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Vietnam Expressway Corporation (VEC)



Project Management Unit No. 85 (PMU. 85)



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Consulting Services for / Dịch vụ tư vấn
Detailed Design for Da Nang - Quang Ngai Expressway Development Project
/ Thiết kế kỹ thuật dự án Đường cao tốc Đà Nẵng – Quảng Ngãi

ITS BASIC DESIGN REPORT (PKG13)

Volume 1: Main Report

May 24, 2013

The Joint Venture of / Liên danh Tư vấn:



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NIPPON ENGINEERING CONSULTANTS CO.,LTD.



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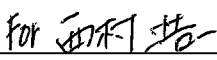
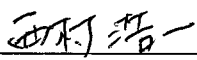
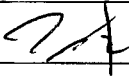
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Volume 1: Main Report

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May 24, 2013

Letter of Submission
Project Location Map

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List of Abbreviations

ANPR	: Automatic Number Plate Recognition
ANSI	: American National Standards Institute
API	: Application Programming Interface
AP-DATEX	: Application Profile- Data Exchange
ATM	: Asynchronous Transfer Mode

ATS	: Automatic Transfer Switch
DEG	: Diesel Engine Generator
CCTV	: Closed Circuit Television
CCD	: Charge Coupled Device
CMOS	: Complementary Metal-Oxide-Semiconductor
CIF	: Common Intermediate Format
CSMA/CD	: Carrier Sense Multiple Access with Collision Detect
D/D	: Detailed Engineering Design
DCT	: Discrete Cosine Transform
DC Power	: Direct Current Power
DQE	: Da Nang - Quang Ngai Expressway
DRVN	: Directorate for Roads of Vietnam
DSF	: Dispersion- Shifted Fiber
DSRC	: Dedicated Short Range Communications
DWDM	: Dense Wavelength Division Multiplexing
EFC	: Electronic Fee Collection
ETC	: Electronic Toll Collection
ETSI	: European Telecommunications Standards Institute
FON	: Fiber Optic Node
FOC	: Fibre Optic Cable
F/S	: Feasibility Study
FTP	: File Transfer Protocol
GOVN	: Government of Vietnam
GSM	: Global System For Mobile Communications
GPRS	: General Packet Radio Service
HCMC	: Ho Chi Minh City
HTTP	: Hypertext Transfer Protocol
HDTV	: High-definition Television
IC	: Interchange
IC Card	: Integrated Circuit Card (ICC)
IP	: Internet Protocol
IP-PBX	: Internet Protocol - Private Branch Exchange
ISO	: International Organization for Standardization
IT	: Information Technology
ITU-T	: International Telecommunication Union - Telecommunication Standardization Sector
ITU-R	: International Telecommunication Union – Radiocommunications Sector
ITS	: Intelligent Transport System
JICA	: Japan International Cooperation Agency
JETRO	: Japan External Trade Organization
LAN	: Local Area Network
LDP	: Large Display Panel
LCD	: Liquid Crystal Display
LED	: Light-emitting Diode
MAC	: Media Access Control
MET	: Meteorological Monitoring
MIC	: Ministry of Information and Communication
MOF	: Ministry of Finance
MOT	: Ministry of Transport

MPEG	: Moving Picture Experts Group
M-JPEG	: Motion - Joint Photographic Experts Group
NH	: National Highway
NK	: Nippon Koei Co., Ltd.
NVR	: Network Video Recorder
NTP	: Network Time Protocol
O&M	: Operation and Maintenance
OBU	: On Board Unit
OD	: Origin/Destination
PCU	: Passenger Car Unit
PBX	: Private Branch Exchange
PCS	: Physical Coding Sublayer
PKG	: Package
PPP	: Point – to – Point Protocol
P/Q	: Prequalification
PTZ	: Pan-tilt-zoom
PMU	: Project Management Unit
PVC	: Polyvinyl Chloride
QCIF	: Quarter Common Intermediate Format
QCVN	: Vietnamese National Standards
RFID	: Radio Frequency Identification
SCADA	: Supervisory Control And Data Acquisition
SDTV	: Standard-definition Television
SDH	: Synchronous Digital Hierarchy
RFP	: Request for Proposal
SIM	: Subscriber Identity Module
SNMP	: Simple Network Management Protocol
SNTP	: Simple Network Time Protocol
TB	: Toll Barrier
TCP	: Transmission Control Protocol
TCN	: National Technical Regulations
TEDI	: Transport Engineering Design. Incorporated
TOR	: Terms of Reference
UDP	: User Datagram Protocol
UPS	: Uninterruptible Power Supply
UHF	: Ultra High Frequency
VDS	: Vehicle Detector System
VEC	: Vietnam Expressway Corporation
VHF	: Very High Frequency
VMS	: Variable Message Sign
VNPT	: Vietnam Posts and Telecommunications
VoIP	: Voice over IP
VTR	: Video Tape Recorder
WB	: World Bank
WIM	: Weigh In Motion

1 GENERAL

1.1 Chronicle

Chronicle-1: The workshop for O&M, ITS and road safety audit was held on 30th October, 2012. The comments on workshop made by relevant authorities such as MOT, VEC, VEC O&M and PMU No. 85 were summarized and enclosed in the VEC's letter No. 2968/VEC-KTCNMT dated 2nd November, 2012. ITS plan report was prepared and submitted on 16th November, 2012 in accordance with the comments on the workshop.

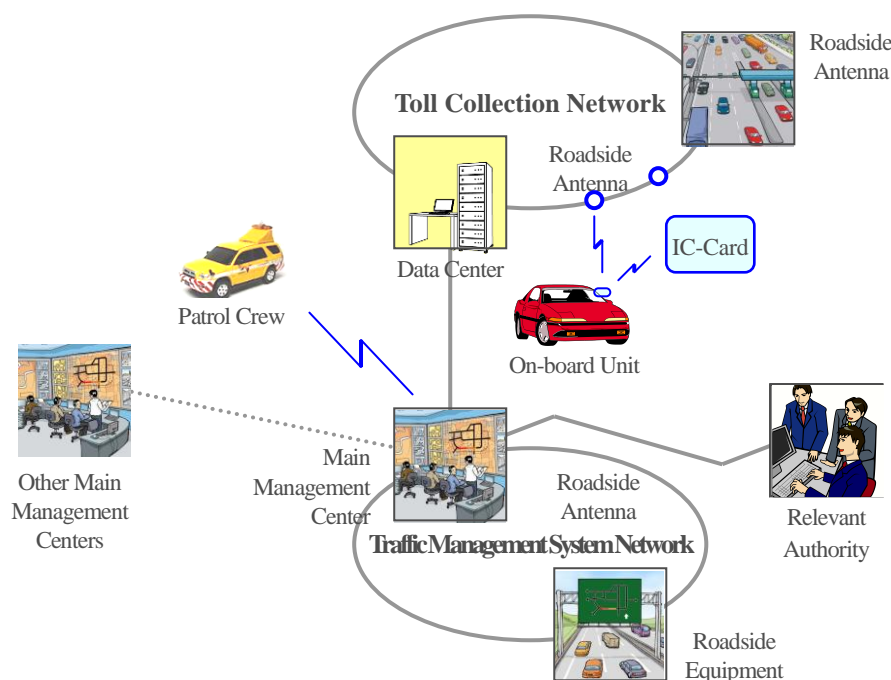
Chronicle-2: After submission of the ITS plan report, following major design modifications were made and ITS plan report (revision 1) was submitted on 2nd May, 2013 together with other O&M plan reports as O&M/ITS plan report;

- Cancellation of Binh Son IC,
- Relocation and cancellation of PA/SA, and
- Additional design for VNPT's communication system implementation.

Chronicle-3: This ITS design report is prepared based on the updated ITS plan report mentioned above.

1.2 Background and Necessity of ITS Introduction

Intelligent Transportation System (ITS) is a new approach to the transportation problems such as congestion, traffic accident and air pollution. Unlike the conventional measures of physical improvement, it utilizes modernized information and communication technologies to promote efficient, convenient and safe traffic.



Source: Consultant

Figure 1-1 Conceptual Image of Intelligent Transport System

Usefulness of IT technologies in transportation system is not only limited to the developed countries but also to developing countries. The ITS offers a wide variety of services toward road administrators, road users, public transport operators and general public. The ITS enables to utilize the expressway effectively and safely, and promotes the new model of cultural and industrial systems in the country. Applications of ITS to the expressway include traffic management system, electronic toll collection (ETC) system, communication system, etc.

Ministry of Transport (MOT) has decided to construct the Da Nang - Quang Ngai Expressway (hereinafter referred as "DQE") to improve the inter-regional transport networks for supporting the socio-economic development in the central region and in the whole country and promoting traffic safety.

In line with this decision, the Government of the Socialist Republic of Vietnam (GOVN) has initially carried out a Feasibility Study in 2003 which was subsequently revised and completed in March 2008 by JETRO, and further updated in May 2009 by the World Bank and completed by Transport Engineering Design Incorporated (TEDI) in 2010. One of the key components among three project components is Intelligent Transport System work. The introduction of ITS is expected to enhance efficiency, convenience and safety of the Da Nang - Quang Ngai Expressway.

1.3 Scope of Work and TOR Requirements

The ITS needed for the Project will include vehicle and incident detection, CCTV, information systems, traffic management center system, data transmission, toll collection system, etc. The Scope of ITS work is summarized as table below.

Table 1-1 Scope of ITS Work

Item	Works	Ref. in TOR	Target of ITS Plan Report
(1) Review of previous studies	<ul style="list-style-type: none"> - Review of traffic control/management operation and system - Review of toll operation and toll collection system 	TOR 3.2 (1)	X
(2) Establishing the detailed design framework	<ul style="list-style-type: none"> - Establishment of design criteria - Establishment of design standards 	TOR 3.2 (2)	X
(3) ITS Plan	<ul style="list-style-type: none"> - Identification of potential data and information need, traffic management issues and emergency support - Conceptual design for ITS - Setting of ITS configuration - Conceptual plan for institutional arrangement and staffing for ITS management 	TOR 3.3.4 (1)	X
(4) ITS Design	<ul style="list-style-type: none"> - Design for ITS facilities - Preparation of a cost estimate for ITS - Preparation of technical specifications as reference - Preparation of implementation program for ITS 	TOR 3.3.4 (2), TOR 3.3.7, TOR 3.3.8, TOR 3.3.9, TOR 3.3.10	X

Source: Consultant

This report includes comprehensive ITS plan and design including review of previous studies, establishment of ITS planning standard, ITS plan and design to show ITS implementation program of Da Nang - Quang Ngai Expressway.

1.4 Technical Specifications

Technical Specification is prepared in accordance with JICA Sample Bidding Document "Procurement of Plant Design, Supply and Installation Version 1.0 (September 2010)" as shown in Appendix-3 as reference.

2 REVIEW OF PREVIOUS STUDY AND OTHER ON-GOING ITS PROJECTS IN VIETNAM

2.1 Review of Previous F/S

Operation and maintenance plan including traffic management system, toll collection system and communication system plan for DQE are described in Feasibility Study report carried out by TEDI in 2010 (hereinafter referred as “TEDI F/S report”). However, TEDI F/S report does not mention in detail about system introduction policies, reference standards, system requirements, etc. On the other hand, Feasibility Study report prepared by Nippon Koei Co., Ltd. (hereinafter referred as “NK F/S report”) has more description regarding the ITS. Thus, both previous F/Ss are reviewed to clarify the features of previous ITS plans and identify key issues to be solved and further studied in this design.

The ITS proposed in both previous studies consists of following system components.

- Traffic Management System
- Toll Collection System
- Communication System

Table 2-1 below shows the summary of TEDI F/S ITS plan in comparison with NK F/S results.

Table 2-1 Outline of TEDI F/S and NK F/S ITS Plans

No.	Category	Equipment Type	Unit	Quantity		Location	
				NKF/S	TEDI F/S	NKF/S	TEDI F/S
1	Organization for Expressway O&M	Expressway Management Center	lot	1	1	KM1+000	KM0+950
		Operation & Maintenance Office	lot	2	1	KM1+000, KM125+200	KM64+750
		Toll Office	lot	9	9	Each toll barrier and tollgate	Each toll barrier and tollgate
		Toll Barrier	lot	2	2	KM1+000, KM130+000	KM4+750, KM129+600
		Tollgate	lot	7	7	7 ICs	7 ICs
2	ITS Component	- Traffic Management System - Toll Collection System - Communication System	lot	1	1	Entire expressway	Entire expressway
3	Traffic Management System	CCTV System	nos.	36	34	At the interchange and outside of tunnel	At the Intersection
4		Vehicle Detector System	Set	32	300	One each between ICs (8 sections x 4 lanes)	Along with the highway, installed for each 2km to monitor 4 lanes and at the intersections
5		Meteorological Monitoring System (Weather Sensor System)	Set	2	1	At Da Nang main center, Quang Ngai management office	At the management center
6		Variable Message Sign System	nos.	31	12	Upstream of each on-ramp: 17 Upstream of each off-ramp: 14	5 signals on major alignment and 1 signals at the intersections
7		Overload Monitoring System (Weigh in Motion)	Set	15	9	1 lane on every entrance tollgate	At entrance of the toll collection stations
8		Center Operating System	lot	1	1	At the main management center	At the Operating Center
9		Traffic Management Center System			1		At the Maintenance Center

10	Toll Collection System	Toll Collection System	Lane/Station	Manual: 46 lanes ETC: 28 lanes	12	1 ETC lane for each IC toll plaza, 2 ETC lanes for toll barrier, manual for remaining lanes	2 stations on the alignment and 10 substations
11	Communication System	Communication System (Fiber Optic)	lot	1	1	Installed for whole alignment	Installed for whole alignment
12		Emergency Telephone	Set	Not planned	130	-	1 piece installed for each 2km on each way
13		Internal Telephone System	Set	1IP-PBX 180 phones	1 switchboard and 240 phones	IP-PBX at main center, phones at main center, management and toll offices	On the whole management systems
14		Wireless radio system (Walkie-talkie System)	lot	1	1	1 control center station, 1 base station, 30 vehicle mobile unit, 50 portable mobile unit	1 receiving and transmitting antenna, 120 vehicle-installed sets and 120 hand held sets

Source: Consultant

2.2 Review of ITS Decisions and On-going ITS Projects in Vietnam

The studies on relevant decisions issued by MOT and other on-going ITS projects in Vietnam are quite important to propose the consistent ITS development plan in the country. In this section, the comparisons of F/S ITS plan results of the DQE with those relevant decisions and other on-going projects are described.

Two (2) decisions related to the ITS have been issued by MOT. One is MOT Decision No. 2530/BGVT-KHCN dated on 4th May 2011 which specifies non-stop ETC collection, communication network protocol and utilization of IP digital camera and the other is MOT Decision No. 4244/BGVT-KHCN dated on 1st June 2012 which approves application of DSRC-Active 5.8 GHz as follows.

[MOT Decision No. 2530/BGVT-KHCN]

- In terms of non-stop ETC: it is agreed to apply RFID passive 860-960 MHz following Standard ISO/IEC 18000-6C, 2nd generation for expressway construction projects in Vietnam.
- In terms of technology for information communication: for synchronization with development tendency in information technology in the whole country and avoiding the waste due to changing technology during utilization, the implementation of communication system for expressway management shall be oriented to apply Gigabit Ethernet technology since early stage such as investment decision and project design.
- At present, utilization of IP digital camera with high resolution is more and more popular due to reasonable price and its remarkable advantages in image centralization recording and traffic management. Therefore, it is priority to choose digital IP camera in design of surveillance camera system in expressway combining with traffic detection, traffic volume and traffic flow speed function (VDS). The utilization of Analog-IP camera is not recommended.

[MOT Decision No. 4244/BGVT-KHCN]

- MOT allowed to apply the pilot technology of DSRC-Active 5.8GHz of Japan in the opened - principle of technology criteria in order to ensure the connection among the systems for the projects funded by JICA, such as New NH No.3, Da Nang - Quang Ngai Expressway Project, East-West Avenue (HCMC).

On the other hand, following ITS projects are currently on-going in Vietnam.

- Cau Gie – Ninh Binh Expressway
- Ho Chi Minh – Trung Luong Expressway
- Ho Chi Minh – Dau Giay Expressway
- Ha Noi – Thai Nguyen Expressway (New National Highway No.3)

Table 2-2 shows the comparisons of ITS plan results of the DQE with the relevant decisions and other on-going ITS projects whose information are collected by the Consultant.

Table 2-2 Comparison of DQE ITS Plans with Relevant MOT Decisions and Other On-going Projects (1/2)

No.	Decisions and ITS Projects		Vietnamese Standards or MOT Decision	Cau Gie - Ninh Binh	Ho Chi Minh - Trung Luong	Ho Chi Minh - Dau Giay	Ha Noi - Thai Nguyen	Da Nang - Quang Ngai (Previous TEDI F/S 2010)	Da Nang - Quang Ngai (Previous WB F/S in 2009)
1	Traffic Management System								
1-1	Vehicle Detector System	Type of Detector	Image Recognition Type (MOT Decision No. 2503/BGTVT-KHCN)	Image recognition type	Image recognition type	Loop-coil or Ultrasonic or Image recognition type	Image Recognition Type	Image recognition type	Not specified (Loop-coil or Ultrasonic or Image recognition type)
		Location	Not Specified	12 sets at toll barriers (2 sets) and toll gates (10 set)	2 km intervals on expressway	2 km intervals on expressway	One each upstream of IC	2 km intervals on expressway	One each for every lane between ICs
1-2	Meteorological Observation System	Type of Sensor	Not Specified	No information	Not Planned	Anemometer, thermometer and rain gauge	Anemometer, Thermometer, Rain gauge and Visibility meter	Anemometer, thermometer and rain gauge	Anemometer, Thermometer and Rain gauge
		Location	Not Specified	1 locations at Vuc Vong toll gate	-	1 location at Road Management Office	1 location at Road Management Office, km 38+600	1 location (Main Management Centre in Da Nang)	2 locations (Main Management Centre in Da Nang and Management Office in Quang Ngai)
1-3	CCTV Monitoring System	Type of Camera	IP Digital Camera (MOT Decision No. 2503/BGTVT-KHCN)	Planned (Not clearly specified)	PTZ Camera (IP Digital Camera)	PTZ Camera (IP Digital Camera)	PTZ Camera (IP Digital Camera)	PTZ Camera (IP Digital Camera)	PTZ Camera (IP Digital Camera)
		Location	Not Specified	1 km intervals on expressway (78 sets) and ICs (24 sets)	2 km intervals on expressway	Tollgates, merging and diverging sections on expressway	2 km intervals	At intersections	Merging and diverging sections (interchanges), outside of tunnel
1-4	Overload Monitoring System	Type of Sensor	Circular No. 07/2010/TT-BGTVT dated 11th February 2010 and Decree No. 34/2010/ND-CP dated 2nd April 2010	Weigh-In-Motion	Weigh-In-Motion	Weigh-In-Motion and Mobile Weigh Station	Weigh-In-Motion	Weigh-In-Motion	Weigh-In-Motion
		Location		13 lanes (of total 36 lanes) of exit tollgates	All lanes of entering tollgates	Entrance Tollgate	One every lanes of connection road that entering New NH3	Entrance Tollgate	Entrance Tollgate
1-5	Variable Message Sign (VMS) System	Type of VMS	Not Specified	Tollgate VMS	Exit VMS and Entrance VMS	Exit VMS and Entrance VMS	Exit VMS and Entrance VMS	Exit VMS and Entrance VMS	Exit VMS and Entrance VMS
		Location	Not Specified	Toll barrier (2 sets)	Upstream of each on-ramp and off-ramp	Upstream of each on-ramp and off-ramp	Upstream of each on-ramp and off-ramp	Major alignment and intersections	Upstream of each on-ramp and off-ramp
1-6	Variable Speed Limit Sign System	Introduction	Not Specified	10 sets at upstream of 5 ICs	Not Planned	Not Planned	Not Planned	Not Planned	Future Plan
1-7	Highway Radio System	Introduction	Not Specified	Not Planned	Not Planned	Not Planned	Not Planned	Not Planned	Future Plan
1-8	Vehicle Information and Communication System (VICS)	Introduction	Not Specified	Not Planned	Not Planned	Not Planned	Not Planned	Not Planned	Future Plan
1-9	Information Exchange System	Introduction	Not Specified	Not Planned	Not Planned	Future Plan	Not Planned	Not Planned	Future Plan
1-10	Internet Dissemination System	Introduction	Not Specified	No information	Planned	Planned	Not Planned	Not Planned	Planned
1-11	Water Level Monitoring System	Introduction	Not Specified	Not Planned	Not Planned	Not Planned	Not Planned	Not Planned	Not Planned
1-12	Incident Detection & Information System	Introduction	Not Specified	No information	Not Planned	Not Planned	Not Planned	Not Planned	Not Planned
1-13	Bus Location System	Introduction	Not Specified	Not Planned	Not Planned	Not Planned	Not Planned	Not Planned	Not Planned
1-14	Traffic Management Center System	Introduction	Not Specified	Planned	Planned	Planned	Planned	Planned	Planned
		Location	Not Specified	Vuc Vong toll plaza, km218+737	Traffic management center system at traffic management center	Central server system at traffic control and operation management office	Traffic management center system (temporally) at Maintenance Office (In future, the system will be integrated in Ha Noi Main Management Center System)	Center operating system at Main Management Center, and Maintenance and emergency installation at Maintenance Office	Traffic management center system at Main Management Center, and monitoring PCs at Maintenance Office

Source: Consultant

Table 2-2 Comparison of DQE ITS Plans with Relevant MOT Decisions and Other On-going Projects (2/2)

No.	Decisions and ITS Projects		Vietnamese Standards or MOT Decision	Cau Gie - Ninh Binh	Ho Chi Minh - Trung Luong	Ho Chi Minh - Dau Giay	Ha Noi - Thai Nguyen	Da Nang - Quang Ngai (Previous TEDI F/S 2010)	Da Nang - Quang Ngai (Previous WB F/S in 2009)
2	Toll Collection System			No information					
2-1	General	Open/Closed System	Not Specified	Closed system	Closed system	Closed system	Open system	Closed system	Closed system
		Tariff Rate System	Not Specified	No information	No information	No information	Flat rate tariff system by vehicle class	Not Specified	Distanced based tariff system or Distance based sectional tariff system
		Vehicle Classification	Not Specified	Manual	No information	at least 7	Based on MOF Circular No. 90/2004/TT-BTC	Not Specified	Based on MOF Circular No. 90/2004/TT-BTC
		Tollgate Arrangement	Not Specified	entrance: 30 gate Exit: 36 gate	No information	No information	1 toll barrier	At each entrance and exit ramp	At each entrance and exit ramp
2-2	Type of System	Manual Toll Collection	TCCS 01:2008/VRA: HIGHWAY TOLL STATION SPECIFICATION FOR THE SINGLE STOP STATION WITH BARCODES RECEIPTS	paper ticket, bar code card, magcard, IC card,	Yes (IC card Tyket Type)	No information	Yes (Bar-code Ticket Type)	Not clearly specified (Applying to IC card system)	Yes
		Semi-automatic Toll Collection	Not Specified	Touch & Go in combination with Manual Toll Collection	No information	Touch & Go system	No		No
		Automatic Toll Collection (ETC)	Passive RFID (MOT Decision 2530/BGVT-KHCN) Active-DSRC (MOT Decision 4244/BGVT-KHCN)	RF-ID Pasive	Yes (Passive DSRC)	Yes (Active-DSRC)	Yes (Active-DSRC)		Yes (Active-DSRC)
3	Communication System								
3-1	Digital Transmission System	Type of Communication	Not Specified	Private fiber optic network	Private fiber optic network	Private fiber optic network	Private fiber optic network	Private fiber optic network	Private fiber optic network
		Network Protocol	Gigabit Ethernet (MOT Decision 2530/BGVT-KHCN)	Gigabit Ethernet	No information	Gigabit Ethernet	Gigabit Ethernet	Not clearly specified	IP over SDH/SONET or Gigabit/10Gigabit Ethernet
		Cable Installation	Not Specified	No information	1 direction (initial phase)	At median (2 directions)	At median (2 directions)	Not clearly specified	Bose side of expressway
3-2	Emergency Telephone	Introduction	Not Specified	Planned	No information	Planned	Not Planned (using mobile phone)	Planned	Not Planned (using mobile phone)
		Location	Not Specified	No information	-	1 km intervals	-	2 km intervals on each direction on expressway	-
3-3	Wireless Radio System	Type of Radio	Under Low on Radio Frequencies No. 42/2009/QH12	No information	No information	400 MHz band radio	VHF or UHF band radio	VHF or UHF band radio	VHF or UHF band radio
		Location	Not Specified	No information	-	1 base station at Management Office	1 base station at Road Management Office and another 2 repeater station at km 0+000 and km 17+530	1 base station,120 vehicle-installed sets, 120 hand-held sets	2 base stations,30 vehicle-installed sets, 50 hand-held sets
3-4	Internal Telephone System	Introduction	Not Specified	No information	No information	Yes	Yes	Yes	Yes
		Location	Not Specified	No information	-	1 IP-PBX at traffic control and operation management office, 200 phones at management office, tollgates and service areas	Management Office (1 IP-PBX, 50 telephone set), SA (10x2 telephone set), Toll barrier (12x2 telephone set)	1 IP-PBX, 240 phones	Main management center (1IP-PBX, 50 telephone set), Management office (20x2 telephone set), Toll office (10x9 telephone set)

Source: Consultant

Main findings from the comparison above are summarized as follows;

- Almost all system component selected in both TEDI F/S and NK F/S is consistent with that of other projects except emergency telephone system. Some of other projects will deploy the emergency telephone system and others will utilize mobile phone instead of emergency telephone.
- Major technical specifications proposed in the TEDI F/S and NK F/S are basically in accordance with relevant decisions issued by MOT.
- The location plan of ITS equipment differs in each project. The following attentions are to be paid at ITS equipment arrangement.
 - CCTV camera: at 2km interval or at each interchange
 - Vehicle detector: at 2km interval or at each interchange
 - Overload monitoring sensor (Weigh-In-Motion): at entrance tollgate or at exit tollgate
- The image recognition type vehicle detector is to be specified in the MOT decision. However, it is possibility that image recognition detector may not be well functioning under the bad weather conditions. Therefore, alternatives for vehicle detector shall be carefully examined in the design.

2.3 Comments on Previous F/S

Through careful review works, the Consultant makes comments against the previous ITS plans in TEDI F/S and NK F/S as follows.

(1) Traffic Management System

1) System Components

- The traffic management system component consisted of (1)CCTV system, (2)Vehicle detector system, (3)Meteorological observation system, (4)Variable message sign system, (5)overload monitoring system, (6)traffic management center system is appropriate in consideration of expressway characteristic of the DQE.

2) CCTV System

- PTZ camera selected in both TEDI F/S and NK F/S is appropriate and acceptable due to the consistency with MOT Decision No. 2503/BGTVT-KHCN.
- CCTV camera location plan of both previous F/Ss (locations at hazardous area) is basically acceptable. In addition to the proposed locations, CCTV cameras will be introduced to monitor natural disaster prone areas.

3) Vehicle Detector System

- Type of vehicle detector shall be reviewed because the selected image recognition type detector in the TEDI F/S may not be well functioning in bad weather conditions or night time.
- The vehicle detector location in the NK F/S is acceptable since the detector location at 2km interval proposed in the TEDI F/S is too much for inter-city expressway on rural area and at the time of road opening.

4) Meteorological Observation System

- A visibility meter shall be introduced to identify poor visibility conditions in addition to the anemometer, thermometer and rain gauge planned in both F/Ss.
- The meteorological sensor locations shall be reviewed to measure weather conditions on entire expressway section.

5) Variable Message Sign (VMS) System

- The type and location of VMS system proposed in both F/Ss are reasonable and acceptable.

6) Overload Monitoring System

- The type and location of overload monitoring system in both F/Ss are basically acceptable. However, the procedures for overloaded vehicle enforcement and requirements of system equipment shall be further reviewed in line with O&M plan proposed in this Project.

7) Traffic Management Center System

- The scale of traffic management center system proposed in both previous F/Ss is acceptable. Detailed functions and specifications of the system will be further studied in the design.

(2) Toll Collection System

1) Tariff Rate System

- Distance based tariff rate system and closed system are acceptable and appropriate system for this project.

2) Vehicle classification

- Vehicle classification based on MOF Circular No. 90/2004/TT-BTC is acceptable.

3) Tollgate arrangement

- Tollgate arrangements are basically acceptable. However number of tollgate and ETC lane shall be further reviewed in the design.

4) Type of Toll Collection System

- Manual toll collection system with contactless IC card in both F/S is acceptable. Detailed functions, component and specifications of the system will be further studied in the design.
- DSRC-Active 5.8 GHz ETC system based on MOT Decision No. 4244/BGVT-KHCN for automatic toll collection system is acceptable. Detailed functions and specifications for this expressway will be further studied in the design.

(3) Communication System

1) Digital Transmission System

- The private fiber optic digital transmission system selected in the TEDI F/S and NK F/S is appropriate and acceptable in view of high speed data transmission capability, high reliability against disaster, etc.
- Gigabit Ethernet proposed in the NK F/S is acceptable as fiber optic transmission protocol due to the consistency with MOT Decision No. 2503/BGTVT-KHCN.

- Considering the enhancement of network reliability, the fiber optic cable installation along the expressway by loop topology in the NK F/S is acceptable. Detailed cable installation plan shall be further examined in order to meet latest expressway cross section and alignment and cope with future road widening.

2) Emergency Telephone System

- There is a discrepancy between the TEDI F/S and the NK F/S ITS plan about the introduction of emergency telephone system. The necessity of emergency telephone system shall be further clarified in accordance with emergency response system which will be studied in O&M plan in the design.

3) Wireless Radio System

- In order for securing reliable communications between the management center and patrol crew or other O&M staffs, the introduction of VHF/UHF band dedicated wireless radio system is preferable as proposed in previous F/Ss. However, utilization of dedicated wireless radio requires the permission for frequency allocation from radio regulatory authority. The possibility of frequency allocation shall be discussed with relevant authorities.
- The location of base station shall be further examined so that entire expressway section can be within the coverage of wireless radio system. The wave propagation analysis by using software will be made in the design.

4) Internal Telephone System

- Selected IP internal telephone system is suitable and acceptable in terms of technical trends in the world and system scalability.

The comments on the previous F/S are summarized in **Table 2-3**.

Table 2-3 Summary of Comments on Previous F/Ss (1/3)

No.	Comments and Recommendations		ITS Plan in TEDI F/S	ITS Plan in NK F/S	Comments	Remarks
1	General					
1-1	Organization for expressway O&M		- 1 Expressway Management Center - 1 Operation and Maintenance Center - 9 Toll Offices - 2 Toll Barriers - 7 IC Tollgates	- 1 Traffic Management Center - 2 Operation and Maintenance Offices - 9 Toll Offices - 2 Toll Barriers - 7 IC Tollgates	Institution and its location for expressway O&M are to be reviewed in O&M plan.	
1-2	ITS Component		(1) Traffic Management System (2) Toll Collection System (3) Communication System	(1) Traffic Management System (2) Toll Collection System (3) Communication System	Acceptable	
2	Traffic Management System					
2-1	Traffic Management System Components		(1) CCTV System (2) Vehicle Detector System (3) Meteorological Observation System (4) Variable Message Sign System (5) Overload Monitoring System (6) Traffic Management Center System	(1) CCTV System (2) Vehicle Detector System (3) Meteorological Observation System (4) Variable Message Sign System (5) Overload Monitoring System (6) Traffic Management Center System	Acceptable	
2-2	CCTV System	Type of Camera	PTZ Camera (IP Digital Camera)	PTZ Camera (IP Digital Camera)	Acceptable (In accordance with MOT Decision No. 2503/BGTVT-KHCN)	
		Location	At intersections	Merging and diverging sections (interchanges), outside of tunnel	Basically acceptable (CCTV camera location will be reviewed to collect natural disaster information, etc.)	
2-3	Vehicle Detector System	Type of Detector	Image recognition type	Not specified (Loop-coil or Ultrasonic or Image recognition type)	To be reviewed (Image recognition type is not well functioning in bad weather conditions and night time)	
		Location	2 km intervals on expressway	One each for every lane between ICs	NK F/S is acceptable (To minimize implementation cost at initial stage)	
2-4	Meteorological Observation System	Type of Sensor	Anemometer, thermometer and rain gauge	Anemometer, Thermometer and Rain gauge	To be reviewed (Identification of poor visibility must be considered in the ITS plan)	
		Location	1 location (Main Management Centre in Da Nang)	2 locations (Main Management Centre in Da Nang and Management Office in Quang Ngai)	NK F/S is basically acceptable (Sensors must be located to measure weather conditions on entire expressway)	
2-5	Variable Message Sign (VMS) System	Type of VMS	Exit VMS and Entrance VMS	Exit VMS and Entrance VMS	Acceptable	
		Location	Major alignment and intersections	Upstream of each on-ramp and off-ramp	Acceptable	

Source: Consultant

Table 2-3 Summary of Comments on Previous F/Ss (2/3)

No.	Comments and Recommendations		ITS Plan in TEDI F/S	ITS Plan in NK F/S	Comments	Remarks
2-6	Overload Monitoring System	Type of Sensor	Weigh-In-Motion	Weigh-In-Motion	Acceptable	
		Location	Entrance Tollgate	Entrance Tollgate	Basically acceptable (The procedures for overloaded vehicle enforcement and requirements of system equipment shall be further reviewed in line with O&M plan proposed in this design)	
2-7	Traffic Management Center System	Introduction	Planned	Planned	Acceptable	
		Location	Center operating system at Main Management Center, and Maintenance and emergency installation at Maintenance Office	Traffic management center system at Main Management Center, and monitoring PCs at Maintenance Office	Acceptable	Detailed functions and specifications of the system will be further studied in the design
3	Toll Collection System					
3-1	General	Open/Closed System	Closed system	Closed system	Acceptable	
		Tariff Rate System	Not Specified	Distanced based tariff system or Distance based sectional tariff system	Acceptable	Approval of distance based system shall be consult with authorities related.
		Vehicle Classification	Not Specified	Based on MOF Circular No. 90/2004/TT-BTC	Acceptable	
		Tollgate Arrangement	At each entrance and exit ramp	At each entrance and exit ramp	Basically Acceptable	Number of ETC lane will be further reviewed in the O&M & ITS plan.
3-2	Type of System	Manual Toll Collection	Not clearly specified (Applying to IC card system)	Yes	Acceptable	
		Semi-automatic Toll Collection		No	Acceptable	
		Automatic Toll Collection (ETC)		Yes (Active-DSRC)	Acceptable (In accordance with MOT Decision No. 4244/BGV-T-KHCN)	

Source: Consultant

Table 2-3 Summary of Comments on Previous F/Ss (3/3)

No.	Comments and Recommendations		ITS Plan in TEDI F/S	ITS Plan in NK F/S	Comments	Remarks
4	Communication System					
4-1	Digital Transmission System	Type of Communication	Private fiber optic network	Private fiber optic network	Acceptable	
		Network Protocol	Not clearly specified	IP over SDH/SONET or Gigabit/10Gigabit Ethernet	Acceptable (In accordance with MOT Decision No. 2503/BGTVT-KHCN)	
		Cable Installation	Not clearly specified	Bose side of expressway	NK F/S is basically acceptable (To be further checked to meet latest expressway cross section, etc.)	Future road widening must be paid attention to cable installation location
4-2	Emergency Telephone	Introduction	Planned	Not Planned (using mobile phone)	To be reviewed (The necessity of emergency telephone will be further reviewed in line with emergency response system to be studied in the O&M plan)	
		Location	2 km intervals on each direction on expressway	-		
4-3	Wireless Radio System	Type of Radio	VHF or UHF band radio	VHF or UHF band radio	Basically acceptable	Necessary to obtain permission for frequency allocation by MIC
		Location	1 base station, 120 vehicle-installed sets, 120 hand-held sets	2 base stations, 30 vehicle-installed sets, 50 hand-held sets	Basically acceptable (The coverage of base station will be reviewed to cover entire expressway section)	
4-4	Internal Telephone System	Introduction	Yes	Yes	Acceptable	
		Location	1 IP-PBX, 240 phones	Main management center (1 IP-PBX, 50 telephone set), Management office (20×2 telephone set), Toll office (10×9 telephone set)	Acceptable	

Source: Consultant

3 ITS PLANNING STANDARD

The objectives of this section are to define the applicable standards for planning in ITS.

3.1 Vietnamese Standards

Since the ITS is a modernized information technology, no specific technical standards are currently existed in Vietnam except the standards for general communication and conduit systems listed below.

Table 3-1 Applicable Vietnamese Standards

No.	Reference	Descriptions	Category		
			TMS	TCS	CMS
1	TCN 68 - 254: 2006	Outside Plant Communication – Technical Specification			X
2	TCN 68 - 153: 1995	Cable duct and cable connection box – Technical Standard			X
3	TCN 68 - 144: 1995	Rigid Polyvinyl pipe for underground cables – Technical Standard			X
4	TC.VNPT - 06:2003	PVC-U pipe for underground cables – Technical Standard			X
5	TCN 68 - 178: 1999	Code of Practice for the construction of optical fiber – Communication system			X

Source: Consultant

Instead of technical standards, two (2) decisions related to the ITS have been issued by MOT as mentioned earlier. The ITS plan of DQE will be established in accordance with relevant Vietnamese technical standards and decisions, basically.

3.2 International Standards

Several international standards will be referred to the ITS works for the DQE.

(1) Referential Standards for Traffic Management System

Even though the specific international technical standards for each traffic management system component are not being published, international standards listed below will be utilized for the traffic management system plan and design as reference.

Table 3-2 Referential International Standards for Traffic Management System

No.	Reference	Descriptions
1	ISO 14813	Reference model architecture for the ITS sector
2	ISO 14817:2002	Transport information and control systems – Requirements for ITS/TICS central data registry and ITS/TICS data dictionaries
3	ISO 14827-1:2005	Transport information and control systems – Data interfaces between centers for transport information and control system – Part1: message definition requirements
4	ISO 14827-2:2005	Transport information and control systems – Data interfaces between centers for transport information and control systems – Part 2: DATEX-ASN
5	ISO 15784-1:2008	Intelligent transport systems (ITS) – Data exchange involving roadside modules communication Part1: General principles and documentation framework of application profiles
6	ISO 15784-2:2008	Intelligent transport systems (ITS) – Data exchange involving roadside modules communication Part2:Application Profile-SNMP
7	ISO 15784-3:2008	Intelligent transport systems (ITS) – Data exchange involving roadside modules communication --- Part3: Application profile-data exchange (AP-DATEX)

Source: Consultant

(2) Technical Standards for Toll Collection System

The ETC system for the DEQ will apply to DSRC-Active 5.8GHz of Japan as specified in the MOT Decision No. 4244/BGVT-KHCN. Following technical standards for the DSRC-Active 5.8GHz and contactless IC card will be utilized for the toll collection system plan and design.

Table 3-3 International Standards for Toll Collection System

No.	Reference	Descriptions
1	ISO/IEC 11179	Information technology – specification and standardization of data elements
2	ITU-R M.1453-2	ITS – Dedicated Short Range Communication (DSRC) at 5.8GHz
3	ISO 15628	Road transport and traffic telematics – Dedicated Short Range Communication (DSRC) – Application Layer
4	ARIB STD-T75	DSRC System
5	ISO 14906	Road transport and traffic telematics – Electronic fee collection Application Interface Definition for DSRC
6	ISO/TS 25110	Electronic fee collection -- Interface Definition for on-board account using integrated circuit card (ICC)
7	ISO 17573	Road transport and traffic telematics – Electronic fee collection (EFC) – systems architecture for vehicle related transport services
8	ISO/IEC 14443-1	Identification cards – Contactless integrated circuit cards – Proximity cards – Part 1: Physical characteristics
9	ISO/IEC 14443-2	Identification cards – Contactless integrated circuit cards – Proximity cards – Part 2: Radio frequency power and signal interface
10	ISO/IEC 14443-3	Identification cards – Contactless integrated circuit cards – Proximity cards – Part 3: Initialization and anticollision
11	ISO/IEC 14443-4	Identification cards – Contactless integrated circuit cards – Proximity cards – Part 4: Transmission protocol
12	ISO/IEC 7816-4	Identification cards – Integrated circuit cards – Part 4: Organization, security and commands for interchange
13	ISO/IEC 18092	Information technology – Telecommunication and information exchange between systems – Near Field Communication – Interface and Protocol (NFCIP-1)
14	IEC 60721-3-4	Classification of environment conditions – Part 3 : Classification of groups of environmental parameters and their severities – Section 4: Stationary use at non-weatherprotected locations
15	IEC 60721-3-5	Classification of environment conditions – Part 3 : Classification of groups of environmental parameters and their severities – Section 5: Ground vehicle installations
16	ISO 14815	Road transport and traffic telematics – Automatic vehicle and equipment identification –System specifications
17	IEC 60068-1	Environmental testing. Part 1: General and guidance
18	ISO/TS 14907-1	Road transport and traffic telematics – Electronic fee collection – Test procedures for user and fixed equipment – Part 1: Description of test procedures
19	ISO/TS 14907-2	Road transport and traffic telematics – Electronic fee collection – Test procedures for user and fixed equipment – Part 2: Conference test for the onboard unit application interface

Source: Consultant

(3) Technical Standards for Communication System

In accordance with the MOT Decision No. 2530/BGVT-KHCN, an IP (Internet Protocol) based communication network named Gigabit Ethernet will be applied to digital transmission system for the DQE. Following international technical standards for communication system including IP technology will be employed for the communication plan and design.

Table 3-4 International Standards for Communication System

No.	Reference	Descriptions
1	Ethernet	<ul style="list-style-type: none"> 8802-3: 2000 (ISO/IEC) (ANSI/IEEE Std 802.3 2000 Edition): Information Technology – Telecommunications and information exchange between systems – Local and Metropolitan area networks – Specific equipment -- Part3: Carrier sense multiple access with collision detection (CAMA/CD) access method and physical layer specifications.
2	Fast Ethernet	<ul style="list-style-type: none"> IEEE 802.3u-1995 IEEE Standards for Local and metropolitan area networks: Supplement to Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications: Media access control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100Mb/s Operation, Type 100BaseT (Clauses 21-30) (ANSI) EIA/TIA568B (AT and T-258A) Commercial Building Telecommunications Wiring Standard, 1991
3	Gigabit Ethernet	<ul style="list-style-type: none"> IEEE 802.3ab : Physical coding sublayer (PCS), physical medium attachment (PMA) sublayer and baseband medium, type 1000BASE-T IEEE 802.3z : Media Access Control(MAC) Parameters, Physical Layer, Repeater and Management Parameters for 1000 Mb/s Operation
4	FTP	<ul style="list-style-type: none"> RFC 959 File Transfer Protocol, RFC 1350 The TFTP Protocol (Revision 2),
5	HTTP	<ul style="list-style-type: none"> RFC 1945 Hypertext Transfer Protocol -- HTTP/1.0. RFC 2068 Hypertext Transfer Protocol -- HTTP/1.1. RFC 2616 Hypertext Transfer Protocol /1.1 June 1999 RFC 2617 HTTP Authentication: Basic and Digest Access Authentication, June 1999
6	IP	<ul style="list-style-type: none"> RFC 791 Internet Protocol
7	PPP	<ul style="list-style-type: none"> RFC 1661 The Point-to-Point Protocol (PPP)
8	SNMP	<ul style="list-style-type: none"> RFC 1157 Simple Network Management Protocol (SNMP)
9	TCP	<ul style="list-style-type: none"> RFC 793 Transmission Control Protocol
10	UDP	<ul style="list-style-type: none"> RFC 768 User Datagram Protocol
11	MPEG4	<ul style="list-style-type: none"> ISO/IEC 144916-1:1999 Information technology -- Coding of audio visual objects -- Part 1: Systems ISO/IEC 144916-2:1999 Information technology -- Coding of audio-visual objects -- Part 2: Visual ISO/IEC 144916-2:1999 Information technology -- Coding of audio-visual objects -- Part 3: Audio ISO/IEC 14496-10:2003: Information technology -- Coding of audio-visual objects -- Part 10: Advanced Video Coding
12	FOC	<ul style="list-style-type: none"> ITU-T G 652: Characteristics of a single-mode optical fibre and cable ITU-T G 655: Characteristic of a non-zero dispersion-shifted single-mode optical fibre and cable

Source: Consultant

4 ITS PLAN

4.1 Basic ITS Planning Policies for DQE

The ITS is integration of several equipment in order to provide appropriate services to road operator, road users, traffic police and so on. General objectives of ITS implementation are as follows;

[General Objectives of ITS Implementation]

- To manage and control the traffic to make road user's travel safety, convenient and comfortable.
- To monitor road and conditions on the expressway continuously.
- To provide information on the expressway to road users promptly and accurately.
- To plan and implement countermeasures earlier to minimize the negative impact in case of incident or any other emergency cases.
- To monitor operational status and maintain the various facilities installed along the expressway in good working conditions.

Type and level of ITS to be implemented on the expressway are depended on required services which are strongly related to characteristics of expressway.

The characteristics of DQE are summarized as follows;

- DQE is inter-city expressway with long travelling distance, 131km length;
- Estimated traffic volume as of 2025 is not so high, around 14,000 – 31,000 PCU/day;
- There are eight (8) interchanges/intersection;
- DQE is basically passing through agricultural land, but with two (2) flood prone areas, two (2) deep cut sections and one (1) tunnel section; and
- DQE is passing through three (3) municipalities, Da Nang, Quang Nam and Quang Ngai.

The basic ITS planning policies for DQE is set up as follows in consideration of both general ITS requirements for expressway O&M and particular conditions or requirements of DQE mentioned above to be paid attentions to establish proper ITS plan.

[Basic Planning Policies on ITS]

- Realize general objectives of ITS implementation
- Cope with expressway characteristics
- Meet the requirements of DQE expressway O&M activities studied in the O&M plan
- Apply efficient and latest ITS technologies with harmonization with other on-going projects in Vietnam.
- Minimize implementation costs at initial phase.
- Equip with future expandability to manage in whole central region but system capacity is targeting on DQE section only at initial stage.
- Public traffic information shall be provided through internet for expressway user's convenient.
- Provide SCADA function for supervising ITS facilities' operational status.

4.2 Traffic Management System Plan

4.2.1 Traffic Management System Components

The traffic management system consists of various types of system components. These are categorized into 1) data acquisition system, 2) information dissemination system and 3) traffic management system as shown in table below.

Table 4-1 Typical Traffic Management System Components

No.	Category	System Component
1-1	Data Acquisition System	CCTV Camera System
1-2		Vehicle Detector System
1-3		Meteorological Monitoring System
1-4		Overload Monitoring System
1-5		Incident Detection System
1-6		Vehicle Trucking (Probe Car) System
2-1	Information Dissemination System	Variable Message Sign (VMS) System
2-2		Variable Speed Limit Sign System
2-3		Highway Radio System
2-4		Vehicle Information and Communication System (VICS)
2-5		Internet Dissemination System
2-6		Bus Location System
3-1	Traffic Management Center System	Traffic Management Center System
3-2		Facility Management System
3-3		Information Exchange System

Source: Consultant

The data acquisition system is to collect expressway and traffic information which generally include traffic volumes, travel speeds, degree of congestions, visual traffic flow conditions and incidents such as adverse weather, accidents, broken downs, road works and natural disasters from various sources.



CCTV Camera



Overload Monitoring System



MET Observation Station

Samples of Data Acquisition System Component

The information dissemination system is to provide the road users with essential road and traffic information processed and integrated in the traffic management center system through various methods such as variable message sign, highway radio, bus location system and internet dissemination.



Variable Message Sign



Bus Location System



Internet Dissemination System

Samples of Information Dissemination System Component

The traffic management center system is a centralized traffic information and control system to manage and integrate all information related to road and traffic conditions, incidents and any other required information for expressway traffic management activities.

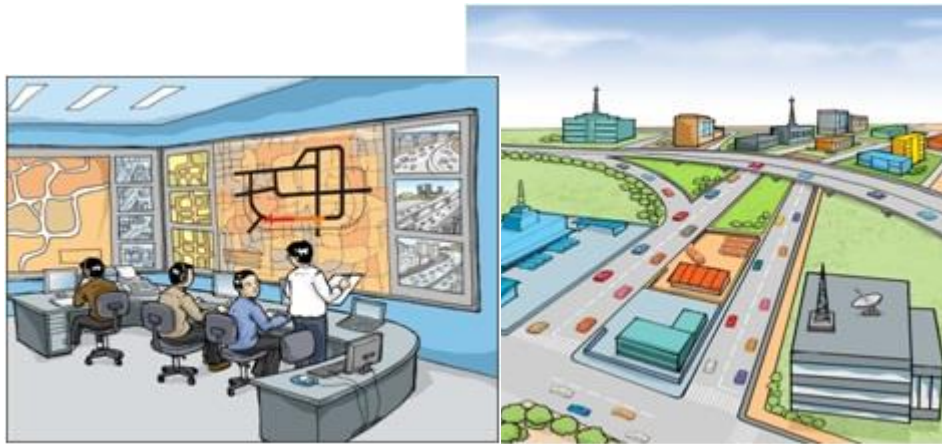


Image of Traffic Management Center System

In initial phase of expressway operation, the system components contributing to traffic safety rather than components for user's convenience and comfortable must be put emphasis because the traffic safety is most important target of the expressway operation. The implementation of systems for collecting basic traffic data of expressway is also necessary for proper road and facility management. Upon this concept, the traffic management system components for the DQE are proposed as shown in the table below.

Table 4-2 Proposed Traffic Management System Components in the Project

No.	System Component	Objective
1.	CCTV Monitoring System	To monitor and supervise road & traffic conditions on expressway visually from main management center and/or management offices in order to take necessary actions promptly in case of any incident.
2.	Vehicle Detector System	To measure traffic volume, especially large-sized traffic volume, in order for utilizing future road widening, road structure and facility maintenance planning.
3.	Meteorological Monitoring (MET) System	To measure and detect weather conditions and take appropriate actions such as road closure and maximum speed limit reductions in case of adverse weather conditions.
4.	Overload Monitoring System	To detect and prevent to enter overloaded vehicles to expressway in order for protecting road structure.
5.	Variable Message Sign (VMS) System	To provide road & traffic conditions on expressway to road users for safety driving. VMS is one of most effective information provision tools since it can provide information without any user's equipment like on-board unit.
6.	Traffic Management Center System (including Facility Management System)	To manage and integrate all information related to road & traffic conditions, incidents and facility operational status at main management center for proper traffic management operation.

Source: Consultant

4.2.2 Location Plan of Traffic Management System

Location plan of each traffic management system component is proposed as follows;

- CCTV Camera:** At initial stage of road opening, the CCTV camera is to be located at only hazardous areas such as merging and diverging points (adjacent to interchanges), outside of tunnel, flooding and falling stone areas. Total 33 sets of CCTC camera will be introduced in the Project.
- Vehicle Detector:** One set of vehicle detector shall be installed at each section between interchanges to mainly detect traffic volumes and large-sized vehicle volumes to/from each interchange as planned in the NK F/S. Because the detector location at 2km interval proposed in the TEDI F/S is too much for inter-city expressway on rural area and at the time of road opening. Also, this arrangement has some disadvantages such as difficulty of supplying power to each detector, etc.
- MET Observation:** To detect abnormal weather conditions on entire expressway, three (3) sets of meteorological observation station located at Da Nang main management center, Tam Ky toll office and Quang Ngai management office are proposed.
- Overload Monitoring:** Overload monitoring sensor will be installed at every entrance tollgate to prevent to enter overloaded vehicles to the expressway as planned in both TEDI F/S and NK F/S.
- Variable Message Sign:** The VMS will be located at upstream of each off-ramp and on-ramp including toll plaza to provide road & traffic information on the expressway to drivers passing through expressway or intending to enter the expressway. In addition to those VMs, the VMS located at tunnel entrance will be installed to provide information in and ahead of tunnel since the tunnel is one of most critical sections in the expressway.

Traffic Management Center System: Traffic management center system will be installed in Da Nang main management center and PC monitors to confirm and share road & traffic information will be installed at management offices.

Table below shows proposed location plan of traffic management system and **Figure 4-1** illustrates the traffic management system location map.

Table 4-3 Proposed Location Plan of Traffic Management System

No.	Component	Unit	Quantity	Location Plan
1	CCTV System	set	33	Diversion and merging section: 15 Entrance of tunnel : 2 Flood area: 12 Falling stone area: 4
2	Vehicle Detector System	set	28	Between ICs: 7 x 4 lanes
3	Meteorological Monitoring System	set	3	Da Nang main management center:1 Quang Ngai management office:1 Tam Ky toll office: 1
4	Variable Message Sign System	set	26	Upstream of each off-ramp: 13 Upstream of each on-ramp including toll barrier: 11 Tunnel entrance: 2
5	Overload Monitoring System	set	11	Every entrance toll gate
6	Traffic Management Center System	lot	1	Da Nang main management center (PC monitors at Da Nang and Quang Ngai management office)

Source: Consultant

4.2.3 System Configuration

The proposed traffic management system would be initially configured as **Figure 4-2**.

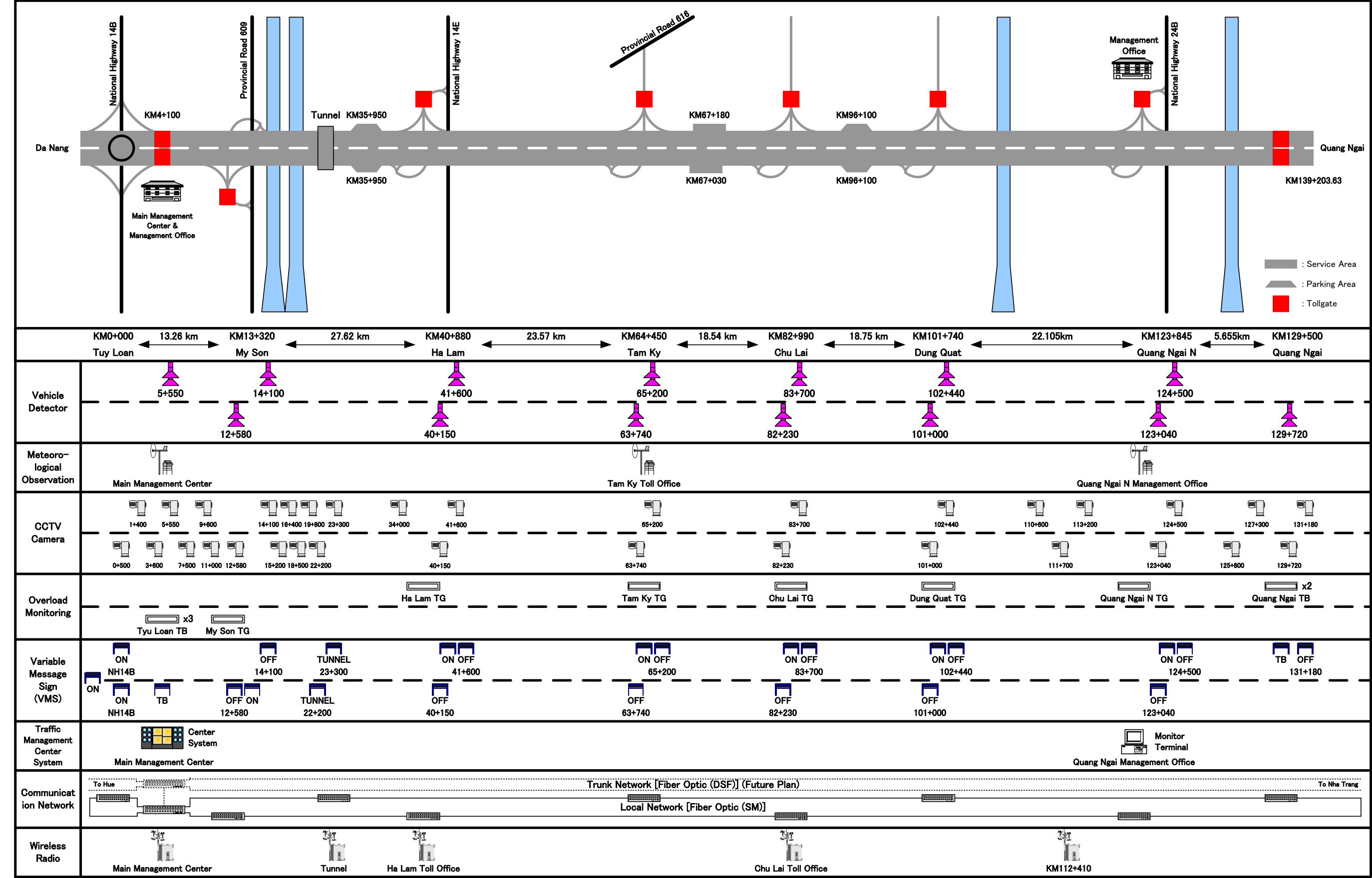
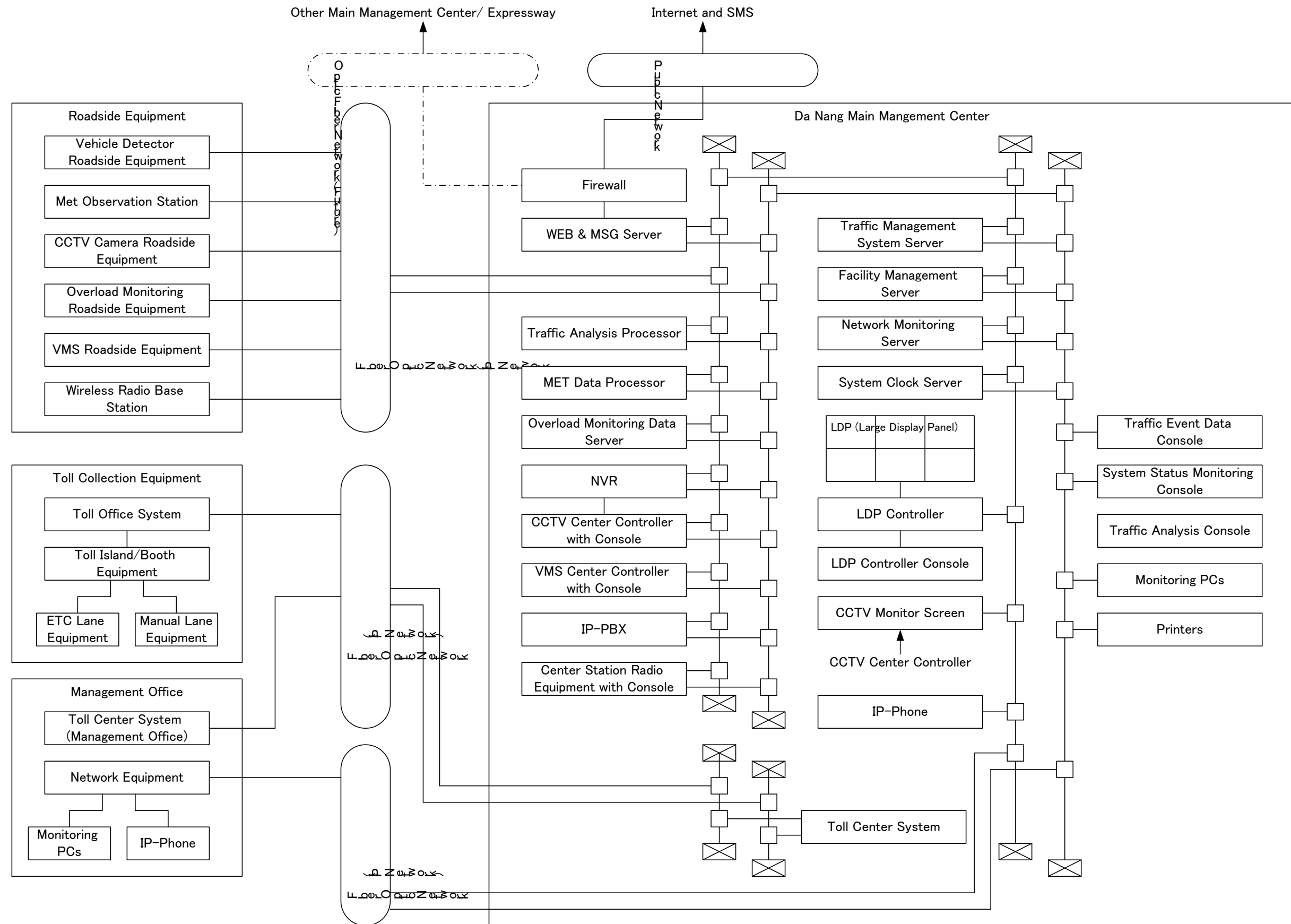


Figure 4-1 Proposed Location Map for Traffic Management System

Source: Consultant



Source: Consultant

Figure 4-2 Proposed Traffic Management System Configuration

4.2.4 CCTV System Plan

In order to monitor road, traffic and weather conditions on the expressway visually, the CCTV camera system will be introduced in the Project with following objectives:

- To visually monitor road, traffic and weather conditions on the road from the Main Management Center,
- To detect abnormal conditions on the road within the coverage of CCTV camera in order to take necessary actions such as lane control road closure, etc. in case any incidents occur,
- To confirm traffic flows on the expressway by live camera images to provide drivers with information when the incident area is identified, and
- To share live camera images among the main management center and maintenance offices for proper expressway operation and maintenance.



CCTV Camera

(1) Location of CCTV Camera

The CCTV cameras will be located at roadside in accordance with following criteria to meet the system objectives and requirements.

[At initial stage]

- The CCTV camera will be placed at merging and diverging points on main carriageway neighboring to interchange which is one of most accident prone areas in the expressway. The CCTV camera will be installed at same locations with traffic detector to effectively monitor actual traffic flows and abnormal conditions visually.
- The CCTV cameras will be located at following flood prone areas in order to confirm water logging situation by image.
 - Beginning point – KM21+000
 - KM124+000 – KM127+000

It is quite important for the DQE to supervise flooding water level because the evacuation area, where residence people can escape, will be constructed beside expressway. The CCTV camera will be installed at the flood prone areas, continuously.

- The DQE is passing through two (2) deep cut sections and natural disaster including falling stone is expected to occur in these areas. To monitor such disaster situation, CCTV camera will be located at following areas.
 - KM34+000 – KM36+000
 - KM111+000 – KM112+500

- In order to monitor the conditions around tunnel section, CCTV camera will be installed at both entrances of tunnel.

[Future]

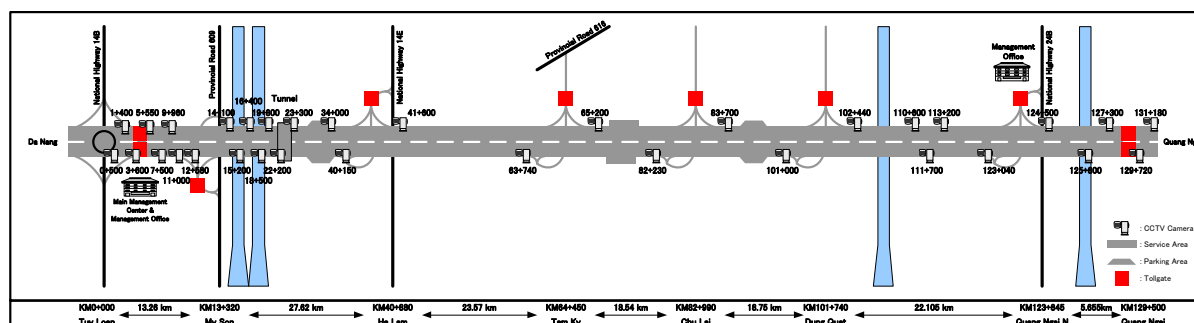
- The CCTV camera will be arranged at a certain interval (2km or some interval) in order to monitor whole section of the expressway.

Proposed location plan of CCTV camera in initial stage is shown in **Table 4-4** and **Figure 4-3** below. Total of 33 CCTV cameras will be provided in the Project.

Table 4-4 Location of CCTV Camera

Km	Category	Remarks	Km	Category	Remarks
0+500	Tuy Loan IC and Flood Area	On South-Bound	41+600	Ha Lam IC	On North-Bound with VMS, Vehicle Detector
1+400	Flood Area	On North-Bound	63+740	Tam Ky IC	On South-Bound with VMS, Vehicle Detector
3+600		On South-Bound	65+200		On North-Bound with VMS, Vehicle Detector
5+550		On North-Bound with Vehicle Detector	82+230	Chu Lai IC	On South-Bound with VMS, Vehicle Detector
7+500			83+700		On North-Bound with VMS, Vehicle Detector
9+600		On North-Bound	101+000	Dung Quat IC	On South-Bound with VMS, Vehicle Detector
11+000		On South-Bound	102+440		On North-Bound with VMS, Vehicle Detector
12+580	My Son IC and Flood Area	On South-Bound with VMS, Vehicle Detector	110+600	Falling Stone Area	On North-Bound
14+100		On North-Bound with VMS, Vehicle Detector	111+700	Falling Stone Area	On South-Bound
15+200	Flood Area	On South-Bound	113+200	Falling Stone Area	On North-Bound
16+400		On North-Bound	123+040	Quang Ngai N IC	On South-Bound with VMS, Vehicle Detector
18+500		On South-Bound	124+500	Quang Ngai N IC and Flood Area	On North-Bound with VMS, Vehicle Detector
19+800		On North-Bound	125+800	Flood Area	On South-Bound
22+200	Tunnel Entrance	On South-Bound with VMS Entrance = 22+485	127+300		On North-Bound
23+300	Tunnel Entrance	On North-Bound with VMS Entrance = 23+037	129+720	Quang Ngai IC Diverging and Merging	On South-Bound with VMS, Vehicle Detector
34+000	Falling Stone Area	On North-Bound	131+180		On North-Bound with VMS
40+150	Ha Lam IC	On South-Bound with VMS, Vehicle Detector			

Source: Consultant



Source: Consultant

Figure 4-3 Location Map for CCTV System

(2) Type of CCTV Camera

The CCTV camera is roughly classified into three types of camera, fixed camera, PTZ camera and network camera. The fixed camera and PTZ camera are categorized as analogue camera and network camera is defined as IP digital camera.

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

Table 4-5 Type of CCTV Camera

Item \ Network	Fixed Camera	PTZ Camera (Industrial TV Camera)	Network Camera (IP Digital Camera)
Image			
Outline	Camera device with fixed lens, auto focus function	Camera device with zoom lens, pan-tilt, auto focus functions	Camera device with zoom lens, pan-tilt, auto focus functions and encode software
Image sensor	1/4" - 1/2" sensor	1/4" - 2/3" sensor	1/4" - 1/2" sensor
Focal length of lens	e.g. 3.8 mm	e.g. 7.0 mm – 363 mm	e.g. 3.8 mm – 114 mm
Minimum illuminance intensity	0.05 lx (day mode) 0.001 lx (night mode)	0.01 lx (day mode) 0.001 lx (night mode)	0.5 lx (day mode) 0.1 lx (night mode)
Ingress protection	IP66	IP67 or IP68	IP66
Advantages	<ul style="list-style-type: none"> - Cost is cheaper than industrial camera. - Once the camera is fixed, no operation for camera control is needed. <p>Therefore, fixed cameras are installed in the tunnel where continuous and seamless monitoring is required and a lot of cameras are installed.</p>	<ul style="list-style-type: none"> - Capable of using high spec. zoom lens. - CCTV monitoring can be realized under condition of darkness, since required minimum illuminance intensity is low. 	<ul style="list-style-type: none"> - Cost is around 1/5 of industrial camera since network camera is basically provided for private sector. - No need to be equipped with hard encoder to connect network. - Wide-spreading in the world
Disadvantages	<ul style="list-style-type: none"> - Limited monitoring coverage - Necessary to have hard or soft encoder to connect network in addition to camera device 	<ul style="list-style-type: none"> - Equipment cost is quite high. - Necessary to have hard or soft encoder to connect network in addition to camera device 	<ul style="list-style-type: none"> - No compatibility on control commands among different manufactures due to lack of international standard.
Cost	Low	High	Low

Source: Consultant

Due to its big advantages such as wider and longer distance coverage, cost performance and easiness of network connectivity, the network camera (IP digital camera) is utilized as CCTV camera device in this project in accordance with MOT decision related.

(3) Monitoring Range of CCTV Camera

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

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

Where,

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

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

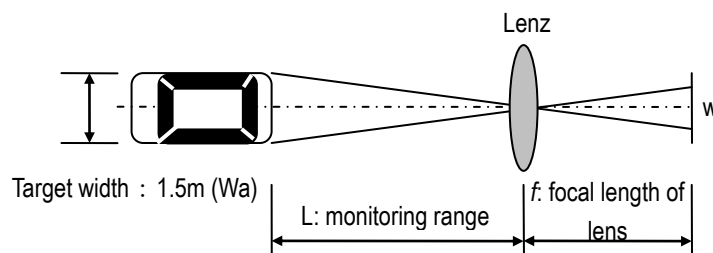
$$w: \text{required size on monitor} = b \times \frac{s}{u}$$

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

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

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

0.9: Over-scanning ratio



Source: Consultant

Figure 4-4 Principle of CCTV Monitoring Range

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

$$\begin{aligned} L &= f \times \frac{Wa}{0.9 \times w} \\ &= 114 \times \frac{1.5}{0.9 \times (6.4 \times \frac{15}{531})} \\ &= \underline{1050.9 \text{ m}} \end{aligned}$$

The CCTV camera would take image around 1.0 km ahead from its location in case of keeping the line-of-sight. Thus, CCTV camera will be located at an interval of 2km in the areas to be continuously monitored such as flooding area.

(4) Digital Image Encoding

To transmit image over IP (Internet Protocol) network, live-image taking by CCTV camera must be compressed into digital image format. Various types of image compressing method are standardized by international telecommunication organizations as shown in table below.

Table 4-6 Digital Image Encoding

Item \ Network	M-JPEG	MPEG-2	H.264/MPEG-4
Outline	M-JPEG is a moving image compressing format by continuously transmitting a JPEG image which is one of still image encoding. The encoding efficiency of M-JPEG is not so high, but M-JPEG has advantages that can easily generate the still images from moving image.	MPEG-2 is used as the format of digital television signals that are broadcast by radio, cable and broadcast satellite TV systems.	MPEG4 was introduced in 1998 and designated a standard for a group of audio and video coding formats and related technology. Uses of H.264/MPEG-4 are wide and include compression of AV data for web (streaming media) and CD distribution, etc.
Standard	ISO/IEC 29199-3	ISO/IEC 13818	ITU-T Rec. H.264 ISO/IEC 14496-10
Main usages	Digital camera Network camera	TV Broadcast DVD	Network camera Internet streaming TV conference Blue-ray Disc, etc
Image compressing algorism	DCT	DCT, Inter-frame prediction coding	DCT, Inter-frame prediction coding, intra-frame coding
Image size (Resolution)	320 x 240 (QVGA) 640 x 480 (VGA)	720 x 480 (SDTV) 1920 x 1080 (HDTV)	176 x 144 (QCIF) 352 x 288 (CIF) 720 x 480 (SDTV) 1920 x 1080 (HDTV)
Normal Bit-rate	10 Mbps	6.3 Mbps	2 Mbps
Application to network camera	Frequent	Not so many	Frequent
Conversion to Still Image	Easy	Difficult	Difficult
Advantages	<ul style="list-style-type: none"> - High compression ratio - Wide-range usage to network camera - Easiness to generate still images - Low Cost 	<ul style="list-style-type: none"> - High definition video image - Interoperability can be strictly secured since the ISO/IEC 13818 defines the formats in detail. 	<ul style="list-style-type: none"> - High compression ratio (to reduce network capacity) - Wide-range usage to network camera - High encoding efficiency - Low Cost
Disadvantages	<ul style="list-style-type: none"> - No compatibility among different manufactures. - Encoding efficiency is not so high. 	<ul style="list-style-type: none"> - Large capacity network system will be required. - Expensive comparing with other compressed method - Not utilized as network camera encoding system. 	<ul style="list-style-type: none"> - No compatibility among different manufactures.
Recommendation	Recommended (still image encoding)	Average	Recommended (live image encoding)

Source: Consultant

Considering the efficiency of data compressing, wide-range usage to network camera and easiness of conversion from moving picture to still image, CCTV camera shall have both of image compressing functions for H.264/MPEG-4 and M-JPEG.

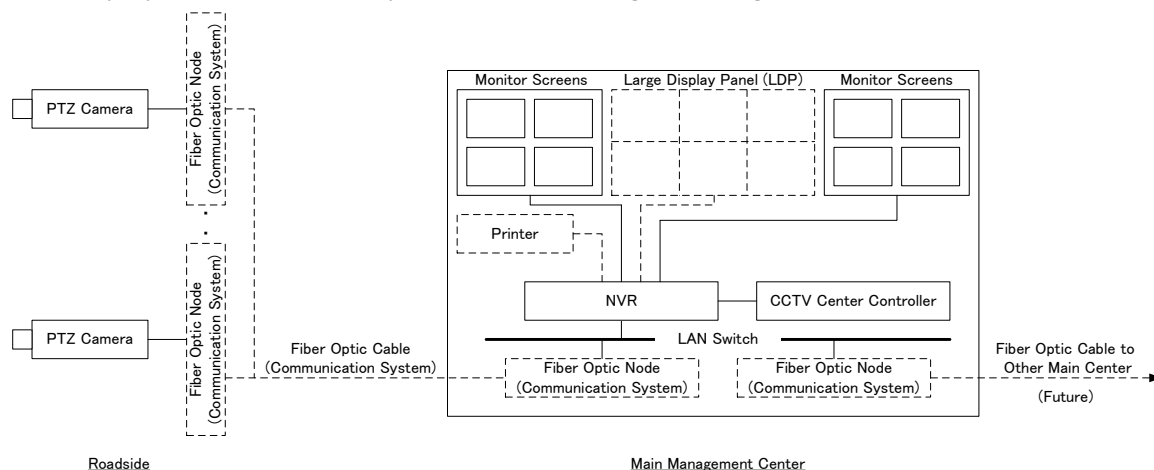
(5) CCTV System Configuration

The CCTV system will consist of the following equipment;

- CCTV camera with supporting structure at roadside;
- Network Video Recorder (NVR) in Main Management Center;
- CCTV center controller with application software in Main Management Center;
- Monitor screen in Main Management Center

- Power supply unit and peripheral.

The proposed CCTV camera system would be configured as **Figure 4-5** below.



Source: Consultant

Figure 4-5 CCTV System Configuration

4.2.5 Vehicle Detector System Plan

In planning for expressway improvement works including road widening and asphalt repair, it will be required to measure a total traffic volume and a large-sized vehicle traffic volume on the expressway, continuously. To meet such requirements for road operation and maintenance, the vehicle detector system shall be introduced in the Project with following objectives:

- To measure the traffic volume between interchanges to be used for planning on future road widening,
- To analyze the current traffic flow from measured traffic volume and average travelling speed, and provide necessary information to drivers on the expressway or intending to enter the expressway for diverting their traveling route from congested road section,
- To measure large-sized vehicle traffic for planning of future asphalt repair or other necessary road facility maintenance,
- To identify abnormal conditions at expected accident prone areas on the expressway from average traveling speed and occupancy ratio, and
- To share the above measured and analyzed traffic information with expressway planning agencies, expressway operators and other relevant authorities.



Vehicle Detector (Ultrasonic Detector)



Vehicle Detector (Inductive Loop Detector)

(1) Location of Vehicle Detector Roadside Equipment

The vehicle detectors will be located at roadside in accordance with following criteria to meet the system objectives and requirements.

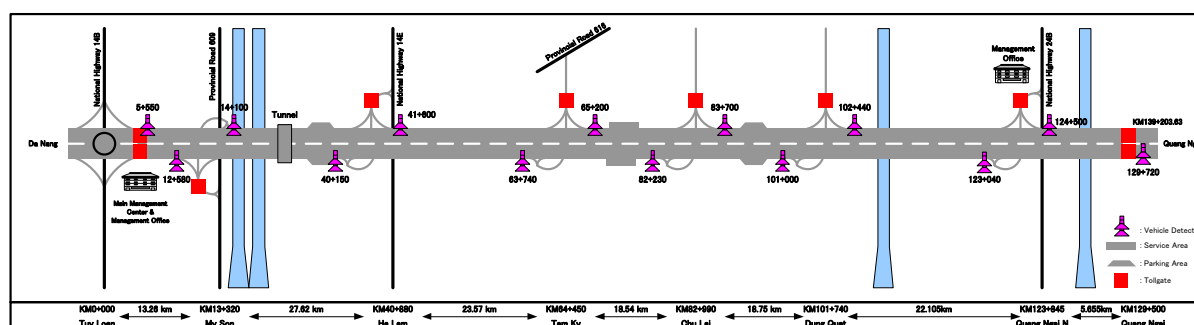
- The vehicle detector roadside equipment shall be installed at one place of each section divided by interchanges to measure traffic volumes of each section and estimate entrance /exit traffic volumes at the interchange. The system shall measure both bound traffic volumes at each section.
- Minimum two (2) sets of detector must be placed at the installation location to measure each lane traffic volume.
- The detector will be located at the upstream of diverging point with exit ramp, which is one of accident prone areas on the expressway, to effectively detect abnormal conditions. This location also has advantages that power can be easily fed from power supply system installed in each toll office and the equipment can be mounted on same supporting pole with VMS and CCTV camera.

Proposed location plan of vehicle counter roadside equipment is shown in **Table 4-7** and **Figure 4-6** below.

Table 4-7 Vehicle Detector Roadside Equipment Location

Section \ Bound	North Bound	South Bound
Tuy Loan – My Son	2 at 5+550 with CCTV	2 at 12+580 with VMS,CCTV
My Son – Ha Lam	2 at 14+100 with VMS,CCTV	2 at 40+150 with VMS,CCTV
Ha Lam – Tam Ky	2 at 41+600 with VMS,CCTV	2 at 63+740 with VMS,CCTV
Tam Ky – Chu Lai	2 at 65+200 with VMS,CCTV	2 at 82+230 with VMS,CCTV
Chu Lai – Dung Quat	2 at 83+700 with VMS,CCTV	2 at 101+000 with VMS,CCTV
Dung Quat – Quang Ngai N	2 at 102+440 with VMS,CCTV	2 at 123+040 with VMS,CCTV
Quang Ngai N – Quang Ngai	2 at 124+500 with VMS,CCTV	2 at 129+720 with CCTV

Source: Consultant



Source: Consultant

Figure 4-6 Location Map for Vehicle Detector System

(2) Measurement Items of Vehicle Detector System

The vehicle detector system is generally installed to detect and process data of traffic volume,

large-sized vehicle traffic, time occupancy rate and vehicle average speed for the purpose of followings.

Table 4-8 Purpose of Traffic Counter Measurements

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

Source: Consultant

The vehicle detector system in the Project will be introduced with the aim of measuring mainly the traffic volume, the large-sized vehicle traffic, traffic congestion and incident only at diverging sections on the expressway for saving the initial costs.

The location of vehicle detector would be expanded in future to detect the traffic congestion and incident on the entire expressway and/or to provide travel time information to the drivers.

The vehicle detector system shall detect vehicles, measure and calculate the required traffic data separately for each lane. Unit duration of detection, measurement and calculation shall be within one (1) minute. All data shall be periodically transmitted to the traffic analysis processor installed in the Main Management Center through fiber optic cable network. The transmitted data shall be processed, stored, retrieved in a server and monitored on a display. The vehicle detector system must have an overall detection accuracy of 95 % or better in vehicle counting for any types of vehicles expected to pass the expressway.

(3) Type of Vehicle Detector

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

[Loop-coil type detector]

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

[Ultrasonic type detector]

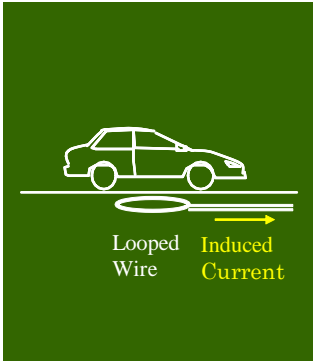
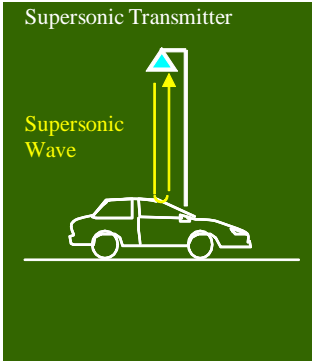

Ultrasonic type detects passing vehicles by using arrival time difference of ultrasonic waves reflected from objects and from the road. Since the detector can be fixed on the supporting structure above the road, maintenance work on road is not required. Also, number of vehicles can be counted with relatively high accuracy.

[Image recognition type detector]

Image recognition type is to detect moving objects in images captured from video cameras according to preset size/speed of the object. This type of detector has advantages such as capability of multiple lane/zone detection, identification of traffics swerved from lanes, etc. However, comparing with other type detectors, the overall counting accuracy is not so high (it is said that the accuracy of image recognition detector is less than 85% and varies in day time and night time, in ambient conditions).

Table below shows the comparison of vehicle detectors.

Table 4-9 Comparison of Vehicle Detectors

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

Source: Consultant

In MOT decision No.2503/BGTVT-KHCN, it is mentioned that it is priority to choose digital IP camera in design of surveillance camera system in expressway combining with traffic detection, traffic volume and traffic flow speed function (VDS). However, it is possibility that image recognition type detector may not be well functioning under the bad weather conditions such as dense fog and heavy rain and in night time. In the past practice in Japan, it has been identified that the accuracy of image recognition detector descend to 85% or lower in bad visible conditions. Therefore, the Consultant recommends the application of ultrasonic type with following reasons;

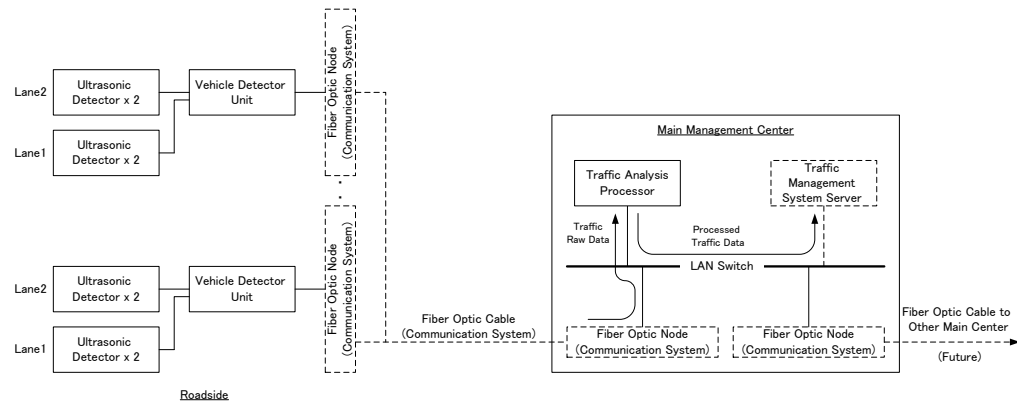
- The ultrasonic detector can be located on any places on the expressway section including bridge ,
- Maintenance work on the pavement can be avoided, and
- Detection accuracy is relatively high comparing with image recognition type detector.

(4) Vehicle Detector System Configuration

The vehicle detector system will consist of the following equipment;

- Ultrasonic type detector and vehicle detector unit with supporting structure at roadside;
- Traffic analysis processor installed in Main Management Center;
- Power supply unit and peripheral.

The proposed vehicle detector system would be initially configured as **Figure 4-7** below.



Source: Consultant

Figure 4-7 Vehicle Detector System Configuration

4.2.6 Meteorological Monitoring (MET) System

The meteorological monitoring (MET) system is one of indispensable systems to measure weather conditions, take appropriate countermeasures in bad weather conditions and provide warning information to the drivers. The system shall be introduced in the Project with following objectives:

- To measure weather conditions including rainfall, temperature, wind velocity/direction and visibility on the expressway in consideration of weather characteristics in DQE area,
- To utilize measured meteorological data as a parameter for taking appropriate countermeasures such as road closure and maximum speed limit reduction, etc. in case hazardous weather condition is detected,
- To provide the weather information to the road users through the information dissemination systems in order for taking cautions to them.
- To share measured meteorological data with alerting signals among expressway operators and other relevant authorities.



Meteorological Sensors

(1) Location of MET Observation Station

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

[At initial stage]

- It is generally said that the MET observation station must be located to cover certain area for measurement and identification of small-scale weather phenomena such as localized torrential rain. According to practice and experience in the world, the possible measurement area is normally set up around 1,000 - 3,000 square kilometers (equal to radius of 20 - 30km). Thus, it is proposed that three (3) MET stations at Da Nang Main Management Center, Tam Ky toll office and Quang Nagi North Management Office are installed to cover entire expressway section.
- Anemometers and visibility meters are normally located at following critical points.
 - [Anemometer]
 - Long bridges across the river
 - Precipitous terrain areas
 - [Visibility Meter]
 - Roads along or across large river or lake

The DQE has four (4) major bridges across the river and passes thorough some precipitous terrain areas. However, actual weather conditions at those areas are not currently identified, and equipment installation and maintenance works at such locations contain some difficulties such as feeding commercial power with backup power supply, etc. From this reason, the location of MET station shall be limited at three (3) locations mentioned above in the initial stage and it will be expanded in next stage after obtaining enough statistics of weather data at the hazardous areas.

[Future]

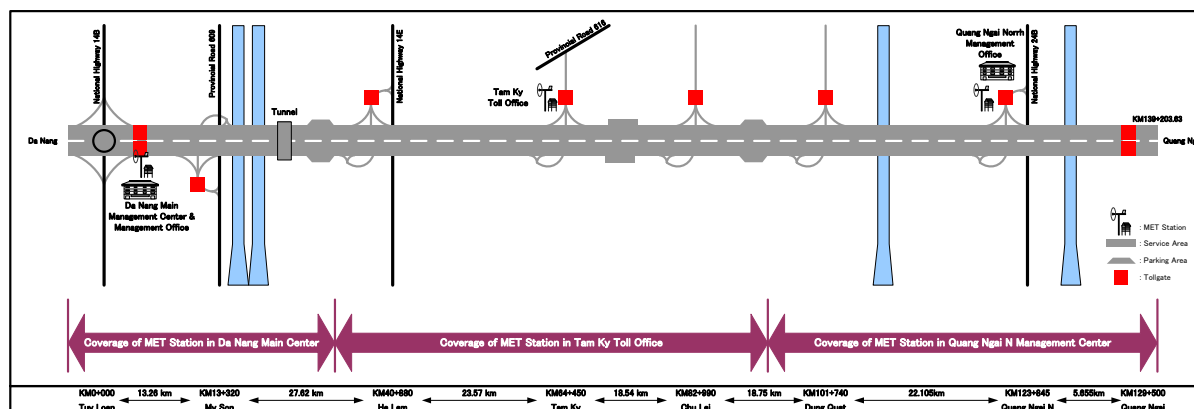
- The MET station will be additionally installed at the location or area to be identified as weather critical point through actual expressway operation.

Proposed location plan of MET observation station at initial stage is shown in **Table 4-10** and **Figure 4-8** below.

Table 4-10 Location of MET Observation Station

No.	Location	Remarks
1	Da Nang Main Management Center	
2	Tam Ky Toll Office	
3	Quang Ngai North Management Office	

Source: Consultant



Source: Consultant

Figure 4-8 Location Map for MET Observation Station

(2) Measurement Items of MET System

The MET observation station consists of various types of sensor to measure weather data required as shown in table below.

Table 4-11 Meteorological Observation Items and Required Sensors

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

Source: Consultant

It is considered road surface thermometer and seismometer are not necessary in the Project since average minimum temperature is around 20 degree Celsius and major earthquake has not occurred in this area in the past hundreds of years.

In the project, thus, an anemometer, a thermometer, a rain gage and a visibility meter will be provided for collecting necessary weather information. In addition to those sensors, the rainfall detector will be also provided to detect the coming in rainfall and to give alerting information to the drives, because the road surface is getting much slippery at the time of starting of rainfall.

(3) Traffic Control Criteria for Disaster Management

The meteorological monitoring system is to measure weather conditions on or near the expressway. A driving environment on the expressway is judged by the data from the MET observation station. If hazardous weather condition is detected by the system, warning message will be issued to road users through the information dissemination system. In case weather condition is too dangerous for driving, the road operators must take appropriate countermeasures such as maximum speed limit

reduction and/or road closure.

