island with Chambers
		Cable Conduit from chamber to Equipment	-
		-	Entrance to Tunnel (Stair type Entrance)
3.	Other around Toll Booth	Cable rack and cable along with Tunnel	Tunnel from toll island to Toll Plaza

<Building>3/3

No.	Item	ITS Project	Civil Project
1.	Toll Plaza	-	Toll Plaza architecture
		-	Basic Electric facility for Toll Plaza (S/S, Distribution board Emergency, Generator Power socket etc.)
		-	Telephone system with Exchanger
		-	Cable duct for ITS Cable
		-	Other facility (desk etc.)
2.	Control Center for Advanced Traffic Management Center/ Toll Management Center	Control Table for ITS system for Advanced Traffic Management Center	Center architecture
		-	Raised floor for Control/ Server room
		-	Basic Electric facility for Toll Plaza (S/S, Emergency Generator, Distribution board Power socket etc.)
		Network system between telephone exchangers of between Toll Plaza and Control Center	Telephone system with Exchanger
		-	Cable duct for ITS Cable
		-	Other facility (Normal desk etc.)

Source: JICA Study Team

2) ITS Project/Civil Project of work demarcation shown inTable 1-2.

Table 1-2 ITS Project/Civil Project of work demarcation

		Work Demarcation		
No.	**Description**	**ITS**	**Civil**	**Remarks**
1.	**Survey & Design**			
1.1	Engineering Route Survey	○	○	
1.2	Preparation of Installation/ Construction design drawings	○	○	
1.2.1	Main duct route with road cross section	–	○	Figure 2.3.1-3
1.2.2	Sub-duct route with road cross section	–	○	Figure 2.3.1-3
1.2.3	Tunnel design (Main Gate No.1 & No.2)	–	○	
1.2.4	Duct installation from tunnel to toll booth (Main Gate No.1 & No.2)	–	○	
1.2.5	Handhole & Manhole with accessories & covers	–	○	
1.2.6	Culvert crossing	–	○	
1.2.7	Bridge attachment	–	○	
1.2.8	Installing facility diagram (including sub-duct installation)	○	–	
1.2.9	Road side equipment typical plan	○	–	
1.2.10	Toll management system (Main IC/ Entrance/ Exit)	○	–	
1.2.11	Sub center	○	–	
1.2.12	Control center	○	–	
1.2.13	Preparation of BOQ	○	○	
1.2.14	Check and Verification of Installation design drawings and BOQ	○	○	
1.2.15	Submission of design documents	○	○	
1.2.16	Design review	○	○	Finalization of BOQ
1.2.17	Reproduction and distribution of design documents	○	○	
2.	**Acquisition of Permissions and Preparation of Sites**			
2.1	Acquisition for any Right of Way permission from authorities concerned and utility owners (gas, water, electricity etc.) for construction of duct route.	○	○	
2.2	Site acquisition for all necessary work and permission related to its acquisition	○	○	
3.	**Manufacture, Procurement and delivery of the installation materials**			
3.1	Manufacturing or procurement of HDPE pipe including its sockets, plugs and etc.	○	○	
3.2	Procurement of other installation materials	○	○	
3.3	Site delivery from main warehouse (including loading and unloading)	○	○	
3.4	Storage of the materials at site	○	○	
3.5	Inspection upon delivery	○	○	
4.	**Installation/ Construction**			
4.1	Preparation of detail implementation schedule	○	○	
4.2	Test digging for confirmation of existing facility	○	○	
4.3	Installation of Main duct route	–	○	
4.4	Installation of Sub-duct route	–	○	
4.5	Construction of Tunnel (Main Gate No.1 & No.2)	–	○	
4.6	Duct installation from tunnel to toll booth (Main Gate No.1 & No.2)	–	○	
4.7	Construction of Handhole & Manhole	–	○	
4.8	Installation of Culvert crossing	–	○	
4.9	Installation of Bridge attachment	–	○	
4.10	Installation of Sub-duct route (Existing handhole or manhole to each ITS equipment)	○	–	
4.11	Cable laying works/ testing	○	–	All cable
4.12	Installation of ITS equipments & etc.	○	–	
4.13	Construction of gantry and foundation	○	–	
4.14	Construction of pole, foundation and etc.	○	–	
5.	**Acceptance and Commissioning**			
5.1	Provisional Acceptance Test	○	○	
5.2	Preparation of Test Report	○	○	
5.3	Final Acceptance Test	○	○	
6.	**Documentation**			
6.1	Preparation of red-marked drawings/ documents	○	○	
6.2	Preparation of as-built drawings/ documents	○	○	
7.	**Project Management**			
7.1	Progress monitoring and control	○	○	
7.2	Quality assurance	○	○	
7.3	Coordination Meeting	○	○	

Source: JICA Study Team

3) ITS Project/Civil Project of work demarcation shown in Figure 1-1.

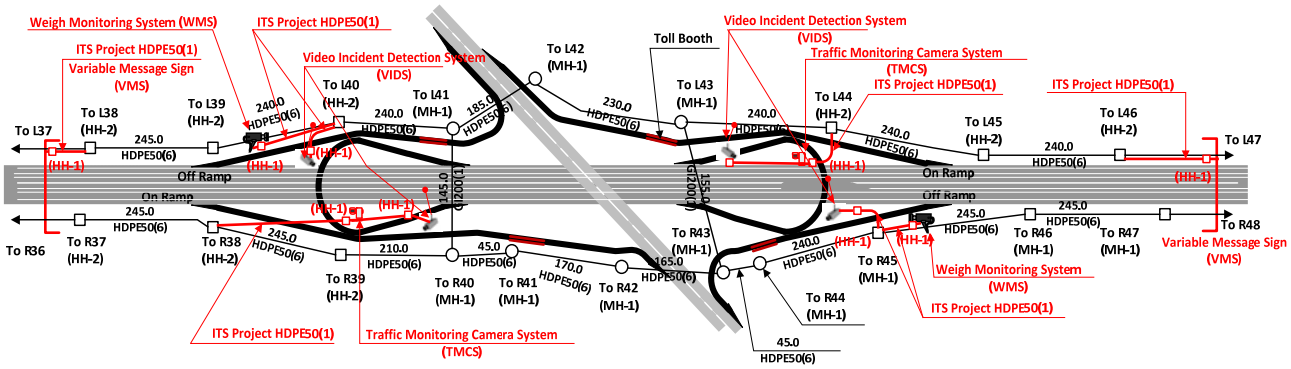


Figure 1-1 ITS Project/Civil Project of work demarcation (Sample DWG)

4) The detailed view of the ITS Project/Civil Project of work demarcation in the following shown in Figure 1-2.

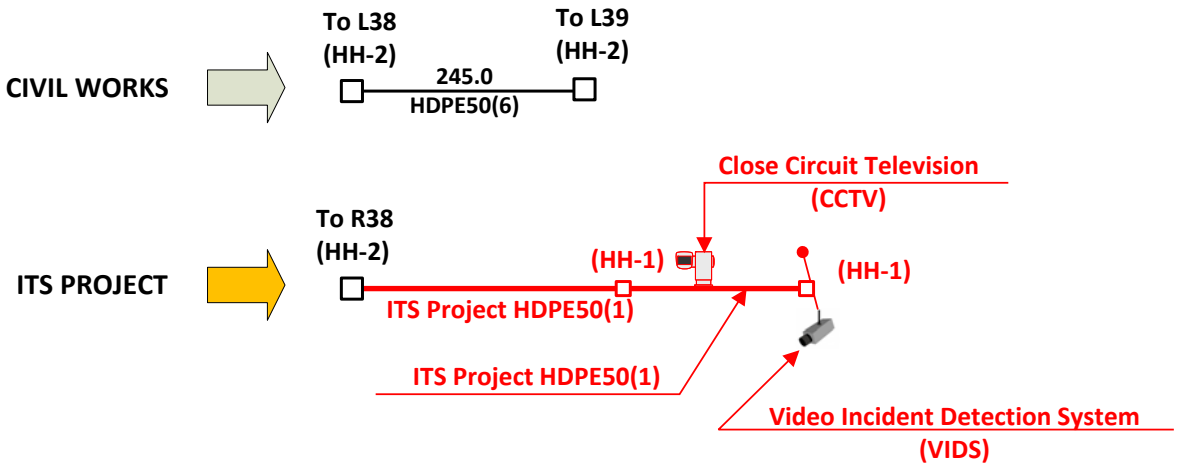


Figure 1-2 Detailed View (Sample DRW)

(2) Demarcation Drawing

1) ITS Project/Civil Project of demarcation drawing shown in Table 1-3.

Table 1-3 ITS Project/Civil Project of demarcation drawing

		Demarcation Drawing		
No.	**Drawing Title**	**ITS**	**Civil**	**Remarks**
1.	**General**			
1.1	Location Map	○		
1.2	Overall System Configuration Diagram	○		
1.3	General Layout Plan	○		
1.4	Installing Facility Diagram	○		
2.	**Road side Equipment Typical Plan**			
2.1	Traffic Monitoring Camera System (TMCS)	○		
2.2	Video Incident Detection System (VIDS)	○		
2.3	Automatic Traffic Counter cum Classifier (ATCC)	○		
2.4	Meteorological/Environmental observation station (MEOS)	○		
2.5	Variable Message sign (VMS) Type A	○		
2.6	Variable Message sign (VMS)Type B /Travel Time	○		
2.7	Vehicle Speed Detection System(VSDS)	○		
2.8	Weigh Monitoring System(WMS)	○		
3.	**Toll Management System (Main IC/Entrance/Exit)**			
3.1	Equipment Layout Plan (Main IC Island)	○		
3.2	Equipment Layout Plan (Main IC Toll Plaza)	○		
3.3	Wirering Conceptual Diagram (Main IC)	○		
3.4	Equipment Layout Plan (Entrance/Exit)	○		
3.5	Equipment Layout Plan (Entrance/Exit Toll Plaza)	○		
3.6	Wirering Conceptual Diagram (Entrance/Exi)	○		
3.7	Island Equipment Typical Plan (Reference)	○		
4.	**Sub Center**			
4.1	Equipment Layout Plan	○		
4.2	Wiring Conceptual Diagram	○		
4.3	Control Centre	○		
4.4	Equipment Layout Plan (Traffic Management Centre)	○		
4.5	Equipment Layout Plan (Toll Management Centre)	○		
4.6	Wiring Conceptual Diagram	○		
5.	**Civil**			
5.1	Proposed Duct Location & Handhole Location		○	
5.2	Scheme of Proposed Handhole Type-HH-1 & HH-2 Diagram		○	
5.3	Scheme of Proposed Manhole Type MH-1 Diagram		○	
5.4	Manhole & Handohole Accessories		○	
5.5	Handhole & Manhole Cover		○	
5.6	Culvert Crossing		○	
5.7	Bridge Attachment		○	
5.8	Duct Installation of Toll Island (Single Lane)		○	
5.9	Duct Installation of Toll Island (Double Lane)		○	
5.10	Construction of Proposed Tunnel (Main Gate- No.1 & No.2)		○	
5.11	Installation of Proposed Tunnel to Toll Booth (Main Gate-No.1 & No.2)		○	
5.12	General Layout of Duct Route Plan		○	

Source: JICA Study Team

(3) BQ/Cost

1) The summary of Bill of Quantity as show in the Table 1-4.

Table 1-4 Bill of Quantity (BQ)

			Main Duct Route				
No.	Item	Unit	L-Route	R-Route	Sub-total	Sub-duct Route	Total
1.	**Type of Chamber**						
1)	Handhole Type : HH-1	each	-	-	-	264	264
2)	Handhole Type : HH-2	each	488	482	970	-	970
3)	Manhole Type : MH-1	each	92	110	202	66	268
	TOTAL-1		**580**	**592**	**1,172**	**330**	**1,502**
2.	**Tyep of Conduit**						
1)	HDPE Pipe Φ50mm (6 way)	m	132,441.0	132,530.0	264,971.0	-	264,971.0
2)	GI Pipe Φ200mm (1 way)	m	2,028.0	-	2,028.0	-	2,028.0
3)	HDPE Pipe Φ63mm (2 way)	m				165.0	165.0
4)	HDPE Pipe Φ63mm (4 way)	m				1,185.0	1,185.0
5)	HDPE Pipe Φ75mm (2 way)	m	945.0	415.0	1,360.0	156.0	1,516.0
6)	GI Pipe Φ75mm (2 way)	m				79.8	79.8
	TOTAL-2		**135,414.0**	**132,945.0**	**268,359.0**	**1,585.8**	**269,944.8**
3	**Proposed Tunnel & Conduit**						
1)	Tunnel (Main Toll Plaza No.1 & No.2)	Lot	2.0				**2.0**
2)	HDPE Pipe Φ63mm (6 way)	m	986.0				**986.0**

Source: JICA Study Team

2) The Main Duct Route and Sub-duct Route of demarcation shown in Figure 1-3.

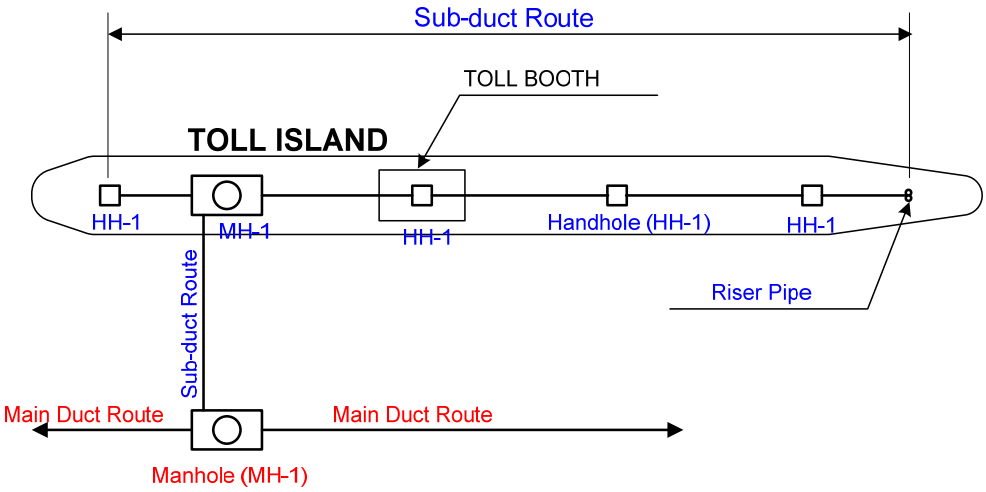


Figure 1-3 Main Duct Route and Sub-duct Route of demarcation

3) The summary of Cost as show in the Table 1-5.

Table 1-5 Cost

No.	Item	Unit	Qty	Unit Price (INR)	Total (INR)
1.	Type of Chamber				
1)	Handhole Type : HH-1	each	264	3,247	857,208
2)	Handhole Type : HH-2	each	970	14,106	13,682,820
3)	Manhole Type : MH-1	each	268	32,040	8,586,720
	Subtotal - (1)		**1,502**		**23,126,748**
2.	Tyep of Conduit				
1)	HDPE Pipe Φ50mm (6 way)	m	264,971.0	1,114	295,177,694
2)	GI Pipe Φ200mm (1 way)	m	2,028.0	513	1,040,364
3)	HDPE Pipe Φ63mm (2 way)	m	165.0	374	61,710
4)	HDPE Pipe Φ63mm (4 way)	m	1,185.0	727	861,495
5)	HDPE Pipe Φ75mm (2 way)	m	1,516.0	395	598,820
6)	GI Pipe Φ75mm (2 way)	m	79.8	488	38,942
	Subtotal - (2)		**269,944.8**		**297,779,025**
3.	Tunnel & Conduit				
1)	Tunnel (Main Toll Plaza No.1 & No.2)	Lot	2.0	12,027,349	24,054,698
2)	HDPE Pipe Φ63mm (6 way)	m	986.0	1,124	1,108,264
	Subtotal - (3)				**25,162,962**
	Subtotal - (1)+(2)+(3)				**346,068,735**
4.	General and administrative expenses		10%		**34,606,874**
	Total				**380,675,609**

Source: JICA Study Team

1.3.2 Civil Design Review

(1) Suggested Design Change

Eliminate weaving/merging section in ramps at:

15+360 Interchange on SH-57 (Dumbbell Type)

83+743 Interchange on Kasna (Dumbbell Type)

108+570 Interchange on Atali-Chainsa Road (Dumbbell)

Apply unified width of Toll Lane and Toll island

Toll Lane: 3.50 m

Toll Island: 2.20 m

Change the path into/from Amenities and Truck Lay-By with the provision of smooth alignment ramps as given in the sample layout of Service Area in Japan.

(2) Outline of Highway Design Criteria

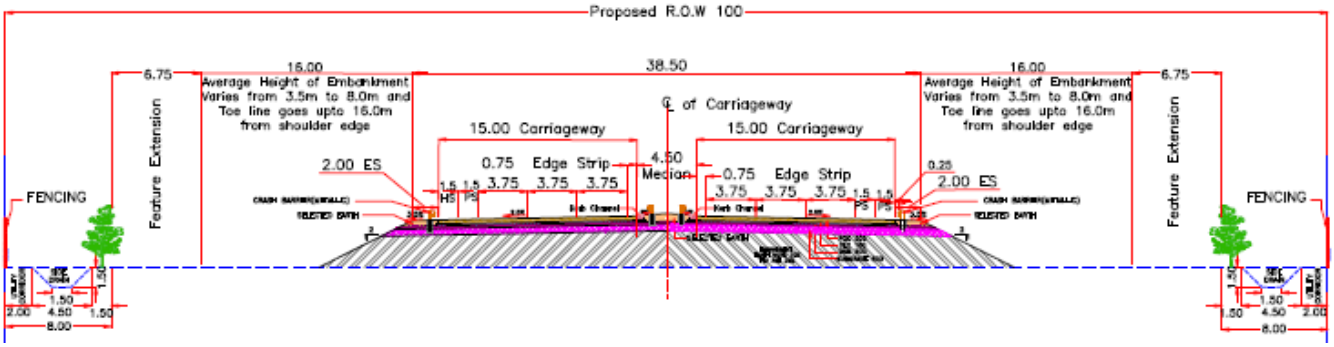
Main Road

Design Speed	:	120 km/h
Carriageway	:	3@3.750=11.250 m
Inner Shoulder	:	0.750 m
Outer Shoulder	:	3.000 m
Earthen Shoulder	:	2.000 m
Median	:	4.500 m
Vertical Clearance	:	5.500 m
ROW	:	100 m

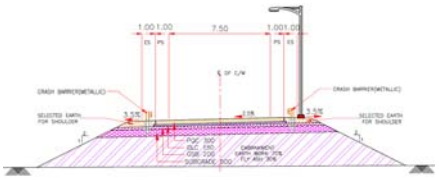
Interchange Ramps

Design Speed	:	80 km/h (Minimum 60 km/h)
Carriageway	:	2@3.750=7.500 m
Inner Shoulder	:	1.000 m
Outer Shoulder	:	1.000 m
Earthen Shoulder	:	2.000 m
Vertical Clearance	:	5.500 m

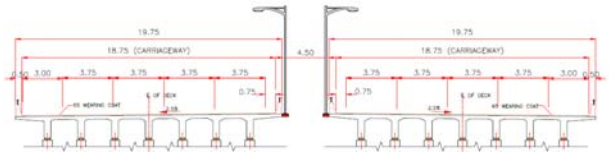
Figure 1-4 shows the typical cross section of the main road, ramps and bridges on the main road. It is noted that the ultimate stage of EPE is proposed as the dual 4-lane highway. In the first stage, the main road is scheduled to be constructed as the dual 3-lane highway, while the bridges on the main road will be constructed as the dual 4-lane structure.



(1) Main Road (Embankment Height Up To 6.0 M)



(2) Ramp



(3) Bridge on the Main Road

Source: Feasibility cum Preliminary Design Report

Figure 1-4 Typical Cross Section

(3) Location of Toll Plazas/Tollgates

According to the drawings, the total length of EPE is around 136 km. At the both end of EPE, the North end and the South end, there are toll plazas of barrier type on the main highway. EPE has nine (9) Interchanges which are linked with the existing trunk highways. Tollgates are deployed on the ramps of these nine (9) interchanges. Table 1-6 shows the location of Toll Plazas/Tollgates.

Table 1-6 Location of Toll Plaza/Tollgates

	Km	Name	Type
Package - I		0+000 ~ 22+000	
1	5+500	Toll Plaza (Kundli Side)	Barrier
2	15+360	Interchange on SH-57	Dumbbell
Package - II		22+000 ~ 46+500	
3	44+512	Interchange on NH-58	Cloverleaf
Package – III		46+500 ~ 71+000	
4	52+193	Interchange on NH-24	Cloverleaf
5	61+200	Interchange for Greater NOIDA	Cloverleaf
Package – IV		71+000 ~ 93+000	
6	72+723	Interchange on NH-91	Cloverleaf
7	83+743	Interchange on Kasna	Dumbbell

8	91+875	Interchange on Taj Expressway	Cloverleaf
Package – V		93+000 ~ 114+000	
9	108+570	Interchange on Atali-Chainsa Road	Dumbbell
Package – VI		114+000 ~ 136+000	
10	132+049.78	Toll Plaza (Palwal Side)	Barrier
11	134+934	Interchange on NH2	Cloverleaf

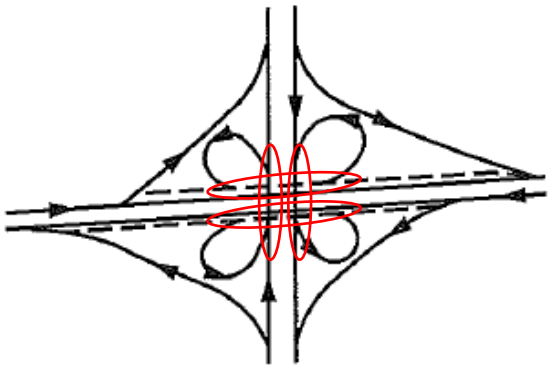
Source: Feasibility cum Preliminary Design Report

Note: Tollgates of Interchange on NH-2 are located only in between NH-2 and Delhi Western Peripheral Expressway.