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

Table 4-12 Traffic Control Criteria for Disaster Management

Cause of Disaster	Operation by Expressway Operator		
	Special Patrol	Alert Operation	Emergency Operation
		Speed Control Lower the regulatory speed (ex. to 50km/h)	Roadway Closure
Earthquake	Subject to Earthquake Inspection Manual	Over 50 gal	Over 80 gal, or Actual damage confirmed
Heavy Rain	Accumulated Rain between 100mm and 150mm	Accumulated Rain > 150mm, or Hourly Rain > 30mm	Accumulated Rain > 300mm, or Hourly Rain > 50mm after Accumulated Rain reaches 220mm
Strong Wind	—	Storm Warning Issued	Maximum Wind Speed > 25m/s
Tsunami	—	Tsunami Warning Issued	Major Tsunami Warning Issued
Dense Fog	—	Visibility between 50m and 100m	Visibility less than 50m
Others	—	Disasters probable	Closure judged to be necessary

Source: Consultant

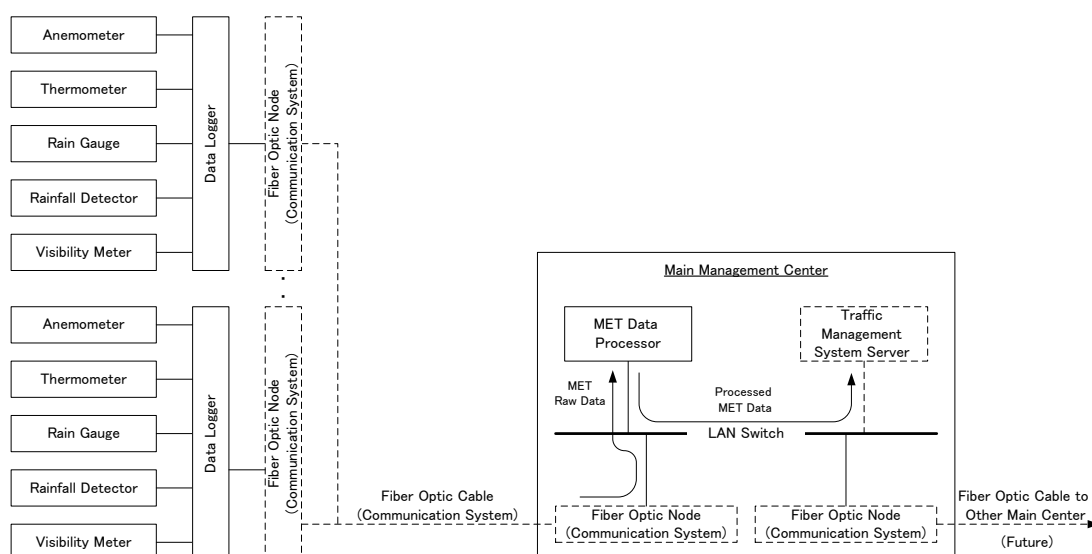
Such criteria must be set up for the DQE in advance of expressway operation and the MET system shall have functions to automatically issue weather alerting signals when the measuring and analyzed data are over the predetermined threshold levels.

(4) MET System Configuration

The MET system will consist of the following equipment;

- Meteorological monitoring sensors (anemometer, thermometer, rain gage, rainfall detector and visibility meter) with data logger at meteorological observation station;
- MET data processor with application software in Main Management Center;
- Power supply unit and peripheral.

The proposed meteorological monitoring system would be configured as **Figure 4-9** below.



Source: Consultant

Figure 4-9 MET System Configuration

4.2.7 Overload Monitoring System

Passing heavy vehicles causes damage to the structure and pavement, the vehicle with illegal weight are not allowed to use public road as regulated by Circular 07/2010/TT-BGTVT and other relevant Vietnamese circulars and decisions. The overload monitoring system shall be introduced in the Project to measure the axle load of vehicle intending to enter the expressway in order to control the vehicles and protect the expressway.



Overload Monitoring System

(1) Overload Monitoring System Arrangement

There are three (3) alternatives for overload monitoring sensor arrangement as follows;

- At entrance toll plaza (tollgate lane)
- At on-ramp
- At exit toll plaza

Table below shows the comparison of each alternative.

Table 4-13 Comparison on Overload Monitoring Sensor Arrangement

Item \ Alternative	Alternative 1 Entrance Toll Plaza	Alternative 2 On-Ramp	Alternative 3 Exit Toll Plaza
Installation of Axle Load Scale	Possible	Possible	Possible
Accuracy of Measurement (Tire Passing Track)	Capable	Difficult	Capable
Control/Stop of Overloaded Vehicles	Easy	Difficult	Easy
Prevent Overloaded Vehicles from Entering	Possible	Difficult	Impossible
Evaluation	Recommended	N/A	N/A

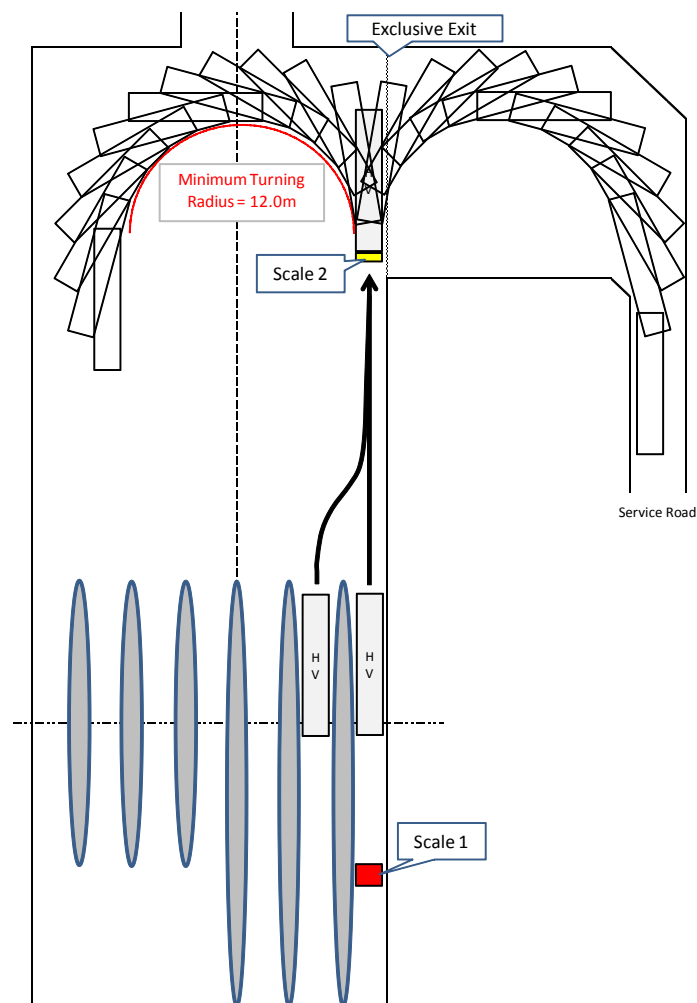
Source: Consultant

As shown in table above, in order to prevent overloaded vehicles from entering the expressway, overload monitoring sensor arrangement at the entrance toll plaza is strongly recommended.

(2) Proposed Enforcement Procedure and Basic Layout of Toll Plaza

Overloaded heavy vehicles are not allowed to enter the expressway and have to be excluded to outside. There are 2 operations for exclusion; one is u-turn, the other is provision of exclusive exit. Both operations have conditions for the layout of interchange or toll barrier.

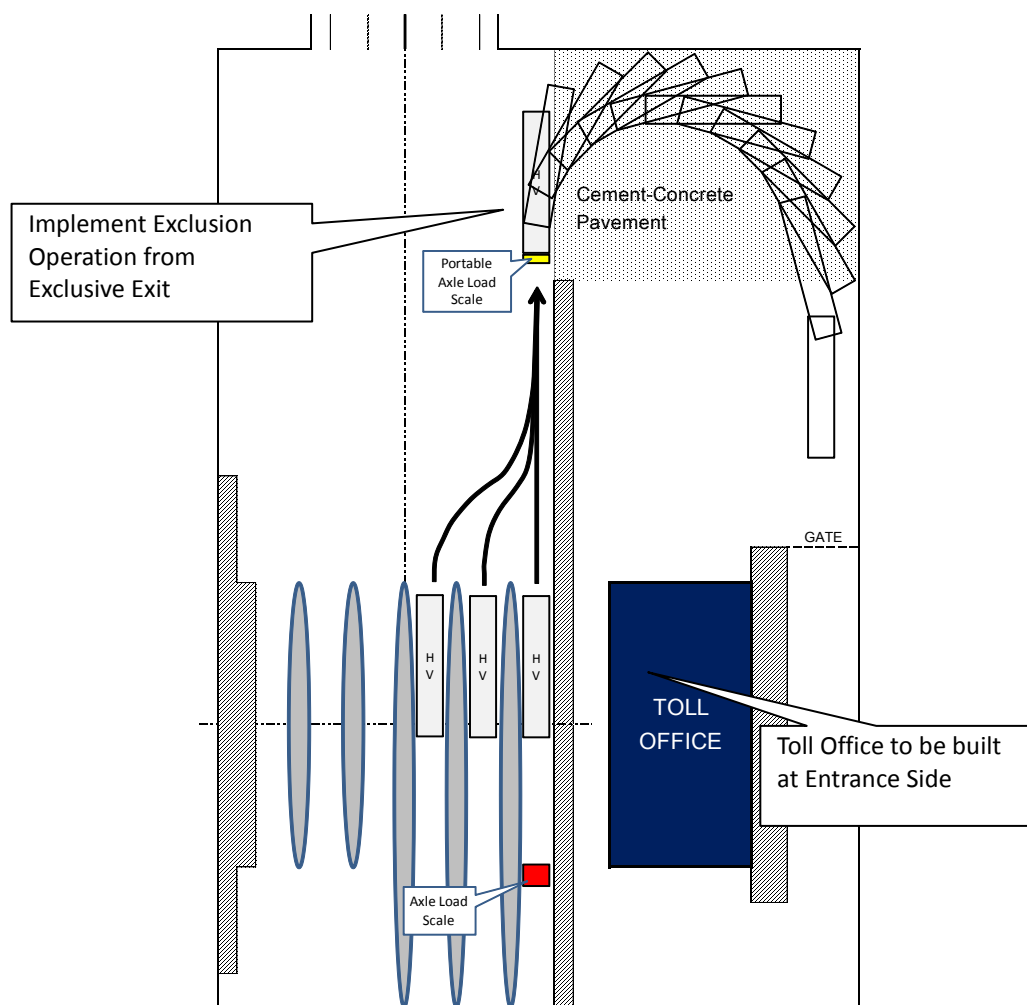
Left half of **Figure 4-10** below shows the u-turn operation. Heavy vehicle is first checked by scale 1 at the entrance lane, and taken to the right shoulder to be checked again. After being judged as overloading, it has to be excluded by u-turning in the toll plaza.



Source: Consultant

Figure 4-10 Exclusion Methods of Overloaded Vehicle

Right half of **Figure 4-10** is the exclusive exit operation. If there is a service road on the right side, excluding from the exclusive exit is possible and more preferable because it does not interrupt the other passing traffic. Thus, the Consultant strongly recommends that exclusive exit and service road should be constructed with utilization of the land space for toll office effectively to complete the purpose of overload monitoring system. In line with this policy, toll office shall be built at the entrance side of each interchange or toll plaza. Figure below shows the proposed toll plaza layout for overload monitoring operation.



Source: Consultant

Figure 4-11 Proposed Toll Plaza Layout

In order to strictly manage the overloaded vehicles and avoid negative impact against the traffic flow, two (2) step measurements system is proposed as follows;

- First, heavy vehicle is checked by Weigh-In-Motion (WIM) type axle load scale installed at entrance side of the tollgate; and
- Secondly, checking is implemented at the right shoulder of toll plaza by weigh station or bridge. To minimize the implementation cost for overload monitoring system, utilization of portable axle load scale instead of static weigh station or bridge is recommended.

(3) Location of Weigh-In-Motion

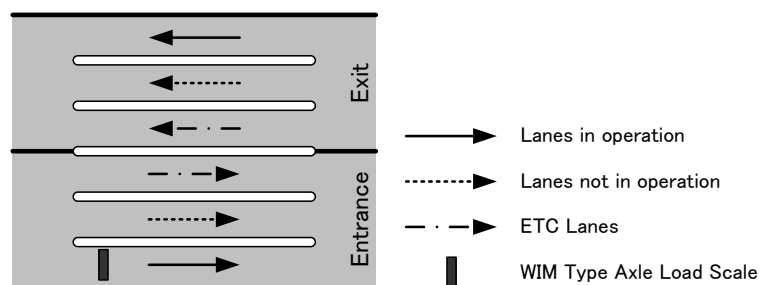
The WIM type axle load scale will be installed at each tollgate of the DQE to management and control the overloaded vehicles. Table below shows the number of entrance tollgate lanes in each toll barrier and interchange of the DQE.

Table 4-14 Number of Entrance Tollgate Lanes in Each TB and IC

Sort \ TB, IC	Tuy Loan TB	My Son IC	Ha Lam IC	Tam Ky IC	Chu Lai IC	Dung Quat IC	Quan Ngai N IC	Quan Ngai TB
Number of Entrance Lanes to be Constructed	3	3	3	3	3	3	3	3
Number of Entrance Lanes to be in Operation	3	1	1	1	1	1	1	2

Source: Consultant

WIM installation at entrance lanes to be in operation is recommended to reduce the initial costs. Typical WIM arrangement at tollgate is shown in figure below.



Source: Consultant

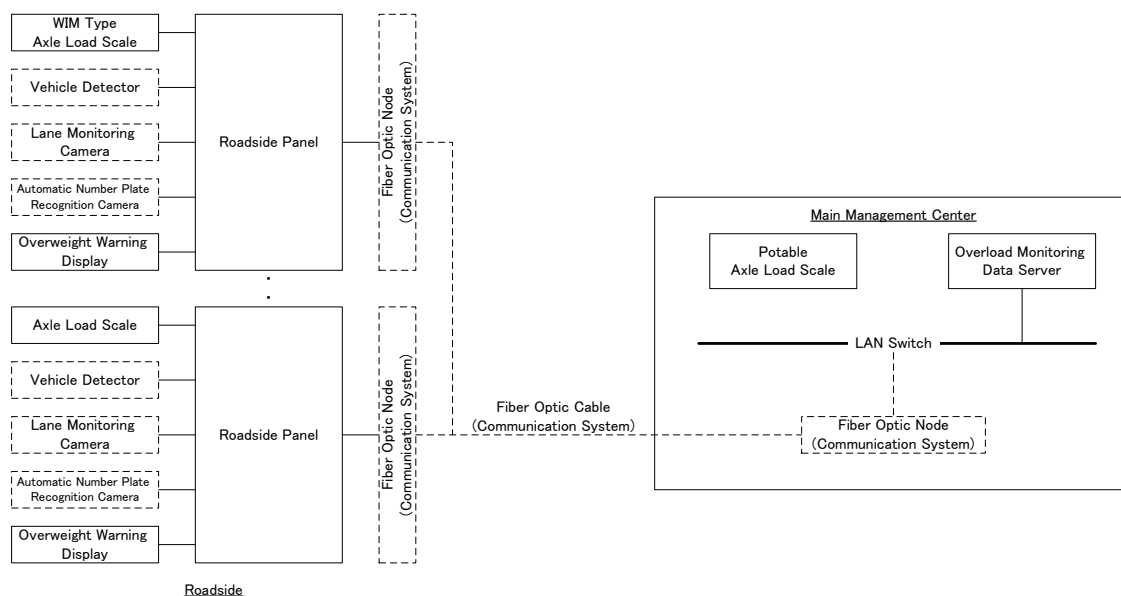
Figure 4-12 Typical WIM Arrangement

(4) Overload Monitoring System Configuration

The overload monitoring system will consist of the following equipment;

- WIM type axle load scale;
- Vehicle detector (provided by toll collection system);
- Lane monitoring camera (provided by toll collection system);
- Automatic number plate recognition (ANPR) camera (provided by toll collection system);
- Overweight warning display;
- Roadside panel;
- Portable axle load scale;
- Overload monitoring data server with application software in Main Management Center;
- Power supply unit and peripheral.

The proposed overload monitoring system would be configured as **Figure 4-13** below.



Source: Consultant

Figure 4-13 Overload Monitoring System Configuration

4.2.8 Variable Message Signboard (VMS) System

The Variable Message Signboard (VMS) system is to provide the information of traffic status, incident, and weather conditions on the road to the driver on real time basis. The VMS is one of most effective measures for information provision since the information can be provided to every road user even when the vehicle and driver have no other devices to collect the information. The VMS system will be introduced in the Project with following objectives;

- To provide road users with information of traffic status, incident, and weather conditions on the expressway;
- To provide option of alternative route selection such as NH-1 to driver in the case of congestion and incidents on the expressway;
- To disseminate necessary information regarding traffic status, incident, and weather conditions to every road users equally without any special user's devices; and
- To control the VMS at the Main Management Center, where all information related to traffic, incident and weather conditions are collected, to provide the information with timely manner.



Variable Message Signboard (for egress)



Graphic Information Signboard

(1) Type and Location of VMS

The variable message signboard is categorized into following types of VMS depending on their objectives and locations.

Table 4-15 Type of Variable Message Sign

Type of VMS	Objectives	Necessity in the Project
VMS for Ingress	<ul style="list-style-type: none"> To inform the road, traffic and weather conditions to drivers who intend to use the expressway in advance and allow them to determine whether use expressway 	Yes
VMS for Egress	<ul style="list-style-type: none"> To promptly inform road closure to drivers who are on expressway, when it is closed due to an accident or other reasons and have them exit from the interchange To inform drivers of the road conditions on expressway ahead of them and advise them to drive carefully 	Yes
Toll Gate & Toll Barrier VMS	<ul style="list-style-type: none"> To inform drivers of the road conditions on expressway ahead of them 	Yes (Only TB)
Travel Time VMS	<ul style="list-style-type: none"> To inform travel time from VMS to major destinations 	No (Future)
Tunnel VMS	<ul style="list-style-type: none"> To inform conditions inside tunnel 	Yes
Graphic Information VMS	<ul style="list-style-type: none"> To inform congestion on expressway to make drivers select most suitable route 	No

Source: Consultant

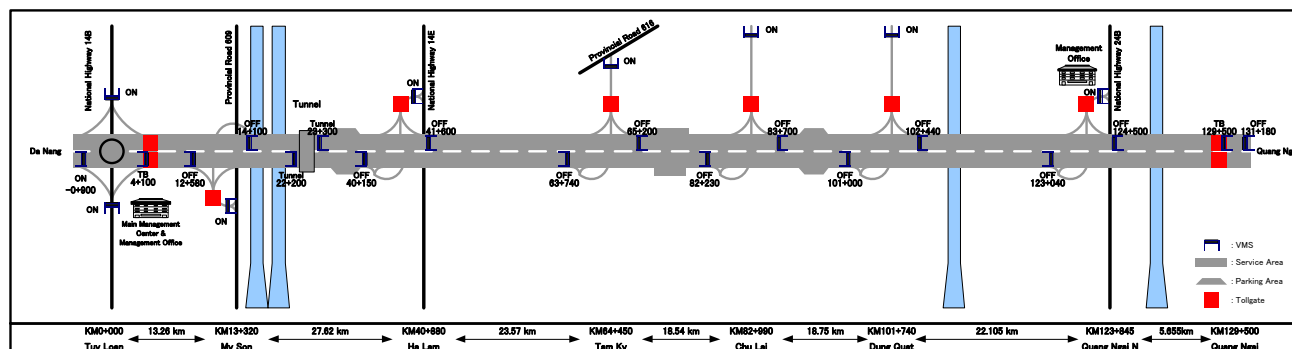
In consideration of level of user services, VMS for ingress installed at each access road before tollgate, VMS for egress located on expressway before each off-ramp, toll barrier VMS and tunnel VMS will be introduced at the initial stage with the objectives mentioned in table above. The travel time VMS will be introduced in next phase to provide high level of service to road users after the implementation of system to measure and calculate the travel time on the expressway. The graphic information VMS will not be introduced for the DQE because no diverging expressway will be connected to the expressway.

Proposed location plan of VMS in initial stage is shown in **Table 4-16** and **Figure 4-14** below. Total of 32 VMSs will be procured in the Project.

Table 4-16 Location of VMS

No.	Location	Bound	Remarks	No.	Location	Bound	Remarks
1	DQE KM-0+900	Southbound	Tuy Loan IC (ingress VMS)	14	Tam Ky IC access road	-	Tam Ky IC (ingress VMS)
2	NH14B	From east side	Tuy Loan IC (ingress VMS)	15	DQE KM65+200	Northbound	Tam Ky IC (egress VMS)
3	NH14B	From west side	Tuy Loan IC (ingress VMS)	16	DQE KM82+230	Southbound	Chu Lai IC (egress VMS)
4	DQE KM4+100	Southbound	Tuy Loan TB (TB VMS)	17	Chu Lai IC access road	-	Chu Lai IC (Ingress VMS)
5	DQE KM12+580	Southbound	My Son IC (egress VMS)	18	DQE KM83+700	Northbound	Chu Lai IC (egress VMS)
6	My Son IC access road	-	My Son IC (ingress VMS)	19	DQE KM101+000	Southbound	Dung Quat IC (egress VMS)
7	DQE KM14+100	Northbound	My Son IC (egress VMS)	20	Dung Quat IC access road	-	Dung Quat IC (Ingress VMS)
8	DQE KM22+200	Southbound	Tunnel	21	DQE KM102+440	Northbound	Dung Quat IC (egress VMS)
9	DQE KM23+300	Northbound	Tunnel	22	DQE KM123+040	Southbound	Quang Ngai N IC (egress VMS)
10	DQE KM40+150	Southbound	Ha Lam IC (egress VMS)	23	Quang Ngai N IC access road	-	Quang Ngai N IC (Ingress VMS)
11	Ha Lam IC access road	-	Ha Lam IC (ingress VMS)	24	DQE KM124+500	Northbound	Quang Ngai N IC (egress VMS)
12	DQE KM41+600	Northbound	Ha Lam IC (egress VMS)	25	DQE KM129+500	Northbound	Quang Ngai TB (TB VMS)
13	DQE KM63+740	Southbound	Tam Ky IC (egress VMS)	26	DQE KM131+180	Northbound	Quang Ngai IS (egress VMS)

Source: Consultant



Source: Consultant

Figure 4-14 Location Map for VMS System

(2) Message Indication

The variable message signboard shall indicate the following information obtained from other system components automatically or verbally from patrol crew, road users or 113/114/115 call center through wireless radio system, telephone line, etc. on real time basis.

- Location
- Incident (Cause)
- Event (Traffic regulation or action to be taken by road user)

Table below shows the list of expected messages to be shown on the signboard.

Table 4-17 List of Contents Displayed on VMS

Location		Cause	Event
Section (IC1)	Section (IC2)		
TUY LOAN	to TUY LOAN	ACCIDENT	CLOSED
TUY LOAN TB	to TUY LOAN TB	FIRE	EXIT CLOSED
MY SON	to MY SON	BROKEN VEHICLE	SPEED REGULATION
HA LAM	to HA LAM	ROAD OBSTACLE	LEFT LANE CLOSED
TAM KY	to TAM KY	FLOOD	RIGHT LANE CLOSED
CHU LAI	to CHU LAI	DISASTER	SHOULDER CLOSED
DUNG QUAT	to DUNG QUAT	HEAVY RAIN	CONGESTED
BINH SON	to BINH SON	STRONG WIND	CONGESTED 10KM
QUANG NGAI N	to QUANG NGAI N	DENSE FOG	CONGESTED 5KM
QUANG NGAI TB	to QUANG NGAI TB	O&M WORK	BE CAREFUL
QUANG NGAI	to QUANG NGAI	ANIMAL INVASION	DO NOT ENTER
NH1	EXIT		
TUNNEL INSIDE			
TUNNEL EXIT			
AHEAD OF TUNNEL			
____KM AHEAD			
FROM HERE			

Source: Consultant

Considering the necessary information to be shown on the signboard, the display panel shall indicate three (3) lines, i.e. “location”, “incident” and “event”, and each line shall be capable of displaying 24 characters or more. VMS must display two (2) languages, that is, English and Vietnamese.

Apart from text-based message indication, VMS shall have capability of symbol mark indication or combined indication of characters and symbol marks to allow drivers easy understanding and quick response to messages. The figure below shows the sample of symbol mark.





Source: Consultant

Figure 4-15 Sample of Symbol Mark

All collected information, especially emergency incidents, is provided to expressway users. However, since all information cannot be provided at once, some processing rules such as prioritization of events and incidents are necessary. Table below describes the proposed priority of events and causes.

Table 4-18 Priority of Cause and Event

		Cause	High ←			Cause					→ Low	
			Disaster or Flood	Traffic Accident	Fire	Broken Vehicle	Road Obstacle	Animal Invasion	O&M Work	Concentration	Dense Fog	Strong Wind
Event												
High ←	Road Closure	1	2	3	-	-	4	5	-	6	7	8
	Exit Closed	1	2	3	4	5	-	6	-	-	-	-
	Be Careful (Incident)	1	2	3	4	5	6	-	-	-	-	-
Event	Congestion 10km	-	1	2	-	-	-	3	4	-	-	-
	Congestion 5km	-	1	2	-	-	-	3	4	-	-	-
	Congestion	-	1	2	-	-	-	3	4	-	-	-
	Lane Control	1	2	3	-	-	-	4	-	-	-	-
→ Low	Speed Regulation	1	2	3	-	-	-	4	-	5	6	7
	Be Careful (O&M Work)	-	-	-	-	-	-	1	-	-	-	-
	Be Careful (Weather)	-	-	-	-	-	-	-	-	1	2	3

Source: Consultant

When several incidents or events occur at the same time, at the same location, the most influential event has to be informed to drivers. The order is based on the principle in consideration of

avoiding any secondary accidents.

Incidents or events often occur at different locations, and even if some incidents happen at sections ahead and back simultaneously, information enabled to be provided on VMS is limited. Therefore, the priority order has to be considered. **Table 4-19** expresses the proposed priority order of subsequence events to be displayed on VMS on the expressway. The base of the order is to prevent drivers from being involved in more serious incidents.

Table 4-19 Priority Event Order on VMS

Event location Event	Next Section	2section Ahead	3section Ahead	4section Ahead	5section Ahead	6section or More
Road Closure	1	8	10	12	14	16
Exit Closed	2	9	11	13	15	17
Be Careful (Incident)	3	-	-	-	-	-
Congestion 10km	4	18	20	22	24	26
Congestion 5km	5	19	21	23	25	27
Congestion	6	28				
Lane Control	7	-	-	-	-	-
Speed Regulation	29	-	-	-	-	-
Be Careful (O&M Work)	30	-	-	-	-	-
Be Careful (Weather)	31	-	-	-	-	-

Source: Consultant

(3) Size of Character

The required size of character to be shown on the VMS shall be decided to meet the requirements specified in Vietnamese Standard for traffic sign on highway “22-TCN-331-05”. According to the standard, the action for recognition and understanding of traffic sign must be able to start 10 seconds before the sign. The correlation between deciphering distance of signboard and letter height are defined as table below;

Table 4-20 Correlation between Required Deciphering Distance and Letter Height

Deciphering distance	250m	325m	400m
Letter Height	200mm	300mm	400mm

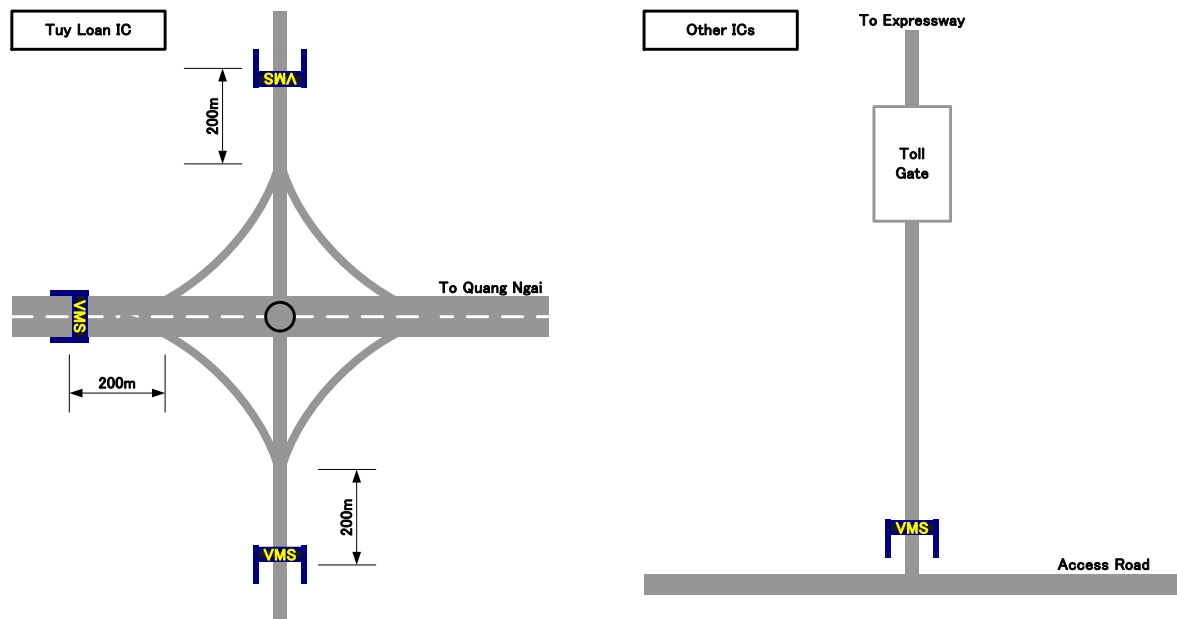
Source: 22-TCN-331-05

When driving at 120km/h, which is design speed of the DQE, deciphering distance of sign board in 10 seconds is estimated as 333m. Thus, the letter height needs more than 400mm. Considering the indication of Vietnamese circumflex representation, the letter height with 450mm is recommended for VMS.

(4) Arrangement of VMS

1) VMS for Ingress

VMS for the ingress of expressway will be arranged at the intersection or junction of access road. As for Tuy Loan IC, as there are 3 directions to enter the expressway from access road, and the junction is relatively large, three (3) VMS will be installed on each direction and should be approximately 200m upstream of the diverging point. As to other ICs, as the intersection is small, one (1) VMS for each will be installed at the beginning of the approach ramp. **Figure 4-16** shows arrangement of VMS for ingress.

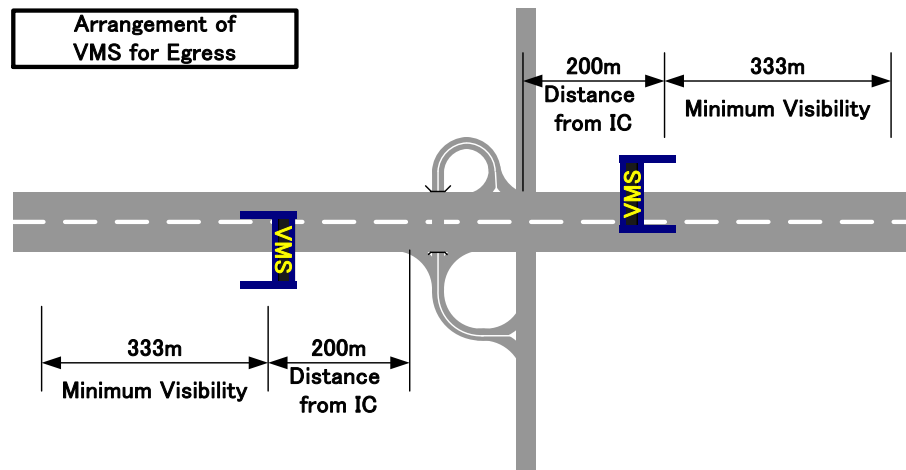


Source: Consultant

Figure 4-16 Arrangement of VMS for Ingress

2) VMS for Egress

The arrangement of VMS for egress on expressway and distance from the interchange must be considered sufficient for road users to read and understand information on the signboard and to safely change lane. Thus, the VMS will be located approximately 200m – 300m upstream of diverging-starting point of interchange. Also, minimum visibility to the direction showing message to the driver must be kept for 333m as specified by the Vietnamese Standard.



Source: Consultant

Figure 4-17 Arrangement of VMS for Egress

3) Tunnel VMS

The tunnel VMS displays mainly emergency information when some incident occurs inside or ahead of the tunnel. Thus, the VMS will be located approximately 200m – 300m upstream of tunnel entrance to keep enough distance to let vehicle stop in case of tunnel accident.

4) Toll Barrier VMS

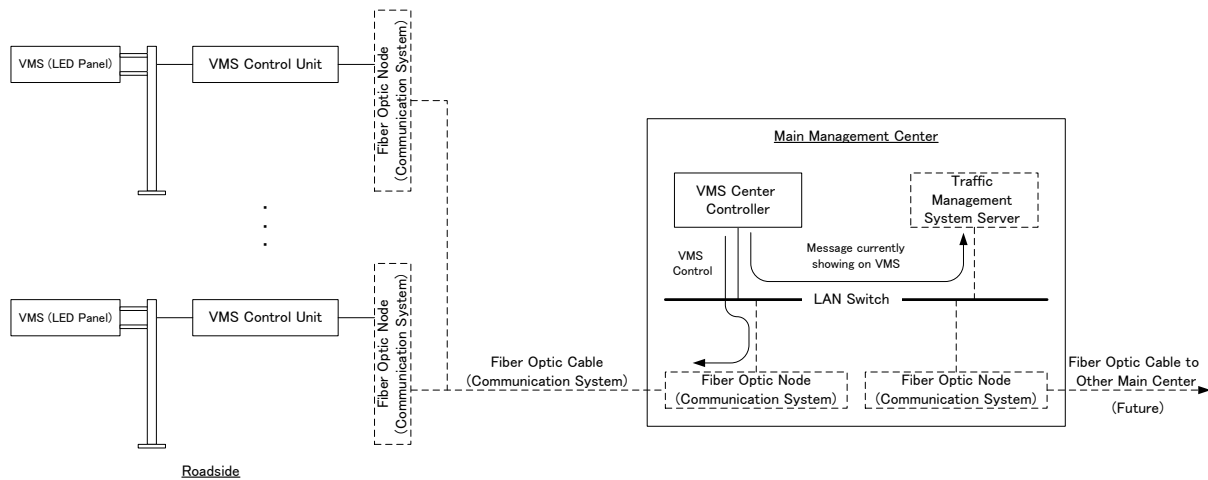
Toll barrier VMS will be arranged closely to the roof of toll barrier.

(5) VMS System Configuration

The VMS system will consist of the following equipment:

- LED panel and control unit in VMS with supporting structure (gantry type or F-shaped cantilever type) at roadside;
- VMS center controller with application software installed in Main Management Center;
- Power supply equipment and peripheral.

The proposed VMS system would be configured as **Figure 4-18** below.



Source: Consultant

Figure 4-18 VMS System Configuration

4.2.9 Traffic Management Center System

The proposed traffic management system in the Project consists of many system components. The traffic management center system manages the total system, encourages data exchange between the system components in order to realize fully their functions and achieve the overall objectives of the traffic management system as follows;

- To manage and integrate all information related to road and traffic conditions, incidents, weather conditions and any other necessary data for expressway operation;
- To process, store and record the necessary data for effective expressway operation and maintenance;
- To display and share the above collected and processed information on real time basis, and share the information among operators in Main Management Center, Management Offices or other places;
- To disseminate the information converted appropriate data to the road users in order to take notice of road conditions on the expressway; and
- To totally manage the traffic management system operation in the Main Management Center.



Traffic Management Center System

(1) Traffic Management Center System Configuration

The traffic management center system consists of traffic management system server, facility management server, large display panel, etc. installed in the traffic management room of Main Management Center.

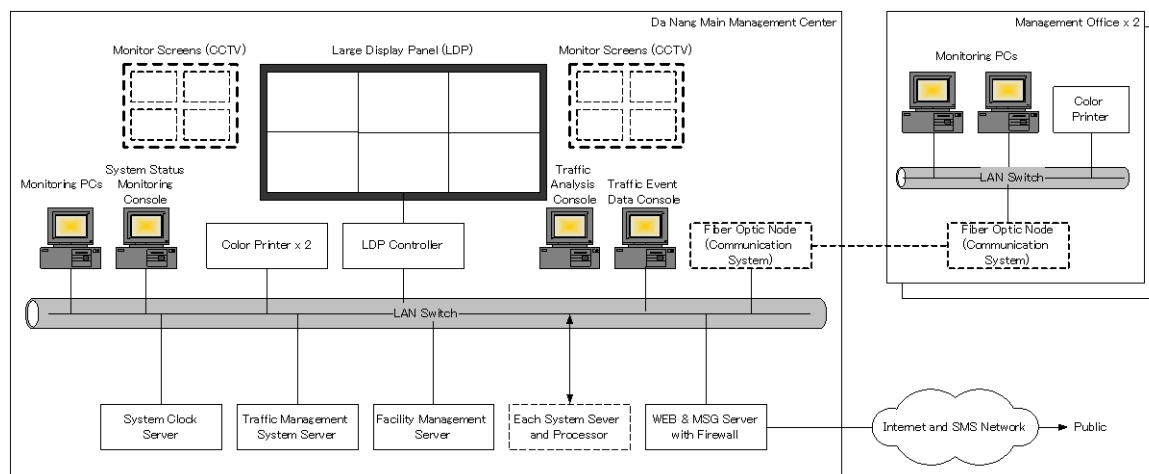
The traffic management system server is central equipment of the traffic management system and to collect, process, store, record and display the information related to road and traffic conditions, incidents and expressway operation. The facility management server is to monitor the operational status of the each system facility.

The large display panel (LDP) and LDP controller are used for a purpose of sharing the traffic information among the personnel in the traffic management room. The LDP shows the information on the current traffic condition, facility operation status and any other information on the image of expressway map on the screen. Proposed system components and configuration of traffic management center system are shown in **Table 4-21** and **Figure 4-19** respectively.

Table 4-21 List of Traffic Management Center System Components

No.	System Component	Quantity	Remarks
Hardware			
1	Traffic Management System Server	1	
2	Facility Management Server	1	
3	Large Display Panel (LDP) with Controller	1	LCD 55 inch display x 6
4	Traffic Event Data Console	1	
5	Traffic Analysis Console	1	Offline console for traffic analysis
6	System Status Monitoring Console	1	
7	WEB & MSG Server	1	
8	System Clock Server	1	
9	Monitoring PC	6	MMC and MOs
10	Printers	4	MMC and MOs
11	Network Equipment	1	LAN Switch, Firewall, etc.
Software: all software shall include operating software (OS)			
1	Traffic Management System Software	1	
2	Facility Management System Software	1	
3	LDP Control Software	1	
4	WEB & MSG generating application	1	
5	System clock software	1	
6	NVR application	1	CCTV system
7	CCTV control application software	1	CCTV system
8	Traffic analysis processing application	1	Vehicle detector system
9	MET data processing application	1	MET system
10	Overload monitoring data processing app.	1	Overload monitoring system
11	VMS control application software	1	VMS system
12	Network management software	1	Communication system

Source: Consultant



Source: Consultant

Figure 4-19 Traffic Management Center System Configuration

(2) Basic Functions of Traffic Management Center System

1) Traffic Management System Server

The traffic monitoring system server is central equipment of the traffic management system and shall have the following main functions.

[Data Collection]

The traffic management system server shall collect road and traffic conditions, incidents, weather condition and any other necessary data from the respective system components as listed below.

Table 4-22 Data Collecting Function

Data Subsystem	Types of Data	Interval	Remarks
CCTV System	CCTV video image	On real-time	Still image
	Equipment failure		
Vehicle Detector System	Traffic volume	1 minutes	every 1 minute data
	Large-sized vehicle traffic		every 1 minute data
	Time occupancy rate		every 1 minute data
	Vehicle average speed		every 1 minute data
	Equipment failure		
MET System	Instantaneous value of ambient temperature	1 minute	every 1 minute data
	Hourly cumulative value of rainfall in past 1 hour		
	Cumulative value of rainfall from start of rainfall		
	Instantaneous rainfall detection		every 1 minute data
	Maximum and minimum value of wind speed		every 1 minute data
	Wind direction at the max. and min. velocity		every 1 minute data
	Maximum and minimum value of visibility		every 1 minute data
	Equipment failure		
Overload Monitoring System	Axle and vehicle weight of vehicle	5 minutes	
	Plate number of overloaded vehicle		
	Video image of overloaded vehicle		Still image
	Equipment failure		
VMS System	Operation status	On real-time	
	Equipment failure		

Source: Consultant

[Event Data Management]

This function is to manage the information of all incidents and events related to expressway operation as listed below.

- Traffic congestion or incident near off-ramp (vehicle detector system)
- Abnormal weather condition (MET system)
- Audio information (Wireless radio communication system / Internal telephone system)
- Incident information input by operators themselves
- Other incident and event information

The purpose of function is to share the incident and event information with other staff engaged in the expressway and to make record of these events. The event information can be input, updated or deleted by the operators through traffic event data console.

Table below shows the proposed event data items to be managed in the traffic management center system.

Table 4-23 Proposed Event Data Management Items

Event \ Data	Types of Data	Source	Remarks
Incident	Traffic Accident	Call Centre / System	Manual
	Broken-down Vehicle	Call Centre / System	Manual
	Left Obstacle	Call Centre / System	Manual
	Natural Disaster	Call Centre / System	Manual
Traffic Congestion	Heavy Congestion	System	Automatic
	Congestion	System	Automatic
Adverse Weather	Heavy Rain	System	Automatic
	Strong Wind	System	Automatic
	Dense Fog	System	Automatic
	Water Logging	System	Automatic
Construction Work	Construction Work	Road Operator	Manual
Traffic Regulation	Closure	Road Operator / Traffic Police	Manual
	Lane Closure	Road Operator / Traffic Police	Manual
	Max. Speed reduction	Road Operator / Traffic Police	Manual

Source: Consultant

[Database Management]

The server must handle an enough amount of information such as the data listed below.

- Traffic data (traffic volume, vehicle average speed, time occupancy rate, large-sized vehicle traffic)
- Weather data (air temperature, instantaneous wind velocity and direction, average wind velocity and direction, rainfall gauge, visibility)
- Overload monitoring data
- VMS display message
- Statistic data (daily, monthly, annual data)
- Incident and event information input by operators themselves
- Other data

The server shall have function to process, store and record these data efficiently and uniformity. The period of data storing shall not be shorter than two (2) years for statistical data usage.

[Display Function]

The display function is to display current or past record of traffic information, individual system window, etc. on the large display panel, operator consoles and monitoring PCs. The server must generate following display screens as minimum.

Item	Contents
Route map	<ul style="list-style-type: none"> • Schematic road map of DQE with name of IC, TB • Location of roadside equipment • Major road and traffic conditions (traffic volume, MET data, event)
List of road side equipment and status in each system	<ul style="list-style-type: none"> • List of roadside equipment in each system component • Value of measuring data or VMS message in each location
Equipment operational status	<ul style="list-style-type: none"> • Operational status of equipment through facility management server
Other screens necessary for traffic management operation	-

[Information Sharing Function]

In order to recognize the information among all staffs engaged in the expressway O&M activity, information sharing function shall be equipped on the server. All data shall be converted Web data or equivalent so that the information shall be monitored by the large display panel, operator console or the monitoring PCs.

[Reporting Function]

The server shall have a reporting function in which various daily, monthly and annual reports can be prepared with color laser printer. The report will be produced in two modes. In automatic mode, reports will be printed automatically at the timing specified for each report. In manual mode, report is printed when the operator requests it. All reports will be in Vietnamese.

Database management software and highly reliable external storage device shall be introduced for the traffic management system server.

2) Facility Management Server

The facility management server shall be provided to monitor the operational condition of facilities on the expressway. The server shall monitor the operation status of following system components;

- CCTV System
- Vehicle Detector System
- Meteorological Monitoring System
- Overload Monitoring System
- Variable Message Sign System
- Traffic Management Center System
- Digital Transmission System
- Wireless Radio System
- Internal Telephone System
- Tunnel Safety Facility System
- Power Supply System

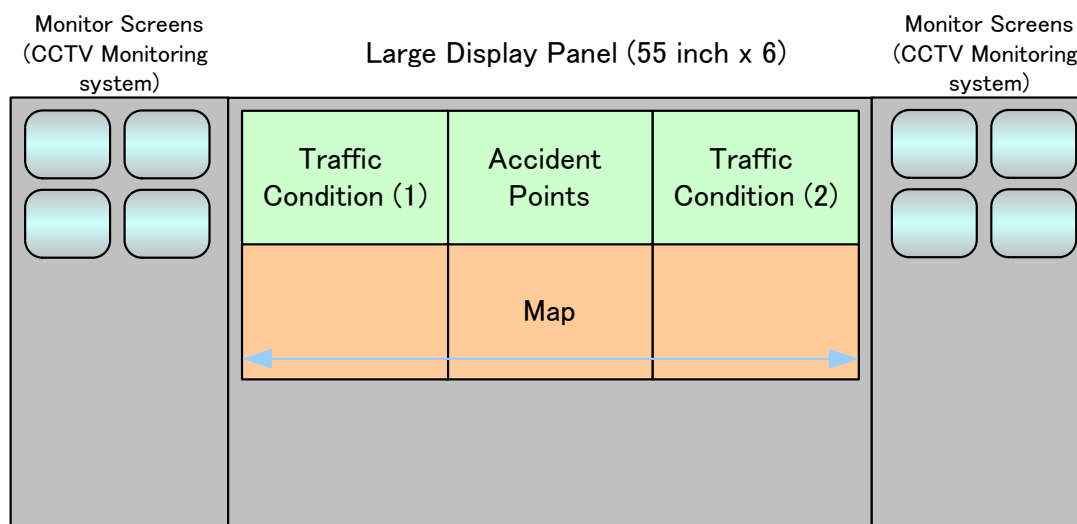
The role of the server is to consolidate the system operation status monitoring function undertaken by each system component, present the status to operators and record the system operation. In case any abnormality or malfunction is detected, the server shall issue an alarm together with information regarding type and location of the failure so that remedial action can be taken smoothly.

3) Large Display Panel and LDP Controller

The Large Display Panel (LDP) and LDP controller are used for a purpose of sharing the traffic information among the personnel in the Main Management Center. The equipment shows the information on the current road and traffic conditions, weather conditions, incidents, facility operation status and any other information on the image of expressway map on the screen or in the manner of equipment list.

The LDP shall be multi screen type and large enough to cover the entire expressway. The display shall be comprised of six (6) multi screens or more. The size of one screen shall be 55 inch or more. Liquid crystal display (LCD) shall be used for the multi screen display in consideration of its image quality, lifecycle time, cost merit, versatility.

The LDP controller shall have functions to control display on the LDP by obtaining the data from traffic management system server, facility management server or other system component server. The LDP controller shall be PC type. Figure below shows the reference layout image of the display panel.



Source: Consultant

Figure 4-20 Layout Image of Large Display Panel

4) Operator Consoles

The operator consoles will allow operators to handle the traffic information, input event data into the system or monitor each system operational status individually at the traffic management room in Main Management Center. Following types of operator console will be provided in the Project;

- Traffic Event Data Console;
- Traffic Analysis Console;
- System Status Monitoring Console;
- CCTV Center Controller Console (CCTV system); and
- VMS Center Controller Console (VMS system).

Each of operator consoles shall display various kinds of information in text and graphic. The operator consoles shall consist of personal computer with 24 inch LCD monitor.

5) WEB & MSG Server

The road and traffic conditions, weather condition and incident information collected and processed in the traffic management center system will be provided to the public through internet, e-mail or SMS in the Project.

Information dissemination system through Internet and e-mail/SMS shall consist of Web & MSG server, firewall and application software. The basic information to be provided to the road users through those media shall include but not limited to the following:

[Internet]

- Traffic information on map
- Weather conditions on map
- Event and incident information on map
- Traffic regulation on map
- Overall schematic map indicating all information above

[e-mail/SMS]

- Weather conditions in text
- Event and incident in text
- Traffic regulation in text

The system shall have subscriber management function to register and deregister the e-mail and

SMS users. Firewall shall be provided to protect the server against the possible attack.

6) System Clock Server

Each system component will be equipped with a clock system for its operation. These clocks shall be synchronized to collect and process the data correctly. A system clock server will be provided to the traffic management center system as a reference clock. All clocks in the system component shall be synchronized with the clock provided by the server using network time protocol (NTP) or simple network time protocol (SNTP).

7) Monitoring PC

To confirm road and traffic information at main management center and management offices, monitoring PCs will be introduced at each office. The monitoring PC provides necessary information for expressway operation and management through the servers. Two (2) sets of monitoring PC with 24 inch LCD monitor will be provided in each office.

4.3 Toll Collection System

4.3.1 Basic Toll Collection System Planning Policies

Generally, the toll collection system for a toll road can have a variety of configurations depending upon;

- Toll rate principles such as the flat rate, sectional flat rate and traveled-distance dependent rate;
- Physical feature of the expressway whether it constitutes a network, or a singular expressway with a single or multiple section(s);
- Number and distribution of tollgates;
- Classification of toll-charged vehicles;
- Toll charging principle, closed system or open system;
- Type and location of the expressway, whether it is urban or rural; and
- Toll collection method to be adopted whether automatically by modern electronic equipment or manually with labor-collective manpower, etc.

In Vietnam, the toll collection is basically implemented based on the national policy stipulated by the “Circular Regulation on Collection, Payment, Management and Use of Road Toll (No.90/2004/TT-BTC)”. However, the regulations and standards for toll collection on expressway are not yet stipulated at this moment. Therefore the toll collection system plan for DQE will be proposed in this design in consideration of MOF circular above, toll collection plans on other on-going projects in Vietnam and practices in ITS advanced countries such as Japan.

Thus, the policy of the toll collection for the DQE is set as follows.

Table 4-24 Policy of Toll Collection

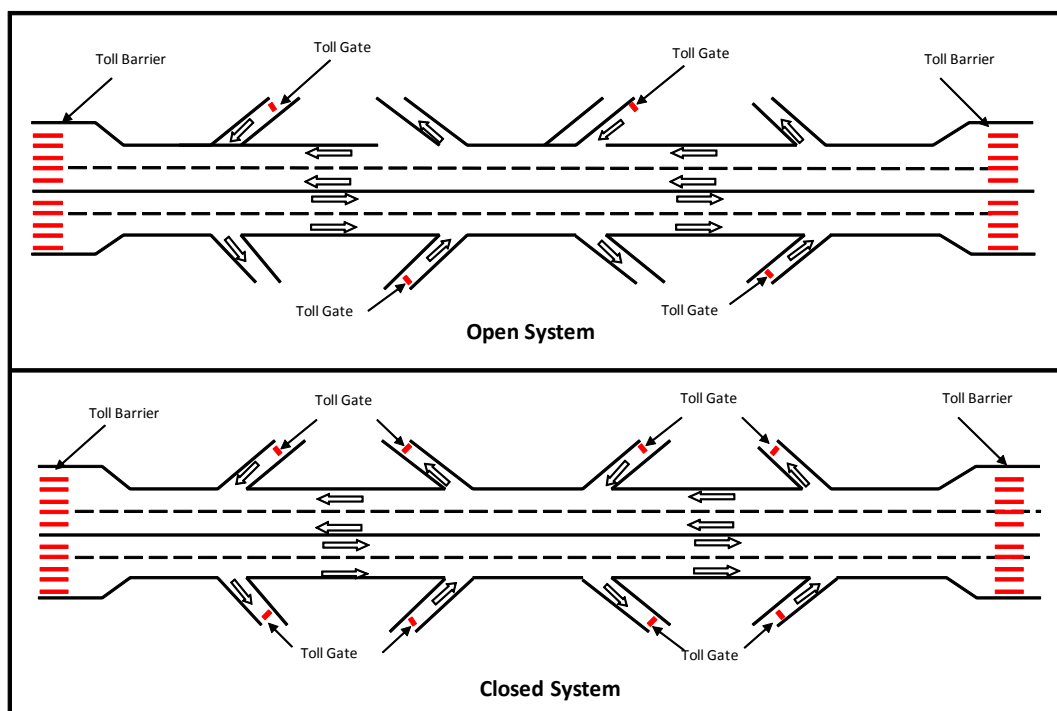
Component	Policy	Remarks
1. Toll Charging Principle	Closed system	
2. Toll Rate Principle	Distance based rate by vehicle class	
3. Vehicle Classification	5 classifications	As specified by MOF
4. Tollgate	2 toll barriers: Tuy Loan and Quang Ngai 6 interchange tollgate: My Son, Ha Lam, Tam Ky, Chu Lai, Dung Quat and Quang Ngai North	
5. Number of Toll Lanes	As shown in Table 4-27	
6. Toll Collection Method	Manual toll collection: cash and IC card based Automatic toll collection (ETC): DSRC-Active 5.8GHz	

Source: Consultant

4.3.2 Toll Charging Principle

In general, there are two (2) types of toll charging principle, open system and closed system. In open system, there is one (1) tollgate in each or represented toll section and toll is collected at the tollgate. The tollgate is constructed on mainline or entry/exit ramps in the section. Fixed tariff rate system such as flat tariff and sectional tariff system are basically applied for the open system.

In closed system, tollgate is installed at both entry and exit ramps. Typical toll collection process is that a ticket is issued at entry ramp and the toll is made payment, which depends on vehicle path, driving distance and vehicle classifications, at exit ramp together with the ticket. Distance based tariff system or any other tariff system can flexibly be adopted for the closed system. The concept of open and closed system is shown in **Figure 4-21** below.



Source: Consultant

Figure 4-21 Open/Closed System

The comparison of both charging systems is summarized as **Table 4-25** below.

Table 4-25 Comparison of Open/Closed System

	Open System	Closed System
1.Toll Arrangement	Tollgate at each toll section (on Main line or ON/OFF-Ramp)	Tollgate at both On and OFF-Ramp
2.Tariff Rate	Flat tariff or Sectional tariff	Distance based or flexible tariff rate system
3.Toll Collection	Possible to be secured toll tariff collection	Possible to be secured toll tariff collection due to fully access control
4.Number of transactions	Variable (1 to multiple) depending on distance traveled	At entrance to take ticket and at exit ramp to pay toll
5.Access control	Access control possible at each toll section (on Main line or ON/OFF-Ramp)	Strict access control possible
6.Congestion at tollgate	Congestion may occur at mainline tollgate	Congestion occurs, but limited at ramps
7.Additional interchange	Additional toll gate is required at ON or OFF-Ramp of new interchange or on mainline	Additional toll gate is required at ON and OFF-Ramp of new interchange
8.Conformity with regulations	Conformity with existing Vietnamese regulation	Not yet stipulated in Vietnamese regulation
9.Applicable road network	Suitable for single and short expressway network	Suitable for large and long expressway network

Source: Consultant

The closed system is recommended as the toll charging principle for the DQE as proposed in previous F/Ss from the following reasons;

- Various tariff rate system, especially, distance based tariff system can be adopted;
- Strict toll collection is possible;
- Traffic controls such as prevention of illegal entry is possible;
- Congestion on mainline can be avoided; and
- OD (Origin/Destination of the vehicle) data, which are valid as the data for planning of future widening or road maintenance, are available.

4.3.3 Tariff Rate System

Following toll rate principles are existed in the expressway toll collection system.

- Flat rate
- Sectional rate with fixed amount
- Sectional rate (distance base rate)
- Distance based rate

The concept of each toll rate is shown in **Figure 4-22** below.

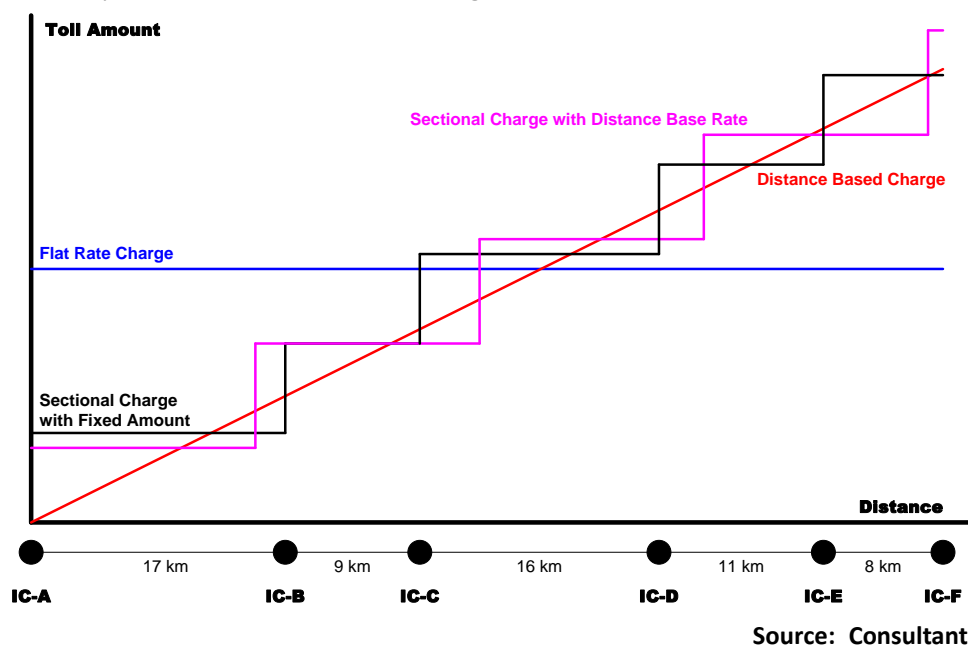


Figure 4-22 Tariff Rate System Concept

According to the circular (90/2004/TT-BTC) issued by Ministry of Finance (MOF), the flat tariff rate is only stipulated as toll rate. However, flat tariff system as well as sectional tariff rate system with fixed amount system is not suitable for the long distance expressway such as the DQE which will be one part of North – South Expressway in future and from view point of fair payment in proportion to driving distance. The ITS project of Ho Chi Minh City - Long Thanh – Dau Giay (HLD) expressway constituting North – South Expressway will also not apply flat tariff system and sectional tariff system but will apply the distance based tariff rate system.

From this reason, the distanced based tariff rate system or distance based sectional tariff system are recommended for the DQE tariff rate system.

Distance based sectional tariff system has 2 type “sectional charge with distance base rate system” and “sectional charge with fixed amount system”. In case of sectional charge with distance base rate system requires toll barriers at each sectional charge point and additional cost will be required for land acquisition. In addition, sectional charge with fixed amount system seems as same as distance based charge system, but it is not be able to deal with change of the growth of communities around the DQE such as demand of additional interchange between existing Interchanges.

Therefore, consultant recommends distance based rate tariff system for the DQE.

4.3.4 Vehicle Classification

Vehicle classification for the expressway payment shall basically follow the requirements of MOF circular. The classification of vehicle is defined in accordance with the number of seats, maximum axle loads and type of vehicle as shown in **Table 4-26** below.

Table 4-26 Vehicle Classification

Ordinal Number	The Categories of the Vehicle	Applicable for the Project
1	Two wheelers, three wheelers, mopeds and the like	
2	Lambretta, rudimentary trucks, tractors	
3	Cars of under 12 seats, trucks of a tonnage of under 2 tons and mass transit buses	O
4	Cars of between 12 and 30 seats, trucks of a tonnage of between 2 tons and under 4 tons	O
5	Cars of 31 seats or more; trucks of a tonnage of between 4 and under 10 tons	O
6	Trucks of a tonnage of between 10 and under 18 tons and 20ft-container lorries	O
7	Trucks of a tonnage of 18 tons or over and 40 ft-container lorries	O

Source: 90/2004/TT-BTC, MOF, VN

The DQE does not allow to enter the vehicles categorized as ordinal number 1 and 2 in table above such as two wheelers, mopeds and tractors. Thus, five (5) vehicle classifications will be applied to the toll collection system in the Project.

4.3.5 Toll Collection Method

The toll collection method is basically divided into three types, i.e. manual, semi-automatic and automatic, and each toll collection method is generally defined as follows;

[Manual Toll Collection]

The manual toll collection is to manually collect toll with cash and ticket or IC card by the tollgate staffs.

[Semi-Automatic Toll Collection]

In the semi-automatic toll collection, the toll payment is made by IC card or other type of ticket without cash transaction and tollgate staffs.

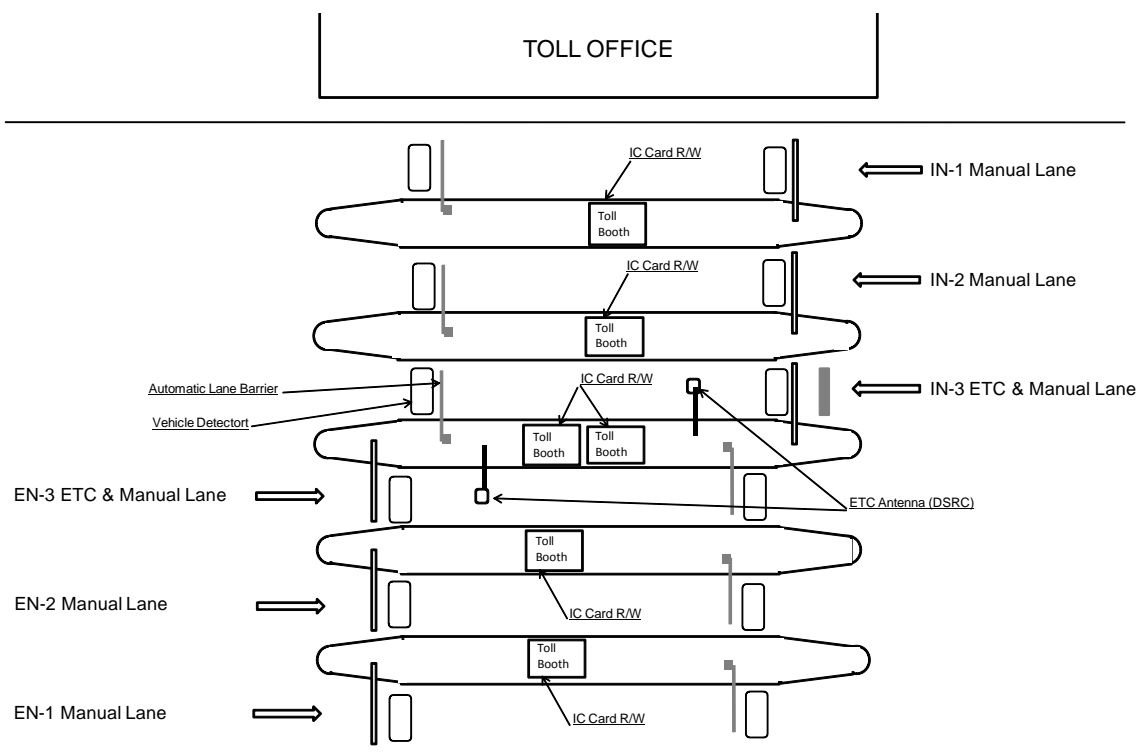
[Automatic Toll Collection (ETC)]

The automatic (electronic) toll collection (ETC) allows drivers to automatically pay toll without stopping the vehicle on the tollgate by utilizing wireless communications between On-board Unit (OBU) and road side antenna.

The toll collection system in the Project must have functions of manual toll collection system. Additionally, introduction of the automatic toll collection system in each direction is proposed to provide high level toll collection service to the drivers and cope with future growing traffic volumes.

4.3.6 Tollgate Arrangement

Both entrance and exit tollgates must be established for selected distance based tariff system. Figure below shows the typical equipment arrangement of interchange tollgate.



Source: Consultant

Figure 4-23 Typical Tollgate Arrangement

ETC lane will be provided one each for both ingress and egress tollgates and other lanes equip with manual toll collection equipment. Also, ETC lane must have manual toll collection equipment in case that ETC roadside equipment is in failure or maintenance.

ETC system is able to collect expressway toll automatically and accurately. However, traffic ratio of ETC users will be low in the initial stage. Main toll collection service will be implemented by manual at initial phase and ETC equipment is able to add other manual lanes in future. Reviewing ratio of ETC lane and manual lane will be able to deal with when the rate of ETC vehicle will be increased. In addition, if an ETC lane will be closed by something such as accident, toll collector will be able to cope with ETC users by IC card Reader/Writer.

Therefore, the consultant recommends the number of toll lane should be arranged required number of manual lanes and ETC system will be introduced minimum number (1) of lane at both manual ingress and egress lanes. And ETC lane will be installed left side of traveling direction because of the difference of passing velocity.

Table below shows required number of toll lanes which is computed by mean of dividing the traffic volume to the several toll lanes by TCVN5729-1997.

The minimum number of lanes and toll booths are three (3) because the number of lanes at toll gate should be 1.5 times more than the one on expressway. The number of toll lanes at each interchange tollgate and toll barrier has been reviewed in line with updated traffic volume data in 2025 (duration term: 10 years). One (1) ETC system will be introduced on each left side manual ingress/egress lane.

Followings are input conditions.

- Maximum toll lane capacity for entrance gate: 650 vehicles/hour
- Maximum toll lane capacity for exit gate: 350 vehicles/hour
- Maximum toll lane capacity for toll barrier: 500 units/hour
- K factor: 0.10 (based on traffic survey by the Consultant)

Table 4-27 Required Number of Toll Lanes

IC	Assumed traffic volume on Enter (ADT) (Y2025)	Assumed traffic volume on Exit (ADT) (Y2025)	Assumed traffic volume on Enter (vehicle/h) (Y2025)	Assumed traffic volume on Exit (vehicle/h) (Y2025)	Number of Toll Booth						Remarks
					Entrance		Exit		Total		
					Manual	Manual & ETC	Manual	Manual & ETC	Manual	Manual & ETC	
Tuy Loan	13,742	15,624	1,375	1,563	2	1	4	1	6	2	Toll barrier
My Son	1,245	762	125	77	2	1	2	1	4	2	IC
Ha Lam	2,619	2,285	262	229	2	1	2	1	4	2	IC
Tam Ky	3,755	4,680	376	468	2	1	2	1	4	2	IC
Chu Lai	2,112	1,654	212	166	2	1	2	1	4	2	IC
Dung Quat	2,906	1,957	291	196	2	1	2	1	4	2	IC
North Quang Ngai	5,355	4,898	536	490	2	1	2	1	4	2	IC
Quang Ngai	7,254	7,128	726	713	2	1	2	1	4	2	Toll barrier
Total					16	8	18	8	34	16	

Source: Consultant

4.3.7 Technical Requirements of Toll Collection System

(1) Manual Toll Collection System

1) System Components

Cash and contactless IC card based manual toll collection system is recommended to be introduced in the Project considering the following advantages of contact-less IC card as proposed in the NK F/S;

- For high secured data management, anti tamper and high reliability
- Applicable for long time or repeated usage in certain term (Lifecycle is 50,000 read & write or more)
- To have superior operability such as multi-purpose use, user-friendly and high processing speed
- Applicable for both manual toll collection and automatic toll collection system
- Lifecycle cost effectiveness

The manual toll collection facilities at the tollgate for the DQE will be composed of following equipment.

[Lane Equipment]

- Vehicle Detector:
used for counting vehicle number and closing the barrier automatically after vehicles pass the tollgate.
- IC Card Reader/Writer:
to collect the toll charge by using IC card, process toll transaction data and transmit it to toll office system.
- Lane Control Equipment:
including lane control panel, automatic lane barrier, traffic sign and alarm horn and lamp to let drivers stop at the toll lane for payment or prevent to enter the closed lanes.
- Inspection Equipment:
including lane camera, lane VMS and automatic number plate recognition camera (ANPR) to monitor passing vehicle, read its number plate, and provide necessary information such as toll fare and lane situation to the drivers.
- Others:
UPS, manual lane barrier and indication lamp

[Toll office]

- Toll office Equipment:
including various servers, computers, monitors, storages, etc. to acquire, monitor and store all toll transaction data from tollgate

[Others]

- Network equipment, power supply, internal telephone, others

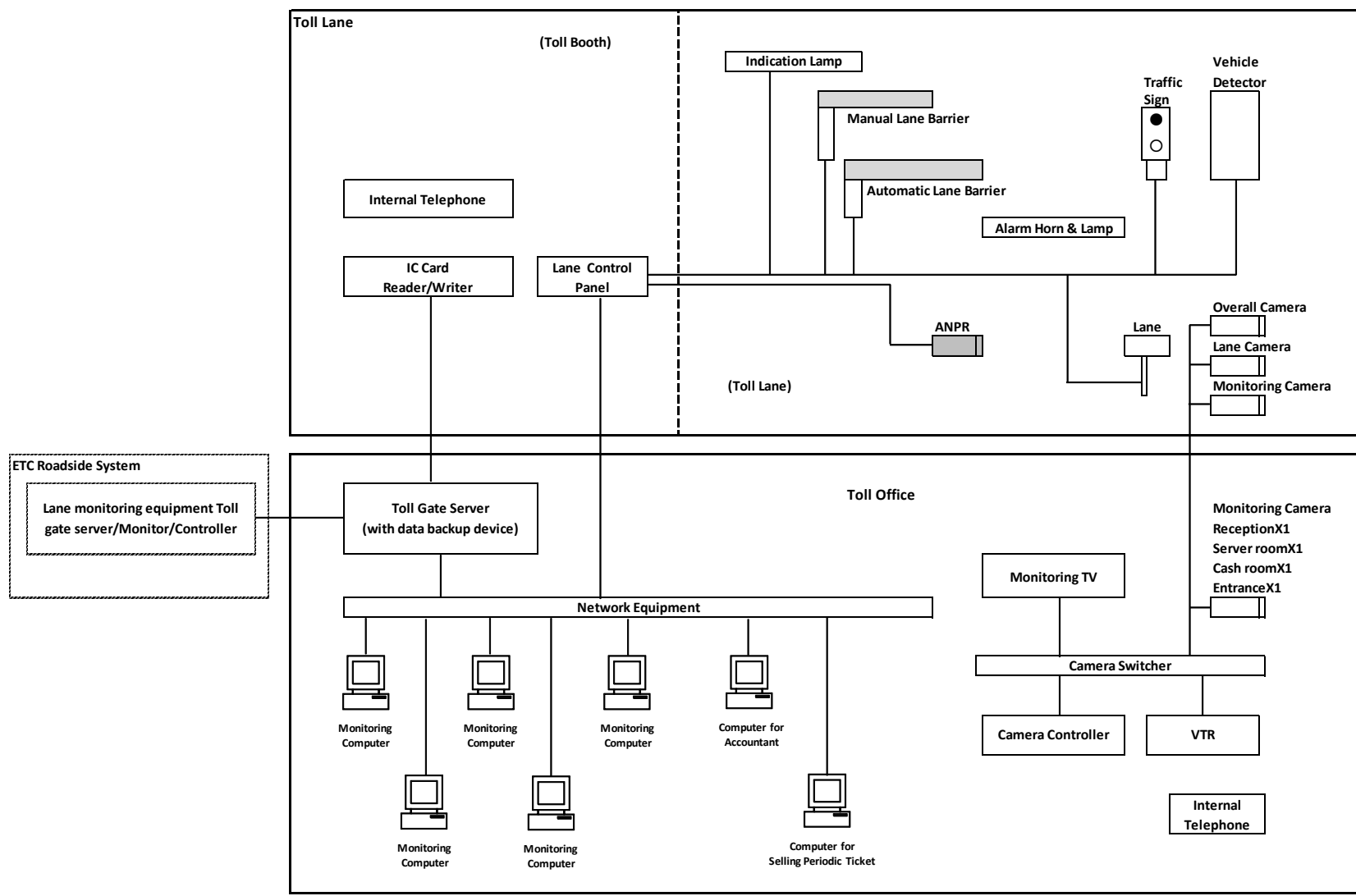
Table 4-28 List of Manual Toll Collection System Equipment

No.	System Component			Quantity		Remarks
				Toll lane	Toll Office	
(1)	Lane Equipment	Vehicle Detector	Vehicle Detector	68		Manual lane: 34X2=68
(2)		Toll Transaction Equipment	IC Card Reader/Writer	34		Manual lane: 34
(3)		Lane Control Equipment	Lane Control Panel	34		Manual lane: 34
(4)			Automatic Lane Barrier	34		Manual lane: 34
(5)			Traffic Sign	34		Manual lane: 34
(6)			Alarm Horn and Lamp	34		Manual lane: 34
(7)		Inspection Equipment	Lane Camera	34		CCD color camera Manual lane: 34
(8)			Lane VMS	34		LED type Manual lane: 34
(9)			Automatic License Number Plate Recognition Camera (ANPR)	34		ANPR-CAM Manual lane: 34
(10)			Lane Server	34		Manual lane: 34
(11)		Others	Manual Lane Barrier	34		Manual lane: 34
(12)			Indication Lamp	34		Manual lane: 34
(13)	Toll office	Toll Office Equipment	Server		8	with data backup device
(14)			Monitoring Computer		40	with IC Card Reader/Writer
(15)			Computer for selling periodic ticket		8	with IC Card Reader/Writer
(16)			Computer for accountant		8	with IC Card Reader/Writer
(17)			Monitoring TV		8	
(18)			Camera Switcher		8	
(19)			Camera Controller		8	
(20)			Monitoring Camera		42	5 camera/Toll Office X 8 + 2camera/Service Tunnel X 1
(21)			VTR		8	
(22)	Others	Others	Overall camera	16		8 toll station X 2(entry, exit)
(23)			Internal Telephone	34	27	Toll Office:3x9 Manual lane: 34
(24)			Power Supply Equipment	34	8	UPS, etc.
(25)			Network Equipment	34	8	Including network cable
(26)			Others	34	8	Lighting Arrester, etc.

Source: Consultant

2) System Configuration

A configuration of manual toll collection system (contactless IC card ticket system) is illustrated as figure below.



Source: Consultant

Figure 4-24 Proposed Manual Toll Collection System Configuration

3) System Requirements

a) Vehicle Detector

The vehicle detector is used for counting number of vehicle and closing the barrier automatically after vehicle passes the tollgate. The vehicle detector shall be controlled by computer system.

b) Toll Transaction Equipment

● Lane Server

The lane server shall display the necessary information for toll transaction such as toll transaction data and contactless IC card data. The computer can also be input required data made through an IC card reader/writer and keyboard by toll staff.

● IC Card Reader/Writer

The contactless IC card will be adopted as the toll ticket for the project. A single trip ticket, a round trip ticket, a monthly ticket, quarterly ticket will be utilized for the IC card system. The contactless IC card ticket shall be recorded on following information.

- Code of local tax bureau
- Type of ticket (Single trip, round trip, monthly, quarterly)
- Type of vehicle
- Issue number
- Ticket number
- Number/code of toll collector at entrance Interchange
- Code of entrance tollgate
- Issued time/date/year at Entrance toll gate
- Code of exit toll gate
- Time/date of exit

The IC card reader/writer shall have a function to read and write all required information above from the contactless IC card.

c) Lane Control Equipment

● Lane Control Panel

The lane control panel shall be capable of connecting all control equipment of toll lane to computer network. The control panel should have separate switch for manual barrier open/close in emergency case. The control panel also has a separate vehicle auto-counter and shall be able to store data of at least 2 weeks.

● Automatic Lane Barrier and Manual Lane Barrier

Two types of barrier, the automatic lane barrier and the manual lane barrier, are provided to let the driver stop at the toll lane or prevent to enter the toll lane. The automatic lane barrier shall be used for control the "Stop" and "Go" of the vehicle. When the driver makes toll payment at tollgate, automatic lane barrier shall be opened automatically based on a signal from lane control panel. The manual lane barrier shall be placed around the edge of toll island to indicate the toll lane is available or not.

● Traffic Sign

The traffic sign is a traffic signal with a red "Stop" and green "Go" light, and located at the vehicle departure side of each toll lane to control passage. The green "Go" light indicates that the toll ticket was issued or the toll fee was paid and the driver is free to move on.

● Alarm Horn and Lamp

The alarm horn and lamp are used for warning the violation driver and calling for the

support from toll security in the enforcement of violation vehicle. This equipment is controlled by lane computer in special situation.

d) Inspection Equipment

● **Lane Camera**

The lane camera is used to observe the condition of toll collection on the lane. The video image shall be recorded by toll office system. The lane camera shall be located where it is possible to observe the vehicle fully when the driver stops at the toll booth. A CCD color camera shall be used as the lane camera.

● **Lane VMS**

The lane VMS is used to show the toll fare, vehicle classification registered by the toll staffs, toll charge and other information related toll transaction and lane situation. The toll fare display shall be placed where a driver can see it when he stops at the toll booth.

● **Automatic License Number Plate Recognition Camera (ANPR)**

At toll plaza of high traffic volume, ANPR is installed for speed up the passing of vehicle. ANPR is used for reading vehicle number plate and checking the IC ticket database. If vehicle have monthly or quarterly ticket and this ticket is still validated, the barrier shall be opened automatically.

e) Other Lane Equipment

● **Indication Lamp**

The indication lamp is mounted on the toll canopy above the each toll lane and shall indicate whether the lane is opened or closed to the driver.

f) Toll Office Equipment

The toll office equipment will be provided in the toll office building. The toll office equipment consists of server, monitoring computer, computers for selling periodic ticket and accountant, monitoring TV, camera switcher and controller, monitoring camera and VTR. Main functions of the system are;

- Transaction data acquisition/store from lane equipment and provision of real time monitoring through visual displays in the toll office
- Data processing and toll office management via visual display units, printer terminals, auxiliary memory media and data transfer facilities
- Camera monitoring, controlling and recording

Two units of the database server for backup purpose and seven (7) units of computer will be introduced in the toll office building.

g) Others

● **Overall Camera**

The overall camera shall be of PTZ camera and used for monitoring overall location of toll barrier.

● **Internal Telephone**

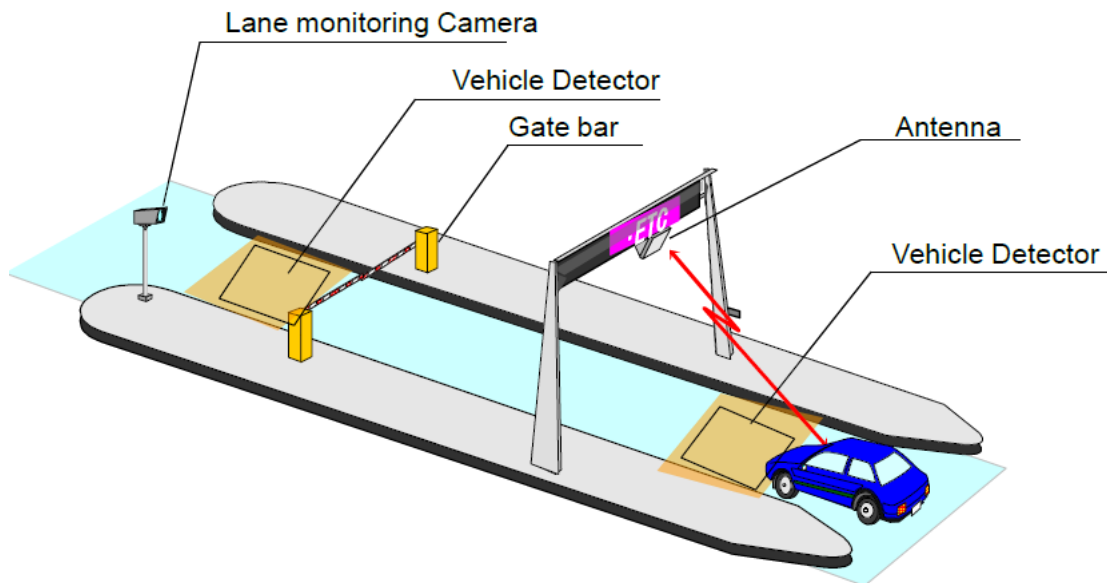
The internal telephone is used for communication between toll lanes and toll office in case of emergency. This equipment will be procured in the communication system.

● **Others**

Other required facilities such as power supply equipment (UPS), network equipment, etc. shall be provided in the system

(2) Automatic Toll Collection (ETC) System

The ETC realizes automatic toll transaction by utilizing wireless communications between the OBU and road side antenna as typically shown in **Figure 4-25** below.



Source: Consultant

Figure 4-25 ETC Operation Image

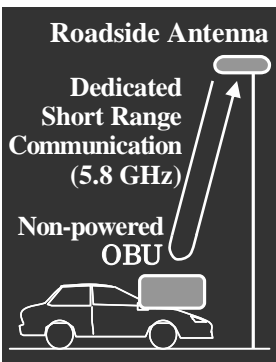
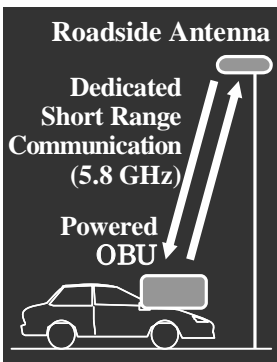
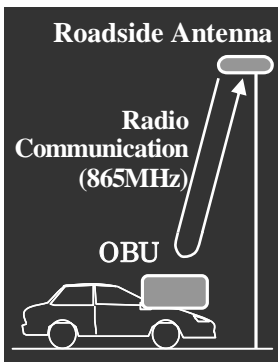
Basic toll collection procedures under the ETC system will be as follows;

- A driver who intends to use the ETC system installs and set up the OBU on his vehicle. The driver also has to purchase the IC card for pre-payment.
- When the approaching vehicle equipped with the OBU to the tollgate, communications are made between the OBU and the road side antenna.
- The validities of the OBU and IC card inserted into the OBU are checked through the communications, firstly. If the communications are made successfully, vehicle classification recorded into OBU is read through the communications and the toll is automatically calculated and withdrawn from the remaining deposit of IC card. Then, automatic lane barrier will be automatically opened.
- Information including vehicle number, passing date and time, toll charge, reaming deposit of IC card, etc. are transferred and recorded into the toll office system.

1) Type of the Road-to-Vehicle Communication Method for ETC

There are various kinds of road-to-vehicle communication method for ETC in the world. Each type of ETC has its advantages and disadvantages. Table below shows the comparison of major ETC communication methods.

Table 4-29 Comparison on Road-to-Vehicle Communication on ETC

Item	DSRC-Active	DSRC-Passive	Passive RFID
Outline	 <p>Roadside Antenna Dedicated Short Range Communication (5.8 GHz) Non-powered OBU</p>	 <p>Roadside Antenna Dedicated Short Range Communication (5.8 GHz) Powered OBU</p>	 <p>Roadside Antenna Radio Communication (865MHz) OBU</p>
Shared use by different operators	Many Experiences	Many Experiences	Few Experiences
Shared suppliers in actual road operations	Many Experiences	Few Experiences	No Experience
Application to distance based tariff system	Many Experiences	Few Experiences	N/A under international standard
Accuracy of data communication	High (99.9999%)	No regulation	Relatively low
2-piece type OBU	Many Experiences	For trial	Not Capable
Required cost for OBU	Average	Low	Quite low
Required cost for roadside equipment	Low	Average	Average
International standard	Established	Established	Established

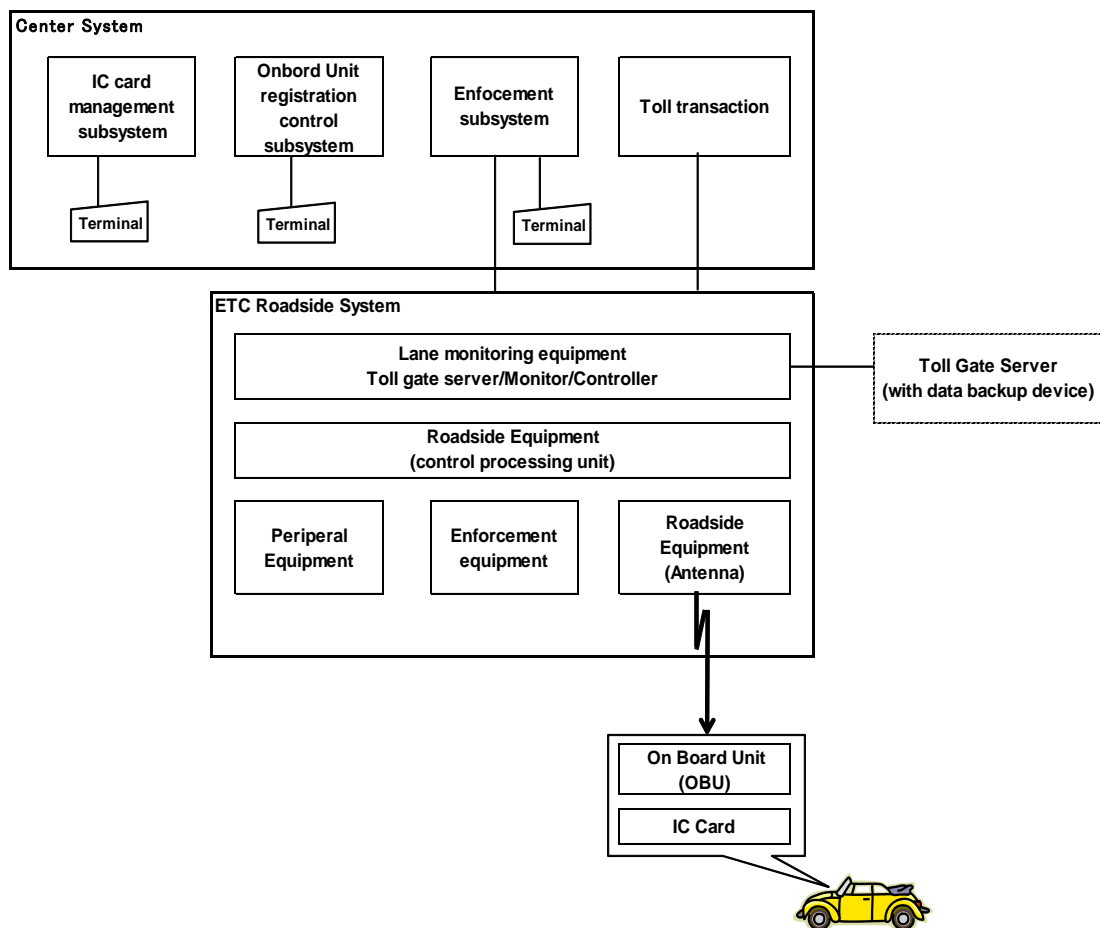
Source: Consultant

In accordance with MOT decision No.4244/BGVT-KHCN and in consideration of following advantages, the DSRC-Active 5.8GHz type will be applied as ETC system for the DQE;

- Applicability for shared use by different operator;
- Applicability for shared use by different suppliers (connectivity between different suppliers equipment can be secured);
- Applicability to distance based tariff system proposed in the Project;
- High accuracy and reliability with high communication capacity (Applicability to multi-lane free-flow in future);
- Capability of 2-piece type OBU (IC card can be used as the multimodal card);
- Cheaper cost for roadside equipment than other alternatives; and
- Conformity of DSRC and IC card specifications with international standards.

2) System Configuration

A configuration of automatic toll collection system is illustrated as figure below.



Source: Consultant

Figure 4-26 Proposed Automatic Toll Collection System Configuration

3) System Component

Automatic toll collection system for the DQE will be composed of following equipment.

Table 4-30 List of Automatic Toll Collection System Equipment

No.	System Component			Quantity			Remarks
				Toll lane	Toll Office	User	
(1)	Lane Equipment	Vehicle Detector	Vehicle Detector	32			Manual & ETC lane:16 X 2
(2)		Toll Transaction Equipment	Roadside Antenna	16			Manual & ETC lane:16
(3)			On-Board Unit			50,000	
(4)			IC Card			625,000	
(5)			Lane Server	16			Manual & ETC lane:16
(6)			IC Card Reader/Writer	16			Manual & ETC lane:16
(7)		Lane Control Equipment	Roadside Controller	16			Manual & ETC lane:16
(8)			Automatic Lane Barrier	16			Manual & ETC lane:16
(9)			Traffic Sign	16			Manual & ETC lane:16
(10)			Alarm Horn and Lamp	16			Manual & ETC lane:16
(11)		Inspection Equipment	Lane Camera	16			CCD color camera Manual & ETC lane:16
(12)			Lane VMS	16			LED type Manual & ETC lane:16
(13)			Automatic License Number Plate Recognition Camera (ANPR)	16			Infra-Red camera Manual & ETC lane:16
(14)		Others	Manual Lane Barrier	16			
(15)			Indication Lamp	16			
(16)	Toll office	Toll Office Equipment	Toll Management Server		8		
(17)			IC Card / OBU Registration Terminal		16		
(18)			IC Card Reader/Writer		16		
(19)	Others	Others	Internal Telephone	16			Manual & ETC lane:16
(20)			Power Supply Equipment	16	8		UPS, etc. Manual & ETC lane:16
(21)			Network Equipment	16	8		Including network cable Manual & ETC lane:16
(22)			Others	16	8		Lighting Arrester, etc. Manual & ETC lane:16

Source: Consultant

In addition to the manual toll collection equipment, roadside antenna will be installed at tollgate to communicate with the OBU. For early wide spreading of ETC system, a total of 50,000 OBU and 625,000 IC cards are proposed to be provided in the Project. In the toll office, toll management server, IC card/OBU registration terminal and IC card reader/writer will be placed to handle the ETC transaction data.

4.3.8 Expected Toll Operation

(1) Manual Toll Collection

In manual toll collection system, when vehicle enters tollgate, a driver receives an IC card. After arriving at exit tollgate and a toll collector collects an IC card with cash. However, IC card shall not only be used to identify both the name of entry point and exit point by IC card Reader/Writer but also be used to pay the toll for the prepaid card such as the monthly, quarterly or periodically commutation ticket. Those prepaid card are able to cash recharge by IC card Reader/Writer.

The consultant recommends that the IC card for prepaid card shall be sold at toll office in the initial stage and the review of expanding selling points shall be implemented after traffic volume increased.

Following are daily basic procedure of audit of collected cash for toll fee.

[Basic procedure of Daily Audit]

- 1st: Store cash (collected toll fee and payment of prepaid IC card) in the toll office.
- 2nd: Check number of passing vehicles and classification, calculated amount of toll fee and collected cash at the toll office. If those data will not match with collected cash, operator

will confirm by the data of ANPR and image data of lane cameras. (Post check)

- 3rd: Check number of passing vehicles, calculated amount of toll fee and toll office accounted cash at the main management center. (Cross check)
- 4th: Transport amount of cash to the nearby bank by vehicle
- 5th: Save amount of cash into the designated bank account.

(2) Automatic Toll Collection

To use the ETC system, purchasing the On-Board Unit (OBU) and prepaid IC Card for ETC is necessary for the driver. At initial phase, the expressway operator shall sell OBU and issue prepaid IC card for ETC at main management center, management offices and/or toll offices. At the time of selling OBU, it will be registered information such as vehicle number, size and classification, etc.

By this registered data, ETC system is able to confirm vehicle classification automatically. Following are basic procedure of ETC settlement.

[Basic procedure of ETC settlement]

- 1st: When ETC vehicle enter ETC lane at entrance (origin interchange), wireless communication and recognition of valid ETC vehicle starts. After recognition, data of entering point is written in IC card.
- 2nd: At exit ETC lane (destination interchange), after recognition by the data of OBU and ANPR, toll fee will be calculated automatically.
- 3rd: After toll settlement finished, automatic gate will be opened automatically.

4.4 Communication System Plan

4.4.1 Basic Requirements of Communication System

The ITS consists of various facilities such as vehicle detector, CCTV camera, variable message sign, toll collection facilities, etc. installed along roadside. These roadside facilities shall be connected with the center equipment installed at a main management center for monitoring traffic flow, expressway conditions and toll collection data through digital transmission system. Apart from the digital transmission system, the communication system between patrol crews must be established.

The requirements for both communication systems are listed as follows:

[Common requirements for ITS communication network]

- To secure high reliability of network even when any disaster such as heavy rain, water flooding occurs or in other emergency cases,
- To have high security system against external attack or hacker,
- To save both initial and running costs for communication system as much as possible,

[Requirements for digital transmission system]

- To handle high capacity data including live-video images captured by CCTV camera,
- To connect with various equipment widely spreading in whole sections on the expressway,
- To meet world-wide standard and be suitable for Vietnamese environment, and
- To have future expandability to connect with other main management centers such as Ha Noi and Ho Chi Minh City main centers,

[Requirements for communication system between patrol crew]

- To have good mobility for communication with patrol crews
- To transfer voice communication data on real-time basis,

To meets such requirements, the introduction of following communication systems are proposed in the Project.

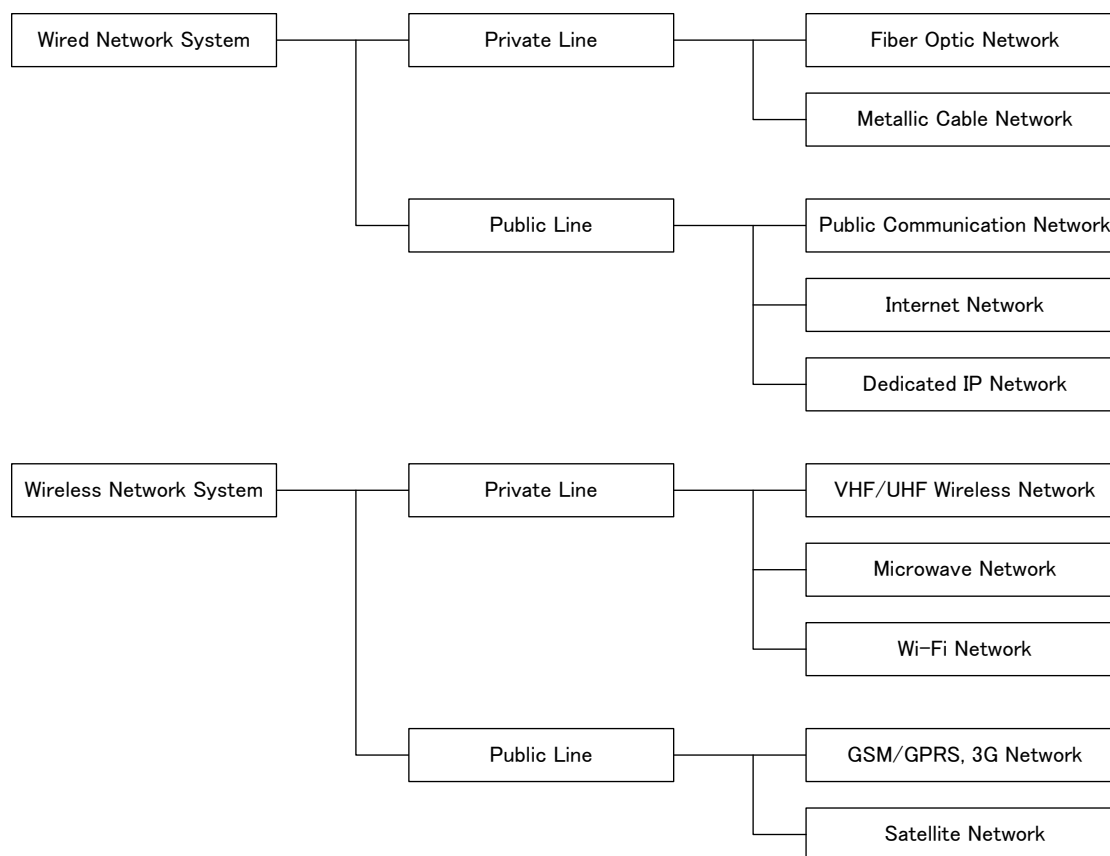
Table 4-31 Summary of Communication System Components

No.	Component		Main Feature	Remarks
1.	Digital Transmission system	Type of Comm. Line	Private fiber optic network	
		Network Protocol	Gigabit Ethernet	Consistent with MOT Decision
		Cable Installation	Bose side of expressway	Securing high reliability
2.	Wireless Radio System		VHF or UHF band exclusive radio	Frequency allocation is necessary
3.	Internal Telephone System		IP Based telephone system	

Source: Consultant

4.4.2 Selection of Communication Lines

Various kinds of communication line are listed as the candidate of communication system applying to this project. Those network systems can be roughly categorized into wired network and wireless network, and further divided into private line and public line provided by carriers. Figure below shows the types of communication line.



Source: Consultant

Figure 4-27 Type and Category of Communication Line

Each of communication network system has advantages and disadvantages as shown in **Table 4-32**.

The Consultant recommends that following types of communication line should be introduced in the Project.

Digital transmission system: Private Fiber Optic Network
Communication system between patrol crew: VHF/UHF Wireless Network

The reasons for selecting those communication lines are summarized as follows:

- Most prioritized requirement of both communication systems is to secure network connectivity even during serious disaster or in any other emergency cases. Because the digital transmission system handles vital information including traffic, road condition and toll collection data and any interruption of communication network cannot be allowed. The communication system between patrol crew is also required in continuous operation to report situations and any damages of expressway caused by such disaster to main management center and management offices. From past experience in the world, it has been identified that public lines are quite low reliability against the disaster and cannot keep continuous operation. Thus, the communication lines in the Project must be selected from private lines.

Table 4-32 Comparison on Communication Lines

Type		Wired Network System					Wireless System				
		Private Line		Public Line			Private Line			Public Line	
		Fiber Optic	Metallic Cable	Public Voice Comm.	Internet	Dedicated IP	VHF/UHF	Microwave	Wi-Fi	GSM/GPRS, 3G	Satellite
Transmission speed		Excellent (up to 40 Gbps)	Limited (Up to 52 Mbps)	Poor (Up to 64 Kbps)	Limited (Max. 100Mbps depended on traffic)	Average (Up to 100Mbps)	Poor (Up to 64 Kbps)	Excellent (Up to 208 Mbps)	Excellent (Up to 600 Mbps)	Poor (Up to 64 Kbps)	Limited (Up to 10 Mbps)
Connectivity with equipment		Easy	Average	Difficult (difficult to connect all equipment point)	Difficult (difficult to connect all equipment point)	Difficult (service area is limited)	Easy	Difficult	Average (wired line is additionally required)	Easy	Easy
Reliability against disaster		High (loop-back function enables high reliable network)	Average (Not reliable against lightning serge)	Low (Carriers may stop to provide service in case disaster or high traffic)	Low (Carriers may stop to provide service in case disaster or high traffic)	Low (Carriers may stop to provide service in case disaster or high traffic)	High	High	High	Low (Carriers may stop to provide service in case disaster or high traffic)	Average (Satellite communication is weak in case of heavy rain)
Network security		High	High	Average	Low	High	High	High	Low	Low	High
Mobility		None	None	None	None	None	Good	None	Good	Good	None
Costs	Initial	High	High	Low	Low	Low	Average	High	High	Low	Average
	Running	Low	Low	Average	Average	High	Low	Low	Low	Average	High
International trends		Widely used as Digital Transmission network	Less used in recent year	Used as wired public voice comm.	Generally used as public internet line	Used as high security dedicated service	Widely used as comm. with patrol	Used as wireless trunk network	Used as wireless IP access network	Generally used as mobile communication	Used as high reliable comm. Network
Grading		Recommended as Digital Transmission network	Not suitable	Not suitable	Not suitable	Average	Recommended as Wireless radio system	Not suitable	Average	Average	Not suitable

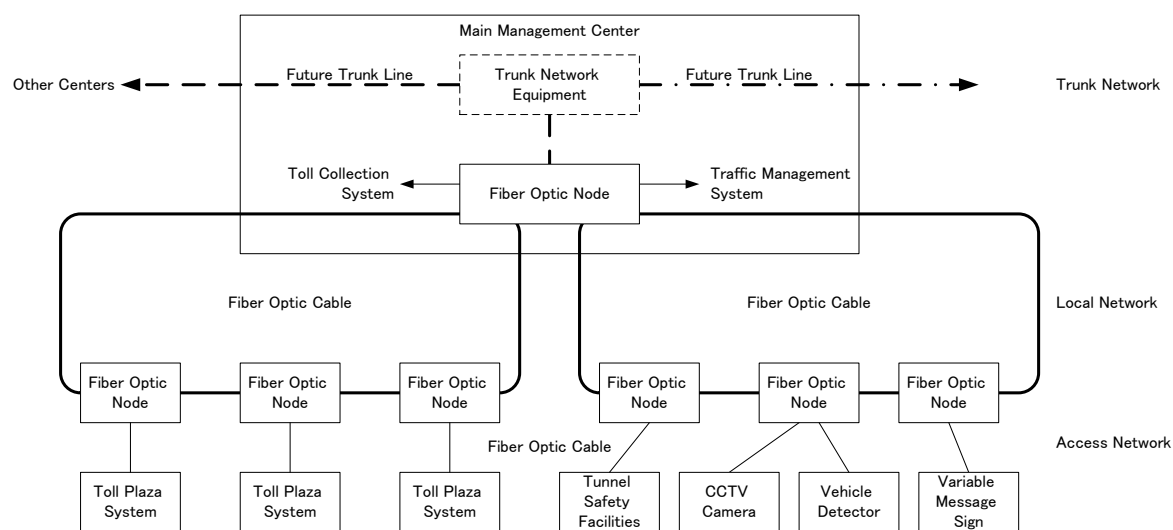
Source: Consultant

- Comparing with each private line, the fiber optic network is best solution for the digital transmission system due to its characteristics such as high transmission capacity, good connectivity with ITS roadside equipment and high network security. Since the digital transmission system shall handle a lot of live-video images captured CCTV cameras (2-10 Mbps/camera), network capacity must be kept as much as possible. The fiber optic network can realize broadband transmission with transmission capacity up to 40Gbps. Also, the fiber optic network can be configured high reliable redundant network equipped with loop-back function.
- As for communication system between patrol crew, the Consultant recommends VHF/UHF wireless network because of good mobility, lower initial cost comparing with other alternatives.

4.4.3 Digital Transmission System

(1) Network Structure and Node Location

A fiber optic network structure will be separated by three (3) hierarchies, that is, trunk network, local network and access network. The trunk network will be introduced in future to connect with the main management centers located in Ha Noi, Da Nang and Ho Chi Minh City, when the expressway is extended. Communication nodes for local network (FON: Fiber Optic Node) will be placed to link between the main management center and management offices, toll offices or other major connecting points. Access network will be established to connect between FON and roadside facilities. The concept of network structure and hierarchy is shown in figure below.



Source: Consultant

Figure 4-28 Network Structure and Hierarchy

All communication cable shall be fiber optic cable having enough number of cores except the metallic cable to be used to directly connect roadside facilities with FON in order to realize high capacity data transmission. An IP (Internet Protocol) based digital transmission system will be adopted in the Project in consideration of its flexibility, expandability, cost effective construction of the system and the technical trends in all over the world.

The location of FON is shown in table below.

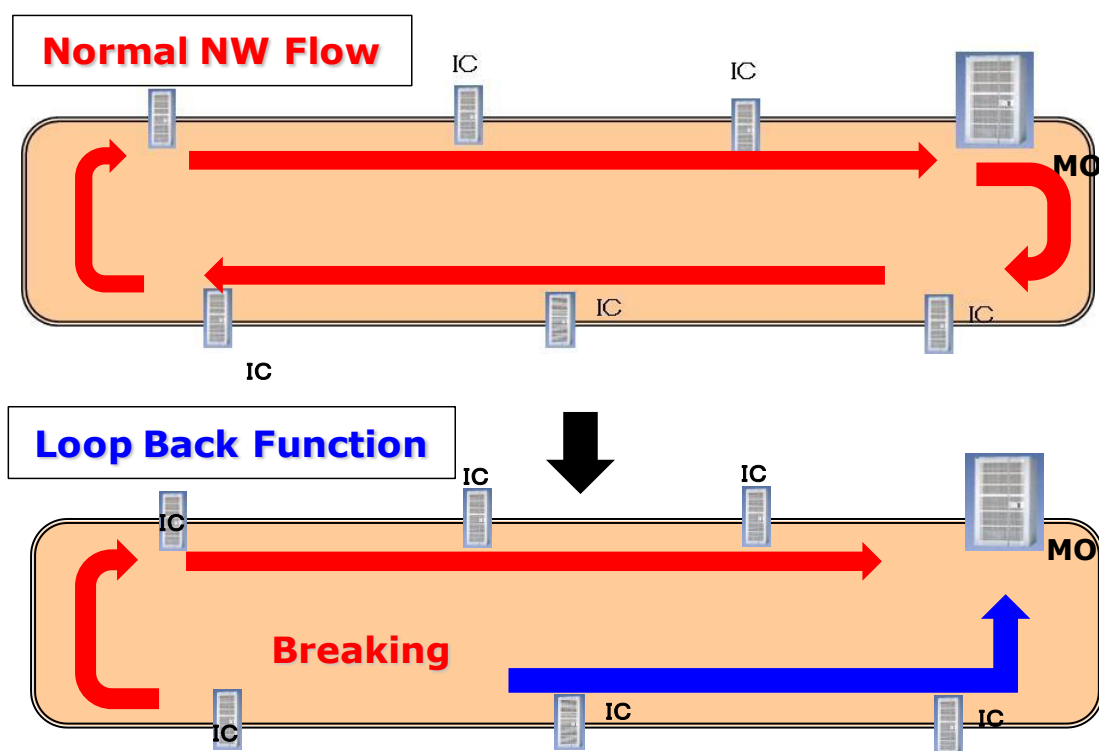
Table 4-33 Location of FON

No.	Location	Remarks	No.	Location	Remarks
1	Tuy Loan IC	KM0+000	6	Tam Ky Toll Office	KM64+450
2	Da Nang Main Management Center	KM4+100	7	Chu Lai Toll Office	KM82+990
3	My Son Toll Office	KM13+260	8	Dung Quat Toll Office	KM101+740
4	Tunnel (north side)	KM22+485	9	Quang Ngai North Management Office	KM123+845
5	Ha Lam Toll Office	KM40+880	10	Quang Ngai Toll Office	KM129+500

Source: Consultant

(2) Network Configuration

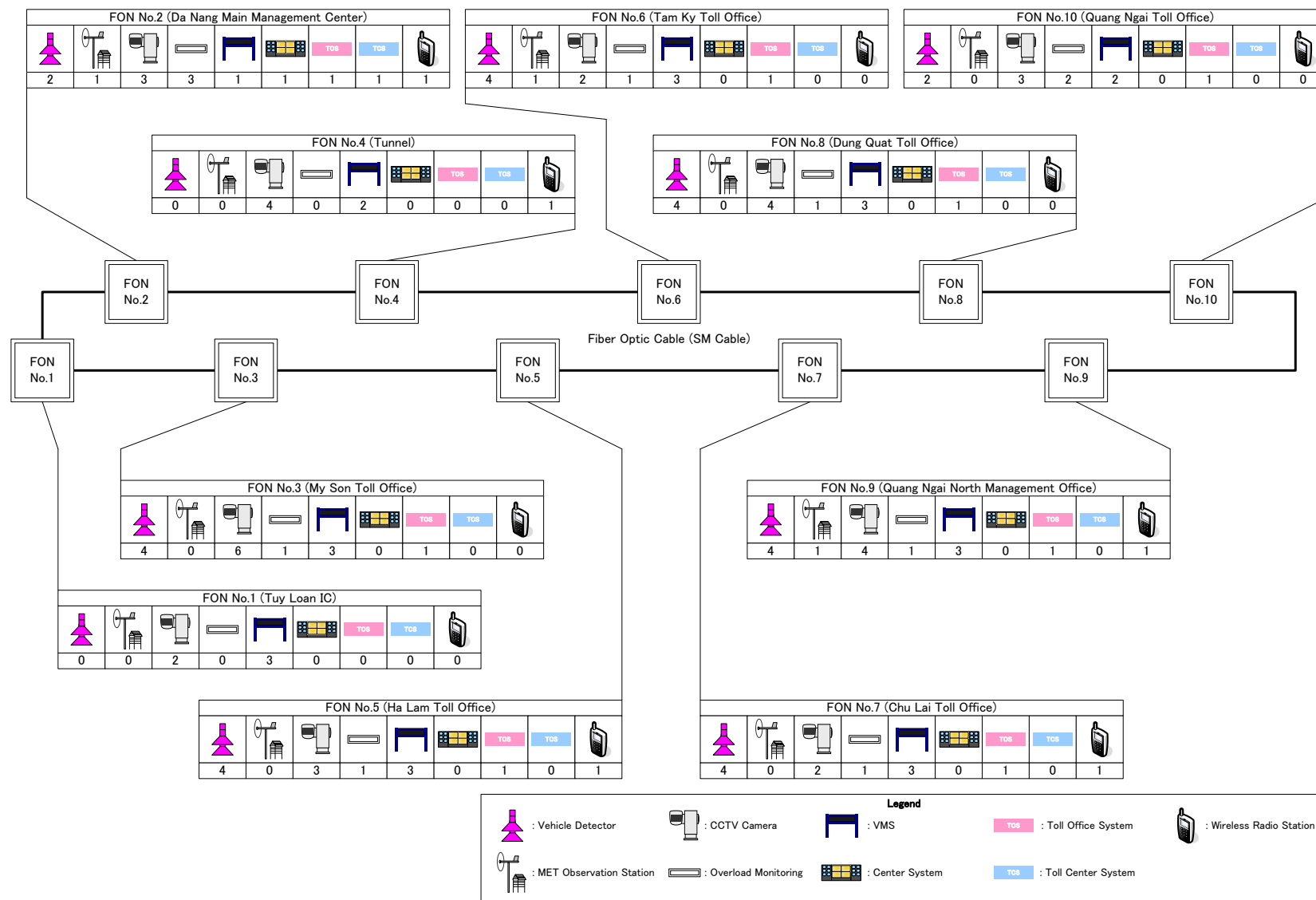
The network topology of local network shall be configured a flattened ring structure with loop-back function to guarantee connectivity even if one node or communication cable fail to operate as shown in figure below.



Source: Consultant

Figure 4-29 Principle of Loop-back Functions

Proposed network configuration of digital transmission system in the Project is illustrated as Figure 4-30.



Source: Consultant

Figure 4-30 Digital Transmission System Configuration

(3) Digital Transmission Method

There are several types of digital transmission method for fiber optic network. These are categorized into Asynchronous Transfer Mode (ATM) switching system, Synchronous Digital Hierarchy (SDH) transmission system and Gigabit Ethernet. Main factors for selecting suitable transmission method are;

- Connectivity with Ethernet interface (since almost all ITS facilities are equipped with Ethernet interface);
- Maximum transmission capacity for future expandability;
- Availability of QoS (Quality of Service) including bandwidth guarantee for VoIP;
- Compatibility among different suppliers' network node; and
- Minimization of implementation costs.

Table below shows the comparison on each digital transmission method.

Table 4-34 Comparison on Digital Transmission Method

Method Item	IP over ATM	Gigabit Ethernet	IP over SDH	IP over ATM/DWDM	IP over SDH/DWDM
Communication Node	ATM	Media Converter	SDH	DWDM	DWDM
Interface of Ethernet	ATM-NIC is necessary	Available	Interface card is necessary	ATM-NIC is necessary	Interface card is necessary
Maximum Capacity	620 Mbps	40 Gbps	40 Gbps	1 Tbps	1 Tbps
Bandwidth Guarantee	Capable	Capable	Capable	Capable	Capable
Network Management	Capable	Capable	Capable	Capable	Capable
Compatibility	Low	High	High	High	High
Implementation Cost	Average	Low	Average	High	High
Recommendation	Not Suitable	Recommended	Average	Not Suitable	Not Suitable

Source: Consultant

The Gigabit Ethernet is recommended for digital transmission method in the Project with the reasons of good connectivity with Ethernet interface, enough transmission capacity for future expandability and less implementation costs comparing with other alternatives.

(4) Estimated Network Traffic

In general, it is difficult to estimate accurate network traffic demand because the demand is highly depended on the service contents to be used by respective system and varies from moment to moment. For this estimation, required network capacity of digital transmission system is calculated on the basis of following conditions.

- Number of system data and unit traffic volume is set as table below.

Table 4-35 Number and Unit of Each System Data Traffic

System	Number (nos.)	Unit Traffic Volume (kbps)	Total Traffic Volume (Mbps)	Remarks
1.CCTV System	33	2,000	66.0	H.264/MPEG-4, multicast
2. Vehicle Detector System	28	128	3.6	
3. MET System	3	128	0.4	
4. Overload Monitoring System	11	2,000	22.0	Including Image
5. VMS System	26	128	3.3	
6. Center System	1	2,000	2.0	Data transfer to MOs
7. Toll Collection System	8	512	4.1	Transaction data

8. Wireless Radio System	4	128	0.5	
9. Internal telephone System	10	128	1.3	
Total			103.2	

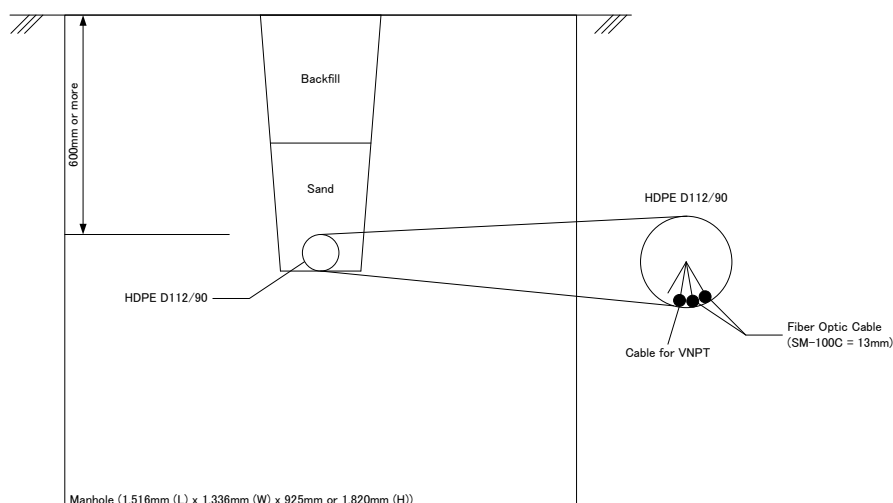
Source: Consultant

- Considering the collision and other factors, the throughput of communication network on IP will be around 50 % of network capacity. The network traffic shall be estimated in consideration of such network efficiency.

The required network capacity is estimated around 206 Mbps. Accordingly the Gigabit Ethernet with a capacity of 1Gbps is recommended in initial stage. In case that ITS equipment will be additionally installed in future, the transmission capacity shall be reviewed in line with the number of equipment to be introduced in later stage.

(5) Conduit Plan

As mentioned earlier, the network topology of local network in this Project will be configured a flattened ring structure with loop-back function. From this concept, two (2) fiber optic cables will be basically laid along the expressway. One (1) HDPE pipes having 4 cells for two (2) ITS fiber optic cables, one (1) VNPT cable and one (1) spare with a diameter of 112/90mm will be installed to protect fiber optic cable. The pipes must be buried at least 600mm depth from surface or covered by concrete. Manhole of which size is 1,440 mm length x 1,600mm width x 1,350mm height will be installed for pulling and connecting/diverting the cable. An interval of manhole must be less than 250m to reduce cable laying tension. Following figures show the typical section of fiber optic cable conduit.



Source: Consultant

Figure 4-31 Typical Section of Fiber Optic Cable Conduit Installation

Location of cable conduit which is 1.5m distance from edge of embankment is arranged to avoid relocation in case the expressway will be widened in ultimate phase.

(6) Technical Requirement of Digital Transmission System

The fiber optic system shall have highly reliability and provide secure communications for real time signals such as voice, video, traffic management data and toll collection data to connect fiber optic cable with Internet Protocol.

1) Fiber Optic Node (FON)

The FON shall have enough capacity and interface, QoS control function, fail-over function and any other required functions. Followings are reference specifications of the FON.

- a. Standards: Gigabit Ethernet
- b. Capacity: 1 Gbps or more
- c. Interface: Fiber Optic Interface: 8 cores or more
LAN Interface: 20 ports or more

- d. Applied Topology: Ring, Star
- e. Fail-Over Function: Resilient Packet Ring (RPR)
- f. Transmission Distance: 60km or more
- g. Changeover Time: 50msec or less
- h. Network Management: SNMP or equivalent
- i. Reliability: 1×10^{-6} or better

2) Access Node

Access node has a function to convert electrical signal to optic signal to connect roadside equipment with the FON. Followings are basic requirements of the access node.

- a. Input/Output: 10Base-T/100Base-TX
Single Mode (SM) Fiber Optic Cable
- b. Number of Core: 2 C or less

3) Communication Cable

The type of cable for the communication system will be as stipulated below table.

Table 4-36 Required Number and Type of Communication Cable

No.	Application	Type of Cable	No. of Cores	Remarks
1.	Trunk Network	Fiber Optic Cable (Dispersion-Shifted Fiber: DSF)	8C	In future
2.	Local Network	Fiber Optic Cable (Single Mode Fiber: SMF)	8C	
3.	Access Network	Fiber Optic Cable (Single Mode Fiber: SMF), Ethernet cable or other communication cable	28C or more	
4.	Inside buildings	Ethernet cable or others	-	
5.	Cable for network management	Fiber Optic Cable (Single Mode Fiber: SMF)	4C	

Source: Consultant

Fiber optic cable installed along the expressway is estimated of 48 cores. To meet the future demand, 100C Single Mode (SM) fiber combined with Dispersion-Shifted Fiber (DSF) cable is proposed to be installed in the Project.

4) Fiber Optic Termination

Fiber optic termination will be installed in the Da Nang Main Management Center, Management Office or other fiber optic connection points, where the FON will be located, and used to connect fiber optic cable with the ITS equipment smoothly by using suitable connectors.

- a. Splicing Number of Core: 100C or more
- b. Connector: SC or FC Connector

5) Network Management

The digital transmission system shall be equipped with a supervisory function which continuously monitors the network operation and issues an alarm in case of malfunction. Supervisory equipment shall have the following functions.

- Management of occurrence on network system
- Registration and modification of network system configuration
- Testing of equipment and circuit
- Logging of equipment operation and cable
- Changeover between primary and backup routes

4.4.4 Wireless Radio System

The VHF/UHF wireless radio system is installed for voice/data communication between the main management center / management offices and personnel engaged in the operation and maintenance who are on the expressway. The system shall cover entire expressway with high quality communication.

In order to provide high reliable communication, it is recommended that an exclusive VHF or UHF band will be used as the frequency of mobile radio communication in conformity to existing laws and regulations regarding radio wave transmission in Vietnam. The system can also provide one-to-one and one-to-many communications. Digital transmission technology shall be used for its advantages over the conventional analog type.

(1) Wave Propagation Analysis

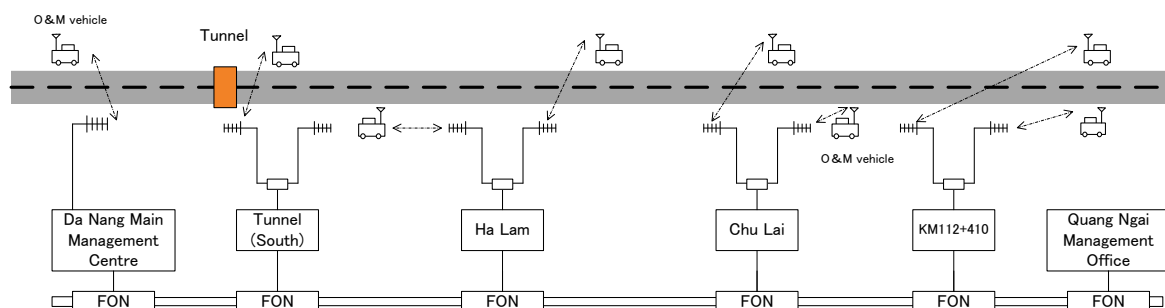
A wave propagation analysis of wireless radio system by using computing software is carried out to clarify the system configuration, required number and location of wireless radio station, the radio output power, frequency to be used, type of antenna, antenna height, and other required factors of each wireless station. The basic conditions and criteria of wave propagation analysis are referred to relevant ITU-R (International Telecommunication Union - Radiocommunications Sector) and ETSI (European Telecommunications Standards Institute) Standards as summarized in the table below.

Table 4-37 Design Conditions and Criteria of Wave Propagation Analysis

No.	Description	Design Conditions and Criteria	Remarks
1.	Analysis Software	Pathloss Ver. 5.0	
2.	Terrain Information Data	ASTER GDEM, 30m mesh data	
3.	Location of Base Station (4 stations)	Da Nang Main management center Tunnel (south side), Ha Lam Toll Office, Chu Lai Toll Office, Binh Son Toll Office	Control Station Repeater Station
4.	Radio Frequency	400 MHz band	Expected frequency
5.	Output Power	50W: Base Station, 2W: Mobile	
6.	Required Receiving Level	-103 dBm	ETSI
7.	Antenna Type	5-element Yagi antenna Whip antenna	Base Station Mobile
8.	Antenna Height	15m: Base Station, 2m: Mobile	
9.	Coaxial Cable length	25 m, 10D-2V or equivalent 3m, 10D-2V or equivalent	Base Station Mobile

Source: Consultant

The figure below shows the arrangement plan of wireless radio system. In the wireless radio system, the radio control will be managed in Da Nang main management center control station. Whole sections of expressway would be covered with the base station including control station and repeater stations disposed to tunnel (south side), Ha Lam toll office, Chu Lai toll office and KM112+410. The wave propagation analysis is executed by this arrangement.



Source: Consultant

Figure 4-32 Arrangement Plan of Wireless Radio System

The expected coverage of wireless radio system by the wave propagation analysis is shown in figure below.

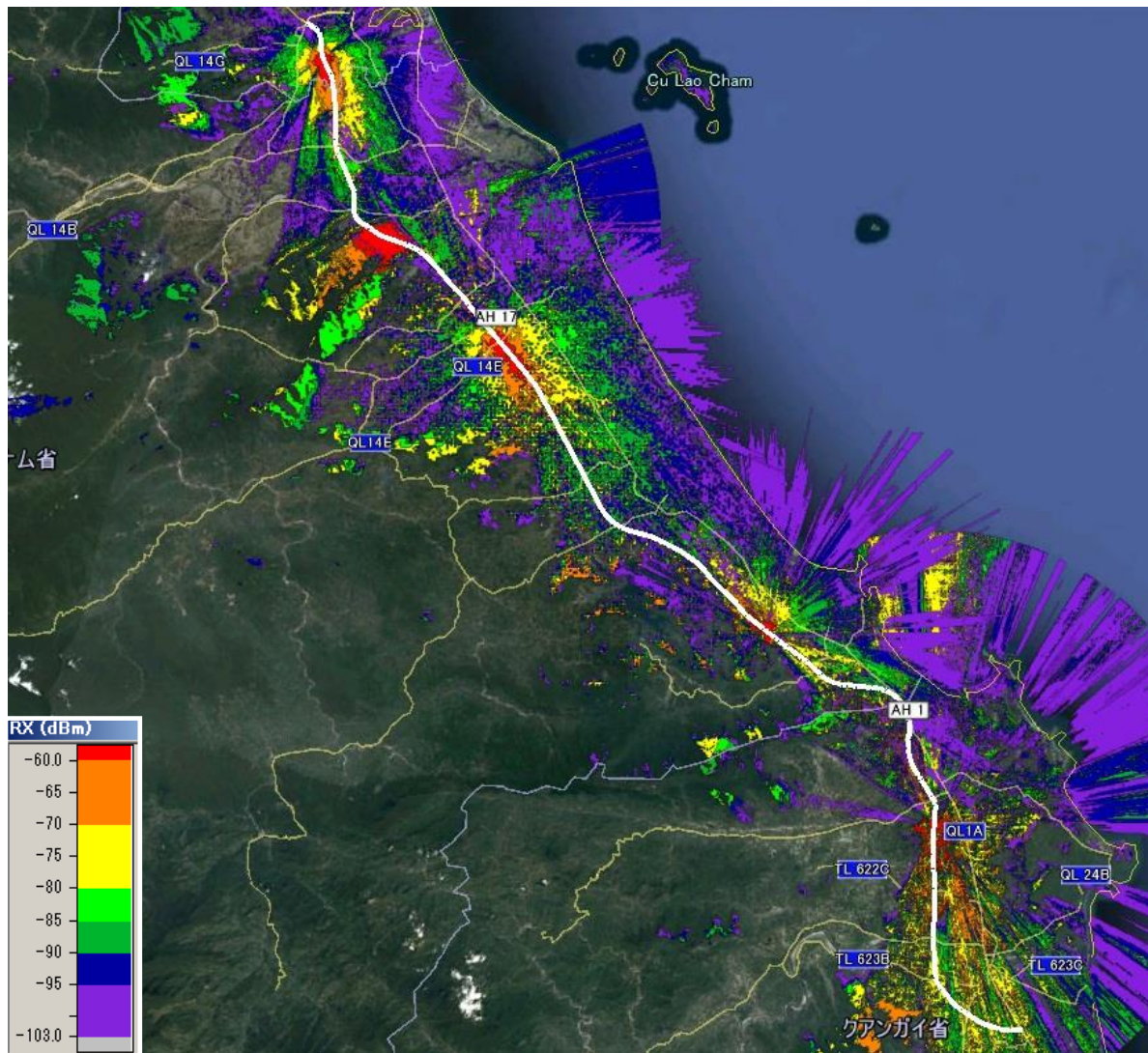


Figure 4-33 Coverage Map of Wireless Radio System (400MHz Band)

In the figure above, colors marked from red to violet indicate strength of receiving power level; red color is strongest level among them. The violet color indicates threshold limit value of receiving sensitivity which can receive the signal from facing base station.

According to the results of analysis, whole sections of expressway are expected to be covered by each base station. However, all of areas are not covered enough with strong radio wave signal level. Also, the wave propagation analysis is made on assumptions that the elevation on each expressway alignment is current ground level, and it is not made consideration of embankment or cut levels. Thus, it is strongly recommended that the Contractor carry out wave propagation tests to make sure the actual wave signal level at the site.

The wave propagation analysis results of each base station are attached in this report.

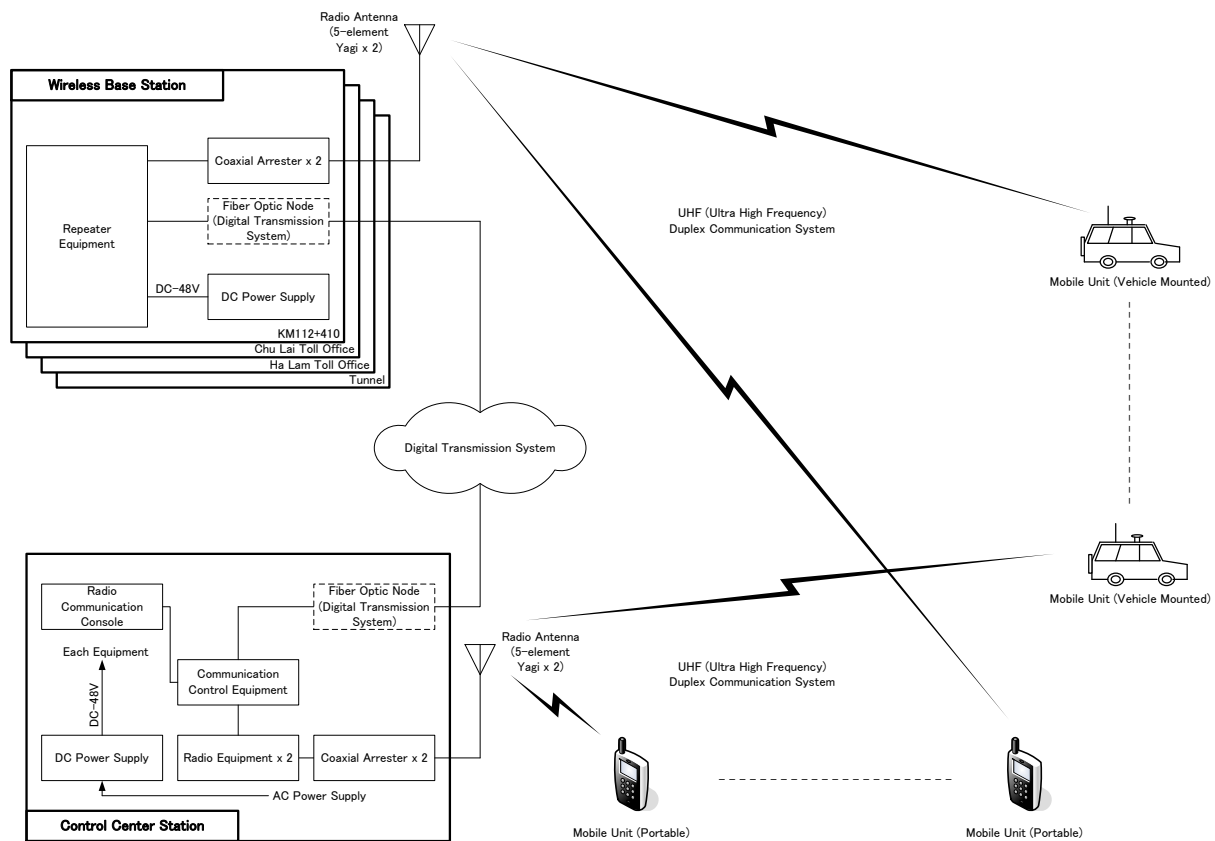
(2) Wireless Radio System Configuration

The system will consist of one (1) control center station to be established at Da Nang main management center, four (4) wireless base stations located at tunnel (south side), Ha Lam toll office, Chu Lai toll office and KM112+410, 30 vehicle mounted mobile units and 50 portable mobile units.

Table 4-38 List of Wireless Radio System Equipment

No.	Wireless Radio Equipment	Location	Quantity	Remarks
1.	Control Center Station	Da Nang Main Management Center	1	Including control equipment
2.	Wireless Base Station	Tunnel (south side), Ha Lam Toll Office, Chu Lai Toll Office, KM112+410	4	
3.	Mobile Unit (vehicle mounted type)	-	30	
4.	Mobile Unit (portable type)	-	50	

Source: Consultant

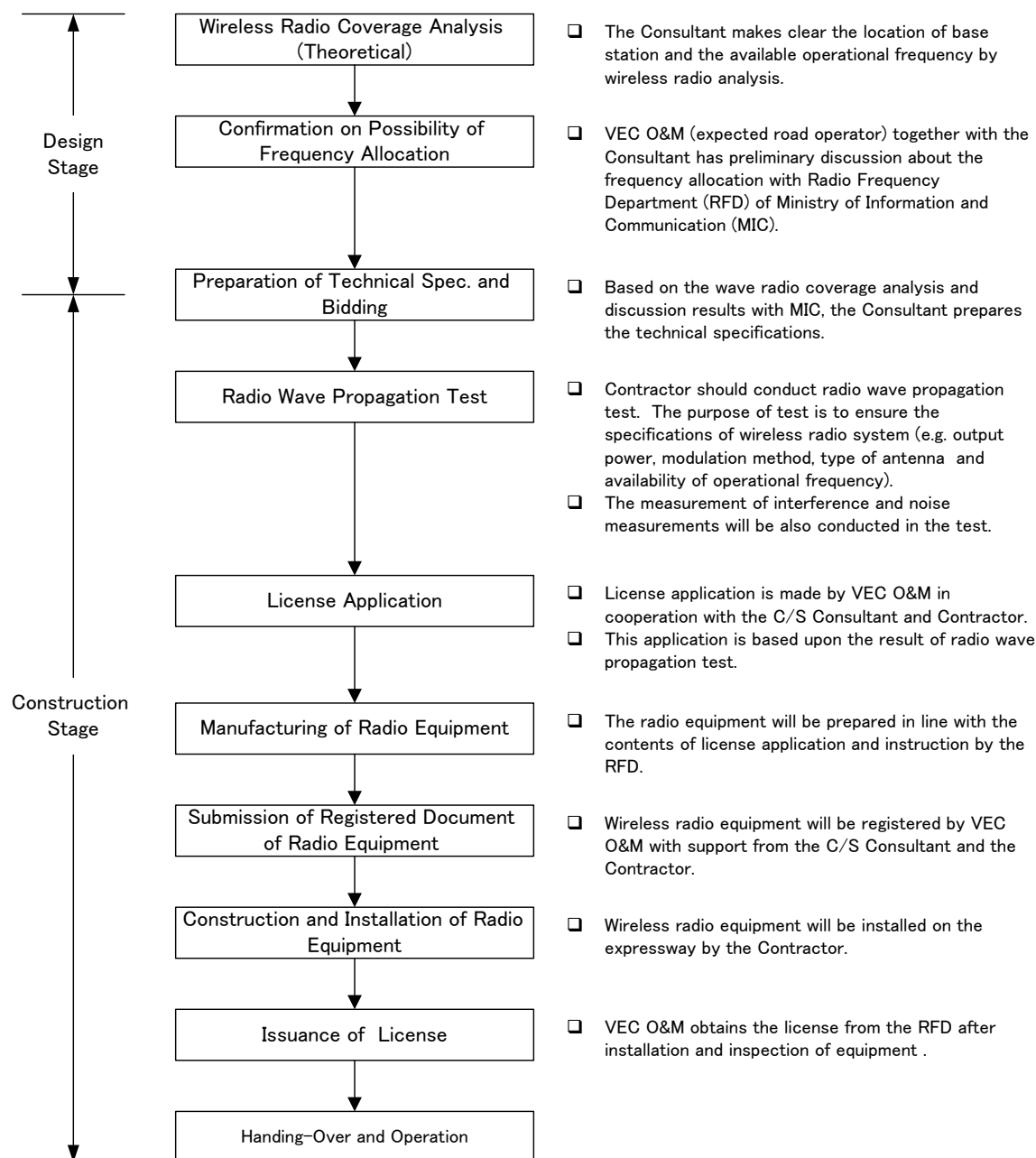


Source: Consultant

Figure 4-34 Wireless Radio System Configuration

(3) Proposed Procedures for Frequency Allocation

The procedures, in-charge units and contents related to registration and obtaining permission for frequency allocation are proposed as figure below.



Source: Consultant

Figure 4-35 Proposed Procedures for Frequency Allocation

The possibility of frequency allocation shall be preliminary discussed with the Radio Frequency Department (RFD) belonging to the Ministry of Information and Communication (MIC) in the design stage in order to prepare feasible and appropriate design and bidding documents. It is expected that VEC O&M, who will be expressway operator and become radio licensee, commence to discuss with the RFD about the frequency allocation with the assistance from the Consultant as early as possible.

(4) Application of VNPT Communication Service

Vietnam Posts and Telecommunications (VNPT) currently provides group calling services. Using the services of VNPT instead of exclusive wireless radio system will have some benefits such as low investment costs and no need procedures to register frequency. However, considering reliability and convenience of the services, the Consultant recommends individual frequency for the wireless radio system with following reasons;

- In case of traffic incident or natural disaster, the mobile radio is an effective tool to maintain communication between the patrol crews with each other and with the main management

center. Such incidents often go together with traffic jams; therefore, at the same time, Base Transceiver Station for mobile phone will make multiple calls. In this case, network congestion is likely to occur and it is possibility of communications interruption.

- Mobile phones will not ensure watertight requirements to operate on the expressway in bad weather conditions.

4.4.5 Internal Telephone System

Internal telephone system over VoIP technology will be provided for voice communication between the personnel at the offices. The system will be also connected to the Public Switched Telephone Network (PSTN) for the communication with public. The system will consist of IP telephone sets at offices and an IP based private branch exchange (IP-PBX) at the main management center. IP-PBX will control centrally all telephone sets.

IP-PBX shall have the capacity to handle the number of telephone sets as shown in table below.

Table 4-39 Number of Internal Telephone

No.	Location	Number of Telephone Sets		Remarks
		Proposed	Future Demand	
1	Da Nang Main Management Center	50	200	
2	Management Offices	20 x 2	50 x 2	
3	Toll Offices	10 x 8	30 x 8	
Total		170	540	

Source: Consultant

The capacity of IP-PBX shall be of minimum 600 ports. The system must also have the capacity of 20 PSTN lines.

4.4.6 Studies on Emergency Calling

In previous ITS studies for the DQE, the TEDI F/S proposes the utilization of emergency telephone system as emergency calling though the NK F/S recommends to use mobile phone instead of emergency telephone. Also, some ITS projects in Vietnam will introduce the emergency telephone system and the other projects will utilize mobile phone. In general terms, almost all persons currently own and utilize the mobile phone in Vietnam, and almost all expressway alignment is assumed within the coverage area of mobile communications. A driver can call to the police, the fire department, the ambulance or the main management center in case of the emergency by using his own mobile phone. Thus, it seems that necessity of emergency telephone system becomes lower.

In this section, method of emergency calling system in the Project is studied and proposed.

(1) Survey on Mobile Carriers' Coverage

In order to clarify the mobile phone availability on the DQE, the Consultant preliminary carried out the coverage survey by using train passing thorough in parallel with DQE. The conditions and procedures of survey are;

- To prepare three (3) mobile phones with following three (3) major carrier's SIM card in Vietnam
 - Mobifone
 - Vinaphone
 - Viettel
- To check the intensity of mobile phone carrier's radio from train at every 1km. The phone to be used in the survey has 4-level indications of radio intensity.
- The survey is carried out two (2) times, i.e. one time going from Da Nang station to Quang

Ngai station and one time coming back to Da Nang station.

The survey results are summarized as table below.

Table 4-40 Mobile Coverage Survey Results

NO. CHECK POINT	STATION	TELEPHONE WAVE LEVEL						NO. CHECK POINT	STATION	TELEPHONE WAVE LEVEL					
		MOBIPHONE		VINAPHONE		VIETTEL				MOBIPHONE		VINAPHONE		VIETTEL	
		DQ > QN	QN > DQ	DQ > QN	QN > DQ	DQ > QN	QN > DQ			DQ > QN	QN > DQ	DQ > QN	QN > DQ	DQ > QN	QN > DQ
1	0+000	4	4	4	4	4	4	67	66+000	3	3	3	2	4	4
2	1+000	4	3	4	4	4	4	68	67+000	3	2	2	3	3	4
3	2+000	3	4	3	3	4	4	69	68+000	3	3	3	3	3	4
4	3+000	4	4	4	4	4	4	70	69+000	1	2	1	2	4	3
5	4+000	3	3	2	3	4	3	71	70+000	4	3	4	4	4	4
6	5+000	4	4	4	4	4	4	72	71+000	4	3	2	3	3	3
7	6+000	3	2	4	4	3	4	73	72+000	3	4	4	2	4	4
8	7+000	3	3	3	3	4	4	74	73+000	3	3	4	3	4	4
9	8+000	4	4	4	4	4	4	75	74+000	4	3	4	4	4	4
10	9+000	1	1	1	3	3	4	76	75+000	3	3	2	3	3	4
11	10+000	2	2	1	3	4	4	77	76+000	3	2	3	4	3	3
12	11+000	2	2	2	2	4	4	78	77+000	2	2	2	2	3	4
13	12+000	3	2	3	4	4	4	79	78+000	3	4	2	2	3	3
14	13+000	4	3	3	4	4	4	80	79+000	3	4	3	3	3	4
15	14+000	4	4	3	3	4	4	81	80+000	2	2	3	2	4	3
16	15+000	3	4	4	3	4	4	82	81+000	3	2	2	2	3	4
17	16+000	2	4	3	4	4	4	83	82+000	3	3	4	3	3	3
18	17+000	1	1	1	1	3	4	84	83+000	4	3	3	3	4	4
19	18+000	2	2	4	2	4	4	85	84+000	3	3	3	3	4	4
20	19+000	4	3	4	2	4	4	86	85+000	2	2	3	3	3	4
21	20+000	4	3	4	4	4	4	87	86+000	4	4	4	3	4	4
22	21+000	4	3	4	3	4	4	88	87+000	3	4	2	3	3	3
23	22+000	3	3	3	3	3	4	89	88+000	2	3	3	2	3	4
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27	26+000	1	2	3	4	2	3	93	92+000	3	2	1	1	3	3
28	27+000	4	3	4	3	4	3	94	93+000	1	3	2	3	3	3
29	28+000	4	3	4	3	4	4	95	94+000	3	4	4	4	3	4
30	29+000	4	3	4	2	4	4	96	95+000	4	4	4	4	3	4
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32	31+000	4	3	3	4	3	4	98	97+000	4	4	3	3	4	4
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35	34+000	2	2	2	2	3	4	101	100+000	3	3	3	4	3	3
36	35+000	2	2	2	2	2	4	102	101+000	2	3	3	4	3	4
37	36+000	2	3	3	3	2	3	103	102+000	2	2	2	3	4	4
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41	40+000	3	3	2	2	4	4	107	106+000	1	1	1	2	3	3
42	41+000	4	4	4	3	4	4	108	107+000	4	2	4	4	4	4
43	42+000	3	3	2	3	3	4	109	108+000	4	2	3	3	4	4
44	43+000	2	3	2	2	3	4	110	109+000	3	3	4	3	4	4
45	44+000	2	4	2	2	2	4	111	110+000	3	4	3	3	3	4
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48	47+000	4	4	3	4	4	4	114	113+000	4	3	2	3	3	3
49	48+000	4	4	3	3	3	4	115	114+000	2	3	1	3	4	4
50	49+000	4	3	3	3	3	4	116	115+000	4	3	3	3	4	4
51	50+000	4	4	4	3	4	4	117	116+000	4	4	3	3	4	4
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53	52+000	3	4	3	3	3	4	119	118+000	4	4	4	4	4	4
54	53+000	4	4	4	3	4	4	120	119+000	4	4	3	4	4	4
55	54+000	4	4	4	4	4	4	121	120+000	4	4	4	4	3	4
56	55+000	4	3	2	3	4	4	122	121+000	4	3	3	3	3	4
57	56+000	4	4	4	3	4	4	123	122+000	4	4	4	4	4	4
58	57+000	4	4	2	3	4	4	124	123+000	4	4	4	4	4	4
59	58+000	3	2	3	3	3	3	125	124+000	4	4	4	3	4	4
60	59+000	3	3	3	2	3	4	126	125+000	4	4	3	3	4	4
61	60+000	1	2	1	2	3	3	127	126+000	3	3	3	4	4	4
62	61+000	3	2	3	1	4	3	128	127+000	4	3	4	3	3	4
63	62+000	4	4	3	3	4	3	129	128+000	4	3	4	4	4	4
64	63+000	3	3	4	3	4	4	130	129+000	-	-	-	-	-	-
65	64+000	4	3	3	4	4	4	131	130+000	-	-	-	-	-	-
66	65+000	3	3	3	3	4	4	132	131+000	-	-	-	-	-	-

Source: Consultant

It is found out through the preliminary survey that all sections of DQE are within the coverage of 3 mobile phone carriers. The detailed survey on actual alignment of DQE will be carried out in later stage.

(2) Comparison of Emergency Calling System

Some alternatives are considered for emergency calling, alternative-1 is to utilize mobile phone, alternative-2 is using emergency telephone and alternative-3 is combined of mobile phone and emergency telephone. Table below shows the comparison of alternatives for emergency calling system.

Table 4-41 Comparison on Emergency Calling System

Item \ Type	Alternative-1 (Mobile Phone)	Alternative-2 (Emergency Telephone)	Alternative-3 (Mobile + Emergency Telephone)
1. Availability (Coverage)	Entire sections are within 3 carriers' mobile coverage	Available	Available
2. Mobility	Excellent (anywhere in coverage)	Limited (depend on interval of telephone)	Excellent
3. Location Identification	KM Post	Automatic identification by the system	Automatic identification by the system or KM Post
4. Initial Cost	-	1.6 million USD (1 km interval)	1.6 million USD (1 km interval)
5. Necessary Measures	<ul style="list-style-type: none"> - Collaborated response with 113, 114, 115 - Construct KM Post and sign board showing dial number of main center 	<ul style="list-style-type: none"> - Collaborated response with 113, 114, 115 (Police, firefighting and ambulance) 	Same as alternative-1 & 2
Recommendations	Recommended	Average	Average

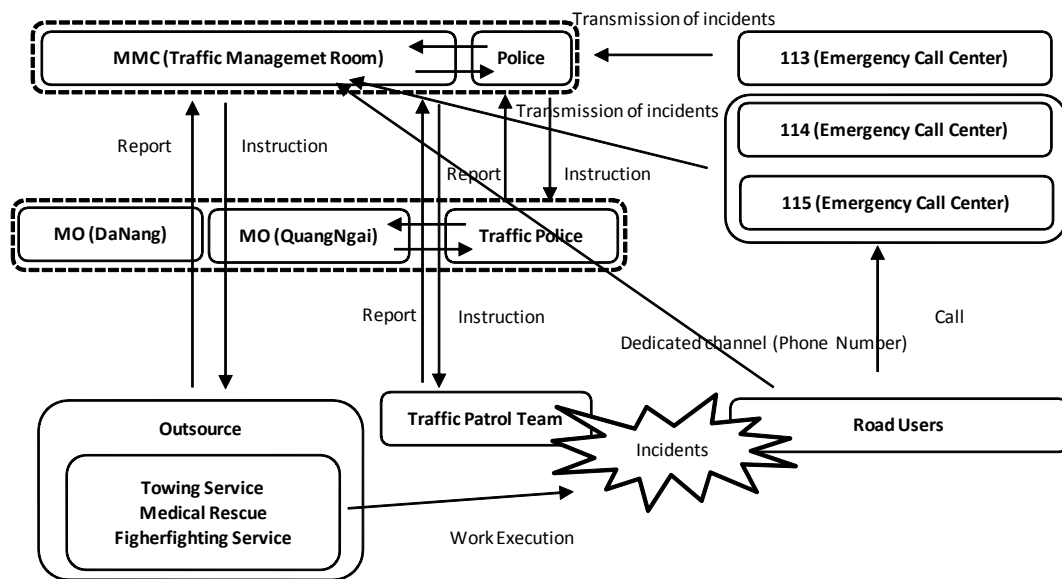
Source: Consultant

In the fact that all sections of DQE are within the coverage of mobile phone carriers, alternative-1 by using mobile phone is considered simplest and most economical alternative even though KM post to identify accident points and signboard showing dial number of main management center must be constructed. Though alternative-2 and alternative-3 using emergency telephone system can keep reliable emergency calling system, those alternatives require much higher cost than alternative-1. Thus, the Consultant proposes to utilize mobile phone as emergency calling means.

However, it must be noted that mobile phone wave may not reach to places except on earth segment, especially in tunnel section. Thus, it is recommended that emergency telephone shall be located in tunnel since it is one of most critical sections in the expressway.

(3) Proposed Emergency Response System

Following figure shows the emergency response system proposed in the O&M plan.



Source: Consultant

Figure 4-36 Proposed Emergency Response System

In the proposed O&M plan, the emergency call to the police (113), the ambulance (114) and the fire department (115) will be made through mobile phone and the calls to the main management center having dedicated phone dial will also be connected through mobile phone. In line with the O&M plan, the emergency telephone system on the expressway except tunnel section is not planned in initial stage. Instead of introduction of emergency telephone system, following measures are proposed to be implemented in the Project.

- Establish direct line with 113, 114 and 115 calling center of each municipality and Da Nang Main Management Center,
- Station traffic polices, ambulance staffs and firemen at the Main Management Center and Management Office for early emergency response,
- Procure and own vehicles required for emergency response activities such as ambulance car and fire-fighting vehicle,
- Construct KM post at interval of 100m to indentify the accident or incident location exactly, and
- Construct signboard to show the phone number of main management office.

4.5 Power Supply System Plan

4.5.1 Basic Conditions on Power Supply System

The power supply system for the DQE is planned to be fed from medium voltage distribution lines of 22 kV to supply road lighting and/or O&M building with commercial power. The receiving points of commercial power will be located at following places.

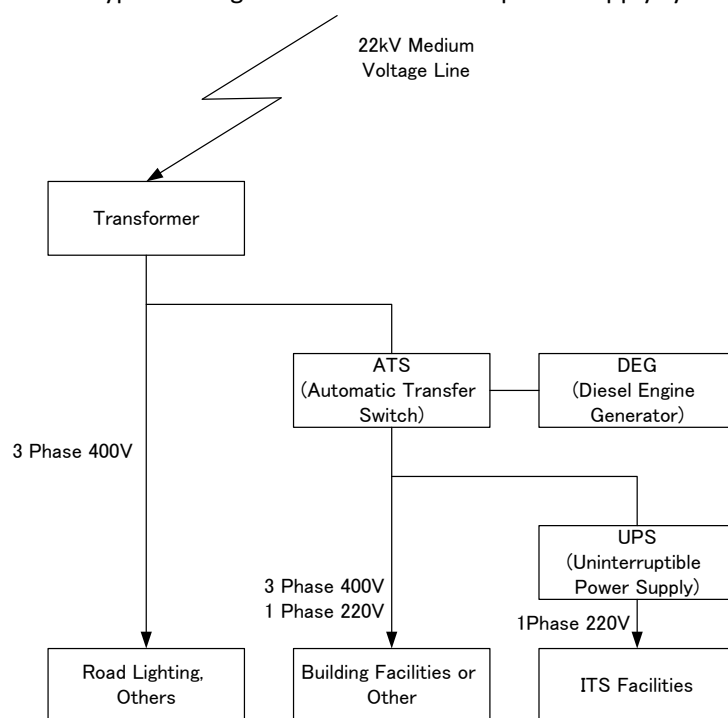
- Da Nang Main Management Center,
- Eight (8) management offices / toll offices,
- One (1) service area / two (2) parking areas,
- Tunnel entrance (north side), and
- Four (4) major bridges.

Almost all of ITS facilities except CCTV camera at the middle between interchanges will be located around the main management center, interchanges or tunnel. Thus, the commercial power with Diesel Engine Generator (DEG) and Uninterruptible Power Supply (UPS) backup are recommend as the power supply system for ITS facilities closely located at the power receiving points.

On the other hand, solar power supply system with backup battery is recommended for CCTV cameras installed at far from power receiving points, since CCTV camera are less power consumptions and it is costly if commercial power is received at each location.

4.5.2 Commercial Power Supply System

Figure below shows the typical configuration of commercial power supply system in the Project.



Source: Consultant

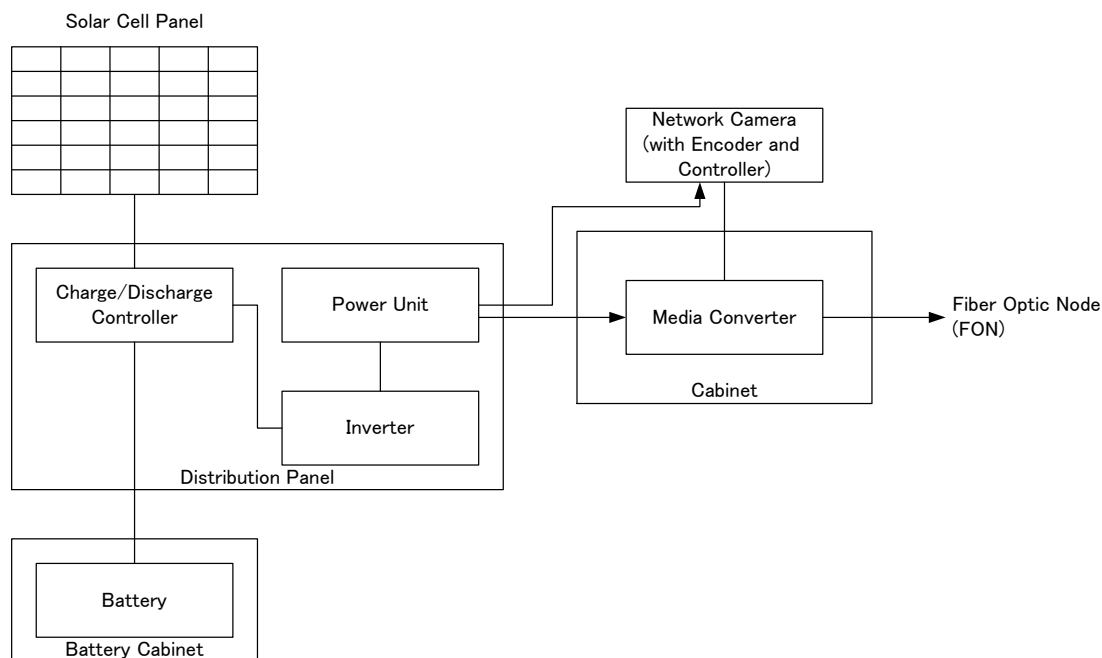
Figure 4-37 Typical Commercial Power Supply System Configuration

ITS facilities including toll collection system must operate even during power interruption of medium voltage distribution lines and maintenance works of power supply equipment. Therefore, the DEG will be required to supply power during long time power cut-off. To compensate short time power interruption during power changeover duration from commercial power to the DEG, the UPS must be provided in the commercial power supply system. The backup time period by DEG will be set as 24 hours and that of UPS will be 10 minutes respectively.

Required capacity of transformer, DEG and UPS will be estimated in consideration of other power demand loads such as road lighting, electrical facilities in O&M building, etc.

4.5.3 Solar Power Supply System

Figure below shows the typical configuration of CCTV roadside equipment by using solar power supply system.



Source: Consultant

Figure 4-38 Typical Solar Power Supply System Configuration

In order to supply power during the periods of insufficient solar radiation and night time, the solar power supply must comprise with solar cell panel, distribution panel including charger/discharger controller and inverter, and storage battery. The capacity of storage battery is highly depended on the expected non-sunshine days. If the non-sunshine days are set for long periods, power supply system has high reliability but it causes to enlarge battery capacity. Thus, 10 days backup periods for storage battery are recommended in consideration of balance between system reliability and cost effectiveness.

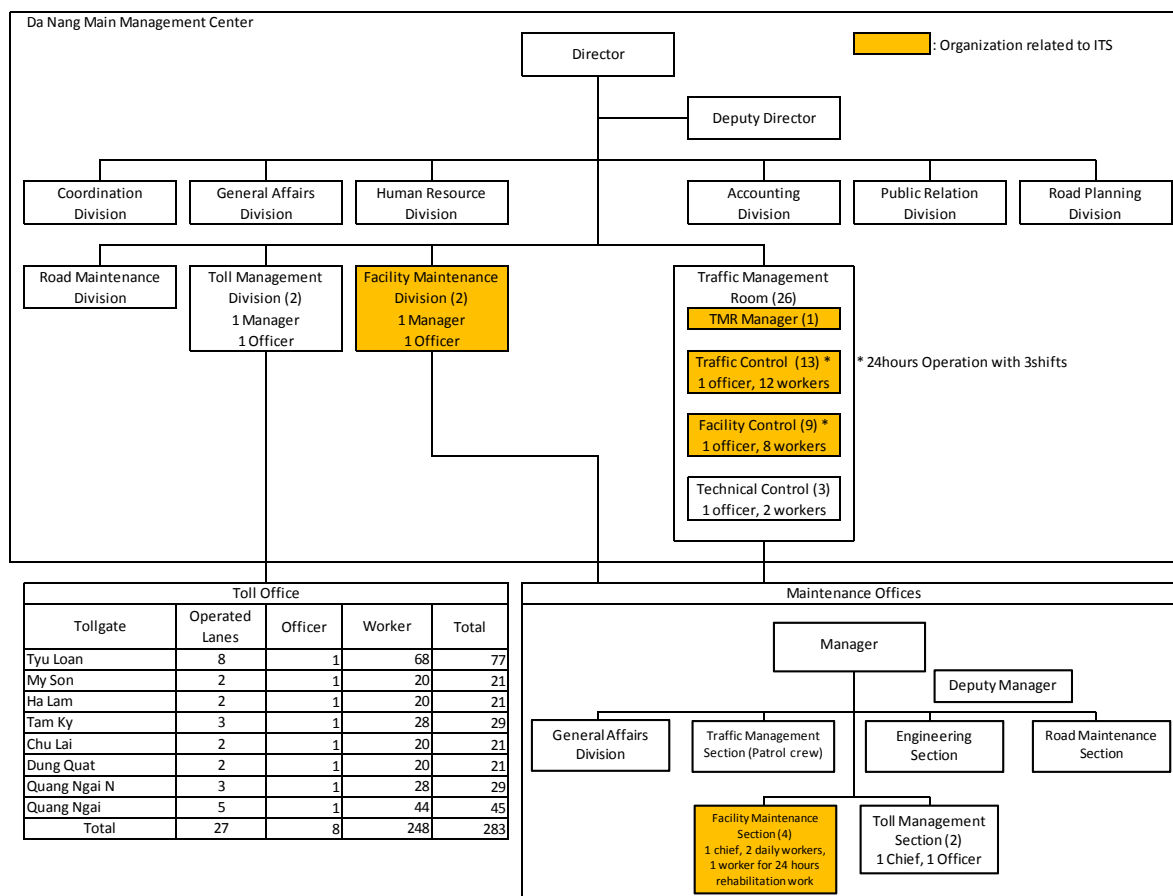
The required solar panel for CCTV camera is estimated around 270W (135W panel x 2) and the capacity of storage battery is calculated as 500AH based on the conditions listed below.

[Solar Panel Supply System Condition]

- Power Consumption: 30W (CCTV camera: 20W, Media converter: 10W)
- Non-sunshine Days: 10 days
- Circuit Voltage: DC 24V
- Type of Battery: Lead-acid battery (2.0V/cell)

4.6 Required Human Resources for ITS operation and maintenance

Human resources required for ITS operation and maintenance are proposed as **Figure 4-39** below.



Source: Consultant

Figure 4-39 Proposed Human Resources for ITS Operation

The required human resources for ITS operation and maintenance are marked yellow in the figure above. The facility maintenance division in Main Management Center has responsibility for facility maintenance planning and consists of one (1) manager and one (1) officer. The traffic management room is a place to install traffic management center system and consists of manager, traffic control section, facility control section and technical control section. The traffic control section is in charge of traffic monitoring and control of the expressway by utilizing traffic management center system. The facility control section is in charge of supervision of facility operational conditions and this division instructs facility management section of each maintenance office in case of any system failure. It is proposed that those two (2) sections in traffic management room are operated for 24 hour basis with three (3) working shifts.

The facility maintenance section in maintenance offices is in charge of actual ITS facility maintenance works based on the instruction from traffic management room. This section will be organized with one (1) manager, two (2) daily workers and one (1) worker for emergency rehabilitation works on 24 hours basis. The daily workers are in charge of daily maintenance and inspection of ITS or other facilities. The worker for 24 hours basis is basically stationed at home and in charge of emergency rehabilitation work for ITS facilities including toll collection system.

Proposed number of human resources for ITS operation and maintenance are total of 33 persons.

5 ITS Design

5.1 Closed Circuit Television (CCTV) Camera System

The CCTV camera system will be introduced in the Project in order to monitor road, traffic and weather conditions on the expressway visually.

The CCTV camera will be placed at merging and diverging points on main carriageway neighboring to interchange which is one of most accident prone areas in the expressway. The CCTV camera will be installed at same locations with traffic detector to effectively monitor actual traffic flows and abnormal conditions visually. Apart from these locations, the CCTV camera will be located at flood prone areas, deep cut sections and tunnel portal sites in order to confirm water logging situation, disaster situation or conditions around tunnel section by image.

The images taken by camera shall be transmitted to the MMC on real time basis. In the MMC, images are selectively shown on the monitor display of CCTV console and monitor screens. At the same time, images from all cameras shall be recorded on the storage device in Network Video Recorder (NVR). The system shall operate on a 24-hour a day 7-day a week basis. The CCTV camera system shall be IP based.

5.1.1 System Requirements

System requirements of the CCTV camera system are as follows.

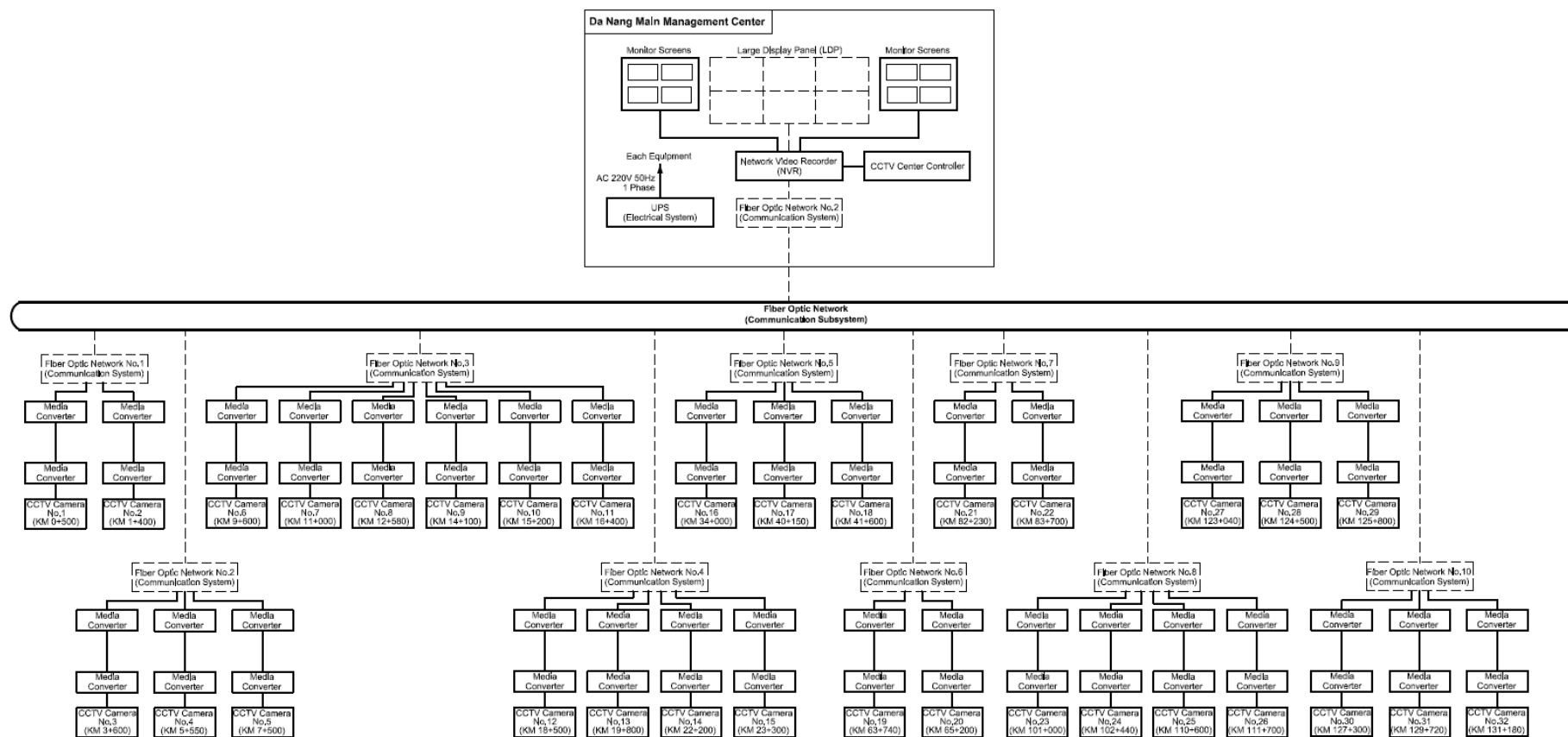
- The CCTV camera system shall collect real-time camera image from each CCTV camera located at roadside and can monitor and control the camera images in the MMC and MO.
- The CCTV camera shall be equipped with zoom and pan-tilt functions (PTZ functions) to secure wider area and longer distance coverage.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

5.1.2 System Configuration

The CCTV camera system shall consist of the following components;

- (1) CCTV camera with controller and supporting structure installed at roadside;
- (2) Network Video Recorder (NVR) in MMC;
- (3) CCTV center controller with application software in MMC;
- (4) Monitor screens in MMC;
- (5) Network equipment; and
- (6) Power supply equipment and peripherals.

A total of 33 cameras shall be provided in the Project. The CCTV camera system would be configured as figure below.



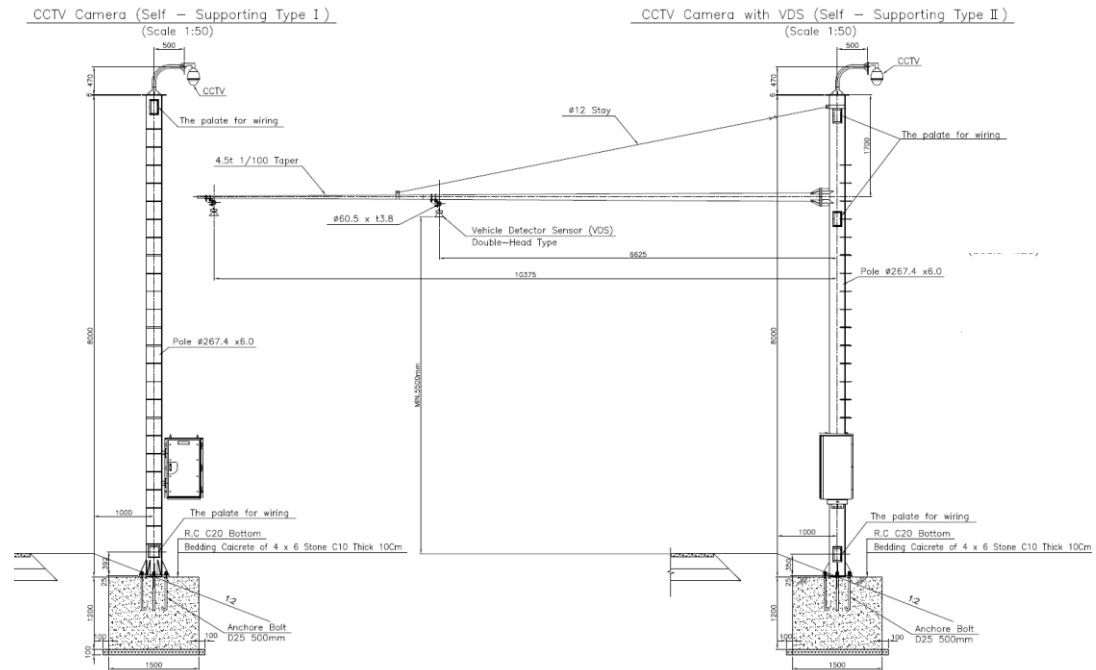
Source: Consultant

Figure 5-1 Configuration of CCTV Camera System

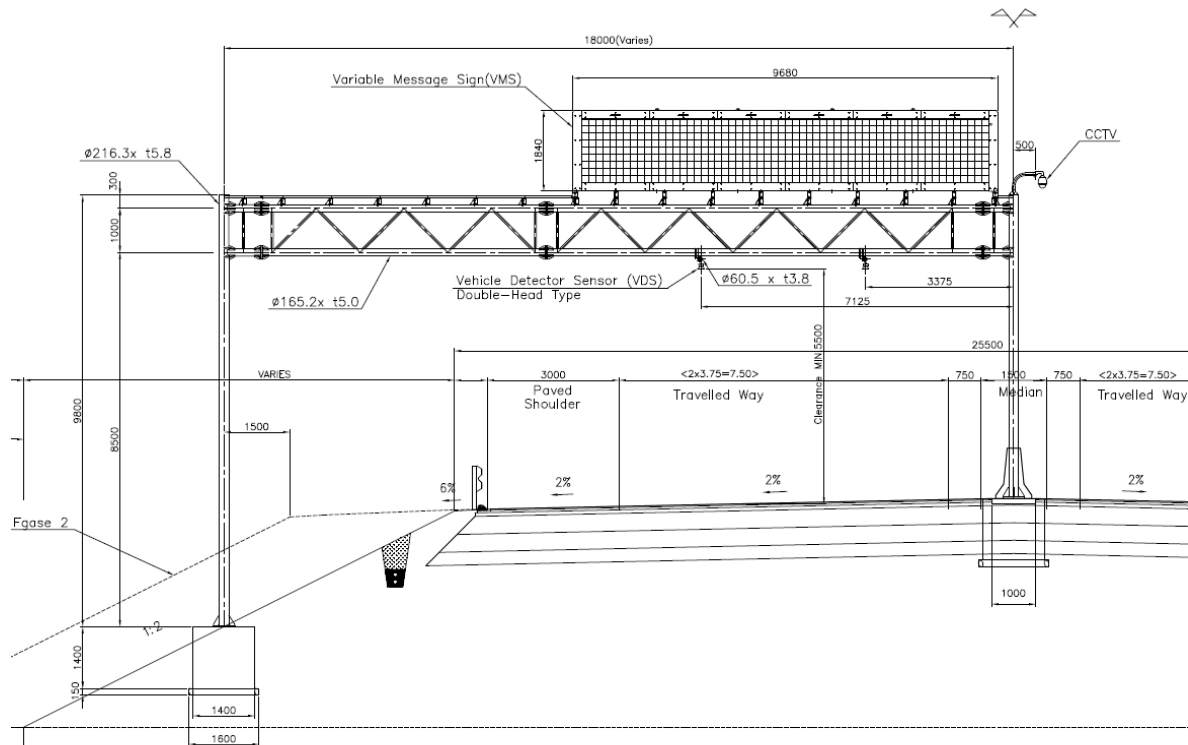
5.1.3 CCTV Camera Location and Installation

The CCTV camera shall be installed at the locations listed in **Table 4-4** above.

The camera shall be installed either on the top of gantry structure for VMS or on the individual pole as shown in figure below.



CCTV Camera Typical Installation (Self-supporting Type)



CCTV Camera Typical Installation (On Gantry Structure)

Source: Consultant

Figure 5-2 CCTV Camera Typical Installation

The CCTV camera on the VMS gantry structure will be basically placed at the median of road and the camera installed on the individual pole will be placed at road shoulder. Regardless of installation method, CCTV camera must be placed at the location where visibilities to both bounds on the road are kept as much as possible.

The individual pole must be equipped with steel ladder to ease the maintenance work of CCTV camera. In any installation cases, clearance of 5.5 meters from road surface shall be secured.

5.1.4 Specifications

(1) General

1) Power Supply

The electrical power supply system for the CCTV roadside equipment located closely to power receiving point will consist of AC commercial power with Diesel Engine Generator (DEG) and Uninterruptible Power Supply (UPS) backup system. The CCTV roadside equipment shall operate with AC single-phase two-wire system 220 V $\pm 10\%$ 50Hz.

The solar power supply system with backup battery will be provided for the power supply to CCTV roadside equipment to be located at far from power receiving points. The solar power supply system shall consist of solar cell panel, battery, distribution panel including charge/discharge controller, inverter and power units. The solar power supply system must be equipped with enough capacity of battery to supply power for a period of 10 days or longer in case of non-sunshine conditions. A total of 13 sets of solar power supply system shall be provided in the Project.

2) Communication

The image transmission of the CCTV camera system shall be made through the fiber optic network provided by communication system in this Project. The media converter shall be provided in the CCTV camera system to connect CCTV camera with nearest Fiber Optic Node (FON) of the fiber optic network. The live image compressed into H.264/MPEG-4 or M-JPEG format at CCTV roadside equipment shall be transmitted to the MMC.

(2) System Functions

CCTV system shall be provided with the functions described below.

1) Monitoring Function

The road and traffic conditions images taken by CCTV cameras on the expressway will be transmitted as video signal to the NVR at the MMC through the communication network. The CCTV center controller via the NVR shall be capable of selecting video signal from any CCTV camera to be displayed on the display monitor of the CCTV center controller console and monitor screens.

Sequential display function will be provided to the CCTV camera system. The sequential display function allows the video image from the multiple cameras to be sequentially displayed at a pre-set interval. It shall be possible to select the cameras for sequential display and to set the display time of the image from each camera.

Character generating function will be provided to the CCTV central equipment to superimpose camera location name over the video image.

The CCTV display monitor on the console and monitor screens will have multiple screen capability and shall display either one image or four images at a time. The image on the monitor screens shall be controlled by the CCTV center controller console.

2) PTZ Control Function

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

3) Image Recording and Retrieval

All images will be automatically recorded in the storage device of the NVR with camera ID and time stamp. Frame rate of the video signal can be reduced to one frame per second or minute to reduce the requirements for the storage capacity. Images will be stored for minimum one (1) week. The CCTV still image together with equipment operational status will be also stored in the storage server of NVR.

4) Data Storage Function

- All data transmitted from the CCTV roadside equipment and processed data in the MMC will be recorded and stored in the NVR for analysis and future usage. Data retrieval and presentation software will be provided that can easily retrieve and show the movie image and still image of the specified roadside equipment at the hour or day.
- Status of roadside equipment (normal or malfunctioned) will be recorded in the NVR as operation log and for future reliability analysis together with error code and time stamp. The equipment status information will be transferred to facility management server of traffic management center system.

Sub-system \ Data	Storage Data	Type	Storage Period
CCTV camera system	CCTV video image	Raw Data	3 days
	CCTV still image	Raw data	2 years
	Equipment operational status	Raw data	

5) Diagnosis

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

The CCTV center controller and the NVR will also have self diagnosis function of the server.

6) Display and Reporting Functions

- The CCTV center controller will be capable of showing the following screens:

Item	Contents
Route map	<ul style="list-style-type: none"> Schematic road map of DQE Name and station number of interchanges and toll barriers
Equipment location and status	<ul style="list-style-type: none"> Location of CCTV cameras and location of selected camera Status of CCTV cameras
CCTV video image	<ul style="list-style-type: none"> Video image from the CCTV camera selected with camera ID Video image from the video recorder with camera ID, date and time Video image from the CCTV camera selected with camera ID and event data such as traffic congestion received from the traffic management system server
Error log	<ul style="list-style-type: none"> Error record
Date and Time	<ul style="list-style-type: none"> Current date and time

- The CCTV center controller will produce the reports listed below. The reports shall be output according to the schedule or upon the system operator's request by the CCTV center

controller consol. It shall be possible to output the report as a file in portable document file format:

Item	Contents
Error log	<ul style="list-style-type: none"> List of CCTV camera currently not in operation Error record

(3) Technical Specifications

Followings are outline of technical specifications on CCTV camera system. Detailed technical specifications are described in **Appendix-3** of this report.

1) CCTV Camera with controller

The CCTV camera shall be housed in a camera housing which is rugged and withstand adverse weather conditions. The camera housing shall be electrically and mechanically robust and shall have a degree of protection of IP 65.

No.	Item	Specifications
1.	Imaging Device	CCD or CMOS
2.	Effective Pixels	768 (H) x 494 (V) or more
3.	Scanning area	3.59 mm (H) x 2.70 mm (V) or larger
4.	Resolution	VGA: 640 x 480, QVGA: 320 x 240
5.	Minimum illuminance	0.5 lx (color), 0.1 lx (white/black mode) or lower
6.	Video S/N ratio	50 dB or more
7.	Pan driving range	360 degree endless turning, maximum speed 120 deg./sec or more
8.	Tilt driving range	+5 (upward) to -90 (downward) degree or more, maximum speed 120 deg./sec or more
9.	Lens Type	Autofocus lens
10.	Zoom Factor	Optical 30x/ digital 10x or more
11.	Focal length	3.8 to 114 mm or longer
12.	Iris	Auto
13.	Compression system	JPEG, MPEG-4/H.264
14.	Line bit rate	64 / 128 / 256 / 512 / 1024 / 2048 / 4096 kbps
15.	Protocol	TCP/IP, UDP/IP, HTTP, RTP, FTP, SMTP, DHCP, DNS, DDNS, NTP, SNMP
16.	FTP client	Alarm image transmission, FTP periodical transmission
17.	Image distribution	MPEG-4/ H.264: Uni-cast/ multi-cast JPEG: Pull/push
18.	Frame rate	0.1 fps – 30 fps
19.	LAN interface	10 BASE-T/100BASE-TX (RJ-45) x 1port
20.	Network interface	100Base-FX (SC) x 2ports or less (10km)
21.	Power Consumption	50 VA or less
22.	Input Voltage	AC 220V±10%, 50Hz or DC 24 V
23.	Ambient operating temperature	0 - 50 degree Celsius
24.	Reliability and maintainability	MTBF: 30,000 hours MTTR: 1.0 hour

2) Solar Power Supply System

No.	Item	Specifications
1.	Solar battery cells	
(1)	Type	Silicone mono-crystalline or multi-crystalline, water

		proof, moisture proof
(2)	Capacity	To be proposed by the Contractor depending on power consumption of CCTV Camera
(3)	Converting power efficiency from solar energy	- 14 % or more in cell base - 10 % or more in module base
(4)	Withstand voltage	2 kV - 1 minute
2.	Array structure or small module structure	To be provided for adjusting tilting angle of solar battery cell
3.	Control panel	
(1)	Type	A metal enclosure
(2)	Function	- Over-charging and discharging protection scheme for the storage battery - Metering scheme (e.g., solar battery open circuit voltage, solar battery short circuit current, storage battery charging/discharging current, storage battery voltage, etc.) - Obstruction scheme for counter-current from storage battery to solar battery (Suitable reserve current blocking diode having small voltage drop shall be applied) - Circuit protection scheme with molded case circuit breaker etc. - Fault indication and status indication scheme (i.e. fault emitting diode (LED) instead of lamp shall be utilized to save power consumption).
4.	Ambient operating humidity	
(1)	Type	Lead-acid battery
(2)	Capacity	To be equipped with enough capacity to supply power for a period of 10 days or longer in case of non-sunshine conditions
(3)	Circuit voltage	DC 24V

3) Network Video Recorder (NVR)

NVR shall have following functions.

- To select any camera image to be displayed on monitor screen
- To receive camera control signal from CCTV center controller and send it to the CCTV camera
- To generate character to indicate camera location over the video image
- To record the video image from any of the camera with suitable storage capacity
- To capture CCTV camera images as still picture
- To encode the video image into suitable format to monitor it on the large display panel and monitoring screens

The NVR shall be standard models manufactured by organizations of international repute.

4) CCTV Center Controller

CCTV center controller shall have various control functions including camera selection, PTZ control, monitor TV control and video control, etc as listed below through operator console.

- Camera selection and display functions with sequential image display,
- Pan-tilt-zoom control function including pre-set camera position setting function,
- Monitor screen control function,

- Image recording and retrieval functions through NVR,
- CCTV camera status monitoring and diagnosis function,
- System status and operational log reporting function

The operator console shall be of PC type. The CCTV center controller and console shall be standard models manufactured by organizations of international repute.

The camera controller keyboard will have the following features:

- Pan, tilt, and zoom control of camera
- 3-D Joystick to control PTZ
- Digital video recorder control
- Video switches control
- RS-232, RS-422, RS-485, or Ethernet interface

5.2 Vehicle Detector System

The vehicle detector system will be introduced in the Project to measure and analyze the traffic flow on the expressway.

The vehicle detector roadside equipment will detect, count and classify vehicles within its sensing area. The traffic flow parameters measured by the vehicle detector roadside equipment will be transmitted to the traffic analysis processor in the Main Management Center (MMC). The system shall operate on a 24-hour a day 7-day a week basis.

5.2.1 System Requirements

System requirements of the vehicle detector system are as follows.

- The vehicle detector system shall measure and analyze following traffic information. Unit duration of measurement, detection and calculation shall be within one (1) minute.
 - Traffic Volume
 - Large-sized Vehicle Traffic
 - Vehicle Speed
 - Traffic Congestion
- The vehicle detector system shall measure both inbound/outbound traffic volumes on the expressway between interchanges. Also, the system shall measure each lane traffic volume.
- The vehicle detector system must measure and detect required traffic information above even under complex traffic and road conditions on the expressway.
- The measured traffic data can be monitored in the MMC, which will be organized by expressway planning agencies, expressway operators and traffic polices, on real-time basis. Also, the data can be stored for a certain period in order to utilize for road planning and road operation and maintenance activities.
- The traffic information measured and analyzed by the vehicle detector system can be provided road users through Variable Message Sign (VMS) System and other information provision systems.
- The vehicle detector roadside equipment can be easily installed at roadside and shall have advantages in its operation and maintenance. The maintenance work on the carriageway for the vehicle detector must be avoided.
- An ultrasonic type vehicle detector shall be adopted in the Project. Two (2) sets of detector for each lane shall be installed to identify the large-sized vehicle.

- The detector will be either mounted on the dedicated pole installed at road shoulder or on the gantry structure together with VMS and CCTV camera.
- The detection target shall be vehicles passing through the sensor area at a speed not less than 1 km/h and not more than 120 km/h.
- The vehicle detector system shall detect the large-sized vehicle of which length is 5.5 meters or longer.