1) Weaving Sections in Interchange

It is noted that every interchange of cloverleaf type and dumbbell type has weaving sections. The "Weaving" is generally studied from the viewpoint of bottleneck against the free-flow speed. A weaving section shall be designed in order not to form the bottleneck of the traffic flow, providing appropriate number of lane, weaving length, taking into consideration of traffic volume.

In this Study, it is also required to review the weaving section from the viewpoint of traffic safety. A cloverleaf type interchange has weaving sections, inevitably due to its geometric structure, between on-ramp and off-ramp as indicated by red ovals in Figure 1-5.



Source: JICA Team

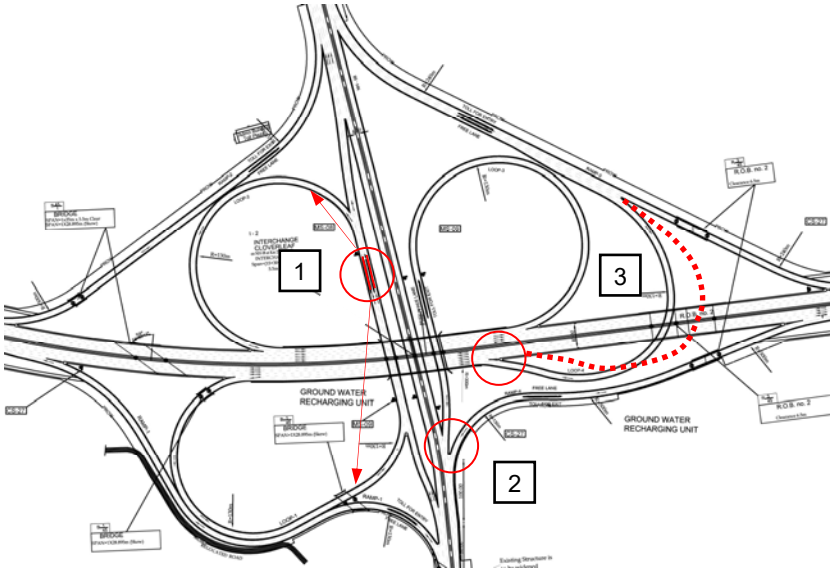
Figure 1-5 Weaving Section in Cloverleaf Type Interchange

According to the design drawings, the weaving length of cloverleaf type interchange is around 400 m, except the interchange on NH-58 at km 44+512. It was judged that the weaving length of around 400 m would be acceptable.

2) Weaving Sections of Interchange on NH-58 at km 44+512

Because of the restriction of available land, the interchange on NH-58 has irregular shape as shown in Figure 1-6. If possible, it is kindly advised to amend the design of following three (3) issues:

There are two (2) tollgates located side by side in the frontage road of NH-58. One tollgate is for entry into and the other is for exit from EPE. The weaving manoeuvre will take place in the section before the tollgates, between the entry traffic from NH-52 and the exit traffic from EPE. The design drawing shows around 230 m of weaving length. In case running speed is 45 ~ 55 km/h and traffic volume is around 1,500 vehicles/hour, minimum 100 m weaving length is generally acceptable. So the current design of tollgate location would be not necessary to change. However, from the viewpoint of traffic safety, the relocation of tollgate to the ramp section would be worthwhile to take into consideration.



Source: Feasibility cum Preliminary Design Report

Figure 1-6 Interchange on NH-58 at km 44+512

The exit traffic from EPE North and EPE South merges into NH-58 at almost one location. From the viewpoint of traffic safety, it would be better to give a certain distance between two (2) merging points.

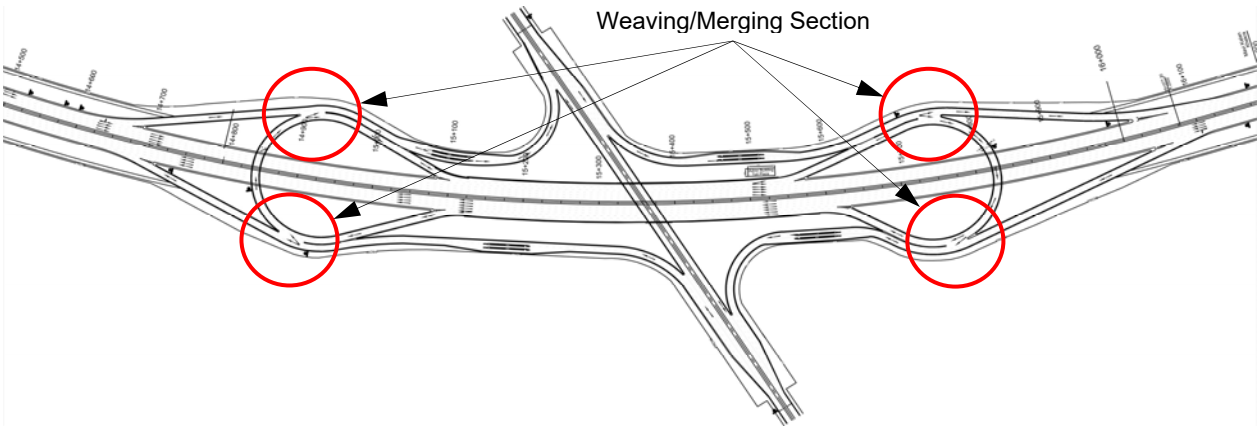
The current weaving length is around 400 m, shorter than the weaving length in opposite lanes. 400 m itself would be acceptable length for weaving manoeuvre. However, in order to enhance the traffic safety, it is possible to provide longer weaving length by the realignment of the ramp.

3) Weaving Sections in Dumbbell Type Interchange

The Dumbbell Type Interchange in EPE has opened area between two parallel ramps, which were intended to enable the traffic crossing of entry into/exit from EPE. The length of this opened area (weaving length) is around 30 m only in Interchange on SH-57 at km 15+360, and around 80 to 100 m in other dumbbell type interchanges. The weaving length in Interchange on SH-57 is extremely short and dangerous.

As these opened areas for weaving/merging have high possibility of causing traffic accidents, it is strongly recommended to make the design change in order to eliminate such

opened area between 2 ramps. Figure 1-7 shows the weaving/merging section in dumbbell type intersection in the original design.

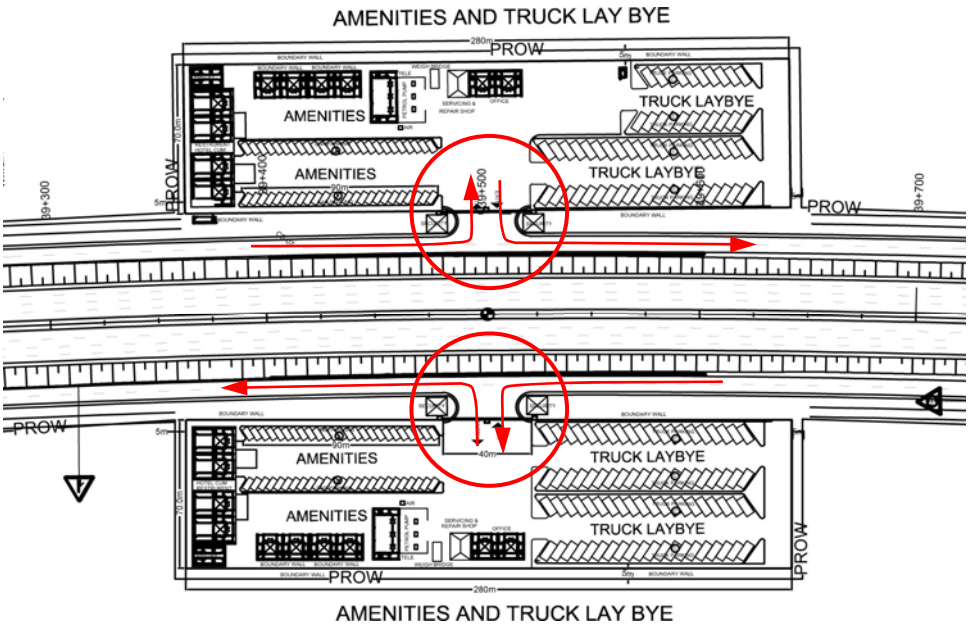


Source: Feasibility cum Preliminary Design Report

Figure 1-7 Weaving/Merging Section in Dumbbell Type Interchange

(4) Amenities and Truck Lay-By

It is noted that the "Amenities and Truck Lay-By" is proposed in two (2) locations, 39+500 and 95+520. It is highly appreciated to provide such facilities for long distance drivers to refresh their driving fatigue in order to enhance traffic safety. Figure 1-8 shows the plan of "Amenities and Truck Lay-By" extracted from the design drawings of Feasibility cum Preliminary Design Report for Restructuring of Eastern Peripheral Expressway in the States of Haryana & Uttar Pradesh. It is noted that the entry/exit between the approach ramp and the area shall be done by right angle turn, similar to the driving manoeuvre at the crossroad intersection. It is advised to apply the smoother alignment for entry into and exit from the Amenities and Truck Lay-by area, as shown in Figure 1-9 of Ashigara Service Area Layout.



Source: Feasibility cum Preliminary Design Report

Figure 1-8 Plan of Amenities and Truck Lay-By

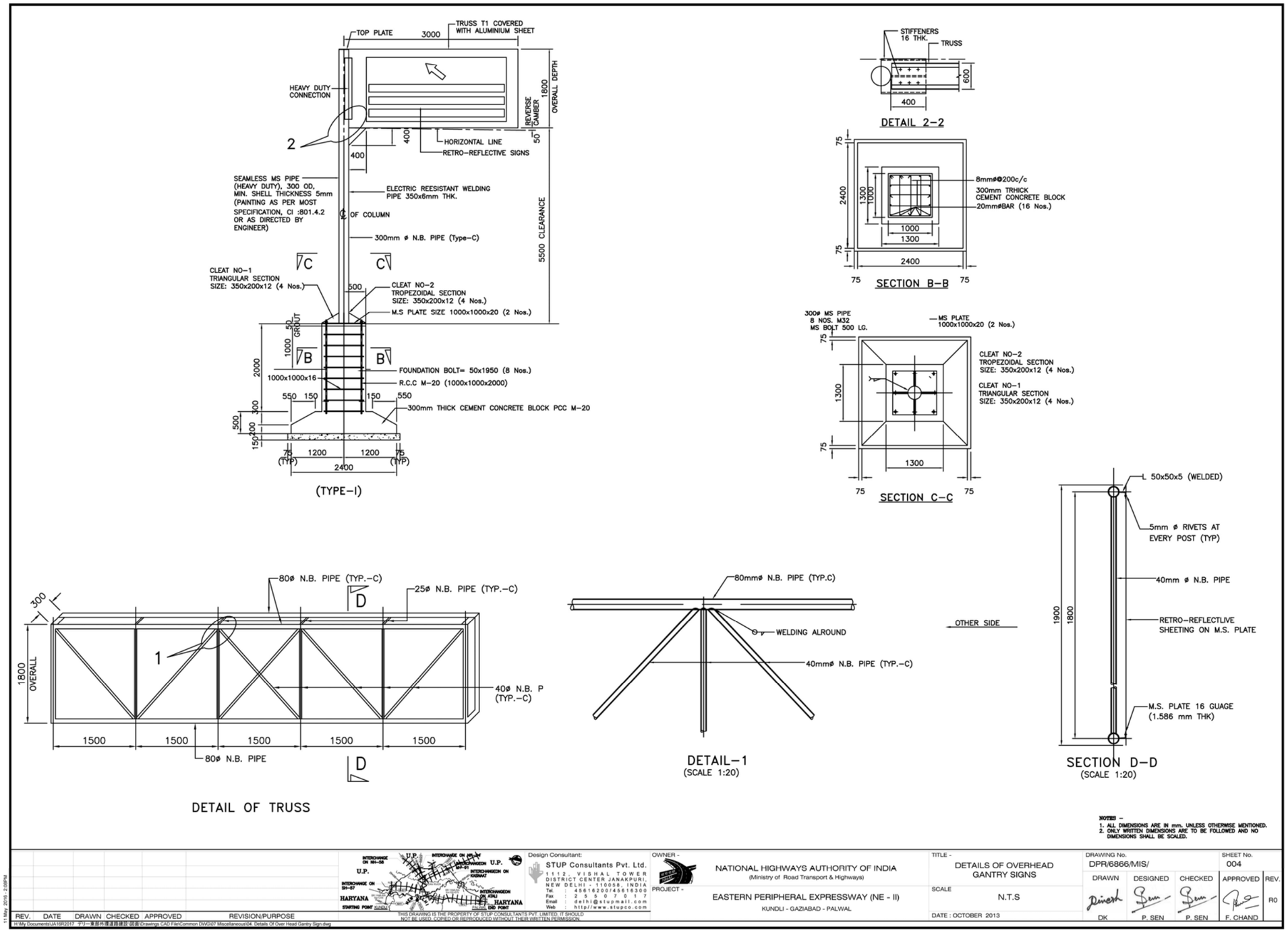
Source: JICA Study Team

Figure 1-9 Layout of Ashigara Service Area

(5) Space for ITS Equipment

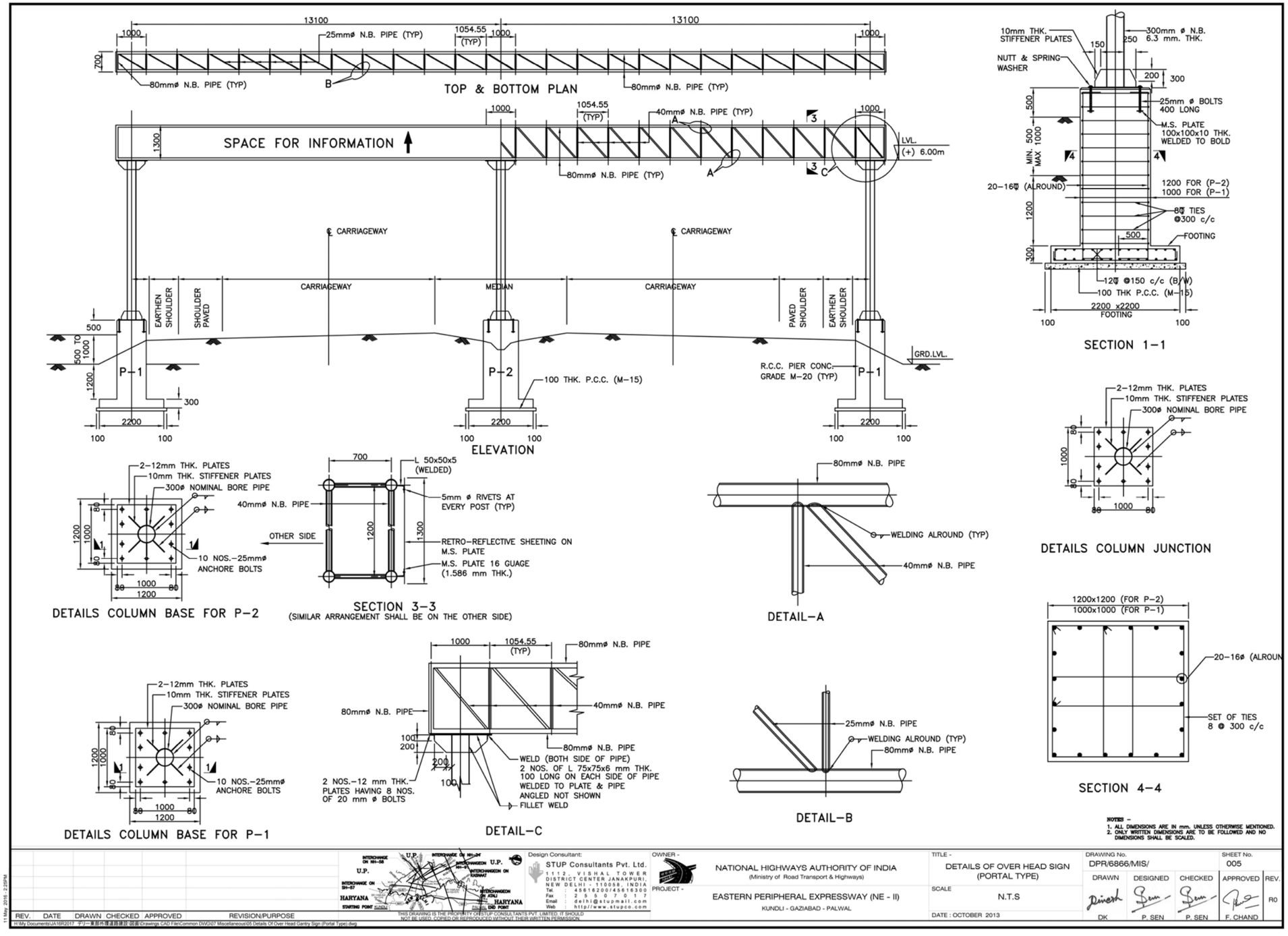
Optical fibre cables are proposed to be embedded at earthen shoulder, running whole section of EPE, 136 km. The roadside ITS equipments proposed by this Study shall be installed to the roadside post or other appropriate structure, which requires a certain space on the highway.

The design drawings of Feasibility cum Preliminary Design Report has drawings of "Details of Overhead Gantry Signs" and "Details of Over Head Sign (Portal Type)" in drawing section 7, Miscellaneous, as given in Figure 1-10 and Figure 1-11. The foundation of both structures are proposed to install outside of the earthen shoulder, touching at the edge of earthen shoulder. This is reasonable and agreeable. The roadside ITS equipments will be installed without any difficulty with the original highway design.



Source: Feasibility cum Preliminary Design Report

Figure 1-10 Original Drawing of Roadside Post



Source: Feasibility cum Preliminary Design Report

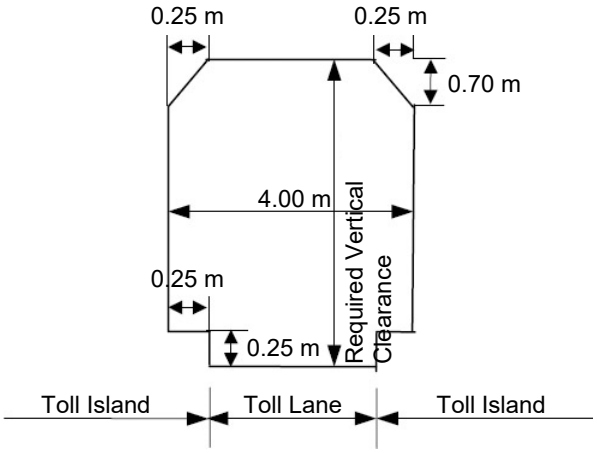
Figure 1-11 Original Drawing of Overhead Gantry

(6) Toll Lane Width and Toll Island Width

The toll lane width of Toll Plaza is 3.50 m in Plan & Profiles of original drawings, while the toll lane width of Toll Plaza has 2 types of 3.20 m and 3.50 m in the drawing of "Conceptual Plan of Toll Plaza (16 Lanes) (Indicative Only)" in drawing section 7, Miscellaneous. The toll island is proposed as 1.80 m in the original drawings.

MLIT (Ministry of Land, Infrastructure, Transport and Tourism) of Japan and JH (Japan Highway) recommends 3.50 m of toll lane width for ETC lane, non-stop payment lane. It is expected that the ETC user of EPE will increase year by year which shall require the conversion from manual tollgates into ETC tollgates. Taking into consideration of this ETC user increase, it is recommended to apply 3.50 m toll lane to all tollgates.

Figure 1-12 shows the clearance limit of ETC toll lane. It is noted that 0.25 m of toll island edge at both sides of toll lane are parts of horizontal clearance of toll lane.

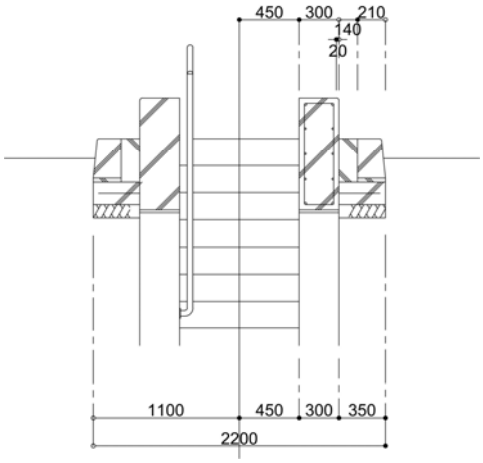


Source: Japanese Road Structure Ordinance

Figure 1-12 Clearance Limit of ETC Toll Lane

In order to secure the safety of toll collectors in tollgate area, it is proposed to provide the tunnel access between toll plaza building and each tollgate. The stairs is proposed to access between the tunnel and tollbooth. The width of stairs is 0.90 m and structural wall of stairs is 0.30 m as given in Figure 1-13. Thus total 1.50 m is required to install stairs within a tollbooth. In case the toll island width is 1.80 m, 0.15 m at both ends is remained for toll collector's walkway. It is not enough width to secure the toll collector's safety.