5.2.2 System Configuration

The vehicle detector system shall consist of the following equipment;

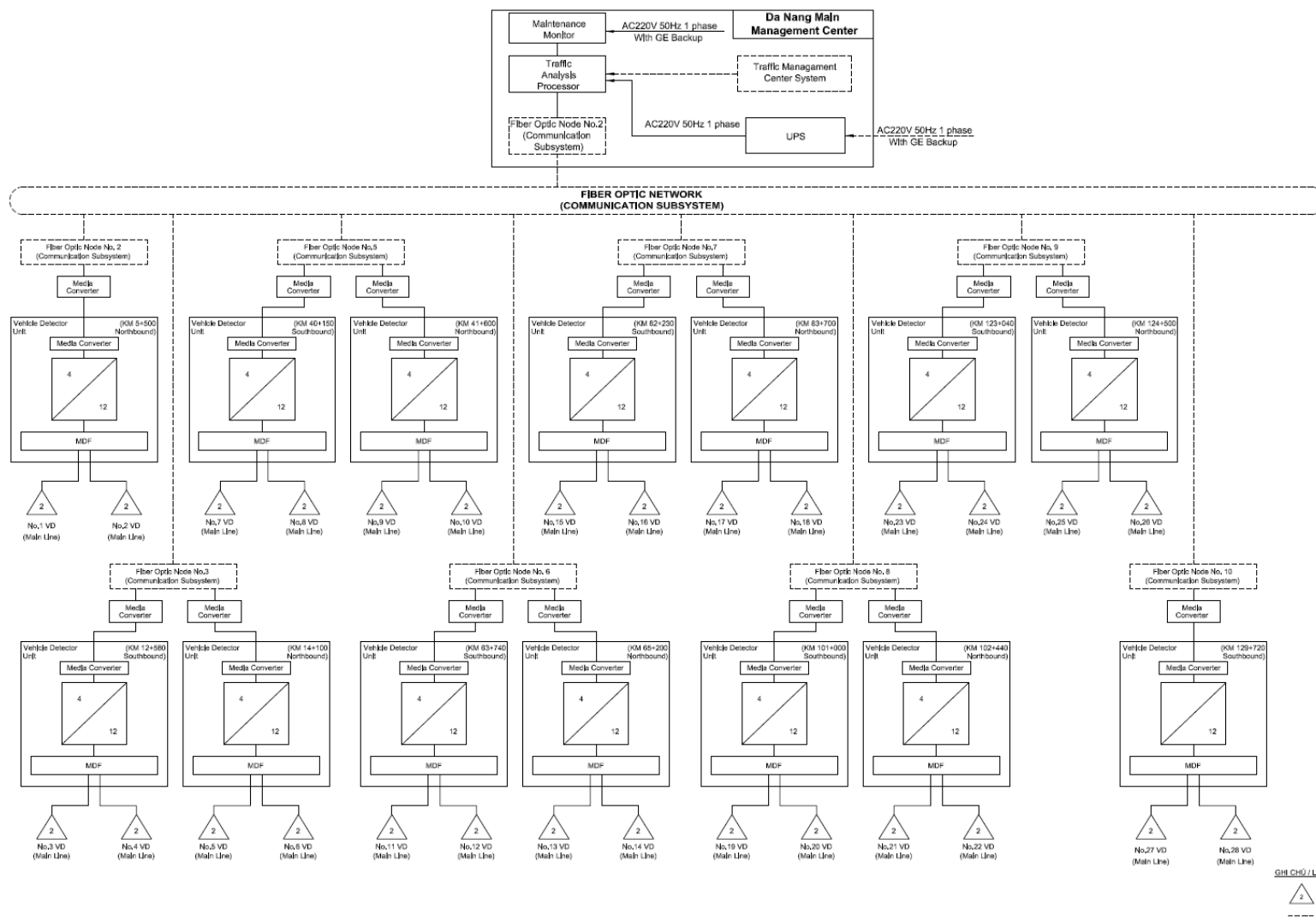
- (1) Ultrasonic type detector and vehicle detector unit with supporting structure at roadside;
- (2) Traffic analysis processor installed in the MMC;
- (3) Network equipment;
- (4) Power supply unit and peripheral.

The vehicle detector roadside equipment shall be placed at 14 locations in the Project. The vehicle detector system would be configured as **Figure 5-3** below.

5.2.3 Vehicle Detector Location and Installation

The vehicle detector roadside equipment will be installed at the locations listed in **Table 4-7** above.

The vehicle detector shall be installed either on a supporting steel pole together with CCTV camera or on a gantry structure for VMS as shown in **Figure 5-2**. The vehicle detectors for each lane detection shall be basically put on same supporting steel pole or gantry structure. The supporting steel pole and gantry structure must be equipped with steel ladder to ease the maintenance work of vehicle detector. In any installation cases, clearance of 5.5 meters from road surface shall be secured.



Source: Consultant

Figure 5-3 Configuration of Vehicle Detector System

5.2.4 Specifications

(1) General

1) Power Supply

The electrical power supply system for the vehicle detector roadside equipment and the traffic analysis processor in the MMC will consist of AC commercial power with Diesel Engine Generator (DEG) and Uninterruptible Power Supply (UPS) backup system. The roadside equipment and traffic analysis processor shall operate with AC single-phase two-wire system 220 V \pm 10% 50Hz.

2) Communication

The data transmission of the vehicle detector system shall be made through the fiber optic network provided by communication system. The media converter, which will be provided in the CCTV camera system, will be used to connect vehicle detector unit with nearest Fiber Optic Node (FON) of the fiber optic network.

(2) System Functions

The vehicle detector system shall be provided with the functions described below.

1) Traffic data measuring and processing functions at roadside

- The vehicle detector shall continuously transmit ultrasonic waves and receive the waves reflected from objects or the road surface to detect vehicles passing.
- Signals generated by the vehicle detector shall be processed to obtain the required traffic data in the vehicle detector unit. The processing unit shall be capable of:
 - Detecting vehicle running under the detector:
 - Counting the number of vehicles that pass the sensing area during the unit measurement time on a lane basis.
 - Classifying the vehicle into large and small size. The definition of the large and small size shall be made according to the vehicle length and the classification parameter shall be adjustable.
 - Calculating the time occupancy rate per unit measurement time.
 - Calculating an average speed per unit time which is an average of the speed of vehicles passed in the past unit measurement time.
- The system shall detect vehicles, measure and calculate the required traffic data above separately for each lane.
- Unit duration of detection, measurement and calculation shall be within one (1) minute.
- The vehicle detector system is expected to have an overall detection accuracy of 95 % or better in vehicle counting for any types of vehicles to pass the road except vehicles running in the opposite direction and completely hidden vehicles owing to overlapping.

2) Data Transmitting Function

- Following data pre-processed at roadside shall be periodically transmitted to the traffic analysis processor installed in the MMC.
 - Traffic volumes in every 1 minute
 - Large-sized vehicle traffic in every 1 minute
 - Time occupancy rate in every 1 minute
 - Vehicle average speed in every 1 minute
 - Equipment failure
 - Other necessary data

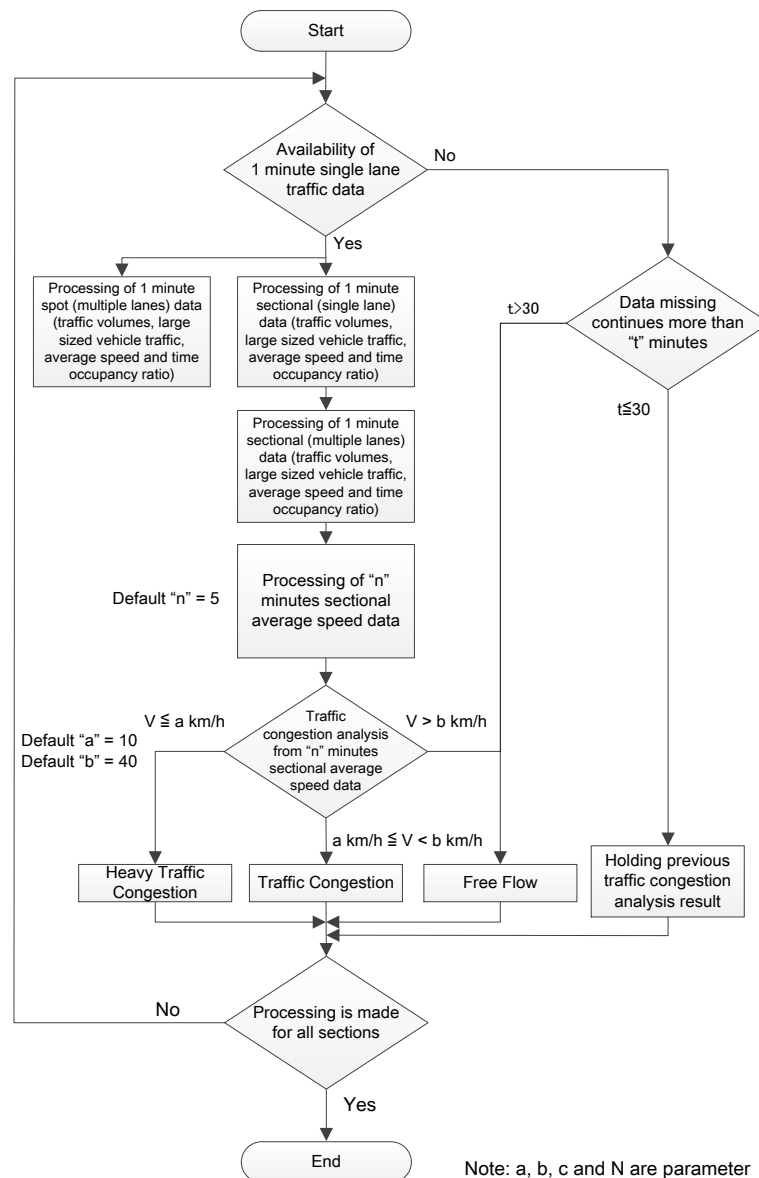
- Unit time period of data transmitting shall be of one (1) minutes.

3) Data Collecting Function

- The traffic analysis processor shall collect the data from the vehicle detector roadside equipment at the unit measurement interval above. The unit measurement time shall be a system parameter and shall be adjustable.
- Should traffic data collected be lower or higher than the predetermined threshold, the traffic analysis processor shall issue an alarm to the monitor display as abnormal transmitted data.

4) Data Processing and Management Functions

- The traffic analysis processor shall process the traffic data collected from the vehicle detector roadside equipment and identify the traffic congested section from average speed and time occupancy ratio data with following processing flow and algorism or equivalent.



Source: Consultant

Figure 5-4 Traffic Data Processing and Congestion Analysis Flow and Algorism

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

- To avoid the fluctuation of analysis results, the average speed data for certain period (n) must be utilized in the processing. The default of the time period is initially set as five (5) minutes and this value must be changeable.
- The analysis result is classified into three (3) traffic congestion levels, that is, "Heavy Traffic Congestion", "Traffic Congestion" and "Free Flow". The thresholds of traffic congestion level, "a" and "b" are tentatively set as 10km/h and 40km/h respectively in initial stage. Also, those thresholds must be variable and determinable by each location since average speed may differ according to the road conditions, alignment, etc. at the site and would be optimized in future after collecting the enough volumes of traffic data.
- In case any data are not available from the vehicle detector roadside equipment, previous analysis result has been held for 30 minutes. If the absence of data continues more than 30 minutes, previous data is reset and the traffic is processed as "Free Flow".

The algorithm for traffic congestion analysis shown above are tentative and the Contractor shall examine and propose the algorithm in detail.

- If the processed at a lane or a section is lower or higher than the predetermined threshold, the server shall issue an alarm to the monitor display as abnormal traffic condition.
- The (n)-minute traffic flow data shall be accumulated and converted to hourly traffic data.
- It shall be possible to monitor in real-time traffic flow data through monitor display of operation console and printed report. Traffic flow data of single and multiple lanes can be specified for monitoring. Both numerical and graphical presentation of the data shall be provided. The data on the display shall be automatically updated at unit time of data. Real-time monitoring of operating condition of vehicle detector roadside equipment shall also be possible.
- The occupancy rate to be detected in the vehicle detector system will be as reference only. It is generally said that the accuracy of traffic congestion analysis processing can be improved by utilizing both average speed and occupancy data.

5) Data Storage Function

- All data transmitted from the vehicle detector roadside equipment and processed data in the MMC shall be recorded and stored in the traffic analysis processor for analysis and future usage. Data retrieval and presentation software shall be provided that can easily retrieve and show the traffic flow data and operating condition of the specified roadside equipment location at the specified time, hour or day. Graphical presentation of historical traffic flow data such as hourly variation and daily variation shall also be possible.
- Status of roadside equipment (normal or malfunctioned) shall be recorded in the traffic analysis processor as operation log and for future reliability analysis together with error code and time stamp.

Data Sub-system		Storage Data		Type	Storage Period
Vehicle Detection system	1 minute spot (single lane) data	Traffic volume		Raw data	2 years
		Large-sized vehicle traffic			
		Time occupancy rate			
		Vehicle average speed			
	Equipment operational status			Raw data	
	1 minute spot (multiple lanes) data	Traffic volume		Processed data	
		Large-sized vehicle traffic			
		Time occupancy rate			
		Vehicle average speed			

Data Sub-system	Storage Data	Type	Storage Period
	1 minute sectional (single lane) data	Traffic volume	Processed data
		Large-sized vehicle traffic	
		Time occupancy rate	
		Vehicle average speed	
	1 minute sectional (multiple lanes) data	Traffic volume	
		Large-sized vehicle traffic	
		Time occupancy rate	
		Vehicle average speed	
	"n" minutes sectional average speed		Processed data
	Traffic congestion analysis results with parameters		Processed data

6) Diagnosis Function

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

7) Display and Reporting Function

- The traffic analysis processor shall be capable of showing the following screens:

Item	Contents
Route map	<ul style="list-style-type: none"> • Schematic road map of DQE • Name and station number of interchanges and toll barriers
Equipment location and status	<ul style="list-style-type: none"> • Location of vehicle detector roadside equipment and its status (normal / error)
Traffic conditions	<ul style="list-style-type: none"> • Current traffic volume at vehicle detector location (total traffic volume and large-sized vehicle traffic volume) • Current average speed in list and in map • Current traffic congested section in list and in map • Hourly traffic volume variation (text and in graphics) • Hourly average speed variation (text and in graphics)
Operation log	<ul style="list-style-type: none"> • List of roadside equipment currently not in operation • Error record
Date and Time	<ul style="list-style-type: none"> • Current date and time

- The processor shall produce the reports listed below. The reports shall be output according to the schedule or upon the system operator's request. It shall be possible to output the report as a file in portable document file format:

Item	Contents
Traffic volume	<ul style="list-style-type: none"> • Daily report containing hourly sectional traffic volume by vehicle class • Daily report containing hourly sectional average speed • Monthly report containing daily sectional traffic volume by vehicle class and that of the day of the week • Monthly report containing daily sectional average speed and that of the day of the week
Error log	<ul style="list-style-type: none"> • List of roadside equipment currently not in operation • Error record

8) Display and Reporting Function

Following data processed in the traffic analysis processor shall be stored in the database of traffic management center system for total system management at interval of 5 minutes.

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

(3) Technical Specifications

Followings are outline of technical specifications on vehicle detector system. Detailed technical specifications are described in **Appendix-3** of this report.

1) Vehicle Detector Roadside Equipment

The vehicle detector roadside equipment shall be connected to the traffic analysis processor located in the MMC.

The vehicle detector shall be housed in a detector housing which is rugged and withstand adverse weather conditions. The detector housing shall be electrically and mechanically robust and shall have a degree of protection of IP66 or higher. The vehicle detector unit shall be housed in a cabinet together with power supply unit. The cabinet shall have a degree of protection of IP 55 or higher. The data transmission of vehicle detector roadside equipment with the traffic analysis processor in the MMC shall be made through network equipment provided by the CCTV camera system.

The technical specifications for vehicle detector roadside equipment mentioned hereunder are minimum guidelines.

No.	Item	Specifications
1.	Power Requirements	Input voltage: 220 V \pm 10% AC, 50Hz
2.	Power Consumption	500 VA or less
3.	Type of Detector	Ultrasonic type detector
4.	Vehicle Speed	0 - 120 km/h or better
5.	Detection Area	1 +/- 0.4 m/sensor or equivalent
6.	Wave Transmitting Cycle	60ms +/- 5ms or equivalent
7.	Half - value Angle	11.5 +/- 2 degrees or less
8.	Detector Dimensions	ϕ 160mm
9.	LAN Interface	10BASE-T/100BASE-TX (RJ-45) x 1port
10.	Environmental conditions	0 to +50 degree Celsius
11.	Reliability and maintainability	MTBF: 30,000 hours MTTR: 0.5 hours

2) Traffic Analysis Processor

Transmitted data from traffic detector unit shall be processed, analyzed, stored and retrieved by

traffic analysis processor. Followings are minimum required functions of the processor.

- Data reception
- Error checking
- Data accumulation and averaging (Sectional data, Hourly data and Daily data)
- Congestion and incident detection
- Reporting and display
- Transferring the processed data to the Traffic Management System Server

The traffic analysis processor shall be standard models manufactured by organizations of international repute.

5.3 Meteorological Monitoring (MET) System

The MET system will be introduced in the Project to recognize weather conditions on the expressway and take appropriate countermeasures in bad weather conditions.

The MET system shall collect weather condition data at the meteorological observation stations continuously. The data collected shall be transmitted to the MET data processor at the Main Management Center (MMC) for data processing and logging. In case of adverse weather, the system shall automatically issue an alarm to the system operator.

5.3.1 System Requirements

System Requirements of the MET system are as follows.

- The system shall measure and analyze following weather information. Unit duration of measurement, detection and calculation shall be within one (1) minute.
 - Rainfall (detection and level)
 - Air temperature
 - Wind velocity and direction
 - Visibility
- The system shall measure and analyze meteorological data covering entire expressway.
- The measured meteorological data can be monitored in the MMC, which will be organized by expressway planning agencies, expressway operators and traffic polices, on real-time basis. Also, the data can be stored for a certain period in order to utilize as weather statistics.
- The weather and its alerting information detected and measured by the system can be provided road users through the VMS system and other information provision systems.
- The meteorological monitoring sensors can be easily installed at roadside and shall have advantages in its operation and maintenance. All of meteorological monitoring sensors will be put on a supporting steel pole together.
- The meteorological monitoring sensors shall be placed in the yard of MMC, Management Office (MO) or Toll Office (TO) having enough distance from carriage way or buildings to avoid obstacles or negative impacts for measurements.

5.3.2 System Configuration

The MET system shall consist of the following components:

- (1) Rain gauge;
- (2) Rainfall detector;

- (3) Thermometer;
- (4) Vane anemometer;
- (5) Visibility meter;
- (6) Data logger at MET observation station;
- (7) MET data processor in the MMC;
- (8) Network equipment;
- (9) Power supply equipment and peripheral.

There will be a total of three (3) MET observation stations. The MET data processor will be provided to the MMC for receiving all MET data. IP based network equipment will be provided to connect the MET observation stations with the MET data processor at the MMC.

The MET system would be configured as **Figure 5-5** below.

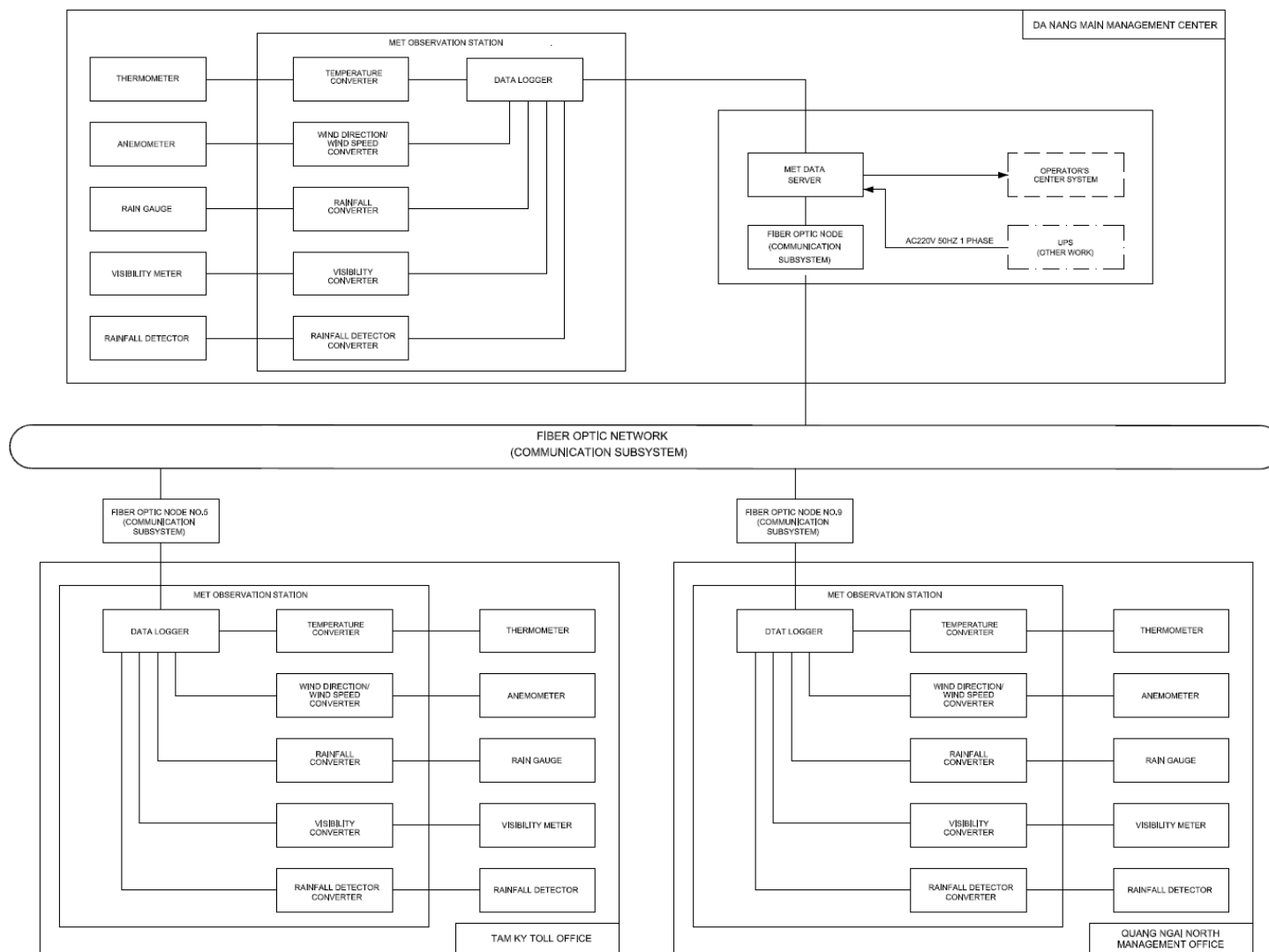
5.3.3 Location and Installation of MET Observation Station

The MET observation station will be established at the Da Nang MMC, Quang Ngai North MO and Tam Ky TO.

The MET roadside equipment shall be installed as follows:

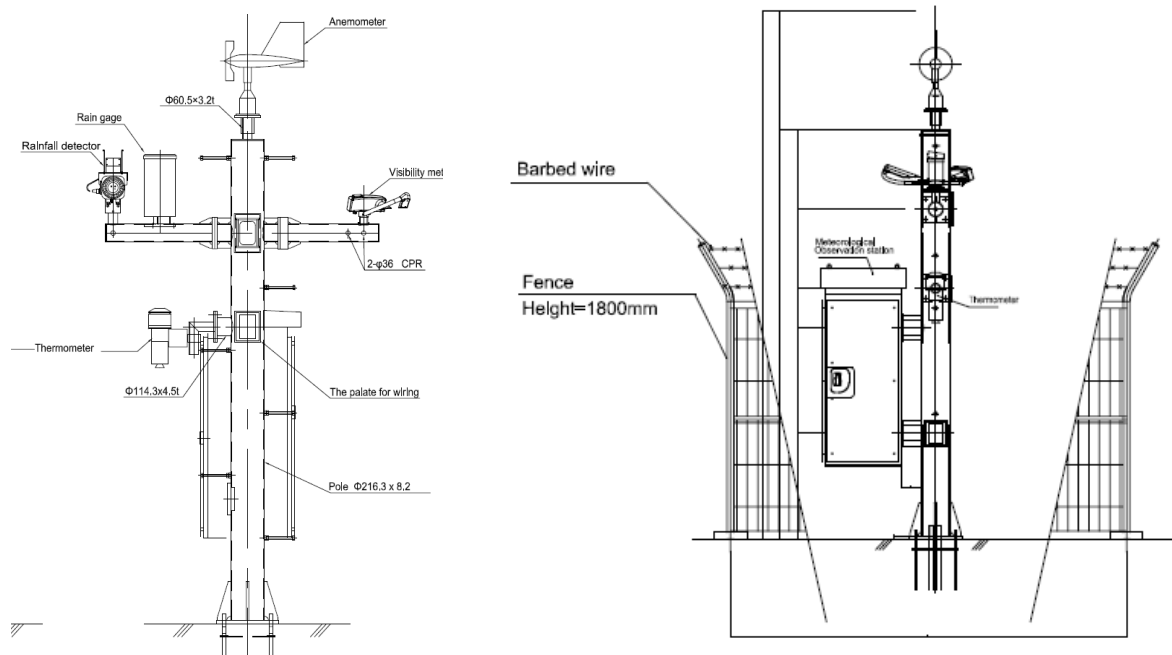
- All of meteorological monitoring sensors shall be put on a supporting steel pole together.
- The rain gauge and rainfall detector must keep 45-degree upward clearance from measuring obstacles such as buildings and trees.
- The anemometer must avoid air stream impacts receiving from passing vehicles.
- The MET observation station including communication unit, processor unit, power supply unit and other devices installed at outside other than the sensors shall be housed in a cabinet.
- The supporting steel pole with meteorological monitoring sensors and cabinet shall be enclosed with steel fence.

Figure 5-6 shows typical installation plan of MET observation station.



Source: Consultant

Figure 5-5 Configuration of MET System



Source: Consultant

Figure 5-6 MET Observation Station Typical Installation Plan

5.3.4 Specifications

(1) General

1) Power Supply

The electrical power supply system for the MET observation station and the MET data processor will consist of AC commercial power with Diesel Engine Generator (DEG) and Uninterruptible Power Supply (UPS) backup system. The observation station and the processor shall operate with AC single-phase two-wire system 220 V $\pm 10\%$ 50Hz. Total power consumption of MET observation station shall be 1KVA or less.

2) Communication

The data transmission of the MET system will be made through the fiber optic network. The media converter will be provided in the MET system to connect MET observation stations with nearest Fiber Optic Node (FON) of the fiber optic network located at the MMC, the MO or the TO.

(2) System Functions

1) Weather Measuring Function

The following measurement equipment will be provided to each meteorological observation station.

- Rain Gauge
Tipping bucket rain gauge will be used. The rain gauge will produce a pulse of contact signal every time precipitation reaches 0.5 mm. The signal will be converted into voltage or current signal for transmission to the MET data processor.
- Rainfall detector
The rainfall detector will output ON signal when rain is detected and OFF signal when rain stops.
- Thermometer
Thermometer will continuously measure ambient air temperature at the range of 0 to 70

degree Celsius in units of 0.1 degree. The measured data will be sent to the MET data processor at one minute interval as current air temperature.

➤ **Anemometer**

The anemometer shall measure the wind velocity at the range of 0.4 m/sec to 70 m/sec in units of 0.1 m/sec. The anemometer will also detect wind direction and convert it into one of 16 directions.

➤ **Visibility meter**

The visibility meter will measure the visibility as the amount of light scattered by particles in the air and convert the measured value into the visibility in meter.

2) **Data Processing Function at MET Observation Station**

The MET observation station shall perform the following process:

➤ **Data validity check**

Error checking will be performed for the received data by comparing them with the pre-defined threshold. Threshold may include upper limit, lower limit, and variation from the previous data. The data judged faulty will not be used as observed data.

➤ **Calculation of hourly and cumulative precipitation**

Precipitation data will be processed into hourly precipitation and cumulative precipitation.

3) **Data Transmission Function**

The following processed data will be transmitted from the MET observation station to the MET data processor in the MMC at every one (1) minute.

- Hourly cumulative value of rainfall in the past one hour
- Cumulative value of rainfall from the start of rainfall
- Instantaneous value of rainfall detection on every one minute
- Instantaneous value of ambient temperature on every one minute
- Maximum and minimum value of wind speed in the past one minute
- Wind direction at the maximum and minimum wind speed
- Maximum and minimum value of visibility in the past one minute

4) **Data Processing Function in the MMC**

The MET data processor will gather the observed meteorological data and monitoring signal from the station at a regular interval. The data received from the station will be converted to the physical weather data.

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

Data	Display	Logging
Precipitation		
Moving total for previous 1 hour	X	X
Total continuous precipitation	X	X
Rainfall detection		
Instantaneous (every 1 minute)	X	
Instantaneous (every 5 minutes)		X
Temperature		
Instantaneous (every 1 minute)	X	
Instantaneous (every 5 minutes)		X

Data	Display	Logging
Wind velocity		
Maximum during previous 1 minute	X	X
Wind direction		
Direction at maximum wind during previous 1 minute	X	X
Visibility		
Instantaneous (every 1 minute)	X	
Instantaneous (every 5 minutes)		X

A warning system will be introduced in which an alarm is issued to the system operator when the wind data or precipitation data exceeds the pre-defined threshold, or visibility becomes shorter than the pre-defined threshold. Several types and values of threshold will be provided and the threshold shall be alterable.

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

5) Data Storage Function

- All data transmitted from the MET observation station and processed data in the MMC will be recorded and stored in the MET data processor for analysis and future usage. Data retrieval and presentation software will be provided that can easily retrieve and show the MET data of the specified observation location at the specified time, hour or day. Graphical presentation of historical MET data such as hourly variation and daily variation will also be possible.
- Status of MET observation station equipment (normal or malfunctioned) will be recorded in the MET data processor as operation log and for future reliability analysis together with error code and time stamp.

Data Sub-system	Storage Data	Type	Storage Period
MET system	Instantaneous value of ambient temperature	Raw Data	2 years
	Hourly cumulative value of rainfall	Raw Data	
	Cumulative value of rainfall from the start of rainfall	Raw Data	
	Instantaneous rainfall detection	Raw Data	
	Maximum and minimum value of wind speed	Raw Data	
	Wind direction at the maximum and minimum velocity	Raw Data	
	Maximum and minimum value of visibility	Raw Data	
	Equipment operational status	Raw data	
	Instantaneous temperature (1minute and 5minutes)	Processed data	
	Moving total precipitation for previous 1hour	Processed data	
	Total continuous precipitation	Processed data	
	Instantaneous rainfall detection (1minute and 5minutes)	Processed data	
	Maximum value of wind velocity for previous 1 minute	Processed data	
	Direction at maximum wind during previous 1 minute	Processed data	
	Instantaneous visibility (1minute and 5minutes)	Processed data	
	Heavy rain analysis results with parameters	Processed data	
	Strong wind analysis results with parameters	Processed data	
	Poor visibility analysis results with parameters	Processed data	

6) Diagnosis Function

The MET system will have a diagnosis function. The MET data processor will inquire the connection with the MET observation station and the status of station equipment by sending the diagnosis signal in every five (5) minute. If equipment fault signal is received or there is no response from

the MET observation station, the MET data processor will issue a warning and the fault will be recorded in the log.

7) Display and Reporting Function

- The MET data processor will be capable of showing the following screens:

Item	Contents
Route map	<ul style="list-style-type: none"> Schematic map of DQE Name and station number of interchanges and toll barriers
Equipment location and status	<ul style="list-style-type: none"> Location of MET observation station and its status (normal / error)
Weather conditions	<ul style="list-style-type: none"> Current weather condition (rain, precipitation, air temperature, wind velocity, wind direction, visibility) Historical variation of weather conditions
Operation log	<ul style="list-style-type: none"> List of MET observation equipment currently not in operation Error record
Date and Time	<ul style="list-style-type: none"> Current date and time

- The MET data processor will produce the reports listed below. The reports will be output according to the schedule or upon the system operator's request. It will be possible to output the report as a file in portable document file format.

Item	Contents
Meteorological data	<ul style="list-style-type: none"> Daily report containing hourly precipitation Daily report containing hourly maximum and minimum wind velocity, its direction and time Daily report containing hourly maximum and minimum visibility and its time Monthly report containing daily precipitation Monthly report containing daily maximum and minimum wind velocity, wind direction, and time Monthly report containing daily maximum and minimum visibility and time
Error log	<ul style="list-style-type: none"> List of MET observation equipment currently not in operation Error record

8) Data Transferring Function

The following data processed in the MET data processor shall be stored in the database of traffic management center system for total system management at interval of 1 minute.

- 1-minute and previous 5-minutes data at each MET observation station
- Hourly cumulative value of rainfall in past 1 hour
 - Cumulative value of rainfall from the start of rainfall
 - Instantaneous value of ambient temperature
 - Instantaneous rainfall detection
 - Maximum value of wind speed and its direction
 - Minimum value of visibility

- Alerting signals of abnormal weather conditions with parameters
 - Heavy rain
 - Strong wind
 - Poor visibility
- Equipment operational status

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

(3) Technical Specifications

Followings are outline of technical specifications on the MET system. Detailed technical specifications are described in **Appendix-3** of this report.

1) MET Observation Equipment

- Rain gauge

No.	Item	Specifications
1.	Detection method	Tipping bucket type
2.	Diameter of water inlet	200 mm
3.	Tipping bucket rain gauge	0.5 mm or 1.0mm
4.	Contact output signal	No potential mark contact signal
5.	Material	Stainless
6.	Operating temperature	0 to +50 degree Celsius

- Rainfall detector

No.	Item	Specifications
1.	Detection method	Print electrode plate type
2.	Detected rain drop diameter	More than 0.5 mm diameter
3.	Output signal	No potential mark contact
4.	Power supply	Supplied from observation station
5.	Operating temperature	0 to +50 degree Celsius

- Thermometer

No.	Item	Specifications
1.	Detection method	Platinum resistance type
2.	Measurement range	0 to +70 degree Celsius in unit of 0.1 degree
3.	Specified current	2 mA
4.	Protection tube material	Stainless

- Vent sleeve for thermometer

No.	Item	Specification
1.	Method	Forced ventilation type
2.	Construction	Inside-and-outside double cylinder
3.	Ventilation speed	5 to 7 m/s
4.	Material	Corrosion resistant metal
5.	Power supply	Supplied from the observation station

- Vane anemometer

No.	Item	Specifications
1.	Detection method	Wind direction: Photo encoder type Wind velocity: Pulse type

2.	Measurement range	Wind direction: 0 to 360 degree Wind velocity: 0.4 m/s to 70 m/s in unit of 0.1 m/s
3.	Start-up velocity	Less than 0.4m/s
4.	Output signal	Type: Open collector Wind direction: 8-bit grey code Wind velocity: Pulse
5.	Material	Wind mill body: glass fibre inserted/reinforced polycarbonate resin Tail: Carbon fibre + Foamed urethane Stand: Corrosion resistant aluminum
6.	Power supply	Supplied from observation station
7.	Operating temperature	0 to +50 degree Celsius

➤ Visibility meter

No.	Item	Specifications
1.	Method	Forward scattering method
2.	Measurement range	10 m to 1000 m
3.	Accuracy	± 5%
4.	Light source	LED
5.	Wavelength	875nm
6.	Eye safety	IEC/EN60 825-1
7.	Output	RS485, RS232C, Analogue
8.	Protection class	IP66
9.	Power supply	Supplied from observation station
10.	Operating temperature	0 to +50 degree Celsius
11.	Humidity	20 to 85 % non-condensing
12.	Wind speed endurance	50 m/s

➤ Data logger

No.	Item	Specifications
1.	Cabinet size and ingress protection	Width: 600mm or less Height: 1,500mm or less Ingress protection: IP-55 or higher
2.	Weight	500kg or less
3.	Material	Stainless steel 2.0 t or cold rolled steel sheet (SPCC) 2.3 t
4.	Power consumption	1000 VA or less (sensor included)
5.	Operating temperature	0 to +50 degree Celsius
6.	Humidity	20 to 85 % non-condensing
7.	Wind speed endurance	53 m/s
8.	LAN interface	10BASE-T/100BASE-TX (RJ-45) x 1port
9.	Reliability and maintainability	MTBF : 30,000 hours MTTR : 1.0 hour

➤ Network equipment (media converter)

No.	Item	Specifications
1.	LAN interface	10 BASE-T/100BASE-TX (RJ-45) x 4ports or more
2.	Network interface	100BASE-FX (SC) x 2ports or less
3.	Transmission speed	100Mbps
4.	Maximum segment length	10km (Single mode fibre) or more
5.	Power consumption	10VA or less

2) MET Data Processor

The weather data generated by data logger will be processed and stored in MET data processor at the Main Management Center. The MET data processor shall have following minimum weather data handling functions.

- To collect the processed data from data logger at regular interval of 1-minute
- To compile the processed data into database
- To detect warning weather condition by comparing with the preset threshold and alert with buzzer displayed on screen
- Transferring the processed MET data to the traffic management system server
- To monitor operating conditions of the sensors and identify the failures when occurs

The MET data processor shall be standard models manufactured by organizations of international reputes.

5.4 Overload Monitoring System

The overload monitoring system will be introduced in the Project to measure the axle load of vehicle intending to enter the expressway in order to control the vehicles and protect the expressway.

The overload monitoring roadside equipment shall detect, make alert, record plate number and take photo of overloaded vehicles. All of data measured and captured by the roadside equipment shall be transmitted to the overload monitoring data server in the MMC. The system shall operate on a 24-hour a day 7-day a week basis.

5.4.1 System Requirements

System Requirements of the overload monitoring system are as follows.

- The overload monitoring system shall detect passing vehicles, measure axle weight and calculate total weight automatically.
- If the measured axle weight or total weight of the vehicle exceeds the allowable maximum weight, the overload monitoring system shall memorize the vehicle plate number and recode video image of the vehicle.
- The video image and plate number recorded at roadside shall be promptly sent to the MMC and warning alert and message shall be provided to the traffic inspectors stationed in the MMC.
- If the system detects overloaded vehicle, the warning alert shall be indicated by overweight warning display located at roadside to take caution to the driver and the traffic inspector at roadside.
- Weigh-in-Motion (WIM) type axle load scale shall be applied to measure vehicles passing. The axle load scale shall be installed at entrance side of toll gate in order to prevent entering overloaded vehicle into the expressway. Targeted accuracy of WIM type axle load scale shall be within the range of +/-10% for 95% of vehicles measured.
- Apart from WIM type axle load scale, portable axle load scale shall be provided in the Project to precisely measure the vehicle's axle load by the traffic inspector.
- The measured overloaded vehicle data can be monitored in the MMC on real-time basis. Also, the data can be stored for a certain period in order to utilize for road maintenance activities.
- The overload monitoring roadside equipment can be easily installed at roadside and shall have advantages in its operation and maintenance.

- To minimize required equipment as much as possible, the vehicle detector, lane monitoring camera and automatic number recognition camera to be used in the overload monitoring system shall be shared with those provided by toll collection system

5.4.2 System Configuration

The overload monitoring system shall consist of the following equipment;

- (1) WIM type axle load scale;
- (2) Vehicle detector provided by toll collection system;
- (3) Lane monitoring camera provided by toll collection system;
- (4) Automatic plate number recognition (ANPR) camera provided by toll collection system;
- (5) Overweight warning display;
- (6) Roadside panel;
- (7) Portable axle load scale;
- (8) Overload monitoring data server in the MMC
- (9) Network equipment; and
- (10) Power supply unit and peripheral.

The overload monitoring system would be configured as **Figure 5-7** below.

5.4.3 Location and Installation of Overload Monitoring Roadside Equipment

The overload monitoring roadside equipment shall be installed at the locations listed below.

Facility	Location	Quantity
Overload Monitoring Roadside Equipment	Tuy Loan TB entrance	3
	My Son IC entrance	1
	Ha Lam IC entrance	1
	Tam Ky IC entrance	1
	Chu Lai IC entrance	1
	Dung Quat IC entrance	1
	Quang Ngai North IC entrance	1
	Quang Ngai TB entrance	2
Total	8	11

The overload monitoring roadside equipment shall be installed at each entrance toll gate of the DQE. The WIM type axle load scale shall be placed at lanes in operation as illustrated in **Figure 4-12** above. **Figure 5-8** shows typical installation plan of overload monitoring roadside equipment.

Source: Consultant

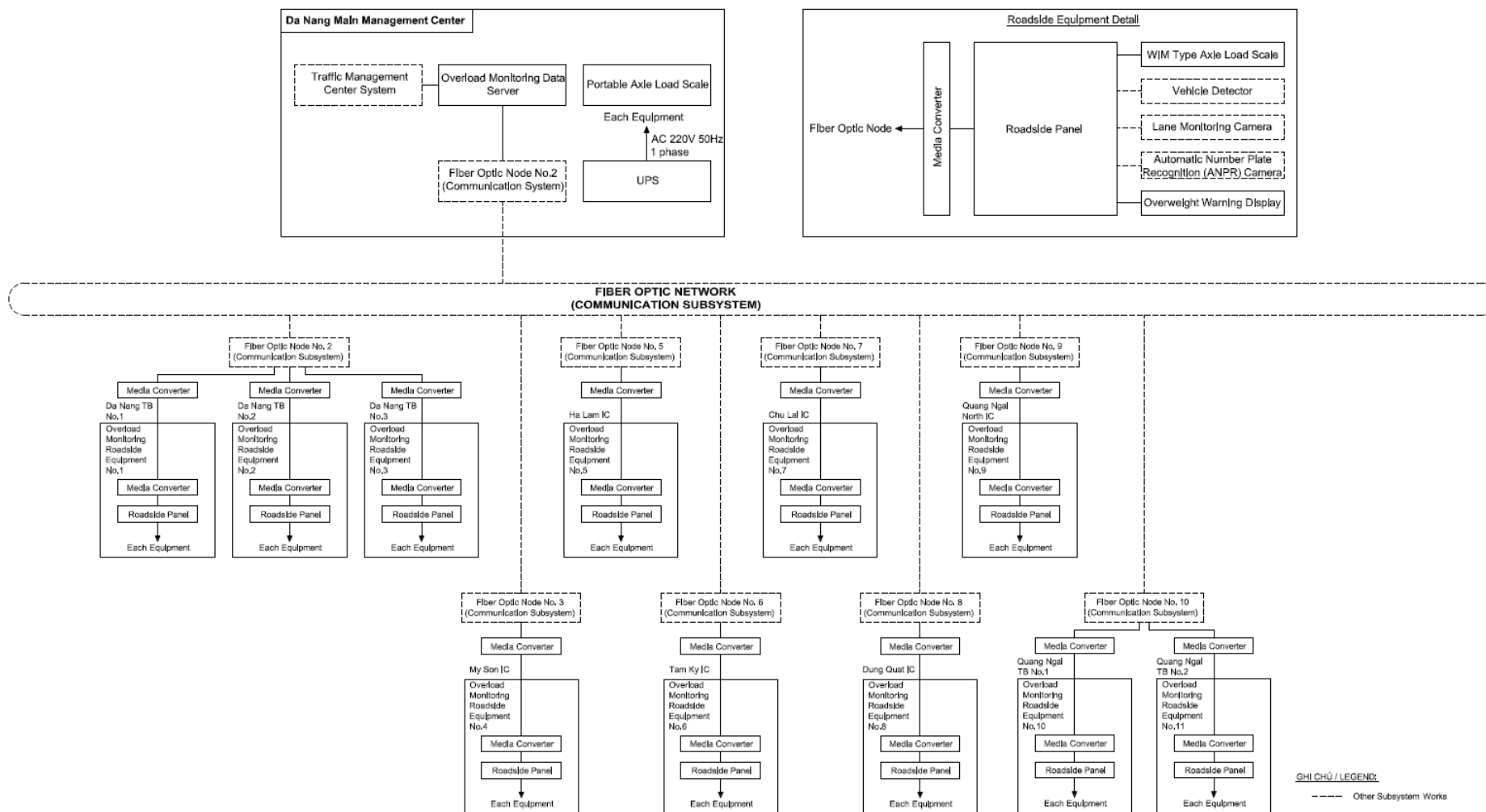


Figure 5-7 Configuration of Overload Monitoring System



Figure 5-8 Overload Monitoring Roadside Equipment Typical Installation Plan (Tollgate)

5.4.4 Specifications

(1) General

1) Power Supply

The electrical power supply system for the overload monitoring roadside equipment and center equipment will consist of AC commercial power with Diesel Engine Generator (DEG) and Uninterruptible Power Supply (UPS) backup system. The overload monitoring roadside equipment and center equipment will operate with AC single-phase two-wire system 220 V \pm 10% 50Hz.

2) Communication

The data transmission of the overload monitoring system will be made through the fiber optic network provided by communication system. The media converter will be provided in the overload monitoring system to connect the roadside equipment with nearest Fiber Optic Node (FON) of fiber optic network.

(2) *System Functions and Specifications*

1) Overall Functions

Followings are overall functions of the overload monitoring subsystem as minimum;

- Weight measurement
- Vehicle detection
- Axle distance measurement
- Video image monitoring

- Photo taking (Number plate recognition)
- Excess weight detection and alarm
- Error detection and alarm
- Local control operation
- Data transmission to the main management center
- Data recording and operation logging at the main management center
- Operation and malfunction report

2) Specifications

- Measurement

The overload monitoring system will be capable of measuring and calculating each axle, total weight, distance between two adjacent axles and vehicle speed. The measurement accuracy of WIM type axle load scale shall be within the range of +/- 10% for 95 % of vehicles measured and that of portable axle load scale must be 99% or better. Allowable vehicle passing speed of WIM shall be 40 km/h or more.
- WIM type axle load scale

Sensor for WIM will be piezoelectric sensor. Two sensors 1 meter apart in longitudinal direction shall be installed at each lane for better measuring accuracy.
- Vehicle detector

Two units of vehicle detector will be installed at each lane, one upstream of sensor and another downstream of the sensor to detect presence of vehicle and measure the vehicle speed. Inductive loop type vehicle detector is considered as detector but other types of vehicle detector are acceptable as long as it performs the required functions. The vehicle detector to be used in the overload monitoring system will be provided in the toll collection system and the detection signal will be input to roadside panel of the overload monitoring system.
- Overweight warning display

A display unit will be provided and installed at appropriate location downstream of WIM type axle load scale to inform the driver and traffic inspector of the overloading. No message will be displayed for vehicles not exceeding the weight limit.
- Lane monitoring camera and automatic plate number recognition (ANPR) camera

CCTV camera will be installed to monitor the operation of the system. The video image during the measurement will be stored temporarily until the vehicle being measured is cleared. If the vehicle is judged over loaded, video image shall be kept permanently until deleted by the operator.

ANPR camera will also be used to take photo of the vehicle judged over loaded. The photo taken by the camera will be used to recognize plate number automatically. Infra red type camera may be used. Signal from the vehicle detector may be used as timing signal for photo.

Both of lane monitoring camera and ANPR camera to be used in the overload monitoring system will be provided in the toll collection system and the captured images will be input to roadside panel of the overload monitoring system.
- Operation

The operation of the system shall be automatic and no action by the operator is required for measurement, data processing, judgment and data transmission to the MMC.

If a vehicle is judged overloaded, an alarm will be shown on the console of overload monitoring data server and a warning message will be shown on the display for drivers. The data collected by the system will be sent to the MMC for recording and monitoring. The data may include station number, date and time of passage, lane number, vehicle sequence number, vehicle speed, weight of axle or axle group, total vehicle weight, code for invalid measurement, and photo of vehicle judged over loaded.

3) Installation

The WIM type axle load scale will be installed at entrance tollgate together with overweight warning display and roadside panel.

As other devices for toll collection system are to be installed at the tollgate, coordination with toll collection system shall be made to ensure normal operation of both overload monitoring system and other systems without interference. Location of equipment may need to be adjusted and cable installation work may be done simultaneously.

5.5 Variable Message Sign (VMS) System

The VMS system will be introduced in the Project to provide the information of traffic status, incident and weather conditions on the road to the driver on real time bases.

The VMS will be placed upstream of interchange, tunnel and toll barrier on the expressway or at access road before each interchange tollgate. The message showing on the VMS will be controlled from the MMC. The VMS system will be capable of creating, managing and displaying messages in two languages (English and Vietnamese) separately and alternately, or simultaneously in case of simple message.

5.5.1 System Requirements

System Requirements of the VMS system are as follows.

- The VMS system shall indicate the following alerting message on the VMS board located at roadside on real time basis;
 - Location
 - Incident (cause)
 - Event (traffic regulation or action to be taken by road user)
- Character including symbol mark indicated on the VMS board can be visible under the natural environment in Vietnam, and the character height shall be enough size for recognition by driver passing through the expressway with high speed.
- The location of VMS board shall be sufficient for road users to read and understand information on the board and to safely change lane to exit at the interchange or to stop before tunnel and tollgate.
- The VMS board shall be fixed on gantry type supporting structure.
- The VMS system shall be capable of creating, managing and displaying messages locally or remotely from the MMC.
- Based on alerting information collected and issued by other sub-systems, the VMS system can control and indicate required information on the VMS board from the MMC by manually or semi-automatically. The VMS control must be easily carried out by the selection of preset message or other method prepared in the system.

5.5.2 System Configuration

The VMS system will consist of the following components;

- (1) VMS board and VMS control unit with supporting structure (gantry type) at roadside;
- (2) VMS center controller;
- (3) VMS center controller console;
- (4) Network equipment; and
- (5) Power supply unit and peripheral.

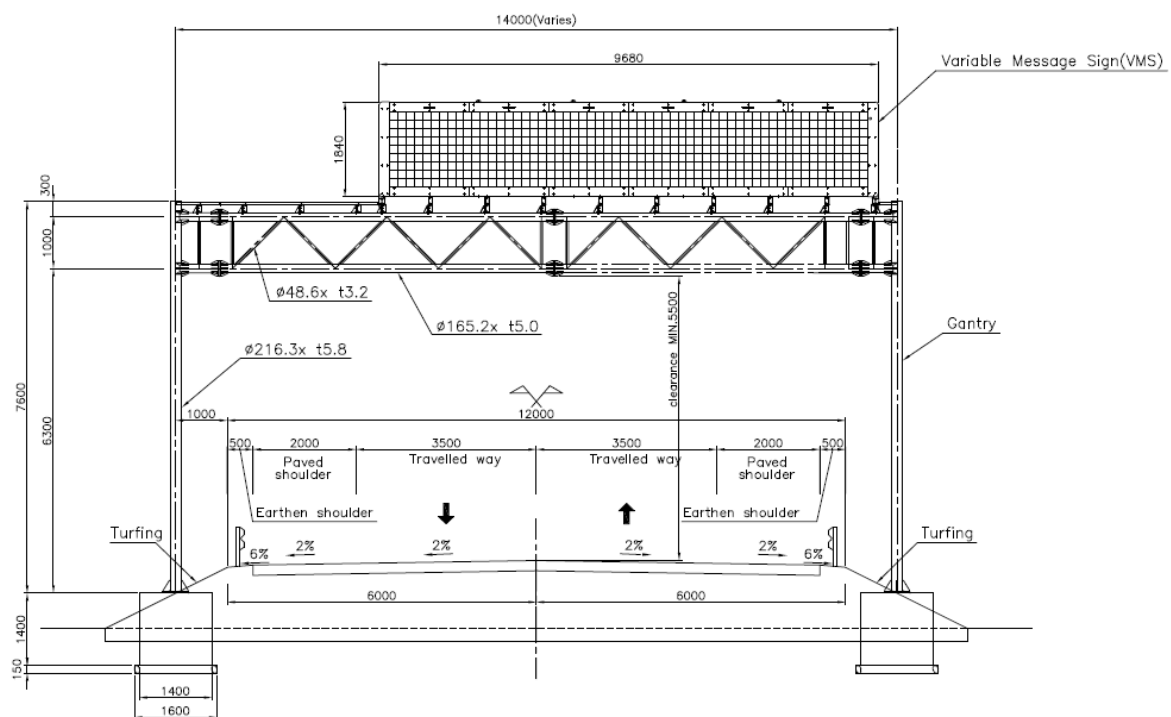
The VMS will be placed at 26 locations in the Project. The VMS system would be configured as **Figure 5-9** below.

5.5.3 System Location and Installation

The VMS board will be established at the locations listed in **Table 4-16** above.

The VMS board will be located at approximately 200m to 300m upstream of targeted interchange and tunnel, at nearest intersection or junction of access road, and at the toll barrier. The VMS board on the expressway must be installed at the location having minimum visibility of 333m to the direction showing message to the drives. 5.5m or more vertical clearance from road surface must be kept under the bottom of VMS board.

Figure below shows typical installation plan of VMS board.



VMS board Typical Installation Plan (Entrance)

Source: Consultant

Node — : Other Subsystem Work

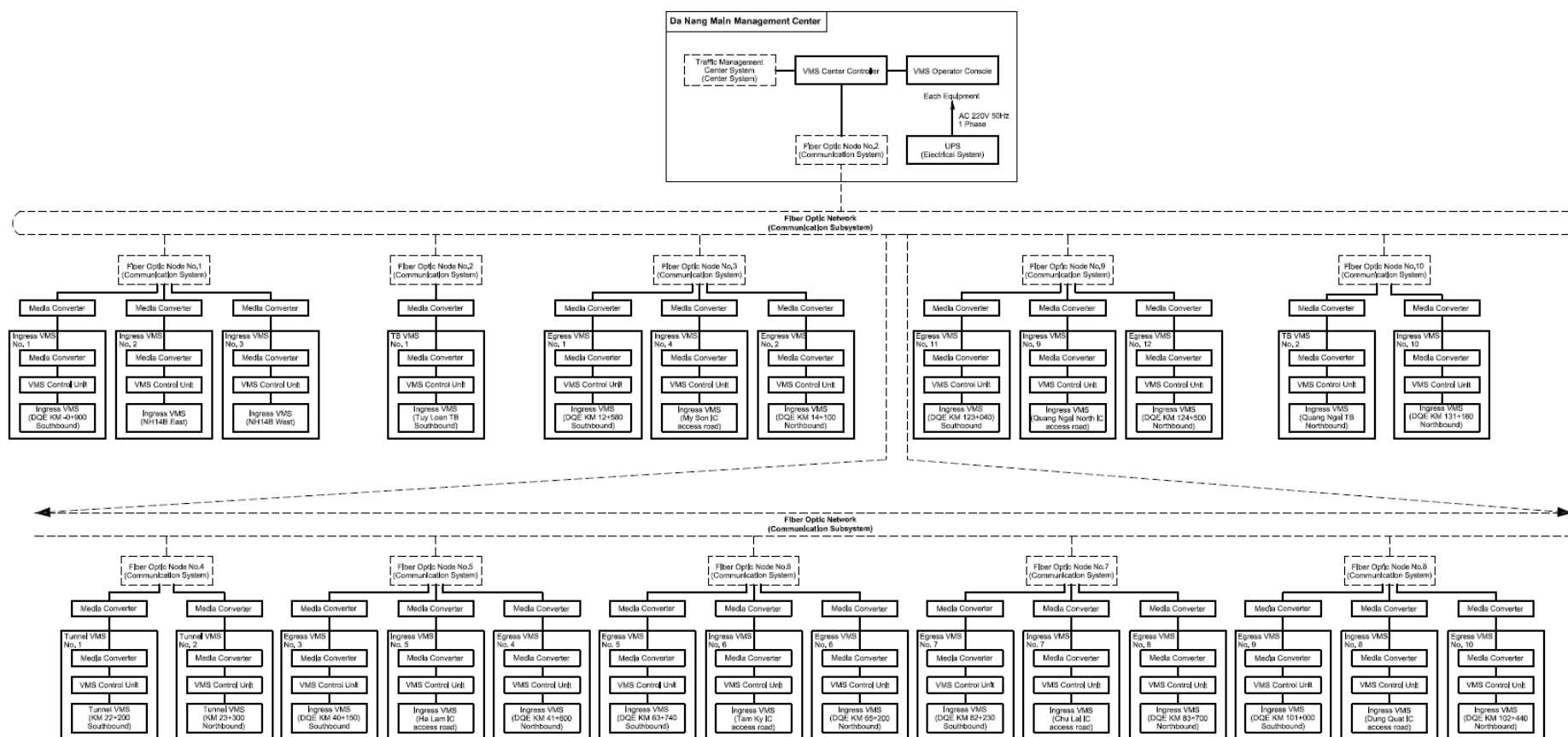


Figure 5-9 Configuration of VMS System

5.5.4 Specifications

(1) General

1) Power Supply

The electrical power supply system for the VMS roadside equipment and center equipment will consist of AC commercial power with Diesel Engine Generator (DEG) and Uninterruptible Power Supply (UPS) backup system. The VMS roadside equipment and center equipment will operate with AC single-phase two-wire system 220 V $\pm 10\%$ 50Hz. Total power consumption of VMS at each location shall be 3KVA or less.

2) Communication

The data transmission of the VMS system will be made through the fiber optic network. The media converter will be provided in the VMS system to connect VMS roadside equipment with nearest Fiber Optic Node (FON) of the fiber optic network except the locations where media converter will be installed by the CCTV camera system.

(2) System Functions

1) Message Indication Function

Message to be displayed on the VMS shall be concise and clear as the road users have to read and understand the message in a short time. Messages shall have uniform structure and simple words shall be used. Messages on the VMS board will be expressed in English and Vietnamese. In principle, a message to be displayed on the VMS board will be composed of three parts, "location", "incident", and "event".

- Location
Location indicates the relationship between the VMS location and the incident location. They can be expressed as section (between interchange A to interchange B), distance (ahead, xx km ahead), station number of expressway (KM xx + xxx) or specific location (near interchange A or the station number).
- Incident
Incident is a thing that has happened or taken place. It includes traffic conditions (accident, congestion), road condition (wet road surface, damaged pavement), and weather condition (fog, rain, strong wind).
- Event
Event includes traffic regulation (lane closure, road maintenance work) and the action is to be taken by the road users such as "slow down", "cautious" and "use right/left lane".

Three components are not necessarily required all the time. Messages consisting of one or two components described above or simple message will also be displayed.

The VMS system will be also capable of displaying the graphic symbol marks. The sample symbol marks are listed in **Figure 4-15**. The system will be capable of having a maximum of twenty (20) graphic symbol marks. The graphic symbol marks will be defined as dot matrix and editing of the symbol mark will be possible. It shall be possible to combine text and graphic symbol marks in a message.

2) Message Creation and Editing Function

Three message composition methods will be provided; (1)manual input, (2)combination of pre-defined phrase, and (3)selection of ready-made message. The functions will be possible in two languages i.e. in English and Vietnamese. In addition, a set of graphic symbol marks will be provided to complement the text message.

- Manual composition
In the manual input, it will be possible to display on the VMS any text message input by the system operator through the keyboard of the VMS center controller console in the MMC.

There will be no restriction as to the contents of message but the length of message is limited to the display capacity of the VMS board. If manual composition mode is selected, the console will show the image of the VMS board and the message as it is input by the system operator.

➤ Combination of pre-defined phrase

In the case of combination of pre-defined phrase, frequently used words or phrases such as “accident”, “congestion”, “construction work”, “slow down” and so on are used to compose a message. It will be possible to insert a word into the message composed by combination method. There will be sets of pre-defined words. They will contain words indicating location, incident and action. Each set will have a capacity of 100 words in each language. In this mode, the operator console will show the categories and the words or phrases in each category for the system operator to select. It will be possible to alter the pre-defined words by the system operator.

➤ Ready-made message

Ready-made message selection method will allow the system operator to choose one of the ready-made messages. If the ready-made message mode is selected, the operator console will indicate the list of ready-made messages grouped into categories for the system operator to select. Message set will have the capacity of 100 messages in each language.

➤ Graphic symbol marks

Graphic symbol marks that show typical incidents such as construction work and heavy rain graphically will be provided to complement the text message.

➤ Dot matrix pattern

The VMS system will be provided with a function to create a display pattern by specifying the on/off status and color of each pixel comprising the display area of the VMS board. It will be possible to mix the dot matrix pattern and character message on the board.

➤ Automatic message creation from incident information

If an adverse weather condition is detected by the MET system or any incidents are manually input in traffic event data console by system operator, these systems will send an alarm to the VMS system via traffic management center system. The VMS system will then create a warning message indicating the location, type of incident and action to be taken by road users. The message created will not be displayed automatically on the VMS board. Instead, a recommendation will be displayed on the VMS center controller console indicating the contents of the message and the location of VMS for which message is recommended. Upon confirmation of the recommendation, the message will be displayed on the specified message.

The VMS center controller console will be provided with updating and editing functions of pre-defined word, phrase, message and symbol mark. Editing of symbol mark will be possible on a pixel basis.

The console will communicate with the operator through monitor and keyboard for message composition and operation monitoring. Message composition will be made interactively with one of the methods described above. Graphic user interface will be adopted in the interface as much as possible for user friendly operation and fail safe mechanism will be incorporated to prevent VMS system from showing inadequate message. The system will be equipped with a text input method in Vietnamese languages commonly used in the Project area through the standard keyboard.

The VMS system will be provided with an automatic message selection function based on the priority or severity of the events and coefficient that represents the importance of event to each VMS as described in **Table 4-18**. The function will select and recommend the message to be shown separately for

each VMS when there are two or more incidents to be informed to the road users as shown in **Table 4-19**.

Each message being displayed on the VMS will be assigned with a time-to-live (TTL) value, during which message is displayed, to prevent inadvertently displaying false message after incident has been removed. Upon expiration of TTL, message will be automatically extinguished, if no response is made to the warning within the preset time limit. A warning will be issued to the operator console before TTL expires for operator to choose extension of TTL or termination of the display as scheduled.

The VMS system will have an alternate display function, in which a maximum of two sets of message can be displayed alternately. The function is intended to display a message in two different languages (English and Vietnamese) but not necessarily limited to the same message.

3) Data Transmitting Function

Text and symbol mark messages to be displayed will be converted to pixel image data to control display unit before transmitting to the variable message sign.

The VMS center controller will communicate with the VMS control unit at roadside through the fiber optic network. It will send out message converted to dot pattern for display. It will also send out command data to control the VMS control unit and to confirm normal operation of the VMS board. In return, the center controller shall receive status data from the control unit.

4) Operation Monitoring and Logging Function

Operating status of the VMS will be checked periodically. Status (message on, no message, fault, local control, test and switch off) will be collected from the VMS control unit at roadside. If any abnormality is reported, an alarm will be issued. The collected operation monitoring data will be recorded as part of operation log. It will be possible for the VMS center controller console to send a command to the control unit and collect the dot pattern data being displayed on the VMS board upon system operator's initiative.

Message displayed together with the starting and ending time will be recorded as operation log. Status or malfunction of the VMS and the control unit will also be recorded. Data retrieval software will be provided and operation log can be retrieved for display on monitor and as printed report.

5) Data Storage Function

- All data transmitted from the VMS roadside equipment and processed data in the MMC will be recorded and stored in the VMS center controller for analysis and future usage. Data retrieval and presentation software will be provided that can easily retrieve and show the recommended message automatically generated against event and message indicating on each VMS of the specified roadside equipment location at the hour or day.
- Status of roadside equipment (normal or malfunctioned) will be recorded in the VMS center controller as operation log and for future reliability analysis together with error code and time stamp.

Data Sub-system	Storage Data	Type	Storage Period
VMS system	Recommended message automatically generated against event	Raw data	2 years
	Manual input operation record	Raw data	
	Equipment operational status	Raw data	
	Current message indicating on each VMS	Processed data	

6) Display and Reporting Function

- The VMS center controller will be capable of showing the following screens.

Item	Contents
Route map	<ul style="list-style-type: none"> Schematic road map of DQE and access road Detailed VMS location map

Item	Contents
	<ul style="list-style-type: none"> Name and station number of interchanges and toll barrier
Equipment location and status	<ul style="list-style-type: none"> Location of VMS and their condition (message / no message and normal / error)
Message	<ul style="list-style-type: none"> Message being displayed at selected VMS with starting time and scheduled end time Pre-defined words and phrases Pre-defined messages Graphic symbol marks
Operation	<ul style="list-style-type: none"> List of VMS currently not in operation Operation log and error record
Date and Time	<ul style="list-style-type: none"> Current date and time

- The VMS center controller will produce the reports listed below. The reports will be output according to the schedule or upon the system operator's request. It will be possible to output the report as a file in portable document file format.

Item	Contents
VMS operation	<ul style="list-style-type: none"> Daily report summarizing VMS location, message displayed, start time, end time
Error log	<ul style="list-style-type: none"> List of VMS currently not in operation Error record

(3) Technical Specifications

Followings are outline of technical specifications on the VMS system. Detailed technical specifications are described in **Appendix-3** of this report.

1) VMS board

No.	Item	Specification
1.	Board size	9,680 mm (W) x 1,840 mm (H) or less
2.	Weight	2,500 kg or less
3.	Material	Cold rolled steel sheet (SPCC) 2.3 t, or aluminum 2.0 t
4.	Character size	450 mm in height
5.	Display pixel pitch	Not larger than 20 mm (vertical and horizontal)
6.	Number of pixels	16 pixels vertically for one character in both English and Vietnamese
7.	Display	24 English characters of standard width without graphic symbol per line.
8.	Display device	Light emitting device LED Luminescent color (blue , red , green)
9.	Power supply	220 V \pm 10% 50 Hz
10.	Power consumption	3,000 VA or less including power consumption of VMS control unit
11.	Operating temperature	0 to 50 degree Celsius
12.	Humidity	20 to 85 % (non-condensing)

13.	Wind	53 m/s
14.	Reliability and maintainability	MTBF: 10,000 hours MTTR: 1.0 hour

2) VMS Control Unit

VMS controller will have the following functions:

- Communication control
- Display control
- Monitoring
- Local operation

The VMS control unit will communicate with the VMS center controller in the MMC through the fiber optic network using NTCIP or other equivalent international protocols. It will receive display data from the VMS center controller and send back the operating status data to the center controller.

Display data received from the VMS center controller will be stored in the buffer until all the data have been correctly received without error. Upon confirmation of correctness of data, display will be changed to the new message. Changeover shall be fast and no irregular display shall be shown during the transition. Under any circumstances, the changeover of message shall be completed within 3 seconds after the system operator in the MMC has issued a message changeover command.

Several test pattern will be provided to the VMS control unit, with which defect of LED can be tested by indicating one of them sequentially.

Operating condition of the VMS will be monitored regularly by VMS itself and the control unit. If any abnormality is detected, error signal will be issued to the VMS center controller together with the type of error.

It will be possible to operate the control unit and the VMS board manually at the site. The manual control panel will be provided to the VMS control unit. Alternatively, manual control will be made with a notebook computer connected to the VMS control unit through serial port or network port.

3) Supporting Structure

The VMS board will be fixed on gantry type supporting structure. The construction of gantry support will be included in the PKG13. A mechanism to adjust the tilting angle of VMS will be provided to the VMS housing or fixture used to attach the VMS to the support. It shall be possible to adjust the tilting between 0 degree (vertical) and 10 degree (tilted forward).

4) VMS Center Controller with Console

VMS center controller consists of data server and operation console, and will have following minimum functions;

- To compose message by three method, manual input, combination of preset words, and selection of preset message;
- To have interface with operator through data input device;
- To convert text and symbol message to be displayed on VMS into dot image data to control LED display matrix;
- To communicate with VMS controller unit at roadside for message data and operating status data transmission;
- To display and store operating status and issue alarm in case of abnormal condition; and
- To record operation log.

The VMS center controller and operation console shall be standard models manufactured by organizations of international repute.

5.6 Traffic Management Center System

The ITS in this Project consists of many system components. The traffic management center system manages the total system, encourages data exchange between the system components in order to realize fully their functions and achieve the overall objectives of the traffic management system.

5.6.1 System Requirements

System Requirements of the traffic management center system are as follows.

- The traffic management center system shall collect all necessary information from each system component listed below on real-time basis.
 - Closed Circuit Television (CCTV) Camera System
 - Vehicle Detection System
 - Meteorological Monitoring (MET) System
 - Overload Monitoring System
 - Variable Message Sign (VMS) System
 - Digital Transmission System
 - Wireless Radio System
 - Internal Telephone System
 - Power Supply System
 - Tunnel Safety Facility System, Tunnel Lighting System Others
- The system shall automatically process the collected data into usable road traffic information including traffic flow data, weather alerting data, etc. Also, the system must have capability of event data management such as traffic accident.
- The collected and processed data shall be stored into database of the system for necessary period so that each data can be utilized as statistics.
- The system shall have function to provide the information collected and processed through VMS system to the road users, and internet, e-mail and/or SMS to the public.
- The collected and processed data shall be monitored on large display panel, operator consoles and monitoring PCs in the MMC and the MO to share the information with organizations related.
- The system shall have future expandability of data exchange with relevant organizations such as other expressway operating bodies to realize the flexible and interactive road information sharing each other.
- The system shall have future expandability to manage the ITS in whole central region of Vietnam.
- The system must have function to monitor and manage the operational status of all system components of the ITS. Also the system shall have a reporting function in which various reports can be prepared with printer.
- The system shall be able to operate continuously 24 hours a day and 7days a week with a redundant system configuration.

5.6.2 System Configuration

The traffic management center system shall consist of the following component;

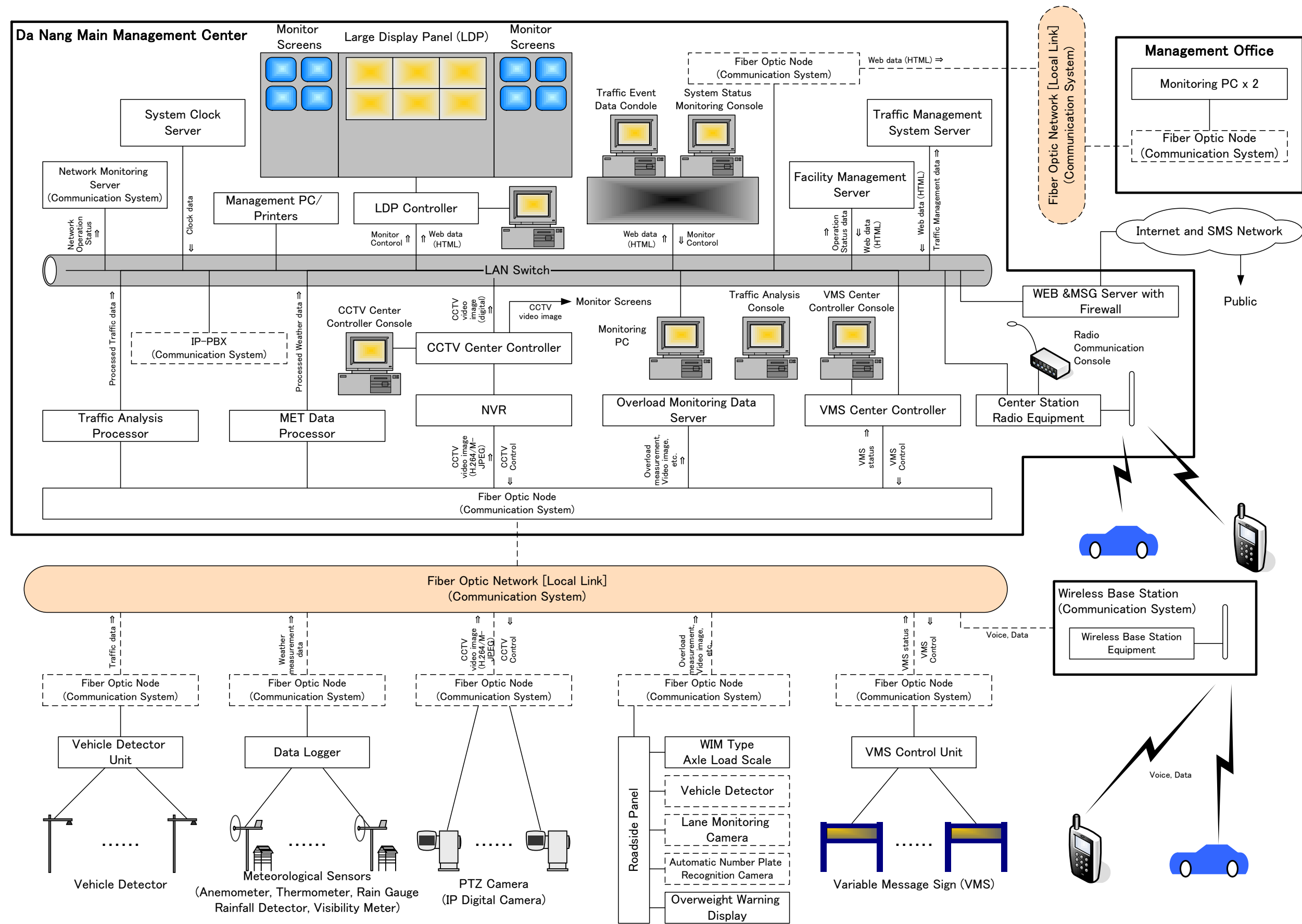
- (1) Traffic Management System Server;
- (2) Facility Management Server;
- (3) Large Display Panel (LDP);
- (4) LDP Controller;
- (5) Traffic Event Data Console;
- (6) Traffic Analysis Console;
- (7) System Status Monitoring Console;
- (8) Monitoring PCs;
- (9) Web & Message (MSG) Server;
- (10) System Clock Server;
- (11) Printers;
- (12) Firewall and Network Equipment; and
- (13) Peripheral.

The traffic management center system would be configured as **Figure 5-10** below.

The traffic management center server, facility management server and Web & MSG server will consist of an operating server and a standby server. In the event of a failure of the operating server, the standby server will take over the operation automatically and there will be no loss of data and abnormal operation of the system.

Each operator console will have its own functions and perform the tasks assigned to it under normal conditions. In the event of unavailability of an operator console due to malfunction or maintenance, however, it will be possible to use any other operator consoles as substitution to perform the same functions. Access privilege control will be applied in the same manner when the operator console is being replaced. The assignment of the functions to each operator console will be as shown below.

No.	Operator console	Main functions
1.	Traffic event data console	<ul style="list-style-type: none"> • Input, editing and management of event data primarily • Having capability of access all contents of sub-systems
2.	Traffic analysis console	<ul style="list-style-type: none"> • Dedicated console for static data analysis • To be equipped with application software such as GIS, DB and traffic data analyzer
3.	System status monitoring console	<ul style="list-style-type: none"> • Monitoring and management of the equipment and network primarily • Having capability of access all contents of sub-systems
4.	LDP controller	<ul style="list-style-type: none"> • Dedicated console for operation of LDP • To be equipped with application software to control LDP
5.	Monitoring PC	<ul style="list-style-type: none"> • Monitoring all contents of sub-systems excluding editing function by operators
6.	CCTV center controller console provided in the CCTV camera sub-system	<ul style="list-style-type: none"> • Observation of traffic conditions and operation of CCTV cameras primarily • Having capability of access all contents of sub-systems
7.	VMS center controller console provided in the VMS sub-system	<ul style="list-style-type: none"> • Creation and editing of VMS message to be displayed primarily • Control and monitoring of VMS primarily • Having capability of access all contents of sub-systems
8.	Maintenance consoles provided in each sub-system	<ul style="list-style-type: none"> • Dedicated console connecting each sub-system server directory for maintenance purpose



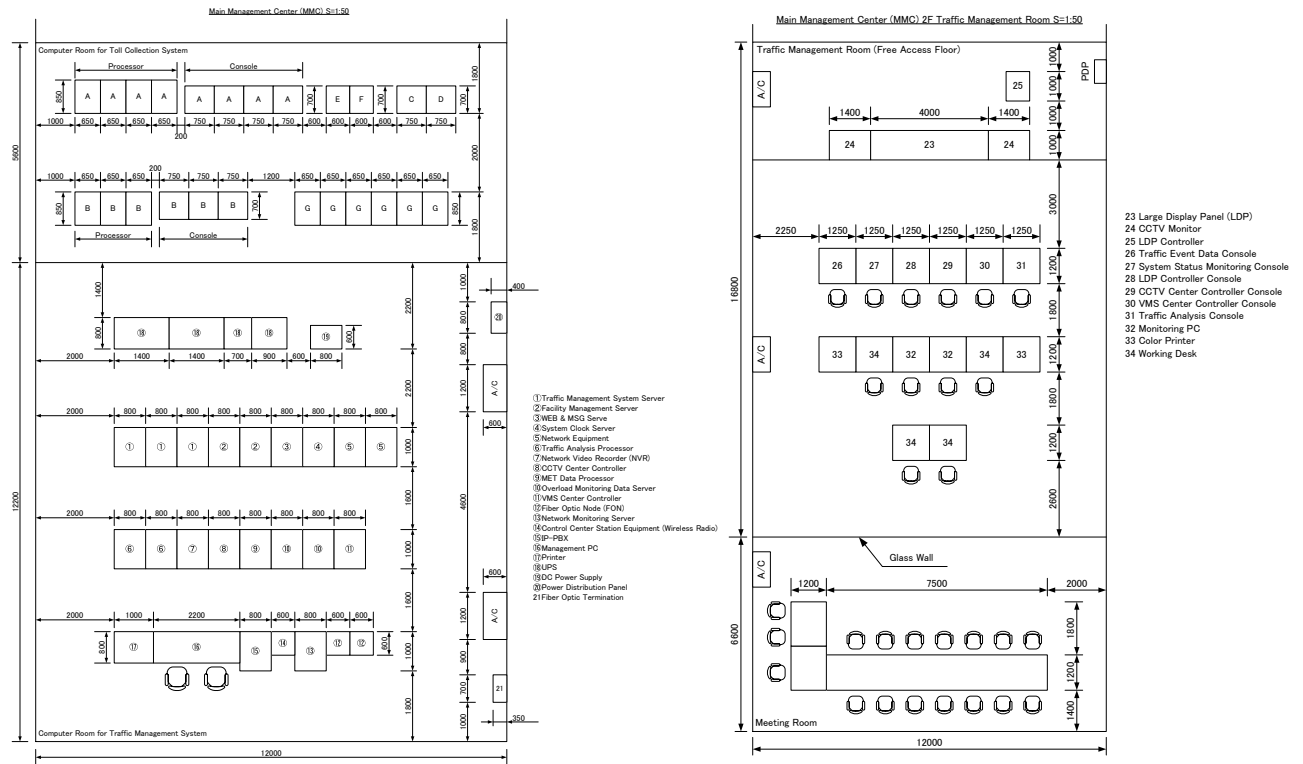
Source: Consultant

Figure 5-10 Traffic Management System Configuration

5.6.3 Traffic Management Center System Location and Installation

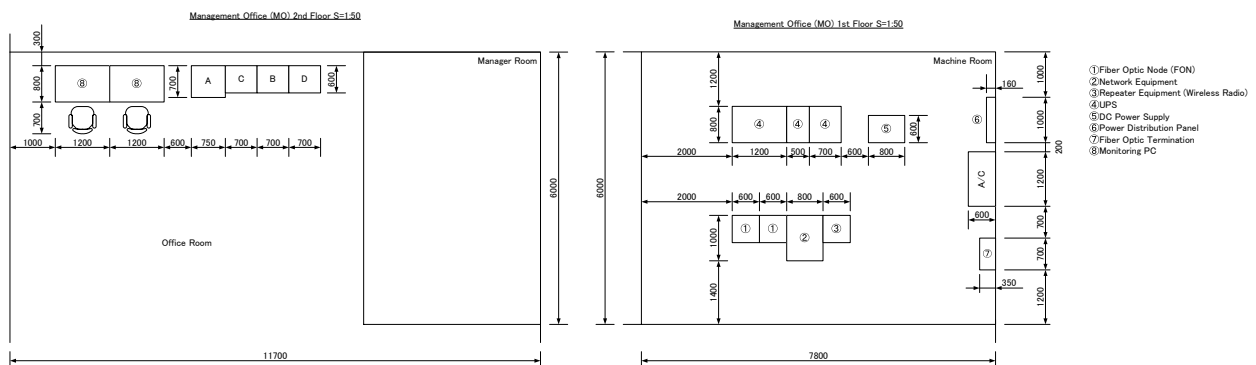
The traffic management center system will be placed in the traffic management room or computer room of MMC located near Tuy Loan toll barrier or in the office room of two (2) MOs which will be located in the same yard of MMC and near Quang Ngai north toll gate.

Figure below shows the proposed layout plan in the MMC and MOs.



Source: Consultant

Figure 5-11 Proposed Layout Plan in MMC



Source: Consultant

Figure 5-12 Proposed Layout Plan in MO

The layout shall be designed by the Contractor in detail taking into consideration the function of the server and operator consoles to be placed in the room, the role of the staff and operators stationed in the room, position of large display panel, cable routes, viewing by visitors, relationships with other equipment procured by the other contract packages and other factors to establish a functional traffic management center system.

5.6.4 Specifications

(1) General

1) System Capacity

The traffic management center system shall be designed to have the system capacity to operate the terminal equipment of the quantity specified below without adding hardware except the device related to data communication. The software shall be designed to function with the maximum capacity.

No.	Terminal Equipment	System capacity
1.	CCTV camera	Three (3) time of the quantity in the Project
2.	Vehicle detection roadside equipment	Three (3) time of the quantity in the Project
3.	MET observation station	Two (2) time of the quantity in the Project
4.	Overload monitoring roadside equipment	Three (3) time of the quantity in the Project
5.	Variable message sign	Three (3) time of the quantity in the Project
6.	Others	Two (2) time of the quantity in the Project

2) Power Supply

The traffic management center system will operate with AC single-phase two-wire system 220 V $\pm 10\%$ 50Hz. The electrical power supply system for the traffic management center system will consist of AC commercial power with Uninterruptible Power Supply (UPS) and Diesel Engine Generator (DEG) backup power supply systems. The equipment to be supplied power from backup power supply systems is listed as table below.

Equipment	Voltages	UPS	DEG
Traffic management system server	1 ϕ - 2W - 220V, 50Hz	X	X
Facility management server		X	X
Large display panel		X	X
LDP controller		X	X
Traffic event data console		X	X
Traffic analysis console		X	X
System status monitoring console		X	X
Monitoring PC			X
Web & MSG server		X	X
System clock server		X	X
Printers			X
Firewall and network equipment		X	X
CCTV center controller and NVR		X	X
Traffic analysis processor		X	X
MET data processor		X	X
Overload monitoring data server		X	X
VMS center controller		X	X
CCTV center controller console		X	X
VMS center controller console		X	X
Maintenance consoles		X	X
Toll collection system equipment (server, etc.)		X	X
Fiber optic node		X	X
Wireless center station		X	X
IP-PBX		X	X

The UPS must be equipped with enough capacity of battery to supply power for a period of 10 minutes or longer in case of commercial power interruption. The UPS will have functions to send the power interruption signal to each equipment for safety system shut-down in case of commercial power failure, and the system shall automatically start-up when the commercial power recovers.

3) Communication

The communication network system will connect the traffic management center system installed in the MMC and MO with each sub-system roadside equipment. The fiber optic network will be utilized in this Project. The network equipment consists of Layer 3 Switch (L3-SW), Layer 2 Switch (L2-SW), Media Converter, Firewall etc.

(2) System Functions

The traffic management center system will have the functions listed below. These functions shall be integrated into a total intelligent transport system.

- Data collection
- Event data management
- Database management
- Facility management
- Network management and control
- Display and monitoring
- Parameter monitoring and management
- Information dissemination
- Human-machine interface
- System clock
- Operation log
- Report production

1) Data Collection Function

The traffic management center system will collect the road and traffic conditions, incidents, weather conditions and any other necessary data from the respective sub-system components in certain periods as listed in **Table 4-22**. The traffic management center system will gather the road, traffic and weather data and equipment operational status from sub-system terminal equipment and their processed data via servers provided in each sub-system component. It will also receive the still image data taken by CCTV camera.

2) Event Data Management Function

The traffic management center system will have data management functions of “event” which includes events automatically generated in the each sub-system components such as adverse weather and traffic congestion, and incidents or traffic regulations that may be reported from expressway operator, traffic police and road users thorough verbal communications and input manually in the system. The system will handle event data shown in **Table 4-23** as minimum requirement.

3) Database Management Function

The traffic management system server will store all data collected and processed within a system in an industry-standard database with the aim of statistics usage for future road planning, operation and maintenance. The system will have one centralized database for managing the complete intelligent transport system. The facility management server will store equipment operational status data into its database. Type, quantity and time period of data to be stored in each database shall be configurable. Each

event shall be stored with necessary data timestamp. At least the following data and events will be stored.

Data Subsystem	Storage Data	Storage	Storage Period
CCTV camera system	CCTV still image	TMS	2 years
	Equipment operational status	FMS	
Vehicle Detection system	Equipment operational status	FMS	2 years
	1 minute spot (multiple lanes) data	Traffic volume	
		Large-sized vehicle traffic	
		Time occupancy rate	
		Vehicle average speed	
	1 minute sectional (single lane) data	Traffic volume	
		Large-sized vehicle traffic	
		Time occupancy rate	
		Vehicle average speed	
	1 minute sectional (multiple lanes) data	Traffic volume	
		Large-sized vehicle traffic	
		Time occupancy rate	
		Vehicle average speed	
	"n" minutes sectional average speed	TMS	
	Traffic congestion analysis results with parameters	TMS	
MET system	Equipment operational status	FMS	2 years
	Instantaneous temperature (1minute and 5minutes)	TMS	
	Moving total precipitation for previous 1hour	TMS	
	Total continuous precipitation	TMS	
	Instantaneous rainfall detection (1minute and 5minutes)	TMS	
	Maximum value of wind velocity for previous 1 minute	TMS	
	Direction at maximum wind during previous 1 minute	TMS	
	Instantaneous visibility (1minute and 5minutes)	TMS	
	Heavy rain analysis results with parameters	TMS	
	Strong wind analysis results with parameters	TMS	
	Poor visibility analysis results with parameters	TMS	
Overload monitoring system	Axle load of overloaded vehicles	TMS	2 years
	Weight of overloaded vehicles	TMS	
	Plate number of overloaded vehicles	TMS	
	CCTV still image of overloaded vehicles	TMS	
	Equipment operational status	FMS	
VMS system	Recommended message automatically generated against event	TMS	2 years
	Manual input operation record	TMS	
	Equipment operational status	FMS	
	Current message indicating on each VMS	TMS	
Traffic management center system	Input event data	Incident	2 years
		Construction work	
		Traffic regulation	
	Equipment operational status	FMS	
	E-mail and SMS subscriber information	TMS	
	Equipment operational status	TMS	
	Access history of Web	TMS	
	Transmitting history of e-mail and SMS	TMS	
Communication system	Digital transmission system operational status	FMS	2 years
	Wireless radio system operational status	FMS	
	Internal telephone system operational status	FMS	
Others	Tunnel safety facility operational status	FMS	2 years
	Tunnel lighting operational status	FMS	
	Other facilities' operational status	FMS	

Note TMS: Traffic management system server, FMS: Facility management server

4) Facility Management Function

The facility management function will be provided to monitor the operational conditions of roadside equipment and traffic management center system equipment. The facility management server

will monitor the operation status of the all sub-system components listed below

- CCTV Camera System
- Vehicle Detection System
- MET System
- Overload Monitoring System
- VMS System
- Digital Transmission System
- Wireless Radio System
- Internal Telephone System
- Power Supply System
- Tunnel Safety Facility System, Tunnel Lighting System, Others

The role of this function is to consolidate the system operation status monitoring function undertaken by each sub-system component, present the status to operators and record the system operation. In case any abnormality or malfunction is detected, the facility management server shall issue an alarm together with information regarding type and location of the failure so that remedial action can be taken smoothly.

5) Network Management and Control Functions

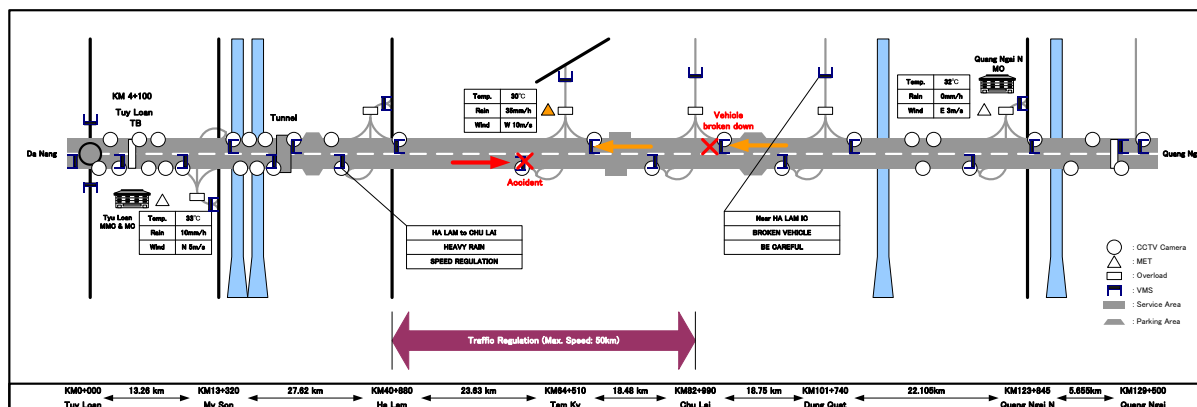
The network management function will be provided to the traffic management center system. The function will continuously monitor the conditions of Layer 2 switch and Layer 3 switch using simple network management protocol. In case a malfunction occurs, network management system shall issue an alarm to the system status monitoring console.

6) Display and Monitoring Functions

The traffic management center system will provide display and monitoring functions of schematic road map of the DQE with various kinds of static and dynamic information for the system operator to understand the current condition and to take necessary action. Such information to be displayed in the schematic map will include but not limited to the followings.

Item	Contents
Route map	<ul style="list-style-type: none"> • Schematic road map of DQE • Name and station number of interchanges and toll barriers
Equipment location and status	<ul style="list-style-type: none"> • Location of CCTV camera • Location of vehicle detection and roadside equipment • Location of MET station • Location of overload monitoring roadside equipment • Location of variable message sign • Their operational status
Road, traffic and weather condition	<ul style="list-style-type: none"> • Traffic congestion • Weather condition (rain, wind velocity, wind direction, precipitation, visibility) • Incident (traffic accident, broken-down vehicle, left obstacle, natural disaster) • Regulation (lane closure, road closure)
CCTV video image	<ul style="list-style-type: none"> • Video image from the CCTV camera selected • Video image from the video recorder
Operator console monitor display	<ul style="list-style-type: none"> • Monitor display of operator console selected
Date and Time	<ul style="list-style-type: none"> • Current date and time

Figure below shows an example of schematic road map of the DQE.



The traffic management system server will have function to generate the schematic road map to be monitored through display devices such as the operator consoles and large display panel. The server will also generate following screens.

- Each sub-system equipment status with list and map
- Event data input screen with map

7) Parameter Monitoring and Management Functions

Some of sub-system components introduce a warning system to detect the traffic congestion or adverse weather condition based on the pre-defined threshold. The traffic management center system will monitor and manage such parameters. The parameters to be monitored and changeable in the traffic management center system will includes followings;

- Vehicle detection system: Two parameters of average speed judging for "heavy congestion" and "congestion";
- MET system: Parameters detecting heavy rain, strong wind and poor visibility.

8) Information Dissemination Function

The road, traffic and weather condition information collected and processed in the traffic management center system will be provided to the road users through variable message sign, Internet, e-mail or SMS in the Project.

- Information dissemination through VMS
 - The VMS system provides road users with road, traffic and weather information through VMS boards at roadside in accordance with the data collected and processed in the traffic management center system. The control of VMS will be made from VMS center controller console procured in the VMS sub-system while the traffic management center system will provide VMS system with automatic message selection function based on the priority or severity of the events and coefficients that represent the importance of event. The function in the traffic management center system will includes;
 - Automatic message generation function that generates the recommended message to be indicated on the VMS when any event occurs
 - Zoning function that selects the VMS necessary for showing message when the event occurs at any place
 - Information screening function that selects the prior event to be displayed on the VMS when several incidents occur at the same time.

➤ Information dissemination through Internet and e-mail/SMS

Information dissemination system through Internet and e-mail/SMS will consist of an Web & MSG server and a firewall and an application software. The basic information to be provided to the road users through those media shall include but not limited to the following:

[Internet]

- Traffic information on map
- Weather conditions on map
- Event and incident information on map
- Traffic regulation on map
- Overall schematic map indicating all information above

[e-mail/SMS]

- Weather conditions in text
- Event and incident in text
- Traffic regulation in text

The system shall have subscriber management function to register and deregister the e-mail and SMS users. Firewall shall be provided to protect the Internet server against the possible attack.

9) Human-machine Interface

Two kinds of display devices will be provided as the human-machine interface, operator consoles including monitoring PC and large display panel. The large display panel will have multiple screen display function in which display area will be divided into four or more small screen areas and each of them can display image from the different sources. Large display panel will be capable of displaying any images from CCTV camera system and any operator consoles.

10) System Clock Function

The traffic management center system will have a real-time clock that is used for the timing of monitoring, data transfer, device control, reports, and print-outs. The clock will have an automatic adjustment function using GPS, Internet, mobile phone or any other references and the clock shall remain accurate within one second all the time. The real-time clock will have an internal battery and will maintain the correct time for at least 48 hours. All sub-systems, equipment and devices comprising the intelligent transport system in the DQE will synchronize with the real-time clock.

11) Operating Log Function

All operations by the system operator through the operator consoles will be recorded as operation log with the operator's ID and time. All malfunctions of the equipment comprising the system will be recorded with time of occurrence, time of recovery and type of error.

12) Report Function

The traffic management center system will have a reporting function in which various daily, monthly and annual reports can be prepared with printer. The types of report shall include but not limited to the followings:

- Traffic conditions and traffic analysis results
- Weather conditions (MET)
- Variable message sign operation
- Equipment malfunction and recovery

The report will be produced in two modes. In automatic mode, reports will be printed

automatically at the timing specified for each report. In manual mode, report is printed when the operator requests it. All reports will be in English and Vietnamese.

(3) Technical Specifications

Followings are outline of technical specifications on the traffic management center system. Detailed technical specifications are described in **Appendix-3** of this report.

1) Traffic Management System Server and Facility Management Server with Storage

The traffic management system server and facility management server computer hardware shall be standard models manufactured by organizations of international reputes. The computer hardware including display terminals shall be readily available in Vietnam. Full maintenance support services and ready availability of consumables, spare parts or replacement units shall also be assured from a third party, based in Vietnam. The specifications in this section are provided as reference. The servers to be provided by the Contractor shall materially comply with these specifications.

No.	Item	Specifications
1.	Server configuration	<ul style="list-style-type: none"> • Latest redundant server with automatic failover ability • Rack mount type enclosure with low energy consumption
2.	Processor	<ul style="list-style-type: none"> • Latest stable multi core or CPU type processor
3.	OS	<ul style="list-style-type: none"> • Latest LINUX stable operating system or latest Windows Server stable operating system
4.	Memory	<ul style="list-style-type: none"> • ECC memory
5.	Storage	<ul style="list-style-type: none"> • Having twice of sufficient volume to process all required work and store all required data including temporary data by OS and application in operation. • Data recovery system like RAID5.
6.	Back-up	<ul style="list-style-type: none"> • High speed and large capacity device for periodical data backup
7.	Graphic card	<ul style="list-style-type: none"> • Five or more video interfaces as RGB Analogue, DVI-D or HMDI to connect display devices.
8.	Peripheral	<ul style="list-style-type: none"> • DVD of high speed and high capacity multi drive supporting latest standard
9.	Availability	<ul style="list-style-type: none"> • Hot-plug, redundant power supplies • Hot-plug, redundant FAN • Hot-plug drive bays
10.	Display monitor	<ul style="list-style-type: none"> • 21-inch or smaller size of LCD type monitor (Full HD) • RGB Analogue, DVI-D or HMDI required as input interface that should be same as of video interface
11.	Network	<ul style="list-style-type: none"> • 1000/100M Base LAN interface • Dual LAN interface
12.	Security	<ul style="list-style-type: none"> • Virus protection • Firewall
13.	Reliability	<ul style="list-style-type: none"> • MTBF > 5 years x 365 days x 24 hours = 43,800 hours as a redundant server • MTTR < 12 hours • Latest SNMP supporting
14.	System availability	<ul style="list-style-type: none"> • Expected rate of operation as a redundant server > 99.97% =MTBF/(MTBF+MTTR)
15.	Power Consumption	<ul style="list-style-type: none"> • 3.6KVA or less as a whole redundant server
16.	Remark	<ul style="list-style-type: none"> • All equipment is mounted in 19-inch type server rack.

2) WEB & MSG Server

No.	Item	Specifications
1.	Server configuration	<ul style="list-style-type: none"> • Latest redundant server with automatic failover ability • Rack mount type enclosure with low energy consumption
2.	Processor	<ul style="list-style-type: none"> • Latest stable multi core or CPU type processor
3.	OS	<ul style="list-style-type: none"> • Latest LINUX stable operating system or latest Windows Server stable operating system
4.	Memory	<ul style="list-style-type: none"> • ECC memory
5.	Storage	<ul style="list-style-type: none"> • Having twice of sufficient volume to process all required work and store all required data including temporary data by OS and application in operation. • Data recovery system like RAID5.
6.	Back-up	<ul style="list-style-type: none"> • High speed and large capacity device for periodical data backup
7.	Graphic card	<ul style="list-style-type: none"> • Two or more video interfaces as RGB Analogue, DVI-D or HMDI to connect display devices.
8.	Peripheral	<ul style="list-style-type: none"> • DVD of high speed and high capacity multi drive supporting latest standard
9.	Availability	<ul style="list-style-type: none"> • Hot-plug, redundant power supplies • Hot-plug, redundant FAN • Hot-plug drive bays
10.	Display monitor	<ul style="list-style-type: none"> • 21-inch or smaller size of LCD type monitor (Full HD) • RGB Analogue, DVI-D or HMDI required as input interface that should be same as of video interface
11.	Network	<ul style="list-style-type: none"> • 1000/100M Base LAN interface • Dual LAN interface
12.	Security	<ul style="list-style-type: none"> • Virus protection • Firewall
13.	Reliability	<ul style="list-style-type: none"> • MTBF > 5 years x 365 days x 24 hours = 43,800 hours as a redundant server • MTTR < 12 hours • Latest SNMP supporting
14.	System availability	<ul style="list-style-type: none"> • Expected rate of operation as a redundant server > 99.97% = MTBF/(MTBF+MTTR)
15.	Power Consumption	<ul style="list-style-type: none"> • 1.8KVA or less as a whole redundant server
16.	Remark	<ul style="list-style-type: none"> • All equipment is mounted in 19-inch type server rack.

3) Large Display Panel

No.	Item	Specifications
1.	Display Type	Color TFT LCD
2.	Display Size	55 inch or more
3.	Number of pixels	1920×1080 (full HD)
4.	Contrast Ratio	3500:1 or higher
5.	Bezel-to-Bezel Width	6.0mm or less
6.	Input Signal	RGB Analogue, DVI-D or HMDI (Input interface shall be equivalent to output interface of Video Switches.)
7.	Video Switches	
(1)	Input Signal	RGB Analogue, DVI-D or HMDI x30 or more
(2)	Output Signal	RGB Analogue, DVI-D or HMDI x6 or more

No.	Item	Specifications
(3)	Controllable Number of pixels	Equivalent to the number of pixels of Large display panel
(4)	Control Interface	10 BASE-T/100BASE-TX (RJ-45)

4) Operator Consoles

The operator consoles as listed hereunder will be provided in the Project. The operator consoles shall be the same model and shall have the same configuration.

- Traffic event data console
- Traffic analysis console
- System status monitoring console
- LDP controller
- Monitoring PCs

The specifications shown hereunder are provided as reference. The operator consoles to be provided by the Contractor shall materially comply with these specifications.

No.	Item	Specifications
1.	PC configuration	<ul style="list-style-type: none"> • Latest PC • Space saving type enclosure with low energy consumption
2.	Processor	<ul style="list-style-type: none"> • Latest stable multi core or CPU type processor
3.	OS	<ul style="list-style-type: none"> • Latest Windows stable operating system
4.	Memory	<ul style="list-style-type: none"> • Having enough ability to process all required work without any delay, and enough space in operation.
5.	Storage	<ul style="list-style-type: none"> • Having twice of sufficient volume to process all required work and store all required data including temporally data by OS and application in operation.
6.	Graphic card	<ul style="list-style-type: none"> • RGB Analogue, DVI-D or HMDI video interface (Full HD), equivalent to video switches and console display monitor interface • Number of video interface shall be as follows: Traffic event data console: Three Traffic analysis console: Two System status monitoring console: Three LDP controller console: One Monitoring PCs: Three
7.	Console Display Monitor	<ul style="list-style-type: none"> • LCD widescreen monitor (Full HD), 24-inch or larger • Number of monitor shall be as follows: Traffic event data console: Two Traffic analysis console: Two System status monitoring console: Two LDP controller console: One Monitoring PCs: Two • RGB Analogue, DVI-D or HMDI input, equivalent to graphic card video interface
8.	Peripheral	<ul style="list-style-type: none"> • DVD of high speed and high capacity multi drive supporting latest standard
9.	Network	<ul style="list-style-type: none"> • 1000/100M Base LAN interface
10.	Security	<ul style="list-style-type: none"> • Virus protection • Firewall
11.	Reliability	<ul style="list-style-type: none"> • MTBF > 3 years x 365 days x 24 hours = 26,280hours • MTTR < 24 hours • Latest SNMP supporting

No.	Item	Specifications
12.	System availability	• Expected rate of operation > 99.90%=(MTBF/(MTBF+MTTR))
13.	Power Consumption	• 500VA or less

5) System Clock Server

Each system component will be equipped with a clock system for its operation. These clocks shall be synchronized to collect and process the data correctly. A system clock server will be provided to the traffic management center system as a reference clock. All clocks in the system component shall be synchronized with the clock provided by the server using network time protocol (NTP) or simple network time protocol (SNTP).

6) Printers

The printer will be a high-speed A3/A4 size color laser printer. The printers will be connected to the LAN of traffic management center system.

No.	Item	Specifications
1.	Printing speed	30 ppm or higher (black, normal quality mode) 30 ppm or higher (colour, normal quality mode)
2.	First page out	Not more than 16 second (black, colour)
3.	Print resolution	600 dpi or higher (black) 600 dpi or higher (colour)
4.	Paper trays	2 (standard)
5.	Media size	A3 / A4
6.	Duplex (both sides) printing	Automatic
7.	Interface	100M Base LAN interface

7) Firewall and Network Equipment

The network equipment consists of Layer 3 Switch (L3-SW), Layer 2 Switch (L2-SW), Media Converter, Firewall etc. Firewall shall also be provided to protect the Internet server against the possible attack.

8) Software

➤ Third Party Software

The third party software to be provided will include but not be limited to the following:

- Server operating system
- Storage device operating system
- Client operating system
- Database management software
- Firewall and antivirus program

All third party programs to be provided shall be widely used and suitable for the application of ITS in the DQE in terms of functions, capacity, speed, interface with other software, maintenance and user friendliness.

➤ ITS Software

The software to be provided as specific ITS software in the Project will include but not be limited to the following:

- Traffic management center server software
- Facility management server software
- LDP control software

- Web & MSG generation software
- System clock software
- NVR application software (CCTV camera sub-system)
- CCTV control application software (CCTV camera sub-system)
- Traffic analysis processing software (Vehicle detector sub-system)
- MET data processing software (MET sub-system)
- Overload monitoring data processing software (Overload monitoring sub-system)
- VMS control application software (VMS sub-system)
- Network management software (communication system)
- Utility software
- Maintenance activity tracking and logging software

All software shall be of modular construction and the interaction between the modules shall be kept minimum. They shall be designed to operate continuously and no periodical maintenance of the software shall be required.

All the display on the display monitor and printed report shall be capable of in both English and Vietnamese.

The utility software shall include but not be limited to the system backup and restoration, database backup and restoration, and access control and operation log functions. Usage of the server and operator consoles shall be controlled by log in/out procedure and different levels of access control shall be provided to restrict the use of certain software by unauthorized persons. All operations shall be recorded as log together with staff identification number.

The software that interacts with the system operator shall be provided with fault tolerant functions and access control functions. They shall be designed in such a way that any operation error shall not cause damage to the system, loss of data or system shut down.

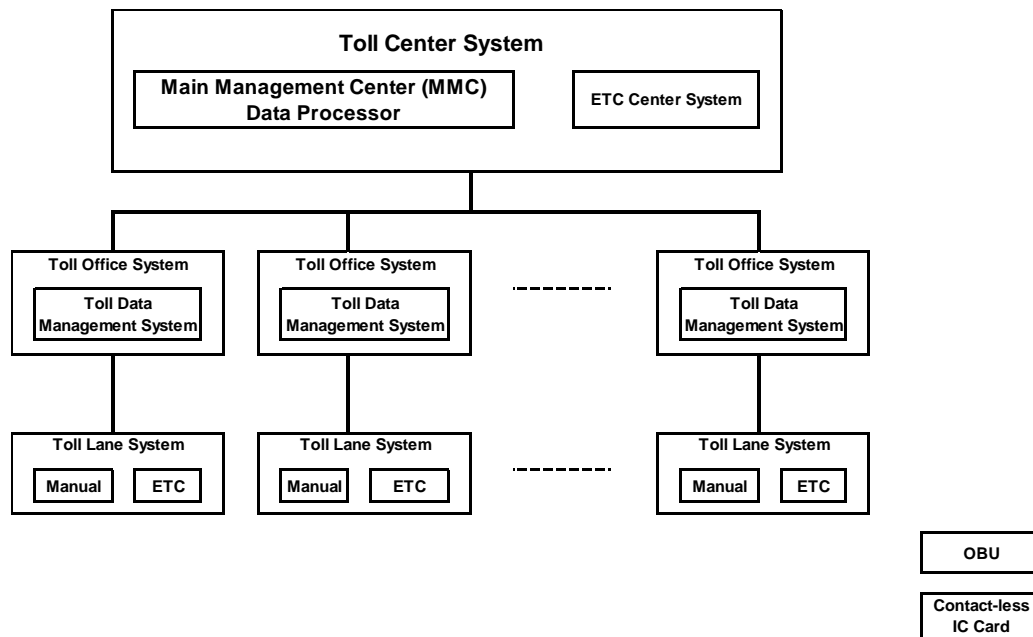
5.7 Toll Collection System

5.7.1 System Configuration

The toll collection system is designed as “Closed System” in which the toll rate is determined by vehicle classification and vehicle running distance on the expressway. The vehicle will stop and take a toll ticket at entry point and pay a toll fee to a toll collector at exit point. After the ticket is handed over or toll fee is paid, the lane will be opened automatically for the vehicle to pass through the tollgate.

The toll collection system for the Project will be configured with four components as follows;

- Toll Lane System
- Toll Office System
- Toll Center System
- User Side Equipment



Source: Consultant

Figure 5-13 Overall Toll Collection System

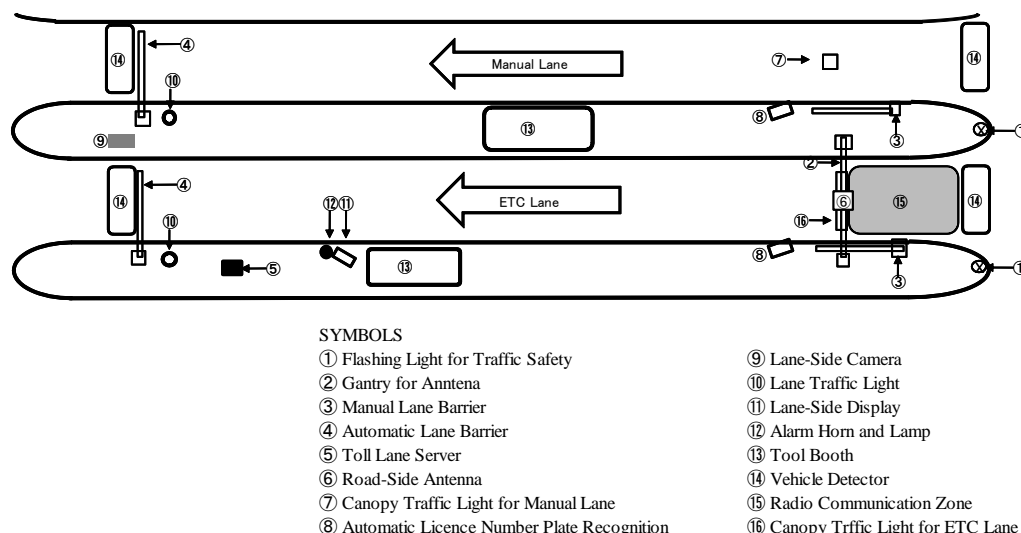
5.7.2 Toll Lane System

The toll lane system is installed both at the toll island and in the tollbooth. The Toll Lane Server (TLS) will form the integrated core equipment to ensure the all lane functions and procedures, and all data of transaction are controlled and retrieved independently by the TLS.}

(1) Toll Island Equipment

Toll island equipment will be composed of, but not be limited to the following equipment.

- Lane Traffic Light (LTL)
- Canopy Traffic Light (CTL)
- Automatic License Number Plate Recognition Camera (ANPR-CAM)
- Lane Side Camera (LS-CAM)
- Vehicle Detector (VD)
- Lane Side Display (LSD)
- Automatic Lane Barrier (ALB)
- Manual Lane Barrier (MLB)
- Flashing Light for Traffic Safety (FLTS)
- Alarm Horn and Lamp (AHL)
- Roadside Antenna (RSA)



Source: Consultant

Figure 5-14 Toll Island Equipment

1) Traffic Sign Equipment

There are four (4) kinds of signs associated with each set of tollbooth equipment, namely:

- Lane Traffic Light (LTL)
- Canopy Traffic Lights (CTL)
- Lane Side Display (LSD)
- Alarm Horn and Lamp (AHL)

The LTL is a traffic signal with a red “Stop” and green “Go” light, and located at the vehicle departure side of each toll lane to control passage of each toll vehicle. The LTL uses LED lamps. The green “Go” light is for indicating a driver that the toll ticket has been issued at entry point or the toll fee has been paid at exit point and he is free to move on.

The CTL for manual lane is mounted on the toll canopy above the entrance of each toll lane and indicates whether that lane is opened or closed for the driver. The CTL for manual & ETC lane is mounted on the gantry above the entrance of each toll lane and indicates whether that lane is opened or closed for the driver. Available maximum loading capacity of the gantry is 800 kg.

The LSD is used to show the toll amount to be paid, vehicle classification registered by the toll collector, amount of value in prepaid card and other information related toll collection. The LSD will be located where the driver can see it while he stopped at the tollbooth.

- | | |
|-------------------------------------|------------------------------|
| - Lamp: | LED type (indicating 4 line) |
| - Text height: | 80mm |
| - Board size: | 340(w)x800(h) mm |
| -Flashing/Alternating display time: | 40 times/min (Standard) |
| -Scrolling speed: | 40ms/dot (Standard) |

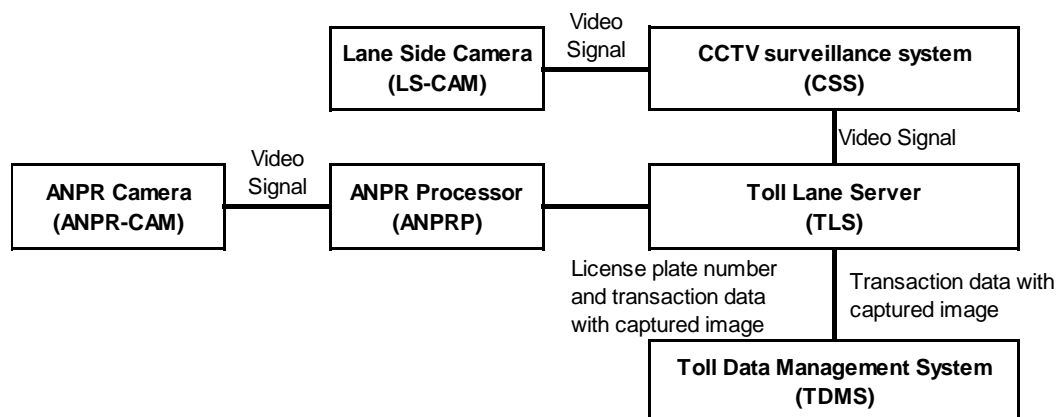
The AHL is used to indicate the warning or sign by sounds or visuals, when any incidents happen. The AHL will be located where the driver can hear and see it while he stops at the booth.

- | | |
|-------------------------------|------------------------|
| - Lamp: | LED type |
| - Alarm sound pressure level: | Max. 95dB/m (Variable) |

2) Camera Equipment

There are two (2) sets of camera associated with tollbooth equipment or toll office system, namely:

- ANPR Camera (ANPR-CAM)
- Lane Side Camera (LS-CAM)



Source: Consultant

Figure 5-15 Configuration of Lane Side Camera and ANPR-Camera

The ANPR-CAM is used to recognize the license number of a vehicle connected with ANPR Processor (ANPRP) in the booth. The ANPR-CAM will be located where it is the best position to take a shot the license number plate properly.

Requirements of ANPR-CAM are as follows,

- Camera: Fixed IP camera with IR lamp
- Number plate imaging area: Width 3500mm × Height 3800mm (Distance 4000mm-5000mm)
- Detectable vehicle speed: Max. 80km/h
- Accuracy: 95% or better
- Functions: Zoom, Focus, Iris, IR light-emitting
- Camera housing: Rainproof

The LS-CAM will be used to observe the conditions of toll collection activity on a lane. The video image will be recorded in associated with toll office system via the Toll Lane Server (TLS). The LS-CAM will be located where it is possible to observe the vehicle fully while the driver stops at the booth.

Requirements of LS-CAM are as follows,

- Camera: PTZ (Pan, Tilt, Zoom) IP digital camera
- Video Compression: MPEG-4/H.264 and M-JPEG
- Image Device: CCD or CMOS, color
- Resolution: DTV: 720 x 576, VGA: 640 x 480, QVGA: 320 x 240
- Minimum subject illuminance: 10 lx
- Maximum subject illuminance: 2000 lx
- Horizontal angle: 45 degree or more
- Vertical angle: 44 degree or more
- Lens type, zoom factor: Autofocus lens, optical 30x/ digital 10x or more
- Focal length: 3.8 to 114 mm or longer
- Line bit rate: 64 / 128 / 256 / 512 / 1024 / 2048 / 4096 kbps
- Frame rate: 0.1 fps – 30 fps
- Communication: Ethernet (TCP/IP)

- Power consumption: 50 VA or less (average: 20W)
- Ingress protection: IP66
- Control code: compatible with NVR

The CCTV surveillance system (CSS) shall be used to display state of vehicle passing through the toll lane via the LS-CAM, and send video signal to the TLS.

3) Vehicle Detector

The Vehicle Detector (VD) will be used to detect the vehicle and retrieve the number of vehicles. The VD will be used to detect whether the vehicle has existed/passed or NOT at the position where the VD is set. Also the VD will be used as a kind of traffic counter to calculate the number of vehicle passing through the toll lane.

- The VD is able to detect the vehicle running by per 80km/hour through the toll lane and to separate a vehicle which runs 1m by the distance between two vehicles. And detection accuracy is 95% at 100km/h or better.
- The VD uses inductive loop detector or equivalent.
- The VD unit will be installed each 1 unit each Entry/Exit lane and processes 12 sensors or more.

4) Roadside Antenna

The Roadside Antenna (RSA) will be used to communicate with the On-Board Unit (OBU) installed in the user's vehicle in order to provide the Electric Toll Collection (ETC) service. The RSA will be mounted on a gantry above the front side of both Ingress/Egress ETC operated lane (hereinafter referred as ETC lane). Following items are requirements of RSA:

- The communication area of RSA shall cover 4 m in the longitudinal (vehicle travel) direction and 3 m in the lateral direction, at a height of 1 m from the surface of toll lane.
- Communication method: Dedicated Short Range Communication (DSRC), Active, Simplex or duplex
- Transmitting/Receiving frequency: 5.8GH Modulation: ASK
- Radio access: TDMA-FDD
- Data transmission speed: 1,024kbps
- Antenna gains: 20dBi or under
- Polarized wave: Dextrorotatory circularly polarized wave

5) Barriers

There will be two (2) kinds of barrier which will provide a physical obstruction to passage through each lane, namely a Manual Lane Barrier (MLB) and an Automatic Lane Barrier (ALB). The MLB will be located around the front of toll island to indicate the driver whether a toll lane is operated or not. Material of gate bar of the MLB will be used glass fiber. The ALB will be located at the tollbooth forward in order to control the "Stop" and "Go" of the vehicle. Following items are requirements of ALB:

- Gate bar Opening/closing time: 500ms or less (from receiving control signal)
- Opening/closing method: Single or Double gate bar

6) Others

Ancillary items of toll collection system equipment will include, but not limited to, a Flashing Light for Traffic Safety (FLTS) which will provide a warning to avoid the clash against the toll island.

- The FLTS shall be visually recognized from 100m distance from the toll island.
- The FLTS shall be a two LED light type, and emit light alternately.

Table 5-1 Number of Toll Island Equipment

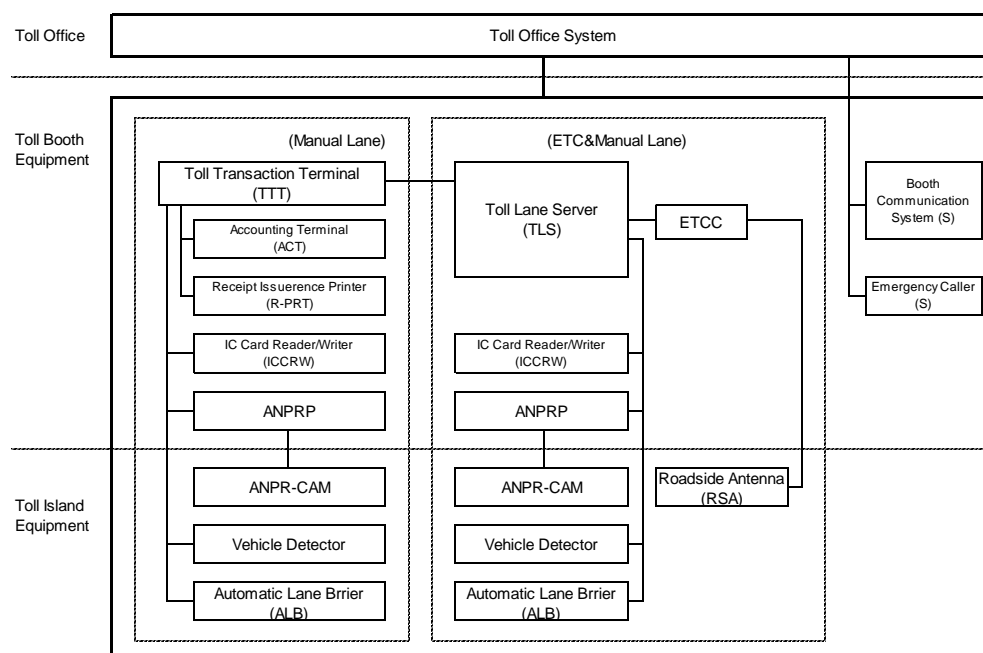
Toll Island Equipment		Manual Lane		Manual & ETC Lane	
		Entry	Exit	Entry	Exit
Lane Traffic Light	LTL	1	1	1	1
Canopy Traffic Light	CTL	1	1	1	1
Automatic License Number Plate Recognition Camera	ANPR-CAM	1	1	1	1
Lane Side Camera	LS-CAM	1	1	1	1
Vehicle Detector	VD	2	2	2	2
Vehicle Detector Unit	VD-U	1/total lanes	1/total lanes	1/total lanes	1/total lanes
Lane Side Display	LSD	1	1	1	1
Automatic Lane Barrier	ALB	1	1	1	1
Manual Lane Barrier	MLB	1	1	1	1
Flashing Light for Traffic Safety	FLTS	1	1	1	1
Alarm Horn and Lamp	AHL	1	1	1	1
Roadside Antenna	RSA			1	1

Source: Consultant

(2) Toll Booth Equipment

The toll booth equipment will be composed of , but not be limited to, following equipment.

- Toll Lane Server (TLS)
- Toll Transaction Terminal (TTT)
- IC-Card Reader/Writer (ICCRW)
- Receipt Printer (R-PRT)
- ETC controller (ETCC)
- ANPR Processor (ANPRP)
- Booth Communication System (slave) (BCS-S)
- Emergency Caller (slave) (ECALL-S)
- LAN cable and necessary number of hubs and routers
- Tollbooth facilities: UPS, Air Conditioner, Exhaust Gas Diffuser, etc
- Power and switch boxes as necessary to meet the specification



Source: Consultant

Figure 5-16 Toll Booth Equipment Configuration

The tollbooth equipment will operate in an autonomous mode controlling all the lane peripherals, analyzing inputs from the Vehicle Detector (VD), the ETC Controller (ETCC), the IC-Card Reader/Writer (ICCRW) in conjunction with the toll collector's inputs made via a keyboard on the Toll Transaction Terminal (TTT) and other automatic and semi-automatic inputs provided by the equipment itself.

1) Toll Lane Server (TLS)

The Toll Lane Server (TLS) will store and, under normal operating conditions, transmit the individual data including exceptional transactions data of the toll collector's job to both the Toll Office System (TOS) for storing the data into the its database, in real time, confirming all events, individual transactions and alarms.

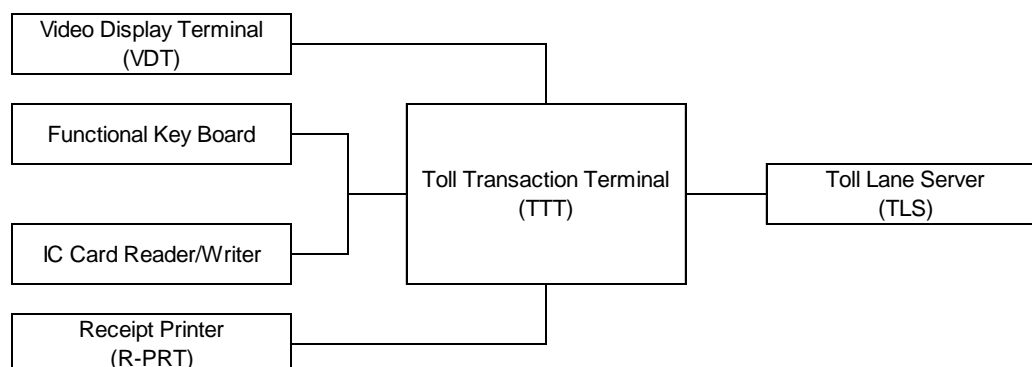
At the closing event of the lane, the TLS will transmit the job and traffic data after summarizing all the toll transactions of the toll collector's job.

Each TLS will have the capability of operating in the normal on-line mode and off-line mode. When the TOS failed, the TLS shall store data relating to at least one (1) week operation under specified conditions and throughput, for later transmission to ensure no loss of audit or statistical data.

The TLS will send a captured image from the LS-CAM with some retrieval keys to Toll Data Management System (TDMS) at each transaction. Required image storage period is of more than one (1) week. One of retrieval keys to search the image will be a transaction number.

2) Toll Transaction Terminal (TTT)

The Toll Transaction Terminal (TTT) serves as the toll collector's input terminal. The TTT will be connected by a plug and socket, arranged so that the connection is secure from unauthorized disconnection. The TTT will be constructed to resist against split beverages, dust and exhaust pollutants.



Source: Consultant

Figure 5-17 Configuration of Toll Transaction Terminal (TTT)

The following items of equipment will be neatly fitted on or accommodated in the TTT or provided as separate unit as necessary for the proper registration of transactions:

- Hardware:
 - Processor: 3GHz dual cores or better
 - RAM: 12 GB DDR3 or more
 - HDD: 500GB or more
 - Network: Gigabit Ethernet
 - Monitor: LCD 17
 - Server storage rack : 800mm (W) x 1000mm (D) x 1800mm (H)
- Functional keyboard or the touch screen as an input device.
- A digital time display.
- Compatible with an IC-Card Reader/Writer (ICCRW), able to read all IC-Card of the Project.

- An indication to show that booth equipment power is available.
- This indication shall only be extinguished for loss of a power supply to the tollbooth equipment. It shall not be extinguished by faults in the processing and registration equipment.
- A “lane open” and “lane closed” control which shall switch display status of the Canopy Traffic Lights (CTL).
- A clear and easily distinguishable indication to show whether the “lane open” or “lane closed” aspects is currently displayed on the CTL.
- Vehicle classification selection keys function, at least five (5).
- A “Force Reset” key to allow reset of the equipment at the end of a transaction in the event of failure of the vehicle detection equipment.
- A “Cancel” key to allow correction of an erroneous input function.
- A “Manual Input” key function.
- A color monitor display with at least 14” screen with an appropriate resolution.
- An “Accept” key function to confirm receipt of payment.
- An “Enter” key function to confirm inputs.
- Allowance for at least four additional keys to be added to the keyboard for Future use.
- A Receipt Printer (RPR) with a receipt request key function.

3) IC-Card Reader/Writer (ICCRW)

The IC-Card Reader/Writer (ICCRW) will be used to read and write the data in the contactless IC-Card. The ICCRW shall comply with the following requirements:

- The communication distance with contactless IC-Card shall be possible from the equipment exterior side by the range of about 5mm.
- The frequency of the RF operating magnetic field shall be 13.56MHz.
- The ICCRW shall transfer power to the contactless IC-Card by producing RF operating magnetic field and make communications by magnetic field modulation.
- The bit rate between ICCRW and contactless IC-Card shall be 13.56 MHz/64 (approximately 212 k bit/s).
- ICCRW shall be equipped with high-security data management conforming to ISO/IEC 15408 EAL4.

4) Receipt Printer (R-PRT)

The Receipt Printer (R-PRT) will be installed in each tollbooth, located adjacent to TTT to issue receipts. A receipt will be automatically printed, cut, and fed out when the collector depresses the key assigned for “CASH” transactions on TTT. The speed of issuing a receipt from the collector’s action shall be 1.5 second maximum.

The R-PRT will use a well-proven durable print head mechanism which can allow clear printing of receipts. The reliability of print head shall have a minimum of 80 million characters between failures of 5,000 hours, whichever is greater. The receipts will be printed on a paper roll which shall have sufficient capacity for a minimum of 2,500 receipts.

The R-PRT will use a dot matrix to form characters and symbols in the standard ASCII character set. The minimum dimension of printed characters and the minimum definition of dot matrix shall be as follows:

- Dimension : 1.8 mm (W)×2.7 mm (H)

- Definition : 7×7 dot matrix

A paper feed facility and a “Test Print” mode will be provided to verify correct insertion and alignment of paper, and operation of the printer. Outputs of “Test Print” shall be identified easily as the output of test print.

5) ETC Controller (ETCC)

The ETC Controller (ETCC) will be used to communicate with the On-Board Unit (OBU). The ETCC will comprise with the part of radio transmitter/receiver connected with a Roadside Antenna (RSA), encoder/decoder for encryption and the other related processor. The ETCC will be connected with the TLS to exchange the data of transaction.

The ETCC allows the radio communication with OBU by using transceiver mode of Dedicated Short Range Communication (DSRC) complied with the active method requirements on Annex 1 on Recommendation ITU-R M.1453.

6) Automatic License Number Plate Recognition Processor (ANPRP)

The Automatic License Number Plate Recognition Processor (ANPRP) will be used to recognize the License Number Plate by scanning an image from an Automatic License Number Plate Recognition Camera (ANPR-CAM) when a vehicle approaches to the toll lane. The result of recognition will be a formatted text data and transmitted to the Toll Lane Server (TLS). The ANPRP shall comply with the following requirements:

- The ANPRP shall capture an image of the license number plate of a vehicle passing the toll lane at a maximum speed of 80km/hr at any time day or night. Required image storage period is of more than one (1) week.
- The ANPRP shall transmit a result of recognition combined with the captured image of license number, a time stamp and a transaction number to Toll Data Management System (TDMS).

7) Booth Communication System (BCS)

The Booth Communication System (BCS) will be installed to allow the direct inter-communication between master and slaves which are located in toll office and toll booth.

The BCS will be composed of a Booth Communication System (Master) (BCS-M) on the supervisor's desk in the office room of toll office building and Booth Communication System (Slave) (BCS-S) in each toll booth, and other locations in the toll office building. The BCS shall comply with the following requirements:

- The BCS system shall be designed to enable a communication between BCS-Ss and shall include an “all call” facility to allow the supervisor to broadcast messages to all BCS-S simultaneously from the BCS-M.
- The BCS-M shall include, at least, the following parts:
 - Speaker/Microphone
 - Volume control for speaker
 - Call button for each BCS-S (with expansion to a maximum of 40)
 - “Press to talk” button
 - Station indicator lamp
 - “All call” button for simultaneous announcement to all BCS-S
 - Power on-off switch with “Power on” indicator
 - Lamp test button
 - Sound pressure (built-in speaker): 70dB and above (Variable)

- Communication shall be controlled from the BCS-M. The operation of the BCS shall be by “hands free” facilities.
- BCS -M controls BCS-S: maximum 8 or more
- The BCS-S shall comprise a speaker/microphone and an illuminated call button. An audible tone and illuminated call button shall signify an incoming call. Operation of the BCS-S shall be independent of a toll collector being “logged in” to the TTT, or not.

8) Emergency Caller (ECALL)

The Emergency Caller (ECALL) will provide an emergency call in each toll booth and other locations in the toll office building. The ECALL will be composed of an Emergency Caller (Master) (ECALL-M) on the supervisor’s desk in the office room of toll office building and an Emergency Caller - Slave (ECALL-S) in each toll booth and other locations in the toll office building.

The ECALL shall comply with the following requirements:

- An ECALL-S shall be provided in each toll booth. The alarm shall be raised by pressing the button.
- The ECALL-S shall be installed in an agreed position within the toll booth and toll office so as to be easily and discretely operated, but not being liable to accidental operation during normal collection activities.
- Once the ECALL is activated, alarm indications shall be given to ECALL-M at the Toll Supervisor's desk.
- ECALL (M) controls ECALL(S)s: max 8 or more
 - Frequency band: 0.3 kHz to 3.4 kHz
 - Speech wire: 2 wire
 - Make ratio: 33 % +/-10 %

Table 5-2 Number of Toll Booth Equipment

Equipment		Manual Lane		Manual & ETC Lane	
		Entry	Exit	Entry	Exit
Toll Lane Server	TLS	1	1	1	1
Toll Transaction Terminal	TTT	1	1	1	1
IC-Card Reader/Write	ICCRW	1	1	1	1
Receipt Issuance Printer	R-PRT		1		1
ETC Controller	ETCC			1	1
ANPR Processor	ANPRP	1	1	1	1
Booth Communication System (slave)	BCS	1	1	1	1
Emergency Caller (slave)	E-CALL	1	1	1	1

Source: Consultant

5.7.3 Toll Office System

The Toll Office System (TOS) will be provided in toll office building. The TOS will consist of management and data processing of toll collection transaction (hereinafter: TDMS, which is an abbreviation of Toll Data Management System) for each Toll Lane System (TLS). The TOS will have following two main functions:

- Transaction data acquisition/store from the Toll Lane System and provision of real time monitoring facilities via a visual display unit in the office room of toll office
- Data processing and toll office management via visual display units, printer terminals, auxiliary memory media and data transfer facilities.

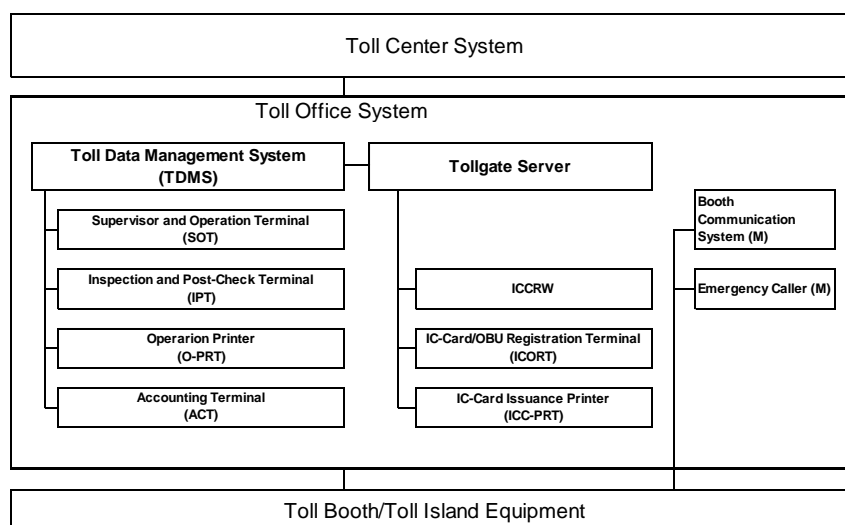
The TOS will be composed of, but not be limited to, following equipment.

- Database Server for Toll Data Management System (TDMS)
- Supervisor and Operation Terminal (SOT): to supervise toll collection work
- Inspection and Post-check Terminal (IPT): to inspect toll collection work by image data
- Tollgate Server: to store and controls access of data of ETC vehicles passing tollgate, and transmit data to Toll Center System (TCS)
- Accounting Terminal (ACT): to manage toll account
- IC-Card/OBU Registration Terminal (ICORT)
- IC-Card Reader/Writer (ICCRW)
- LAN cable and necessary number of hubs or routers
- Booth Communication System (master)
- Emergency Caller (master)
- Operation Printer (O-PRT)
- Receipt Printer (R-PRT)
- IC-Card Issuance Printer (ICC-PRT)
- CCTV system
- Monitor/Controller: Color monitors and necessary number of multiplexer, digital video recorder and other related devices

(1) Toll Data Management System (TDMS)

The Toll Data Management System (TDMS) will be located in the Equipment room for TCS of toll office building. The TDMS will be connected to all terminals of Toll Office System (TOS) and each Toll Lane Server (TLS) through Local Area Network (LAN) in order to carry out real time or fixed interval functions, such as data communication with lane equipment and data archiving.

The TDMS will be a server to carry out real time functions, such as data communication with the TLS and data archiving including a captured image and a result of license number recognition to inspect and post-check the toll collection work. Visual display units and printer terminals for the TDMS will be provided for control, selection and data input/output. Comprehensive back-up facilities will be provided through the use of mass storage device or equivalent means to ensure that the loss of data or restrictions on operation must not occur as a result of TOS failure for a long term.



Source: Consultant

Figure 5-18 Toll Office System Configuration

In the event of power failure of the TOS, or a communication failure between the Toll Lane Server (TLS) and TOS, the TLS will function as stand-alone equipment together with its all peripherals and maintain one (1) week at least of data in the TLS. When the link is restored, all data shall be automatically up-loaded.

The TDMS will be linked to all lane equipment and receive details of data on the individual transaction basis in real time and fixed interval, summary of a toll collector's job at each end of his job and hourly traffic data at each hour basis.

The disk capacity of the TDMS shall be calculated by taking account of the need to store the operating system, the application software and other software packages necessary for operation of the system and the data generated by the system to meet the requirements of the Specification.

The TDMS will send, at intervals of not less than one (1) hour, the current date and time of its real time clock to the TLSs and other terminals for their time synchronization purpose. The TDMS will be provided its time synchronization from network time system of other system.

The TDMS will treat necessary, but not limited to, data for toll transaction data and other related information as follows;

- Type of transaction
- The number of transaction
- Unique identification number for the IC-Card and OBU
- Status of authorization and/or validation
- Type of vehicle classification
- License number
- Name of interchange at entry
- Number of toll lane
- Name of toll collector at entry
- Transaction date at entry
- Transaction time at entry
- Name of interchange at exit
- Number of toll lane at exit
- Name of toll collector at exit
- Transaction date at exit
- Transaction time at exit
- Toll fee of a transaction
- Remaining value on prepaid value
- Charged value on prepaid value
- Personal identification number
- Job number for toll collector
- History of "Record of Use"
- Captured image of the LS-CAM and ANPR-CAM
- System Parameter
- Other related record

Following items are Requirements of Hardware of TDMS.

- Processor: 3GHz multi cores or better
- RAM: 12 GB DDR3 or more, expandable up to 144GB
- RAID controller: Integrated
- HDD: 2TB or more

- Network: Gigabit Ethernet
- Human Machine Interface: Mouse + keyboard + monitor LCD 17
- Server storage rack : 800mm (W) x 1000mm (D) x 1800mm (H)

Some data/message will be translated into a code in order to handle effectively on the data base system in advance.

(2) Tollgate Server

Tollgate server stores data of ETC vehicles passing Entry/Exit tollgate and controls access On-Board Unit (OBU) of ETC vehicles, and transmit those data to Toll Center System (TCS)

Following items are requirements of hardware of the tollgate server.

- Processor: 3GHz multi cores or better
- RAM: 12 GB DDR3 or more, expandable up to 144GB
- RAID controller: Integrated
- HDD: 2TB or more
- Network: Gigabit Ethernet
- Human Machine Interface: Mouse + keyboard + monitor LCD 17
- Server storage rack: 800mm (W) x 1000mm (D) x 1800mm (H)

(3) Terminal Equipment

There are four (4) kinds of terminals associated with TDMS, namely a Supervisor and Operation Terminal (SOT), Inspection and Post-check Terminal (IPT), and an Accounting Terminal (ACT).

1) Supervisor and Operation Terminal (SOT)

A main purpose for a Supervisor and Operation Terminal (SOT) is to operate and monitor the Toll Lane System. The SOT will be used by the "toll supervisor" to monitor particular aspects of the toll operation, to access the stored data in the TDMS for further data processing, and to conduct data backup procedure. The SOT will receive the lane transaction and event data (including the status information of the lane equipment) directly from each TLS, and perform the detailed monitoring of lane equipment operation. The series of computer desks accommodate the SOT with an O-PRT. The desks will be positioned in the office room so that toll supervisor can have an unrestricted view of the plaza through the windows.

Following items are requirements of hardware of SOT.

- Processor: 3GHz or more
- RAM: 1GB
- HDD: 500GB or more
- Human Machine Interface: Mouse + keyboard + monitor LCD 24 inch
- Desk and chairs: To be provided

2) Inspection and Post-check Terminal (IPT)

The Inspection and Post-check Terminal (IPT) will be used to inspect and post-check the negative expression and activity of toll collection. Those inspections shall be implemented as Cross-check by staffs that Cashier (Officer) at each toll office (TO), Chief of Toll Management at each Management Office (MO) and by staff of Toll Management division at Main Management Center (MMC). The IPT will be managed by transaction data and recordings from TDMS. In the TO, the series of computer desks will accommodate two (2) IPTs with an O-PRT. The desks will be positioned nearby staff in charge of toll inspection in the office room. In the MO, the series of computer desks will accommodate two (2) IPTs with an O-PRT at office room. In the MMC, the console arrangement must be proposed by the Contractor to suit his

equipment arrangement. The requirements of hardware of IPT is same as one of SOT.

3) Accounting Terminal (ACT)

The Accounting Terminal (ACT) will be used for both toll collector and toll accountant at the toll office. In order to register collected toll by a toll collector at each end of his job, an accounting room will be established in the toll office building. Two (2) ACTs will be installed in the accounting room with an O-PRT, which forms a part of the TOS and serves as a collected toll entry terminal.

The ACT will have registration screens for the toll collector to enter collected numbers of banknotes for each denomination with his identity card number, job number and moneybag/box number. The ACT will give a caution, if discrepancy between the registered amounts at the ACT and TTT exceeds the pre-defined allowance. The ACT will be used to make proceedings of toll collector's fee based on the shift of them and to make the report of general toll collection results corresponding to the regulations. The series of computer desks will accommodate the ACT with an O-PRT. The desks will be positioned in the accounting room so that toll collector and accountants can have a restricted area in the toll office. The requirements of hardware of ACT is same as one of SOT.

4) IC-Card/OBU Registration Terminal (ICORT)

The IC-Card/OBU Registration Terminal (ICORT) will be used to register the data of IC-Card and OBU. The ICORT will record the data of IC-CARD and OBU, and transfer them to Customer Data Management System (CDMS) of Toll Center System at the MMC. An ACT will be installed in the accounting room with an O-PRT and an ICC-PRT in order to issue/re-issue the ticket (toll ticket, commutation ticket and prepaid card) and OBU. The series of computer desks will accommodate the ICORT with an O-PRT and ICC-PRT. The desks will be positioned in the office room and ticket selling room. The requirements of hardware of ICORT is same as one of SOT.

The registration method of OBU shall be conducted by the specialized IC-Card for the purpose of initialization of the OBU.

(4) Operation Printer (O-PRT)

The Operation Printer (O-PRT) will be provided for production of audit, accounting and statistical reports. The O-PRT will be connected to all terminals of Toll Office System (TOS) through Local Area Network (LAN) in order to produce audit, accounting and statistical reports such as operating logs, alarm messages, traffic statistics, details of "collected cash", etc. The O-PRT will be located in the convenient places with floor stands which incorporate accommodation units of printer papers. The specifications of the OPR shall be as follows:

- | | |
|-------------------------|--|
| - Printing Method : | Monochrome laser printer |
| - Printing Speed : | 24 pages per minute or more |
| - Printing Resolution : | 1,200 dpi |
| - Connectivity : | Ethernet with pre-installed network card |
| - Media Sizes : | A5, A4, A3 |
| - Media Handling : | Multiple input trays |

(5) IC-Card Issuance Printer (ICC-PRT)

The IC-Card Issuance Printer (ICC-PRT) will be installed with ICORT at the reception in the toll office in order to issue some kinds of the IC-Card. The ICC-PRT will be provided for data recording and surface printing in/on some kinds of IC-Cards in order to issue the Commutation Ticket (CMT) and the Prepaid Card (PPC), which are with owner registration. The basic requirement of read/write function of ICC-PRT shall refer that of ICCRW.

- | | |
|---------------------|--|
| - Type of IC-Card : | IC-Card with Leuco dye surface |
| - Printing Method : | Leuco dye type thermal rewritable printing |
| - Interface : | USB / RS-232C/etc |

(6) Emergency Caller (ECALL)

The Emergency Caller (ECALL) will provide an emergency call from each toll booth and some rooms at toll office building. An Emergency Caller (Master) (ECALL-M) will be installed on the supervisor's desk in the office room of toll office building. The ECALL-M will function as main system for any Emergency Callers (Slave) (ECALL-S).

The ECALL-M/S will be located in the following rooms in the toll office.

- Office room 1(M)
- Ticket Selling room 1(S)
- Equipment room for TCS 1(S)
- Accounting room 1(S)
- Sleeping room 1(S)
- Service Tunnel (Tuy Loan IC) 3(S) (Center and both ends of Tunnel)

(7) Booth Communication System (BCS)

The Booth Communication System (BCS) will be installed to allow the direct inter-communication between master and slaves which are located in toll office and toll booth.

The BCS will be composed of a Booth Communication System-Master, (BCS-M) on the supervisor's desk in the office room of toll office building and the Booth Communication System-Slave (BCS-S) in each toll booth, and other locations in the toll office building.

The BCS-M/S will be located in the following rooms in the toll office.

- Office room 1(M)
- Ticket Selling room 1(S)
- Equipment room for TCS 1(S)
- Accounting room 1(S)

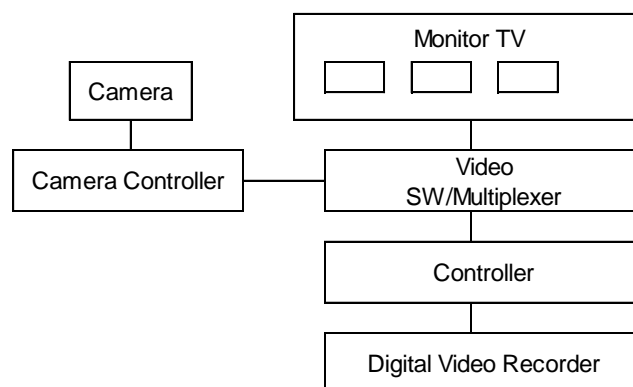
(8) IC-Card Reader/Writer (ICCRW)

Each Toll Office will be equipped two (2) IC-Card Reader/Writer (ICCRW) in order to login in the system and handle the data of IC-Card.

(9) CCTV Surveillance System

The CCTV surveillance system will provide the visual image of the Lane Side Camera (LS-CAM) and toll collection work in the toll office. It is very useful for toll officer to observe visually the situation around/in the toll office.

The system will consist of camera and video signal transmission system around/in the toll office and controller and display in the office room. General system configuration is shown in figure below.



Source: Consultant

Figure 5-19 CCTV Surveillance System (CSS) Configuration

As PAL (Phase Alternating Line) standards is used for TV broadcasting system in Vietnam, same PAL system shall be introduced for the surveillance system.

The CCTV surveillance system except the LS-CAM will be located in the following points, but not be limited to, in the toll office.

- Office room 1
- Ticket Selling room 1
- Equipment room for TCS 1
- Accounting room 1
- Service tunnel (Tuy Loan IC) 2
- Around the entrance 1

Two (2) cameras at least in the service tunnel will be introduced to observe the conditions of the tunnel. Additional two (2) cameras at least will be located around the entrance of toll office in order to observe any persons who approach the entrance.

CCTV camera station will be installed at the location accommodates camera controller. It will receive video image signal from the camera, and transfer it to office room. It will receive control signals from office room, and control a zoom and focus of a camera, wiper of camera housing and movements of pan-tilt head.

CSS at office room will consist of a video signal switcher/multiplexer, central controller and digital video recorder and sets of monitor TV. Character generating function will be provided to the central equipment to superimpose camera location/number overlaid video images.

Operator console will have various control functions including camera control, pan-tilt head control and monitor TV control.

A total of 3 set of monitor TVs will be provided and installed at office room. The size of monitor TV must be 15 inch or larger. Connection between camera and monitor TV must be flexible and made through the video switcher. Each TV monitor will be utilized for four (4) channels of video signal at least by multiplexer. The monitor TV shall be of LCD type.

A video switcher/multiplexer will be provided to flexibly assign monitor TV to any camera. Video switcher/multiplexer will have input terminal to receive video signal from the video recorders and other video sources. It must also have video signal outputs to provide video signal to other monitor TV or system.

Two sets of video recorder will be provided to the office room to record video signal from any of the camera. Video recorder must be equipped with a hard disk unit of suitable storage capacity for temporary recording and a writable DVD unit to record video image permanently. It will have time lapse recording function to record video image for longer period at reduced frame rate and date and time shall be superimposed on the recorded video image.

Table below shows the number of equipment of the Toll Office System (TOS).

Table 5-3 Number of Toll Office System Equipment

Equipment		Unit	Remarks
Database Server for Toll Data Management System	TDMS	1	Location of Toll Office 1. Tuy Loan 2. My Son 3. Ha Lam 4. Tam Ky 5. Chu Lai 6. Dung Quat 7. North Quang Ngai 8. Quang Ngai
Supervisor and Operation Terminal	SOT	1	
Inspection and Post-check Terminal	IPT	1	
Accounting Terminal	ACT	1	
IC-Card/OBU Registration Terminal	ICORT	1	
Operation Printer	O-PRT	1	
Receipt Issuance Printer	R-PRT	1	
IC-Card Issuance Printer	ICC-PRT	1	
Emergency Call (Master)	E-CALL(M)	1	
Booth Communication System (Master)	BCS(M)	1	
CCTV Surveillance System	CSS	1	
IC-Card Reader/Writer	ICCRW	2	

Source: Consultant

Toll Office System has following LAN Network Facilities.

- L2-SW: 4 sets
- LAN cables and others: 1 lot
- Network equipment storage rack : 800mm (W) x 1000mm (D) x 1800mm (H)

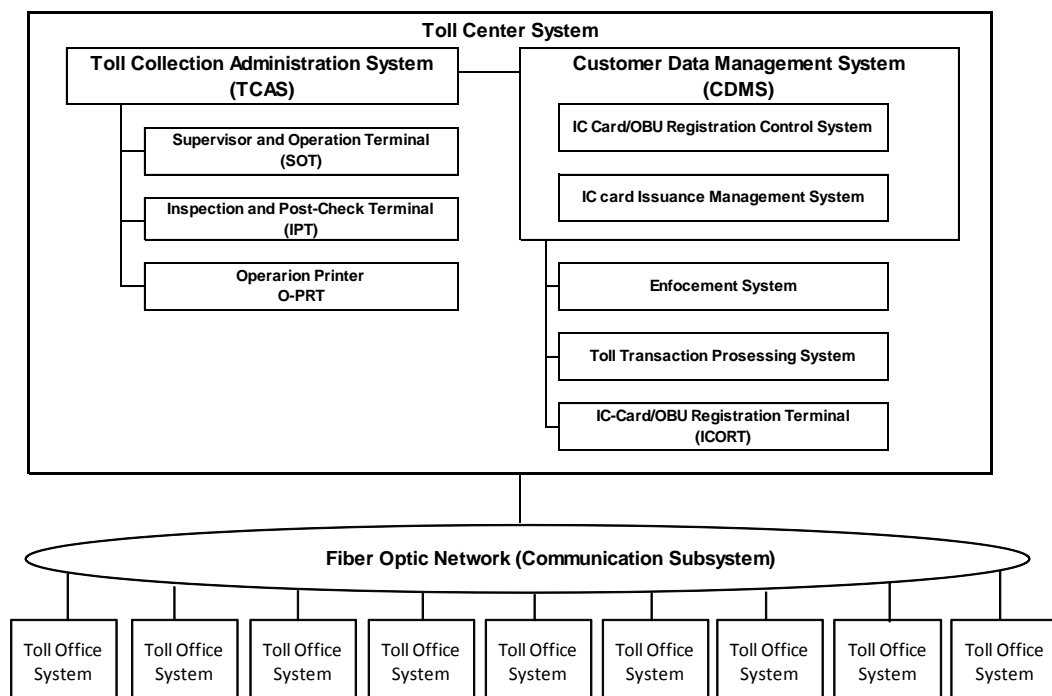
5.7.4 Toll Center System

The Toll Center System (TCS) will be united system with each Toll Office System (TOS). Main function of this system will be as follows:

- Operation and management for all of the Toll Lane System (TLS) and the Toll Office System (TOS)
- Administration system for all toll collection works
- Administration system for customer data (the toll ticket, the Commutation Ticket, the Prepaid Card and On-Board Unit (OBU)

The TOS will be composed of, but not be limited to, following equipment.

- Database Server for Toll Collection Administration System (TCAS)
- Database Server for Customer Data Management System (CDMS)
- Supervisor and Operation Terminal (SOT): to supervise toll collection work
- IC-Card/OBU Registration Terminal (ICORT)
- LAN cable and necessary number of hubs or routers
- IC-Card Reader/Writer (ICCRW)
- Operation Printer (O-PRT)
- LAN Network Facilities



Source: Consultant

Figure 5-20 Toll Center System Configuration

(1) Database Server for Toll Collection Administration System (TCAS)

The TCAS will be a server to carry out real time functions in order to administrate and manage all of toll related information, such as data communication with the Toll Office System. The CDMS will be also a server to carry out real time and fixed interval functions in order to administrate and manage all of customer related information, such as the registered data of Toll Ticket, the Commutation Ticket (CMT), Prepaid Card (PPC) and On-Board Unit (OBU). Visual display units and printer terminals for them will be provided for control, selection and data input and output. Comprehensive back-up facilities shall be provided through the use of mass storage device or equivalent means to ensure that the loss of data or restrictions on operation shall not occur as a result of the Toll Center System (TCS) failure for a long term. The TCAS and CDMS can be expanded effectively to be interoperable with the Bank system in the future.

Following items are Requirements of Hardware of TCAS.

- | | |
|----------------------------|--|
| - Processor: | 3GHz multi cores or better |
| - RAM: | 12 GB DDR3 or more, expandable up to 144GB |
| - RAID controller: | Integrated |
| - HDD: | 2TB or more |
| - Network: | Gigabit Ethernet |
| - Human Machine Interface: | Mouse + keyboard + monitor LCD 17inch |
| - Server storage rack: | 800mm (W) x 1000mm (D) x 1800mm (H) |

The following total report summarized from each toll office will be available on the TCAS, but not limited to:

- Traffic Volume (Weekly, Monthly, Quarterly and Annually)
 - Traffic volume by class
 - Histogram of traffic volume
 - Lane traffic volume
- Management (Weekly, Monthly, Quarterly and Annually)
 - Plaza Performance Evaluation
 - Staff Checkout
- Financial (Weekly, Monthly, Quarterly and Annually)
 - Cash Collection Report and Summary
 - Traffic and Revenue
- Maintenance (Weekly, Monthly, Quarterly and Annually)
 - Log of Equipment Alarms
 - Alarm Activity Summary

The following function will be available on the TCAS, but not limited to:

- Operational Parameter Tables
 - System Constant Table (plaza identity code, lane identity code, operational day closing time, automatic/manual issue of receipt, allowable variance of toll collector's input to TTT, etc)
 - Toll Fare Tables (Current and Future)
 - Personnel Identification Card Number Tables (8 digits, 500 staff)
 - Access Control List
 - Currency Denomination Table
 - Payment Type Tables
 - Access Level Edit

- Table Revision Number
- Filing
 - Parameter download (using memory device)
 - Parameter transfer for TLS (using memory device)
 - Off-line data transfer from TLS (using memory device)
 - Data/parameter backup onto a removable media such as DAT (Digital Audio Tape, etc.)
 - Data/parameter restore from a removable media such as DAT, etc.

(2) **Database Server for Customer Data Management System (CDMS)**

The following function and related report shall be available on the CDMS, but not limited to:

- Toll Ticket Registration and Administration
- Commutation Ticket Registration and Administration
- Prepaid Card Registration and Administration
- On-Board Unit Registration and Administration

Requirements of Hardware of CDMS is same as that of TCAS.

(3) **Computer Desks, Terminal Equipment and Others**

The series of computer desks accommodate each server with an Operation Printer (O-PRT). The desks will be positioned in the Equipment room for the TCS.

There is a client terminal associated with each server system, namely a Supervisor and Operation Terminal (SOT). The SOT will be used to supervise and operate the all of toll information. The series of computer desks accommodate the three (3) SOTs with an Operation Printer (O-PRT). One (1) SOT will be in the MMC, one (1) SOT will be in the Da Nang MO and one (1) SOT will be in the Quang Ngai MO. The desks will be positioned in the office room.

IC-Card/OBU Registration Terminal (ICORT) will be used to register the data of Personnel Identification Card into the ID Card. Three (3) ICORTs will be installed. One (1) ICORT will be in the MMC, one (1) ICORT will be in the Da Nang MO and one (1) ICORT will be in the Quang Ngai MO. The ICORT will record the data of IC-Card and transfer them to Toll Collection Administration System (TCAS). The series of computer desks accommodate the ICORT with an Operation Printer (O-PRT). The desks will be positioned in office room and reception in the MMC and at office room in each MO.

Each terminal shall be equipped ICCRW in order to login in the system and handle the data of IC-Card.

Toll Center System has following LAN Network Facilities.

- L2-SW: 6 sets
- Firewall: 1 lot
- LAN cables and others: 1 lot
- Network equipment storage rack : 800mm (W) x 1000mm (D) x 1800mm (H)

Table below shows the number of equipment of the Toll Center System (TCS).

Table 5-4 Number of Toll Center System Equipment

Equipment Unit		Unit	Remarks
Database Server for Toll Collection Administration System	TCAS	1	MMC
Database Server for Customer Data Management System	CDMS	1	MMC
Supervisor and Operation Terminal	SOT	3	MMC(1) + 2MO(1)
IC-Card/OBU Registration Terminal	ICORT	3	MMC(1) + 2MO(1)
IC-Card Reader/Writer	ICCRW	5	MMC(1) + 2MO(2)
Operation Printer	O-PRT	4	MMC(2) + 2MO(1)

Source: Consultant

5.7.5 User Side Equipment

The user side equipment is a part of the Toll Collection System. The user side equipment is used not only for a road operator but also for a driver.

(1) Toll Ticket

As mentioned earlier, the toll collection system of the Project will apply the “Closed System.” In the Closed System, the toll ticket is essential because the toll due is depended upon the vehicle classification and running distance that is calculated based on toll ticket information recorded at entry point. In addition to the normal toll ticket, cards of the Commutation Ticket (CMT), the Prepaid Card (PPC), and the Personnel Identification Card are used with the Toll Collection System in this Project.

1) Functional Requirement of the Card

Functional and common requirement of the entire card on the Project shall be satisfied with, but not limited to, the following aspects:

- Anti tamper: for high secure data management
- Reliability: to perform and maintain its functions in routine circumstances
- Durability: applicable for long time or repeated use in certain term
- Data Capacity: to be enough data size
- Operability: multi-purpose, user-friendly, operation speed,
- Expandability: applicable for new or future function
- Environment friendly: applicable for re-cycling, not harmful for environment, and
- Cost: cost effectiveness through Operation and Maintenance

Required number of IC cards to be provided in this project is 625,000 based on traffic volume.

Table 5-5 shows number of IC-Cards, and **Table 5-6** shows traffic volume at Tollgate.

Table 5-5 Number of IC-Cards

Type of IC Card	unit	Quantity	Remarks
IC-Card for a Personal Identification	set	1,000	Number of Staff(448) X 2
IC-Card for a Toll Ticket (ICT)	set	546,000	Total traffic volume of all Tollgates in 2 weeks on DQE
IC-Card for a Commutation Ticket	set	23,000	About 2% of Total traffic volume of all Tollgates in 1month on DQE
IC-Card for a Prepaid Valued Payment	set	55,000	About 10% of Total traffic volume of all Tollgates in 2 weeks on DQE
Total	set	625,000	

Source: Consultant

Table 5-6 Traffic Volume at Tollgate

Tollgate	Assumed traffic volume on Enter (ADT) (Y2025)	Assumed traffic volume on Exit (ADT) (Y2025)
Tuy Loan	13,742	15,624
My Son	1,245	762
Ha Lam	2,619	2,285
Tam Ky	3,755	4,680
Chu Lai	2,112	1,654
Dung Quat	2,906	1,957
North Quang Ngai	5,355	4,898
Quang Ngai	7,254	7,128
Total	38,988	38,988

Source: Consultant

The Contactless IC-Card has an advantage in the LCC per one card, although the cost per one card is the most expensive, because durability of a contactless type IC-Card is superior to any other kinds of card. Therefore, "Contactless type IC-Card" (hereinafter referred as IC-Card) should be adopted as a Toll Ticket which will be a common platform on the Project because it is able to keep secured data management, to operate easily and rapidly, and to reduce the cost of toll collection work through Operation and Maintenance.

2) Functional Requirement of the IC-Card

The IC-Card shall be referred to the requirements of ISO/IEC specifications number 18092 or ISO/IEC14443, and shall conform to the following minimum functions.

- **Flexible File System:**
Each toll collection service using various cards inclusive an ID card, Toll Ticket, Commuter Card, or Prepaid Card, shall assigned an area in the card's memory space for registering services in block units. A single area shall be divided hierarchically into multiple areas. Total number of available blocks is 154 (one block is 16bytes), including those used for registering areas and services.
- **File Access Control:**
With the IC-Card, up to 8 user blocks should be written simultaneously, while up to 12 user blocks should be read at a time. As to these block read/write operations, it should be possible to group different services for access control by the use of keys synthesized from the keys set for individual areas and services.
- **High-Speed Transaction:**
The IC-Card shall provide high processing speed at minimum power consumption. This should owe a great deal to the incorporation of a high-performance microprocessor, which combines with dedicated encoding/decoding hardware to speed the enormous amount of calculations necessary for data encryption/decryption and mutual authentication. With its capability to read or write 8 blocks of data in only 100ms including the time required for mutual authentication, the IC-Card should meet perfectly with the performance requirements of automatic toll collection systems.
- **Transaction Reliability:**
The card should be powered by electromagnetic waves from the Reader/Writer. That is, data becomes incomplete due to power failure if the card is moved out of the communication range before writing into the non-volatile memory is finished. In this case, the IC-Card should automatically discard incomplete data and restores the previous state.
- **Wireless Communication Security:**
All data should be encrypted using encryption keys in order to prevent illicit operations during wireless transmission, such as skimming, falsification and reuse of data.
The card shall obtain ISO/IEC 15408 EAL4 both card chip and card Operating Software (OS) for security assurance.

3) Required Physical Characteristics of the IC-Card

The general physical characteristics of the IC-Card should be conformed the card type ID-1 in ISO/IEC 7810 specifications. The physical characteristics of the IC-Card should be followed:

- **Dimensions:**
The nominal dimensions of the Card shall satisfy the specification in ISO/IEC 7810 as the card type ID-1.

- Surface conditions:
The card surface shall be flat and smooth to allow the Card to be carried, etc.
- Substrate material:
The substrate material of the Card shall be made of PET (poly-ethylene terephthalate) or material having equal or better performance.
- Static electricity:
The Card shall continue to operate after testing in accordance with the test methods specified in ISO/IEC 10373-6, where the test voltage is 6kV. Any information recorded in the Card shall not be altered; besides, data shall be able to be re-written.
- Static magnetic field:
The Card shall continue to operate after having been exposed to a static 640 kA/m magnetic fields.
- Operating temperature:
The Card shall continue to operate under the environmental temperature of -5°C to 50°C.
- Moisture proof:
After having been left for 48 hours in an environmental of 40°C temperature and 90% relative humidity, the Card shall continue to operate and satisfy the warpage specification.
- Cyclic thermal proof:
The Card shall continue to operate after having been applied ten thermal test cycles, each consisting of 30 minutes at -25°C, 5 minutes at room temperature and humidity (23°C±3°C, relatively humidity: 40% to 60%), 30 minutes at +85°C and 5 minutes at room temperature and humidity.
- Drop impact proof:
The Card shall continue to operate after having been dropped twice in three directions (longitudinal, lateral and surface directions) from the height of 1.5 m onto a concrete surface
- Bending pressure stiffness:
The Card shall continue to operate after having been applied a load of 0.7N for 1 minute in accordance with the method of specified in ISO/IEC 10373-1.
- Point pressure stiffness:
The Card shall continue to operate after a pressure, generated by applying a force of 1.5N to a φ1mm steel ball, is applied to the position of the IC chip.
- De-lamination:
The Card shall possess the minimum peel strength of a least 6N/cm when tested by the method specified in ISO/IEC 10373-1.
- Storage temperature:
The Card shall continue to operate after having been stored in -35°C and +85°C temperature for 60 minutes each.
- Environment protection:
The Card shall not cause toxic hazard in the normal use. The Card shall not cause toxic gas when it is disposed or incinerated.
- Curl, burr and chipped particles:
The Card shall not cause any malfunction of the issuing or processing machine by curl, burr or chipped particles.

4) Communication Interface

The General Communication Interface of the IC-Card should be conformed the specification defined in ISO/IEC 7810. The Communication Interface of the IC-Card shall follow:

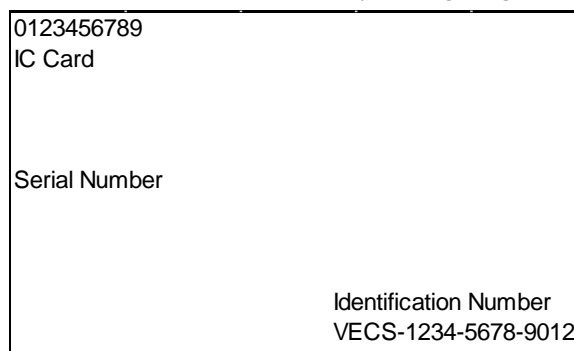
- Power Transmission:
The IC-Card Reader/Writer (ICCRW) shall transfer power to the Card by producing RF operating magnetic field and make communications by magnetic field modulation.
- Frequency:
The frequency of the RF operating magnetic field shall be 13.56MHz.
- Tolerance deviation of frequency:
The tolerance deviation of frequency shall be ± 50 ppm or under.
- Leakage electric field strength:
The leakage electric field strength shall conform to the regulations of the Radio related Low in Vietnam.
- Bit rate:
The bit rate between ICCRW and Card shall be 13.56 MHz / 64 (approximately 212 k bit/s)

5) Serial Number

The serial number is laser-laminated on the rear surface of each IC card, together with the model name, making it possible to identify when is produced.

- Printed items: Serial number (12-digit alphanumerical characters) Model name

As a basic specification, a unique serial number, which is enough space for 12-digit alphanumerical characters, shall be laser-printed on the rear surface of each IC-Card together with the model name, making it possible to identify when and where it was produced. Additionally, an area for identification number, which is enough space for 16-digit alphanumerical characters, shall be reserved to be laser-printed on the rear surface of each IC-Card. A sample image is given in figure below.



Source: Consultant

Figure 5-21 Serial Number and Identification Number

The IC-Card shall be furnished with the term of validation and shall be recorded an attribute of validation and/or a data of validation.

6) IC-Card Service

IC-Card service is necessary to achieve various functions on the IC-Card. The service is used to define the method of accessing the memory in the IC-Card. The IC-Card make it possible to set multiple access modes, such as read/write, read only and authentication necessary or unnecessary, to the same memory area in order to actualize the multi function on the Project.

- **Random Service:**
Random Service means general-purpose service that allows random access to any desired memory block.
- **Cyclic Service:**
Cyclic service is based on a log of write operation. With the reference made to the record of the sequence the blocks were written in the pre-assigned user area, new data is written automatically in the empty block next to the last-written block.
- **Purse Service:**
Designated specifically for such application as deducting fees or charges, the purse service additionally offers a subtraction function.

7) IC-Card for a Personal Identification

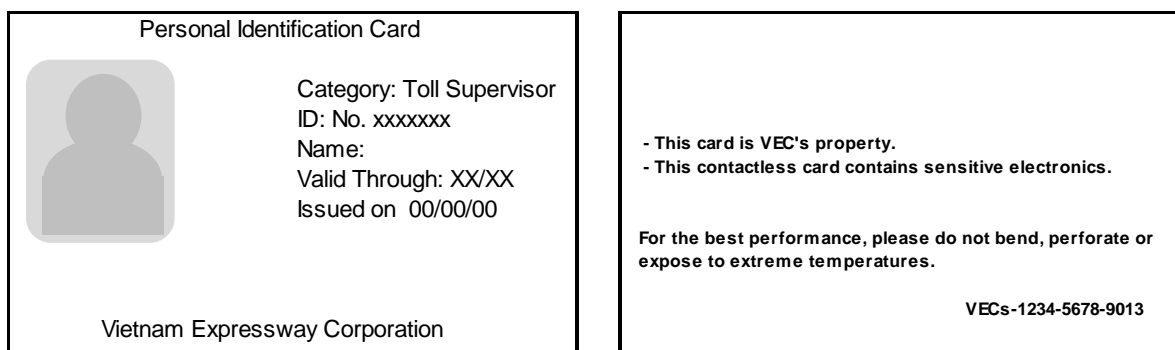
The Personnel Identification Card (ID-Card) will be used to identify all of toll personnel by coupling through an IC-Card Reader/Writer (ICCRW) at the beginning of their job. The ID-Cards shall be pre-encoded and embossed with identification numbers. The ID-Cards shall be printed a portrait image of a person on the ID-Card.

The ID-Card shall be provided for following six categories.

- Toll collector's identity card
- Toll Supervisor's identity card
- Toll Technician's identity card
- Toll Accountant's identity card
- Toll Officer's identity card
- Visitor's/Guest's identity card

The front or backside surface of the ID-Card shall be pre-printed with at least the following information as shown in **Figure 5-22** below.

- Name of a Road Operator
- Category name of the identity card
- Description of important points for instruction



Source: Consultant

Figure 5-22 Sample of Personnel Identification Card

The ID-Card will be used to access various functions and facilities. A unique number for all of toll personnel will be allocated and encoded on the IC-Card. The ID number will be provided to identify the authorized access control level of individuals. It should be noted that the access level is not encoded on the card to enable the quick redeployment of the personnel. The access level number shall be defined in an access control list (ACL) which forms a part of the operational parameters in the toll system.

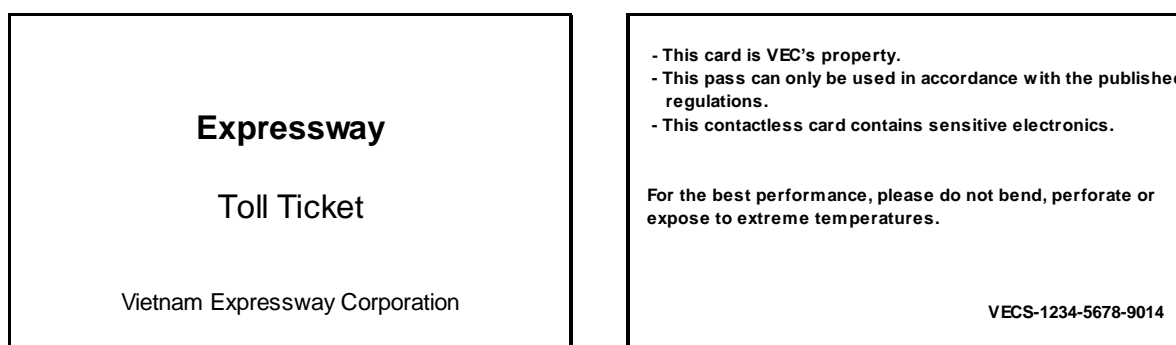
1000 sets of ID-Cards per one tollgate/plaza shall be provided in the Project.

8) IC-Card for a Toll Ticket

The IC-Card Toll Ticket (ICT) will be used to identify both the name of entry point and exit point by scanning through an IC-Card Reader/Writer (ICCRW) in the toll booth. The ICT will be pre-encoded and printed with some information.

The front or backside surface of the ICT shall be pre-printed with at least the following information as shown in **Figure 5-23** below:

- Name of a Road Operator
- Category name of IC-Card Toll Ticket (ICT)
- Description of important points for instruction



Source: Consultant

Figure 5-23 Sample of the IC-Card for Toll Ticket

Total 546,000 sets of the IC-Card Toll Ticket (ICT) shall be provided in the Project.

9) IC-Card for a Commutation Ticket

A commutation ticket, which is defined as a monthly ticket or quarterly ticket in the Circular, No.90/2004/TT-BTC, Ministry of Finance, will be provided with function improvement of both the IC-Card Toll Ticket (ICT) and Prepaid Card.

The IC-Card for a Commutation Ticket (hereinafter referred as Commuter Card) shall be used to confirm the section and terms of the card by coupling through an IC-Card Reader/Writer or with On-Board Unit (OBU) through Electric Toll Collection (ETC) at the toll booth or toll lane.

As a Commuter Card, an available section and a term of validity shall be decided previously. These items are the difference from a Prepaid Card. Basic terms of use of Commuter Card on the Project shall be satisfied with, but not necessarily limited to, the following aspects:

- All users shall pay deposit (such as rental fee) to road operator for the card issuance.
- The deposit shall be returned when the card is returned to road operator.
- The available section for a Commuter Card should be decided prior to operation.
- The function of both IC-Card Toll Ticket and Prepaid Card shall be realized in the function of a Commuter Card.

The Commuter Card shall be pre-encoded and printed/embossed with some information including an available section and terms. The Commuter Card shall be printed an available section, terms, vehicle classification and vehicle license number on the card at every time of issuance. The Commuter Card shall be provided with registration.

The front or backside surface of the Commuter Card shall be pre-printed with at least the following information as shown in **Figure 5-24** below.

- Name of a Road Operator
- Category name of the card
- Description of important points for instruction

Commutation Ticket With Prepaid Value Card From: _____ To: _____ Class: _____ LPN: _____ From: Day/Month/Year To: Day/Month/Year Vietnam Expressway Corporation	<ul style="list-style-type: none">- This card is VEC's property.- This pass can only be used in accordance with the published regulations.- This pass is valid for 5 years from the date of issue.- Stored value is valid for 2 years from the date of first use or the last refill or when the last use of travel, after which any remaining value cannot be refunded or exchanged for other values.- This contactless card contains sensitive electronics. <p>For the best performance, please do not bend, perforate or expose to extreme temperatures.</p> <p style="text-align: right;">VECS-XXXX-XXXX-XXXX</p>
--	--

Source: Consultant

Figure 5-24 Sample of the Commutation Ticket

Total 23,000 sets of the Commuter Card shall be provided in the Project.

10) IC-Card for a Prepaid Valued Payment

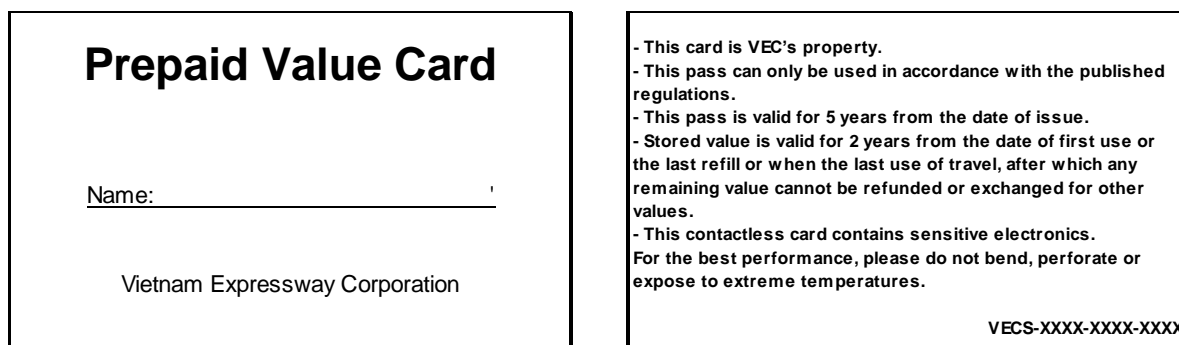
The prepaid valued payment card (hereinafter referred as Prepaid Card) will be used to pay the toll by coupling through an IC-Card Reader/Writer (ICCRW) or with On-Board Unit (OBU) through Electric Toll Collection (ETC) at the toll booth or toll lane.

Basic terms of use of Prepaid Card on the project shall be satisfied with, but not necessarily limited to, the following aspects:

- All users shall pay deposit (such as rental fee) to road operator for the issuance of the card.
- The deposit shall be returned when the card is returned to road operator.
- The minimum amount and maximum amount of deposit in the card per a payment shall be decided prior to the operation.
- Remaining value in the card shall be recorded in both the card itself and Toll Center System.
- The function of IC-Card Toll Ticket shall be realized in the function of a Prepaid Card.

The Prepaid Card shall be pre-encoded and printed/embossed with some information. The front or backside surface of the Prepaid Card shall be pre-printed with at least the following information as shown in **Figure 5-25** below:

- Name of a Road Operator
- Category name of Prepaid Card
- Description of important points for instruction



Source: Consultant

Figure 5-25 Sample of the Prepaid Card

Total 55,000 sets of the Prepaid Card shall be provided in the Project.

(2) On-Board Unit (OBU)

1) Conceptual Requirement

The On-Board Unit (OBU) will be used to communicate with the Roadside Antenna (RSA) in order to provide the service of Electric Toll Collection (ETC) system.

The OBU will be introduced as a two-piece type, which consists of 1) On-Board Unit, and 2) IC-Card. The IC-Card is used as a payment means of toll due. For sophisticated ETC service to reduce transaction time, conceptual requirement of the OBU shall be satisfied with, but not limited to, the following:

- Toll collection without stopping both at entry and exit point
- Harmonization with existing toll collection system or other systems commonly used in Vietnam
- Toll collection with quickness, accuracy and reliability
- Support for enforcement of toll collection (The enforcement of OBU will be made of OBU unique number for road users and by auditing system for road operator)
- To be capable of both prepaid & postpaid method
- To be available for all vehicle classification
- To be available for both “Open System” and “Closed System.”
- To be capable of confirmation of “Record of Use” by a user oneself
- To be available for secured transaction
- To be available for personally identifiable information
- To be capable of common usage among different road operators
- To be capable of various toll policy (such as road pricing or VDM, free flow)

Basic terms of use of OBU on the project shall be satisfied with, but not necessarily limited to, the following aspects:

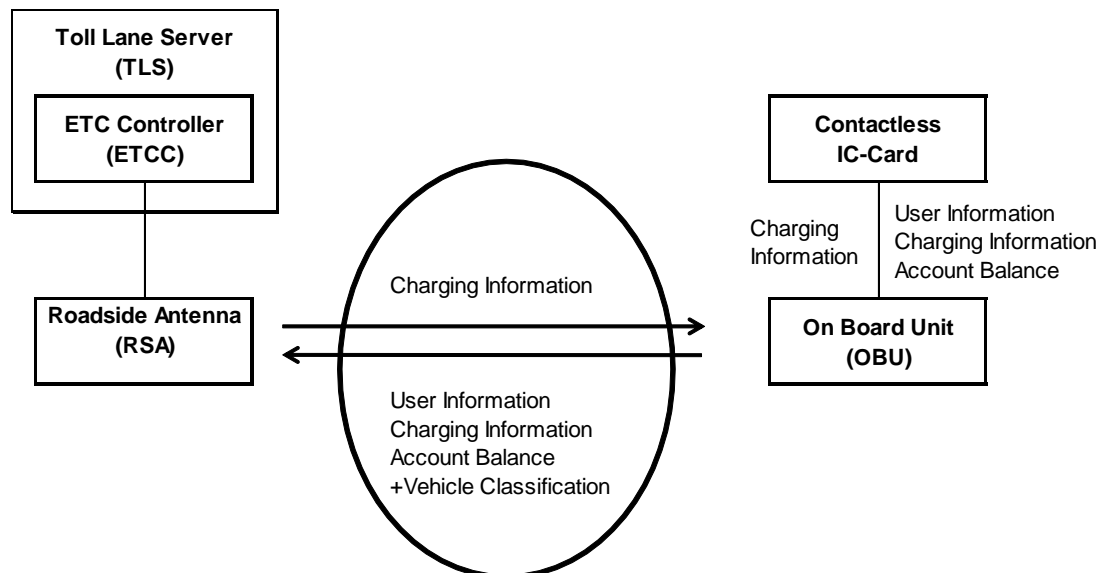
- An OBU shall be applicable for all tollgates/plazas.
- The OBU shall be installed in a vehicle prior to use.
- Ownership of all OBU shall belong to a Road Operator.
- Ownership of all OBU shall be registered in name as a Road Operator.
- All users shall pay deposit (such as rental fee) to borrow an OBU from the Road Operator.
- The deposit shall be returned when the OBU is returned to road operator.

- A unique number shall be recorded on the OBU as carved seal and in the memory area of the OBU as a data.
- The vehicle classification and valid terms of use shall be recorded in the memory area of OBU when a driver borrows it. This information shall be easily read and recognized by convenient way, but shall not be rewritten easily by any way.
- The function of payment on ETC shall be realized in the same way of a Prepaid Card.

A communication method to be actualized high reliability, tough, authenticity and high speed transaction within very short time and limited area around Toll-island between ETC Controller (ETCC) and OBU even under special surroundings of toll lane must need following functional requirements.

- To be capable of stable communication without any affection by any surroundings
- To be capable of high reliable communication for all OBU within a limited communication zone provided on the ETC lane
- To be capable of authenticity of transaction which is processed into OBU, IC-Card and ETCC

Figure below presents the outline of the data flow of the ETC system data including OBU.



Source: Consultant

Figure 5-26 Outline of Data Flow of ETC

The unique number of the OBU shall be pre-encoded and printed/laser-printed with some information. The front or backside surface of the OBU shall be pre-printed with the information of, at least, the followings:

- Name of a manufacture
- Name of a model of OBU
- Number of registered type
- Number of a unique identification
- Coloring space for vehicle classification
- Description of important points for instruction

The OBU shall be referred to the requirements of ISO/IEC and other international standards, and

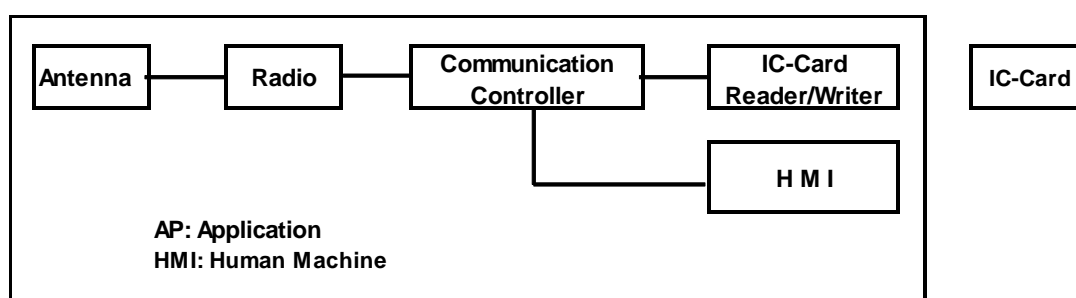
shall conform to the following minimum requirement.