The toll island width of JH's Design Standards is 2.20 m. Referring to JH's design, it is recommended to apply 2.20 m wide toll island to EPE Project.



Source: JICA Study Team

Figure 1-13 Dimension of Staircase in Tollbooth

2 Demand Forecast / Estimation of Booth Number

2.1 Demand Forecast (April 2016)

Planed traffic volume on EPE has been estimated by Indian local consultant STUP Consultants Pvt. Ltd. ordered by NHAI. This is reported in "Restructuring of Eastern Peripheral Expressway in the states of Haryana & Uttar Pradesh". According to this report, Traffic Count Survey and OD Survey were implemented in March and April 2013 at locations which are given in the Table 2-1. Using these data, traffic volume on EPE in 2018, 2042 were estimated as shown in Figure 2-1.

Table 2-1 Traffic Count Survey Location for EPE project

Location（Crossing Road）	Station Number (kp)	Date
Kundli（NH-1）	36.40	18. 03, 2013～25. 03, 2013
Mawi kalan（SH-57）	31.20	18. 03, 2013～25. 03, 2013
Duhai（NH-58）	27.00	29. 03, 2013～05. 04, 2013
Dasna（NH-24）	29.00	29. 03, 2013～05. 04, 2013
Dadri（NH-91）	45.39	30. 03, 2013～05. 04, 2013
Kasna		05. 04, 2013～12. 04, 2013
Taji Expressway（Yamuna Expressway）		18. 04, 2013～25. 04, 2013
Palwal（Nh-2）	64.30	05. 04, 2013～12. 04, 2013

Traffic growth rates for the study have been estimated by adopting the Elasticity Method. The Elasticity Method relates traffic growth to changes in the related economic parameters. This method studies in an appropriate perspective, the changes in observed past traffic volumes in the context of changes in relevant economic indicators in the project influence area, to which it was closely related in the past. Such parameters include GDP, Population, Price Consumer Index (PCI), Income per capita, etc. This method takes into account not only the past growth of the major economic indicators but also the future perspective. The estimated elasticity coefficients in Dlehi are shown in Table 2-2 and adopted rates of traffic growth in this estimation are shown in the Table 2-3.

Table 2-2 Elasticity Coefficient mode wise for Delhi

Vehicle type	**Elasticity**	**Economic parameter**
BUS	0.42	Population
CAR	0.63	PCI
LMV (goods)/ LCV	2.74	NDP
2A/ 3A truck/ Articulated	0.22	GDP

Source: Restructuring of Eastern Peripheral Expressway in the states of Haryana & Uttar Pradesh (NHAI)

Table 2-3 Traffic Growth

年	CAR	BUS	LCV	2-AXLE/ 3-AXLE	Arti / Semi Arti Truck
～ 2014	10.07%	12.71%	16.63%	5.92%	5.92%
2015 ～ 2019	10.07%	12.71%	16.63%	5.92%	5.92%
2020 ～ 2024	8.24%	10.32%	13.91%	4.83%	4.83%
2024 ～ 2029	5.00%	6.20%	8.63%	2.93%	2.93%
2030 ～ 2034	2.27%	2.80%	4.01%	1.33%	1.33%

Source: Restructuring of Eastern Peripheral Expressway in the states of Haryana & Uttar Pradesh (NHAI)

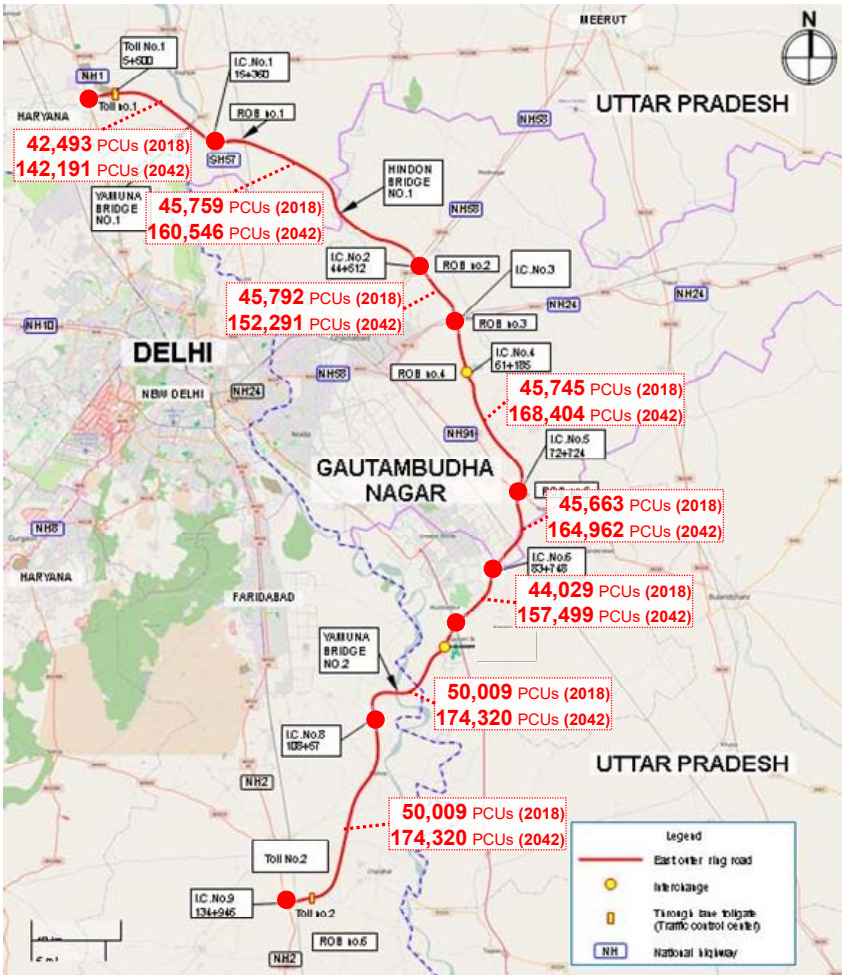


Figure 2-1 Projected Traffic Volume on EPE in2018, 2042

Source: JICA Study Team, based on the Restructuring of Eastern Peripheral Expressway in the states of Haryana & Uttar Pradesh (NHAI)

2.2 Estimation of Exist/Entrance Traffic Volume

The traffic volume using each Exit / Entrance of EPE was not estimated and clarified in the report "Restructuring of Eastern Peripheral Expressway in the states of Haryana & Uttar Pradesh" by NHAI. Therefore the traffic volume of Exit / Entrance was calculated based on the data of traffic survey mentioned above. More concretely, the ratio of using each Entrance to the nearest through traffic was calculated based on the OD survey data by STUP, then impose this ratio on the projected traffic volume of each through traffic volume of EPE. The estimated ratios of using Entrance to the nearest through traffic are shown in Table 2-4 and Exit / Entrance traffic volume from the year of 2018 to 2042 is given in the Table 2-5, Table 2-6 and Table 2-7.

Table 2-4 Estimated Ratios of Using Entrance to the Nearest Through Traffic

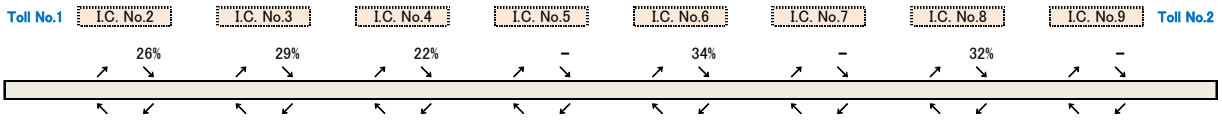


Table 2-5 Estimated Traffic Volume on Exit / Entrance (I.C.) of EPE (PCU/day) (1/3)

	Year	Toll No.1	I.C. No.2		I.C. No.3		I.C. No.4		I.C. No.5		I.C. No.6		I.C. No.7		I.C. No.8		I.C. No.9		Toll No.2
			↗ 4,236	↘ 5,869	↗ 6,531	↘ 6,547	↗ 5,086	↘ 5,062	↗	↘	↗ 7,718	↘ 7,677	↗	↘	↗ 4,956	↘ 7,946	↗	↘	
1	2018	42,493			45,759		45,792		45,745		45,745		45,863		44,029		50,009		50,009
			↖ 4,236	↙ 5,869	↖ 6,531	↙ 6,547	↖ 5,086	↙ 5,062	↖	↙	↖ 7,718	↙ 7,677	↖	↙	↖ 4,956	↙ 7,946	↖	↙	
			↗ 4,611	↘ 6,446	↗ 7,088	↘ 7,226	↗ 5,551	↘ 5,604	↗	↘	↗ 8,631	↘ 8,455	↗	↘	↗ 5,472	↘ 8,748	↗	↘	
2	2019	42,493			42,493		42,493		42,493		42,493		42,493		42,493		42,493		42,493
			↖ 4,611	↙ 6,446	↖ 7,088	↙ 7,226	↖ 5,551	↙ 5,604	↖	↙	↖ 8,631	↙ 8,455	↖	↙	↖ 5,472	↙ 8,748	↖	↙	
			↗ 3,667	↘ 8,100	↗ 10,570	↘ 8,414	↗ 6,404	↘ 6,543	↗	↘	↗ 10,151	↘ 9,834	↗	↘	↗ 6,571	↘ 10,110	↗	↘	
3	2020	54,295			63,161		58,850		59,128		59,128		58,495		56,552		63,631		63,631
			↖ 3,667	↙ 8,100	↖ 10,570	↙ 8,414	↖ 6,404	↙ 6,543	↖	↙	↖ 10,151	↙ 9,834	↖	↙	↖ 6,571	↙ 10,110	↖	↙	
			↗ 3,912	↘ 8,778	↗ 11,383	↘ 9,146	↗ 6,887	↘ 7,134	↗	↘	↗ 11,164	↘ 10,672	↗	↘	↗ 7,141	↘ 10,963	↗	↘	
4	2021	58,710			68,443		63,969		64,464		64,464		63,480		61,355		68,999		68,999
			↖ 3,912	↙ 8,778	↖ 11,383	↙ 9,146	↖ 6,887	↙ 7,134	↖	↙	↖ 11,164	↙ 10,672	↖	↙	↖ 7,141	↙ 10,963	↖	↙	
			↗ 6,836	↘ 9,286	↗ 11,358	↘ 9,950	↗ 5,864	↘ 8,222	↗	↘	↗ 12,955	↘ 12,258	↗	↘	↗ 8,396	↘ 12,524	↗	↘	
5	2022	67,503			72,403		69,587		74,303		74,303		72,910		70,571		78,827		78,827
			↖ 6,836	↙ 9,286	↖ 11,358	↙ 9,950	↖ 5,864	↙ 8,222	↖	↙	↖ 12,955	↙ 12,258	↖	↙	↖ 8,396	↙ 12,524	↖	↙	
			↗ 7,373	↘ 10,071	↗ 12,215	↘ 10,832	↗ 6,284	↘ 8,980	↗	↘	↗ 14,271	↘ 13,325	↗	↘	↗ 9,141	↘ 13,598	↗	↘	
6	2023	73,127			78,524		75,759		81,151		81,151		79,259		76,669		85,584		85,584
			↖ 7,373	↙ 10,071	↖ 12,215	↙ 10,832	↖ 6,284	↙ 8,980	↖	↙	↖ 14,271	↙ 13,325	↖	↙	↖ 9,141	↙ 13,598	↖	↙	
			↗ 6,489	↘ 11,439	↗ 15,127	↘ 11,802	↗ 6,734	↘ 9,816	↗	↘	↗ 14,420	↘ 15,164	↗	↘	↗ 10,588	↘ 15,402	↗	↘	
7	2024	79,294			89,194		82,544		88,708		88,708		90,196		87,311		96,939		96,939
			↖ 6,489	↙ 11,439	↖ 15,127	↙ 11,802	↖ 6,734	↙ 9,816	↖	↙	↖ 14,420	↙ 15,164	↖	↙	↖ 10,588	↙ 15,402	↖	↙	
			↗ 6,807	↘ 12,041	↗ 15,851	↘ 12,453	↗ 7,023	↘ 10,381	↗	↘	↗ 15,349	↘ 15,986	↗	↘	↗ 11,165	↘ 16,219	↗	↘	
8	2025	83,421			93,890		87,094		93,810		93,810		95,084		91,974		102,082		102,082
			↖ 6,807	↙ 12,041	↖ 15,851	↙ 12,453	↖ 7,023	↙ 10,381	↖	↙	↖ 15,349	↙ 15,986	↖	↙	↖ 11,165	↙ 16,219	↖	↙	

Source: JICA Study Team

Table 2-6 Estimated Traffic Volume on Exit / Entrance (I.C.) of EPE (PCU/day) (2/3)

	Year	Toll No.1	I.C. No.2		I.C. No.3		I.C. No.4		I.C. No.5		I.C. No.6		I.C. No.7		I.C. No.8		I.C. No.9		Toll No.2
9	2026	87,799	↗ 7,146	↘ 12,680	↗ 16,616	↘ 13,144	↗ 7,323	↘ 10,982	↗	↘	↗ 16,343	↘ 16,858	↗	↘	↗ 11,777	↘ 17,084	↗	↘	107,528
		98,868				91,925		99,243		99,243		100,273		96,913				107,528	
			↖ 7,146	↙ 12,680	↖ 16,616	↙ 13,144	↖ 7,323	↙ 10,982	↖	↙	↖ 16,343	↙ 16,858	↖	↙	↖ 11,777	↙ 17,084	↖	↙	
10	2027	92,443	↗ 7,504	↘ 13,357	↗ 17,424	↘ 13,878	↗ 7,637	↘ 11,623	↗	↘	↗ 17,408	↘ 17,784	↗	↘	↗ 12,427	↘ 18,001	↗	↘	113,295
		104,149				97,058		105,031		105,031		105,783		102,147				113,295	
			↖ 7,504	↙ 13,357	↖ 17,424	↙ 13,878	↖ 7,637	↙ 11,623	↖	↙	↖ 17,408	↙ 17,784	↖	↙	↖ 12,427	↙ 18,001	↖	↙	
11	2028	97,372	↗ 7,886	↘ 14,075	↗ 18,277	↘ 14,657	↗ 7,962	↘ 12,305	↗	↘	↗ 18,550	↘ 18,769	↗	↘	↗ 13,116	↘ 18,971	↗	↘	119,404
		109,751				102,512		111,198		111,198		111,637		107,694				119,404	
			↖ 7,886	↙ 14,075	↖ 18,277	↙ 14,657	↖ 7,962	↙ 12,305	↖	↙	↖ 18,550	↙ 18,769	↖	↙	↖ 13,116	↙ 18,971	↖	↙	
12	2029	102,606	↗ 8,292	↘ 14,838	↗ 19,180	↘ 15,486	↗ 8,302	↘ 13,033	↗	↘	↗ 19,771	↘ 19,814	↗	↘	↗ 13,849	↘ 20,000	↗	↘	125,878
		115,698				108,310		117,772		117,772		117,858		113,575				125,878	
			↖ 8,292	↙ 14,838	↖ 19,180	↙ 15,486	↖ 8,302	↙ 13,033	↖	↙	↖ 19,771	↙ 19,814	↖	↙	↖ 13,849	↙ 20,000	↖	↙	
13	2030	105,153	↗ 8,492	↘ 15,209	↗ 19,618	↘ 15,890	↗ 8,460	↘ 13,389	↗	↘	↗ 20,377	↘ 20,323	↗	↘	↗ 14,201	↘ 20,499	↗	↘	129,017
		118,588				111,132		120,990		120,990		120,883		116,420				129,017	
			↖ 8,492	↙ 15,209	↖ 19,618	↙ 15,890	↖ 8,460	↙ 13,389	↖	↙	↖ 20,377	↙ 20,323	↖	↙	↖ 14,201	↙ 20,499	↖	↙	
14	2031	107,772	↗ 8,696	↘ 15,590	↗ 20,067	↘ 16,305	↗ 8,621	↘ 13,756	↗	↘	↗ 21,002	↘ 20,846	↗	↘	↗ 14,562	↘ 21,011	↗	↘	132,244
		121,560				114,037		124,308		124,308		123,996		119,345				132,244	
			↖ 8,696	↙ 15,590	↖ 20,067	↙ 16,305	↖ 8,621	↙ 13,756	↖	↙	↖ 21,002	↙ 20,846	↖	↙	↖ 14,562	↙ 21,011	↖	↙	
15	2032	110,468	↗ 8,907	↘ 15,982	↗ 20,528	↘ 16,733	↗ 8,784	↘ 14,134	↗	↘	↗ 21,649	↘ 21,385	↗	↘	↗ 14,933	↘ 21,538	↗	↘	135,561
		124,618				117,028		127,729		127,729		127,201		122,351				135,561	
			↖ 8,907	↙ 15,982	↖ 20,528	↙ 16,733	↖ 8,784	↙ 14,134	↖	↙	↖ 21,649	↙ 21,385	↖	↙	↖ 14,933	↙ 21,538	↖	↙	
16	2033	113,243	↗ 9,125	↘ 16,386	↗ 21,003	↘ 17,173	↗ 8,951	↘ 14,525	↗	↘	↗ 22,318	↘ 21,940	↗	↘	↗ 15,316	↘ 22,080	↗	↘	138,970
		127,765				120,106		131,255		131,255		130,500		125,442				138,970	
			↖ 9,125	↙ 16,386	↖ 21,003	↙ 17,173	↖ 8,951	↙ 14,525	↖	↙	↖ 22,318	↙ 21,940	↖	↙	↖ 15,316	↙ 22,080	↖	↙	

Source: JICA Study Team

Table 2-7 Estimated Traffic Volume on Exit / Entrance (I.C.) of EPE (PCU/day) (3/3)

	Year	Toll No.1	I.C. No.2		I.C. No.3		I.C. No.4		I.C. No.5		I.C. No.6		I.C. No.7		I.C. No.8		I.C. No.9		Toll No.2
17	2034		9,349	16,801	21,489	17,626	9,120	14,927			23,009	22,511			15,710	22,637			
		116,098		131,002		123,276		134,891		134,891		133,896		128,619		142,474		142,474	
			9,349	16,801	21,489	17,626	9,120	14,927			23,009	22,511			15,710	22,637			
18	2035		9,580	17,228	21,990	18,093	9,292	15,342			23,724	23,099			16,114	23,209			
		119,037		134,333		126,540		138,641		138,641		137,392		131,886		146,077		146,077	
			9,580	17,228	21,990	18,093	9,292	15,342			23,724	23,099			16,114	23,209			
19	2036		9,819	17,668	22,504	18,574	9,467	15,770			24,462	23,704			16,530	23,798			
		122,062		137,761		129,901		142,508		142,508		140,992		135,244		149,781		149,781	
			9,819	17,668	22,504	18,574	9,467	15,770			24,462	23,704			16,530	23,798			
20	2037		10,064	18,120	23,032	19,068	9,644	16,211			25,226	24,327			16,957	24,403			
		125,176		141,289		133,362		146,496		146,496		144,699		138,698		153,590		153,590	
			10,064	18,120	23,032	19,068	9,644	16,211			25,226	24,327			16,957	24,403			
21	2038		10,318	18,586	23,575	19,578	9,825	16,666			26,016	24,969			17,397	25,025			
		128,383		144,920		136,927		150,609		150,609		148,516		142,250		157,507		157,507	
			10,318	18,586	23,575	19,578	9,825	16,666			26,016	24,969			17,397	25,025			
22	2039		10,578	19,065	24,133	20,103	10,010	17,136			26,833	25,630			17,850	25,665			
		131,684		148,658		140,599		154,852		154,852		152,447		145,903		161,534		161,534	
			10,578	19,065	24,133	20,103	10,010	17,136			26,833	25,630			17,850	25,665			
23	2040		10,849	19,559	24,706	20,644	10,196	17,620			27,677	26,310			18,315	26,323			
		135,084		152,505		144,381		159,229		159,229		156,496		149,660		165,677		165,677	
			10,849	19,559	24,706	20,644	10,196	17,620			27,677	26,310			18,315	26,323			
24	2041		11,126	20,067	25,296	21,201	10,386	18,120			28,551	27,011			18,794	27,000			
		138,585		156,467		148,277		163,745		163,745		160,666		153,524		169,937		169,937	
			11,126	20,067	25,296	21,201	10,386	18,120			28,551	27,011			18,794	27,000			
25	2042		11,413	20,590	25,903	21,775	10,579	18,635			29,455	27,734			19,286	27,696			
		142,191		160,546		152,291		168,404		168,404		164,962		157,499		174,320		174,320	
			11,413	20,590	25,903	21,775	10,579	18,635			29,455	27,734			19,286	27,696			

Source: JICA Study Team

2.3 Estimation of Booth Number (ETC/Manual)

Based on the estimated traffic volume of Exit / Entrance in each year, required number of ETC-Lane is calculated using traffic survey data and assumed ETC usage ratio.

The prospective change of ETC usage ratio in India is assumed based on the interview to IHMCL. According to the interview, renewed ETC system will start from 2016 then they assume that usage ratio will grow at a 10% annual rate. Moreover, RFID-tag has been stuck to a new car. Therefore, final usage rate is assumed to reach 100%. The assumed change of ETC usage ratio is given in Table 2-8.