- Communication:
The OBU shall comply with the Active method requirements of Annex 1 on Recommendation ITU-R M.1453.
- Reliability:
Minimum number of communication per year: 2,000 MTBF (Mean Time between Failures):
0.5×10⁵ hours Minimum service life: 5 year.

50,000 sets of the OBU will be provided in the Contract.

2) OBU Specifications

- DSRC should comply with the Active method requirements of Annex 1 on Recommendation ITU-R M. 1453.
- The OBU shall be a two-piece type. One-piece type would be a possible option.
- For the two-piece type OBU, the IC-Card shall be a contactless IC-Card conforming to Specification mentioned in this report.



Source: Consultant

Figure 5-27 Configuration of On-board Unit

- A single channel shall be used and communication method is based on a simplex system.

Table 5-7 On-board Unit Specifications

	Item	Specifications
Layer 1	Radio frequency bands	5.8GHz bands
	Number of Channel	2
	Operating method and multiple access	Simplex
	Access method	TDMA-FDD
	Modulation method	ASK
	Transmission data rate	1,024kbps
	Communication zone	3m×4m
Layer 2	Association	Available
	Point to point communication	Available
	Retransmission control	Available
	Duplication check	Available
	Scramble / Descramble	Available
Layer 7	Link Address	Random number
	Normal association	Available
	Release timer	Available
	ASN.1 encoding / decoding	Available
	ACTION primitives	Available
	EVENT-REPORT primitives	Available
Application	Application interface	Conformity to ISO/IEC 14906 (EFC)
	Vehicle data registration	Vehicle classification and License Plate Number

Source: Consultant

- HMI for displaying account balance and passage history information is offered as an optional feature. However, as it is considered necessary to notify users of the situations listed in Table below somehow at least, minimum levels of HMI, such as LED or buzzer, should be available.

Table 5-8 HMI Functions

No.	Situation	Notification to user
1	Power ON	Results of on-board unit Power ON self-test
2	IC card insertion	Results of on-board unit / IC card self-test
3	Communication with roadside equipment	Roadside commands to on-board unit or communication error
4	Completion of toll transaction	Amount of toll to be paid
5	On-board unit error	Detection of on-board unit error

Source: Consultant

- A registered vehicle classification should be able to be distinguished easily with the color plate attached on the OBU. A number of the color should be five (5) at least.
- A vehicle data registration in the OBU such a vehicle classification number and a vehicle license number should be easily available to read out in order to inspect it.
- OBU should comply with the following environmental conditions.
 - IEC60721-3-5 5K3/5B1/5C1/5S1/5F1/5M2 or above

5.7.6 Other requirements on Toll Collection System

(1) Authorization and Validation

To prevent the improper and/or illegal use of toll ticket, including the Toll Ticket, the Prepaid Card, and the OBU, authorization and/or validation must be forced effectually in the following aspects;

- Authorization : check whether it is genuine or not, available for toll road or not and other confirmation of the card
- Validation : check the effective date

The negative result of authorization and validation are called “Negative Data”.

The negative data must be administered at Toll Center System (TCS) and must be transferred to Toll Office System at fixed interval in order to check the card and OBU. The negative data shall be preserved at least 10,000 data in each Toll Lane Server (TLS).

(2) Data Communication

All the Toll Lane Server (TLS) will be linked to the Toll Office System (TOS) installed in the toll office building. Data stored by the TLS will be transmitted to the TOS at various times during collection activities so as to allow compilation of audit and statistical data and monitoring of lane operation and equipment status.

The following information, but not limited to, shall be both stored by the TLS on an individual event basis and transmitted to the TOS in real time under normal operation conditions.

- System status and operational status including alarms
- Start of toll collector’s job including allocated job number
- End of toll collector’s job data
- Individual transactions
- Exceptional transactions (Emergency, Violation, etc.)

The data storage available within the TLS shall be sufficient to store the above data for a minimum period of 14 days based on the relevant designing parameter. The data shall be sufficient to allow all requirements to be met with respect to monitoring, report generation, data transfer and the like.

The TLS shall include comprehensive automatic testing routines which shall be implemented on a frequent basis to the toll equipment. Any detected fault condition shall be reported to the TOS as soon as possible from the detection. There would be occasions either the TOS is off-line or data communication between one or more lane equipments and the TOS is not available. Under such condition the TLS shall continue to store data for later transmission to the TOS. Means shall be provided to extract the data from the TLS by external data storage device and directly load to the TOS in consideration of such occasions.

Each toll collector's job shall be allocated a job number. The job number together with the data of operational day shall uniquely identify the job at the tollgate/toll plaza. The TLS shall receive operational parameters from the TOS. These shall include, but not limited to:

- "Current" toll fare data for each vehicle classification, and "Future" toll fare data with date and time of implementation.
- Validation data for IC-Card and OBU (called Negative Data)
- Other various system constants deemed to be necessary for the control, data acquisition and processing for the toll lane equipment.

Downloading of the operating parameters shall be completed within 3 seconds for each toll lane and not exceed 60 seconds for all toll lanes.

The data communication cables between the TLS and the TOS shall be of metallic cable or optical fiber cable to avoid a magnetic or electric interference. The data communication shall be of a secured Local Area Network (LAN) on 100-BASE Fast Ethernet to fulfill the requirements of the System.

Operating parameters received from the TOS shall be stored in secured read-write memory modules which allow the integrity of stored data to be maintained for a minimum of five days under power failure conditions.

Two toll fare tables for each vehicle classification shall be provided, one for current toll fares and the other for future toll fares with a date and time for implementation. In case no future toll fares are defined, both tables shall contain the same current toll fares data for security. Routines in the lane equipment shall ensure that once a change in toll fares has been implemented, data relating to the previous fares is deleted from memory.

(3) Report and Documentation

The Toll Office System (TOS) shall produce reports for the purpose of management and monitoring of toll collection activities, including toll collector's End of Job report, summarized daily activity reports as well as traffic related reports.

In addition to the audit reports of toll collection activities, the TOS shall produce printouts relating to warning messages, alarm messages, toll equipment failures and other maintenance events. These shall be printed by an Operational Printer (O-PRT) on demand through SOT.

The followings present some kinds of tentatively proposed audit reports. These reports shall be also provided on the visual display of Supervisor and Operation Terminal's (SOT) Console.

- Transaction Related Reports retrieval on line for 6 month
- Traffic Related Reports retrieval on line for 3 month
- Equipment Maintenance Related Reports retrieval on line for 3 month
- System Parameter Related Reports retrieval on line for 6 month
- Enforcement Related Reports retrieval on line for 3 month
- Registration Related Reports retrieval on line for 6 month
- Negative Data Related Reports retrieval on line for 6 month
- Filing Related Reports (On visual display only)

5.7.7 Operational Procedure and Function on Toll Collection System

The operational procedures and the functions of toll collection system are described in **Appendix-3** of this report.

5.8 Digital Transmission System

The ITS in the DQE deploys various devices such as CCTV camera, vehicle detector and variable message sign along the roadside. These devices are connected with the central equipment at the Main Management Center (MMC), and data and voice are exchanged between them. Digital transmission system is required to perform the service of data and voice communication. IP based digital transmission system over fiber optic cable will be introduced for this purpose.

5.8.1 System Requirements

System requirements of the digital transmission system are as follows.

- Digital transmission system shall adopt IP based system.
- The digital transmission shall have a sufficient capacity in terms of speed and bandwidth to meet the demands to be decided based on the estimated amount of data including digitized voice data at each office such as the MMC, the Management Offices (MO) and the Toll Offices (TO). Video signal from the CCTV camera shall be transmitted in MPEG 4/H.264 or Motion-JPEG format and the digital transmission system shall provide sufficient capacity for it.
- Loop topology based on resilient packet ring (RPR) shall be adopted for local line transmission system for redundant operation. Physically separate fiber optic cables shall be used to for a ring topology and for back up route in the local line transmission system. Compressed image data, toll collection system data and data from other devices must be separately allocated by theoretical methods in the communication system.
- Digital transmission system shall have high reliability to ensure continuous operation of the system. Bit error rate for the end to end data communication must be 1×10^{-6} or better.
- Quality of service (QoS) capability shall be provided to the digital transmission system to ensure smooth and uninterrupted delivery of data for voice and video image transmission required for internal telephone system and CCTV camera system.

5.8.2 System Configuration

Digital transmission system will consist of local line transmission system and access line transmission system. The former connects between fiber optic nodes (FON) established at locations listed in **Table 4-33** and uses optical fiber cable while the latter connects roadside equipment to the FON using media converter provided in other sub-systems and fiber optic cable.

It is noted that when the Expressway is extended, trunk line transmission system will be introduced for long distance data transmission between the Da Nang MMC and other MMCs. Digital transmission equipment for trunk line transmission system will not be installed under this Project. However, the local line transmission system to be provided in the Project shall be compatible with the standard digital transmission system commonly used in trunk line transmission. The fiber optic cable to be installed along the DQE shall have the sufficient number of cores to accommodate trunk line system.

All transmission cables shall be fiber optic cable having suitable number of cores.

5.8.3 Specifications

1) Fiber Optic Node (FON)

The FON shall have enough capacity and interface, QoS control function, fail-over function and any other required functions. Followings are reference specifications of the FON.

- | | |
|---------------------------|---|
| a. Standards: | Gigabit Ethernet |
| b. Capacity: | 1 Gbps or more |
| c. Interface: | Fiber Optic Interface: 8 cores or more
LAN Interface: 20 ports or more |
| d. Applied Topology: | Ring, Star |
| e. Fail-Over Function: | Resilient Packet Ring (RPR) |
| f. Transmission Distance: | 60km or more |
| g. Changeover Time: | 50msec or less |
| h. Network Management: | SNMP or equivalent |
| i. Reliability: | 1×10^{-6} or better |

2) Layer 3 Switch

- | | |
|-------------------------|--|
| a. Switching Bus Speed: | 20 Gbps or equivalent |
| b. WAN Interface: | 10BASE-T/100BASE-TX x 8 ports or more |
| c. LAN Interface: | 10BASE-T/100BASE-TX x 20 ports or more |
| d. LAN Protocol: | TCP/IP, IP multi-cast, etc |
| e. Layer 3 Switching: | Shall be Provided |
| f. Maximum VLAN: | Approx. 200 |
| g. VLAN Trunk: | Shall be provided |
| h. Spanning Tree: | Shall be provided |
| i. Routing Protocol: | RIP, RIPv2, OSPF, etc. |
| j. Multicast: | IGMP, etc. |
| h. Network Management: | SNMP |

3) Layer 2 Switch

- | | |
|------------------------|--|
| a. LAN Interface: | 10BASE-T/100BASE-TX x 20 ports or more |
| b. LAN Protocol: | TCP/IP, IP multi-cast, etc |
| c. Layer 2 Switching: | Shall be provided |
| d. Maximum VLAN: | Approx. 200 |
| e. VLAN Trunk: | Shall be provided |
| f. Spanning Tree: | Shall be provided |
| g. Multicast: | IGMP, etc. |
| h. Connector: | RJ-45 jacks |
| i. Network Management: | SNMP |

4) Fiber Optic Termination

Fiber optic termination will be installed in the Da Nang MMC, the MOs or other fiber optic connection points, where the FON will be located, and used to connect fiber optic cable with the ITS equipment smoothly by using suitable connectors.

- | | |
|-----------------------------|--------------------|
| a. Splicing Number of Core: | 100C x 2 or more |
| b. Connector: | SC or FC Connector |

5) Network Supervisory Equipment

The digital transmission system will be equipped with a supervisory function which continuously monitors the system operation and issues an alarm in case malfunction is found. The network supervisory equipment will have the following functions:

- a. Management of occurrence and recovery of malfunction
- b. Registration and modification of system configuration
- c. Registration and modification of network configuration
- d. Testing of equipment and circuit
- e. Logging of equipment operation and cable
- f. Changeover between primary and backup routes

6) Communication Cable

The type of cable for digital transmission system will be as stipulated below. The cable having suitable number of fiber optic cores and pairs for metallic cable, if used, will be selected.

Application	Cable Type
Outdoor Cable	
Trunk Line System	Fiber Optic Cable (Dispersion-Shifted Fiber: DSF)
Local Line System	Fiber Optic Cable (Single Mode Fiber: SMF)
Access Line System	Fiber Optic Cable (SMF) or CCP cable if required
Cable of Network Management	Fiber Optic Cable (Single Mode Fiber: SMF)
Indoor Cable	
Data/ Voice	Ethernet Cable or SWVP

Fiber optic cable to be installed along the expressway will have a minimum of 100 cores. Branching of fiber optic cable will be made in such a way that only the cores connected to the equipment are taken into the equipment and other cores will be bypassed. Splicing of optical fiber cable will be made with the method that allows re-opening of splicing housing and change of connection. The connection of core will be made with fusion splicing.

7) Conduit and Cable Works

Conduit work includes cable conduit from nearest manhole or pull box, which will be provided in other contract packages, to each ITS equipment, additional manhole and pull box if required, associated accessories necessary for cable installation. For the section where electromagnetic induction or electrostatic induction caused by high power transmission line is expected, countermeasures such as use of aluminum sheath cable shall be taken.

- Type and size of conduit
HDPE pipe shall be used for underground conduit and conduit must be protected by concrete at the section where conduit is exposed or underground conduit does not keep enough depth from the top of base. The conduit shall be buried at least 60 cm from the top of base. Inner diameter of conduit shall be about 1.5 times of the cable to be installed and conduit having inner diameter of 90 mm for fiber optic cable or 50mm for power cable shall be used as standard.
- Conduit attached to wall
Conduit attached to wall, box culvert or other structure shall be designed taking weight, vibration, expansion and contraction into consideration. Flexible joint shall be used at proper location to compensate for the expansion and contraction by temperature.

- Manhole and pull box
Manhole and pull box shall be used for cable installation, cable splicing and cable branching. They shall have suitable dimensions for its use. Fixture shall be provided to hold cable splicing if manhole is used for cable splicing.
Manhole and pull box shall be placed at the proper location. Spacing of manhole shall not exceed 250 meter.

5.9 Wireless Radio System

Wireless radio system is to be used for communications with personnel engaged in the expressway operation and maintenance and each office. The system shall cover the entire DQE section with high quality of voice and data communication. The system shall conform to the existing laws and regulations regarding radio wave transmission.

5.9.1 System Requirements

System requirements of the wireless radio system are as follows.

- The wireless radio system shall use 400 MHz band frequency. The exact frequency allocation shall be specified and approved by the Agency managing of the radio frequency.
- Digital type wireless communication system shall be used for its advantages over the conventional analogue type. Communication shall be scrambled for privacy.
- Quality of communication indicated by the received power level shall be better than -103 dBm.
- One-to-one, one-to-many communications shall be possible as minimum.
- ID data shall be automatically transmitted every time call is made.
- Mobile units both vehicle mounted type and portable type shall be equipped with GPS and the system has a vehicle tracking function.
- Portable units shall be rain proof.

5.9.2 System Configuration

The wireless radio system shall consist of control center station to be established at MMC, four (4) wireless base stations located at tunnel (south portal), Ha Lam toll office, Chu Lai toll office and KM112+410, and mobile units.

Additional base stations may be established to ensure the coverage area. The mobile unit shall be installed in the vehicles used for expressway operation and maintenance or accompanied with the staff engaged in the operation and maintenance work.

The base stations will be connected to the control center station through digital transmission system to be constructed under this Project.

5.9.3 Specifications

1) Control Center Station

The control center station will consist of, but not limited to, radio equipment (transmitter and receiver), antenna, coaxial arrester, communication control equipment and radio communication console. Two sets of transmitter and receiver shall be installed as hot standby system.

The radio communication console equipped with microphone shall have such functions as to select and communicate with any mobile unit or mobile unit group to be preset, select transmitter and receiver (No.1 / No.2) to be used, control the base station equipment, track vehicle location, and log operation record through the communication control equipment.

8-element Yagi type antenna or equivalent shall be used to transmit the radio signal effectively. The coaxial arrester shall be installed to protect the equipment from lightning surge.

The power supply to the each equipment will be made from DC power supply or Uninterruptible Power Supply (UPS) with battery having enough capacity to supply power until the emergency generator starts.

2) Base Station

The base station shall consist of, but not limited to, repeater equipment including two sets of transmitter and receiver, control equipment, antenna (8-element Yagi type or equivalent) and coaxial arrester. The base station shall have following functions.

- To connect and communicate with control center station and mobile units
- To receive control signal from control center station or mobile units and initiate repeater equipment
- To change over No.1/No.2 transmitter or receiver based on the control signal from control center station
- To detect transmitter and receiver failure, and have automatic radio changeover function
- To send operating status in compliance with control signal from control center station

The power supply to the each equipment will be made from DC power supply or UPS with battery having enough capacity to supply power until the emergency generator starts.

3) Mobile Unit

Both vehicle mounted type unit and portable type mobile unit with cradle type battery charger will be provided. The mobile unit shall be of compact size and light in weight in consideration of the usability. The number of equipment to be provided in the Project is shown below.

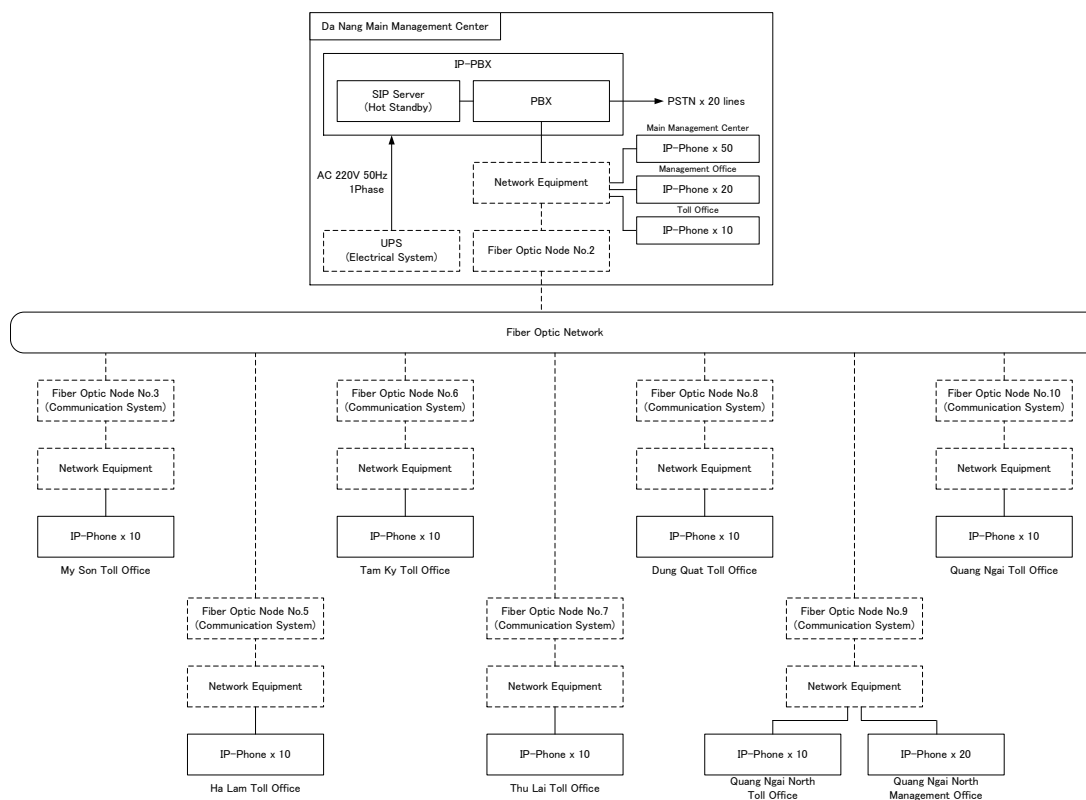
No.	Mobile Units	Quantity	Remarks
1.	Vehicle mounted type mobile unit	30	
2.	Portable type mobile unit	50	
3.	Battery charger	50	

5.10 Internal Telephone System

Internal telephone system with VoIP technology is to be utilized for voice communication between the personnel at the office along the expressway such as MMC, MO and TO. The system will be also connected to the public switched telephone network for the communication with the public and other organizations.

5.10.1 System Configuration

The internal telephone system will consist of the specified number of IP telephone sets to be installed at each office along the expressway and an IP based private branch exchange (IP-PBX) at the MMC. IP-PBX will be capable of controlling centrally all telephone sets installed along the expressway regardless of the location. The internal telephone system will be made through the digital transmission system to be constructed under the Project. Figure below shows the system configuration of internal telephone system.



Source: Consultant

Figure 5-28 Internal Telephone System Configuration

5.10.2 System Capacity

The telephone exchange must have the capacity to handle around 600 sets of telephone. The number of telephone sets to be provided under the Project shall be 170 sets.

Connection to public switched telephone network shall be possible. The system shall have the capacity of 20 PSTN lines or more. Type of connection shall be discussed with the local telephone company. Each telephone set will be assigned with an access class and connection to outside public switched telephone network, long distance call and overseas call shall be restricted according to the class.

5.10.3 Specifications

1) System Functions

The PBX will perform the basic call processing functions of establishment of connection, maintaining connection, terminating connection, and providing information for accounting purpose.

In addition to the basic functions listed above, the PBX will have at least the following functions:

- Call forward
- Call transfer
- Call hold
- Call park
- Call waiting
- Camp on
- Conference call
- Speed dialing
- Busy override

- Do not disturb
- Follow me

2) Firewall and DMZ

Demilitarized zone (DMZ) shall be created by firewall between inner network and outer network and IP-PBX shall be placed at DMZ to protect the inner network from the outer network access.

3) Quality of Service Control

IP-PBX shall support virtual local area network (VLAN) and quality of service (QoS) control to ensure uninterrupted and smooth calls. Quality of service shall adopt VLAN tag and voice priority tag embedded in type of service (TOS) and differentiated services code point (DSCP) to allow the network to process packets by priority.

4) Session Initiation Protocol (SIP)

IP-PBX shall support session initiation protocol (SIP) to allow communication with users in the third-part VoIP system.

5) Installation

IP-PBX and telephones sets shall be installed at the specified location in the MMC, the MO and the TO, and connect them with network. The system includes network cable, router and layer switch if necessary, connector, and other parts and accessories to construct a functioning telephone system. Power will be supplied to the IP-PBX, telephone set and other devices. Power of Ethernet (PoE) technology specified in IEEE 802.3af will be applied as much as possible to reduce the power cable installation works.

Installation work of internal telephone system will also include initial setting of the system parameters, registration of account, and other works necessary for the operation of the system.

5.11 Power Supply Work

The power supply system for the DQE is to be fed from medium voltage lines of 22 kV to supply ITS equipment, road lighting and/or O&M building with commercial power. The receiving points of commercial power will be located at the MMC, the MO, the TO, tunnel portal, major bridges, etc. Almost all of ITS facilities except CCTV camera located at the middle between interchanges will be supplied commercial power with DEG and UPS backup. Solar power supply system with backup battery will be provided for CCTV cameras installed at far from power receiving points as mentioned in **Section 5.1** above.

5.11.1 General

- (1) The electrical facilities provided in this Package will be located at following places;
 - Tuy Loan Interchange
 - Da Nang Main Management Center (MMC)
 - My Son Toll Office
 - Tunnel portal site (north side)
 - Ha Lam Toll Office
 - Tam Ky Toll Office
 - Chu Lai Toll Office
 - Dung Quat Toll Office
 - Quang Ngai North Management Office
 - Quang Ngai Toll Office

(2) The electrical facility will include, but not limited to, the followings;

- 10 Uninterruptible Power Supply (UPS) systems
- 10 low voltage distribution panels
- Cablings and wirings
- Lighting protection systems
- Grounding systems

It is noted that power receiving system including 22kV distribution line, 22kV CB panel, 22kV/400V transformer, diesel engine generator (DEG) with fuel tank and automatic transfer switch (ATS), etc. will be provided by Package14. Thus, well coordination between other contract package is necessary for power supply works. Installation of the cables and conduit systems from DEG distribution panel to low voltage distribution panel, UPS and ITS equipment will be included in this Package. The lighting protection systems and grounding systems for ITS equipment will also be provided in this Package.

5.11.2 Specifications

(1) Uninterruptible Power Supply (UPS)

1) Schedule

The UPS which will be furnished and installed under this Package, are summarized in the following table:

No.	Location	UPS		
		20kVA	50kVA	100kVA
1	Da Nang Main Management Center			X
2	Tuy Loan Interchange	X		
3	My Son Toll Office		X	
4	Tunnel Portal Site (north side)	X		
5	Ha Lam Toll Office		X	
6	Tam Ky Toll Office		X	
7	Chu Lai Toll Office		X	
8	Dung Quat Toll Office		X	
9	Quang Ngai North Management Office		X	
10	Quang Ngai Toll Office		X	
Total		2	7	1

2) Specifications

The type, ratings and characteristics of UPS will be as follows:

- Type
 - Capacity As shown in table above
 - Compensation period 10 minutes
 - Rating Continuous duty
 - Cooling system Forced air-cooling
 - System Synchronized AC line (By-pass)
 - Rectifier/Charger Full wave rectifier
 - Inverter Transistor bridge
- AC input
 - Phase & Wiring three phase 3 wires
 - Rated voltage 380V
 - Voltage variation range Within +/- 10%
 - Rated frequency 50 Hz

- Frequency variation range	Within +/- 5%
➤ AC output	
- Rated capacity	As shown in table above
- Frequency	50 Hz
- Phase & Wiring	single phase 2 wires
- Rated voltage	220V
- Voltage variation range	Within +/-2%
- Transient voltage variation range	Within +/-2%
- Frequency stability	Within 50Hz +/-0.1% (at asynchronous)
- Harmonic distortion	Within 5% (at non linear load)
- Available load power factor range	0.7 (lag) ~ 1.0
- Recovery time	Within 0.1 sec
- Over load rating	120 % 1 minute
- Efficiency	More than 85 % (at rated input and output)
➤ Alarm signals	
- Power suspension signal	to be equipped for supply signals to equipment
➤ Battery	
- Type	Sealed lead acid battery
- Backup time	Minimum period 10 minutes at +25oC

(2) **Low Voltage Panel**

The type, ratings and characteristics of low voltage panel will be as follows:

Type:	Metal-enclosed, self-supported or wall mounted type
Number of phases:	Three (3) Phase, four(4) wire
Rated frequency(Hz):	50
Rated insulation voltage	
- Main circuit V (r.m.s)	600 AC
- Control circuit V (r.m.s)	250 AC
Rated operation voltage	
- Main circuit V	380/220 AC
- Control circuit V	220 AC
Power frequency withstand voltage	
- Main circuit V (r.m.s)	2500 AC
- Control circuit V (r.m.s)	1500 AC
Rated operation and control voltage V (r.m.s)	220V + 10% - 15% (IEC 694 Clause 4.8)

(3) **Wire and Cables**

The wires and cables used will be as hereinafter specified.

- 600V PVC insulated wire (IV)
- 600V Vinyl insulated vinyl sheath cable (CVV)

- 600V vinyl insulated vinyl sheath cable with shield (CVVS)
- 600V cross-linked polyethylene insulated vinyl sheath cable (XLPE)

Manhole and/or pull box shall be provided at both end of the conduit duct run and a maximum of 50m interval, at all changes of direction of more than 45 degrees. The size of manhole and pull box shall be enough space for cable installation or maintenance. Following conduit material will be used to protect wires and cables.

- Rigid steel conduit
- Flexible steel conduit
- HDPE conduit
- Corrugated hard polyethylene pipes (FEP pipe)
- Cable racks
- Cable trays

(4) Lightning and Grounding System

1) Wires

The wire used for the wiring will be as hereinafter specified.

- 600V Vinyl Insulated Wire (IV)
- Soft annealed Copper Stranded Bare Conductor

2) Materials

Wire will be of soft drawn annealed, 98% conductivity, stranded copper and bare conductor.

SPD (Surge Protection Device) shall be discharge the lightning current and protect electrical equipment from surge lightning.

3) Grounding Plates

Ground plates will be copper plate of 1.5 mm or more thickness and 1000 mm x 1000 mm square or equal. The connections between the ground plates and grounding wires shall comply connected by brass-welding with electrolytic corrosion-proof treatment.

4) Grounding Rods

Grounding rods will be copper clad steel rods or galvanized steel rods, 10 mm or more in diameter, 1.5 meter long and with pointed and chamfered tops. Grounding rods will be equipped with couplings and driven bolts, and shall be driven to the depths and number of rods needed to obtain the desired resistance. Grounding rod clamps will be cast copper alloy, and shall tightly grip the rod and cable.

5) Grounding Connectors

Grounding connectors will be made by compression type. Grounding connectors will be corrosion resistant and provided for cable to flat surface connections on equipment and structural steel.

6) Ground Electrode Markers

The marker for buried ground plates and rods will be installed to construction wall near each electrode. Each marker will be made of brass or stainless steel, and will have written down the bury position, depth, resistance and date, etc.

5.12 Tunnel Safety facility

Tunnel safety facility has an important role to promptly detect incident, especially fire accident, and inform it to road users and road operator for preventing the enlargement of accident. The tunnel safety facility will be introduced in both bound tunnels located at around KM22+500.

5.12.1 Design Criteria

The design standard applied in the tunnel safety facility is Japanese NEXCO standards, since no design standard is existed in Vietnam. According to the standard, the level of tunnel safety facility is determined by traffic volume and length of tunnel as shown in table below.

Table 5-9 Classification of Tunnel Safety Facility

Standard	Tunnel Class	Calculation for Classification: NL = Traffic Volume (vehicle/day) X Tunnel Length (km)	Remarks
Design Manual Vol. 3: Tunnel Facilities Section 4: Tunnel Safety Facility (NEXCO)	AA	NL > 40,000	
	A	$40,000 \geq \text{NL} > 12,000$	
	B	$12,000 \geq \text{NL} > 4,000$	
	C	$4,000 \geq \text{NL} > 2,000$	
	D	$2,000 \geq \text{NL}$	

No.	Tunnel Safety Facility	Tunnel Class					Installation Interval	Remarks
		AA	A	B	C	D		
1	Tunnel Telephone	X	X	X	X	X	About 200m interval	Right side
2	Information Push Button	X	X	X	X		About 50m interval	Right side
3	Emergency Information Board	X	X	X	X	X	Tunnel Entrance	
4	Sprinkler	X					Depends on the conditions	
5	Fire Hydrant	X	X				About 200m interval (RLS)	
6	Fire Extinguisher	X	X	X	X	X	About 50m interval (RLS)	
7	Instruction Indication Board	X	X	X			200m interval	Both side
8	Information Control Board	X	X	X	X	X	Tunnel portal	

Source: Design Manual Volume.3 (NEXCO)

Classification B is applied to the targeted tunnels based on the calculation below.

Traffic Flow	Traffic volume (Vehicle/day)	Length (km)	NL	Classification
North Bound	17,248	0.556	$12,000 \geq 9,590 > 4,000$	B
South Bound		0.515	$12,000 \geq 8,883 > 4,000$	B

5.12.2 Tunnel Safety Facility Layout

Figure below shows the layout and quantity of tunnel safety facility.

Facility	Quantity	Location Interval (m)											
		(Right Lane Side)											
Emergency Telephone	3 (3)	85		200				200				71	
Fire Extinguisher	11 (11)	35	50	50	50	50	50	50	50	50	50	50	21
Information Push Button	11 (11)												
Insruction Indication Board	2 (2)	185				200				171			
North Bound Tunnel L = 556m	Right Lane	Northportal ←											
	Left Lane	→ Southportal											
Insruction Indication Board	3 (5)	85		200				200				71	
(Left Lane Side)													

Figure 5-29 Layout of Tunnel Safety Facility

5.12.3 Specifications

Followings are outline of requirements and specifications on the tunnel safety facility. Details are described in **Appendix-3** of this report.

(1) Tunnel Telephone System

Tunnel telephone system is provided to inform promptly and clearly conditions and location of incident to road operator at the MMC and receive proper advices from the operator. Tunnel telephone is connected directly to main management center without any exchange. The tunnel telephone must be equipped with swing door to avoid disturbance conversation due to noise from high speed traffic. Marker lamp for the telephone will be installed above telephone box in order to find out telephone box easily inside tunnel.

2) Information Push Button

Information push button is to inform location of incident to main management center by pushing button when the road user involved in the incident cannot vocalize in panic. An emergency signal from each push button will be integrated into defined observation division separated by 200m interval to understand the location easily by the operator. The marker lamp will be put into the cabinet of information push button. For convenience of regular maintenance works in tunnel, telephone jack for handset will be provided in the cabinet to communicate with staff in substation located at tunnel north portal or the main management center.

3) Fire Extinguisher

Two (2) units of fire extinguisher with cylindrical casing will be installed in fire extinguisher box. This box is made by stainless steel and has door with handle for security. In this box, information push button will be built in together. Class, type and capacity of fire extinguisher should be ABC class powder type with 6 kg weight capacity at least or recommendations of local authorities. Class ABC type fire extinguisher will be effective against ordinary combustible (class A), flammable liquids (class B) and flammable gases (class C).

4) Indication Board

An indication board will be provided to show the distance from each tunnel entrance for prompt evacuation. The letters indicated on the board shall be readable in dim conditions.

5) Master Controller

The master control installed in substation house at north tunnel portal site will be connected to the VMS boards located near the tunnel to promptly inform the incident occurred inside tunnel to the road users who are intending to enter the tunnel. The controller will also be connected to facility management server through fiber optic network to manage efficiently tunnel safety facilities such as tunnel telephone, information push button, etc. The controller supplies power to safety facilities in tunnel and relays signal from information push button to the VMS board and server.

6 IMPLEMENTATION PROGRAM

6.1 Implementation Schedule

Table 6-1 shows expected ITS implementation schedule including ITS design review, bidding and construction stage. The ITS implementation schedule is proposed on the basis of the following conditions.

[ITS Design Review Stage]

- C/S consultant of ITS package will start to review the ITS design and prepare bidding documents after approval of ITS design by relevant authorities. The period of design review works including approval of MOT is estimated around five (5) months.

[Bidding Stage]

- Bidding will include two (2) stage, i.e. Prequalification (P/Q) stage and Tender stage.
- The prequalification period will require 45 days after P/Q announcement to applicants.
- P/Q evaluation and approval of P/Q evaluation report by relevant authorities need four (4) months after P/Q close. Subsequently, bidding document and Request for Proposal (RFP) will be issued to eligible bidders. The bidding period is estimated for 60 days.
- After bid open, bid evaluation and clarification (separately both technical and price), contract negotiation and concurrence from MOT and JICA are required. Period for those processes is estimated around nine (9) months.

[Construction Stage]

- The construction work will be commenced after the bidding process. Construction work includes following ITS works.
 - Preparation of detailed design and shop drawings (6.0 months)
 - Manufacturing (8.0 months)
 - Factory inspection (1.0 month)
 - Overseas/Inland transportation (2.0 months)
 - Installation (6.0 months)
 - Trial operation and site training (3.0 months)
 - Commissioning test (2.0 months)
 - Handover
- A period of construction stage will be total of 24 months
- The handing over of ITS package is expected in the beginning of August 2017.


[Defect Liability Stage]


- Two (2) years defect liability period will be commenced after the handing over of ITS equipment.

Table 6-1 ITS Implementation Schedule

No	Stage	Work Item1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	
1	ITS Design Review Stage	ITS Design Review																																																	
2		Preparation of Bidding Document																																																	
3	Bidding Stage	P/Q Announcement																																																	
4		P/Q by Applicants																																																	
5		P/Q Evaluation																																																	
6		Approval, Concurrence of P/Q Evaluation																																																	
7		Issuance of Bidding Document / RFP																																																	
8		Bidding Period / Bid Open																																																	
9		Bid Evaluation and Clarification																																																	
10		Approval, Concurrence of Bid Evaluation																																																	
11		Contract Negotiation																																																	
12		Approval, Concurrence of Contract / NTP																																																	
13	Construction Stage	Preparation of Detailed Design and Shop Drawings																																																	
14		Manufacturing																																																	
15		Factory Inspection																																																	
16		Overseas / Inland Transportation																																																	
17		Installation																																																	
18		Trial Operation and Site Training																																																	
19		Commissioning Test																																																	
20		Handover																																																	
21	Defect Liability Period	Defect Liability Period (2 years)																																																	

Note:

 : Work Item

 : Approval, Concurrence by Authorized Organization

Source: Consultant

6.2 Cost Estimate

The ITS implementation costs are estimated as rough order basis with following conditions:

- Cost is on 2013 basis
 - ROM (Rough Order Magnitude) cost information from major international manufacturers
 - Past projects contract price information
- Consultant's internal cost estimation data
- Not including power receiving system, diesel engine generator and cable conduit which will be procured in different packages
- Not including costs for creation of new organization and site preparation (building), etc.
- Not including contingencies and government tax

The ITS implementation costs are estimated around 43.5 million USD as shown in table below.

Table 6-2 ITS Implementation Costs

No.	Item	Amount		Amount Equivalent in USD	Remarks
		VND	USD		
1	Traffic Management System	11,529,000,000	8,818,000	9,367,000	
1-1	CCTV Camera system	2,520,000,000	516,000	636,000	
1-2	Vehicle Detector System	1,176,000,000	544,000	600,000	
1-3	MET System	315,000,000	509,000	524,000	
1-4	Overload Monitoring System	1,848,000,000	1,236,000	1,324,000	
1-5	Variable Message Sign System	5,460,000,000	3,570,000	3,830,000	
1-6	Traffic Management Center System	210,000,000	2,443,000	2,453,000	
2	Toll Collection System	6,930,000,000	14,669,000	14,999,000	
2-1	Toll Center System	0	3,500,000	3,500,000	
2-2	Toll Lane System	5,250,000,000	3,530,000	3,780,000	
2-3	Toll Office System	1,680,000,000	3,264,000	3,344,000	
2-4	User Side Equipment	0	4,375,000	4,375,000	
3	Communication System	7,003,500,000	5,398,950	5,732,450	
3-1	Digital Transmission System	6,268,500,000	4,342,450	4,640,950	
3-2	Wireless Radio System	525,000,000	787,000	812,000	
3-3	Internal telephone system	210,000,000	269,500	279,500	
4	Power Supply Work	6,919,500,000	700,000	1,029,500	
5	Tunnel Safety Facility	420,000,000	397,600	417,600	
6	General Requirements	14,238,000,000	4,131,000	4,809,000	
7	Detailed Design	0	1,500,000	1,500,000	
8	Overhead, Others (15%)	7,056,000,000	5,342,000	5,678,000	
	Total	54,096,000,000	40,956,550	43,532,550	

Note Exchange Rate: 1USD=21,000VND

Source: Consultant

The breakdown of ITS implantation costs is attached in **Appendix-4** of this report.

6.3 Outstanding Issues on ITS Implementation

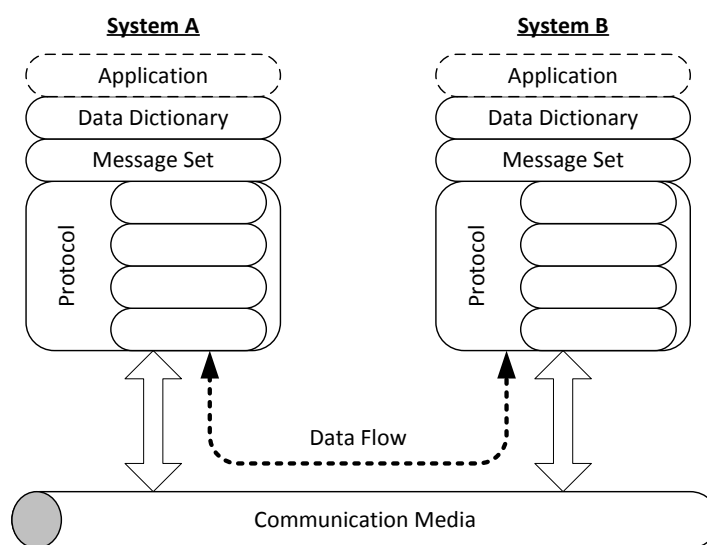
(1) Standardization of Data Exchange Format

The ITS consists of various system components including roadside equipment and management center system. The system data monitoring are to be conducted by controlling or communicating with roadside equipment and actual data transmission is made on the data transmission rules and protocols specifying how message and data elements are coded and transmitted between electronic devices of ITS.

In the ITS implementation of DQE, standardization of data exchange format is quite important because the Da Nang main management center is a center to manage entire expressway sections in central region of Vietnam and integration of ITS equipment into the DQE system will be necessary when the expressway is extended beyond DQE section.

1) Data Exchange Structure

The data exchange structure of ITS will be configured with three (3) hierarchy, namely Data Dictionary, Message Set and Communication Protocol. The configuration of the structure is shown in figure below.



Source: Consultant

Figure 6-1 Data Exchange Structure

Data Dictionary:

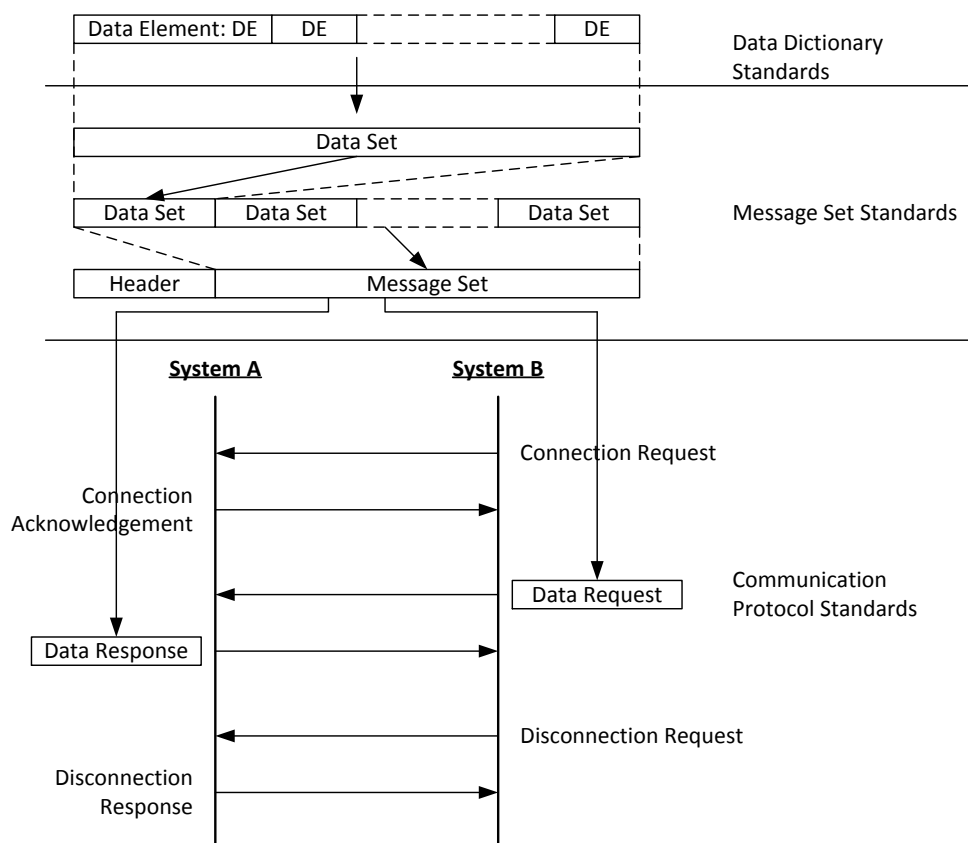
Data dictionary is a repository of information about data such as meaning, relationships to other data, origin, usage, and format. In the case of data dictionary for ITS, it normally consists of three parts of road related information dictionary, device control data dictionary and administrative data dictionary.

Road related information covers road and traffic condition (such as traffic congestion information and weather information), and organization information (such as road related facilities). Device control data dictionary contains command and operation information to the equipment. Administrative data dictionary is a dictionary for other data elements not covered by two dictionaries above including event numbers and operation and test classification flags.

Message Set:

Message set is a set of information arranged in the specified sequence to interpret message exchanged between two systems correctly without misunderstanding. Message set standard specifies the sequence of data elements in a message with which data is stored. An example of message set of traffic regulation information would contain location of regulation, type of regulation, starting time and ending time of regulation, and reason for regulation in the sequence and format as specified.

A message can be composed following the rules prescribed by the message set standard. The concept of message set in relation with data set and communication protocol is shown below.



Source: Consultant

Figure 6-2 Relation with Data Dictionary, Message Set and Communication Protocol

Communication Protocol:

Protocol is a procedure for data exchange between two devices and specifies type, meaning, expression format, exchange sequence of control message that controls the data exchange.

Communication protocol has many levels of control from the level of meaning of data to physical and electrical conditions. In order to systematically define the protocol, a model called Open System Interconnection Basic Reference Model was developed by International Organization for Standardization (ISO). The ISO model divides the functions of protocol into seven layers as shown in table below. The details at all of seven layers must be same if two systems exchange the data.

Table 6-3 Seven-Layers OSI Basic Reference Model

	Data unit	Layer	Function
Host layers	Data	7. Application	Network process to application
		6. Presentation	Data representation and encryption
		5. Session	Inter-host communication
	Segment/Datagram	4. Transport	End-to-end connections and reliability
Media layers	Packet	3. Network	Path determination and logical addressing
	Frame	2. Data Link	Physical addressing (MAC & LLC)
	Bit	1. Physical	Media, signal and binary transmission

Source: Consultant

2) Proposed Implementation Plan of Standardization

For the establishment of data exchange standard required for future ITS integration with other expressway, the nationwide framework which becomes beyond the scope of individual projects including the ITS works for the DQE will be required. It is strongly recommended to establish national standards for data exchange in advance of ITS implementation of the DQE.

In developing Vietnamese standards, the following approaches are recommended.

a. Global Standards Adaptation

When transport information and control system were first developed, proprietary data format and communication protocol were adopted at each system and there was no interoperability among the systems except the systems constructed by the same supplier with the same design principle. Then, the national standards have been developed in Japan, USA and European countries to facilitate data exchange between two systems. Currently, there is a move to develop global standards for intelligent transport system among not only developed countries but also developing countries and ISO TC 204 is working on it. Some standards have been already published and others are under development.

It is important to follow and adopt global standards mainly for two reasons. The standards incorporate technically most reasonable solutions based on the experience in many years and technologies available so that they are technically most sound. Secondly, as the number of systems that adopt global standards increases, the number of suppliers who offer global standard compliant products is also increasing. There are multiple choices as to the vendor resulting in the cost reduction.

b. Organization Setup

Standardization of data exchange format for ITS has impact on many organizations and agencies dealing with traffic and transportation related information. In order to incorporate the needs and requirements by variety of organizations, their involvement into the standard development process is crucial. Thus, suitable organizational setup must be established to develop the standards with Ministry of Transport as leading agency taking initiative of the process. The organizations that must be involved in the process include:

- Ministry of Transport (MOT)
- Ministry of Information and Communication (MIC)
- Vietnamese Expressway Corporation (VEC) and VEC O&M
- Directorate for Roads of Vietnam (DRVN)
- People's Committee in large cities

Developing data exchange standards is a highly technical task. It requires extensive knowledge of information and communication technologies in general and both hardware and software sides of data transmission technologies. Thus, each member agency must be represented by the knowledgeable person to have effective discussion on the standards.

As many expressways are being constructed or planned, it is an urgent task to develop data exchange standards. Target date of standards must be set and a roadmap to the publication of standards must be defined to adopt the standards on these expressways.

3) Provision of API Specifications

Application Programming Interface (API) is one of specifications to be used as an interface of software components to communicate with each other. The API specifications include an International Standard such as POSIX, vendor documentation and libraries of programming language. Using the API will bring advantages in changes of interfaces, operational mode of equipment in response to the requirements of the users. However, use of API may also have some risks such as hang up, data losses or failures in case of faulty of API programming. The provision of API specifications will highly depend on the manufacturer's system design. The Consultant recommends that, prior to specify the programming specifications, the standardization of data exchange format shall be established since it is most pivotal element in the system.

(2) Toll Collection System Operation

The manual toll collection system by utilizing the Contactless IC card and DSRC Active 5.8GHz type ETC system will be introduced in this Project. In the toll collection system, operational scheme such as rules of IC card operation, OBU operation and toll check scheme must be initially considered. Following are expected operational scheme and assumed issues on toll collection system operation.

[IC Card Operation]

- The IC card for prepaid card will be sold at toll offices at initial phase. Also, the road operator is in charge of charging, re-charging and invalidated IC card management.
- After traffic volume and the IC card users increase, the selling points shall be expanded at other places and IC card management will be sublet to other company. In this case, the collaboration with bank is recommended in consideration of strict toll charge management and future expandability of post-paid payment, etc. If the IC card is managed by the bank, check scheme for the toll fee, networking with the bank and other operational frameworks are required.
- The IC card will also be used as toll ticket. Thus, the toll collector is required to manage the IC card collection and delivering. For instance, the IC card collected at exit toll booth together with toll charge must be delivered to entrance toll booth for next road user's transaction and sometimes the IC card shall be distributed to other interchanges having heavy traffic volumes. Such IC card management rules must be preliminary determined.

[OBU Operation]

- Road operator would directly manage registration of OBU data and invalidated OBU list at initial phase when the ETC users are few.
- If the registered data of OBU and the data of ANPR are not matched, toll operator must confirm by image data of lane camera and data of ANPR to prevent illegal use of the OBU. Such framework must be considered in the actual ETC operation.
- If the bank interests in OBU management, the schemes as mentioned in IC card operation shall be newly established.

[Toll check scheme]

- To prevent improper and illegal use of IC card and OBU or misbehavior of toll collector, checking system against a negative list (frequent improper incident list) and organization must be established for the toll collection system.
- At initial phase, check function and organization would be equipped with the road operator. The supervisor of each toll office is in charge of toll charge check activities at each tollgate and the supervisor in main management center shall crosscheck all toll charge data.

[Operation of Vehicle Classification]

- As for ETC vehicles, automatic vehicle classification is available by using registered data in the OBU. However, in manual toll collection system, it is difficult to automatically detect the vehicle classification because the vehicles are classified by not only vehicle length and weight but also seat capacity under current MOF circular. Also, automatic vehicle classification generally requires various types of sensor for measuring moving vehicle scale accurately and data processing equipment, etc. and it causes high implementation costs. Thus, the manual vehicle classification is recommended for manual toll collection system. The toll collectors must be well trained for the vehicle classification operation.

(3) Actions for Frequency Allocation on Wireless Radio System

The procedures for frequency allocation on wireless radio system are proposed in this design. According to the procedures, it is recommended that the VEC O&M, who is expected expressway operator and will become radio licensee, will preliminary discuss with the RFD of MIC regarding the possibility of frequency allocation. The necessary actions for this matter are expected to be taken timely by the Client with the assistance from the C/S Consultant.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

In this report, the ITS plan and design are examined to clarify the ITS requirements and implementation program of Da Nang - Quang Ngai Expressway. As the results of ITS design works, following major proposals and conclusions are made by the Consultant.

Conclusion-1: ITS components selected for the DQE are almost same level with previous FSs and other ITS on-going projects in Vietnam as listed in table below.

Table 7-1 Proposed ITS Components in the Project

No.	Category		ITS Component
1-1	Traffic Management System	Data Acquisition System	CCTV System
1-2			Vehicle Detector System
1-3			Meteorological Monitoring (MET) System
1-4			Overload Monitoring (WIM) System
1-5		Information Dissemination System	Variable Message Sign (VMS) System
1-6			Internet Dissemination System (included in traffic management center system)
1-7		Traffic Management Centre System	Traffic Management System
1-8			Facility Management System
2-1	Toll Collection System		Manual Toll Collection System
2-2			Electronic Toll Collection System (ETC)
3-1	Communication System		Fiber Optic Communication System
3-2			Internal Telephone System
3-3			Wireless Radio System

Source: Consultant

Conclusion-2: The locations of ITS facility are proposed as the location map illustrated in **Figure 4-1** of this report. The ITS facilities are being arranged in consideration of minimum ITS requirements at road opening, expressway characteristics, cost effectiveness, etc.

Conclusion-3: To cope with natural disaster, especially for flooding and falling stone, continuous monitoring by CCTV camera at such disaster prone areas is proposed in the Project.

Conclusion-4: In accordance with MOT decision, IP digital camera with a resolution dealing with SDTV is proposed as the CCTV camera device. Also, H.264/MPEG-4 and M-JPEG will be utilized for digital image encoding method.

Conclusion-5: The consultant proposes to apply ultrasonic type vehicle detector in consideration of accuracy in bad weather and night time.

Conclusion-6: The anemometer, thermometer, rain gauge, rainfall detector and visibility meter will be provided for collecting necessary weather information in the Project.

Conclusion-7: The axle load scale arrangement at entrance toll plaza, enforcement procedure by using exclusive U-turn exit and two (2) step measurements with WIM type axle load scale and portable weigh station for overload monitoring system is proposed in the Project.

Conclusion-8: The VMS will be located at upstream of each on-ramp including toll barrier, off-ramp and tunnel. The VMS has display function of 3 lines with 24 characters in each line. The character size shall be 450mm in height or larger to comply with relevant Vietnamese standard.

Conclusion-9: To manage and integrate all information related to expressway O&M, the traffic management center system will be provided in the Project. The system must have future expandability to manage whole central region, but the system capacity at initial stage is limited to manage only DQE section.

- Conclusion-10:** The traffic management center system will have two main functions. One is traffic management system function and the other is facility management (SCADA) function. The facility management system is to have important role in the ITS to consolidate the system operational status monitoring in order to smoothly take remedial actions in case of system failure. The implementation cost of SCADA system is estimated around USD 700,000.
- Conclusion-11:** The traffic management center system will consist of traffic management system server, facility management system server, large display panel with controller, operator consoles, WEB & MSG server, other hardware devices and various types of application software listed in **Table 4-21** of this report. The WEB & MSG server will be introduced to provide expressway information to the Public through internet, e-mail and/or SMS.
- Conclusion-12:** The toll collection of DQE will be implemented in accordance with relevant circular issued by MOF, basically. However, the regulations on toll collection for expressway are not yet strictly stipulated at this moment. Thus, the policy of toll collection for the DQE is proposed by the Consultant as shown in **Table 4-24** of this report.
- Conclusion-13:** Manual (Contactless IC card based) and DSRC Active 5.8GHz type ETC are proposed as toll collection system in accordance with relevant MOT decision.
- Conclusion-14:** In order to meet the communication system requirements such as enhancement of network reliability even during any disasters and high capacity data transmission including CCTV images, private fiber optic network is proposed as digital transmission system in this Project. As for the communication system between patrol crews, wireless radio system by using exclusive VHF/UHF radio frequency is proposed due to its advantage of good mobility and cost effectiveness.
- Conclusion-15:** The network topology of digital transmission system will be configured with a flatten ring structure with loop-back function to guarantee even if one fiber optic node or cable fail to operate. Gigabit Ethernet with a capacity of 1Gbps will be utilized as digital transmission protocol in line with relevant MOT decision and estimated network traffic.
- Conclusion-16:** Based on the wave propagation analysis results made by the Consultant, five (5) wireless radio base stations including Da Nang main management center, tunnel, Ha Lam, Chu Lai and KM112+410 will be provided in the Project.
- Conclusion-17:** The procedures required for frequency allocation on wireless radio system is proposed as shown in **Figure 4-35** in this report.
- Conclusion-18:** Necessity of emergency telephone system is examined in this report. As the study results, the Consultant proposes to utilize mobile phone instead of emergency telephone system for emergency calling due to the fact that all sections of DQE are within the coverage of mobile phone carriers.
- Conclusion-19:** Commercial power with generator and UPS backup is recommended for power supply system of ITS equipment closely located at the main management center, ICs and tunnel. Solar power with backup battery is proposed for power supply system of CCTV camera located between ICs.
- Conclusion-20:** Required human resources for ITS operation and maintenance are proposed as **Figure 4-39** in this report. Three sections, i.e. traffic management room and facility maintenance division in the main management center and facility maintenance section are in charge of ITS operation and maintenance. Total of 33 staffs is proposed for proper ITS operation and maintenance.
- Conclusion-21:** Construction period of ITS package is expected as total of 24 months. ITS Implementation cost is estimated around 43.5 million USD.

7.2 Recommendations

Recommendation-1: The ITS plan and design to show the outline of ITS requirements and implementation program on the DQE are clarified in this report. It is expected to obtain comments against the ITS plan and design from relevant authorities to reflect such comments to ITS design review work by the C/S Consultant.

Recommendation-2: For the establishment of data exchange standard required for future ITS integration with other expressway, the nationwide framework which becomes beyond the scope of individual projects will be required. It is strongly recommended to establish such national standards for data exchange in advance of ITS implementation of the DQE.

Recommendation-3: The manual toll collection system by utilizing the Contactless IC card and DSRC Active 5.8GHz type ETC system will be introduced in this Project. In the toll collection system, operational scheme such as rules of IC card operation including issuance, charging, re-charging and invalidated IC card management, OBU operation and toll charge check scheme must be initially set up.

Recommendation-4: The procedures for frequency allocation on wireless radio system are proposed in the report. Necessary actions for this matter are expected to be taken timely by the Client with the assistance from the C/S Consultant.

Appendix-1 Wave Propagation Analysis

APPENDIX-1, Wave Propagation Analysis

1. Term of wave propagation analysis

Wave propagation analysis is described by the coverage area that is analyzed in the simulation software. Term of analysis used with the simulation software is shown below.

2. Coordinates and elevation of base station

The coordinates and elevation of base station in the simulation software is listed below.

Table A1-1, coordinates and elevation of base station

Name of base station	Coordinates (deg. hour, min.)		Elevation (Terrain data) [m]
Da Nang Main management center	15 58 18.58 N	108 09 46.95 E	7.4
Tunnel south side	15 48 49.70 N	108 12 28.20 E	73.3
Ha Lam Toll office	15 42 37.30 N	108 19 55.77 E	13.0
Chu Lai Toll office	15 26 25.72 N	108 35 25.47 E	11.0
KM112+410	15 15 43.82 N	108 45 00.52 E	83.0

Source: Consultant

3. Radio and Antenna

Term of radio and antenna in the simulation is listed below table.

Table A1-2 radio and antenna of base station and mobile

	Base station	Mobile
Antenna height	15.0 [m]	2.0 [m]
Type of antenna	5 elements YAGI narrow band width, 9.5 [dBd]	Whip antenna, 2.1 [dBd]
Cable length	25 [m]	3 [m]
Transmission power	50 [w]	3 [w]
Radio frequency	400 MHz band	

Source: Consultant

4. Terrain data

Terrain data used is ASTER GDEM which is a product of METI (Ministry of Economy, Trade and Industry, JAPAN) and NASA (National Aeronautics and Space Administration, U.S.A). There is limitation in use though these data is being offered free of charge. It is to describe the supply origins which are METI and NASA. ASTER that is NASA's Terra spacecraft has two telescopes, one for nadir-viewing and another for backward-viewing, with a base-to-height ratio of 0.6. The spatial resolution is 15 m in the horizontal plane. One scene consists of 4,100 samples by 4,200 lines which correspond to about 60 km by 60 km ground area. ASTER global DEM (ASTER GDEM version 2.0) was created by stacking all cloud-masked scene DEMs and non-cloud-masked scene DEMs, and statistical selection algorithm to remove abnormal data. The data coverage is North 83 degrees to South 83 degrees. Tiles including at least 0.01 % land area were processed. The number of tiles is 22,702. Our expressway is also covered by this data. The data formats are summarized in below table.

Table A1-3 data formats of terrain data

Tile Size / Posting interval	3601 x 3601 (1 degree by 1 degree) / 1 arc-second
Geographic coordinates	Geographic latitude and longitude
DEM output format	GeoTiff, signed 16 bits, and 1m/DN, WGS84/EGM96 geoid
Special DN values	-9999 for void pixels, and 0 for sea water body
Coverage	North 83 degrees to south 83 degrees, 22,600 tiles

Source: Consultant

5. The design criterion

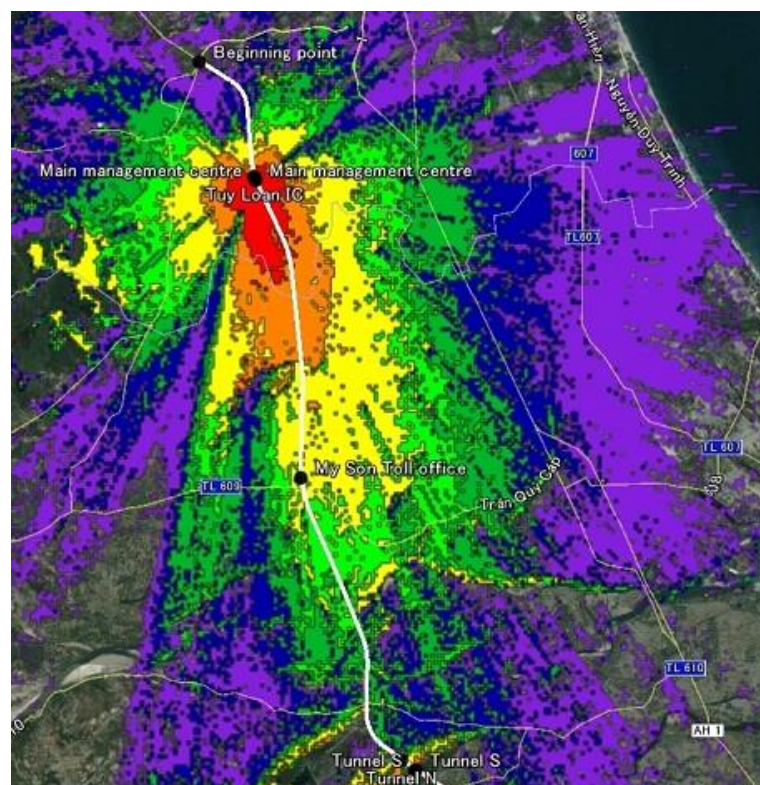
The design criterion has used receiving sensitivity which is mentioned -103[dBm] as required receiving level at Base station by the standard of ETSI (European Telecommunications Standards Institute).

6. The result of wave propagation analysis

In VHF/UHF radio propagation, a certain radio wave reaches directly, and a certain radio wave reaches while reflecting ground. It looks like the curve of the ping-pong. The energy of radio wave is consumed a lot by the direct and the reflecting propagation. Therefore, the radio wave consumes the energy to exceed the obstruction which is a high mountain on the route. In the simulation, the tendency to the change in strength of receiving power that changes depending on terrain aspect and the distance is analyzed.

The color markers which are from Red to Violet indicate strength of receiving power level; Red color is most strong level among them. Violet color indicates threshold limit value of receiving sensitivity which can receive the signal from facing station. The result and explanation of each Base station analysis is shown as follows,

(1) Da Nang Main management center

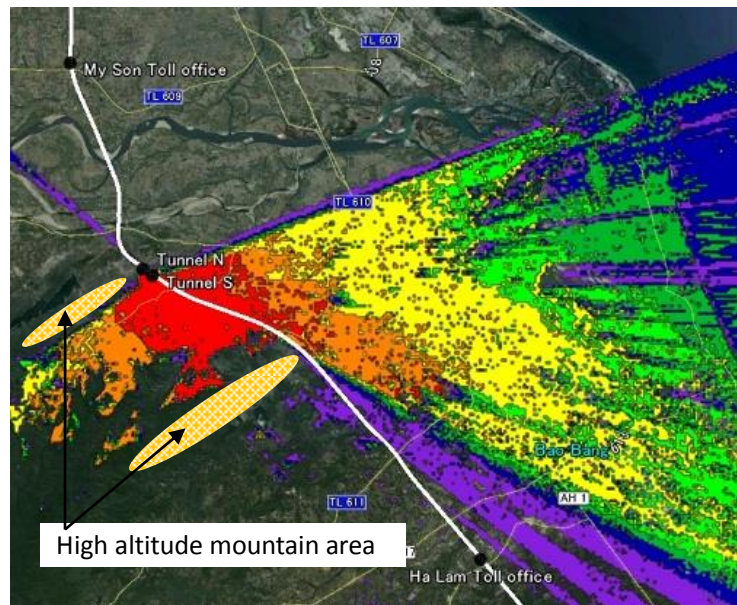


Source: Consultant

Figure A1-1, Coverage of Da Nang Main management center

Base station in Da Nang Main management center is operated from the Beginning point to Tunnel. In this area, the altitude is almost same sea level up to front of Tunnel, and alignment of expressway is planned to the south. This is the reason that Yagi type antenna is located in this station.

(2) Tunnel south side

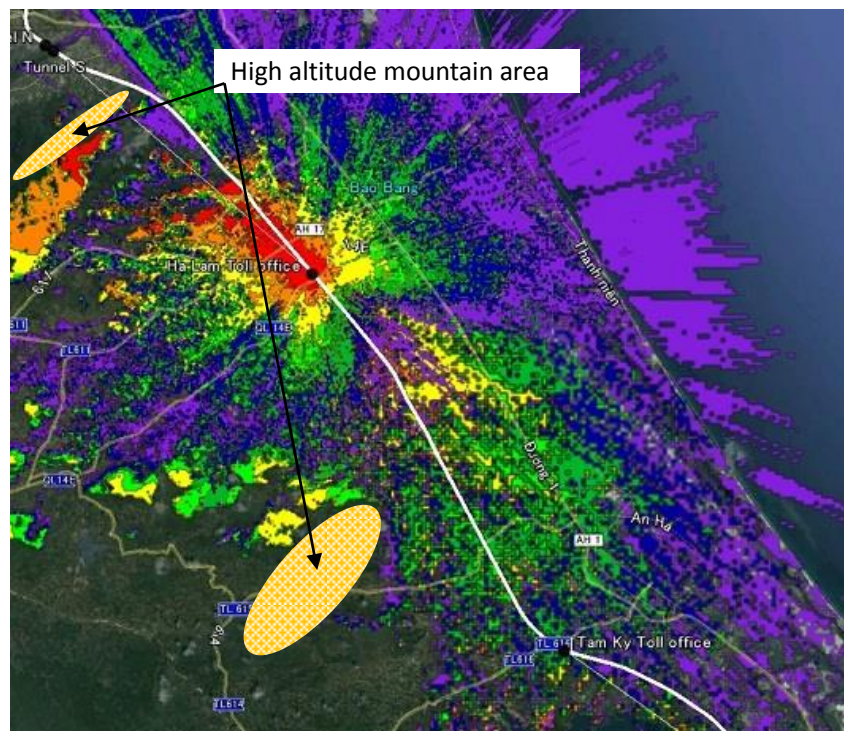


Source: Consultant

Figure A1-2, Coverage of Tunnel South side

Base station in Tunnel south side is operated around Tunnel. Between Tunnel and Ha Lam there is high altitude mountain. The alignment of expressway is planned to avoid this mountains up to Ha Lam. In this geographic condition, the radio propagation can't reach Tunnel from Ha Lam because this mountain will be shield for spread. Moreover, the radio wave should be radiated in the tunnel also. These are reason why Base station with Yagi antenna is located near Tunnel.

(3) Ha Lam Toll office

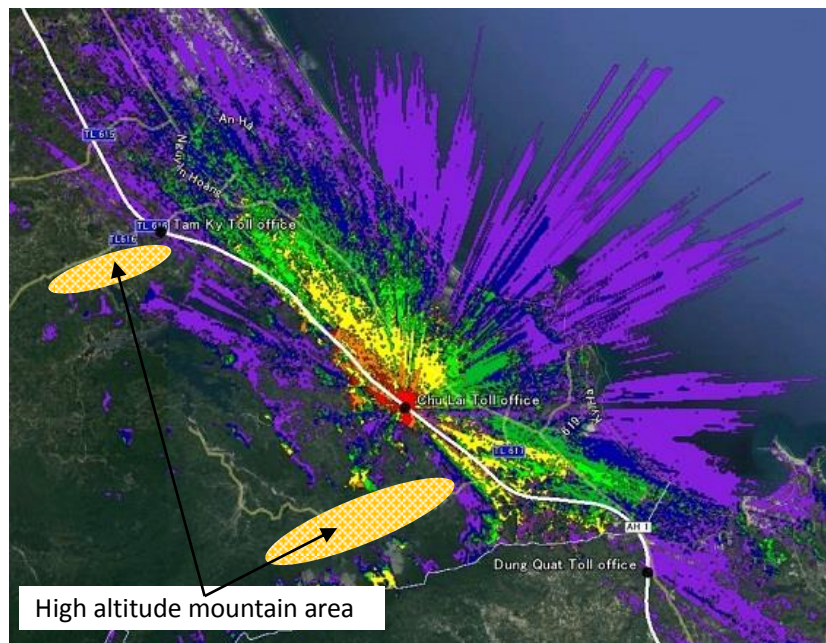


Source: Consultant

Figure A1-3, Coverage area of Ha Lam Toll office

Base station in Ha Lam Toll Office is operated from Tunnel to Tam Ky Toll Office. In this area, there is mountain near Tunnel and Tam ky. These mountains are shield to spread the radio wave from Ha Lam. That is reason why the radio wave is not reachable up to them. This station is also located Yagi antenna to extend the range of the radiation for the radio wave.

(4) Chu Lai Toll office

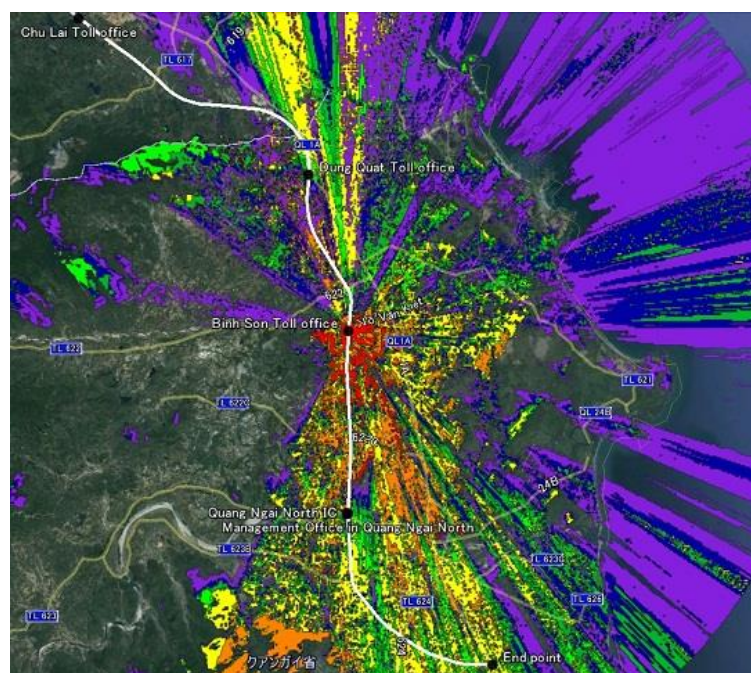


Source: Consultant

Figure A1-4, Coverage area of Chu Lai Toll office

Base station in Chu Lai Toll Office is operated from Tam Ky Toll Office to Dung Quat Toll Office. In this area, there is mountain near Tam ky and Dung Quat. These mountains also are shield to spread the radio wave from Chu Lai. This limited reachable is same reason as Hal Lam. This station is also located Yagi antenna.

(5) KM112+410



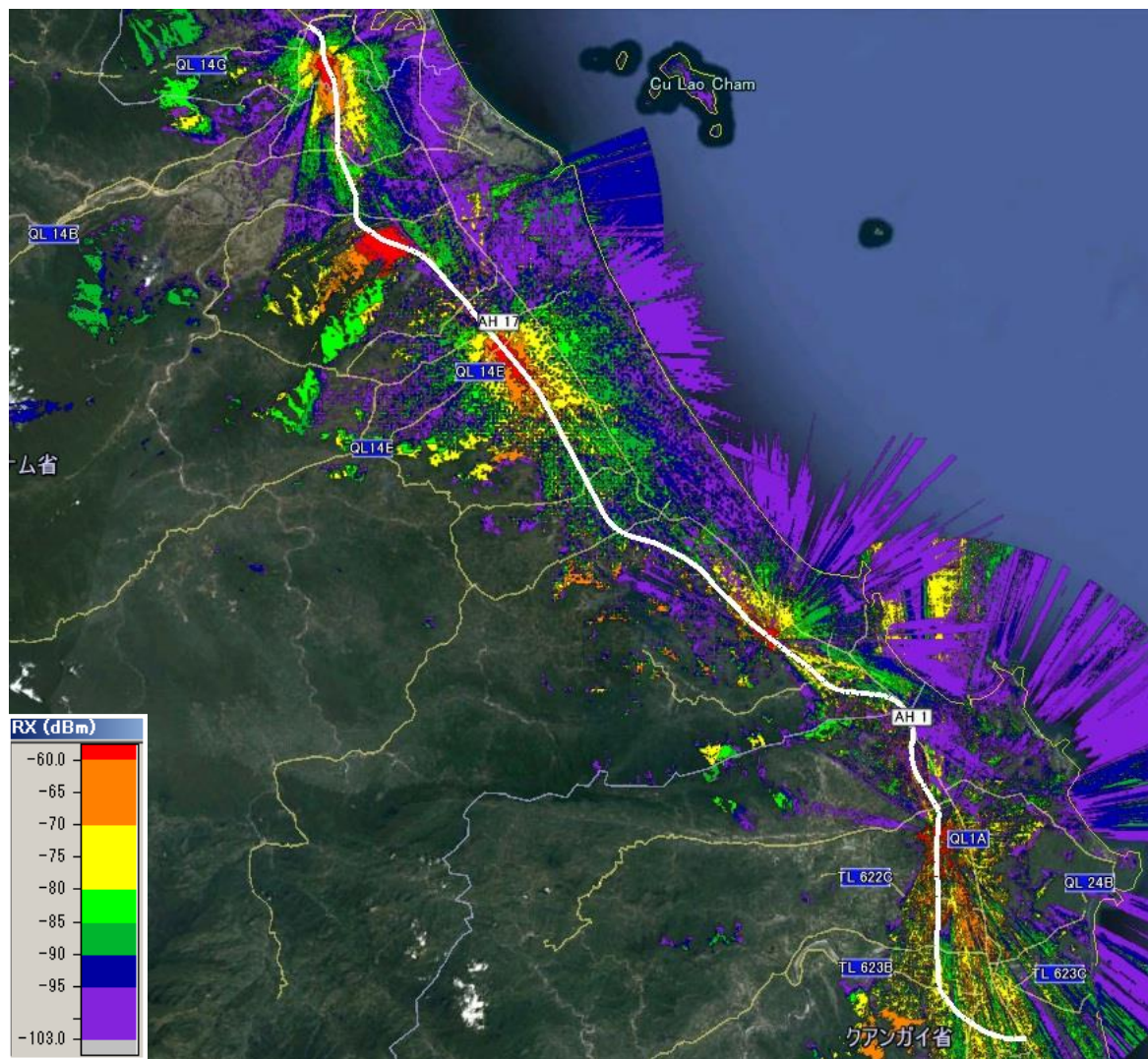
Source: Consultant

Figure A1-5 Coverage area of KM112+410

Base station at KM112+410 is operated from Dung Quat Toll Office to End point. KM112+410 point is located in a high position in this area. From here there are a few hills only. To spread the radio wave the Yagi antenna also is located in this station.

7. Conclusion

According to the result of analysis in mentioned above figure, whole area of expressway is covered by each Base station. However, all of area is not covered enough with a strong radio wave.



Source: Consultant

Figure A1-6 Coverage of whole area in Wireless Radio System

Appendix-2 License Application Form

Số:

CỘNG HOÀ XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập - Tự do - Hạnh phúc

BẢN KHAI

ĐỀ NGHỊ CẤP GIẤY PHÉP SỬ DỤNG TẦN SỐ VÀ THIẾT BỊ VÔ TUYẾN ĐIỆN

(Đối với mạng thông tin vô tuyến điện nội bộ, mạng viễn thông dùng riêng sử dụng tần số vô tuyến điện thuộc nghiệp vụ di động)

- CHÚ Ý:**
1. Đọc kỹ hướng dẫn trước khi điền vào bản khai.
 2. Tổ chức cá nhân chỉ được cấp phép sau khi đã nộp lệ phí cấp phép và phí sử dụng tần số theo quy định của Pháp luật.

KÍNH GỬI : CỤC TẦN SỐ VÔ TUYẾN ĐIỆN

1. TÊN TỔ CHỨC HOẶC CÁ NHÂN ĐỀ NGHỊ CẤP GIẤY PHÉP			
1.1. Số chứng minh thư hoặc số hộ chiếu (nếu là cá nhân đề nghị cấp giấy phép)	Số		Ngày cấp
	Cấp tại		
1.2. Số Quyết định thành lập hoặc số Giấy chứng nhận đăng ký kinh doanh hoặc số Giấy chứng nhận đầu tư (nếu là tổ chức đề nghị cấp giấy phép)	Số		Ngày cấp
	Cơ quan cấp		
1.3. Số Giấy phép viễn thông	Số		Ngày cấp
	Cơ quan cấp		
	Thời hạn sử dụng:	từ ngày	đến ngày
1.4. Tài khoản	Số		
	Ngân hàng		
	Thanh toán phí, lệ phí qua Ngân hàng bằng Ủy nhiệm thu	<input type="checkbox"/> Đồng ý <input type="checkbox"/> Không đồng ý	
1.5. Địa chỉ liên lạc			
1.6. Số FAX/ Số điện thoại		1.7. Người kê khai (số điện thoại cố định/di động/email)	
2. TỔNG HỢP THÔNG TIN ĐỀ NGHỊ	<input type="checkbox"/> Cấp mới cho mạng thông tin (..... tờ của Phụ lục 1)		
	<input type="checkbox"/> Gia hạn chogiấy phép số (..... tờ của Phụ lục 2)		
	<input type="checkbox"/> Bổ sung hoặc thay đổi chogiấy phép (.....tờ của Phụ lục 1)		
	<input type="checkbox"/> Ngừnggiấy phép số (..... tờ của Phụ lục 3)		
3. CÁC THÔNG TIN BỔ SUNG			
4. TỔ CHỨC (CÁ NHÂN) ĐỀ NGHỊ CẤP GIẤY PHÉP CAM KẾT			
4.1. Thiết bị vô tuyến điện phù hợp quy chuẩn kỹ thuật về phát xạ vô tuyến điện, an toàn bức xạ vô tuyến điện và tương thích điện từ.			
4.2. Thực hiện quy định của pháp luật về bảo đảm an toàn, an ninh thông tin; kiểm tra giải quyết khiếu có hại và an toàn bức xạ vô tuyến điện.			
4.3. Thiết kế, lắp đặt đài vô tuyến điện, cột ăng – ten phù hợp với quy định về tương thích điện từ, an toàn bức xạ vô tuyến điện, an toàn xây dựng, an toàn hàng không và các quy định khác của pháp luật có liên quan.			
4.4. Kê khai đúng và chịu hoàn toàn trách nhiệm với bản khai; nộp phí, lệ phí theo quy định.			

*Xác nhận của Thủ trưởng cơ quan
(ký tên và đóng dấu)*

*Làm tại,, ngày..... tháng..... năm.....
Người khai ký, ghi rõ họ tên*

PHỤ LỤC 1
THÔNG SỐ KỸ THUẬT, KHAI THÁC

☐ Cấp mới ☐ Sửa đổi, bổ sung cho giấy phép số

Tờ số:/ tổng số tờ của Phụ lục 1:

1. Tổng số thiết bị trong mạng		2. Giờ liên lạc	
3. Phạm vi hoạt động			
4. Sử dụng mã hoá (khi dùng chung tần số)	<input type="checkbox"/> Có . Loại mã: <input type="checkbox"/> Không		
5. Cấu hình mạng	<input type="checkbox"/> Đơn công		
	<input type="checkbox"/> Song công/ Bán song công	- Khoảng cách thu/phát tối thiểu (kHz):	
		- Khoảng cách thu/phát tối đa (kHz):	
6. Thời hạn đề nghị cấp giấy phép	từ ngày: đến hết ngày:		
7. Mục đích sử dụng			
8. Thông số kỹ thuật và khai thác của các loại thiết bị di động			
Loại thiết bị (số lượng)			
Thông số kỹ thuật			
8.1. Các mức công suất phát (W)			
8.2. Kiểu điều chế			
8.3. Phương thức phát			
8.4. Dải thông(kHz) hoặc tốc độ truyền (Kb/s)			
8.5. Dải tần thiết bị	Phát		
	Thu		
8.6. Ăng-ten	Dải tần làm việc		
	Hệ số khuếch đại (dBi)		
	Độ cao (so với mặt đất) (m)		
8.7. Bổ sung/Thay thế/Hủy bỏ			
8.8. Kinh độ , vĩ độ <i>Chỉ áp dụng cho mạng nội bộ (vị trí trung tâm của vùng hoạt động)</i>		° ’ ” E ° ’ ” N	
8.9. Hồ hiệu của thiết bị VTĐ di động đề nghị			

9. Thông số kỹ thuật và khai thác của các thiết bị cố định				
Thiết bị				
Thông số kỹ thuật				
9.1. Các mức công suất phát (W)				
9.2. Kiểu điều chế				
9.3. Phương thức phát				
9.4. Dải thông (kHz) hoặc tốc độ truyền (Kb/s)				
9.5. Dải tần thiết bị	Phát			
	Thu			
9.6. Địa điểm đặt thiết bị (Thôn, xã, phường, quận, huyện)				
9.7. Hồ hiệu đề nghị				
9.8. Ăng-ten	Kiểu			
	Dải tần làm việc			
	Hệ số khuếch đại			
	Kích thước			
	Độ cao (so với mặt đất)(m)			
	Kinh độ (° ’ ” E)			
	Vĩ độ (° ’ ” N)			
	Góc phương vị của hướng bức xạ chính (°)			
9.9. Bổ sung/Thay thế/Hủy bỏ				
10. CÁC THÔNG TIN BỔ SUNG				

HƯỚNG DẪN**KÊ KHAI LÀM THỦ TỤC ĐỀ NGHỊ CẤP GIẤY PHÉP SỬ DỤNG TẦN SỐ VÀ THIẾT BỊ VTD (Mẫu 1g)****I/ PHẦN HƯỚNG DẪN CHUNG:**

- Tất cả các bản khai không đúng quy cách, mẫu mã, loại nghiệp vụ, kê khai không rõ ràng, đầy đủ sẽ phải yêu cầu làm lại hoặc bổ sung cho đầy đủ.
- Khi cần liên hệ trực tiếp với Cục Tần số vô tuyến điện theo địa chỉ:

*** Cục Tần số vô tuyến điện - Bộ Thông tin và Truyền thông, 115 Trần Duy Hưng - Hà Nội**

Điện thoại: 04.35564919; Fax: 35564930

Hoặc các Trung tâm tần số vô tuyến điện khu vực thuộc Cục

*** Khu vực 1:** 115 Trần Duy Hưng - Hà Nội

Điện thoại: 04.35564919; 04.35564895; Fax: 04.35564913

*** Khu vực 2:** Lô 6 – Khu E – Khu đô thị mới An Phú An Khánh – Phường An Phú – Quận 2 - TP. Hồ Chí Minh.

Điện thoại: 08.37404179; Fax: 08.37404966

*** Khu vực 3:** Lô C1- Đường Bạch Đằng Đông - Khu dân cư An trung - Quận Sơn trà - TP. Đà Nẵng.

Điện thoại: 0511.3933545; Fax: 0511.3933707

*** Khu vực 4:** 386A-Cách mạng tháng 8, TP.Cần Thơ

Điện thoại: 071.88336; 071.883334; Fax:0710.3887087

*** Khu vực 5:** 783 - Đại lộ Tôn Đức Thắng - Quận Hồng bàng - TP. Hải Phòng

Điện thoại: 031.827855; 031. 827420; Fax: 031.3827420

*** Khu vực 6:** Số 19 Đại lộ Lê Nin - TP. Vinh - Nghệ An

Điện thoại: 038. 3833511; Fax: 038. 3849518

*** Khu vực 7:** Số 1 - Đường Phan Chu Trinh - Phường Xương Huân - TP. Nha Trang.

Điện thoại: 058. 3814061; 058.3814063; Fax: 058.3824410.

*** Khu vực 8:** Phường Dữu Lâu, TP. Việt Trì, tỉnh Phú Thọ.

Điện thoại: 0210. 384503; 384507.Fax: 0210. 3840504.

- Để trống những mục không phải điền.

- Không tẩy xóa các số liệu kê khai.

II/ PHẦN HƯỚNG DẪN CHI TIẾT:

Mẫu 1g: Được dùng để kê khai khi đề nghị cấp mới giấy phép, sử dụng tần số và thiết bị phát sóng VTĐ; gia hạn (không thay đổi nội dung trong giấy phép); ngừng (khi giấy phép còn hiệu lực); bổ sung, thay đổi một số nội dung trong giấy phép đã được cấp đối với mạng thông tin vô tuyến điện nội bộ, mạng viễn thông dùng riêng có sử dụng tần số vô tuyến điện thuộc nghiệp di động.

Số: kê khai số ký hiệu công văn của tổ chức đề nghị cấp giấy phép.

Điểm 1. Viết hoa họ tên của cá nhân hoặc tên hợp pháp của tổ chức đề nghị cấp giấy phép.

Điểm 1.1. Chỉ áp dụng đối với cá nhân đề nghị cấp giấy phép. Ghi số chứng minh thư (hộ chiếu), ngày cấp, nơi cấp. Đối với cá nhân là người Việt Nam đề nghị cấp giấy phép; ghi theo hộ chiếu đối với cá nhân là người nước ngoài đề nghị cấp giấy phép.

Điểm 1.2. Chỉ áp dụng đối với tổ chức đề nghị cấp giấy phép. Ghi theo Quyết định thành lập hoặc số Giấy chứng nhận đăng ký kinh doanh hoặc số Giấy chứng nhận đầu tư.

Điểm 1.3. Chỉ áp dụng cho trường hợp quy định của pháp luật viễn thông yêu cầu cần phải có giấy phép viễn thông tương ứng.

Điểm 1.4. Áp dụng đối với cả tổ chức và cá nhân đề nghị cấp giấy phép. Ghi số tài khoản và ghi tên ngân hàng mở tài khoản.. Đánh dấu “X” vào ô “Đồng ý” hoặc “Không đồng ý” nếu chấp thuận hoặc không chấp thuận việc chọn hình thức thanh toán phí sử dụng tần số vô tuyến điện và lệ phí cấp giấy phép bằng Ủy nhiệm thu.

Điểm 1.5. Ghi địa chỉ thường trú của cá nhân hoặc địa chỉ đặt trụ sở của tổ chức.

Điểm 1.6. Ghi số fax/ số điện thoại của tổ chức, cá nhân đề nghị cấp giấy phép (ghi cả mã vùng)

Điểm 1.7. Chỉ áp dụng đối với tổ chức đề nghị cấp giấy phép. Ghi họ tên của người kê khai (người trực tiếp liên lạc với Cục Tần số về các vấn đề liên quan đến cấp giấy phép), số điện thoại cố định/ di động và địa chỉ email của người kê khai.

Điểm 2. Tổng hợp thông tin đề nghị:

- Đánh dấu "X" vào ô "cấp mới" khi tổ chức, cá nhân đề nghị cấp giấy phép mới. Ghi số lượng mạng thông tin vô tuyến điện đề nghị cấp giấy phép và số tờ khai của Phụ lục 1 dành cho cấp mới vào chỗ trống (tương ứng với số lượng mạng thông tin vô tuyến điện). Khai các thông số kỹ thuật, khai thác trong Phụ lục 1 dành cho trường hợp cấp mới.

- Đánh dấu "X" vào ô "gia hạn" khi tổ chức, cá nhân đề nghị gia hạn giấy phép và ghi rõ số lượng giấy phép và tổng số tờ của Phụ lục 2 vào chỗ trống. Khai các thông số trong Phụ lục 2 dành cho gia hạn. Trường hợp đề nghị gia hạn số lượng ít giấy phép có thể ghi trực tiếp số giấy phép và thời gian đề nghị gia hạn vào chỗ trống của dòng khai dành cho gia hạn, không cần khai trong Phụ lục 2.

- Đánh dấu "X" vào ô "bổ sung hoặc thay đổi" khi giấy phép sử dụng còn thời hạn mà tổ chức, cá nhân có đề nghị thay đổi bất kỳ nội dung nào trong giấy phép (trừ thời hạn sử dụng). Ghi số lượng giấy phép và tổng số tờ khai của Phụ lục 1 dành cho sửa đổi, bổ sung vào chỗ trống. Khai các thông số kỹ thuật, khai thác trong Phụ lục 1 dành cho trường hợp sửa đổi, bổ sung.

- Đánh dấu "X" vào ô "Ngừng" khi giấy phép còn thời hạn mà tổ chức, cá nhân có đề nghị ngừng sử dụng. Ghi số lượng giấy phép đề nghị ngừng sử dụng và tổng số tờ của Phụ lục 3 vào chỗ trống. Trường hợp đề nghị ngừng số lượng ít giấy phép có thể ghi trực tiếp số giấy phép vào chỗ trống của dòng khai dành cho ngừng sử dụng và không cần khai Phụ lục 3.

Điểm 3. Ghi các thông tin bổ sung (nếu có)

Phụ lục1: Thông số kỹ thuật, khai thác

- Đánh dấu "X" vào ô "cấp mới" hoặc ô "sửa đổi, bổ sung" nếu tổ chức, cá nhân đề nghị cấp mới hoặc sửa đổi bổ sung nội dung giấy phép tần số vô tuyến điện. Với trường hợp sửa đổi, bổ sung, đề nghị ghi số của giấy phép đề nghị sửa đổi, bổ sung.
- Mỗi tờ khai của Phụ lục dùng để kê khai cho một mạng thông tin vô tuyến điện. Có thể dùng nhiều tờ khai nếu cần kê khai nhiều mạng. Lưu ý ghi rõ số thứ tự tờ khai, tổng số tờ của Phụ lục.
- Kê khai tất cả các thông số trong Phụ lục 1 khi đề nghị cấp mới.
- Chỉ kê khai các thông số có thay đổi hoặc bổ sung vào Phụ lục 1 khi bổ sung, sửa đổi. Các thông số khác không thay đổi, giữ nguyên không cần khai báo.