Table 2-8 Assumed Change of ETC (RFID-Tag) Usage Ratio

2017	10%
2018	20%
2019	30%
2020	40%
2021	50%
2022	60%
2023	70%
2024	80%
2025	90%
2026～	100%

Source: JICA Study Team

In accordance with the drawings for design of toll plazas and Inter Changes of EPE, the maximum number of lanes per tollgate at each I.C. was checked and shown in Table 2-9.

Table 2-9 The Maximum Number of Lanes per Tollgate at each I.C. on EPE

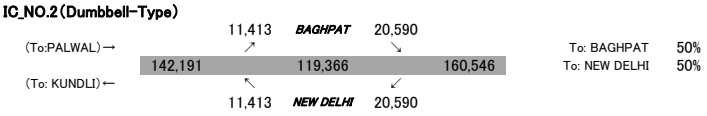
	Location		Type of Junction	No. of Toll Gates for 1-direction	MAX No. of Lanes per toll gate
	Station	Cross Road			
Toll No.1	5+500	NH-1	Toll Barrier	1	8
I.C. No.2	15+360	SH-57	Dumbbell	4	3
I.C. No.3	44+512	NH-58	Cloverleaf(A)	6	2～3
I.C. No.4	52+193	NH-24	Cloverleaf(A)	6	2～3
I.C. No.5	61+185	-	Cloverleaf(B)	8	2
I.C. No.6	72+723	NH-91	Cloverleaf(B)	8	2
I.C. No.7	83+743	-	Dumbbell	4	3
I.C. No.8	91+875	Yamuna Expway	Cloverleaf(B)	8	2
I.C. No.9	108+570	-	Dumbbell	4	3
Toll No.2	132+050	NH-24	Toll Barrier	1	8

Source: JICA Study Team based on the Drawing for Design by STUP Consultants

Traffic volume of each toll gate at peak hour is shown in Table 2-10, Table 2-11 and Table 2-12, where the peak hour rate of traffic volume is set as 8% based on the traffic count survey implemented by Stup Consultants.

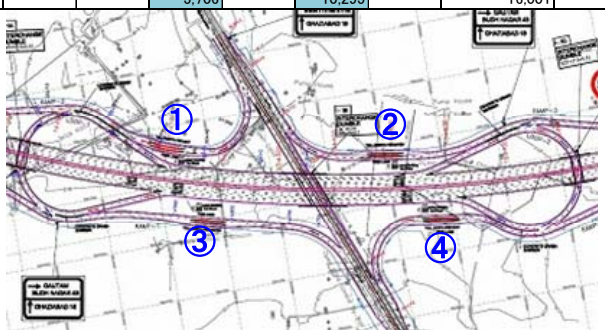
Table 2-10 Traffic Volume of Each Toll Gate at Peak Hour(1)

IC_NO.2(Dumbbell-Type)

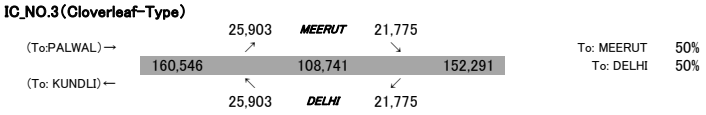


8%

	To:PALWAL (Entrance)		To:KUNDLI (Entrance)		To:PALWAL (Exit)		To:KUNDLI (Exit)		Total [PCU/day]	Traffic Volume at Peak Hour[veh]	Number of Lanes	Trarric volume for a lane	
	To: NEW DELHI	To: BAGHPAT	To: NEW DELHI	To: BAGHPAT	To: NEW DELHI	To: BAGHPAT	To: NEW DELHI	To: BAGHPAT				Entrance	Exit
Toll Gate ①						5,706		10,295	16,001	800	3	–	267
Toll Gate ②		10,295		5,706					16,001	800	3	267	–
Toll Gate ③	10,295		5,706						16,001	800	3	267	–
Toll Gate ④					5,706		10,295		16,001	800	3	–	267



IC_NO.3(Cloverleaf-Type)



8%

	To:PALWAL (Entrance)		To:KUNDLI (Entrance)		To:PALWAL (Exit)		To:KUNDLI (Exit)		Total [PCU/day]	Traffic Volume at Peak Hour[veh]	Number of Lanes	Trarric volume for a lane	
	To: DELHI	To: MEERUT	To: DELHI	To: MEERUT	To: DELHI	To: MEERUT	To: DELHI	To: MEERUT				Entrance	Exit
Toll Gate ①						12,951			12,951	648	2	–	324
Toll Gate ②		10,888		12,951					23,839	1,192	3	397	–
Toll Gate ③	10,888							10,888	21,775	1,089	入口2/出口1	272	544
Toll Gate ④					12,951				12,951	648	2	–	324
Toll Gate ⑤			12,951						12,951	648	2	324	–
Toll Gate ⑥							10,888		10,888	544	2	–	272

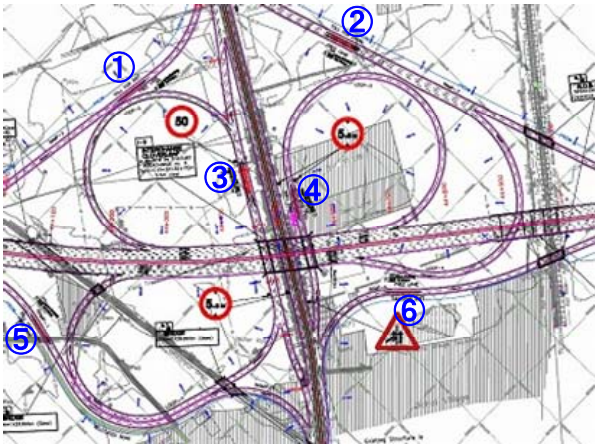
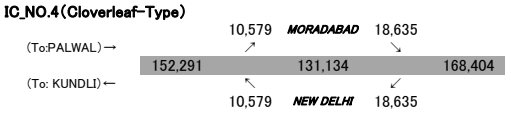


Table 2-11 Traffic Volume of Each Toll Gate at Peak Hour(2)

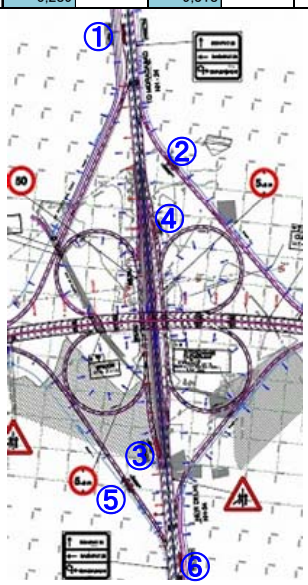
IC_NO.4(Cloverleaf-Type)



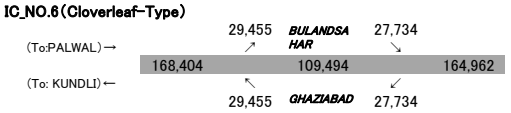
To: MORADABAD 50%
To: NEW DELHI 50%

8%

	To:PALWAL (Entrance)		To:KUNDLI (Entrance)		To:PALWAL (Exit)		To:KUNDLI (Exit)		Total [PCU/day]	Traffic Volume at Peak Hour[veh]	Number of Lanes	Trarric volume for a lane	
	To: NEW DELHI	To: MORADABAD	To: NEW DELHI	To: MORADABAD	To: NEW DELHI	To: MORADABAD	To: NEW DELHI	To: MORADABAD				Entrance	Exit
Toll Gate ①						5,289		9,318	14,607	730	3		243
Toll Gate ②		9,318							9,318	466	2	233	
Toll Gate ③	9,318								9,318	466	2	233	
Toll Gate ④				5,289					5,289	264	2	132	
Toll Gate ⑤			5,289						5,289	264	2	132	
Toll Gate ⑥					5,289		9,318		14,607	730	3		243



IC_NO.6(Cloverleaf-Type)



To: BULANDSAHAR 50%
To: GHAZIABAD 50%

8%

	To:PALWAL (Entrance)		To:KUNDLI (Entrance)		To:PALWAL (Exit)		To:KUNDLI (Exit)		Total [PCU/day]	Traffic Volume at Peak Hour[veh]	Number of Lanes	Trarric volume for a lane	
	To: GHAZIABAD	To: BULANDSAHAR	To: GHAZIABAD	To: BULANDSAHAR	To: GHAZIABAD	To: BULANDSAHAR	To: GHAZIABAD	To: BULANDSAHAR				Entrance	Exit
Toll Gate ①						14,728			14,728	736	2	–	368
Toll Gate ②								13,867	13,867	693	2	–	347
Toll Gate ③				14,728					14,728	736	2	368	–
Toll Gate ④		13,867							13,867	693	2	347	–
Toll Gate ⑤			14,728						14,728	736	2	368	–
Toll Gate ⑥	13,867								13,867	693	2	347	–
Toll Gate ⑦					14,728				14,728	736	2	–	368
Toll Gate ⑧							13,867		13,867	693	2	–	347

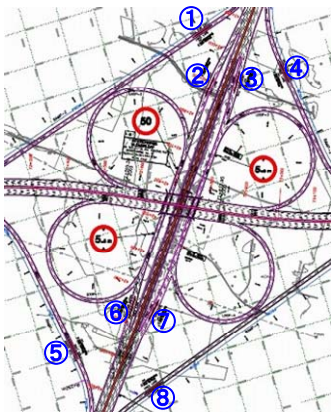


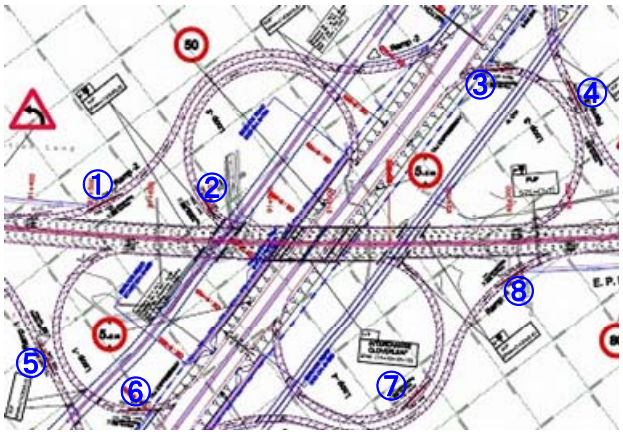
Table 2-12 Traffic Volume of Each Toll Gate at Peak Hour(3)

IC_NO.8(Cloverleaf-Type)

To: AGRA 50%
To: NOIDA 50%

8%

	To:PALWAL (Entrance)		To:KUNDLI (Entrance)		To:PALWAL (Exit)		To:KUNDLI (Exit)		Total [PCU/day]	Traffic Volume at Peak Hour[veh]	Number of Lanes	Trarric volume for a lane	
	To: NOIDA	To: AGRA	To: NOIDA	To: AGRA	To: NOIDA	To: AGRA	To: NOIDA	To: AGRA				Entrance	Exit
Toll Gate ①						9,643			9,643	482	2	–	241
Toll Gate ②	13,848								13,848	692	2	346	–
Toll Gate ③					9,643				9,643	482	2	–	241
Toll Gate ④		13,848							13,848	692	2	346	–
Toll Gate ⑤			9,643						9,643	482	2	241	–
Toll Gate ⑥								13,848	13,848	692	2	–	346
Toll Gate ⑦				9,643					9,643	482	2	241	–
Toll Gate ⑧							13,848		13,848	692	2	–	346



Toll_NO.1(Toll Barrier)

8%

Total [PCU/day]	Traffic Volume at Peak Hour[veh]	Number of Lanes	Trarric volume for a lane	
			Entrance	Exit
71,096	3,555	8	444	–
71,096	3,555	8	–	444

Toll_NO.2(Toll Barrier)

8%

Total [PCU/day]	Traffic Volume at Peak Hour[veh]	Number of Lanes	Trarric volume for a lane	
			Entrance	Exit
87,160	4,358	8	–	545
87,160	4,358	8	545	–

According to the "Manual of Specifications and Standards for Expressways (Indian Roads Congress)", available traffic flow at tollgate (Manual-Lane, ETC-Lane) is defined as Table 2-13. In this study, this traffic capacity is applied to estimate the number of necessary lanes.

Table 2-13 Traffic Capacity of Tollgate for Each Lane by Type of Lane

Type of Lane	Capacity for 1-Lane (Vehicles/hour)
Manual-Lane	240
ETC-Lane	1,200

Source: Manual of Specifications and Standards for Expressways (Indian Roads Congress)

Based on the above information and data, the minimum required number of ETC-lanes in 2042 is calculated and shown in Table 2-14.

There are mainly three types of tollgate by the number of lanes which are "2-Lane in Total", "3-Lane in Total", "8-Lane in Total (Toll Barrier)". In Table 2-14, the minimum required number of ETC-lanes to flow the whole prospective traffic demand at each tollgate by tollgate type is shown. However, due to the following reasons, ETC devices such as RFID Reader should be installed in all lane including Manual-lane to make them mix operation lane and ETC vehicles can pass when it is necessary.

- In case of unavoidable circumstances to close the lanes such as maintenance work, dealing with accidents, responding to the failure in devices, etc.

- Especially for the types of "2-Lane in Total" and "3-Lane in Total" tollgates, it is possible to be forced for operating as a "Mix-Lane" which can cope with both types of cars, "ETC-vehicle" and "Manual vehicle" to flow the whole traffic demand at the tollgate.

In addition to the traffic capacity at the tollgate mentioned above, to decide the placement of ETC-Lane and Manual-Lane at each tollgate, traffic safety would be another critical issue which must be consider to make them most suitable. Therefore, traffic capacity and traffic safety at tollgate should be considered carefully according to the actual traffic volume and traffic condition which will change depending on the ETC usage rate. For the reason above, it is necessary to enable flexible operation of traffic at tollgate by making all lanes "Mix-Lane".

Table 2-14 Minimum Required Number of ETC-Lane by Type of Tollgate

Type of Tollgate	Traffic Volume at Peak Hour	Minimum Required Number of ETC-Lane	Number of Other Lane (Manual-Lane)	Traffic Capacity in Given Case
1. 2-Lane in Total	750 veh/h	1 Lane	1 Lane	1,440 veh/h
2. 3-Lane in Total	1,200 veh/h	1 Lane	2 Lane	1,680 veh/h
3. 8-Lane in Total (Toll Barrier)	4,400 veh/h	4 Lane	4 Lane	5,760 veh/h

Source: JICA Study Team

3 Project Plan

3.1 Project Objective

The Objective of the project are to reduce accident rate and improve the efficiency of the maintenance system and smooth traffic in Delhi Metropolitan region by introducing ITS into EPE, thereby contributing to mitigation of traffic congestion and promoting regional economic development.

Table 3-1 Project Feature

Items	Contents
Project Name	Eastern Peripheral Expressway ITS Installation Project
Project Site	Uttar Pradesh State and Haryana State, India
Project Objective	Reduce accident rate and improve the efficiency of the maintenance system and smooth traffic in Delhi Metropolitan region
Main features of project facility	-Total Length : 136km -Main Toll Gate :2 -Interchange : 8
Relevant study	-Restructuring/Reconfiguring of Eastern Peripheral Expressway (Project) around Delhi, Starting near Kundli and Ending Near Palwal in the Districts of Sonepat & Palwal in Haryana after Passing Through the Districts of Baghpat, Ghaziabad, Gautam Budhnagar in UP.(Oct 2013) -Support of Delhi Eastern Peripheral Expressway Construction work Compilation (Apr 2015)

Source: JICA Study Team

3.2 Project Scope

The Scope of the project are to install the Advanced Traffic Management System (hereinafter referred to as "ATMS") and Toll Management System (hereinafter referred to as "TMS"), and Operation and Management of ATMS is also including the scope to ensure the traffic management to utilize such ATMS and TMS effectively.

(1) ATMS

ATMS is a traffic control system designed to collect information on road conditions, traffic conditions and weather conditions at the traffic control centers and provide the necessary information on roads, traffic and weather to road users 24 hours a day 365 days a year to ultimately ensure safe and smooth traffic.

Table 3-2 Main components of ATMS

Items	Contents
Control Centre	One (1) Traffic Management Centre and two (2) sub centres
Centre system	-Information Collecting system -Information Analysing system

	-Information Dissemination system -Large display and terminal
Sub System (Collection of Information)	- Traffic Monitor Camera System (TMCS) - Video Incident Detection System (VIDS) - Automatic Traffic Counters cum Classifier (ATCC) - Meteorological observation station (MOS) - Travel Time Measurement System (TTMS)
Sub System (Dissemination of information)	- Variable Message Sign (VMS) - Internet - Highway radio (HWR)
Communication System	- Fiber optic cable - Network system - Mobile Radio Communication System (MRCS)
Other system	- Weigh Monitoring System - Vehicle Speed Detection System - Probe Data System(Patrol vehicle monitoring) - Environmental observation System

Source: JICA Study Team

(2) TMS

Distance based toll system will be introduced to EPE. To operate distance based toll system, the toll booth at entry will pass the ticket or transit card to driver which is written the information such as vehicle class, entry interchange, date and time. At the booth at exit, toll collector confirms all above information and imposes fare to drivers by ticket operation, touch and go operation and Electrical Toll Collection (ETC) operation.

Table 3-3 Main components of TMS

Items	Contents
Control Centre	One (1) Toll Management Centre and ten (10) Toll plazas
Toll Plaza	-Smart card(for Touch and Go) registration and payment -RFID (for ETC) registration and payment -Plaza server system -Camera monitoring system
Toll Gate	- RFID ETC antenna - Smartcard Touch and Go reader -Ticket payment and receipt printer - License Plate Image Capture Camera - Automatic Vehicle classification

Source: JICA Study Team

(3) Operation and Maintenance

The training and Technical Transfer for Operation and Maintenance for ATMS will be included in the contract. The technical transfer shall be done in Trial Operation and in Defect Liability Period.

3.3 Consulting Services

The Consultant Team for the design review of the civil works, design review of design by ITS contractor, construction supervision, supervision of Operation and Maintenance of ATMS and other miscellaneous consulting services consist of following key personnel.

8 of Professional (A) consultants and 11 of Professional (B) consultants will be engaged, over 45 month' duration of consulting services, for a total of 114 man-months for Professional (A) and 185 man-months for Professional (B) consultants. Total consulting input is 299 man-months.

Table 3-4 Person-Month by Phases

Designation	No.	Phase wise input in months		Total Input in Months
		Construction work	Defects Notification Period (ATMS OM Period)	
		Design, Procurement Installation, Commissioning Trial Operation		
Team Leader	1	21	4	25
Sr. ITS Engineer (TMS)	1	12	4	16
Sr. ITS Designer (ATMS)	1	16	14	30
Sr. Electrical Engineer	1	7		7
Sr. Cable Specialist	1	7		7
Sr. Communication Specialist	1	8		8
Sr. Contract Specialist	1	8		8
Sr. O/M Specialist	1	5	8	13
ITS Engineer	1	21	24	45
Electrical Engineer	1	13		13
Civil Engineer	1	11		11
Structural Engineer	1	12		12
Material Engineer	1	13		13
Quantity Surveyor	2	22		22
Surveyor (System/Cable)	1	7		7
Surveyor (Civil/Structure)	1	7		7
Quality Control Engineer	1	14		14
Safety Engineer	1	12		12
O/M Engineer	1	5	24	29

Source: JICA Study Team

4 Basic Design

4.1 Advanced Traffic Management System (ATMS)

Advanced Traffic Management System (ATMS) is a system with the aim of ensuring safe and smooth traffic through execution of Traffic Management Center (TMC), which collects/understands information required for road and traffic management, e.g., conditions of road and traffic, meteorological information, then provide it for organizations concerned and road users 24 hours a day, 365 days a year.

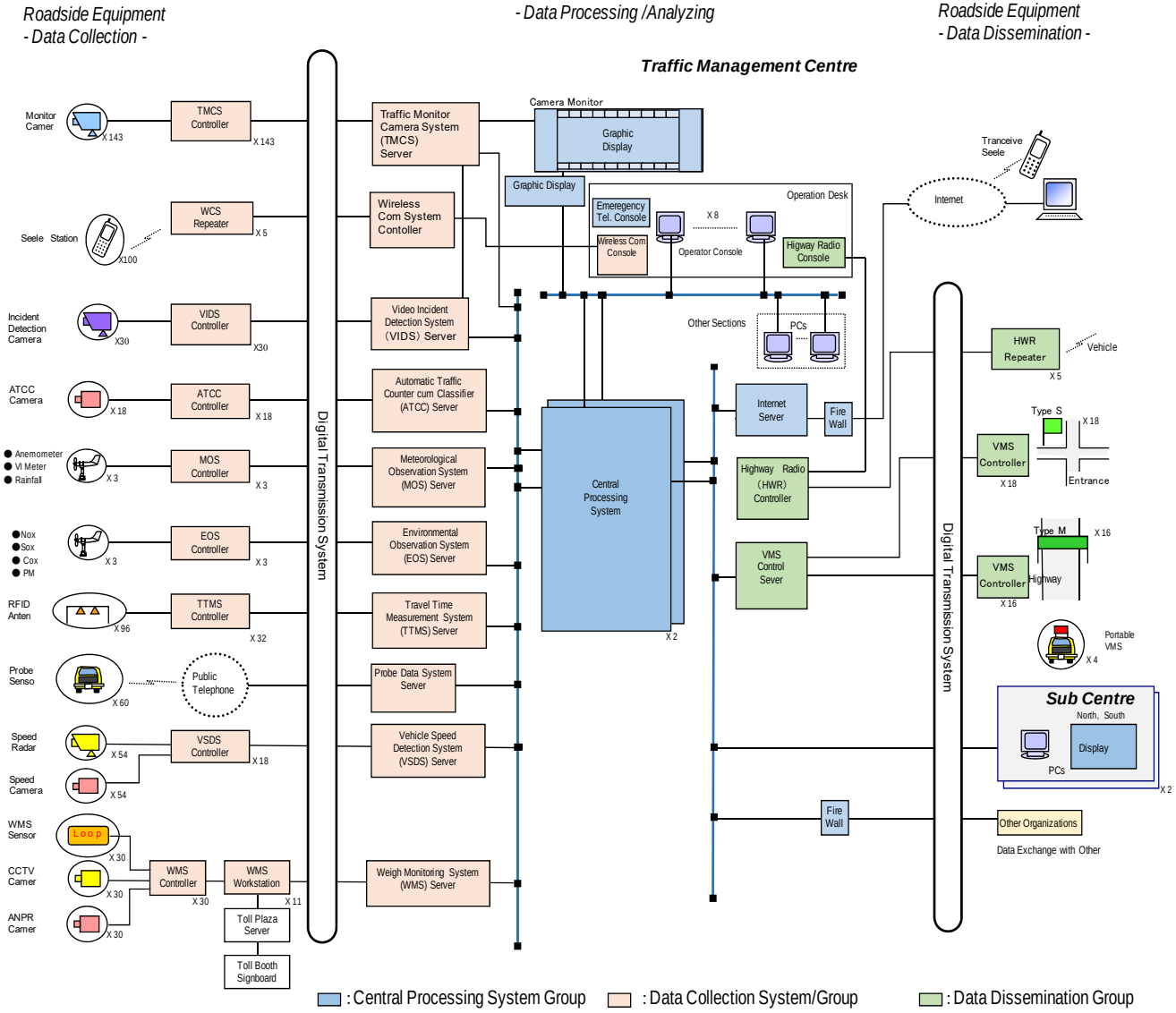
This is building block of ITS and in response to innovation of ITS technology, countries all over the world are studying to develop, introduce and renovate it for Provision of safe, smooth and comfort road information, and Implementation of efficient traffic control & management.

ATMS consists of three steps largely: Collection, Processing and Provision. For Providing Information, elaborated from Collecting Data, Processing, the important function in between will serve as brain.

Figure 4-1 shows the Conceptual Diagram of Advanced Traffic Management System.

As the mentioned below shows all conceivable functions/equipment of ATMS at the present, the practical introduction should be taken into consideration adequate system configuration in the light of actual situation of area concerned, such as introduction purpose/aim, project budget, and spread of terminal devices.

The following describes possible suitable policy on ITS introduction for “Delhi Eastern Peripheral Expressway (EPE)”.



Source: JICA Study Team

Figure 4-1 Conceptual Diagram of Advanced Traffic Management System

As the above-mentioned shows all conceivable functions/equipment of ATMS at the present, the practical introduction should be taken into consideration adequate system configuration in the light of actual situation of area concerned, such as introduction purpose/aim, project budget, and spread of terminal devices.

The following describes possible suitable policy on ITS introduction for "Delhi Eastern Peripheral Expressway (EPE)".

4.1.1 Concept of ATMS

The concept, points of concern, component of ITS devices and others at introduction of ATMS have been formulated in the priority review: "Report on ITS introduction plan", after consultations based on SP: 99-2013 Manual of Specifications and Standards for Expressway published by Indian Road Commission (IRC), with Ministry of Road Transport and Highways (MoRTH), National Highway Authority of India (NHAI) and Indian Highway Management Company Limited (IHMCL).

(1) Basic concept of collecting/providing information

Data collecting devices installed on roadsides collect information of traffic condition and meteorological state and transmit it to Traffic Control Center via optical fiber. Traffic Control Center processes/analyses collected information and under integrated management provides it road users via information providing devices, e.g., Variable Message Sign (VMS), internet.

(2) Cooperation with external organizations

Cooperation with the following organizations concerned is assumed to be required:

Table 4-1 Concerned organizations required for cooperation

Bodies concerned	Role
Traffic Police	• Handling of accidents • Crackdown actions of vehicles of illegal passage
YUMUNA EXPRESSWAY	• CCTV monitoring • Traffic Management System
Delhi Integrated Multimodal Transit System Ltd (DIMTS)	• Operation control of city bus of Delhi and mass-transporting highway bus: • Control with location information collected from GPS equipped in each bus • Lack of preparing system of congestion information with probe information

Source: JICA Study Team

Following are the issues for cooperation:

1) Cooperation with Traffic Police

At detection of traffic accidents and failures by CCTV/Incident Detection System (VIDS), notification and cooperation methods with Traffic Police should be consulted beforehand.

2) Coordination with YAMUNA EXPRESSWAY

YAMUNA EXPRESSWAY is the existing operation expressway, which will be crossed with EPE. CCTV along with expressway is monitoring at control centre for effective traffic management system. The traffic information of YUMUNA EXPRESSWAY is very important, and traffic information of EPE is also important for them. Therefore, Information exchange between YUMUNA EXPRESSWAY and EPE shall be considered in the project.

3) Cooperation with DIMTS

DIMTS is the joint venture between Government of Delhi and infrastructure spending company, studying future provision of traffic information via Information Signboards such as dynamic congestion information through analysis of collected information. However, currently arrangement with parties concerned impedes progress of the plan. In the view of current situation, even though this time the introduction is refrained, consultation about future cooperation on this plan is desirable, because the priority review: "Report on ITS introduction plan" included graphic information board installed outside of EPE, displaying traffic information within city of Delhi, which will help drivers to decide to travel EPE or not.

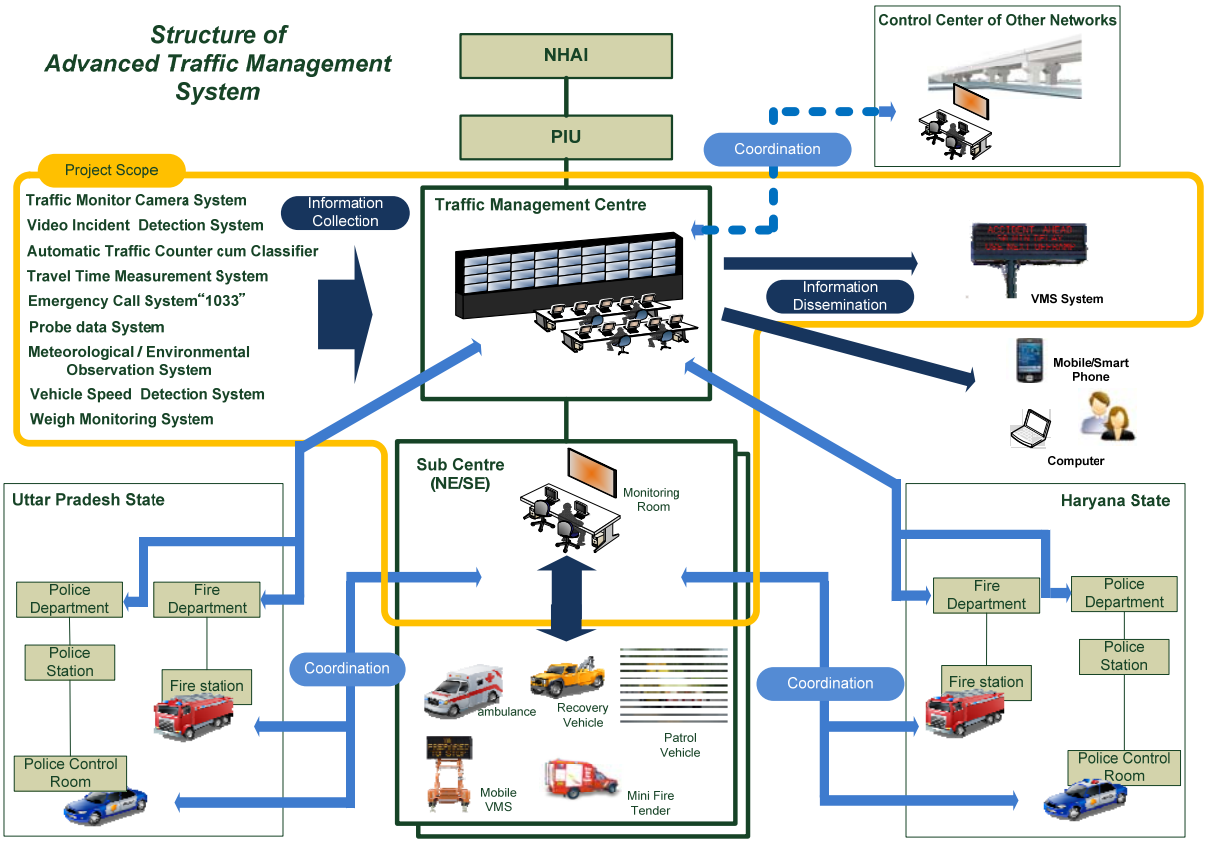
(3) Creating methods of traffic information: assessment of traffic situation, priority setting of provision and others

Employing introduced ITS, in order to response quickly to abnormal events including reports from concerned parties such as accident, fallen object, broken-down vehicle, and to provide drivers useful traffic information, sufficient training in operating body and sophistication based on experience will be needed. For example, automatic detection system of abnormal events and its processing method, and priority setting of information provision should be determined in ITS operation.

4.1.2 Main Components

ITS components of ATMS have been examined based on mainly the priority review: "Report on ITS introduction plan", then new survey results and consultations with concerned bodies such as MoRTH and NHAI.

Figure 4-2 describes entire configuration of ATMS proposed in this project.



Source: JICA Study Team

Figure 4-2 Structure of Advanced Traffic Management System for Delhi EPE

This proposal follows general components of ATMS, three stages of Collection, Processing and Provision. Figure 4-2 shows additionally cooperative relations with agencies and organizations concerned with road traffic, which is indispensable for ATMS.

The section with in yellow frame in the figure will be the scope of this project: system and devices.

Following describes purpose and subject system of each stage:

(1) Collection

These devices are introduced to grasp occurring events on expressway: traffic condition, emergent event, meteorological condition and others.

- Traffic Monitor Camera System (TMCS)
- Video Incident Detection System (VIDS)
- Automatic Traffic Counter and Classifier (ATCC)
- Meteorological Observation Station (MOS)

- Probe Data System
- Environmental Observation System (EOS)
- Travel Time Measurement System using RFID (TTMS)
- Emergency Call System "1033"
- Related Road and Traffic Authority

Generally, Information Collecting does not include environment-monitoring system, but this includes expediently.

Regarding probe data, of which purchase from private sector was planned in the priority review: "Report on ITS introduction Plan", this survey has verified that its quality and quantity are insufficient to create traffic information and decided not to introduce in this project. (However, as it has future possibility to advance, its development deserves continued attention.) In view of diffusion of mobile phones and installation plan of CCTV, emergency telephones neither will be introduced; instead, signboard indicated exclusive number for emergency.

This stage needs to handle information exchange of traffic data/events belonged to Yamuna Expressway, which establishes JCT with DIMTS and EPE, and others conforming to the actual condition and requirement.

Additionally, collected data in this stage should be stored in order to use for analysis that will serve future efficient traffic management.

(2) Processing

These are introduced to process, e.g. coupling, arithmetic operation and visualization, collected data in previous stage: 1) Information Collection, and to create available traffic information for the next stage: 3) Information Provision.

- Data Processing System
- Traffic Management Centre (TMC)

Creating information for VMS includes judgment function from severity level and location (distance) of the event. This function is assumed a type that gives support to traffic control staffs for judgment.

Additionally, it should have tenable function to judge traffic condition and determine priority of displaying information according to operation/ analysis.

(3) Provision

These are introduced to disseminate information of occurring events on expressway such as traffic condition, emergent event, meteorological condition (Information Provision).

- Traffic Management Centre (TMC)
- Variable Message Sign (VMS)
- Internet
- Highway Radio (HWR)*

Regarding graphic signboard planned in the priority review: "Report on ITS introduction Plan", this survey has verified that the quality and quantity of probe data that will be source, are insufficient to create traffic information and decided not to introduce in this project.

*HWR is excluded in this project because HWR will installed by other project of NHAI.

(4) Communication

This is introduced for efficient cooperation between TMC and traffic patrol vehicles. Mobile Radio Communication System (MRCS)

(5) Enforcement

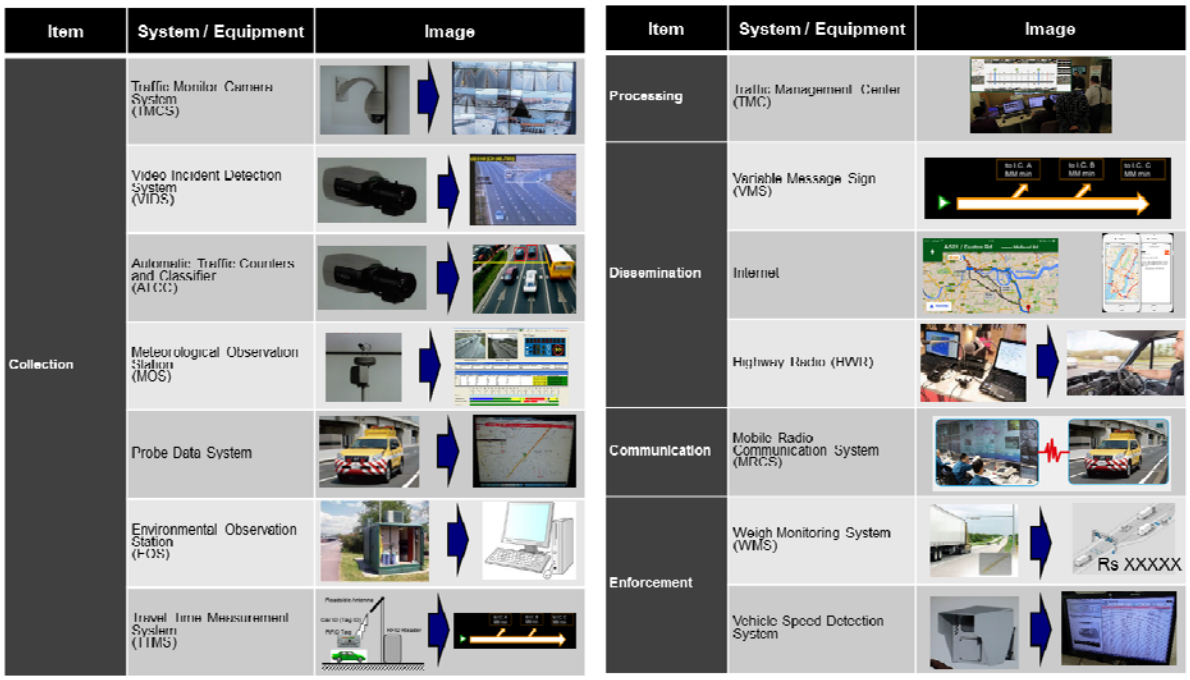
These are introduced to contribute for safe, smooth and comfort road traffic environment.

- Vehicle Speed Detection System
- Weigh Monitoring System (WMS)

These are overview of proposed ATMS in this project. ATMS is nothing more than a tool to achieve goal but it demonstrates its full function when persons in charge of traffic management/ technology master it properly and efficiently. At the same time, it goes without saying that improvement corresponded to ever progressing ICT technology can ensure firm growth conformed to actual condition. Considering this, in order to serve continuous growth of ATMS and traffic control staffs, ATS should equip functions such as storage/usage function of traffic data/events and flexible adjustment function of parameter.

4.1.3 Function and location of equipment

With regard to principal employing equipment of ATMS in this project, Figure 4-3 shows usage image of each equipment and Figure 4-4 describes purpose and layout plan of each.



Source: JICA Study Team

Figure 4-3 Image of ATMS Equipment

Item	System / Equipment	Purpose / Function	Layout
Collection	Traffic Monitor Camera System (TMCS)	Live monitoring of EPE on all locations	Continuous layout along EPE
	Video Incident Detection System (VIDS)	Automatic detection of abnormal condition	Black spots (weaving section)
	Automatic Traffic Counters and Classifier (ATCC)	Traffic (Volume, Speed etc.) monitoring	Between I.C. (each direction)
	Meteorological Observation Station (MOS)	Meteorological data collection *Rainfall, Wind, Fog etc.	3 locations (TMC and bridge at Yamuna river)
	Probe Data System	Patrol vehicle location monitoring	Patrol vehicle
	Environmental Observation Station (EOS)	Environmental data collection *NOx, SOx, PM2.5 etc	3 locations (same place with MOS)
	Travel Time Measurement System (TTMS)		
Processing	Traffic Management Center (TMC) Devices • Large Display • Monitor/Control Terminal • Advanced Data Processing Server • Integrated ATMS Software	Advanced and integrated data processing • Integration of collected data • Information dissemination	Traffic Management Center Sub Center (limited function)
Dissemination	Variable Message Sign (VMS)	Display real time information to the driver	200m before from I.C. and JCT. Mobile VMS
	Internet	Information supply to users by internet • EPE traffic information • EPE fare search • EPE event information	Web server system in Traffic Management Center
	Highway Radio (HWR)	Supply by 3 languages using FM radio station	Antenna tower at TMC, Sub Center and T.B.
Communication	Mobile Radio Communication System (MRCS)	Among office (TMC) and patrol vehicle Radio transmission station	5 locations (same with HWR)
Enforcement	Weigh Monitoring System (WMS)	Monitoring of heavy vehicle • Capture the image • Number plate recognition	T.B. and Exit (before payment)
	Vehicle Speed Detection System	Detection of over speeding vehicle • Capture the image • Number plate recognition	Between I.C. (each direction)

Source: JICA Study Team

Figure 4-4 List of Main System / Equipment of ATMS

Following explains function and layout concept of principal equipment:

(1) Collection

1) Traffic Monitor Camera System (TMCS)

- Image supplementary range should be all main lanes of expressway.
- Camera should be pan-tilled-zoom (PTZ) type. (Hearing survey with manufacturer verified it enable to ensure visual field of 500m)
- Installation interval should be every 1km that enables to capture all directions if adjusting angle.
- Installation place should be arranged staggered on both side (zigzag) considering balance of image supplementary range and preventing appearance of blind spot by installation at road shoulder.
- Installation around I.C. should be more intensive than ordinary points in order to cover hazardous spots of merging points.

2) Video Incident Detection System (VIDS)

- Camera should be fixed-type. (Hearing survey with manufacturer verified PTZ type could not be available).
- It should be installed in weaving section within I.C., where could be black spot because of much merging/branching traffic in short distance.

3) Automatic Traffic Counter and Classifier (ATCC)

- Camera should be fixed-type. (Hearing survey with manufacturer verified PTZ type could not be available).
- Installation place should be one spot of each direction at the center in between I.C.s, where traffic flow is stable.
- Data acquisition should be traffic volume measurement to capture number of vehicles in between I.C.s.
- Vehicle –type classification should be studied and determined in the light of usage.
- Power source should be from solar panels.

4) Meteorological Observation Station (MOS)

- Installation place, considering balance within the scope, should be three points, well-ventilated spots of both banks of Yamuna River and Traffic Management Center.

5) Probe Data System

- System is intended to employ existing application, e.g. Gurgaon Expressway.
- Perceivable scope should include outside of expressway.

- Scope of location should be perceivable in the display of TMC: indication of outside roads of expressway requires some arrangements.

6) Environmental Observation System (EOS)

- Installation place, considering balance within the scope, should be neighboring place to MOS.

7) Travel Time Measurement System using RFID (TTMS)

- It is detailed in 5.1.5.

8) Emergency Call System "1033"

9) Related Road and Traffic Authority

(2) Processing

1) Data Processing System

2) Traffic Management Centre (TMC)

- It is detailed in 5.1.4.

(3) Dissemination

1) Traffic Management Centre (TMC)

- It is detailed in 5.1.4.

2) Variable Message Sign (VMS)

- Form should be small overhung type for roadside installation and portal type for exit of main lanes. Both should be text-display type.

- Indication contents should be textual information such as travelling time, congestion, warning and slogan.

- Display information, as general rule should be entered and confirmed by control staffs.

3) Internet

4) Highway Radio (HWR)

- This is intended to be emitted using frequency obtained by NHAI, considering coverage of radio broadcast for EPE.

- It is assumed that messages will be broadcasted employing narrator from EPE radio.

- Antennas, considering coverage distance of radio wave and power source, should be installed at 5 points: Toll Barrier (2), PA (2), and TMC (1).

(4) Communication

1) Mobile Radio Communication System (MRCS)

- Antennas, considering coverage distance of radio wave and power source, should be installed at 5 points: Toll Barrier (2), PA (2), and TMC (1).