1. Ghi rõ tổng số thiết bị có trong mạng, bao gồm cả thiết bị cố định và di động.

2. Giờ liên lạc: Ghi giờ liên lạc đề nghị, nếu liên lạc vào giờ bất kỳ trong ngày thì ghi "Hx", nếu liên lạc tất cả thời gian trong ngày thì ghi "H24".

3. Phạm vi hoạt động : Kê khai phạm vi lưu động: lưu động trong phạm vi nào: số nhà, đường, phường(xã), quận(huyện), thành phố(tỉnh)/ khu vực... / toàn quốc.

4. Chỉ áp dụng đối với trường hợp dùng chung tần số. Đánh dấu "X" vào ô "có" hoặc "không" nếu có/không sử dụng mã hóa. Ghi loại mã đề nghị sử dụng.

5. Cấu hình mạng: Đánh dấu "X" vào ô "đơn công" nếu mạng hoạt động ở chế độ đơn công hoặc "Song công/Bán song công nếu mạng hoạt động ở chế độ Song công/Bán song công và ghi khoảng cách thu phát tối thiểu, khoảng cách thu phát tối đa theo đơn vị kHz.

6. Thời hạn đề nghị cấp giấy phép: ghi theo đề nghị của tổ chức, cá nhân.

7. Ghi rõ sử dụng tần số và thiết bị VTĐ cho mục đích: Phục vụ sản xuất, kinh doanh, học tập, nghiên cứu, dự phòng,...

8. Thông số kỹ thuật và khai thác của các loại thiết bị di động: Kê khai theo loại thiết bị, không kê khai từng thiết bị. Mỗi loại thiết bị di động được khai vào một cột kèm theo số lượng thiết bị cùng loại đó.

8.1. Các mức công suất phát (W): Kê khai các mức công suất có thể điều chỉnh được theo thiết kế chế tạo như: công suất cực đại, công suất cực tiểu, công suất danh định,...

8.2. Kiểu điều chế: Kê khai kiểu điều chế của thiết bị. Ví dụ: AM, FM, PSK, ...

8.3. Phương thức phát: Kê khai các phương thức phát đề nghị sử dụng theo thiết kế chế tạo của thiết bị. Ví dụ: 100HA1A; 2K10A2A; 6K00A3E; 3K00B3E; 16KF3E; 3M70F3E; 304HF1B; 6K00G8E; 2K70J3E;...

8.4 Dải thông(kHz) hoặc tốc độ truyền (Kb/s): Kê khai độ chiếm dụng băng tần của một kênh (kHz) hoặc khai tốc độ truyền của thiết bị đó theo đơn vị Kb/s.

8.5. Dải tần thiết bị. Là dải tần phát/thu mà thiết bị có thể làm việc theo thiết kế chế tạo.

8.6. Ăng-ten:

- Dải tần làm việc: Kê khai dải tần số mà trong giới hạn đó, ăng-ten làm việc được với các chỉ tiêu kỹ thuật đã cho.

- Hệ số khuếch đại (dBi): Kê khai hệ số khuếch đại của ăng-ten

- Độ cao (so với mặt đất) (m): là độ cao tính từ đỉnh ăng-ten đến mặt đất (chính là kích thước của ăng-ten và độ cao của cấu trúc đặt ăng-ten), tính theo mét (m)

8.7. Chỉ áp dụng đối với trường hợp sửa đổi, bổ sung:

- Ghi bổ sung đối với thiết bị mới bổ sung vào mạng, tên thiết bị, tổng số thiết bị bổ sung tương ứng với từng loại và kê khai toàn bộ thông số.

- Ghi thay thế cho thiết bị (cụ thể: số lượng thay thế, cho thiết bị nào, địa điểm đặt trong giấy phép cũ) đối với trường hợp thay thế thiết bị cũ bằng thiết bị mới. Nếu thiết bị mới thay thế thuộc loại khác so với thiết bị cũ thì phải kê khai toàn bộ thông số.

- Ghi huỷ bỏ đối với trường hợp bỏ bớt thiết bị trong giấy phép đã được cấp, ghi rõ thiết bị nào, đặt tại đâu theo quy định của giấy phép đã được cấp.

8.8. Đối với mạng nội bộ thì kê khai kinh độ, vĩ độ của vị trí trung tâm của vùng hoạt động theo độ, phút, giây.

8.9. Hô hiệu của thiết bị VTĐ di động đề nghị: Liệt kê các hô hiệu đề nghị sử dụng để thuận tiện cho công việc (lưu ý: Khi mạng hoạt động sẽ phải sử dụng các hô hiệu đã được ghi trong giấy phép)

9. Thông số kỹ thuật và khai thác của các thiết bị cố định: Mỗi thiết bị được khai vào một cột.

9.1. Các mức công suất phát (W): Kê khai các mức công suất có thể điều chỉnh được theo thiết kế chế tạo như: công suất cực đại, công suất cực tiểu, công suất danh định,...

9.2. Kiểu điều chế: Kê khai kiểu điều chế của thiết bị. Ví dụ: AM, FM, PSK, ...

9.3. Phương thức phát: Kê khai các phương thức phát đề nghị sử dụng theo thiết kế chế tạo của thiết bị. Ví dụ: 100HA1A; 2K10A2A; 6K00A3E; 3K00B3E; 16KF3E; 3M70F3E; 304HF1B; 6K00G8E; 2K70J3E;...

9.4. Dải thông (kHz) hoặc tốc độ truyền (Kb/s): Kê khai độ chiếm dụng băng tần của một kênh (kHz) hoặc khai tốc độ truyền của thiết bị đó theo đơn vị Kb/s.

9.5. Dải tần thiết bị: Là dải tần phát/thu mà thiết bị có thể làm việc theo thiết kế chế tạo.

9.6. Kê khai địa điểm đặt thiết bị (Thôn, xã, phường, quận, huyện).

9.7. Hô hiệu đề nghị: Liệt kê các hô hiệu đề nghị sử dụng để thuận tiện cho công việc (lưu ý: khi mạng hoạt động sẽ phải sử dụng các hô hiệu đã được cấp phép).

9.8. Ăng-ten:

- Kiểu: Kê khai tên, ký hiệu và hãng sản xuất của ăng-ten theo Catalog. VD: Cản, Dipol...

- Dải tần làm việc: Kê khai dải tần số mà trong giới hạn đó, ăng-ten làm việc được với các chỉ tiêu kỹ thuật đã cho.

- Hệ số khuếch đại (dBi): Kê khai hệ số khuếch đại của ăng-ten.

- Kích thước: Kê khai kích thước của ăng-ten theo thiết kế chế tạo, tính bằng mét (m).

- Độ cao (so với mặt đất) (m): là độ cao tính từ đỉnh ăng-ten đến mặt đất (chính là kích thước của ăng-ten và độ cao của cấu trúc đặt ăng-ten), tính theo mét (m).

- Kinh độ, vĩ độ: kê khai vị trí lắp đặt ăng-ten chính xác đến độ, phút, giây.

- Góc phương vị của hướng bức xạ chính ($^{\circ}$): là góc được tạo bởi đường tâm của búp sóng chính với phương bắc của trái đất theo chiều kim đồng hồ.

9.9. Chỉ áp dụng đối với trường hợp sửa đổi, bổ sung:

- Ghi bổ sung đối với thiết bị mới bổ sung vào mạng, loại thiết bị, tổng số thiết bị bổ sung tương ứng với từng loại và kê khai toàn bộ thông số.

- Ghi thay thế cho thiết bị (cụ thể: số lượng thay thế, cho loại thiết bị nào, địa điểm đặt trong giấy phép cũ) đối với trường hợp thay thế thiết bị cũ bằng thiết bị mới. Nếu thiết bị mới thay thế thuộc loại khác so với thiết bị cũ thì phải kê khai toàn bộ thông số.

- Ghi huỷ bỏ đối với trường hợp huỷ bỏ bớt thiết bị trong giấy phép đã được cấp, ghi rõ thiết bị loại nào, đặt tại đâu theo quy định của giấy phép đã được cấp.

10. Kê khai các thông tin bổ sung (nếu có).

Phụ lục 2: Gia hạn giấy phép sử dụng tần số và thiết bị vô tuyến điện

Mỗi hàng trong phụ lục được ghi cho một hoặc nhiều (nếu các số giấy phép liên tục) giấy phép sử dụng tần số vô tuyến điện đề nghị gia hạn. Ghi rõ số giấy phép (hoặc từ số đến số) đề nghị gia hạn, ngày hết hạn của giấy phép, thời gian gia hạn (gia hạn đến hết ngày , ví dụ: 03/12/2015).

Phụ lục 3: Thông báo ngừng sử dụng tần số và thiết bị vô tuyến điện

Mỗi hàng trong phụ lục được ghi cho một hoặc nhiều (nếu các số giấy phép liên tục) giấy phép sử dụng tần số vô tuyến điện đề nghị ngừng sử dụng. Ghi rõ số giấy phép (hoặc từ số đến số) đề nghị ngừng sử dụng, ngày hết hạn của giấy phép, ngày bắt đầu ngừng sử dụng (ví dụ: 03/12/2015).

Người khai phải ký, ghi rõ họ tên. Đối với các Cơ quan, tổ chức phải có xác nhận của Thủ trưởng cơ quan.

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1. General Requirements

1.1 Scope of Work

The Contractor shall design, manufacture, procure, construct, install, adjust and test Intelligent Transport System (the ITS) in Da Nang – Quang Ngai Expressway (the DQE) and related facilities as specified and indicated in the Employer's Requirements – General Technical Specifications, Particular Technical Specifications and Drawings.

The ITS in the Project consists of following system components.

- **Traffic Management Center System**

Traffic management center system will be established in the building of Main Management Center (MMC) located near Tuy Loan toll barrier and shall manage whole system to achieve overall objectives of the ITS.

- **CCTV Camera System**

CCTV camera system shall be introduced to monitor road, traffic and weather conditions on the expressway visually from the MMC or Management Offices (MO) which will be constructed in the same yard of MMC and near Quang Ngai north toll gate. The CCTV camera will be installed at interchanges, flood prone area and deep cut sections, and tunnel portal sites to particularly monitor traffic conditions at accident prone areas, disaster situation or conditions around tunnel section by image. A total of 33 CCTV cameras shall be introduced in the Project.

- **Vehicle Detection System**

Vehicle detection system shall be introduced to mainly measure traffic volumes between interchanges for the purpose of analyzing traffic flows and characteristics on the expressway. The vehicle detection roadside equipment shall be installed at total of 14 locations on the DQE.

- **Meteorological Monitoring (MET) System**

MET System shall measure weather conditions to take appropriate traffic control in bad weather conditions and provide warning information to the drivers. A total of three (3) MET stations shall be provided in the system to cover entire expressway.

- **Overload Monitoring System**

Overload Monitoring System shall be introduced to measure axle load of vehicles in order to prevent entering overloaded vehicles into the DQE and protect the

expressway structures. The overload monitoring roadside equipment will be installed at total of 11 entrance toll lanes.

- Variable Message Sign (VMS) System

VMS system shall be introduced to provide information of traffic status, incident and weather conditions on the DQE to the driver. A total of 26 VMS boards shall be placed at upstream of interchange, tunnel and toll barrier on the expressway or at access road before interchange tollgate.

- Toll Collection System

Toll collection system shall be introduced in the DQE. Two type of toll collection system, that is, manual toll collection system and electronic toll collection (ETC) system shall be provided at each toll barrier and tollgate. DSRC-Active 5.8GHz type communications shall be applied as ETC communications in this Project.

- Communication System

Three (3) types of communication system shall be provided in the Project. One is a fiber optic network with digital transmission system to connect the MMC with the MO, toll offices (TO) and ITS roadside equipment and transmit all of ITS data. Second is a wireless radio system to be utilized for communications between the management offices and personnel engaged in the operation and maintenance activities on the expressway. The other is internal telephone system for voice communication between the personnel in the offices.

It is the Contractor's responsibility to provide and install a working intelligent transport system. The Contractor shall undertake the works that are not specifically mentioned in these Employer's Requirements and on the Drawings but essential for the efficient operation of the intelligent transport system. The requirements stated herein shall be construed as minimum requirements and meeting the respective requirements shall not relieve the Contractor from the responsibility of supplying the intelligent transport system that functions efficiently as a system.

The Contractor shall check and review the design and Employer's Requirements prepared by the Employer and included in the Contract Documents, and execute the supplemental and/or additional and/or detailed design work as necessary at the Contractor's cost and time, so that the Contractor will supply and delivery the workable intelligent transport system which will suit the intended purpose when completed. The Contractor shall promptly notify the Employer and the Project Manager of any error, omission, fault or any other defect in the design of or Employer's Requirements for the Works which he discovers when reviewing the Contract Documents or in the process of execution of the

Works.

Unless stated otherwise in the Contract Documents, the Contract shall be for the whole Works as described in the Contract Documents. The Contractor shall quote for the entire system and facilities on a “single responsibility” basis such that the Contract Price covers all Contractor’s obligations mentioned in or to be reasonably inferred from the Contract Documents in respect of the design, manufacture, procurement, construction, installation, adjustment and testing of the Works and remedying any defect therein. This includes all requirements under the Contractor’s responsibilities for testing and commissioning of the systems and facilities, and where required by the Contract Documents, the acquisition of all permits, approvals and license, etc.; the training services and such other items and services as may be specified in the Contract Documents.

1.2 Management

1.2.1 Consortium or Joint Venture

If the Contractor is a consortium or a joint venture of two or more firms as members, the Contractor shall comply with the following requirements:

- (a) One of the member firms shall be designated and authorized as Leader of the consortium or joint venture. Such authorization shall be evidenced by submitting a power of attorney signed by legally authorized signatories of the member firms;
- (b) Leader firm shall be authorized to incur liabilities, receive payments and receive instructions for and on behalf of any or all members of the consortium or joint venture; and
- (c) All members of the consortium or joint venture shall be jointly and severally liable for the execution of the Contract in accordance with the Contract terms and a relevant statement to this effect shall be included in the authorization mentioned in item (a) above.

1.2.2 Consortium

The Leader of the consortium shall be fully responsible for any fault of the other constituent firms of the consortium. The Leader shall undertake the entire obligations under the Contract to the Vietnam Expressway Corporation (VEC) just as though it had executed the Contract as one single contractor for the Works.

1.2.3 Joint Venture

The Leader of the joint venture shall act on the execution of the obligations under the Contract just as the Leader under the case of consortium described above. The representative officers of such joint venture company shall concurrently be senior members of the Leader firm

Should the joint venture company become bankrupt or insolvent, or have a receiving order made against it, or compound with his creditors, or be a corporation commencing to be wound up, or be under any situation the VEC would feel uneasy to leave the execution of the Contract to their hands, then the Leader shall take over the entire obligations independently under the Contract just as though it were the single Contractor under the Contract.

1.2.4 Organizational and Membership Changes

Should the consortium or joint venture which had been awarded the Contract ever undergo any membership or organizational changes or alterations, the VEC shall be advised beforehand for his consent on any changes or alteration.

1.3 Work Programme

The Contractor shall update the Work Programme submitted at the time of Tender and submit it at the time of Design Briefing. The updated Work Programme shall reflect the latest information regarding the time required for design, procurement of parts and components, production, assembly, development, in-house testing, factory test, inland and sea transportation, custom clearance, installation, adjustment, stand alone test, combination test, test on completion and commissioning. The timing of training and submission of documentation shall also be indicated.

The Work Programme shall show clearly the relationship between tasks and events that precede or follow a particular task and indicate the critical path that controls the total project period. The Work Programme shall also show the expected start and end date and period required in units of weeks.

The Contractor shall monitor the progress of his work under the Contract and shall update the Work Programme as an event occurs, a task is completed or delay is noticed for any event or task. He shall submit the updated Work Programme on a monthly basis and also when there is a change in the Work Programme. The submission of the Work Programme shall not release the Contractor from his obligation to complete the Works within the time stipulated in the Contract.

1.3.1 Project Meeting

The Contractor shall be available for progress meetings which will be called for by the Project Manager. The notice of such meetings shall be given by the Project Manager in writing, and delivered to the Contractor's field office in **Da Nang** at least seven (7) days in advance of the planned meeting date.

1.3.2 Progress Report

The Contractor shall prepare monthly progress report and submit three (3) printed copies and a soft copy to the VEC. The progress report shall cover such topics as overall progress of work as against the schedule, list of items submitted to the Project Manager

for approval, list of approval and instructions given by the Project Manager, major events occurred during the period covered, summary of tests conducted, issues encountered or expected to encounter, planned work schedule for the next period, amount claimed and disbursed, and other items that will be agreed upon by the VEC and the Contractor.

1.4 Contractor's Personnel and Their Responsibilities

The Contractor shall provide all personnel necessary for the execution of the Works, such as the Project Superintendent, Traffic Management System Chief Engineer, Toll Collection System Chief Engineer, Communication System Chief Engineer, installation supervisors, and senior local personnel to fulfill the Contractor's obligations under the Contract. These personnel shall be able to read, write and converse in English. In addition, at least one of the Contractor's personnel who is on assignment in **Da Nang** for the Project shall be capable of converse fluently in English.

The Project Superintendent, Traffic Management System Chief Engineer, Toll Collection System Chief Engineer and Communication System Chief Engineer shall be either the prime or alternate candidate persons nominated in the prequalification. If the Contractor wishes to propose other persons to these positions, he or she shall have equivalent or better qualifications than those originally nominated. The Contractor shall submit curriculum vitae of the candidate person who is proposed to replace those persons proposed in the prequalification for the Project Manager's approval.

1.4.1 Project Superintendent

The Project Superintendent shall act as the Contractor's representative under the Conditions of Contract and shall be bestowed with authority to receive and carry out the directions and instructions from the Employer and the Project Manager in accordance with the Contract. The Project Superintendent shall be an engineer and well versed in the intelligent transport system, computer system, or data communication system. He shall also have sufficient experience in managing system construction project. He shall be resident in **Da Nang** from the Commencement Date until the Taking-over of the whole system to fulfill the Contractor's obligations under the Contract and shall be given full responsibility to enter into negotiations regarding overall matters arising out of the Contract. In the event of absence of the Project Superintendent in **Da Nang**, the Contractor shall nominate a person staying in **Da Nang** to whom Project Superintendent's authority and responsibility are delegated and inform the Employer of such appointment.

The Project Superintendent shall be primarily a full-time assignment for the execution of the Contract from the date of the written acceptance of the Tender to the issuance of the Taking-Over Certificate. From the date of issuance of the Taking-Over Certificate to the Performance Certificate, he shall be assigned to the Project at least on an as needed basis.

1.4.2 Traffic Management System Chief Engineer

The Contractor shall appoint a traffic management system chief engineer who shall have sufficient knowledge and experience of traffic management system in all of hardware,

software, installation, testing and operation. The chief engineers shall be responsible for the technical aspect of the traffic management system and involved in technical discussions with the Employer and his representative. He shall be also responsible for conducting the training and all testing procedures.

The traffic management system chief engineer shall also supervise the installation works. He shall be resident in **Da Nang** from the start of installation work until the successful completion of test on completion. He shall be empowered to enter into negotiations regarding points arising from the installation work, so that the Works may be carried out with minimum delay. He shall be committed to the Contract on a full-time basis at least until issuance of the Taking-Over Certificate.

1.4.3 Toll Collection System Chief Engineer

The Contractor shall appoint a toll collection system chief engineer who shall have sufficient knowledge and experience of toll collection system in all of hardware, software, installation, testing and operation. The chief engineers shall be responsible for the technical aspect of the toll collection system and involved in technical discussions with the Employer and his representative. He shall be also responsible for conducting the training and all testing procedures.

The toll collection system chief engineer shall also supervise the installation works. He shall be resident in **Da Nang** from the start of installation work until the successful completion of test on completion. He shall be empowered to enter into negotiations regarding points arising from the installation work, so that the Works may be carried out with minimum delay. He shall be committed to the Contract on a full-time basis at least until issuance of the Taking-Over Certificate.

1.4.4 Communication System Chief Engineer

The Contractor shall appoint a communication system chief engineer who shall have sufficient knowledge and experience of both wired and wireless communication systems in all of hardware, software, installation, testing and operation. The chief engineers shall be responsible for the technical aspect of the communication system and involved in technical discussions with the Employer and his representative. He shall be also responsible for conducting the training and all testing procedures.

The communication system chief engineer shall also supervise the installation works. He shall be resident in **Da Nang** from the start of installation work until the successful completion of test on completion. He shall be empowered to enter into negotiations regarding points arising from the installation work, so that the Works may be carried out with minimum delay. He shall be committed to the Contract on a full-time basis at least until issuance of the Taking-Over Certificate.

1.4.5 Senior Accounting Officer

The Contractor shall assign one (1) accounting officer to be a full time participant to the

Project during the course of the Works. He may be stationed in his home country, but shall be available in **Da Nang** whenever the necessity arises.

1.4.6 Chief Maintenance Engineer

The Contractor shall assign a chief maintenance engineer, who shall be responsible for the conduct of maintenance service of the system after taking-over until the issuance of performance certificate and the correction of defect found during the defect liability period. The chief maintenance engineer shall have sufficient knowledge and experience in the intelligent transport system and be capable of identifying the defective part and arrange the remedial action to make good defect with minimum time.

1.4.7 Safety Officer

The Contractor shall appoint a safety officer who shall be responsible for monitoring and assessing hazardous and unsafe situations and developing measures to assure personnel safety. He shall correct unsafe acts of the staff or conditions at work site. He shall also be responsible to ensure the site safety and health plan are prepared and implemented.

The safety office is not required to be present at work site all the time. He shall visit the site and inspect the safety condition on an as needed basis. It is acceptable that one of the key personnel acts as safety officer provided that he shall have sufficient knowledge of work site safety.

1.4.8 Quality Control Manager

The Contractor shall designate a single Quality Control Manager for all equipment to be supplied under the Contract. This individual must have knowledge of quality control and testing, and experience as a quality control manager, and he shall not report to the production personnel. If he wishes, the Project Manager will communicate directly with the Quality Control Manager and his superior, the latter to be defined by the Contractor. The Quality Control Manager shall develop and implement quality assurance program of the device, software and system, and involved in the discussions related to product reliability, testing procedure, defect and other matters related to quality control with the Engineer's Representative. The Quality Control Manager shall ensure that the personnel undertaking the tests are not the same personnel who are involved in the production of equipment.

1.4.9 Senior Local Personnel

The Contractor shall employ at least one (1) senior local personnel as Deputy Project Superintendent under the Contract who is an engineer specialized in electrical engineering, electronics, computer or communication, and familiar with the local standards and regulations related to electrical works, electronics, communication and information technology project.

He shall participate in the technical discussions, testing procedures and engineering

activities of the installation works, adjustment and testing. He shall also be involved in all the maintenance activities including the period of the defect liability period maintenance.

1.4.10 Curriculum Vitae

Within fourteen (14) days after the date of the Contract execution, the Contractor shall submit to the Project Manager detailed written statements including the names, duties, curriculum vitae of key personnel including Project Superintendent, Traffic Management System Chief Engineer, Toll Collection System Chief Engineer, Communication System Chief Engineer, installation supervisors, and senior local personnel to be employed and assigned to the project. Where subsequent replacement or additions of these personnel is proposed, these replacements or additions shall have at least equivalent experience and qualifications, and detailed written statements of their experience and qualifications shall be submitted to the Project Manager prior to their assignment.

1.5 Factory Tests, Inspection and Certification

1.5.1 General

All equipment, device, unit, components, parts, and software comprising the intelligent transport system to be delivered and installed under the Contract shall be tested, inspected, and certified prior to the acceptance in accordance with these Employer's Requirements.

1.5.2 Quality Assurance System

The Contractor shall institute a quality assurance system to demonstrate compliance with the requirements of the Contract. Details of the system shall be notified to the Project Manager who shall be entitled to audit any aspect of the system.

Details of all procedures and compliance documents shall be submitted to the Project Manager for information before each design and execution stage is commenced. When any document of a technical nature is issued to the Project Manager, evidence of the prior approval by the Contractor himself shall be apparent on the document itself.

Compliance with the quality assurance system shall not relieve the Contractor of any of his duties, obligations or responsibilities under the Contract.

1.5.3 Test Procedures

For the off-the-shelf or routinely manufactured equipment or components, factory test with the attendance of the Project Manager may be exempted and replaced with the submission of a test or inspection certificate issued by the original manufacturer. In addition, the Contractor shall submit the factory's routine testing procedures to the Project Manager for review if so requested.

For the equipment or components requiring special order or specifically designed and manufactured for this project, the Contractor shall submit to the Project Manager

proposed factory test items and test procedures for review and approval as soon as the System Design is accepted. The test items shall include as a minimum the following:

- Functional tests (sampling test)
- Power supply tests (sampling test)
- Input voltage fluctuation (sampling test)
- Instantaneous power interruption (sampling test)
- Environmental tests for temperature and humidity ranges as specified (sampling test)
- Insulation resistance (sampling test)
- Dielectric strength (sampling test)
- Rainproof test for field equipment (sampling test)
- Equipment interface tests

Equipment interface tests shall be conducted for all servers, database, network switches, network adapters, and communication equipment in the factory. These tests shall be executed by interfacing as many different kinds of equipment as possible so as to ascertain their suitability as system components. Where there is no appropriate equipment at that particular time to connect to certain equipment, the test shall be executed by connecting to a simulator.

The Contractor shall notify the Project Manager at least 14 days in advance of each factory test to be undertaken and shall make arrangement for the Project Manager to attend the test if requested. Should the Project Manager or his designated representative decide not to attend any of the tests, the tests shall be carried out under the direction of the Quality Control Manager, and the Quality Control Manager shall forward to the Project Manager duly certified copies of the test results.

If the Project Manager is satisfied with the test results, he shall notify the Contractor in writing to that effect, and the Contractor may then ship the equipment. If the Project Manager decides that equipment is defective or produced not in accordance with the Contract, he may reject the equipment, and will inform the Contractor of the reasons in writing. In both cases, the approval or disapproval of the test results shall be notified within 14 days after receiving the duly certified copies of the test results from the Quality Control Manager.

1.5.4 Defects

Should a defect be detected during one of the tests, the cause of the defect shall be ascertained and documented. For minor defects that do not substantially degrade the quality and performance of the items being tested and do not require re-design of the equipment, the defect shall be rectified and the test be repeated. If a design change is required, the Project Manager shall be so informed and the revised design shall be

submitted to the Project Manager for his review and approval.

1.5.5 Sample Test

Test certificates will be issued only for the actual equipment that has passed the tests except sampling test. Sampling test will be made for one (1) unit for each type of equipment and for test item. Sample shall be selected by the Project Manager among the units made as same unit.

For sampling test of equipment, if any defect is detected in any one sample, the entire lot shall be tested and the results shall be reported to the Project Manager for his review and approval. Otherwise, the equipment that was manufactured in the same lot shall be regarded as having passed the test.

1.5.6 Inspection

All equipment shall be inspected before delivery and upon arrival at the site. The inspection shall be performed on the following items:

- Painted surfaces and color
- Condition of assembling
- Design and dimensions
- Parts arrangement
- Wiring within the cabinet
- Damage during transportation

1.5.7 Cost of Test and Inspection

The testing cost allowed for shall cover full cost of providing all facilities, tools, labor, consumable parts, measuring apparatus and appliances required in connection with all inspection and tests at factory or on the manufacturer's premises, and all other expenses as may be required for passage of the Project Manager or his representative to attend the test.

For the factory test to be held outside of Vietnam, the Contractor shall pay for international flight from **Da Nang** to the country, transportation within the country where factory test is held, hotel accommodation and daily allowance. The total estimated number of Employer's staff to attend overseas factory test is four (4) persons for one (1) week. If factory test is to be held in two different countries, the Contractor shall pay the cost of all factory tests in foreign countries.

1.5.8 Location of Test

The Tenderer shall state in his Technical Proposal, the location of factory test for the following test items:

- CCTV camera and controller
- Combination test of CCTV camera, controller and CCTV center controller console
- Traffic detector and vehicle detection unit
- Combination of vehicle detector, vehicle detection unit, traffic analysis processor and its operation console
- MET sensors and data logger
- Combination of MET sensors, data logger, MET data processor and its operation console
- Overload monitoring roadside equipment and portable axle load scale
- Combination of overload monitoring roadside equipment, overload monitoring data server and its operation console
- VMS board and VMS control unit
- Combination of VMS board, VMS control unit and VMS center controller console
- Traffic management center system
- Tollbooth system equipment
- Toll office system equipment
- Toll center system equipment
- Combination of toll lane system equipment, toll office system equipment and toll center system equipment
- Digital transmission equipment and its combination
- Wireless radio equipment and its combination
- Internal telephone system equipment and combination of internal telephone system equipment over digital transmission equipment

The location where the factory test is conducted shall have the necessary facility, testing device, measuring apparatus, recording system, power supply, and other arrangements to conduct the test items listed in the Test Procedure. The Tenderer shall state in his technical proposal the details of the testing facilities and measuring instrument that will be available and used during the factory test at the location proposed.

1.6 Test on Completion

1.6.1 General

Tests on Completion procedure shall be applied to the equipment, devices and software comprising the intelligent transport system including network equipment, fiber optic cable, communication and power cables, and power conditioning equipment after they are installed at the specified location, and adjusted and tested by the Contractor.

Test on completion shall be conducted at two levels; test on completion for a portion of works, and test on completion for the Works. The test on completion for a portion of works shall be conducted for a group of equipment at a site that functions as a sub-system and achieves part of the system functions. The unit of test shall be as specified hereunder.

The test on completion for the Works shall be conducted for the whole of the intelligent transport system in the DQE including the supporting systems such as network equipment and power conditioning equipment. Overall system functions as the intelligent transport system shall be tested.

The Contractor shall keep a clear record of all tests conducted. The record shall include time, place, equipment, procedure, functions, persons attending, and faults or problems encountered. The test results, even if they are not satisfactory, shall be documented and submitted to the Project Manager for review.

The Employer will provide electricity free of charge to the Contractor for the purpose of conducting test on completion if permanent electrical supply is available. Otherwise, the Contractor shall arrange electricity, water and gas necessary for the test on completion.

The Contractor shall prepare or arrange the test apparatus and equipment, temporary connection, testing software, test data, test vehicle, tools and other items necessary for conducting test. The cost of such items shall be included in the cost of test in the Pricing Document and no separate payment shall be made.

1.6.2 Test on Completion for a Portion of Works

(1) Procedure

The Contractor shall give due notice to the Project Manager seven (7) days in advance of the proposed date and contents of the Test on Completion for a portion of Works.

Test on Completion for a portion of works shall be performed for a portion of Works completed in units of the works indicated below.

- CCTV camera system
- Vehicle detection system
- Meteorological monitoring (MET) system
- Overload monitoring system
- Variable message sign (VMS) system
- Traffic management center system
- Connection of CCTV camera system with the traffic management center system
- Connection of vehicle detection system with the traffic management center system
- Connection of MET system with the traffic management center system

- Connection of overload monitoring system with the traffic management center system
- Connection of VMS system with the traffic management center system
- Tollbooth system
- Toll office system
- Toll center system
- Connection of tollbooth system with the toll office and toll center systems
- Digital transmission system
- Wireless radio system
- Internal telephone system

If the test results are judged satisfactory by the Project Manager, he shall notify the Contractor in writing that the equipment is ready for trial operations. If the Project Manager decides the equipment is not in accordance with the Contract, he may reject the equipment, and he shall inform the Contractor as to the reasons why the equipment was rejected in writing within a reasonable time.

(2) Test items

After the delivery and installation of the equipment at the site, tests on completion for that portion of Works shall be conducted for each of equipment.

Appearance of the equipment and required operations in a standalone mode shall be examined in this test. Test items shall include but not be limited to the following:

For terminal equipment

- CCTV camera image output, camera control function, self-diagnosis function, power failure and recovery
- Vehicle detection function, data output, data processing function, self-diagnosis function, power failure and recovery
- MET measuring function, data output, self-diagnosis function, power failure and recovery
- Overload measuring function, data output, alarm output, self-diagnosis function, power failure and recovery
- VMS local operation, display function, self-diagnosis function, power failure and recovery
- Tollbooth system local operation, self-diagnosis function, power failure and recovery

- Fiber optic node (FON) fail-over and self-diagnosis function, power failure and recovery
- Wireless radio transmitter/receiver change-over function and self-diagnosis function, power failure and recovery
- Internal telephone function, power failure and recovery

For center part of CCTV camera system

- Camera selection and control function
- Split screen monitoring function
- Recording function
- Search and retrieval function
- Video display on the monitor and large display
- Alarm detection and recording
- Power failure and recovery function

For center part of vehicle detection system

- Data reception, processing, checking and recording function
- Retrieval of past data
- Screen display and reporting of processed data
- Alarm detection and recording
- Power failure and recovery function

For center part of MET system

- Data reception, processing, checking and recording function
- Retrieval of past data
- Screen display and reporting of processed data
- Alarm detection and recording
- Power failure and recovery function

For center part of Overload monitoring system

- Data reception, checking and recording function
- Retrieval of past data
- Screen display and reporting of processed data
- Alarm detection and recording
- Power failure and recovery function

For traffic management center system

- System operation monitoring and logging
- Automatic changeover to standby server and recovery
- Power failure and recovery function

For toll office and center system

- Data reception, processing, checking and recording function
- Retrieval of past data
- Screen display and reporting of processed data
- Alarm detection and recording
- Automatic changeover to standby server and recovery
- Power failure and recovery function

(3) Testing of fiber optic cable installation

The Contractor shall measure the attenuation of the light source after each splicing of fiber optic cable for all cores. The test shall be conducted with the calibrated measuring apparatus. The Contractor shall provide the Project Manager, the test schedule at least 3 days before the test to allow him to attend the test if he requires so. The test results shall be compiled into a report and submit to the Project Manager for his review.

(4) Testing apparatus

The Contractor shall prepare and make available to him, suitable types of testing and measuring apparatus required for the conduct of test on completion. The purchasing, leasing or depreciation cost of such testing apparatus shall be included in the appropriate cost item of the price schedule and no separate payment shall be made. The testing apparatus shall be suitable for the test in terms of test items, range, capacity, accuracy, and response time. If test apparatus requires periodic calibration, the calibrated apparatus shall be used.

(5) Indicator and test interface

Each device and equipment to be supplied under the Contractor shall be provided with indicator, lamp, monitor or other means to confirm normal operation of the equipment. In addition, interface of suitable type shall be provided to the equipment through which testing apparatus shall be connected for control and monitoring of the equipment.

1.6.3 Test on Completion for the Works**(1) General**

Test on Completion for the Works shall be conducted to confirm that the intelligent transport system supplied under the Contract complies with the Employer's Requirements, and approved specifications and drawings prepared and submitted by the Contractor in all aspects and as a system.

During the Test on Completion, all the functions of the equipment required under the Contract shall be tested. Data exchange between the terminal equipment and the center system will be tested including the case of the interruption and recovering of the communication link between the terminal equipment in addition to the functions of respective systems. The test shall be conducted with the attendance of the Project Manager.

(2) Procedure

The Contractor shall submit, at least 21 days in advance, to the Project Manager the date(s) on which the Tests on Completion for the Works are to be undertaken together with test items, procedure, criteria for judging the test results, and test schedule.

The Contractor shall forward to the Project Manager duly certified copies of the test results when the tests have been successfully completed. When the Project Manager has received the test document and is satisfied with the test results, he will notify the Contractor in writing that the Works are ready for trial operations and issue a Taking-over certificate.

If major defects are uncovered during the test, the Contractor shall prepare and submit to the Project Manager for review and approval a proposal to remedy the defects. The Contractor shall not take corrective actions before the proposed remedies have received the Project Manager's approval. Minor faults and defects detected during the Tests on Completion may be corrected during the trial operation period.

Major defect shall be defined as defect that would cause the following results but not limited to:

- Low quality of image and loss of camera control;
- Loss of data, erroneous data, or inconsistency in the classified traffic count data, meteorological data and overload monitoring data,;
- Loss of VMS control;
- Loss of data, erroneous data, or inconsistency in the toll collection data;
- Failure to changeover to backup network route;
- Low quality of radio signals and loss of wireless radio control;
- Low quality of voice communication in internal telephone system;
- Unexpected shutdown or halt of operation of any part of the intelligent transport system;
- Failure to changeover to backup server; and
- Failure to restart and resume the operation after power recovery of the device that is designed to have such function.

Other defects may be classified as minor defect.

(3) Trial Operation

Trial operation shall be conducted for a portion of Works that have passed Test on Completion for a portion of works for two (2) months after Taking-Over Certificate has been issued for the respective works. The operation of the system will be carried out by the Employer or his designated operator. Should any critical or major defect be found during the trial operation, the trial operations shall restart after rectification of the defects found and the defect liability period shall be extended for the portion of Works, in which the defect is found, or for the Whole Works, as the case may be. For a minor defect, the Contractor shall rectify it to the satisfaction of the Project Manager and the trial operation will continue as if there has been no defect.

1.7 Power Supply and Communication Network

The VEC will perform all the necessary application procedures to the power supply companies required for the power to be supplied to all power receiving points. All the expenses charged by the power supply companies regarding such applications will be borne by the VEC. The work to be undertaken by the power supply companies up to the boundary of property and responsibility between the VEC and the power supply companies, as well as the expenses incurred therefrom, shall be outside the scope of this Contract. The Clause does not apply to the electricity needed for the execution of the Works.

The Contractor shall make his own arrangement for electricity required for the execution and testing of the Works. The Employer shall provide electricity free of charge to the Contractor only after permanent Electric Power is “switched ON” for the purpose of Test on Completion.

Power receiving facilities, standby generator, and power distribution to the main distribution board will be provided under a separate contract and is not included in this Contract. The Contractor shall provide the connection from the main distribution board to the uninterruptible power supply and further to the respective equipment that he supplies, and uninterruptible power supply as required. The Contractor shall submit to the Project Manager for prior approval planned drawings for the power supply connection work.

1.8 Work Area Safety and Traffic Control

(1) General

The Contract shall pay utmost attention to the work area safety and traffic safety during the installation works. When working on or near the construction or installation work site, all persons shall wear the proper personal protective equipment including but not limited to hardhat and reflective safety vest. Open toe shoes shall not be allowed.

Obstructions and excavations in the work areas shall be adequately fenced and guarded at all times and proper traffic control devices shall be installed to protect the workers and the public. Particular attention shall be paid to the positioning of traffic barriers and

traffic cones. Unnecessary blocking of traffic lanes shall not be permitted. Roads shall not be used for the unnecessary storage of materials.

Adequate traffic control devices shall be in place before work begins and all such devices shall be removed immediately when the work is completed. As work progresses, warning devices which were appropriate at one time but are no longer applicable shall be removed immediately.

Signs, lights, barriers and other traffic control devices shall be maintained in good order and in the correct position day and night. Signs shall be neat, clear and legible at all times.

Compensation for meeting the requirements of this section shall be included in the Contract Price and no separate payments will be made therefore.

The Contractor shall also obtain necessary permissions from authorities related to use the ordinary road in case where traffic control and/or works on the road are required for execution of the Works.

(2) Warning signs

All work area warning signs shall conform to the requirements in the relevant regulations in Vietnam.

A "LANE CLOSED AHEAD" and a "LANE CLOSED" sign shall be placed upstream of the lane closure site at a distance of approximately 100 meters and 50 meters respectively when one lane of the roadway is closed. These signs shall be placed further upstream of the work area if more than one lane of the roadway is closed.

All work area warning signs shall be made of reflective sheet or material if the signs are to remain in place during hours of darkness.

(3) Temporary warning flashers

Temporary warning flashers shall be used throughout a day if traffic cones, barricades or other barriers are to remain in position day and night. Lamps shall be kept alight at all times. The flashers shall clearly mark the site of obstructions and delineate the transition zone.

(4) Traffic cones

Traffic cones shall be placed on the roadway in advance of the work site to form a transition taper. The length of the transition taper shall be at least 50 meters so as to guide traffic smoothly from the full width section to the narrowed down section. Spacing between the cones shall be no more than 10 meters.

(5) Plant and equipment

In all cases where traffic is permitted to use the whole or a portion of the road before the work is completed, all plant items and similar obstructions shall be removed from the road at night, if at all possible. Otherwise, they shall be delineated at night if they stay within 2 meters of the edge of the roadway by two red lights suspended vertically from the point of obstruction nearest to the roadway.

During the day, a red flag shall project beyond the extremity of all plant items (other than vehicles) adjacent to the traffic lane.

(6) Vehicles

Vehicles that are used to carry out operations on the roadway and that are required to travel slowly or to stop frequently shall be made as conspicuous as possible. This shall be achieved by painting them in a distinctive color or painting the rear portion with diagonal stripes of a contrasting color or providing flashing lights on the top of the vehicle. They shall also have a plate on the rear side with the words "Slow Moving".

(7) Safety plan

The Contractor shall prepare and submit a safety plan before the start of work at site for approval of the Project Manager. The safety plan shall describe the precautions and measures to be followed by all members of the Contractor including the staff of subcontractors to prevent accident to the Contractor's staff and general public during the work. It shall also contain the emergency response measures in case of accident.

The Tenderer shall describe the safety plan that the Tenderer intends to adopt for the works at site in his Technical Proposal.

1.9 Documentation

1.9.1 General

The documentation shall contain complete details of how the system was actually built, and how it works, together with complete operating and maintenance information. The documentation shall consist of the following manuals and drawings:

- System design manual
- System operator's manual
- Software manual
- Hardware manual
- Maintenance manual
- As built drawing
- Manager's manual

- Operator's manual

The documentation shall be a detailed presentation with text and illustrations. All documentation shall be both in English and Vietnamese, and shall be subject to the approval by the Project Manager.

The documentation process shall include the preparation, editing, submittal for approval, publication, delivery and acceptance of the documentation in accordance with the requirements of the Contract.

The manuals and as-built drawings as listed above shall be updated and re-submitted during the defect liability period for review by the Project Manager if there is any change made to the system or if errors and omissions are found in the manuals and drawings.

1.9.2 Presentation of Documentation

All documentation shall be prepared in a clear, concise manner with appropriate illustrations. Except otherwise specified by the Project Manager, all documentation except drawings shall be prepared on A4 size sheets. Drawing shall be printed in principle on A3 size sheet in a separate volume with plastic protective covers. All documentation shall carry an issue number, revision number and date. A uniform style and format shall be followed as much as possible.

Five (5) printed copies and ten (10) sets of electronic files on CDROM or DVD of all documentation, manuals and drawings of as built conditions shall be submitted. Electronic file shall be in the latest version of portable document format. In addition, as-built drawing in the latest version of AutoCAD at the time of tender must be included on CDROM or DVD.

In order to maintain liaison between parts of the Contractor and the Project Manager, documentation concerning each part of the Contract shall be produced and submitted as the part of each component device or equipment are completed and not be left until the preparation of the final manuals. Effort may be saved and familiarity with the presentation of information will be maintained by writing the documentation during the Contract in a form suitable for inclusion in the relevant final manuals.

All system manuals shall be available at the beginning of classroom training. Reissues shall be provided if site commissioning and testing make this necessary.

If changes or modifications are required in any of the documents previously submitted, the Contractor shall fully describe the changes or modifications, and immediately submit them to the Project Manager for approval.

1.9.3 Standard Documentation

Standard documentation shall be provided for the computer and peripherals (hardware and software), programming manuals including the languages to be used, communication

network equipment, uninterruptible power supplies, and other standard products manufactured by a third party and to be supplied under the Contract.

1.9.4 System Design Manual

The intent of the system design manual is to give an overall description of the intelligent transport system supplied under the Contract. The manual may be divided into sections to cover all and every aspect of the system. The description shall be plain and the detail of operation shall be left to other manuals with adequate reference to them. The manual shall provide cross references to the appropriate manuals of the system when necessary to do so.

The system design manual shall completely define all functions, inputs, and outputs including methods of entering inputs, methods of obtaining outputs, data structure and content, format, sequence, and timing. The system structure and organization shall be described including all the data flow paths through the system and all the data files in the system. This description shall clearly present the functional relationship of the computer program modules with one another and with all peripheral, monitor display, control desks, servers, transmission equipment, detector, video camera or other equipment. An overall system flow diagram shall be provided.

1.9.5 System Operator's Manual

This manual shall comprise a concise set of procedures the system operator may require to operate the system with a minimum of detailed technical description of the internal working of the various parts of the system. Cross references to the appropriate manuals for detailed technical descriptions however shall be provided.

The manual shall list specific procedures to be followed for both hardware and software operations, which may have to be followed either by programmers or hardware engineers. Instructions shall therefore be basic and detailed. A step by step procedure shall be given for switching on and off power, controlling the equipment and for starting up and shutting down the system. This shall include loading of the operating programs, checking that they are running correctly, operation of monitoring camera, monitor display, system backup and restoration, and use of utility programs through keyboard and monitor display.

In addition to the routine operation, procedures shall be given for fault diagnosis. Typical symptoms shall be listed, with corresponding corrective or emergency action to be taken.

1.9.6 Software Manual

The software manual shall be project oriented. The software manual shall therefore include the application programs and database.

(1) Structure

The manual shall describe the overall software structure with particular attention to the points at which further user programs can be interfaced. It is essential that the relationship of program modules, their priority, and their calling sequences are explained in such a manner that it may be clearly understood, especially by any competent programmer who wishes to specify or interface a new program into the system.

(2) Program logic/function

Operational objectives for each program shall be described. All logic and transformations on the input data in order to generate output data and accomplish system functions shall be described, together with their interaction, sequencing and time requirements. Derivations of any mathematical equations shall be stated if appropriate.

(3) Flowcharts

Each major section of the programming logic as described above shall be presented in greater detail. The details shall be developed into a format of flowcharts or other graphical methods using statement and decision blocks to show the flow of information and processing. Within each statement and decision block sufficient information shall be presented to describe what is being accomplished. Mathematical or engineering terminology and equations shall be incorporated when necessary to fully describe the operations to be performed.

(4) Output formats

Sample output formats both printout and monitor display shall be provided from actual printer output and monitor display with explanation for each item on the output format. All outputs shall be both in English and Vietnamese.

(5) Data file in database

The format of all data in the database shall be given together with the structure, type, format, length, default value, and range of allowable value, if any. For constant file that contains system parameters and constants, their initial or default values shall also be shown.

(6) Programs on CD/DVD

As part of the documentation, The Contractor shall provide a copy of all source programs that have been coded for this system on a CD-ROM or DVD ready for compilation. The source programs shall be compatible with the flowcharts and program listings. In addition, a copy of the operating system, utility programs and other programs used in the servers within the limit of copyright of the original developer shall be provided on a CD-ROM or DVD which can be readily loaded.

1.9.7 Hardware Manual

This manual shall provide a complete description of the hardware of all the system equipment and components to be supplied under the Contract. Documents regarding component systems shall be bound in separate volume for convenience of use. For off-the-shelf equipment and device, the standard manual provided by the manufacturer will be accepted.

The following information shall be provided for each applicable equipment or component:

(1) Functional descriptions

All information necessary to fully explain the basic function or use of the equipment shall be provided. It shall include a block diagram presentation of the equipment.

(2) Operating procedure

The operating procedure shall be fully described in a simple and clear language. Appropriate illustrations shall be provided. Explanation and use shall be given to the all keys and switches. Meaning of all meters and indicators shall also be explained.

A list of applicable test instruments and tools required to perform necessary measurements shall be included. Setup tests and calibration procedures shall also be described if applicable.

1.9.8 Maintenance Manual

This manual shall describe both preventive and corrective maintenance procedures in such detail that competent maintenance personnel can perform the proper maintenance work by reading this manual.

(1) Preventive maintenance

The manufacturer's recommended procedures for proper preventive maintenance shall be indicated to ensure reliable equipment operation. Specifications including defined tolerances for all electrical, mechanical and other applicable measurements and adjustments shall be listed. Periodical repainting and lubrication servicing shall also be described.

(2) Corrective maintenance

This section shall provide the information necessary for isolation and repair of failure and malfunctions. Accuracies, limitations and tolerances for all electrical, physical and other applicable measurements shall be described. Instructions for disassembly, overhaul, replacement, testing and reassembly, including workshop performance requirements shall be provided.

Fully detailed step by step instructions shall be given where a failure to follow special procedures would result in danger to operating or maintenance personnel, damage to the equipment, improper operation, or other irrevocable results. Instructions and specifications shall be included for such maintenance work that may be accomplished by specialized technicians and engineers in a modern electro-mechanical workshop. Instructions concerning special test set up, component fabrication, use of special tools, jigs and test equipment shall be included.

Maintenance procedures shall cover the diagnosis of faults, trouble shooting, testing and setting up adjustments, replacements of units and operation of test equipment.

1.9.9 As-Built Drawings

The Contractor shall submit two (2) printed copies of as built plans and drawings to the Project Manager prior to the commencement of the Test on Completion for a portion of Works for the Works to be tested. In addition, the Contractor shall submit three (3) printed copies of as-built drawings and one (1) set of soft copy of all as-built drawings to the Project Manager prior to the issuance of the taking-over.

As built plans and drawings to be submitted by the Contractor shall include but not be limited to the following:

- Detail drawings of all equipment;
- Variable message sign support, CCTV camera pole, vehicle detector pole (if any), etc. with firings (civil structure plans and drawings);
- Equipment layout at the MMC, the MOs , the TOs and all sites;
- Toll lane equipment layout;
- Optic fiber cable, metallic communication cable (if any) and power cable network and connection diagram undertaken by the Contractor;
- Conduit, pull box, junction box and manhole layout undertaken by the Contractor;
- Data cable connection diagram at the MMC, the MOs, roadside equipment and other locations;
- Power supply room layout; and
- Power distribution diagram undertaken by the Contractor.

These plans and drawings shall incorporate changes made during the installation. A uniform legend shall be used throughout the documentation.

1.9.10 Manager's Manual

The Contractor shall prepare and submit manager's manual to be used by the traffic management room (TMR) manager during his daily operation. The manual shall include the brief non-technical description of all equipment in the MMC, the MOs and roadside

equipment. It shall present the detail procedure for all operations associated with the managing and supervising traffic management and operator management.

Non-technical explanations of print-outs normally produced on printers and displays available on the operator console shall also be included.

1.9.11 Operator's Manual

The Contractor shall prepare and submit operator's manual to be used by the operators belonging to traffic management room in the MMC or facility management section in the MOs during their daily operation. The manual shall explain the procedure to log-on and log-off at tour of duty operator console and other procedures necessary for operators' daily operation. In addition, the manual shall describe the operating procedure of the equipment installed at roadside. The description shall be plain and concise in a step-by-step manner using illustrations and photos as much as possible. The details of the internal mechanism are not required in the manual.

The manual shall also describe the operator's action to take in exceptional cases. The description will be limited to the operation of the equipment and system operation and the action to events occurring on the road is not required.

Likewise, the manual shall describe the actions to be taken when any of the devices comprising the intelligent transport system becomes defective or malfunctions.

1.9.12 Submission Schedule

The initial version of the documentation shall be submitted as per the schedule presented below.

No.	Documentation	Submission
1	System design manual	Within 45 days of the commencement of the Works
2	System operator's manual	30 days before the intended date of maintenance training
3	Software manual	30 days before the intended date of maintenance training
4	Hardware manual	30 days before the intended date of maintenance training
5	Maintenance manual	30 days before the intended date of maintenance training
6	As-built drawings	Prior to Test on Completion
7	Manager's manual	30 days before the intended date of management and operations training
8	Operator's manual	30 days before the intended date of management and operations training

1.10 Training

1.10.1 General

A training program as specified herein shall be provided for the management and operation of the intelligent transport system in the DQE. The subjects and contents of the training shall focus on the operation of the equipment and system. The training on the administrative procedure will be provided separately and not included in this Contract. All trainings shall be conducted in **Da Nang or at site**.

The Contractor shall develop all materials required for training and furnish twenty (20) copies of each manual, class note, visual aid, and other instructional materials to the VEC for distribution to the attendants. The manuals, instructions, and training notes shall be in loose-leaf binder form.

The outline of the lectures or demonstrations and a sample or description of all training aids shall be submitted to the Project Manager for review at least thirty (30) days prior to their proposed presentation or use. Written approval by the Project Manager of these materials shall be required prior to the scheduling of training sessions and/or the production in quantity of any training materials

The minimum content and duration (contact hours) of classroom training sessions shall be as specified herein, plus such other topics as are necessary, to ensure effective training. Notwithstanding the contact hours specified herein, all training shall be effective and shall be completed by the Contractor to the satisfaction of the VEC.

1.10.2 Management and Operations Training

The management and operations training shall include classroom instructions, on-site demonstrations, and follow-up reviews. The training shall be designed for the VEC's engineers and intelligent transport system operators (up to 20 persons) and shall cover all operations and procedures of comprising the intelligent transport system in the DQE.

The initial classroom instructions and on-site demonstrations shall be completed after the Test on Completion for a portion of Works but before the issuance of taking-over certificate. The contents of this training shall include as a minimum the following:

(1) System management (Minimum of 12 contact hours)

- System overview
- System operation
- Operations overview
- Data requests and data displays
- Reports

- Functions and duties of the traffic management room and the facility management section personnel.

(2) Control procedures (Minimum of 24 contact hours)

- Server, operator console and peripheral equipment operations
- Orderly start-up and shut-down
- Use of diagnostic programs and procedures
- Response to alarms, errors and faults
- Interpretation of alarms and fault messages
- Operation of CCTV camera system equipment
- Operation of the vehicle detection system equipment
- Operation of meteorological monitoring system equipment
- Operation of overload monitoring system equipment
- Operation of variable message sign system equipment
- Operation of digital transmission system equipment
- Operation of wireless radio system
- Operation of internal telephone system
- Large display panel and monitor display

(3) Analyst procedures (Minimum of 24 contact hours)

- Data requests and data displays
- Data base management
- Coding input
- Edit checks
- Insertion, deletion and alteration of data
- Modifications
- Addition, deletion or alteration of default values and parameters
- Interpretation of displays and reports

(4) Toll collection procedure (Minimum of 24 contact hours)

- Toll booth opening/closing procedure
- Toll booth equipment start-up/shut-down procedure
- Manual toll transaction procedure
- Use of supervisor and operation terminal
- Use of inspection and post-check terminal
- User of toll transaction terminal

- Use of accounting terminal
- Use of IC card/OBU registration terminal
- Use of IC card reader/Writer
- Use of IC-Card Issuance Printer
- Use of CCTV surveillance system
- Booth communication system and emergency caller
- Human-machine interface

1.10.3 Maintenance Training

The Contractor shall provide maintenance training to the VEC staff or to the staff of the party designated by the Employer during the trial operation using maintenance manuals provided under the Contract. The training shall include at least 80 contact hours of classroom instructions and hands-on workshop sessions, and on-the-job training:

The training shall consist of system maintenance, software maintenance and hardware maintenance.

(1) System maintenance training

The system maintenance training shall include but not be limited to the following:

- Modification of system parameters and version control
- System backup and restoration
- Switchover between prime and backup servers
- Use of diagnosis program

(2) Software training

The software maintenance training shall include but not be limited to the following:

- Software configuration
- Version up of the operating system and other software provided by the third party
- Updating of software developed by the software supplier
- Software backup and restoration
- Database backup and restoration
- Use of diagnosis programs

(3) Hardware training

The hardware maintenance training shall be provided for all equipment provided under the contract and shall include but not be limited to the following:

- Routine check-up, adjustment and cleaning

- Diagnosis of all equipment
- Identification of defective unit
- Disassembly and assembly procedure
- Replacement of unit, printed circuit and parts
- Test procedure and threshold
- Use of measuring apparatus

1.11 Spares Parts, Consumables and Maintenance Equipment

1.11.1 General

The Contractor shall furnish the spare parts and maintenance equipment as specified hereunder and in the Pricing Documents. Spare parts shall consist of mandatory spare parts and recommended spare parts. The mandatory spare parts are the spare parts of type and quantities required and listed in these Employer's Requirements and in the **Price Schedule No. 9 and No. 10 of the Pricing Documents** and the Contractor shall supply them under the Contract.

The recommended spare parts are spare parts of type and quantity that the Contractor considers necessary to maintain the normal operation of the system after the taking over of the system during the defect liability period in addition to the mandatory spare parts.

The device, equipment and unit to be provided as spare parts shall be properly packaged to prevent deterioration during storage. They shall be provided with a mark, ID or code for easy identification.

1.11.2 Mandatory Spare Parts

The Contractor shall supply the spare parts of the type and in quantity as specified in **Price Schedule No. 9 and No. 10** of the Pricing Documents. These spare parts shall be exactly identical with the equipment, device, unit, component, or parts incorporated into the working system to be provided under the Contract. For the device, equipment or unit that operates on software shall be provided with the necessary software pre-installed and shall operate normally upon replacement of the defective equipment, device, unit, component or parts without loading of software. If the spare parts require any initial loading, adjustment, parameter setting and other preparatory actions upon replacement, the manual or leaflet describing the procedure in detail shall be attached to each spare part.

The workstation to be supplied as spare part shall have the best configuration and the highest performance among the operator consoles to be supplied under the Contract so that it shall be possible to be configured as any of the operator consoles.

The Contractor shall provide the same protection device against lightning incorporated in the working system as spare parts. The same type and the same quantities as those that

are actually installed in the working system shall be provided.

The term “each type” indicated in the table below shall be understood that each and every type of the printed circuit board, power supply unit, and sensor as the case may be shall be supplied in the quantity specified.

No.	Item	Unit	Quantity
1.	Workstation	Set	1
2.	55 inch LCD display panel	No	1
3.	CCTV camera	Set	3
4.	CCTV controller printed circuit board (each type)	Set	3
5.	CCTV power supply unit	Set	3
6.	Vehicle detector unit	Set	3
7.	Vehicle detector unit printed circuit board (each type)	Set	3
8.	Vehicle detector power supply unit	Set	3
9.	MET sensor (each type)	Set	1
10.	MET data logger printed circuit board (each type)	Set	1
11.	MET power supply unit	Set	1
12.	WIM type axle load scale and overweight warning display	Set	1
13.	Roadside panel printed circuit board (each type)	Set	1
14.	Overload monitoring power supply unit	Set	1
15.	VMS LED display unit	Set	30
16.	VMS printed circuit board (each type)	Set	3
17.	VMS power supply unit	Set	3
18.	VMS ventilation fan	Set	3
19.	Layer 3 switch	Set	1
20.	Layer 2 switch	Set	5
21.	Media converter	Set	5
22.	Wireless radio transmitter/receiver with coaxial arresters	Set	1
23.	Telephone set	Set	3
24.	LED Lamp for Lane Traffic Light	Set	3
25.	LED Lamp for Canopy Traffic Light	Set	3
26.	Automatic License Number Plate Recognition Camera	Set	3
27.	Lane Side Camera	Set	3
28.	Lane Side Display	Set	1
29.	Automatic Lane Barrier (actuator unit)	Set	3
30.	LED Lamp for Flashing Light for Traffic Safety	Set	3
31.	Alarm Horn and Lamp	Set	1

32.	ETC Roadside Antenna	Set	3
33.	Toll Lane Server (except housing)	Set	1
34.	Toll Transaction Terminal (except housing)	Set	1
35.	ETC Controller (except housing)	Set	1
36.	ANPR Processor (except housing)	Set	1
37.	Booth Communication System (Master)	Set	1
38.	Booth Communication System (slave)	Set	3
39.	Emergency Caller (Master)	Set	1
40.	Emergency Caller (slave)	Set	3
41.	Database Server for Toll Data Management System (except housing)	Set	1
42.	Tollgate Server (except housing)	Set	1
43.	Supervisor and Operation terminal	Set	1
44.	Inspection and Post-check Terminal	Set	1
45.	Accounting Terminal	Set	1
46.	IC-Card/OBU Registration Terminal	Set	1
47.	Operation Printer	Set	1
48.	Receipt Issuance Printer	Set	1
49.	IC-Card Issuance Printer	Set	1
50.	CCTV Surveillance System (CCTV controller)	Set	1
51.	IC-Card Reader/Writer	Set	3
52.	Lightning arrestor or equivalent	No	Same number as used.

1.11.3 Recommended Spare Parts

The Tenderer shall provide in **Schedule FT-11** of Tender detailed information on the spare parts necessary for the continuous operation and maintenance of the equipment to be installed under this Contract. The information shall include identification, source of supply and numbers and units required for the system for the next 10 years. Recommended quantities for the maintenance during the defect liability period after the taking-over, proposed rates and total prices for these spare parts shall be listed in the **Price Schedule No. 9 and No. 10** of the Pricing Documents Recommended Spare Parts and Maintenance Equipment.

1.11.4 Parts Supply Guarantee

The Contractor, his legitimate successor or his designate, shall guarantee for a period of ten (10) years after the Taking-over of the Works that he will supply promptly upon the written request from the VEC any parts, components or equipment incorporated in the System. This clause shall not necessarily be construed to read that the Contractor be required to maintain the inventory to cover the entire items for anticipated requirement

for such purpose through the 10 years' period. Because of discontinuation of production of such particular items or because of any reasons beyond his control, if the Contractor fails to supply the requested parts, components or equipment, he shall satisfy the need of the VEC by whatever appropriate substitutes available with consent and approval of the VEC, but always in such a manner and outcome that the substitutes can maintain or improve the system's performance or capabilities as a whole.

The Contractor shall be paid for such supply duly made at such costs as he shall charge to his domestic customers on similar occasions at the time plus freight, insurance, import custom and duties, handling charge and other related expense actually paid.

1.11.5 Maintenance Equipment

The Contractor shall provide the maintenance equipment as listed hereunder and in the quantities as specified in the **Price Schedule No. 9 and No. 10** of the Pricing Documents.

Unless the details and specifications are specified in the Employer's Requirement, the Tenderer shall select the types and model of the maintenance equipment that he considers adequate for the maintenance work of the equipment and system to be supplied under the Contract. The Tenderer shall specify the manufacturer, brand, and make of the maintenance equipment he proposes together with the specifications in the Technical Proposal.

- Maintenance computer (notebook computer)
- Digital multi meter
- Level meter
- Insulation resistant meter
- Dielectric strength meter
- Ground resistance meter
- Oscilloscope
- Network analyzer

Maintenance computer shall be a notebook computer with the following minimum specifications:

No.	Item	Specifications
1.	Processor	Intel Core i5
2.	Memory	4 G byte
3.	Hard disk	Serial ATA 2.5 inch 160 GB
4.	Display	15.6 inch LCD with LED back light
5.	IC card reader	Capable of reading the data in IC card to be supplied under the Contract
6.	Interface	USB 2.0 (3)

		Rj-45 Display port
7.	Ethernet	10BASE-T/100BASE-TX/1000BASE-T
8.	Operating system	Latest Windows stable operating system
9.	Software	Microsoft Office latest version AutoCAD latest version The same database software as the intelligent transport system

Operation, simulation and diagnosis software developed specifically to the equipment to be supplied under the Contract, if any, shall be supplied in CD-ROM or DVD. They shall be also installed in the maintenance computer.

In addition to the specified maintenance equipment, the Tenderer shall identify maintenance equipment, tools, test equipment, and measuring apparatus which will be required to effectively maintain the intelligent transport system, if any, and provide all necessary details in **Schedule FT-11** of Form of Tender. The costs of furnishing the recommended maintenance equipment shall be quoted in the **Price Schedule No. 9 and No. 10** Recommended Spare Parts and Maintenance Equipment.

The VEC reserves the option to require the Contractor to furnish any or all of the recommended spare parts, consumables and maintenance equipment.

1.12 Technical Proposal

The Tenderers shall describe the proposed works in sufficient detail in his Technical Proposal to enable the VEC to evaluate the technical adequacy of the proposed system. The Technical Proposal shall include the statement of compliance with the Specifications indicating whether the proposed equipment comply with the specified requirements. If the proposed system does not comply with the Specifications, the details of differences shall be described together with the alternative features of facilities offered.

The Tenderers shall propose and describe in detail in his Technical Proposal the approach, methodology, technology and procedure of the detailed design of the traffic management system, toll collection system, communication system and associated works. Expected output of the detailed design shall be described together with the submission schedule for review and approval by the VEC.

For the items for which type, procedure, method, or configuration is left to the supplier's design, The Tenderers shall clearly indicate in the proposal the type, procedure, method or configuration he chooses with reason.

The Technical Proposal shall describe in detail how the system requirements defined in the Tender Documents will be achieved with block diagram, data flow, timing chart, calculation or other supporting data.

If the Tenderer wishes, an alternative may be proposed, insofar as it is advantageous to the VEC either functionally or economically in the opinion of the Tenderer. However, the VEC reserves the right to accept or reject such alternative proposal.

The Technical Proposal shall be written in the same sequence as the Employer's Requirements. Where the supporting documents are provided, a cross reference shall be prepared. The Technical Proposal shall be written in English.

The Technical Proposal shall include the description of system as a whole and equipment comprising the System. The description shall include how the requirements of the Employer's Requirements are achieved. If necessary, block diagram, flowchart, timing chart or other explanatory documents shall be attached.

Equipment comprising the System shall be defined. For each equipment, the following items shall be stated:

- Electrical and/or mechanical specifications
- Interface with other equipment
- Human-machine interface, if applicable
- Capacity
- Reliability as expressed in MTBF and MTTR
- Environmental conditions
- Physical dimensions
- Power consumption
- Operator console layout
- Brand, model, and/or type
- Catalogue, brochure, or other supporting document (if any)

2. Design Requirements

2.1 General

Intelligent Transport System (the ITS) in Da Nang – Quang Ngai Expressway (the DQE) and the equipment comprising the system to be installed under this Contract shall be capable of continuous, 24 hours a day, 7 days a week operation under the environmental conditions prevailing in the central Vietnam. Should the design require periodic replacement of any equipment or component, the replacement schedules of such equipment or component shall be described in the Technical Proposal and in the maintenance manual.

The ITS shall have high reliability, accuracy and security in design. Stoppage of the total system shall not be allowed under any circumstances. Redundant hardware configuration shall be adopted for key components to ensure continuous road traffic control and management operation. Data backup mechanism shall be used to prevent data loss. Operation log shall be kept to allow tracing of operation in case of any irregularity in the operation of the system.

The ITS to be introduced to the Project is a comprehensive traffic control and management system for the DQE. The component systems comprising the ITS to be constructed under the Contract shall include but not be limited to the following component systems:

- Traffic management center system
- CCTV camera system
- Vehicle detection system
- Meteorological monitoring (MET) system
- Overload monitoring system
- Variable message sign (VMS) system
- Toll collection system
- Communication system

These systems shall function as a component system and, at the same time, cooperate each other by exchanging data between the systems to achieve the intended function of the total system.

2.2 Standards

2.2.1 General

All equipment the Contractor supplies shall be new and subject to the acceptance test to the satisfaction of the Project Manager. Unless other standards are specifically required to be complied with herein or in the Contract, all materials and components used under the

Contract and all design calculations and tests shall be performed in accordance with Vietnamese standards.

In the absence of such standards in Vietnam, relevant clauses of international standards including but not limited to International Electrotechnical Commission (IEC), Institute of Electrical and Electronic Engineers (IEEE), International Organization for Standardization (ISO), International Telecommunication Union Telecommunication Standardization Sector (ITU-T) and Radiocommunication Sector (ITU-R) shall be applied.

In the absence of such standards in Vietnam and in the international standards mentioned above, industry standards generally accepted and approved in one of the major industrialized countries such as Japan, U.S.A, Germany and Great Britain shall be applied.

Whenever in the Employer's Requirements reference is made to the Japanese Industrial Standards (JIS), British Standards (BS), American Association of State Highway Transportation Officials (AASHTO) standards, American Society for Testing and Materials (ASTM) standards, and American National Standards Institute (ANSI) standards, and the like, it shall be understood that equivalent internationally acknowledged standards will be accepted.

If Tenderer offers materials, equipment, design calculations or tests which conform to the standards other than those specified standards, full details of the differences between the proposed standard and the specified standards shall be submitted when required by the Project Manager.

2.2.2 Applicable Standards

The following standards shall apply to the data exchange between the component systems:

No.	Reference	Descriptions
1	ISO 14813	Reference model architecture for the ITS sector
2	ISO 14817:2002	Transport information and control systems – Requirements for ITS/TICS central data registry and ITS/TICS data dictionaries
3	ISO 14827-1:2005	Transport information and control systems – Data interfaces between centers for transport information and control system – Part1: message definition requirements
4	ISO 14827-2:2005	Transport information and control systems – Data interfaces between centers for transport information and control systems – Part 2: DATEX-ASN
5	ISO 15784-1:2008	Intelligent transport systems (ITS) – Data exchange involving roadside modules communication Part1: General principles and documentation framework of application profiles
6	ISO 15784-2:2008	Intelligent transport systems (ITS) – Data exchange involving

No.	Reference	Descriptions
		roadside modules communication Part2:Application Profile-SNMP
7	ISO 15784-3:2008	Intelligent transport systems (ITS) – Data exchange involving roadside modules communication --- Part3: Application profile-data exchange (AP-DATEX)

The following standards shall apply to the toll collection system:

No.	Reference	Descriptions
1	ISO/IEC 11179	Information technology – specification and standardization of data elements
2	ITU-R M.1453-2	ITS – Dedicated Short Range Communication (DSRC) at 5.8GHz
3	ISO 15628	Road transport and traffic telematics – Dedicated Short Range Communication (DSRC) – Application Layer
4	ARIB STD-T75	DSRC System
5	ISO 14906	Road transport and traffic telematics – Electronic fee collection Application Interface Definition for DSRC
6	ISO/TS 25110	Electronic fee collection -- Interface Definition for on-board account using integrated circuit card (ICC)
7	ISO 17573	Road transport and traffic telematics – Electronic fee collection (EFC) – systems architecture for vehicle related transport services
8	ISO/IEC 14443-1	Identification cards – Contactless integrated circuit cards – Proximity cards – Part 1: Physical characteristics
9	ISO/IEC 14443-2	Identification cards – Contactless integrated circuit cards – Proximity cards – Part 2: Radio frequency power and signal interface
10	ISO/IEC 14443-3	Identification cards – Contactless integrated circuit cards – Proximity cards – Part 3: Initialization and anticollision
11	ISO/IEC 14443-4	Identification cards – Contactless integrated circuit cards – Proximity cards – Part 4: Transmission protocol
12	ISO/IEC 7816-4	Identification cards – Integrated circuit cards – Part 4: Organization, security and commands for interchange
13	ISO/IEC 18092	Information technology – Telecommunication and information exchange between systems – Near Field Communication – Interface and Protocol (NFCIP-1)
14	IEC 60721-3-4	Classification of environment conditions – Part 3 : Classification of groups of environmental parameters and their severities – Section 4: Stationary use at non-weatherprotected locations
15	IEC 60721-3-5	Classification of environment conditions – Part 3 : Classification of groups of environmental parameters and their severities – Section 5: Ground vehicle installations
16	ISO 14815	Road transport and traffic telematics – Automatic vehicle and equipment identification –System specifications
17	IEC 60068-1	Environmental testing. Part 1: General and guidance
18	ISO/TS 14907-1	Road transport and traffic telematics – Electronic fee collection –

No.	Reference	Descriptions
		Test procedures for user and fixed equipment – Part 1: Description of test procedures
19	ISO/TS 14907-2	Road transport and traffic telematics – Electronic fee collection – Test procedures for user and fixed equipment – Part 2: Conference test for the onboard unit application interface

The following standards or de facto standards shall apply to the digital transmission system:

No.	Reference	Descriptions
1	Ethernet	<ul style="list-style-type: none"> 8802-3: 2000 (ISO/IEC) (ANSI/IEEE Std 802.3 2000 Edition): Information Technology – Telecommunications and information exchange between systems – Local and Metropolitan area networks – Specific equipment -- Part3: Carrier sense multiple access with collision detection (CAMA/CD) access method and physical layer specifications.
2	Fast Ethernet	<ul style="list-style-type: none"> IEEE 802.3u-1995 IEEE Standards for Local and metropolitan area networks: Supplement to Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications: Media access control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100Mb/s Operation, Type 100BaseT (Clauses 21-30) (ANSI) EIA/TIA568B (AT and T-258A) Commercial Building Telecommunications Wiring Standard, 1991
3	Gigabit Ethernet	<ul style="list-style-type: none"> IEEE 802.3ab : Physical coding sublayer (PCS), physical medium attachment (PMA) sublayer and baseband medium, type 1000BASE-T IEEE 802.3z : Media Access Control(MAC) Parameters, Physical Layer, Repeater and Management Parameters for 1000 Mb/s Operation
4	FTP	<ul style="list-style-type: none"> RFC 959 File Transfer Protocol, RFC 1350 The TFTP Protocol (Revision 2),
5	HTTP	<ul style="list-style-type: none"> RFC 1945 Hypertext Transfer Protocol -- HTTP/1.0. RFC 2068 Hypertext Transfer Protocol -- HTTP/1.1. RFC 2616 Hypertext Transfer Protocol /1.1 June 1999 RFC 2617 HTTP Authentication: Basic and Digest Access Authentication, June 1999
6	IP	<ul style="list-style-type: none"> RFC 791 Internet Protocol
7	PPP	<ul style="list-style-type: none"> RFC 1661 The Point-to-Point Protocol (PPP)
8	SNMP	<ul style="list-style-type: none"> RFC 1157 Simple Network Management Protocol (SNMP)
9	TCP	<ul style="list-style-type: none"> RFC 793 Transmission Control Protocol
10	UDP	<ul style="list-style-type: none"> RFC 768 User Datagram Protocol
11	MPEG4	<ul style="list-style-type: none"> ISO/IEC 144916-1:1999 Information technology -- Coding of audio visual objects -- Part 1: Systems

No.	Reference	Descriptions
		<ul style="list-style-type: none"> • ISO/IEC 144916-2:1999 Information technology -- Coding of audio-visual objects -- Part 2: Visual • ISO/IEC 144916-2:1999 Information technology -- Coding of audio-visual objects -- Part 3: Audio • ISO/IEC 14496-10:2003: Information technology -- Coding of audio-visual objects -- Part 10: Advanced Video Coding
12	FOC	<ul style="list-style-type: none"> • ITU-T G 652: Characteristics of a single-mode optical fibre and cable • ITU-T G 655: Characteristic of a non-zero dispersion-shifted single-mode optical fibre and cable

2.3 System Requirements

2.3.1 System Capacity

The ITS in the DQE shall have a sufficient capacity in terms of response time, data processing speed, data transmission bandwidth, and storage capacity to monitor and control all equipment connected to the system. The system, hardware and software shall be designed to perform the required function without excessive delay, lack of storage space or any other critical limitations for the system with twice the number of all terminal equipment.

2.3.2 Reliability

The equipment and device comprising the ITS in the DQE shall have high reliability. They shall have the mean time between failures (MTBF) as specified for respective equipment in these Employer's Requirements. The Tenderer shall state in his Technical Proposal the expected MTBF of the equipment he will supply. The MTBF shall be either the calculated figure based on the reliability of components comprising the equipment, or the actual MTBF achieved by the same or similar equipment. For the off-the-shelf equipment supplied by the third party, the MTBF published by the manufacturer or supplier will be accepted.

The traffic management center system shall have an availability of 100 % with redundant system configuration.

2.4 Detailed Design

2.4.1 Design Briefing

Within 45 days of Commencement Date of the Works, the Contractor shall conduct a design briefing session in Vietnam. The design briefing shall cover all the system components included in the Contract. The main objective of the briefing is to acquaint the Project Manager and VEC staff with the design concept and outlines of the proposed

systems, and to allow them to examine whether or not the Contractor's design complies with the Contract.

2.4.2 Design Review and Approval

Within four (4) months of the Commencement Date of the Works, the Contractor shall submit a System Detailed Design to the Project Manager for his review and approval. The System Detailed Design shall provide detailed information of the proposed system, including system configuration, system function, outline dimensions of equipment, block diagrams, input and output, flow charts, interface, design calculation and manufacturer's specification sheets and shall cover all necessary hardware, software, database and operating procedures. The Contractor shall obtain the “Notice of No Objection” or “Notice of No Objection subject to.....” from the Project Manager with regard to the System Detailed Design within five (5) months of the Commencement date of the Works.

The submission of the system design shall be made in multiple timings to avoid the situation in which the total design approval is submitted in one time with many volumes of document. Individual submission shall be made in units of component system.

If design change is necessary for the portion of the detailed design that has been submitted and approved due to the design of other portions, revised detailed design shall be submitted with the modification noted for approval.

The Contractor shall not, without specific approval in writing by the Project Manager, place any material, part or component on order, nor commence manufacturing of any equipment or software coding until the System Detailed Design has been approved by the Project Manager. The Contractor shall not implement any changes on the approved system design without prior approval of the Project Manager.

The approval of the System Detailed Design by the Project Manager, however, shall not relieve the Contractor from delivering a fully operational and reliable system.

2.4.3 Hardware System Design

Hardware portion of the System Detailed Design shall include among others the following:

- Functional and physical system block diagram of the each component system.
- Connection and interface between the blocks in the block diagram.
- Functions, capacity, input, output, and method of operation.
- Response time, delay, allowance, attenuation, loss and other figures as appropriate for applicable equipment.
- Environmental and physical design specifications of the equipment. Manufacturer's product specification sheets may be accepted for standard products.
- Power consumption of equipment.

- Cable network diagram.
- Cable work plane plan.
- Conduit line plan.
- Equipment layout in the machine rooms at the Main Management Center (MMC), the Management Offices (MO), toll offices, toll booths and other locations where system, communication and power supply devices are placed.
- Layout in traffic management room in the MMC
- Equipment layout at roadside.
- Manner of installation.

2.4.4 Software System Design

Software portion of the System Detailed Design shall include, as a minimum, description of module, identification of tasks, priority level, execution schedule, input and output, algorithms and parameters, database structure and contents, parameter update procedures, data flow, calling sequences, error detection, backup and recovery and programming languages.

Structure of software shall be simple and straightforward. Interdependency and interaction between modules shall be clear and kept to minimum to prevent defect in one module from affecting many other modules. Data and parameters shall be separate from the program and kept in the database.

2.4.5 Operating Procedures

The system operation shall cover the procedures that the system operator follows in monitoring, checking and diagnosing the system operation. The procedure shall include but not be limited to the monitoring of operating status of component devices, modification and updating of operation parameters, connection and disconnection of device, identifying the cause of failure, recovery of the system from failure, and display and printout of various reports.

The system operation procedure is the procedure that the operators take in their daily work. The procedure shall cover the start and end of duty procedure and other procedures necessary for operators' daily operation.

Fool proof mechanism shall be incorporated as much as possible in the operation procedure to prevent any inadvertent mistake to cause serious damage to the system, expressway operation and driver's safety. Frequently used operating sequences shall be described in a step by step manner.

2.5 System Configuration

A simplified block diagram showing overall configuration of the ITS is given in the Drawings. It is specifically noted that most of these drawings are reference only. The plan is intended to show the component systems comprising ITS and does not indicate physical configuration and connection between equipment. The Contractor may adopt different system configuration as long as the functionality and performance of the system meet the system requirements specified herein. It is the Contractor's obligation to show that the proposed system will satisfy all the requirements in the system specifications.

2.5.1 Local Area Network

It is required that the central server system employs an open network architecture consisting of several servers, operator consoles and central controllers connected through a standard local area network based on TCP/IP. To ensure a high level of reliability and operational flexibility, it is required that the operator consoles connected to the network shall be complementary each other and shall not be dedicated to a specific function. Breakdown of an operator console shall not affect the normal operation of the system and in any aspect. Database server shall have a redundant configuration of RAID system or similar highly reliable configuration.

2.5.2 Component Systems

The ITS to be constructed on the DQE composes of many component systems as described above. Some of them are closely integrated with other systems, while others are stand alone system with no data exchange with other systems. All of them shall be designed with a consistent design policy and concept to achieve the overall objectives of the total system. Functional and performance requirements for each component system are defined in these specifications. The Contractor shall undertake the detailed design of each system in such a way that the total system is efficient, reliable and user friendly in operation. The system design shall incorporate the latest technology in each field but propriety technology available from a single vendor only shall be avoided.

2.5.3 Digital Transmission System

Digital transmission system for data exchange between roadside equipment and central equipment shall use IP based transmission system complying with the established international standards such as ITU and IEEE. All data transfer between the central equipment and the roadside equipment including video image shall be made in digital format except the section between local controller and the terminal device. Voice communication for internal telephone and wireless communication system shall also adopt digital form.

Hierarchical configuration shall be adopted for data communication system consisting of trunk line system, local line system, and access line system. Trunk line system connects Main Management Centers and bulk of data will be transmitted at high speed over fiber optic cable. The system will not be installed under the Contract, however, local line

system takes a form of digital loop and exchanges data among the nodes located on the loop. Access line system connects roadside equipment to the node.

Although trunk line system will not be constructed under the Contract, the Contractor shall take the future introduction of trunk line system and establishment of expressway management system covering the nationwide expressway network into consideration. The MMC in the DQE which will covers wide area traffic information in the central region of Vietnam shall be ready for communication and connection with ITS of other projects and other MMCs.

The Contractor shall propose and explain the outline of the trunk line system that is suitable for future introduction to the expressway network. The local line system shall be compatible with the proposed trunk line system.

Data transmission shall be made through a dedicated cable network and cables shall be installed along the expressway for data transmission under the Contract. The Contractor shall undertake the detailed design of cable and conduit installation work for entire section of the DQE.

2.5.4 Toll Collection System

The toll collection system shall have high reliability, accuracy and security in design. Stoppage of the total system shall not be allowed under any circumstances. Redundant hardware configuration shall be adopted for key components to ensure continuous toll collection operation. Data backup mechanism shall be used to prevent data loss. Operation log shall be kept to allow tracing of operation in case of any dubious transaction. Mechanism shall be incorporated in the system design to prevent illegal or fraudulent activities by toll collector or road user.

2.6 Power Supply

The input power supply of any equipment shall not be connected to any electric components except arresters without connecting first through fuses, power switches and circuit breakers.

All equipment shall be provided with a clearly visible label indicating the input power supply type (AC or DC) and voltage. All equipment shall operate with the power supply of 220V plus or minus 10 percent, and 50 hertz plus or minus 3 percent. All equipment shall operate normally under instantaneous power supply interruption of 20 milli-second or shorter.

The power supply voltage available in the field will be 220V AC. Unless specified otherwise or with the approval of the Project Manager, all roadside equipment shall be designed to operate directly on 220 V AC. The Contractor shall be responsible for arranging the terminal devices necessary to receive the power supply.

2.7 Design Life

All components and materials used in this Contract, excluding consumable items such as lamps, shall be of a design life of 10 years or longer, except On-Board Unit (OBU) used in toll collection system, unless specifically stated otherwise in the Employer's Requirements. The Tenderer shall state in his Technical Proposal whether there is any equipment or component that do not have the design life specified. The Project Manager may approve them if they are easily replaceable and a 10-year design life is generally considered infeasible or uneconomical. The replacement of such equipment shall be possible without displacing other component.

2.8 Workmanship

All equipment and components shall be new and shall be designed and manufactured in the soundest manner, using materials most suited to the particular services. All materials shall comply with the latest relevant authorized standards for testing materials unless otherwise specified or permitted by the Project Manager. For the design of all equipment, it shall be considered to enable to make ease of their maintenance work.

All workmanship shall be of the highest class throughout to ensure smooth and vibration free operation under all possible operating conditions, and the design, dimensions and materials of all parts shall be such that the stresses to which they may be subjected shall not render them liable to distortion, undue wear, or damage under the most severe conditions encountered in service.

All parts shall conform to the dimensions shown on the Employer's Requirements – Drawings and shall be built in accordance with approved drawings. All joints, datum surfaces, and mating components shall be machined and all castings shall be spot faced for nuts. All machined finishes shall be shown on the approved drawings. All screws, bolts, studs & nuts and threads for pipe shall conform to the latest standards of the International Organization for Standardization covering these components and shall either all conform to the standards for metric sizes.

2.9 Nameplate

All equipment supplied under the Contract shall have a nameplate. The nameplate shall indicate as a minimum, manufacturer's name, model, type or make, serial number, manufactured month and year. In addition, other information such as input voltage, current, frequency, and complying standards may be described. Information on the nameplate shall be printed or inscribed in indelible manner.

The nameplate shall be firmly attached to the cabinet at the suitable position by screw, rivet or adhesive and shall not be easily removed.

2.10 Environmental Conditions

2.10.1 General

All equipment shall be designed to operate properly under the environmental conditions normally encountered at the site of the equipment in the central Vietnam and shall conform to the minimum requirements specified herein.

2.10.2 Environmental Conditions

Unless specified otherwise, indoor equipment shall be designed to operate in the temperature range of 5 to 40 degree Celsius, and the relative humidity range of 5 to 85 percent, whereas outdoor equipment shall operate in the ambient temperature and relative humidity ranges of 5 to 60 degrees Celsius and 40 to 95 percent non condensing humidity, respectively. Adequate protection from moisture condensation, fungus, rust, insects, rodents, and dust shall be provided.

All equipment shall be adequately treated to prevent rust and corrosion due to high humidity or moisture condensation. Unless otherwise specifically approved by the Project Manager, all steel housing, pole, fittings, and conduit shall be galvanized and paint finish shall not be accepted. All galvanized steel surface shall have a minimum plated zinc amount of 350 g/m². Any signs of rust or corrosion occurring within the defect liability period shall be deemed a defect and the Contractor shall be responsible for correcting, at his own expense, the defect to the satisfaction of the Project Manager.

2.10.3 Protection Code

Unless otherwise specified, all indoor equipment shall have the protection code of IP54, while all outdoor equipment shall have the protection code of IP65.

2.10.4 Wind

All outdoor equipment and their support, individually and fully assembled and installed as a whole, shall withstand an instantaneous wind velocity of at least 53 m/sec.

2.11 Cabling and Wiring

All cables and wires shall be of good quality, conforming to normally accepted industry standards, and shall be of the proper type and have sufficient ratings for the particular application.

All exposed ends of unconnected cables and wires shall be coated with water tight sealing compound or sealing tape to avoid damage to conductors. All communication cables used shall have a clearly marked label securely fixed near each end in accordance with the cable network diagram.

All cables and wires shall be adequately protected from the edges of equipment housing or other surrounding objects. All of the cables and wires shall be neatly arranged and

securely placed in such a way that all terminals are relieved of the weight of the cables. Terminals shall be coded and identified according to wiring diagrams. Live metal shall be recessed or protected to avoid accidental contact.

2.12 Grounding

All exposed metal not forming part of the electrical circuitry, including equipment enclosures, cable supports, structure and pole shall be grounded to the earth.

Equipment which is supplied with voltages of 100 volt or more shall be provided with grounding terminals insulated from their frames. The central equipment shall be equipped with a grounding terminal of earth resistance of 10 ohms or less. Field equipments shall be also equipped with a grounding terminal of earth resistance of 10 ohms or less.

Compensation for furnishing and installing grounding equipment shall be included in the prices of various bid items and no separate payment shall be made therefore.

2.13 Protecting against Lightning

All outdoor equipment shall incorporate gap arresters or other suitable device approved by the Project Manager to prevent lightning damages which may enter through input AC lines, communication cables, signal cables, detector feeder cables or other metallic elements exposed to the open air. Likewise, surge arrester or other suitable protection device against lightning shall be provided to the suitable points of the local area network and to the devices that could be subjected to the surge caused by the lightning.

Compensation for furnishing and installing lightning protection equipment shall be included in the Contract Price and no separate payment shall be made therefor.

2.14 Cabinets

All equipment cabinets for outdoor uses shall have the protection code specified with smooth exterior and adequate protection against moisture condensation. The cabinet shall be made of hot-rolled mild steel plate complying with JIS G 3131 or equivalent having thickness of 2.3 t or stainless steel plates of adequate thickness. Steel plate cabinets shall be treated with abrasive blasting before zinc thermal painting complying with JIS H 8300 or equivalent. Then two coating of polyurethane resin enamels and varnishes shall be applied before the cabinet is painted in final color.

Past experience has indicated that condensation may develop inside a completely enclosed outdoor cabinet connected with underground conduit due to breathing effect which is caused by a change in ambient temperature even when the conduit is sealed by foamed sealant. The Tenderer shall state in his Technical Proposal how he will overcome this problem

Cabinet doors shall permit complete access to the interior of the cabinet and shall encompass essentially the whole area of the front surface of the cabinet. All door hinge

pins shall be of stainless steel construction.

All outdoor equipment cabinets shall be equipped with a build-in lock. All cabinets for the same type of equipment shall have an identical lock. The specified number of keys for each type of cabinet shall be furnished to the Project Manager.

2.15 Radio Interference

All data processing and transmission equipment shall be designed to prevent radio interference with the satisfactory operation of other equipment regardless of whether the interference is due to radiation, induction or conduction.

Vehicle detector units shall be designed to operate normally in the presence of radio interferences.

2.16 Metering

All electrical and electronic equipment shall be provided with waveforms, voltage test points or voltage meters as necessary for indicating circuit conditions.

2.17 Unit of Measurement

In all documentations, correspondences, technical schedules and drawings, metric units of measurement shall be employed. On drawings where other units have been used, the metric equivalent shall be marked in addition.

2.18 Expressway widening

The Da Nang – Quang Ngai Expressway is planned to be widened in the future. The widening will take place toward outside of the expressway being designed. Thus, the shoulder of the initial stage will become new carriageway after widening. The Contractor shall take widening into consideration and select the equipment installation location and cable route carefully so as to avoid the interruption of operation and minimize the waste of resources due to the widening work.