(5) Enforcement

1) Vehicle Speed Detection System

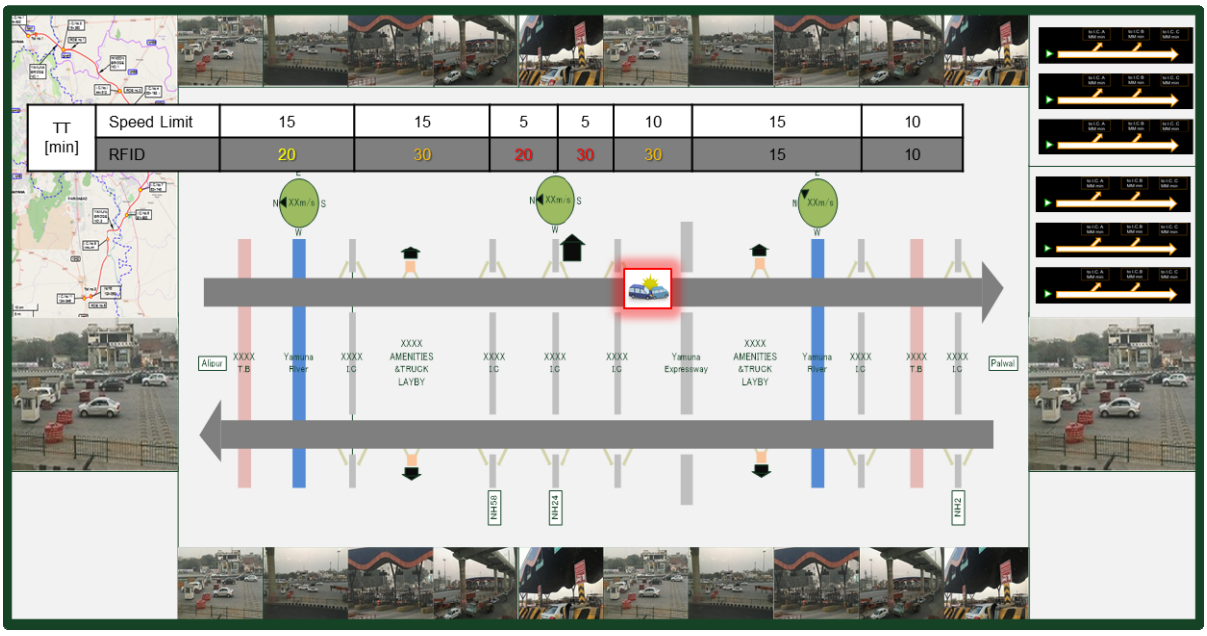
- Installation place should be one spot of each direction at the center in between I.C.s, where traffic flow is stable.
- It is assumed that operations are executed in random order.
- Power source should be from solar panels.

2) Weigh Monitoring System (WMS)

- Measurement place, considering collection of penalty at tollgate, should be in ramp way before exits: in 2 lanes at I.C. and 3 lanes at both ends.

4.1.4 Display image

Monitor for traffic control in TMC should have screen configuration of multi-screen basically, which includes advanced functions corresponding to ATMS, referring introduction situation of other expressways. It is intuitively understandable and tractable with displays: center one shows road traffic condition, upper and lower ones show images of CCTV and right and left side ones show displaying situation of VMS, enlarged image of emergent events and others.



Source: JICA Study Team

Figure 4-5 Display of Traffic Management Centre (Concept Image)

Sub TMC (branch office) will have similar monitor with smaller displays, but without input device. It is supposed to be shared with base of patrol team.

Following explains concept of event management in TMC.

(1) Unit of event (link)

Relation between location and link of CCTV in main lanes is as follows.

- One link is set in each direction by the scope of CCTV (at installation interval, every 1km approx.).
- One link is set for each camera, of which borders should be determined in the center of distance between adjacent cameras.

As CCTVs will be installed without invisible range, one camera, which detects and determines an event, corresponds to one link: one-to-one relation. This can facilitate definition and registration of occurrence point of event. It also has merit when length of congestion includes in information provision, the installation interval of 1km served as spatial resolution will enable give the value mentioned.

Additionally, link to I.C. should be set under available management even when traffic closures at merging/branching point.

(2) Registration and release of event

Regardless means of event recognition via CCTV, VIDS, MOS, reports, etc. , as a general rule, occurrence of event should be confirmed and registered by traffic control staffs of TMC (with image and data).

CCTV in ATMS will covers all sections without invisible range; type of event should be determined from images in general. If it is difficult, but incident is observed at least, other registration method will be employed; once tentative registration, e.g., “detained vehicle observed” done, then it will be replaced actual type, when detail is confirmed.

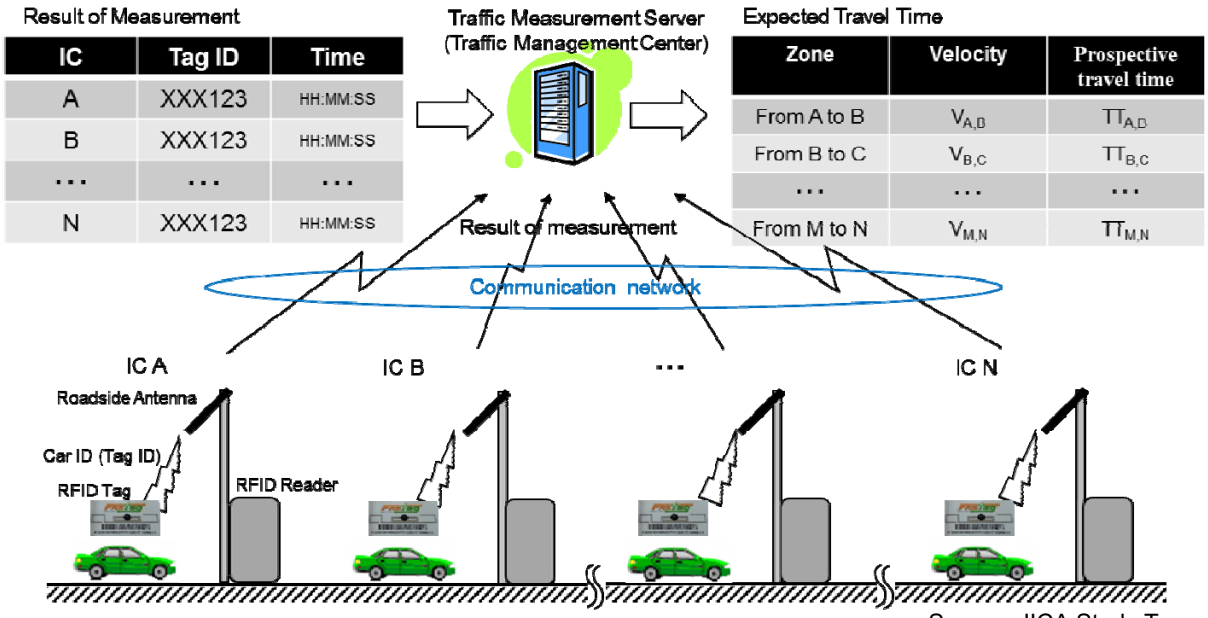
It is assumed that type of subject events will be accident, fallen object, congestion, fog, etc., input support such as pull-down menu will be incorporated and linkage with checking devices enables to omit registration of location.

In order to prevent from forgetting release of event, checking function such as alarm system on events remaining unchanged for a certain time, e.g., 30 minutes is intended to be incorporated also.

4.1.5 Travel Time Measurement System using RFID (TTMS)

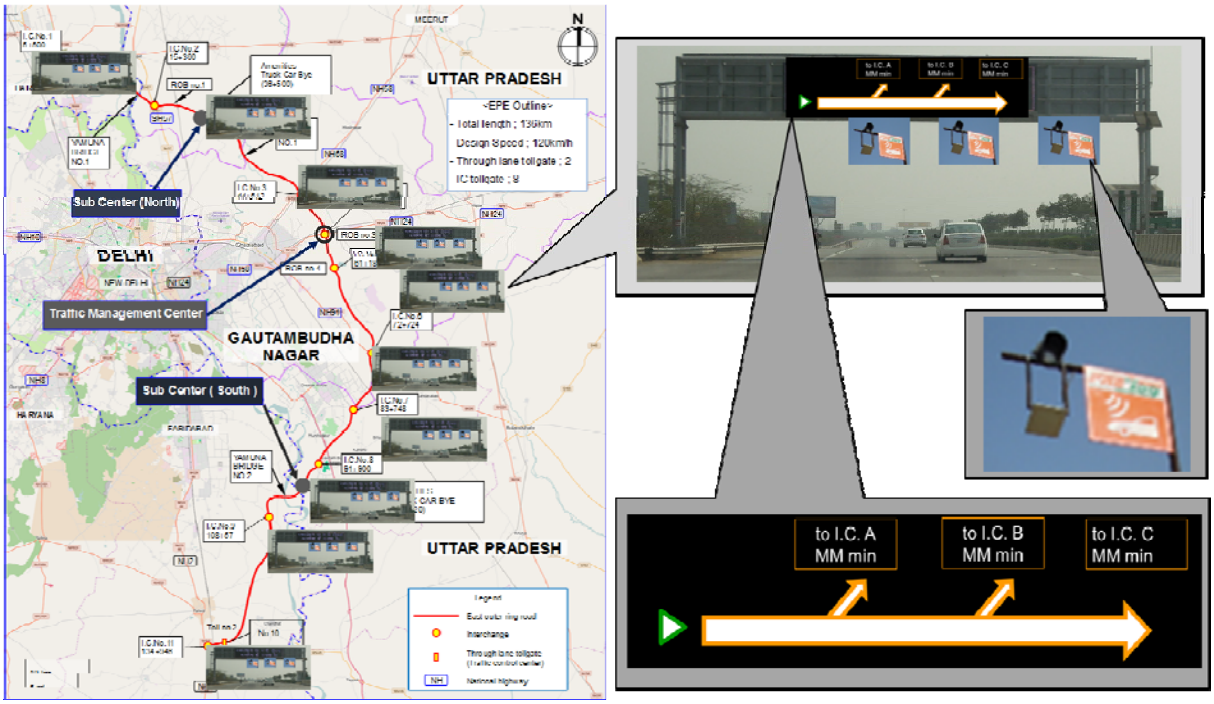
Considering standardization of toll collection with RFID in India and introduction to newly registered vehicles, following methods applied RFID are proposed as efficient and effective way in traffic data collection

Although this survey limits the proposal to measurement between I.C.s, according to usage and purpose, RFID can be developed to accurate grasp system of traffic-condition by defined spatial resolution with intensive installation of RFID readers (replaced grasp and registration of traffic condition with CCTV).



Source: JICA Study Team

Figure 4-6 Usage of RFID for Traffic Information System (Concept Image)



Source: JICA Study Team

Figure 4-7 Usage of RFID for Traffic Information System (Installation Image)

4.2 Toll Management System (TMS)

4.2.1 Concept of TMS

(1) Outline

The toll management system uses both manual collection and automatic electronic toll collection systems, and charges by distance-based pricing.

Toll Management System (TMS) will be introduced to EPE. Three toll collection methods will be adopted; (i) Cash, (ii) Touch and Go using prepaid smartcard, and (iii) Electronic Toll Collection (ETC) using prepaid smartcard on on-board unit. Thus the smartcard system needs to be designed along with TMS system for EPE and the prepaid smartcard shall be available by the time of commencement of operation of TMS.

In the ETC system, roadside facility and in-vehicle facility are required. The in-vehicle part of ETC being employed in India is the RFID tag with sticker seal, which can be easily pasted on the front glass of vehicle. As to the roadside facility, RFID readers are installed at the tollgate. It reads the vehicle ID from RFID passing through the tollgate, and fare is settled based on the vehicle type. RFID readers which were standardized by the NHAI have been installed at 24 stations on National Road 8 connecting Delhi and Mumbai.

(2) Coordination with India Highway Management Co., Ltd.（IHMCL）

IHMCL is understood to be the company that supplies the ETC system equipment. It should be confirmed if management maintenance control of the ETC system is to be part of the scope of work on ITS contractor or it should be performed by IHMCL.

4.2.2 Main Components

(1) Additional Equipment for TMS

1) Adoption of Felica in IC card.

Since the standard method of toll management system in Indian national road has advised that the RFID from the Indian Ministry of Road and Transport shall be standard, the RFID as “ITS implementation plan report” shall be used in this project.

Meanwhile, the manual for toll management of touch and go style in Delhi Noida Direct (DND) Flyway and National Highway No. 2 (NH 2) among the toll road surrounding Delhi city has been implemented. In Delhi Eastern Peripheral Expressway, adoption of the touch and go has not been planned; however, since stop time reduction at the manual tollgate, shortening of travelling time associated with this system and adoption effect such as traffic congestion are expected, the consortium suggests combining touch and go using Felica.

2) Ticketing machine

Since the EPE is distance-based pricing, entrance ramp must be specified at exit ramp, and the fare must be charged to drivers. ETC can easily specify the entrance ramp, but it is

necessary to issue tickets at the entrance ramp to drivers who pay in cash. In the equipment list of "ITS adoption plan report", since such ticketing machine has not been planned, it is necessary to implement it for improving work efficiency of toll management work.

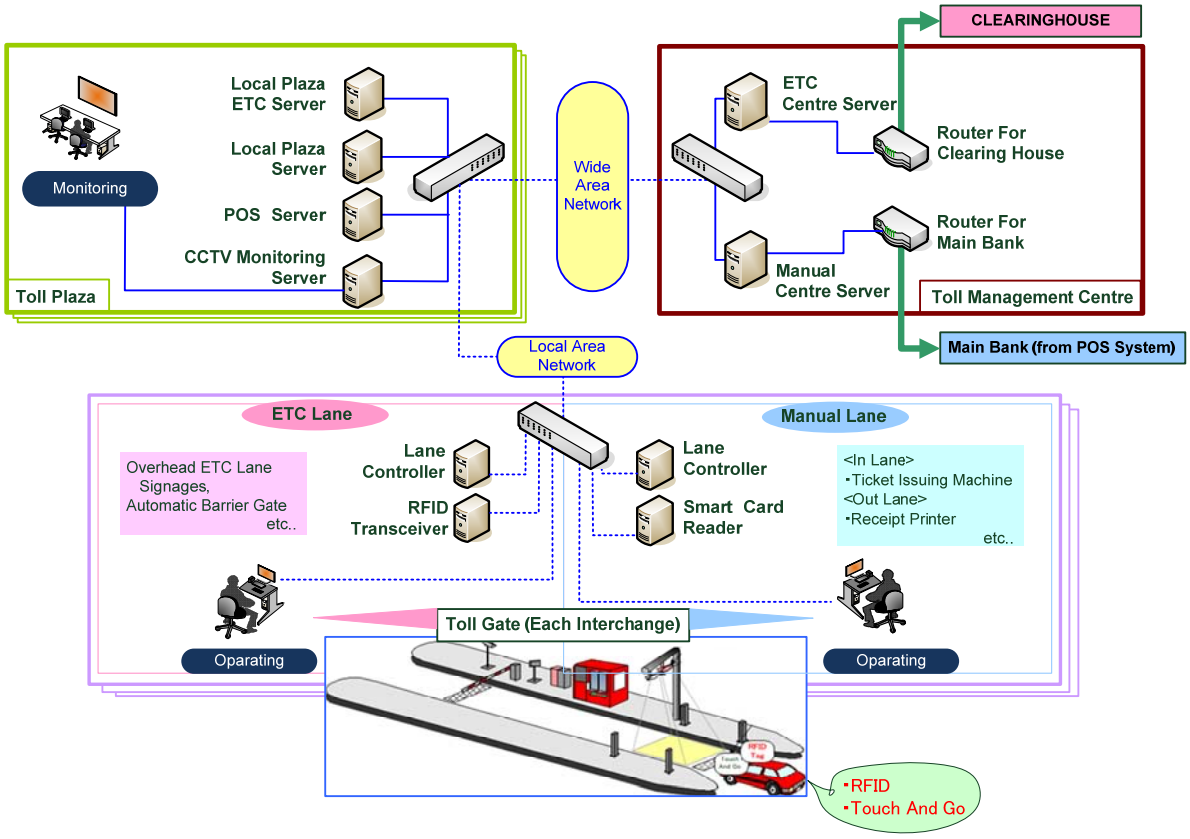
(2) Outline of system configuration

ITS components of TMS have been examined based on mainly the priority review: "Report on ITS introduction plan", then new survey results and consultations with concerned bodies such as MoRTH and NHAI.

The toll management system is composed of three levels (toll lane, toll plaza, toll management centre) of equipment. As shown below, the toll lane equipment will be controlled by the plaza computer system and centre system.

The toll lane equipment will be installed on the toll lane island or inside of toll booth. Operation of all lane equipment should be concentrated in the plaza computer system and continuously monitored. The toll management centre system will be installed in the same building as the traffic management centre. This is because most of the buildings are planned to small size except building for traffic control centre.

Following describes entire configuration of TMS proposed in this project.



Source: JICA Study Team

Figure 4-8 Structure of Advanced Traffic Management System for Delhi EPE

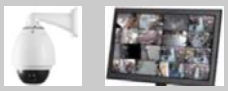
4.2.3 Equipment Function and Location

(1) Image of TMS Equipment

With regard to principal employing equipment of ATMS in this project, Figure 4-9 shows usage image of each equipment and Table 4-2 ~ Table 4-5 describes purpose and layout plan of each.

Source: JICA Study Team

Item	System/ Equipment	Image
Manual Toll Collection	-Automatic Ticket Issuing Machine -Automatic Boom Barrier -Violation Alarm -LPIC Camera -Integrated UFD & Traffic light	
	Receipt printer, Industrial Keyboard, Touch Panel, booth Camera, Touch & Go Smart Card Reader	
	Toll Communication	
	Lane AVC Incident Camera	

Item	System/ Equipment	Image
ETC	-RFID ETC transceiver -Hand-held RFID Reader -RFID Tag	
	Vehicle Guidance Signal – Traffic light	
Plaza	Monitoring camera (PTZ) for Traffic monitoring both direction	
	Servers & Plaza Network	

Source: JICA Study Team

Figure 4-9 Image of TMS Equipment

(2) Equipment list of TMS

TMS will consist of the following components;

Table 4-2 List on Main System – 1 / Equipment of Toll Lane < Manual >

Items	Equipment	Purpose / Function	Unit	In Lane	Out Lane
Manual Toll Collection	Lane Controller with Industrial PC	Control and Monitor all the sub systems	1/Lane	O	O
	Automatic Ticket Issuing Machine	Automatic ticket issuing station at the entry lane to issue tickets. The ticket will be presented at the out/exit lane and distance based toll fare will be charged at the out lane	1/Lane	O	X
	Receipt Printer, Industrial Keyboard, Touch Panel TFT	Toll Collector Terminal for processing transaction and printing receipt	1/Lane	X	O
	Toll communication	Communication network	1/Lane	O	O
	Independent AVC Controller and Lane AVC system including sensors and loop	Sensors, controller and other peripherals for Automatic Vehicle classification	1/Lane	O	O
	Booth monitoring camera, Intercom slave unit	Camera for monitoring TC activities inside the booth, intercom unit for 2-way communication with control room	1/Lane	X	O
	Manual booth controller	To manually control (open/close) boom barrier, traffic light & OHLS	1/Lane	O	O
	Siren and Blinking light and panic alarm switch	Panic alarm switch to secretly inform control room about any danger from the booth. Siren & blinker is to alert the security staff about any violation in the lane	1/Lane	Only Siren	O
	Smart Card Reader	Touch-and-go card reader	1/Lane	O	O
	Automatic Barrier Gate, loop and vehicle separator	Barrier gate to stop vehicle to pay. Loop & separator to detect vehicle presence and separate 2 vehicles.	1/Lane	O	O
	Overhead Lane Status light (OHLS)	Lane open/close LED sign mounted on the canopy to inform commuter about lane open/close status	1/Lane	O	O
	Integrated User Fare Display With Traffic Light System & Siren	46" LED backlid Panel to display user information/fare details and traffic light	1/Lane	O	O
	Incident Capture Camera with mounting pole	Capture vehicle image with every transaction	1/Lane	O	O
	License Plate Image Capture Camera with mounting poles	capture vehicle registration number plate	1/Lane	O	O
	Manual entry barrier integrated to OHLS, Load gauge detector for booth & equipment protection from over size vehicle entering normal lane	Barrier gate to close lane at entry, OHLS turns red when it is closed. Load gauge detector for booth & equipment protection from over size vehicle entering normal lane. Detects and Raises alarm when any oversized vehicle enters normal lane	1/Lane	O	O

Source: JICA Study Team

Table 4-3 List on Main System – 2 / Equipment of Toll Lane < ETC >

Items	Equipment	Purpose / Function	Unit	In Lane	Out Lane
ETC	RFID ETC transceiver (entry) – over lane entrance (AVI)	ETC tag reader at the entry zone to validate the ETC tag	1/Lane	O	O
	RFID ETC transceiver (exit) – for transaction – over lane Canopy near AVC	ETC tag reader at the exit zone to process ETC transaction	1/Lane	X	O
	Lane Controller with Industrial PC	Control and Monitor all the sub systems	1/Lane	O	O
	AVC including sensors, loop and detector	Sensors, controller and other peripherals for Automatic Vehicle classification	1/Lane	O	O
	Integrated User Fare Display With Traffic Light System & Siren	46" LED backlid Panel to display user information/fare details and traffic light	1/Lane	O	O
	Automatic Barrier Gate	Barrier gate to stop vehicle from entering exit zone in case of invalid ETC tag or vehicle without Tag	1/Lane	O	O
	Overhead Lane Status light (OHLS)	Lane open/close LED sign mounted on the canopy to inform commuter about lane open/close status	1/Lane	O	O
	Vehicle Guidance Signal – Traffic light with mounting pole	Green and Amber arrow to guide vehicles with valid tags to exit zone and invalid/without tag vehicles to ejection zone	3/Lane	O	O
	Light Curtain	for vehicle separation	3/Lane	O	O
	Incident Capture Camera with mounting pole	Capture vehicle image with every transaction	1/Lane	O	O
	License Plate Image Capture Camera with mounting poles	capture vehicle registration number plate	1/Lane	O	O
	Overhead ETC Lane Signages (4 boards of 1.2 m X 1.2 m dimensions)	Lane signages to guide ETC tag users	1/Lane	O	O
	Loop Detector	To detect presence of vehicles	6/Lane	O	O

Source: JICA Study Team

Table 4-4 List on Main System – 3 / Equipment of Toll Plaza

Items	Equipment	Purpose / Function	Unit
For Manual Toll Collection	Local Plaza Server	TMS server with TMS application and database at every toll plaza control room	1/Plaza
	Incident Management Workstation	To control and monitor the incidents and audit transactions	1/Plaza
	Network Printer	For printing reports	3or4/Plaza
	POS Server		
	Monitoring PC	PCs in control room for management, MIS and audit purpose	6/Plaza
	Intercom Master station	Master intercom unit in control room to communicate with TC in lanes	1/Plaza
	Camera monitoring display for Control room(50inch)	for monitoring camera footage	3/Plaza
	Monitoring camera (PTZ) for Traffic monitoring both direction, Toll gate	CCTV surveillance of Toll lane area	4or 5/Plaza
	Monitoring cameras (bullet/dome) for important rooms in plaza building and tunnel	CCTV surveillance of activities in plaza building & tunnel	10-12/Plaza
For ETC	Local ETC Plaza Server	dedicated server for ETC lanes at each toll plaza	1/Plaza
	Incident Management Workstation	To control and monitor the incidents and audit ETC transactions	1/Plaza
	Network Printer	For printing reports	1/Plaza
	Hand-held RFID Reader	for processing ETC transactions manually in case lane reader not working or ETC lane offline	4/Plaza
	RFID Registration PC and Receipt printer	For issuing ETC tags at POS	1/Plaza
Network System	Network system	Network switches for Toll Plaza connectivity	1/Plaza
Power system	Uninterruptable power supply (UPS)	to supply uninterrupted clean power supply to all TMS equipment	1/Plaza

Source: JICA Study Team

Table 4-5 List on Main System – 4 / Equipment of Toll Management Centre

Items	Equipment	Purpose / Function	Unit
For Manual Toll Collection	Manual Centre Server	TMS central server with central TMS application and database at central control room to connect every toll plaza local server	1set/Centre
For ETC	ETC Centre Server	ETC central server with central ETC application and database at central control room to connect every toll plaza local ETC server	1set/Centre
	Internet router for connection to the CCH	Dedicated internet router to connect plaza ETC server with the CCH	1set/Centre
Network System	Network system	Network switches for Toll Management Centre connectivity, Modem for clearing house, bank.	1set/Centre
Power system	Uninterruptable power supply (UPS)	to supply uninterrupted clean power supply to all TMS equipment	1set/Centre

Source: JICA Study Team

(3) Tollgate booth quantity plan

As for tollgate booth quantity plan, please refer to <Chapter3.3 Estimation of Booth Number (ETC/Manual)> of this report.

This is based on the estimated traffic volume of Exit / Entrance in each year, required number of ETC-Lean is calculated using traffic survey data and assumed ETC usage ratio.

5 Project Implementation Schedule

5.1 Project Status of Civil Package

Civil project is divided into 6 packages and four packages were started and PK1 and PK4 are expected to start in April 2016.

Table 5-1 Status of Civil Packages (April 2016)

Package	Location	Company	Situation
PK1	0km - 22 km	Sadbhav Engineering Ltd	No progress (expected to be started from 21-Apr-16)
PK2	22km - 46.5 km	Sadbhav Engineering Ltd	Civil Work started
PK3	45.5km - 71 km	Jaiprakash Associates Ltd	Civil Work started
PK4	71 km - 93 km	Ashoka Buildcon	No Progress (expected to be start by April month end)
PK5	93 km - 114 km	Oriental Structural Engineers	Civil work started (including Yamuna Bridge)
PK6	114 km - 136 km	Gayatri Projects Ltd	Civil work started

Source: JICA Study Team

Civil consultant for PK1-PK3 was already assigned to M/s Egis India Consulting Engineers Pvt.Ltd. but Civil consultant for PK4-PK6 has not been assigned yet.

Civil project is expected to complete by March 2018.

5.2 Project Implementation Schedule

(1) Installation Period

The Project of TMS and ATMS will be started on January 2017. Completion of TMS will be on March (Installation period 15 months) and operation of ATM will be started on April 2018 and Completion of ATMS will be Jun 2018 (Installation period 18 months).

Table 5-2 Implementation schedule (May 2018)

Item	Timing	2016	2017	2018	2019	2020	2021
Technical Spec/Drawing	2016 April-May						
Bid Doc Preparation	2016 Jun						
Tender	2017 Jun-Sep						
Evaluation	2017 Sep-2018 May						
Installation &Test (TMS)	2018 Jul-2019 Sep						
Design/Approval	2018 Jul-2018 Oct						
Procurement	2018 Nov-2019 Apr						
Installation/Testing	2019 May-2019 Sep						
Trial Operation	2019 Oct-2019 Dec						
Installation & Test (ATMS)	2018 Jul-2019 Dec						
Design/Approval	2018 Jul-2018 Nov						
Procurement	2018 Dec-2019 Jun						
Installation	2019 Jul-2019 Nov						
Integration/Testing	2019 Oct-2019 Dec						
Trial Operation	2020 Jan-2020 Mar						
Operation of TMS	2019 Oct						
Operation of ATMS (By Yen Loan Contract)	2020 Jan-2021 Dec						

Source: JICA Study Team

(2) Trial Operation & DLP Period

After installation and procurement, Trial operation will start and when trial operation will be completed successfully, system will be handed over to Client and Defect Liability period will be started.

TMS Operation will start with Technical Transfer to the operator appointed by NHAI in Trial operation. And ATMS Operation will start by Contractor during Trial Operation.

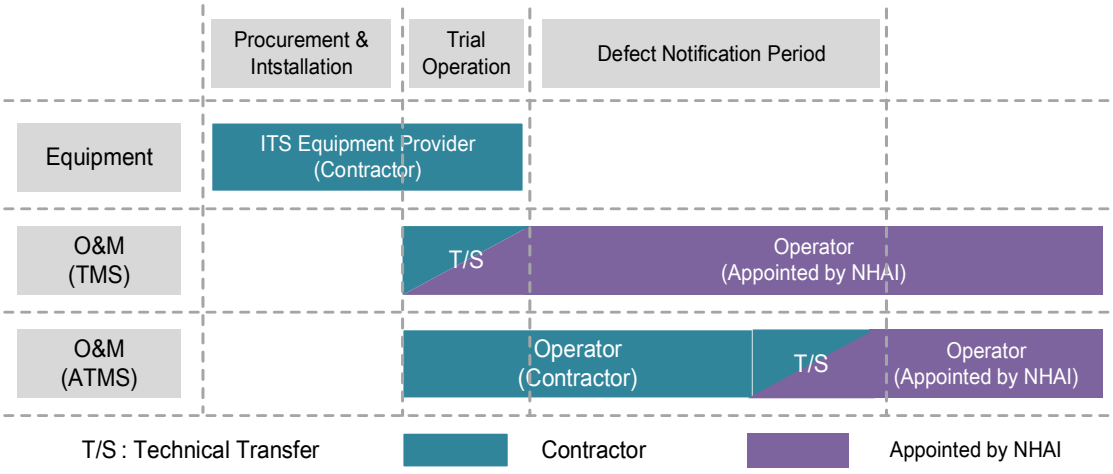


Figure 5-1 Plan of after Installation

6 Implementation Structure

6.1 Case Study of Contract & Implementation in Foreign Country

(1) Vietnam

Table 6-1 Contract Information for Vietnam

Item	Contents
Project Name	**The HCM City–Long Thanh–Dau Giay expressway**
Executing Agency	VEC(Vietnam Expressway Company)
Fund	JICA Loan
System	-Toll Management system, two(2) Main gate and one(1) IC -Traffic Management system -Control Centre
Contract	Design, Installation, Training, Commissioning, Trial Operation (2 months) Defect liability Period: 2 years

Source: JICA Study Team

(2) India

Table 6-2 Contract Information for India

Item	Contents		
Project Name	HYDERABAD OUTER RING ROAD PROJECT: Toll Management System	HYDERABAD OUTER RING ROAD PROJECT: Highway Traffic Management System	HYDERABAD OUTER RING ROAD PROJECT: City Intelligent Transport System
Executing Agency	Hyderabad Growth Corridor Limited (HGCL)		
Fund	JICA Loan		
System	-Toll Management System	-Traffic Management System -Control Centre	-City ITS System -Probe System -ITS Centre
Contract	Design, Installation, Training, Commissioning, Trial Operation (2 months) Defect liability Period: 2 years	Design, Installation, Training, Commissioning, Trial Operation (2 months) Defect liability Period: 2 years ***Operation and Maintenance : 5 years***	

Source: JICA Study Team

6.2 Implementation Structure

(1) Executing Agency

- Ministry of Road Transportation and Highways (MoRTH)
- National Highways Authority of India (NHAI)

(2) Organization's Role

NHAI will take all necessary measures required from time to time, in a timely and efficient manner and be fully responsible for the Project implementation.

Under the Project, NHAI is responsible for all the tendering process including employment of consultants, as well as for the construction process.

(3) Project Implementation Unit (PIU)

The PIU will be in charge of the Project. The PIU will be headed by a senior officer of the rank of Deputy General Manager or above, supported by 3 Managers (1 Technical manager for ATMS, 1 Technical Manager for TMS, 1 Financial Manager), Consultant and supporting staff.

7 Operation and Maintenance (O&M)

7.1 Operation and Maintenance Status of NHAI

NHAI is responsible for the O&M of the projects executed under EPC model. These projects are termed as public funded projects.

O&M of BOT projects is under the scope of the concessionaire in all respect.

NHAI appoints sub-contractors for the O&M of public funded projects. The O&M is broadly divided into following sub categories

- O&M of Road and facilities (civil works)
- Toll Collection (Temporary Toll Management System is included in the scope of Toll Collection agency)
- Route patrol and emergency services (Route patrol vehicle and emergency response vehicles are in the scope of the contractor)

7.2 Contract Model for O&M

(1) Contract Model

The tenders are called for the O&M of each project. NHAI awards contract to the eligible contractor as per the standard procurement process.

(2) Ridership Risk

The EPE project is public funded project and the toll collection is managed by NHAI by appointing a O&M agency called as Toll collection agency. The toll is collected for the period till the project cost is recovered along with operational and maintenance expenditure. Upon recovery of project cost from the toll, the toll fees maybe revised to be sufficient for O&M expenses or for upgradation of the project as the case maybe at that time. Hence NHAI will be at risk of loss of revenue.

(3) Contract Period

Standard contract period for O&M services is of 1 year for public funded projects. The contract period also varies from project to project as per the project requirement.

(4) Demarcation between NHAI and O&M Contractor

NHAI is the project owner and concerned PIUs are responsible for monitoring of project and O&M contractor.

7.3 Item to be considered for O&M

7.3.1 O & M Function

(1) Traffic Management Centre (TMC) Functions

An effective Control Centre will have the ability to improve traffic management, traveller information, and maintenance operation. It will also facilitate more effective use of O&M staff and resources.

- Intelligent Video Wall for efficient monitoring of CCTV footage
- Coordination with the Police, authorities and operators of connecting highways (Yamuna Expressway, KMP, NH-2, NH-1 etc.), sharing of resources, and chalk-out procedures that does not threaten any agencies' roles.

(2) Divisional Sub-Centres (DSC) Functions

- Two Divisional Sub-Centres will enable better traffic incident & emergency management. Provides support and assistance to TMC
- Manage & Monitor Mobile Sub-Stations
- Mobile sub-station (Patrol Vehicles) stationed and patrolling on the expressway will improve the emergency response & rescue time
- Patrol Vehicle, Recovery vehicle, Advance Life Support Ambulance, Mini Fire Tender & Man lift vehicle located as per requirement and monitored by TMC & DSC

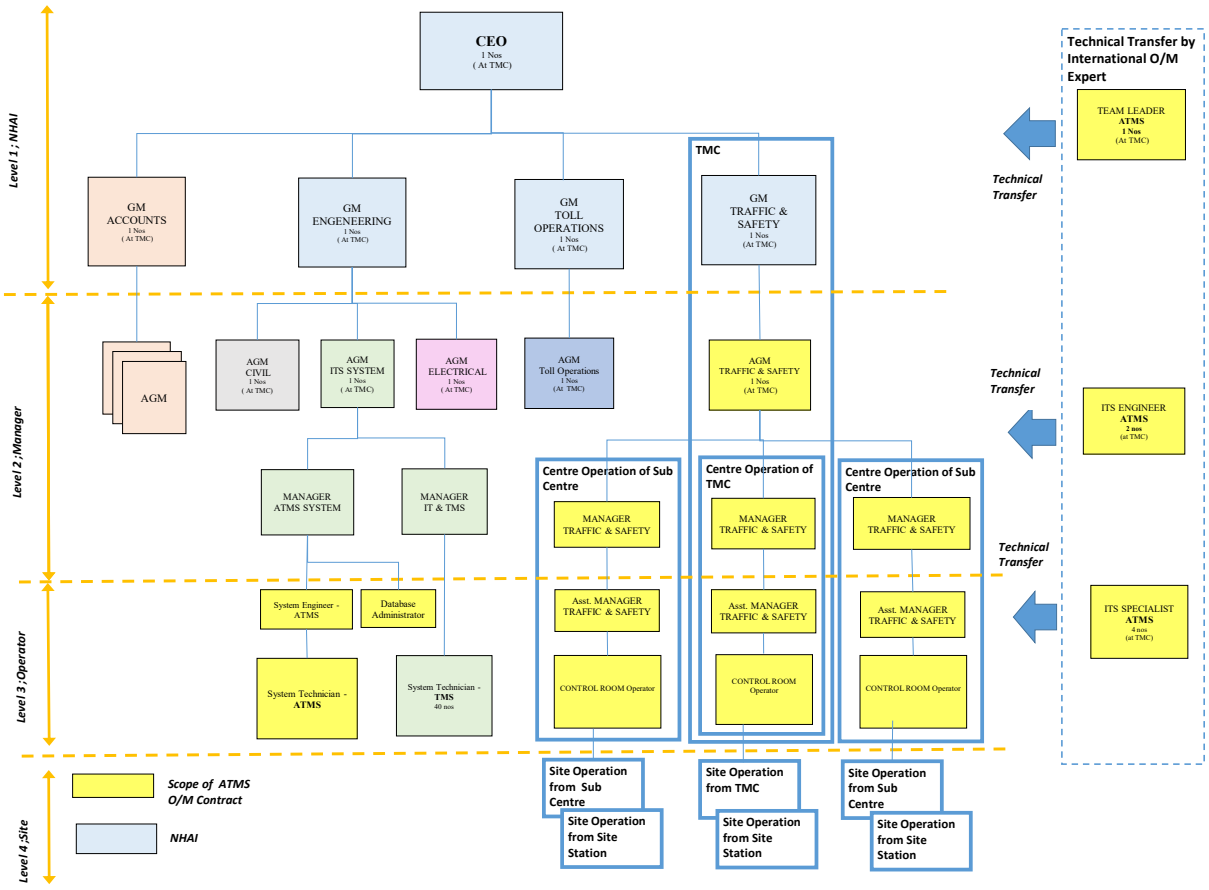
7.3.2 Comprehensive O&M Organization Structure

Comprehensive O&M organization Structure shall be made based on following approach;

- Well-structured and optimized O&M manpower plan
- Comprehensive O&M approach include operations structure and strategy, O&M plans and programs, systems data and storage, performance measurement and evaluation.
- Periodic evaluation and upgrading of O&M program on regular basis.
- Provide enhanced communication and coordination among all the stakeholders
- Focus on daily Documentation, tracking, monitoring and evaluation
- Documentation of Maintenance procedures & operations manual for each ITS sub-system and Comprehensive O&M system
- Staffing & Training

Consideration of Technical Transfer shall be made based on following approach;

- CEO and Main GMs (Engineering, Tool Operation and Traffic & Safety) shall be NHAI staff.
- International Experts shall provide technical transfer of O&M technology.



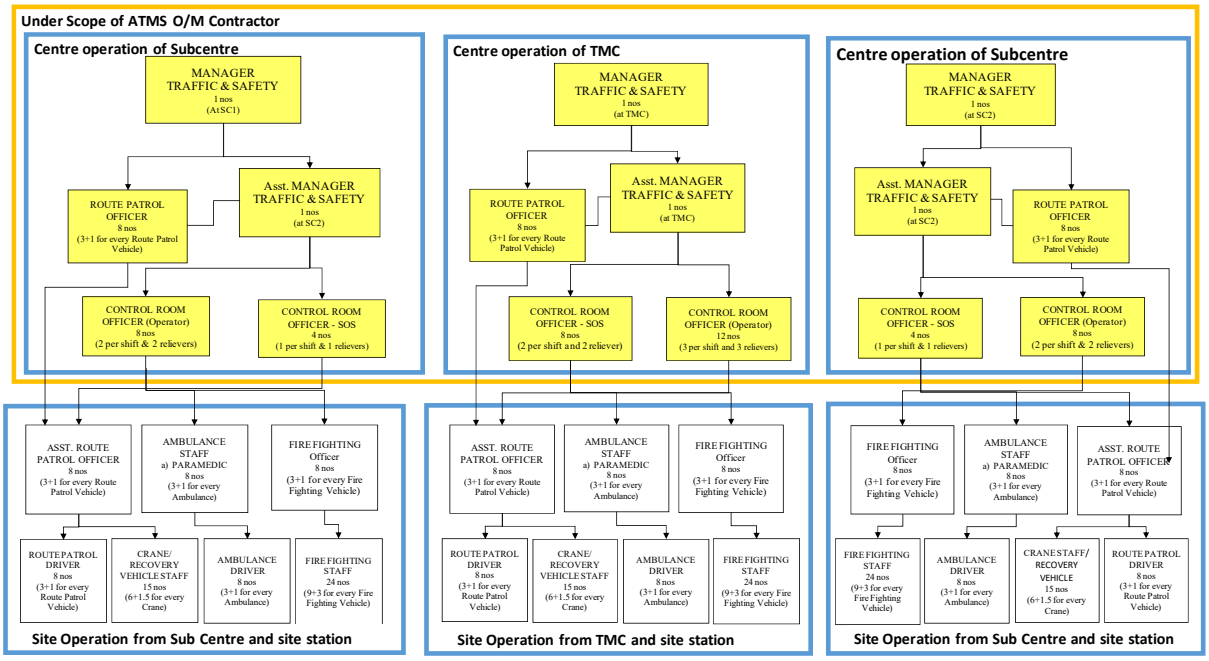
Source: JICA Study Team

Figure 7-1 Comprehensive O&M Structure

7.3.3 Organization Structure and staffing of Operation

Operation structure and staffing shall be made based on following approach;

- One(1) Manager of Traffic & Safety shall be at each Sub Centre and TMC, and Assistant Manager shall be under the manager
- Under the Manager, Assistant Manager and Route patrol officer
- Route patrol Officer, Control Room Operator shall be three(3) shift +1 backup system
- Site operation including patrol, and operating Ambulance, Fire fighting, Crane/Recovery vehicle, shall be done by another contract from ATMS.
- Site operation team will be stand by in each office (Two(2) Sub Centre and TMC) and another three(3) site stations along the highway.



Source: JICA Study Team

Figure 7-2 Structure and Staffing for Operation

7.3.4 ITS Maintenance Challenges

(1) Software & Hardware

- Adequate staffing to handle the increased responsibilities of maintaining ITS system & sub-systems
- Obtain annual maintenance contract for all hardware
- Technical expertise required to maintain new & sophisticated Integrated ITS systems
- ITS deployment involves both hardware and software, so software maintenance is also essential

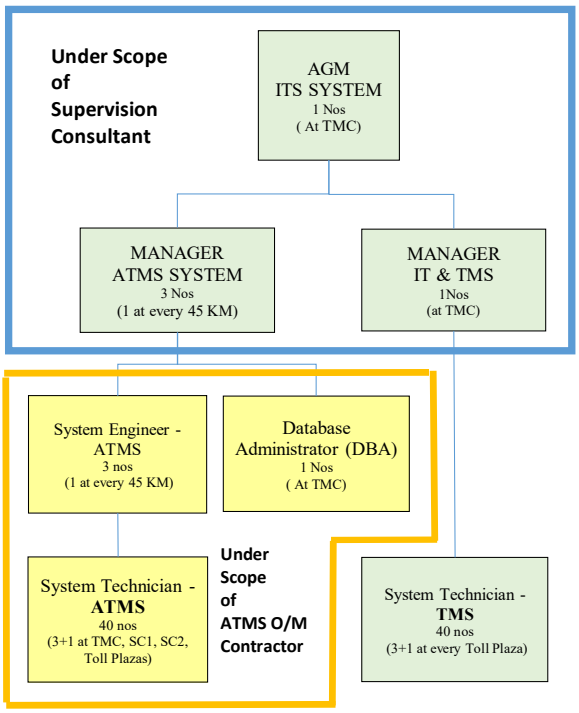
(2) Operations

- The suitable and effective operation of system shall be contributed to comprehensive traffic management for road operator and road users.
- Proper documentation such as established maintenance procedures, spare parts lists, as-built drawings etc.
- Maintaining new technologies frequently requires specialized tools and test equipment that are not readily available
- In-house technical maintenance team improves performance and reduces dependency on third party for day to day maintenance and also ensures periodic preventive maintenance
- Adequate training to in-house staff

(3) Consideration of structure and Staffing of Maintenance

- Supervision Consultant shall be monitored and instructed for effective and timely maintenance.

- System technical shall be three(3) shift and one(1) back up system



Source: JICA Study Team

Figure 7-3 Structure and Staffing for Operation

7.4 Candidate Company for O&M

The below mentioned companies are for TMS operations (Toll Collection purpose mainly) and most of them has not the proper experience of operating ATMS (operational ATMS in India are very few and mostly managed by the concessionaire team)

(1) Egis India

Egis is a world-wide industry leader in road/ tunnel/ bridge operations, toll collection systems, infrastructure/ equipment(s)/ asset(s) management & maintenance, traffic & safety management, etc.

Egis has inculcated a blend of international exposure and Indian experience to usher the dawn of a new era in road operation & maintenance in India. Egis's major strengths is the understanding of the Indian environment, ability to use the best practices. Egis is determined to offer world-class quality operation and maintenance services on Indian highways.

With Egis's strong understanding of the Indian markets, it has been able to add immense value to its projects in India.

Apart from the specialized Operations & Maintenance services offered in India, the Company also undertakes a range of allied services like:

- Audit of Project Operations & Maintenance covering all scope
-Asset Ma Management
-OMT projects
-Due-Diligence missions
-Consulting services (Advisory and Audit services) to optimize operation and maintenance
-Turnkey projects on Fixed Operating Equipment (FOE)
-Implementation and Management of Central Clearing House-Design and implementation of commercial policies

(2) Feedback Brisa

Feedback Brisa Highways OMT, at the other end, also manages Tolling along with O&M at 15 national and state highways across India.

Feedback Brisa Highways OMT Private Limited (FBH) is a joint venture between Feedback Infra Private Limited and Brisa, Auto-estradas de Portugal.

The joint venture endeavors to create a unique user experience on the Indian roads through lowering waiting time at toll plazas; reducing accidents through better signages and safety measures; proactive maintenance to improve life of asset—thereby raising OMT quality standard on the Indian roads at par with the best in the world.

FBH is bringing innovation and international best practices from Brisa to the Operations, Maintenance and Tolling (OMT) of Indian highways which is complemented with the strong local project management skills of Feedback Infra.

-Operating 5,800+ Lane kms – Leader of outsourced Highway OMT market
-End to end ownership across tolling, route operations & incident management, routine maintenance and IT System support.

(3) Markoline

MARK-O-LINE, A group of companies, based in Mumbai, has an expertise experience in Highway Operations & Maintenance Services. The group is also actively involved in Micro Surfacing (An alternate cost effective treatment for Pavement Maintenance & Renewal course.) MARK-O-LINE is the only company in India having highest number of outsourced projects under their supervision for O&M.

MARK-O-LINE offers the complete hassle free management solutions on site. This helps leveraging their clients to focus on and strengthen their core business processes to grow in today's highly competitive market. MARK-O-LINE offers Traffic & Financial management

services, Asset management, Incident management, Automation in terms of Operations and Maintenance,and all other related services to give smooth day-to-day operations.

MARK-O-LINE offers the complete array of services in Micro-surfacing. Under this vertical MARK-O-LINE undertakes the Turnkey jobs for Application. MARK-O-LINE with their partners offers consultancy on various aspects of Micro-surfacing & provides the world class equipment required for surface preservation.

-The Only Company having highest number of Outsourced O&M Projects.
-Vast Experience of Managing 5400 Lane Km of Roads across India.
-End-to end integrated services in Toll Operations and Corridor Management.

(4) ITNL

IL&FS Transportation Networks Limited (ITNL) is the largest BOT Road Asset owner in India in terms of length of road in its portfolio. ITNL has a diverse portfolio of projects in the surface transportation segment mainly in the PPP (Public Private Partnership) Road Sector. ITNL acts as developer, operator and facilitator of surface transportation infrastructure projects, taking projects from conceptualization through commissioning to operations and maintenance.

ITNL is a market leader in the transportation infrastructure sector with more than 13,100 lane km in its portfolio comprised in 25 road projects. The project portfolio of ITNL has an optimum blend of toll and annuity based projects, is geographically diversified with presence in 17 states within India and has projects in various stages of commissioning as well as commissioned projects thus offering a significantly de-risked and scalable business model.

ITNL has also ventured into other transportation sub-sectors such as Railways, Urban Transportation Systems and Border Check-posts. ITNL is currently developing a metro rail project in Gurgaon, a border check post project for the state of Madhya Pradesh, and operating a city bus transportation network in the city of Nagpur. In March 2008, ITNL commenced its international operations through the acquisition of Elsamex S.A. (“Elsamex”), a Spanish group involved in providing maintenance services primarily for highways and roads in many European and Latin American countries.

8 Cost Estimation

(1) Basic Condition for cost estimation

Table 8-1 Basic Condition for cost estimation

Item	Value
Price Escalation	FC: 1.6% LC: 1.3%
Physical Contingency	Construction: 10% Consultant: 10%
Rate of Tax	VAT: 14.5% Import Tax: 26.4%
Rate of Administration Cost	5%
Rate of Interest	Construction: 0.3% Consultant: 0.1%
Front End Fee	0.2%

Source: JICA Study Team

(2) Cost estimation (July 2016)

Table 8-2 Cost Estimation

Breakdown of Cost	Foreign Currency Portion			Local Currency Portion			Total		
	Total (JPY mil)	JICA Portion (JPY mil)	Others (JPY mil)	Total (INR mil)	JICA Portion (INR mil)	Others (INR mil)	Total (JPY mil)	JICA Portion (JPY mil)	Others (JPY mil)
ITS Package	2,619	2,146	473	2,851	1,997	854	7,089	5,277	1,811
Price Escalation	83	62	21	284	174	110	528	335	193
Physical Contingency	270	221	49	313	217	96	762	561	200
Consulting Services	455	455	0	155	155	0	698	698	0
Administration Cost	0	0	0	289	0	289	454	0	454
VAT	0	0	0	839	0	839	1,316	0	1,316
Import Tax	0	0	0	501	0	501	785	0	785
Interest during construction	94	0	94	0	0	0	94	0	94
Front End Fee	14	0	14	0	0	0	14	0	14
Total	3,535	2,883	651	5,233	2,543	2,689	11,738	6,870	4,867

Source: JICA Study Team

(Note) 1. Exchange Rate: US$1=Rs. 67.3, US$1 = JPY105.5, Rs.1 = JPY1.57
2. Price Escalation (a) Foreign Currency Portion: 1.6% p.a.
(b) Local Currency Portion: 3.7% p.a.
3. Base Year for Cost Estimation: July, 2016

9 Item to be considered for Project Implementation

9.1 Survey of Procurement Condition for ITS Project in India

(1) Tender Condition

The contractor is selected on the following basis:

- experience of ITS implementation
- Solution offered
- Project Management capabilities and manpower of the contractor
- Feedback from the existing customers of the contractor
- Financial bid

This has been observed that the Indian concessionaires are very price sensitive and the financial offer of the contract has more weightage than the technical credentials. As a result, it has been seen that the ITS system performance is compromised/poor.

(2) Local consultant for Supervision

The ITS consultants in India are handful, out of which very few have relevant knowledge and experience and all are occupied with consultant companies for ongoing projects in India.

(3) Local Contractor

Following are the major ITS contractors/System Integrators in India

- VaaaN Infra (India)
- Tecsidel India (Spanish)
- Toshiba India (Japan)
- MHI (Japan)
- Rajdeep (India)
- Efkon India (Austria)
- Metro (India)
- KENT (India)

9.2 Tender Process and Contract Condition

Procurement of goods and services including consulting services, covered by the Japanese ODA Loan should be implemented in accordance with "Guidelines for Procurement under Japanese ODA Loans", dated April 2012.

For smooth progress for preparation of Bid Document and concurrence by JICA, to utilize "JICA SBD Design Build" is highly recommended.

9.3 Procurement of Consultant

Timely employment of the consultants will be important to avoid any delay in the implementation of the Project. In this context, NHAI requested that, in order to compile a short list for selection of consultant as soon as possible, even before signing of the prospective Loan Agreement, for support of preparation of bid document and evaluation of bid. The scope of consultant procured by JICA loan is supervising of project.

The selection of consultant for supervise the project will be done in accordance with "JICA SRFP Selection of Consultants"

9.4 Selecting Policy for Contractor of Implementation and O&M

(1) Prequalification Condition

As this EPE ITS project includes not only system installation but also O&M service in pilot operation, and advanced traffic management shall be transferred from contractor. Therefore, qualification of contractor shall be done on not only on General qualification and experience record but also on technical document submitted by tenderer.

1) General qualification and experience record

- Experience of the same scale project
- Key personnel
- Experience of System integration on TMS and ATMS
- Experience of Operation and Maintenance on TMS, ATMS and Coordination with other agencies.

2) Technical evaluation

- Method of Coordination with other agencies
- Method of Event Generation
- Method of Event management

(2) Local Competitive Bid

Procurement including Consultant and Project shall be International Bid.

(3) Package

Package shall be one(1) including TMS, ATMS and O&M

10 Project Effectiveness

10.1 Quantitative Effect and Qualitative Effect

The focus of this chapter is to analyse the economic effects of the instalment of ITS on Delhi EPE. There are several effects, both quantitative and qualitative, are produced. Quantitative effects are traffic accident reducing effect and travel time saving effect by ETC, which can be quantified by converting into monetary value (generalized cost) and cost benefit analysis of project is implemented to evaluate the economic viability. Qualitative effects are the effects which are difficult or impossible to be quantified such as travel time saving and reduction of congestion loss at time of emergency by installing traffic control system. Those effects are described below in Table 10-1.

Table 10-1 Effects of the instalment of ITS on Delhi EPE

	Items	Quantitative Effect
1	Traffic accident reducing	Due to huge traffic demand in the future on EPE, it is obvious that the capacity at tollgates will not be enough. Some drivers would spill out of EPE if ETC is not installed on EPE. Installing ETC will enable these drivers to use EPE. Generally the accident rate of expressway is much lower than that of ordinary road. If these traffic demands are converted into EPE, the number of accidents would be reduced.
2	Travel time saving by ETC	If there is no ETC at tollgates, drivers must wait in the line. By installing ETC there travel time will be reduced.
		Qualitative effect
3	Travel time saving by Traffic Control System	If drivers can know the real-time traffic condition by the provision of traffic information of their way for their destination, they can choose the best route among their candidate routes. This enables to save their travel time.
4	Reduction of congestion loss by Traffic Control System at Time of Emergency	Accidents on expressway often cause serious congestion. Therefore, shortening reaction time in case of emergency such as fatal accident is one of the key issues to the high-level expressway service. By installing CCTV properly, these incidents could be detected within shorter time.

Source: JICA Study Team

10.2 Quantitative Analysis

The main purpose of quantitative economic analysis is to show the effects of the instalment of ITS on Delhi EPE from the viewpoint of national economy and it aims at evaluating the economic viability of the project implementation. Economic analysis estimates whether the project yields sufficient benefit compared to the economic resources required.

Quantitative economic evaluation is conducted in terms of comparative analysis between benefits and costs. Benefits contain (i) traffic accident reducing benefit and (ii) travel time saving

benefit by ETC, while costs consist of installation cost, system renewal cost, and operation and maintenance cost. Indicator adopted here for quantitative economic analysis is the conventional "economic internal rate of return (EIRR)". EIRR of a given project is defined as the discount rate at which the present value of benefits and the present value of costs are equal. Evaluation was conducted on the basis of traffic demand forecast.

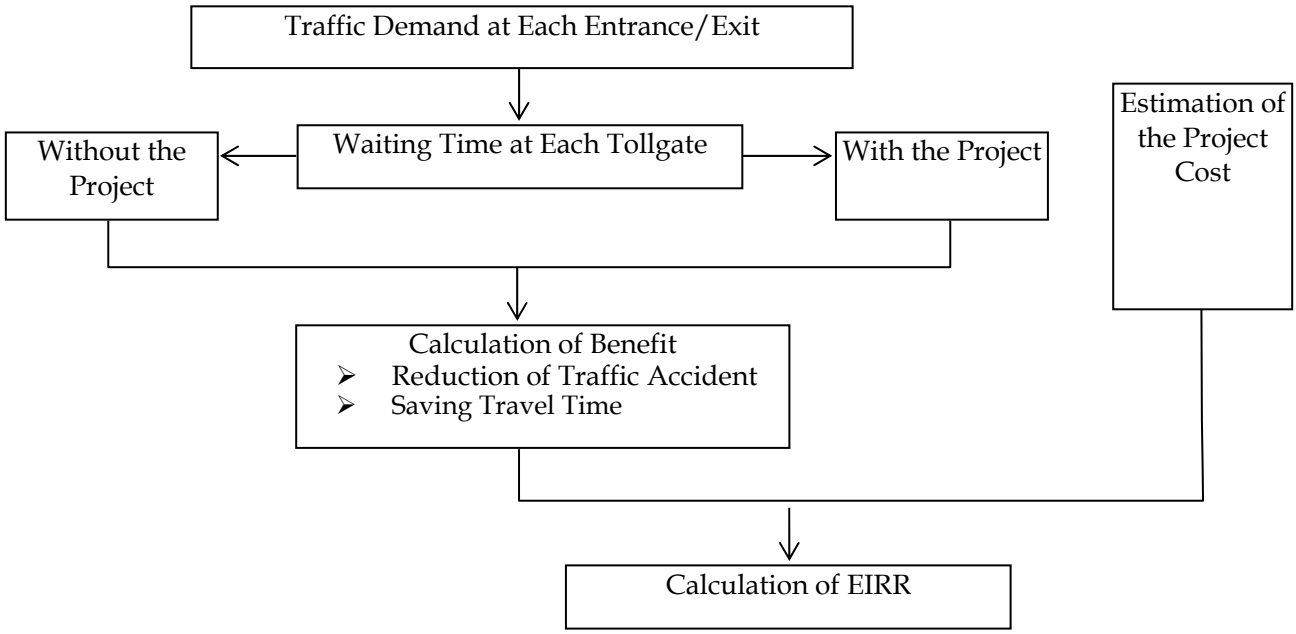
10.3 EIRR Calculation (July 2016)

(1) Evaluation Period

The evaluation period is assumed to be 25 years from 2018 to 2042 taking the service life of the Project into account.

(2) "With Project" and "Without Project"

"With Project" covers the situation where the proposed project is implemented, and "Without Project" covers the situation where such investment does not take place. The quantified economic benefits, realized from the implementation of the project, are defined as traffic accident reducing effect and travel time saving effect by ETC derived from the difference between "With Project" and "Without Project". The economic analysis procedure as illustrated in Figure 10-1 is employed in this study.



Source: JICA Study Team

Figure 10-1 Procedure of Economic Analysis

(3) Estimation of Cost

The total cost of this project would be divided into three sections, installation cost, system renewal cost, and operation and maintenance cost. Installation cost of 3,227 million INR was realized in 2017, System renewal cost of 1,859 million INR was required in 2027 and 2037, and operation and maintenance cost of 313 million INR was required every year. Those costs mentioned above are shown in Table 11.3-1

Table 10-2 Cost for ITS Project on EPE (for 25 years)

[million INR]
* INR = JPY 1.661

Year	Installation Cost	System Renewal Cost (A)	Operation Cost(B)					Total (A)+(B)
			Manpower (TMS Ops)	Manpower (Technical)	Manpower (ATMS Ops)	Repairment/Replacement Cost	Other Operating Cost	
2017	3,227							
1 2018			117.72	38.61	19.44	2.7	134.2	312.6
2 2019			117.72	38.61	19.44	2.7	134.2	312.6
3 2020			117.72	38.61	19.44	2.7	134.2	312.6
4 2021			117.72	38.61	19.44	2.7	134.2	312.6
5 2022			117.72	38.61	19.44	2.7	134.2	312.6
6 2023			117.72	38.61	19.44	2.7	134.2	312.6
7 2024			117.72	38.61	19.44	2.7	134.2	312.6
8 2025			117.72	38.61	19.44	2.7	134.2	312.6
9 2026			117.72	38.61	19.44	2.7	134.2	312.6
10 2027		1,859	117.72	38.61	19.44	2.7	134.2	2172.0
11 2028			117.72	38.61	19.44	2.7	134.2	312.6
12 2029			117.72	38.61	19.44	2.7	134.2	312.6
13 2030			117.72	38.61	19.44	2.7	134.2	312.6
14 2031			117.72	38.61	19.44	2.7	134.2	312.6
15 2032			117.72	38.61	19.44	2.7	134.2	312.6
16 2033			117.72	38.61	19.44	2.7	134.2	312.6
17 2034			117.72	38.61	19.44	2.7	134.2	312.6
18 2035			117.72	38.61	19.44	2.7	134.2	312.6
19 2036			117.72	38.61	19.44	2.7	134.2	312.6
20 2037		1,859	117.72	38.61	19.44	2.7	134.2	2172.0
21 2038			117.72	38.61	19.44	2.7	134.2	312.6
22 2039			117.72	38.61	19.44	2.7	134.2	312.6
23 2040			117.72	38.61	19.44	2.7	134.2	312.6
24 2041			117.72	38.61	19.44	2.7	134.2	312.6
25 2042			117.72	38.61	19.44	2.7	134.2	312.6

Source: JICA Study Team

(4) Estimation of Benefit

1) Traffic Accident Reducing Benefit

When introduction of ETC will not be realized, excessed traffic demand over handling capacity will be produced at each tollgate. Accordingly, it can be assumed that some drivers would travel ordinary roads instead of EPE. Applying this traffic volume, transferred to ordinary road in the following calculation, benefit from reduction of traffic accidents would be derived:

- Traffic volume mentioned above x Difference between accident rate of EPE and ordinary roads = Reduction volume of accidents occurred ・・・ (a)

- (a) x Loss amount caused by one accident = Benefit from reduction of traffic accidents

Loss amount caused by one accident was employed by the adjusted value of "Manual on Economic Evaluation of Highway Projects in India (Second Revision), Indian Road Congress, 2009" shown in Table 10-3.

Table 10-3 Economic Cost for different type of Accidents

Type of Accident	Economic Cost of Accidents (in Rs)
Fatal	864 350
Serious	391 800
Major	172 650
Minor	30 450

Source: Manual on Economic Evaluation of Highway Projects in India (Second Revision), Indian Road Congress, 2009

2) Travel Time Saving Benefit by ETC

Travel time saving benefit is brought with calculation: difference between the times required at tollgate for manual payment and ETC multiples value of time, employed the adjusted value of "Manual on Economic Evaluation of Highway Projects in India (Second Revision), Indian Road Congress, 2009" shown in Table 10-4.

Table 10-4 Value of Travel Time of Passengers

Nature of Journey by Passenger	Value of Time (in Rs per hour)
Cars	62.5
Two Wheelers	32.0
Ordinary Bus Passenger	39.5

Source: Manual on Economic Evaluation of Highway Projects in India (Second Revision), Indian Road Congress, 2009

(5) Cost Benefit Analysis

The result of the economic analysis is shown in Table 10-5 and Table 10-6.

Table 10-5 Result of Economic Analysis

Indicator	Result
Economic Internal Rate of Return (EIRR)	9.0%

Source: JICA Study Team

Table 10-6 Economic Analysis

Year								EIRR		9.0%
	Installation Cost	Operation Cost	Total Cost	Value of Reducing Traffic Accidents	Value of Saving Time	Total Benefit	Net Benefit	Cost	Benefit	Net Benefit
2016			0			0	0	0	0	0
2017	3,227		3,227		0	0	-3,227	2,960	0	-2,960
2018		313	313		0	0	-313	263	0	-263
2019		313	313		0	0	-313	241	0	-241
2020		313	313		23	23	-290	221	16	-205
2021		313	313		74	74	-239	203	48	-155
2022		313	313	2	175	177	-136	186	105	-81
2023		313	313	4	274	278	-35	171	152	-19
2024		313	313	7	480	487	174	157	244	87
2025		313	313	9	603	612	299	144	282	138
2026		313	313	12	737	749	436	132	316	184
2027		2,172	2,172	15	879	894	-1,278	842	347	-495
2028		313	313	19	1,036	1,055	742	111	375	264
2029		313	313	23	1,218	1,241	929	102	405	303
2030		313	313	26	1,310	1,335	1,023	94	400	306
2031		313	313	28	1,404	1,432	1,119	86	393	307
2032		313	313	31	1,501	1,532	1,219	79	386	307
2033		313	313	34	1,601	1,634	1,322	72	378	305
2034		313	313	37	1,703	1,740	1,428	66	369	303
2035		313	313	40	1,809	1,849	1,537	61	360	299
2036		313	313	43	1,918	1,962	1,649	56	350	294
2037		2,172	2,172	47	2,030	2,077	-95	356	340	-16
2038		313	313	50	2,146	2,196	1,883	47	330	283
2039		313	313	54	2,265	2,319	2,006	43	319	276
2040		313	313	58	2,387	2,445	2,132	40	309	270
2041		313	313	62	2,513	2,575	2,262	36	299	262
2042		313	313	66	2,643	2,709	2,396	33	288	255
Total	3,227	11,535	14,761	667	30,728	31,395	16,634	6,803	6,811	8

Source: JICA Study Team