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1. Closed Circuit Television (CCTV) Camera System

1.1 General

This specification covers closed circuit television (CCTV) camera system to be installed as one of the sub-systems of the Intelligent Transport System. The CCTV camera system will be introduced in the Project with following objectives.

- (1) To visually monitor road, traffic and weather conditions on the road in the Da Nang – Quang Ngai Expressway (DQE) from the Main Management Center located at Da Nang city,
- (2) To detect abnormal conditions on the expressway within the coverage of CCTV camera in order to take necessary actions such as lane control, road closure, etc. in case any incidents occur,
- (3) To confirm traffic flows on the expressway by live camera images to provide drivers with information when the incident area is identified, and
- (4) To share live camera images among the Main Management Center (MMC) and Management Office (MO) for proper expressway operation.

The CCTV camera will be placed at merging and diverging points on main carriageway neighboring to interchange which is one of most accident prone areas in the expressway. The CCTV camera will be installed at same locations with traffic detector to effectively monitor actual traffic flows and abnormal conditions visually. Apart from these locations, the CCTV camera will be located at flood prone areas, deep cut sections and tunnel portal sites in order to confirm water logging situation, disaster situation or conditions around tunnel section by image.

The images taken by camera shall be transmitted to the MMC on real time basis. In the MMC, images are selectively shown on the monitor display of CCTV console and monitor screens. At the same time, images from all cameras shall be recorded on the storage device in Network Video Recorder (NVR). The system shall operate on a 24-hour a day 7-day a week basis. The CCTV camera system shall be IP based.

1.2 System Requirements

System requirements of the CCTV camera system are as follows.

- (1) The CCTV camera system shall collect real-time camera image from each CCTV camera located at roadside and can monitor and control the camera images in the MMC and MO.
- (2) The CCTV camera shall be equipped with zoom and pan-tilt functions (PTZ functions) to secure wider area and longer distance coverage.
- (3) The CCTV camera shall have functionality to take images in night time and

connectivity with high-capacity communication network.

- (4) The CCTV camera devices shall be easily available in Vietnam.
- (5) The live camera images collected by the system can be shared among road operators and traffic polices, etc. in the MMC and provided to the public through internet.
- (6) The camera device with soft encoder shall be put on the top of gantry structure of VMS or individual supporting pole. The supporting structure with enough length must be provided to keep good visibility.
- (7) The CCTV camera must be placed at the location where visibilities to both bounds on the road are kept as much as possible.

1.3 System Configuration

The CCTV camera system shall consist of the following components;

- (1) CCTV camera with controller and supporting structure installed at roadside;
- (2) Network Video Recorder (NVR) in MMC;
- (3) CCTV center controller with application software in MMC;
- (4) Monitor screens in MMC;
- (5) Network equipment; and
- (6) Power supply equipment and peripherals.

A total of 33 cameras shall be provided in the Project. The CCTV camera system would be configured as figure below.

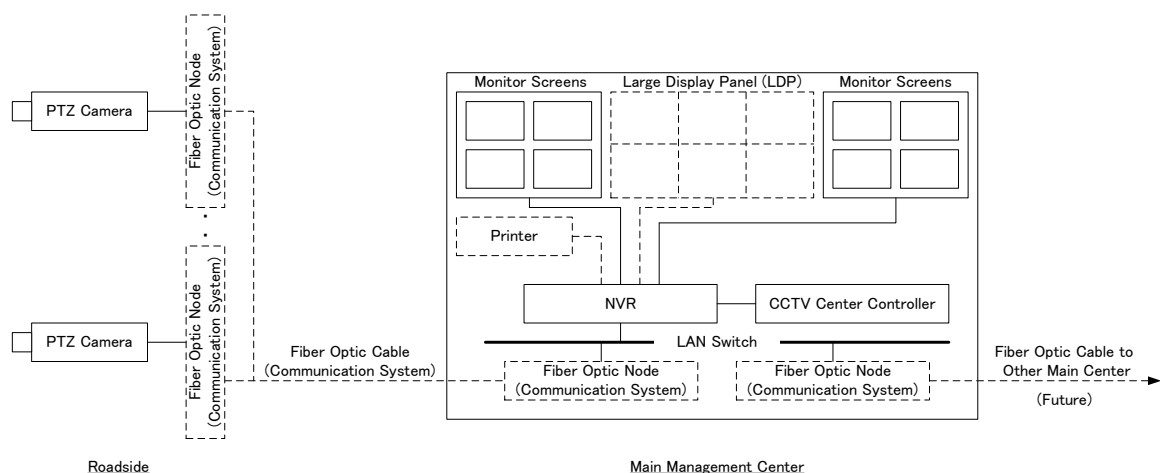


Figure 1-1 CCTV System Configuration

1.4 Camera Location

The CCTV camera shall be installed at the locations listed below.

Table 1-1 CCTV Camera Locations

Km	Category	Remarks	Km	Category	Remarks
0+500	Tuy Loan IC and Flood Area	On South-Bound	41+600	Ha Lam IC	On North-Bound with VMS, Vehicle Detector
1+400	Flood Area	On North-Bound	63+740	Tam Ky IC	On South-Bound with VMS, Vehicle Detector
3+600		On South-Bound	65+200		On North-Bound with VMS, Vehicle Detector
5+550		On North-Bound with Vehicle Detector	82+230	Chu Lai IC	On South-Bound with VMS, Vehicle Detector
7+500		On South-Bound	83+700		On North-Bound with VMS, Vehicle Detector
9+600		On North-Bound	101+000	Dung Quat IC	On South-Bound with VMS, Vehicle Detector
11+000		On South-Bound	102+440		On North-Bound with VMS, Vehicle Detector
12+580	My Son IC and Flood Area	On South-Bound with VMS, Vehicle Detector	110+600	Falling Stone Area	On North-Bound
14+100		On North-Bound with VMS, Vehicle Detector	111+700	Falling Stone Area	On South-Bound
15+200	Flood Area	On South-Bound	113+200	Falling Stone Area	On North-Bound
16+400		On North-Bound	123+040	Quang Ngai N IC	On South-Bound with VMS, Vehicle Detector
18+500		On South-Bound	124+500	Quang Ngai N IC and Flood Area	On North-Bound with VMS, Vehicle Detector
19+800		On North-Bound	125+800	Flood Area	On South-Bound
22+200	Tunnel Entrance	On South-Bound with VMS Entrance = 22+485	127+300		On North-Bound
23+300	Tunnel Entrance	On North-Bound with VMS Entrance = 23+037	129+720	Quang Ngai IC Diverging and Merging	On South-Bound with VMS, Vehicle Detector
34+000	Falling Stone Area	On North-Bound	131+180		On North-Bound with VMS
40+150	Ha Lam IC	On South-Bound with VMS, Vehicle Detector			

The detailed locations of CCTV camera are indicated on the **Employer's Requirement Part D: Drawings**. The locations shown on the **Employer's Requirement Part D: Drawings** are tentative and the Contractor shall examine and select the camera location and obtain the approval from the Project Manager.

The camera shall be installed either on the top of gantry structure for VMS or on the individual pole. The CCTV camera on the VMS gantry structure will be basically placed at the median of road and the camera installed on the individual pole will be placed at road shoulder. Regardless of installation method, CCTV camera must be placed at the location where visibilities to both bounds on the road are kept as much as possible.

The individual pole must be equipped with steel ladder to ease the maintenance work of CCTV camera. In any installation cases, clearance of 5.5 meters from road surface shall be secured.

1.5 Specifications

1.5.1 General

(1) Power supply

The electrical power supply system for the CCTV roadside equipment located closely to power receiving point shall consist of AC commercial power with Diesel Engine Generator (DEG) and Uninterruptible Power Supply (UPS) backup system which will be provided by other sub-system or other contract package. The CCTV roadside equipment shall operate with AC single-phase two-wire system 220 V \pm 10% 50Hz.

The solar power supply system with backup battery shall be provided for the power supply to CCTV roadside equipment to be located at far from power receiving points. The solar power supply system shall consist of solar cell panel, battery, distribution panel including charge/discharge controller, inverter and power units. The solar power supply system must be equipped with enough capacity of battery to supply power for a period of 10 days or longer in case of non-sunshine conditions. A total of 13 sets of solar power supply system shall be provided in the Project.

The Tenderer shall present the calculation of power consumption and capacity of solar cell panel and battery to be used for the CCTV camera system.

(2) Communication

The image transmission of the CCTV camera system shall be made through the fiber optic network provided by other sub-system. The media converter shall be provided in the CCTV camera system to connect CCTV camera with nearest Fiber Optic Node (FON) of the fiber optic network. The live image compressed into H.264/MPEG-4 or M-JPEG format at CCTV roadside equipment shall be transmitted to the MMC.

1.5.2 System Functions

CCTV system shall be provided with the functions described below.

(1) Monitoring function

The road and traffic conditions images taken by CCTV cameras on the expressway shall be transmitted as video signal to the NVR at the MMC through the communication network. The CCTV center controller via the NVR shall be capable of selecting video signal from any CCTV camera to be displayed on the display monitor of the CCTV center controller console and monitor screens.

Sequential display function shall be provided to the CCTV camera system. The sequential display function shall allow the video image from the multiple cameras to be sequentially displayed at a pre-set interval. It shall be possible to select the cameras for sequential display and to set the display time of the image from each camera.

Character generating function shall be provided to the CCTV central equipment to superimpose camera location name over the video image.

The CCTV display monitor on the console and monitor screens shall have multiple screen capability and shall display either one image or four images at a time. The image on the monitor screens shall be controlled by the CCTV center controller console.

(2) PTZ control function

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

(3) Image recording and retrieval

All images shall be automatically recorded in the storage device of the NVR with camera ID and time stamp. Frame rate of the video signal can be reduced to one frame per second or minute to reduce the requirements for the storage capacity required. Images shall be stored for minimum one (1) week. The CCTV still image together with equipment operational status shall be also stored in the storage server of NVR.

(4) Data storage function

- All data transmitted from the CCTV roadside equipment and processed data in the MMC shall be recorded and stored in the NVR for analysis and future usage. Data retrieval and presentation software shall be provided that can easily retrieve and show the movie image and still image of the specified roadside equipment at the hour or day.
- Status of roadside equipment (normal or malfunctioned) shall be recorded in the NVR as operation log and for future reliability analysis together with error code and time stamp. The equipment status information shall be transferred to facility management server of traffic management center system.

Data Sub-system	Storage Data	Type	Storage Period
CCTV camera system	CCTV video image	Raw Data	3 days
	CCTV still image	Raw data	2 years
	Equipment operational status	Raw data	

(5) Diagnosis

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

The Tenderer shall state in his Technical Proposal, the types of error and malfunction of the CCTV camera System that can be diagnosed from the CCTV center controller. The CCTV center controller and the NVR shall also have self diagnosis function of the server.

(6) Display and reporting functions

- The CCTV center controller shall be capable of showing the following screens:

Item	Contents
Route map	<ul style="list-style-type: none"> Schematic road map of DQE Name and station number of interchanges and toll barriers
Equipment location and status	<ul style="list-style-type: none"> Location of CCTV cameras and location of selected camera Status of CCTV cameras
CCTV video image	<ul style="list-style-type: none"> Video image from the CCTV camera selected with camera ID Video image from the video recorder with camera ID, date and time Video image from the CCTV camera selected with camera ID and event data such as traffic congestion received from the traffic management system server
Error log	<ul style="list-style-type: none"> Error record
Date and Time	<ul style="list-style-type: none"> Current date and time

- The CCTV center controller shall produce the reports listed below. The reports shall be output according to the schedule or upon the system operator's request by the CCTV center controller consol. It shall be possible to output the report as a file in portable document file format:

Item	Contents
Error log	<ul style="list-style-type: none"> List of CCTV camera currently not in operation Error record

1.5.3 Technical Specifications

(1) CCTV Roadside Equipment

- General

No.	Item	Specifications
1.	Power supply	Input voltage: 220 V \pm 10% AC, 50Hz or DC 24 V
2.	Protection class	IP 65 or higher
3.	Ambient operating temperature	0 - 50 degree Celsius
4.	Ambient operating humidity	90 % or less (non-condensing)

- CCTV camera and controller

No.	Item	Specifications
1.	Imaging Device	CCD or CMOS
2.	Effective Pixels	768 (H) x 494 (V) or more
3.	Scanning area	3.59 mm (H) x 2.70 mm (V) or larger
4.	Resolution	VGA: 640 x 480, QVGA: 320 x 240
5.	Minimum illuminance	0.5 lx (color), 0.1 lx (white/black mode) or lower
6.	Video S/N ratio	50 dB or more
7.	Pan driving range	360 degree endless turning, maximum speed 120 deg./sec or more
8.	Tilt driving range	+5 (upward) to -90 (downward) degree or more, maximum speed 120 deg./sec or more
9.	Lens Type	Autofocus lens
10.	Zoom Factor	Optical 30x/ digital 10x or more
11.	Focal length	3.8 to 114 mm or longer
12.	Iris	Auto
13.	Compression system	JPEG, MPEG-4/H.264
14.	Line bit rate	64 / 128 / 256 / 512 / 1024 / 2048 / 4096 kbps
15.	Protocol	TCP/IP, UDP/IP, HTTP, RTP, FTP, SMTP, DHCP, DNS, DDNS, NTP, SNMP
16.	FTP client	Alarm image transmission, FTP periodical transmission
17.	Image distribution	MPEG-4/ H.264: Uni-cast/ multi-cast JPEG: Pull/push
18.	Frame rate	0.1 fps – 30 fps
19.	LAN interface	10 BASE-T/100BASE-TX (RJ-45) x 1port
20.	Power Consumption	50 VA or less
21.	Reliability and maintainability	MTBF: 30,000 hours MTTR: 1.0 hour

• Network Equipment (Media Converter)

No.	Item	Specifications
1.	LAN interface	10 BASE-T/100BASE-TX (RJ-45) x 4ports or more
2.	Network interface	100BASE-FX (SC) x 2ports or less
3.	Transmission speed	100Mbps
4.	Maximum segment length	10km (Single mode fibre) or more
5.	Power consumption	10VA or less

• Camera Housing and Cabinet

The CCTV camera shall be housed in a camera housing which is rugged and withstand

adverse weather conditions.

- The camera housing shall be electrically and mechanically robust and shall have a degree of protection of IP 65.
- The anti-lightning and surge protection complying with the IEC 61643-1 shall be provided.
- The camera housing shall be finished with the anticorrosive treatment. **The Tenderer shall state the details of the anticorrosive treatment and painting.**

CCTV controller shall be housed in a cabinet together with power supply units and network equipment.

- The cabinet shall be electrically and mechanically robust and shall have a degree of protection of IP 55 or higher specified in IEC60529.
- If necessary, the cabinet may be provided with a ventilation fan for controlling internal temperature but the protection code requirements shall be met.
- A right hinged door shall be provided on the front to realize easy maintenance work. The turning direction of the handle shall be counter clockwise.
- The power supply unit shall be provided with a circuit breaker.
- The anti-lightning and surge protection complying with the IEC 61643-1 shall be provided.
- The cabinet shall be finished with the anticorrosive treatment. **The Tenderer shall state the details of the anticorrosive treatment and painting.**

• Solar Power Supply System

The specifications in this section are provided as reference. The solar power supply system to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Project Manager.

No.	Item	Specifications
1.	Solar battery cells	
(1)	Type	Silicone mono-crystalline or multi-crystalline, water proof, moisture proof
(2)	Capacity	To be proposed by the Contractor depending on power consumption of CCTV Camera
(3)	Converting power efficiency from solar energy	- 14 % or more in cell base - 10 % or more in module base
(4)	Withstand voltage	2 kV - 1 minute
2.	Array structure or small module structure	To be provided for adjusting tilting angle of solar battery cell
3.	Control panel	

(1)	Type	A metal enclosure
(2)	Function	<ul style="list-style-type: none"> - Over-charging and discharging protection scheme for the storage battery - Metering scheme (e.g., solar battery open circuit voltage, solar battery short circuit current, storage battery charging/discharging current, storage battery voltage, etc.) - Obstruction scheme for counter-current from storage battery to solar battery (Suitable reserve current blocking diode having small voltage drop shall be applied) - Circuit protection scheme with molded case circuit breaker etc. - Fault indication and status indication scheme (i.e. fault emitting diode (LED) instead of lamp shall be utilized to save power consumption).
4.	Ambient operating humidity	
(1)	Type	Lead-acid battery
(2)	Capacity	To be equipped with enough capacity to supply power for a period of 10 days or longer in case of non-sunshine conditions
(3)	Circuit voltage	DC 24V

(2) CCTV Center Equipment

• General

No.	Item	Specifications
1.	Power supply	Input voltage: 220 V \pm 10% AC, 50Hz Backup power supply: DEG and UPS backup
2.	Ambient operating temperature	10 - 35 degree Celsius
3.	Ambient operating humidity	70 % or less (non-condensing)

• CCTV Center Controller and Network Video Recorder (NVR)

The CCTV center controller and NVR shall be standard models manufactured by organizations of international repute. Custom built or non-standard equipment shall not be acceptable.

The computer hardware shall be readily available in Vietnam. Full maintenance support services and ready availability of consumables, spare parts or replacement units shall also be assured from a third party, based in Vietnam; who is not connected with the Contractor and his agent.

The specifications in this section are provided as reference. The server to be provided by the Contractor shall materially comply with these specifications and shall be subject to

the approval by the Project Manager.

No.	Item	Specifications
1.	Server configuration	<ul style="list-style-type: none"> • Latest redundant server with automatic failover ability • Prominent manufacturer • 10 years hardware supporting warranty • Readily available in Vietnam • Rack mount type enclosure • Low energy consumption
2.	Processor	<ul style="list-style-type: none"> • Latest stable multi core or CPU type processor • Having enough ability to process all required work without any delay.
3.	OS	<ul style="list-style-type: none"> • Latest LINUX stable operating system or Latest Windows Server stable operating system • 10 years supporting warranty
4.	Memory	<ul style="list-style-type: none"> • ECC memory • Having enough ability to process all required work without any delay, and enough space in operation.
5.	Storage	<ul style="list-style-type: none"> • Having twice of sufficient volume to process all required work and store all required data including temporary data by OS and application in operation. • Having latest stable and high speed interface as for real-time operation. • Data recovery system like RAID5.
6.	Back-up	<ul style="list-style-type: none"> • High speed and large capacity device for periodical data backup • Software driven data mirroring mechanism to meet the availability criteria mentioned below in case of site outage
7.	Graphic card	<ul style="list-style-type: none"> • Two or more video interfaces as RGB Analogue, DVI-D or HMDI to connect display devices. • Video interface must support video switches and maintenance display monitor to display pixel to pixel matching full HD images.
8.	Peripheral	<ul style="list-style-type: none"> • DVD of high speed and high capacity multi drive supporting latest standard • High speed and large capacity device for periodical data backup
9.	Availability	<ul style="list-style-type: none"> • Hot-plug, redundant power supplies • Hot-plug, redundant FAN • Hot-plug drive bays
10.	Network	<ul style="list-style-type: none"> • 1000/100M Base LAN interface • Dual LAN interface
11.	Security	<ul style="list-style-type: none"> • Virus protection • Firewall

No.	Item	Specifications
12.	Reliability	<ul style="list-style-type: none"> • MTBF > 5 years x 365 days x 24 hours = 43,800 hours as a redundant server • MTTR < 12 hours • Monitoring temperature of CPU & inside casing, FAN moving, HD status, Memory status, peripheral status • Alerting function when faults. • Latest SNMP supporting
13.	System availability	<ul style="list-style-type: none"> • Expected rate of operation as a redundant server > 99.97% =MTBF/(MTBF+MTTR)
14.	Serviceability	<ul style="list-style-type: none"> • Onsite support service. • Automatically alert the service center without human intervention when the system experiences a system fault.
15.	Power Consumption	<ul style="list-style-type: none"> • 2KVA or less as a whole redundant server
16.	Remark	<ul style="list-style-type: none"> • All equipment is mounted in 19-inch type server rack.

• CCTV Center Controller Console

The CCTV center controller console shall be standard models manufactured by organizations of international repute. Custom built or non-standard equipment shall not be acceptable.

The specifications in this section are provided as reference. The CCTV center controller console to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Project Manager.

No.	Item	Specifications
1.	PC configuration	<ul style="list-style-type: none"> • Latest PC • Prominent manufacturer • 5 years hardware supporting warranty • Readily available in Vietnam • Space saving type enclosure • Low energy consumption
2.	Processor	<ul style="list-style-type: none"> • Latest stable multi core or CPU type processor • Having enough ability to process all required work without any delay.
3.	OS	<ul style="list-style-type: none"> • Latest Windows stable operating system • 5 years supporting warranty
4.	Memory	<ul style="list-style-type: none"> • Having enough ability to process all required work without any delay, and enough space in operation.
5.	Storage	<ul style="list-style-type: none"> • Having twice of sufficient volume to process all required work and store all required data including

No.	Item	Specifications
		temporally data by OS and application in operation. <ul style="list-style-type: none"> Having latest stable and high speed interface as for smooth operation.
6.	Graphic card	<ul style="list-style-type: none"> Three or more video interface as RGB Analogue, DVI-D or HDMI to connect display device. Video interface must support video switches and console display monitor to display pixel to pixel matching full HD images.
7.	Console Display Monitor	<ul style="list-style-type: none"> Two or more monitors that are 24-inch or more size of LCD type widescreen monitor (Full HD) RGB Analogue, DVI-D or HDMI required as input interface that should be same as of video interface.
8.	Peripheral	<ul style="list-style-type: none"> DVD of high speed and high capacity multi drive supporting latest standard
9.	Network	<ul style="list-style-type: none"> 1000/100M Base LAN interface
10.	Security	<ul style="list-style-type: none"> Virus protection Firewall
11.	Reliability	<ul style="list-style-type: none"> MTBF > 3 years x 365 days x 24 hours = 26,280 hours MTTR < 24 hours Monitoring temperature of CPU & inside casing, HD status. Alerting function when faults. Latest SNMP supporting
12.	System availability	<ul style="list-style-type: none"> Expected rate of operation > 99.90% $= \text{MTBF} / (\text{MTBF} + \text{MTTR})$
13.	Serviceability	<ul style="list-style-type: none"> Onsite support service.
14.	Power Consumption	<ul style="list-style-type: none"> 500VA or less

The Contractor shall provide the required number of camera controller keyboard to be used to select and control cameras and control NVR. The camera controller keyboard shall have the following features:

- Pan, tilt, and zoom control of camera
- 3-D Joystick to control PTZ
- Digital video recorder control
- Video switches control
- RS-232, RS-422, RS-485, or Ethernet interface

1.5.4 Quality

CCTV camera system shall be designed to operate 24 hours a day and 7 days a week without shutdown. Thus high reliability and availability shall be achieved.

Design target of MTBF in a total system shall be 3×10^4 hours or better except the mechanical part of pan-tilt head. Expected MTBF shall be calculated based on the announced reliability of parts and component, or operation record of similar products.

Availability of the system and each camera shall be 99 % or better.

1.5.5 Acceptance Test

Camera, camera housing, pan-tilt head, CCTV camera roadside equipment in a whole system and CCTV center equipment shall be subjected to the test before acceptance. Test shall be conducted at factory, during installation work and upon completion depending on the test item. Two types of test, function and performance test and general test shall be conducted.

Details of the test item, test procedure and criteria to judge test result shall be proposed by the Contractor subject to the approval by the Employer.

(1) Function and Performance Test

In principle, function and performance requirement stated above shall be tested. More specifically, the following tests shall be conducted as minimum:

- Resolution
- Color
- Wiper control
- Maximum pan and tilt angle and speed
- Remote control
- Video switching function
- Video recording

(2) General Test

The following general tests shall be conducted as minimum:

- Appearance
- Power supply fluctuation
- Instantaneous power interruption
- Insulation resistance
- Dielectric strength
- Temperature variation
- Water proof test (roadside equipment)

2. Vehicle Detection System

2.1 General

This specification covers vehicle detection system to be installed as one of the sub-systems of the Intelligent Transport System in the Da Nang – Quang Ngai Expressway (DQE). The vehicle detection system will be introduced in the Project with following objectives.

- (1) To measure the traffic volume between interchanges to be used for planning on future road widening or other expressway improvement works,
- (2) To analyze the current traffic flow from measured traffic volume and average travelling speed, and provide necessary information to drivers on the expressway or intending to enter the expressway for diverting their traveling route from congested road section,
- (3) To measure large-sized vehicle traffic for planning of future asphalt repair or other necessary road facility maintenance,
- (4) To identify abnormal conditions at expected accident prone areas on the expressway from average traveling speed and occupancy ratio, and
- (5) To share the above measured and analyzed traffic information with expressway planning agencies, expressway operators and other relevant authorities.

The vehicle detection roadside equipment shall detect, count and classify vehicles within its sensing area. The traffic flow parameters measured by the vehicle detection roadside equipment shall be transmitted to the traffic analysis processor in the Main Management Center (MMC). The system shall operate on a 24-hour a day 7-day a week basis.

It shall be the responsibility of the Contractor to furnish all necessary hardware and software, install equipment at the specified location, provide necessary wiring, integrate all system components, and deliver a complete operational vehicle detection system.

2.2 System Requirements

System requirements of the vehicle detection system are as follows.

- (1) The vehicle detection system shall measure and analyze following traffic information. Unit duration of measurement, detection and calculation shall be within one (1) minute.
 - Traffic Volume
 - Large-sized Vehicle Traffic
 - Vehicle Speed
 - Traffic Congestion

- (2) The vehicle detection system shall measure both inbound/outbound traffic volumes on the expressway between interchanges. Also, the system shall measure each lane traffic volume.
- (3) The vehicle detection system must measure and detect required traffic information above even under complex traffic and road conditions on the expressway.
- (4) The measured traffic data can be monitored in the MMC, which will be organized by expressway planning agencies, expressway operators and traffic polices, on real-time basis. Also, the data can be stored for a certain period in order to utilize for road planning and road operation and maintenance activities.
- (5) The traffic information measured and analyzed by the vehicle detection system can be provided road users through Variable Message Sign (VMS) System and other information provision systems.
- (6) The vehicle detection roadside equipment can be easily installed at roadside and shall have advantages in its operation and maintenance. The maintenance work on the carriageway for the vehicle detector must be avoided.
- (7) An ultrasonic type vehicle detector shall be adopted in the Project. Two (2) sets of detector for each lane shall be installed to identify the large-sized vehicle.
- (8) The detector will be either mounted on the dedicated pole installed at road shoulder or on the gantry structure together with VMS and CCTV camera.
- (9) The detection target shall be vehicles passing through the sensor area at a speed not less than 1 km/h and not more than 120 km/h.
- (10) The vehicle detection system shall detect the large-sized vehicle of which length is 5.5 meters or longer.

2.3 System Configuration

The vehicle detection system shall consist of the following equipment;

- (1) Ultrasonic type detector and vehicle detector unit with supporting structure at roadside;
- (2) Traffic analysis processor installed in the MMC;
- (3) Network equipment;
- (4) Power supply unit and peripheral.

The vehicle detection roadside equipment shall be placed at 14 locations in the Project. The vehicle detection system would be configured as Figure below.

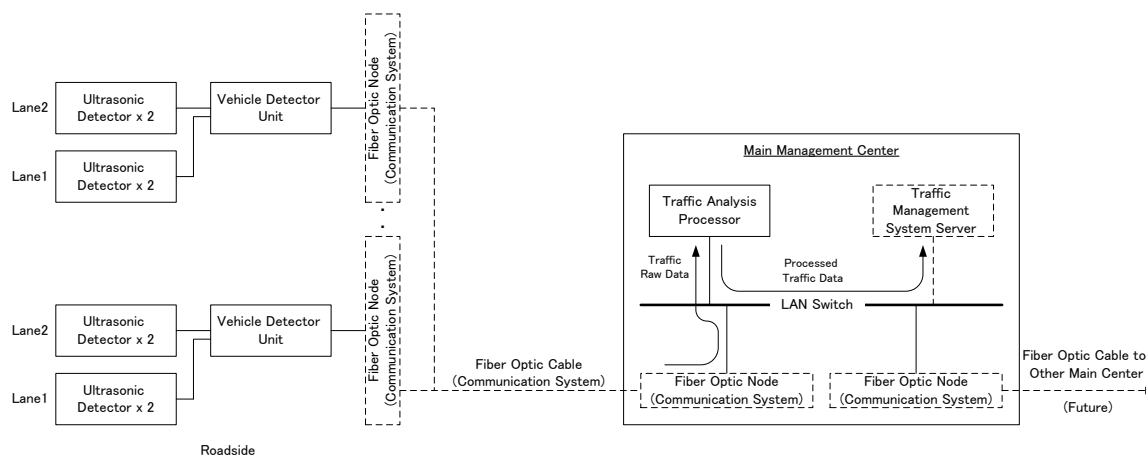


Figure 2-1 Vehicle Detection System Configuration

The vehicle detector and vehicle detection unit shall be fully interchangeable except minor adjustment, and the combination of the detector and processing unit shall not be fixed. It shall be possible to connect detector to any vehicle detection unit. No periodical manual adjustment shall be required for the detector and vehicle detection unit.

The traffic analysis processor shall be provided to the MMC for receiving pre-processed data from the vehicle detection roadside equipment. IP based network equipment shall be provided to connect the roadside equipment with the traffic analysis processor through fiber optic network.

2.4 Location of Vehicle Detection Roadside Equipment

The vehicle detection roadside equipment shall be installed at the locations listed below.

Table 2-1 Locations of Vehicle Detection Roadside Equipment

Section \ Bound	North Bound	South Bound
Tuy Loan – My Son	2 lanes at 5+550 with CCTV	2 lanes at 12+580 with VMS,CCTV
My Son – Ha Lam	2 lanes at 14+100 with VMS,CCTV	2 lanes at 40+150 with VMS,CCTV
Ha Lam – Tam Ky	2 lanes at 41+600 with VMS,CCTV	2 lanes at 63+740 with VMS,CCTV
Tam Ky – Chu Lai	2 lanes at 65+200 with VMS,CCTV	2lanes at 82+230 with VMS,CCTV
Chu Lai – Dung Quat	2 lanes at 83+700 with VMS,CCTV	2 lanes at 101+000 with VMS,CCTV
Dung Quat – Quang Ngai N	2 lanes at 102+440 with VMS,CCTV	2 lanes at 123+040 with VMS,CCTV
Quang Ngai N – Quang Ngai	2 lanes at 124+500 with VMS,CCTV	2 lanes at 129+720 with CCTV

The detailed locations of vehicle detection roadside equipment are indicated on the **Employer's Requirement Part D: Drawings**. The locations shown on the **Employer's Requirement Part D: Drawings** are tentative and the Contractor shall examine and select the locations and obtain the approval from the Project Manager.

The vehicle detector shall be installed either on a supporting steel pole together with CCTV camera or on a gantry structure for VMS. The vehicle detectors for each lane detection shall be basically put on same supporting steel pole or gantry structure. The supporting steel pole and gantry structure must be equipped with steel ladder to ease the maintenance work of vehicle detector. In any installation cases, clearance of 5.5 meters from road surface shall be secured.

2.5 Specifications

2.5.1 General

(1) Power supply

The electrical power supply system for the vehicle detection roadside equipment and the traffic analysis processor in the MMC shall consist of AC commercial power with Diesel Engine Generator (DEG) and Uninterruptible Power Supply (UPS) backup system which will be provided by other sub-system or other contract package. The roadside equipment and traffic analysis processor shall operate with AC single-phase two-wire system 220 V $\pm 10\%$ 50Hz.

The Tenderer shall present the calculation of power consumption to be used for the vehicle detection system.

(2) Communication

The data transmission of the vehicle detection system shall be made through the fiber optic network provided by other sub-system. The media converter, which will be provided in the CCTV camera system, shall be used to connect vehicle detector unit with nearest Fiber Optic Node (FON) of the fiber optic network.

2.5.2 System Functions

The vehicle detection system shall be provided with the functions described below.

(1) Traffic data measuring and processing functions at roadside

- The vehicle detector shall continuously transmit ultrasonic waves and receive the waves reflected from objects or the road surface to detect vehicles passing.
- Signals generated by the vehicle detector shall be processed to obtain the required traffic data in the vehicle detector unit. The processing unit shall be capable of:
 - Detecting vehicle running under the detector:
 - Counting the number of vehicles that pass the sensing area during the unit measurement time on a lane basis.
 - Classifying the vehicle into large and small size. The definition of the large and small size shall be made according to the vehicle length and the classification

parameter shall be adjustable.

- Calculating the time occupancy rate per unit measurement time.
- Calculating an average speed per unit time which is an average of the speed of vehicles passed in the past unit measurement time.
- The system shall detect vehicles, measure and calculate the required traffic data above separately for each lane.
- Unit duration of detection, measurement and calculation shall be within one (1) minute.
- The vehicle detection system is expected to have an overall detection accuracy of 95 % or better in vehicle counting for any types of vehicles to pass the road except vehicles running in the opposite direction and completely hidden vehicles owing to overlapping. **The Tenderer shall state in his Technical Proposal, the proposed overall detection accuracy of vehicle detection system.**

(2) Data transmitting function

- Following data pre-processed at roadside shall be periodically transmitted to the traffic analysis processor installed in the MMC.
 - Traffic volumes in every 1 minute
 - Large-sized vehicle traffic in every 1 minute
 - Time occupancy rate in every 1 minute
 - Vehicle average speed in every 1 minute
 - Equipment failure
 - Other necessary data
- Unit time period of data transmitting shall be of one (1) minutes.

(3) Data collecting function

- The traffic analysis processor shall collect the data from the vehicle detection roadside equipment at the unit measurement interval above. The unit measurement time shall be a system parameter and shall be adjustable.
- Should traffic data collected be lower or higher than the predetermined threshold, the traffic analysis processor shall issue an alarm to the monitor display as abnormal transmitted data.

(4) Data processing and management functions

- The traffic analysis processor shall process the traffic data collected from the vehicle

detection roadside equipment and identify the traffic congested section from average speed and time occupancy ratio data with following processing flow and algorithm or equivalent.

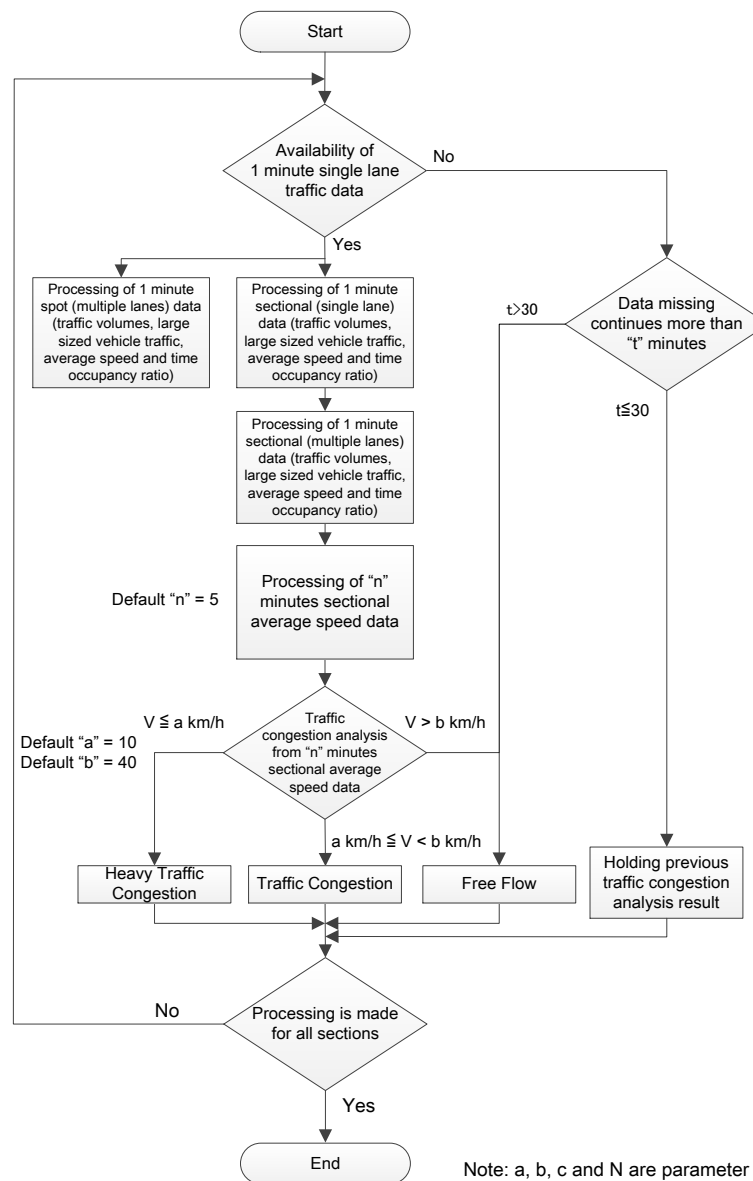


Figure 2-2 Traffic Data Processing and Congestion Analysis Flow and Algorithm

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

- To avoid the fluctuation of analysis results, the average speed data for certain period (n) must be utilized in the processing. The default of the time period is initially set as five (5) minutes and this value must be changeable.
- The analysis result is classified into three (3) traffic congestion levels, that is, “Heavy Traffic Congestion”, “Traffic Congestion” and “Free Flow”. The thresholds of traffic congestion level, “a” and “b” are tentatively set as 10km/h and 40km/h respectively in initial stage. Also, those thresholds must be variable

and determinable by each location since average speed may differ according to the road conditions, alignment, etc. at the site and would be optimized in future after collecting the enough volumes of traffic data.

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

The algorithm for traffic congestion analysis shown above are tentative and the Contractor shall examine and propose the algorithm and obtain the approval from the Project Manager.

- If the processed at a lane or a section is lower or higher than the predetermined threshold, the server shall issue an alarm to the monitor display as abnormal traffic condition.
- The (n)-minute traffic flow data shall be accumulated and converted to hourly traffic data.
- It shall be possible to monitor in real-time traffic flow data through monitor display of operation console and printed report. Traffic flow data of single and multiple lanes can be specified for monitoring. Both numerical and graphical presentation of the data shall be provided. The data on the display shall be automatically updated at unit time of data. Real-time monitoring of operating condition of vehicle detection roadside equipment shall also be possible.
- The occupancy rate to be detected in the vehicle detection system will be as reference only. It is generally said that the accuracy of traffic congestion analysis processing can be improved by utilizing both average speed and occupancy data. **The Tenderer shall state in his Proposal, proposed traffic analysis algorithm and usage of occupancy rate to be detected in the system.**

(5) Data storage function

- All data transmitted from the vehicle detection roadside equipment and processed data in the MMC shall be recorded and stored in the traffic analysis processor for analysis and future usage. Data retrieval and presentation software shall be provided that can easily retrieve and show the traffic flow data and operating condition of the specified roadside equipment location at the specified time, hour or day. Graphical presentation of historical traffic flow data such as hourly variation and daily variation shall also be possible.
- Status of roadside equipment (normal or malfunctioned) shall be recorded in the traffic analysis processor as operation log and for future reliability analysis together with error code and time stamp.

Data Sub-system		Storage Data	Type	Storage Period
Vehicle Detection system	1 minute spot (single lane) data	Traffic volume	Raw data	2 years
		Large-sized vehicle traffic		
		Time occupancy rate		
		Vehicle average speed		
	Equipment operational status		Raw data	
	1 minute spot (multiple lanes) data	Traffic volume	Processed data	
		Large-sized vehicle traffic		
		Time occupancy rate		
		Vehicle average speed		
	1 minute sectional (single lane) data	Traffic volume	Processed data	
		Large-sized vehicle traffic		
		Time occupancy rate		
		Vehicle average speed		
	1 minute sectional (multiple lanes) data	Traffic volume	Processed data	
Large-sized vehicle traffic				
Time occupancy rate				
Vehicle average speed				
“n” minutes sectional average speed		Processed data		
Traffic congestion analysis results with parameters		Processed data		

(6) Diagnosis function

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

(7) Display and reporting function

- The traffic analysis processor shall be capable of showing the following screens:

Item	Contents
Route map	<ul style="list-style-type: none"> Schematic road map of DQE Name and station number of interchanges and toll barriers
Equipment location and status	<ul style="list-style-type: none"> Location of vehicle detection roadside equipment and its status (normal / error)
Traffic conditions	<ul style="list-style-type: none"> Current traffic volume at vehicle detector location (total traffic volume and large-sized vehicle traffic volume) Current average speed in list and in map Current traffic congested section in list and in map Hourly traffic volume variation (text and in graphics) Hourly average speed variation (text and in graphics)
Operation log	<ul style="list-style-type: none"> List of roadside equipment currently not in operation Error record
Date and Time	<ul style="list-style-type: none"> Current date and time

- The processor shall produce the reports listed below. The reports shall be output according to the schedule or upon the system operator's request. It shall be possible to output the report as a file in portable document file format:

Item	Contents
Traffic volume	<ul style="list-style-type: none"> • Daily report containing hourly sectional traffic volume by vehicle class • Daily report containing hourly sectional average speed • Monthly report containing daily sectional traffic volume by vehicle class and that of the day of the week • Monthly report containing daily sectional average speed and that of the day of the week
Error log	<ul style="list-style-type: none"> • List of roadside equipment currently not in operation • Error record

(8) Data transferring function

Following data processed in the traffic analysis processor shall be stored in the database of traffic management center system for total system management at interval of 5 minutes.

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

2.5.3 Technical Specifications

(1) Vehicle detection roadside equipment

The vehicle detection roadside equipment shall be connected to the traffic analysis processor located in the MMC.

The technical specifications for vehicle detection roadside equipment mentioned hereunder are minimum guidelines. The contractor shall not deviate materially from the specifications.

- Vehicle detector and vehicle detector unit

No.	Item	Specifications
1.	Power Requirements	Input voltage: 220 V \pm 10% AC, 50Hz
2.	Power Consumption	500 VA or less

3.	Type of Detector	Ultrasonic type detector
4.	Vehicle Speed	0 - 120 km/h or better
5.	Detection Area	1 +/- 0.4 m/sensor or equivalent
6.	Wave Transmitting Cycle	60ms +/- 5ms or equivalent
7.	Half - value Angle	11.5 +/- 2 degrees or less
8.	Detector Dimensions	φ160mm
9.	LAN Interface	10BASE-T/100BASE-TX (RJ-45) x 1port
10.	Environmental conditions	0 to +50 degree Celsius
11.	Reliability and maintainability	MTBF: 30,000 hours MTTR: 0.5 hours

- Network Equipment

The data transmission of vehicle detection roadside equipment with the traffic analysis processor in the MMC shall be made through network equipment provided by the CCTV camera system.

- Housing and Cabinet

The vehicle detector shall be housed in a detector housing which is rugged and withstand adverse weather conditions.

- The detector housing shall be electrically and mechanically robust and shall have a degree of protection of IP66 or higher specified in IEC60529 “Test for protection against water for electrical equipment and degrees of protection against ingress of solid foreign objects”.
- The anti-lightning and surge protection complying with IEC 61643-1 shall be provided.
- The detector housing shall be made of anticorrosive material or finished with the anticorrosive treatment.

The vehicle detector unit shall be housed in a cabinet together with power supply unit.

- The cabinet shall be electrically and mechanically robust and shall have a degree of protection of IP 55 or higher specified in IEC60529.
- If necessary, the cabinet may be provided with a ventilation fan for controlling internal temperature but the protection code requirements shall be met.
- A right hinged door shall be provided on the front to realize easy maintenance work. The turning direction of the handle shall be counter clockwise.
- The power supply unit to feed power to each roadside equipment shall be provided with a circuit breaker.
- The anti-lightning and surge protection complying with the IEC 61643-1 shall be

provided.

- The cabinet shall be finished with the anticorrosive treatment. **The Tenderer shall state the details of the anticorrosive treatment and painting.**

(2) Traffic Analysis Processor

The traffic analysis processor shall be standard models manufactured by organizations of international repute. Custom built or non-standard equipment shall not be acceptable.

The computer hardware shall be readily available in Vietnam. Full maintenance support services and ready availability of consumables, spare parts or replacement units shall also be assured from a third party, based in Vietnam; who is not connected with the Contractor and his agent.

The specifications in this section are provided as reference. The processor to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Project Manager.

No.	Item	Specifications
1.	Server configuration	<ul style="list-style-type: none"> • Latest redundant server with automatic failover ability • Prominent manufacturer • 10 years hardware supporting warranty • Readily available in Vietnam • Rack mount type enclosure • Low energy consumption
2.	Processor	<ul style="list-style-type: none"> • Latest stable multi core or CPU type processor • Having enough ability to process all required work without any delay.
3.	OS	<ul style="list-style-type: none"> • Latest LINUX stable operating system or latest Windows Server stable operating system • 10 years supporting warranty
4.	Memory	<ul style="list-style-type: none"> • ECC memory • Having enough ability to process all required work without any delay, and enough space in operation.
5.	Storage	<ul style="list-style-type: none"> • Having twice of sufficient volume to process all required work and store all required data including temporary data by OS and application in operation. • Having latest stable and high speed interface as for real-time operation. • Data recovery system like RAID5.
6.	Back-up	<ul style="list-style-type: none"> • High speed and large capacity device for periodical data backup • Software driven data mirroring mechanism to meet the availability criteria mentioned below in case of site outage

No.	Item	Specifications
7.	Graphic card	<ul style="list-style-type: none"> Two or more video interfaces as RGB Analogue, DVI-D or HDMI to connect display devices. Video interface must support video switches and maintenance display monitor to display pixel to pixel matching full HD images.
8.	Peripheral	<ul style="list-style-type: none"> DVD of high speed and high capacity multi drive supporting latest standard High speed and large capacity device for periodical data backup
9.	Availability	<ul style="list-style-type: none"> Hot-plug, redundant power supplies Hot-plug, redundant FAN Hot-plug drive bays
10.	Display monitor	<ul style="list-style-type: none"> 21-inch or smaller size of LCD type monitor (Full HD) RGB Analogue, DVI-D or HDMI required as input interface that should be same as of video interface
11.	Network	<ul style="list-style-type: none"> 1000/100M Base LAN interface Dual LAN interface
12.	Security	<ul style="list-style-type: none"> Virus protection Firewall
13.	Reliability	<ul style="list-style-type: none"> MTBF > 5 years x 365 days x 24 hours = 43,800 hours as a redundant server MTTR < 12 hours Monitoring temperature of CPU & inside casing, FAN moving, HD status, Memory status, peripheral status Alerting function when faults Latest SNMP supporting
14.	System availability	<ul style="list-style-type: none"> Expected rate of operation as a redundant server > 99.97% $= \frac{MTBF}{MTBF + MTTR}$
15.	Serviceability	<ul style="list-style-type: none"> Onsite support service. Automatically alert the service center without human intervention when the system experiences a system fault
16.	Power supply	<ul style="list-style-type: none"> Input voltage: 220 V \pm10% AC, 50Hz
17.	Power consumption	<ul style="list-style-type: none"> 2KVA or less as a whole redundant server
18.	Ambient operating temperature	<ul style="list-style-type: none"> 10 - 35 degree Celsius
19.	Ambient operating humidity	<ul style="list-style-type: none"> 70 % or less (non-condensing)
20.	Remark	<ul style="list-style-type: none"> All equipment is mounted in 19-inch type server rack.

2.5.4 Acceptance Test

The detector, detector unit and traffic analysis processor shall be subjected to the test before acceptance. Test shall be conducted at factory, during installation work and upon completion depending on the test item. Test items will be classified into two types, function and performance test and general test.

Details of the test item, test procedure and criteria to judge test results shall be proposed by the Contractor subject to the approval by the Employer.

(1) Function and Performance Test

In principle, function and performance requirements stated above shall be tested. More specifically, the following tests shall be conducted as minimum:

- Traffic volume accuracy
- Speed detection accuracy
- Internal time adjustment function
- Malfunction detection and processing
- Interface between equipment
- Human machine interface (display screen and report)
- Recording, statistics and logging

Traffic volume accuracy and speed detection accuracy shall be conducted by comparing the actual data manually measured at the detector site and the data measured by the vehicle detector for all sensors.

In malfunction detection and processing test, all kinds of possible malfunction including power supply interruption shall be tested. A test data generator shall be used in the test to produce unrealistic measured data.

Correctness of all wirings and parameters in the database shall be confirmed as one of the interface tests and it shall be confirmed that measured data of a detector is correctly processed and stored at right place in the database.

(2) General Test

The following tests shall be conducted as minimum:

- Appearance
- Power supply fluctuation
- Instantaneous power interruption

- Insulation resistance
- Dielectric strength
- Temperature variation
- Water proof test (roadside equipment)

3. Meteorological Monitoring (MET) System

3.1 General

This specification covers meteorological monitoring (MET) system to be installed as one of the sub-systems of the Intelligent Transport System in the Da Nang – Quang Ngai Expressway (DQE). The MET system will be introduced in the Project with following objectives.

- (1) To measure weather conditions including rainfall, temperature, wind velocity/direction and visibility on the expressway,
- (2) To utilize measured meteorological data as a parameter for taking appropriate countermeasures such as road closure and maximum speed limit reduction, etc. in case hazardous weather condition is detected,
- (3) To provide the weather information to the road users thorough the information dissemination systems in order for taking cautions to them, and
- (4) To share measured meteorological data with alerting signals among expressway operators and other relevant authorities.

The MET system shall collect weather condition data at the meteorological observation stations continuously. The data collected shall be transmitted to the MET data processor at the Main Management Center (MMC) for data processing and logging. In case of adverse weather, the system shall automatically issue an alarm to the system operator. They shall operate on a 24-hour a day 7-day a week base.

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

3.2 System Requirements

System Requirements of the MET system are as follows.

- (1) The system shall measure and analyze following weather information. Unit duration of measurement, detection and calculation shall be within one (1) minute.
 - Rainfall (detection and level)
 - Air temperature
 - Wind velocity and direction
 - Visibility
- (2) The system shall measure and analyze meteorological data covering entire expressway.

- (3) The measured meteorological data can be monitored in the MMC, which will be organized by expressway planning agencies, expressway operators and traffic polices, on real-time basis. Also, the data can be stored for a certain period in order to utilize as weather statistics.
- (4) The weather and its alerting information detected and measured by the system can be provided road users through the VMS system and other information provision systems.
- (5) The meteorological monitoring sensors can be easily installed at roadside and shall have advantages in its operation and maintenance. All of meteorological monitoring sensors will be put on a supporting steel pole together.
- (6) The meteorological monitoring sensors shall be placed in the yard of MMC, Management Office (MO) or Toll Office (TO) having enough distance from carriage way or buildings to avoid obstacles or negative impacts for measurements.

3.3 System Configuration

The MET system shall consist of the following components:

- (1) Rain gauge;
- (2) Rainfall detector;
- (3) Thermometer;
- (4) Vane anemometer;
- (5) Visibility meter;
- (6) Data logger at MET observation station;
- (7) MET data processor in the MMC;
- (8) Network equipment;
- (9) Power supply equipment and peripheral.

There shall be a total of three (3) MET observation stations. The MET system would be configured as figure below.

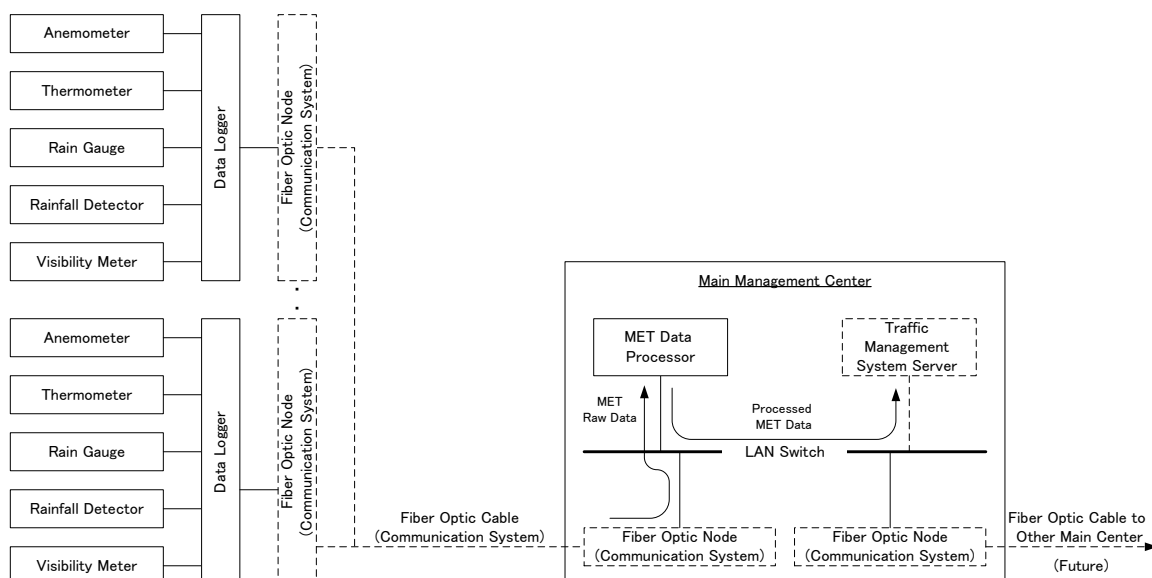


Figure 3-1 MET System Configuration

The MET data processor shall be provided to the MMC for receiving all MET data. IP based network equipment shall be provided to connect the MET observation stations with the MET data processor at the MMC.

3.4 Location of MET Observation Station

The MET observation station shall be established at the locations listed below.

Table 3-1 Locations of MET Observation Station

No.	Location	Remarks
1	Da Nang Main Management Center	
2	Tam Ky Toll Office	
3	Quang Ngai North Management Office	

The detailed locations of MET observation station are indicated on the **Employer's Requirement Part D: Drawings**. The locations shown on the **Employer's Requirement Part D: Drawings** are tentative and the Contractor shall examine and select the MET location and obtain the approval from the Project Manager.

The MET roadside equipment shall be installed as follows:

- All of meteorological monitoring sensors shall be put on a supporting steel pole together.
- The rain gauge and rainfall detector must keep 45-degree upward clearance from measuring obstacles such as buildings and trees.
- The anemometer must avoid air stream impacts receiving from passing vehicles.

- The MET observation station including communication unit, processor unit, power supply unit and other devices installed at outside other than the sensors shall be housed in a cabinet.
- The supporting steel pole with meteorological monitoring sensors and cabinet shall be enclosed with steel fence.

The Contractor shall construct MET roadside equipment at the designated locations and undertake the necessary works including wiring for data communication and power supply.

3.5 Specifications

3.5.1 General

(1) Power supply

The electrical power supply system for the MET observation station and the MET data processor shall consist of AC commercial power with Diesel Engine Generator (DEG) and Uninterruptible Power Supply (UPS) backup system which will be provided by other sub-system or other contract package. The observation station and the processor shall operate with AC single-phase two-wire system 220 V $\pm 10\%$ 50Hz. Total power consumption of MET observation station shall be 1KVA or less.

The Tenderer shall present the calculation of power consumption to be used for the MET system.

(2) Communication

The data transmission of the MET system shall be made through the fiber optic network provided by other sub-system. The media converter shall be provided in the MET system to connect MET observation stations with nearest Fiber Optic Node (FON) of the fiber optic network located at the MMC, the MO or the TO.

3.5.2 System Functions

(1) Weather measuring function

The following measurement equipment shall be provided to each meteorological observation station.

- Rain Gauge
Tipping bucket rain gauge shall be used. The rain gauge shall produce a pulse of contact signal every time precipitation reaches 0.5 mm. The signal shall be converted into voltage or current signal for transmission to the MET data processor.
- Rainfall detector
The rainfall detector shall output ON signal when rain is detected and OFF signal

when rain stops.

- Thermometer

Thermometer shall continuously measure ambient air temperature at the range of 0 to 70 degree Celsius in units of 0.1 degree. The measured data shall be sent to the MET data processor at one minute interval as current air temperature.

- Anemometer

The anemometer shall measure the wind velocity at the range of 0.4 m/sec to 70 m/sec in units of 0.1 m/sec. The anemometer shall also detect wind direction and convert it into one of 16 directions.

- Visibility meter

The visibility meter shall measure the visibility as the amount of light scattered by particles in the air and convert the measured value into the visibility in meter.

(2) Data processing function at MET observation station

The MET observation station shall perform the following process:

- Data validity check

Error checking shall be performed for the received data by comparing them with the pre-defined threshold. Threshold may include upper limit, lower limit, and variation from the previous data. The data judged faulty shall not be used as observed data.

- Calculation of hourly and cumulative precipitation

Precipitation data shall be processed into hourly precipitation and cumulative precipitation.

(3) Data transmission function

The following processed data shall be transmitted from the MET observation station to the MET data processor in the MMC at every one (1) minute.

- Hourly cumulative value of rainfall in the past one hour
- Cumulative value of rainfall from the start of rainfall
- Instantaneous value of rainfall detection on every one minute
- Instantaneous value of ambient temperature on every one minute
- Maximum and minimum value of wind speed in the past one minute
- Wind direction at the maximum and minimum wind speed
- Maximum and minimum value of visibility in the past one minute

(4) Data processing function in the MMC

The MET data processor shall gather the observed meteorological data and monitoring signal from the station at a regular interval. The data received from the station shall be converted to the physical weather data.

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

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

A warning system shall be introduced in which an alarm is issued to the system operator when the wind data or precipitation data exceeds the pre-defined threshold, or visibility becomes shorter than the pre-defined threshold. Several types and values of threshold shall be provided and the threshold shall be alterable.

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

(5) Data storage function

- All data transmitted from the MET observation station and processed data in the MMC shall be recorded and stored in the MET data processor for analysis and future usage. Data retrieval and presentation software shall be provided that can easily retrieve and show the MET data of the specified observation location at the specified

time, hour or day. Graphical presentation of historical MET data such as hourly variation and daily variation shall also be possible.

- Status of MET observation station equipment (normal or malfunctioned) shall be recorded in the MET data processor as operation log and for future reliability analysis together with error code and time stamp.

Data Sub-system	Storage Data	Type	Storage Period
MET system	Instantaneous value of ambient temperature	Raw Data	2 years
	Hourly cumulative value of rainfall	Raw Data	
	Cumulative value of rainfall from the start of rainfall	Raw Data	
	Instantaneous rainfall detection	Raw Data	
	Maximum and minimum value of wind speed	Raw Data	
	Wind direction at the maximum and minimum velocity	Raw Data	
	Maximum and minimum value of visibility	Raw Data	
	Equipment operational status	Raw data	
	Instantaneous temperature (1minute and 5minutes)	Processed data	
	Moving total precipitation for previous 1hour	Processed data	
	Total continuous precipitation	Processed data	
	Instantaneous rainfall detection (1minute and 5minutes)	Processed data	
	Maximum value of wind velocity for previous 1 minute	Processed data	
	Direction at maximum wind during previous 1 minute	Processed data	
	Instantaneous visibility (1minute and 5minutes)	Processed data	
	Heavy rain analysis results with parameters	Processed data	
	Strong wind analysis results with parameters	Processed data	
	Poor visibility analysis results with parameters	Processed data	

(6) Diagnosis function

The MET system shall have a diagnosis function. The MET data processor shall inquire the connection with the MET observation station and the status of station equipment by sending the diagnosis signal in every five (5) minute. If equipment fault signal is received or there is no response from the MET observation station, the MET data processor shall issue a warning and the fault shall be recorded in the log.

The Tenderer shall state in his Technical Proposal, the types of error and malfunction of the MET system that can be diagnosed from the MET data processor.

(7) Display and reporting function

- The MET data processor shall be capable of showing the following screens:

Item	Contents
Route map	<ul style="list-style-type: none"> • Schematic map of DQE • Name and station number of interchanges and toll barriers
Equipment location and status	<ul style="list-style-type: none"> • Location of MET observation station and its status (normal / error)
Weather conditions	<ul style="list-style-type: none"> • Current weather condition (rain, precipitation, air temperature, wind velocity, wind direction, visibility) • Historical variation of weather conditions
Operation log	<ul style="list-style-type: none"> • List of MET observation equipment currently not in operation

	<ul style="list-style-type: none"> • Error record
Date and Time	<ul style="list-style-type: none"> • Current date and time

- The MET data processor shall produce the reports listed below. The reports shall be output according to the schedule or upon the system operator's request. It shall be possible to output the report as a file in portable document file format.

Item	Contents
Meteorological data	<ul style="list-style-type: none"> • Daily report containing hourly precipitation • Daily report containing hourly maximum and minimum wind velocity, its direction and time • Daily report containing hourly maximum and minimum visibility and its time • Monthly report containing daily precipitation • Monthly report containing daily maximum and minimum wind velocity, wind direction, and time • Monthly report containing daily maximum and minimum visibility and time
Error log	<ul style="list-style-type: none"> • List of MET observation equipment currently not in operation • Error record

(8) Data transferring function

The following data processed in the MET data processor shall be stored in the database of traffic management center system for total system management at interval of 1 minute.

- 1-minute and previous 5-minutes data at each MET observation station
 - Hourly cumulative value of rainfall in past 1 hour
 - Cumulative value of rainfall from the start of rainfall
 - Instantaneous value of ambient temperature
 - Instantaneous rainfall detection
 - Maximum value of wind speed and its direction
 - Minimum value of visibility
- Alerting signals of abnormal weather conditions with parameters
 - Heavy rain
 - Strong wind
 - Poor visibility
- Equipment operational status

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

3.5.3 Technical Specifications

(1) MET observation equipment

- Rain gauge

No.	Item	Specifications
1.	Detection method	Tipping bucket type
2.	Diameter of water inlet	200 mm
3.	Tipping bucket rain gauge	0.5 mm or 1.0mm
4.	Contact output signal	No potential mark contact signal
5.	Material	Stainless
6.	Operating temperature	0 to +50 degree Celsius

- Rainfall detector

No.	Item	Specifications
1.	Detection method	Print electrode plate type
2.	Detected rain drop diameter	More than 0.5 mm diameter
3.	Output signal	No potential mark contact
4.	Power supply	Supplied from observation station
5.	Operating temperature	0 to +50 degree Celsius

- Thermometer

No.	Item	Specifications
1.	Detection method	Platinum resistance type
2.	Measurement range	0 to +70 degree Celsius in unit of 0.1 degree
3.	Specified current	2 mA
4.	Protection tube material	Stainless

- Vent sleeve for thermometer

No.	Item	Specification
1.	Method	Forced ventilation type
2.	Construction	Inside-and-outside double cylinder
3.	Ventilation speed	5 to 7 m/s
4.	Material	Corrosion resistant metal
5.	Power supply	Supplied from the observation station

- Vane anemometer

No.	Item	Specifications
1.	Detection method	Wind direction: Photo encoder type Wind velocity: Pulse type
2.	Measurement range	Wind direction: 0 to 360 degree Wind velocity: 0.4 m/s to 70 m/s in unit of 0.1 m/s
3.	Start-up velocity	Less than 0.4m/s
4.	Output signal	Type: Open collector Wind direction: 8-bit grey code Wind velocity: Pulse
5.	Material	Wind mill body: glass fibre inserted/reinforced polycarbonate resin Tail: Carbon fibre + Foamed urethane Stand: Corrosion resistant aluminium
6.	Power supply	Supplied from observation station
7.	Operating temperature	0 to +50 degree Celsius

- Visibility meter

No.	Item	Specifications
1.	Method	Forward scattering method
2.	Measurement range	10 m to 1000 m
3.	Accuracy	± 5%
4.	Light source	LED
5.	Wavelength	875nm
6.	Eye safety	IEC/EN60 825-1
7.	Output	RS485, RS232C, Analogue
8.	Protection class	IP66
9.	Power supply	Supplied from observation station
10.	Operating temperature	0 to +50 degree Celsius
11.	Humidity	20 to 85 % non-condensing
12.	Wind speed endurance	50 m/s

- Data logger

No.	Item	Specifications
1.	Cabinet size	Width: 600mm or less Height: 1,500mm or less
2.	Weight	500kg or less
3.	Material	Stainless steel 2.0 t or cold rolled steel sheet

		(SPCC) 2.3 t
4.	Power consumption	1000 VA or less (sensor included)
5.	Operating temperature	0 to +50 degree Celsius
6.	Humidity	20 to 85 % non-condensing
7.	Wind speed endurance	53 m/s
8.	LAN interface	10BASE-T/100BASE-TX (RJ-45) x 1port
9.	Reliability and maintainability	MTBF : 30,000 hours MTTR : 1.0 hour

• Network equipment (media converter)

No.	Item	Specifications
1.	LAN interface	10 BASE-T/100BASE-TX (RJ-45) x 4ports or more
2.	Network interface	100BASE-FX (SC) x 2ports or less
3.	Transmission speed	100Mbps
4.	Maximum segment length	10km (Single mode fibre) or more
5.	Power consumption	10VA or less

• Cabinet

The data logger shall be housed in a rugged cabinet. The cabinet shall also accommodate MET circuit and devices, power supply, network device and terminal board.

- The cabinet shall be electrically and mechanically robust and shall have a degree of protection of IP55 or higher specified in IEC60529."Tests for protection against water for electrical equipment and degrees of protection against ingress of solid foreign objects."
- The cabinet shall be provided with a ventilating fan for controlling internal temperature, as necessary.
- A right hinged door shall be provided on the front to realize easy maintenance work. The turning direction of the handle shall be counter clockwise.
- The power supply unit to feed power to each equipment shall be provided with a circuit breaker.
- The anti-lightning and surge protection complying with the IEC 61643-1 shall be provided.
- The cabinet shall be finished with the anticorrosive treatment. **The Tenderer shall state the details of the anticorrosive treatment and painting.**

(2) MET data processor

The MET data processor shall be standard models manufactured by organizations of international repute. Custom built or non-standard equipment shall not be acceptable.

The computer hardware shall be readily available in Vietnam. Full maintenance support services and ready availability of consumables, spare parts or replacement units shall also be assured from a third party, based in Vietnam who is not connected with the Contractor and his agent.

The specifications in this section are provided as reference. The processor to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Project Manager.

No.	Item	Specifications
1.	Server configuration	<ul style="list-style-type: none"> • Latest redundant server with automatic failover ability • Prominent manufacturer • 10 years hardware supporting warranty • Readily available in Vietnam • Rack mount type enclosure • Low energy consumption
2.	Processor	<ul style="list-style-type: none"> • Latest stable multi core or CPU type processor • Having enough ability to process all required work without any delay.
3.	OS	<ul style="list-style-type: none"> • Latest LINUX stable operating system or latest Windows Server stable operating system • 10 years supporting warranty
4.	Memory	<ul style="list-style-type: none"> • ECC memory • Having enough ability to process all required work without any delay, and enough space in operation.
5.	Storage	<ul style="list-style-type: none"> • Having twice of sufficient volume to process all required work and store all required data including temporary data by OS and application in operation. • Having latest stable and high speed interface as for real-time operation. • Data recovery system like RAID5.
6.	Back-up	<ul style="list-style-type: none"> • High speed and large capacity device for periodical data backup • Software driven data mirroring mechanism to meet the availability criteria mentioned below in case of site outage
7.	Graphic card	<ul style="list-style-type: none"> • Two or more video interfaces as RGB Analogue, DVI-D or HMDI to connect display devices. • Video interface must support video switches and maintenance display monitor to display pixel to pixel matching full HD images.
8.	Peripheral	<ul style="list-style-type: none"> • DVD of high speed and high capacity multi drive supporting latest standard • High speed and large capacity device for periodical data backup

No.	Item	Specifications
9.	Availability	<ul style="list-style-type: none"> Hot-plug, redundant power supplies Hot-plug, redundant FAN Hot-plug drive bays
10.	Display monitor	<ul style="list-style-type: none"> 21-inch or smaller size of LCD type monitor (Full HD) RGB Analogue, DVI-D or HDMI required as input interface that should be same as of video interface
11.	Network	<ul style="list-style-type: none"> 1000/100M Base LAN interface Dual LAN interface
12.	Security	<ul style="list-style-type: none"> Virus protection Firewall
13.	Reliability	<ul style="list-style-type: none"> MTBF > 5 years x 365 days x 24 hours = 43,800 hours as a redundant server MTTR < 12 hours Monitoring temperature of CPU & inside casing, FAN moving, HD status, Memory status, peripheral status Alerting function when faults. Latest SNMP supporting
14.	System availability	<ul style="list-style-type: none"> Expected rate of operation as a redundant server > 99.97% $= \text{MTBF} / (\text{MTBF} + \text{MTTR})$
15.	Serviceability	<ul style="list-style-type: none"> Onsite support service. Automatically alert the service center without human intervention when the system experiences a system fault.
16.	Power supply	<ul style="list-style-type: none"> Input voltage: 220 V \pm10% AC, 50Hz
17.	Power Consumption	<ul style="list-style-type: none"> 2KVA or less as a whole redundant server
18.	Ambient operating temperature	<ul style="list-style-type: none"> 10 - 35 degree Celsius
19.	Ambient operating humidity	<ul style="list-style-type: none"> 70 % or less (non-condensing)
20.	Remark	<ul style="list-style-type: none"> All equipment is mounted in 19-inch type server rack.

3.5.4 Acceptance Test

The MET sensors, data logger and MET data processor shall be subjected to the test before acceptance. Test shall be conducted at factory, during installation work and upon completion depending on the test item. Test items will be classified into two types, function and performance test and general test.

Details of the test item, test procedure and criteria to judge test results shall be proposed

by the Contractor subject to the approval by the Employer.

(1) Function and Performance Test

In principle, function and performance requirements stated above shall be tested. More specifically, the following tests shall be conducted as minimum:

- Data accuracy
- Internal time adjustment function
- Malfunction detection and processing
- Interface between equipment
- Human machine interface (display screen and report)
- Recording, statistics and logging

The test on data accuracy shall be conducted by comparing the actual data manually measured at the site and the data measured by the MET observation station for all sensors.

In malfunction detection and processing test, all kinds of possible malfunction including power supply interruption shall be tested. A test data generator shall be used in the test to produce unrealistic measured data.

Correctness of all wirings and parameters in the database shall be confirmed as one of the interface tests and it shall be confirmed that measured data of a sensor is correctly processed and stored at right place in the database.

(2) General Test

The following tests shall be conducted as minimum:

- Appearance
- Power supply fluctuation
- Instantaneous power interruption
- Insulation resistance
- Dielectric strength
- Temperature variation
- Water proof test (roadside equipment)

4. Overload Monitoring System

4.1 General

This specification covers overload monitoring system to be installed as one of the sub-systems of the Intelligent Transport System in the Da Nang – Quang Ngai Expressway (DQE). The overload monitoring system will be introduced in the Project with following objectives.

- (1) To measure weight of vehicle to prevent entering the overloaded vehicle for protecting the expressway as regulated in Vietnamese circulars and decisions;
- (2) To detect and make alert to overloaded vehicles at the site for vehicle control and enforcement,
- (3) To accumulate the overloaded vehicle record for the purpose of future road maintenance works such as structure and asphalt repair planning; and
- (4) To monitor the overloaded vehicle information at the Main Management Center (MMC) with expressway planning agencies, expressway operators, traffic inspectors and other relevant authorities.

The overload monitoring roadside equipment shall detect, make alert, record plate number and take photo of overloaded vehicles. All of data measured and captured by the roadside equipment shall be transmitted to the overload monitoring data server in the MMC. The system shall operate on a 24-hour a day 7-day a week basis.

It shall be the responsibility of the Contractor to furnish all necessary hardware and software, install equipment at the specified location, provide necessary wiring, integrate all system components, and deliver a complete operational overload monitoring system.

4.2 System Requirements

System requirements of the overload monitoring system are as follows.

- (1) The overload monitoring system shall detect passing vehicles, measure axle weight and calculate total weight automatically.
- (2) If the measured axle weight or total weight of the vehicle exceeds the allowable maximum weight, the overload monitoring system shall memorize the vehicle plate number and recode video image of the vehicle.
- (3) The video image and plate number recorded at roadside shall be promptly sent to the MMC and warning alert and message shall be provided to the traffic inspectors stationed in the MMC.
- (4) If the system detects overloaded vehicle, the warning alert shall be indicated by overweight warning display located at roadside to take caution to the driver and the traffic inspector at roadside.

- (5) Weigh-in-Motion (WIM) type axle load scale shall be applied to measure vehicles passing. The axle load scale shall be installed at entrance side of toll gate in order to prevent entering overloaded vehicle into the expressway. Targeted accuracy of WIM type axle load scale shall be within the range of +/-10% for 95% of vehicles measured.
- (6) Apart from WIM type axle load scale, portable axle load scale shall be provided in the Project to precisely measure the vehicle's axle load by the traffic inspector.
- (7) The measured overloaded vehicle data can be monitored in the MMC on real-time basis. Also, the data can be stored for a certain period in order to utilize for road maintenance activities.
- (8) The overload monitoring roadside equipment can be easily installed at roadside and shall have advantages in its operation and maintenance.
- (9) To minimize required equipment as much as possible, the vehicle detector, lane monitoring camera and automatic number recognition camera to be used in the overload monitoring system shall be shared with those provided by toll collection system

4.3 System Configuration

The overload monitoring system shall consist of the following equipment;

- (1) WIM type axle load scale;
- (2) Vehicle detector provided by toll collection system;
- (3) Lane monitoring camera provided by toll collection system;
- (4) Automatic plate number recognition (ANPR) camera provided by toll collection system;
- (5) Overweight warning display;
- (6) Roadside panel;
- (7) Portable axle load scale;
- (8) Overload monitoring data server in the MMC
- (9) Network equipment; and
- (10) Power supply unit and peripheral.

The overload monitoring system would be configured as figure below.

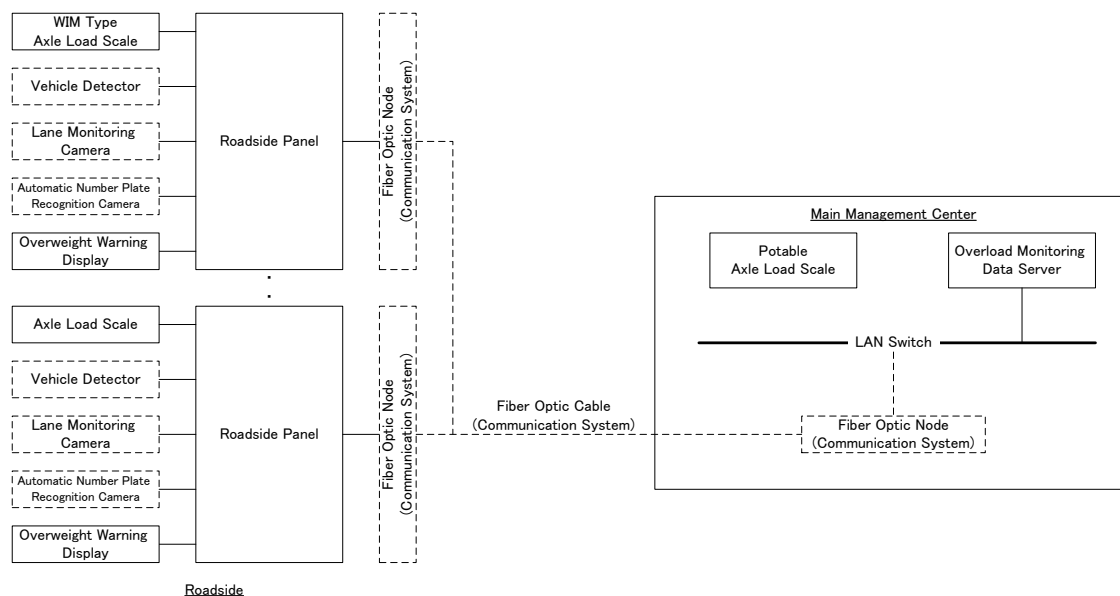


Figure 4-1 Overload Monitoring System Configuration

4.4 Location of Overload Monitoring Roadside Equipment

The overload monitoring roadside equipment shall be installed at the locations listed below.

Table 4-2 Overload Monitoring Roadside Equipment Locations

Facility	Location	Quantity
Overload Monitoring Roadside Equipment	Tuy Loan TB entrance	3
	My Son IC entrance	1
	Ha Lam IC entrance	1
	Tam Ky IC entrance	1
	Chu Lai IC entrance	1
	Dung Quat IC entrance	1
	Quang Ngai North IC entrance	1
	Quang Ngai TB entrance	2
Total	8	11

The overload monitoring roadside equipment shall be installed at the location indicated on the **Employer's Requirement Part D: Drawings**. The locations shown on the **Employer's Requirement Part D: Drawings** are tentative and the Contractor shall examine and select the locations and obtain the approval from the Project Manager.

The overload monitoring roadside equipment shall be installed at each entrance toll gate of the DQE. The WIM type axle load scale shall be placed at lanes in operation as illustrated in figure below.

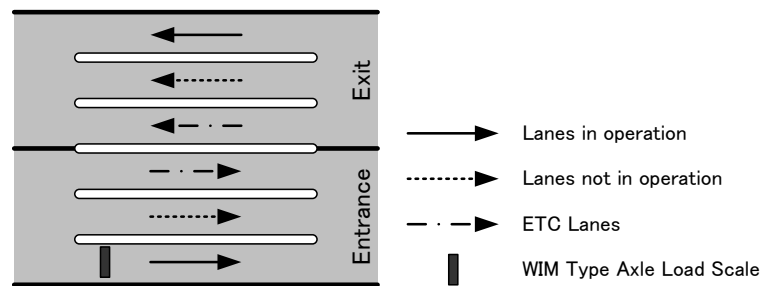


Figure 4-2 Typical WIM Arrangement

4.5 Specifications

4.5.1 General

(1) Power supply

The electrical power supply system for the overload monitoring roadside equipment and center equipment shall consist of AC commercial power with Diesel Engine Generator (DEG) and Uninterruptible Power Supply (UPS) backup system which will be provided by other sub-system or other contract package. The overload monitoring roadside equipment and center equipment shall operate with AC single-phase two-wire system 220 V $\pm 10\%$ 50Hz.

The Tenderer shall present the calculation of power consumption to be used for the overload monitoring system.

(2) Communication

The data transmission of the overload monitoring system shall be made through the fiber optic network provided by other sub-system. The media converter shall be provided in the overload monitoring system to connect the roadside equipment with nearest Fiber Optic Node (FON) of fiber optic network.

4.5.2 System Functions and Specifications

(1) Overall functions

Followings are overall functions of the overload monitoring subsystem as minimum;

- Weight measurement
- Vehicle detection
- Axle distance measurement
- Video image monitoring
- Photo taking (Number plate recognition)
- Excess weight detection and alarm
- Error detection and alarm
- Local control operation
- Data transmission to the main management center

- Data recording and operation logging at the main management center
- Operation and malfunction report

(2) Specifications

- Measurement

The overload monitoring system shall be capable of measuring and calculating each axle, total weight, distance between two adjacent axles and vehicle speed. The measurement accuracy of WIM type axle load scale shall be within the range of +/- 10% for 95 % of vehicles measured and that of portable axle load scale must be 99% or better. Allowable vehicle passing speed of WIM shall be 40 km/h or more.

- WIM type axle load scale

Sensor for WIM shall be piezoelectric sensor. Two sensors 1 meter apart in longitudinal direction shall be installed at each lane for better measuring accuracy.

- Vehicle detector

Two units of vehicle detector shall be installed at each lane, one upstream of sensor and another downstream of the sensor to detect presence of vehicle and measure the vehicle speed. Inductive loop type vehicle detector is considered as detector but other types of vehicle detector are acceptable as long as it performs the required functions. The vehicle detector to be used in the overload monitoring system will be provided in the toll collection system and the detection signal shall be input to roadside panel of the overload monitoring system.

- Overweight warning display

A display unit shall be provided and installed at appropriate location downstream of WIM type axle load scale to inform the driver and traffic inspector of the overloading. The Contractor shall design and propose the type, size and capacity of display together with the contents of message. No message shall be displayed for vehicles not exceeding the weight limit.

- Lane monitoring camera and automatic plate number recognition (ANPR) camera

CCTV camera shall be installed to monitor the operation of the system. The video image during the measurement shall be stored temporarily until the vehicle being measured is cleared. If the vehicle is judged over loaded, video image shall be kept permanently until deleted by the operator.

ANPR camera shall also be used to take photo of the vehicle judged over loaded. The photo taken by the camera will be used to recognize plate number automatically. Infra red type camera may be used. Signal from the vehicle detector may be used as timing signal for photo.

Both of lane monitoring camera and ANPR camera to be used in the overload monitoring system will be provided in the toll collection system and the captured images shall be input to roadside panel of the overload monitoring system.

- **Operation**

The operation of the system shall be automatic and no action by the operator is required for measurement, data processing, judgment and data transmission to the MMC.

If a vehicle is judged overloaded, an alarm shall be shown on the console of overload monitoring data server and a warning message shall be shown on the display for drivers.

The data collected by the system shall be sent to the MMC for recording and monitoring. The data shall include station number, date and time of passage, lane number, vehicle sequence number, vehicle speed, weight of axle or axle group, total vehicle weight, code for invalid measurement, and photo of vehicle judged overloaded.

(3) Installation

The WIM type axle load scale shall be installed at entrance tollgate together with overweight warning display and roadside panel.

As other devices for toll collection system are to be installed at the tollgate, the Contractor shall coordinate with other contractor working at the same site to ensure normal operation of both overload monitoring system and other systems without interference. Location of equipment may need to be adjusted and cable installation work may be done simultaneously.

4.5.3 Acceptance Test

Acceptance test shall be conducted for the overload monitoring system before acceptance. Test shall be conducted at factory, during installation work and upon completion depending on the test item. Test will be classified into three types, functional and performance test, general test and calibration and trial operation. In addition, trial operation shall be conducted after the acceptance test.

(1) Function and performance test

The function and performance test to check all overall functions mentioned above shall be conducted for all roadside equipment supplied under the contract.

(2) General test

The following tests shall be conducted as minimum:

- Appearance
- Power supply fluctuation
- Instantaneous power interruption
- Insulation resistance

- Dielectric strength
- Temperature variation
- Water proof test (roadside equipment)

Appearance test shall be conducted for all the equipment, while other test will be conducted for selected sample.

(3) Calibration

Once system is installed and normal operation of the system is confirmed, calibration shall be made to ensure the accurate measurement and to offset the effects of site condition, vehicle speed, and pavement conditions. Calibration shall be made by comparing the estimation from the overload monitoring system to the actual static weight of a number of different types of trucks. At least five (5) different types of truck having two axles, three axles, four axles, five axles, and six axles with lightly loaded and heavy loaded condition shall be used for calibration. For each type of trucks and weight, test shall be made at different speed ranging from 5 km/h to 40 km/h.

The calibration shall be repeated until all overload monitoring systems perform measurement with the required accuracy. The results of calibration shall be tabulated and summarized in a report for submission to the Employer for his approval.

5. Variable Message Sign (VMS) System

5.1 General

This specification covers variable message sign (VMS) system to be installed as one of the sub-systems of the Intelligent Transport System in the Da Nang – Quang Ngai Expressway (DQE). The VMS system will be introduced in the Project with following objectives;

- (1) To provide road users with information of traffic status, incident, and weather conditions on the expressway;
- (2) To provide option of alternative route selection such as National Highway No.1 (NH-1) to driver in the case of congestion and incident on the DQE,
- (3) To disseminate necessary information regarding traffic status, incident and weather conditions to every road users equally without any special user's devices; and
- (4) To control the VMS at the Main Management Center (MMC), where all information related to traffic, incident and weather conditions are collected, to provide the information with timely manner.

The VMS at roadside shall provide the information of traffic status, incident and weather conditions on the road to the driver on real time bases. The VMS shall be placed upstream of interchange, tunnel and toll barrier on the expressway or at access road before each interchange tollgate. The message showing on the VMS shall be controlled from the MMC. The VMS system shall be capable of creating, managing and displaying messages in two languages (English and Vietnamese) separately and alternately, or simultaneously in case of simple message. The system shall operate on a 24-hour a day 7-day a week basis.

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

5.2 System Requirements

System requirements of the VMS system are as follows.

- (1) The VMS system shall indicate the following alerting message on the VMS board located at roadside on real time basis;
 - Location
 - Incident (cause)

- Event (traffic regulation or action to be taken by road user)
- (2) Character including symbol mark indicated on the VMS board can be visible under the natural environment in Vietnam, and the character height shall be enough size for recognition by driver passing through the expressway with high speed.
- (3) The location of VMS board shall be sufficient for road users to read and understand information on the board and to safely change lane to exit at the interchange or to stop before tunnel and tollgate.
- (4) The VMS board shall be fixed on gantry type supporting structure.
- (5) The VMS system shall be capable of creating, managing and displaying messages locally or remotely from the MMC.
- (6) Based on alerting information collected and issued by other sub-systems, the VMS system can control and indicate required information on the VMS board from the MMC by manually or semi-automatically. The VMS control must be easily carried out by the selection of preset message or other method prepared in the system.

5.3 System Configuration

The VMS system shall consist of the following components;

- (1) VMS board and VMS control unit with supporting structure (gantry type or F-shaped cantilever type) at roadside;
- (2) VMS center controller;
- (3) VMS center controller console;
- (4) Network equipment; and
- (5) Power supply unit and peripheral.

The VMS shall be placed at 26 locations in the Project. The VMS system would be configured as figure below.

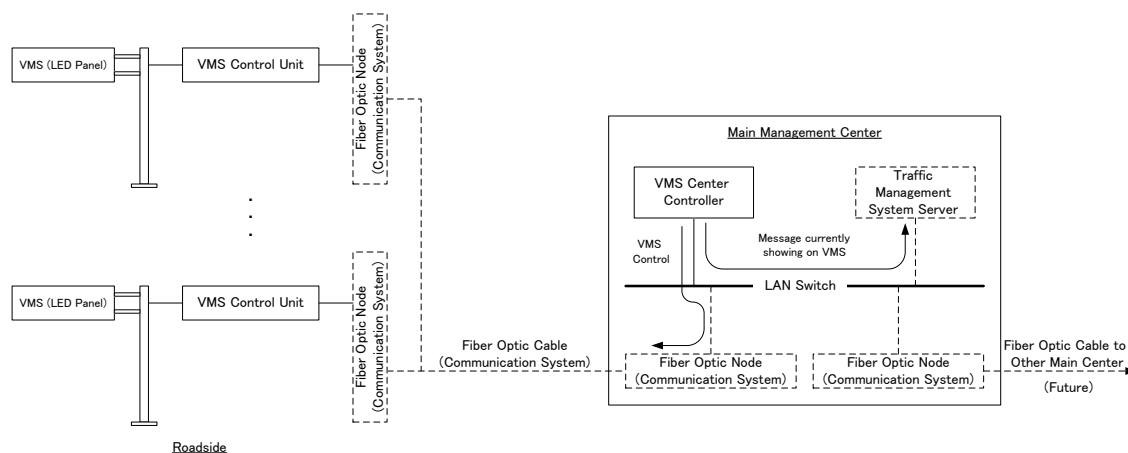


Figure 5-1 VMS System Configuration

The VMS control unit will be accommodated in a separate cabinet or in the VMS board housing. A dedicated operator console for VMS shall be provided to the MMC for message preparation, monitoring and control of the variable message signs. IP based network equipment shall be provided to connect the VMS with the VMS center controller at the MMC through fiber optic network.

5.4 VMS Location

The VMS board shall be established at the following locations:

Table 5-1 VMS Locations

No.	Location	Bound	Remarks	No.	Location	Bound	Remarks
1	DQE KM-0+900	Southbound	Tuy Loan IC (ingress VMS)	16	Tam Ky IC access road	-	Tam Ky IC (ingress VMS)
2	NH14B	From east side	Tuy Loan IC (ingress VMS)	17	DQE KM65+200	Northbound	Tam Ky IC (egress VMS)
3	NH14B	From west side	Tuy Loan IC (ingress VMS)	16	DQE KM82+230	Southbound	Chu Lai IC (egress VMS)
4	DQE KM4+100	Southbound	Tuy Loan TB (TB VMS)	17	Chu Lai IC access road	-	Chu Lai IC (Ingress VMS)
5	DQE KM12+580	Southbound	My Son IC (egress VMS)	18	DQE KM83+700	Northbound	Chu Lai IC (egress VMS)
6	My Son IC access road	-	My Son IC (ingress VMS)	19	DQE KM101+000	Southbound	Dung Quat IC (egress VMS)
7	DQE KM14+100	Northbound	My Son IC (egress VMS)	20	Dung Quat IC access road	-	Dung Quat IC (Ingress VMS)
8	DQE KM22+200	Southbound	Tunnel	21	DQE KM102+440	Northbound	Dung Quat IC (egress VMS)
9	DQE KM23+300	Northbound	Tunnel	22	DQE KM123+040	Southbound	Quang Ngai N IC (egress VMS)
10	DQE KM40+150	Southbound	Ha Lam IC (egress VMS)	23	Quang Ngai N IC access road	-	Quang Ngai N IC (Ingress VMS)
11	Ha Lam IC access road	-	Ha Lam IC (ingress VMS)	24	DQE KM124+500	Northbound	Quang Ngai N IC (egress VMS)
12	DQE KM41+600	Northbound	Ha Lam IC (egress VMS)	25	DQE KM129+500	Northbound	Quang Ngai TB (TB VMS)
13	DQE KM63+740	Southbound	Tam Ky IC (egress VMS)	26	DQE KM131+180	Northbound	Quang Ngai IS (egress VMS)

The VMS board shall be installed at the location indicated on the **Employer's Requirement Part D: Drawings**. The locations shown on the **Employer's Requirement Part D: Drawings** are tentative and the Contractor shall examine and select the locations and obtain the approval from the Project Manager.

The VMS board shall be located at approximately 200m to 300m upstream of targeted interchange and tunnel, at nearest intersection or junction of access road, and at the toll barrier. The VMS board on the expressway must be installed at the location having minimum visibility of 333m to the direction showing message to the drives. 5.5m or more vertical clearance from road surface must be kept under the bottom of VMS board.

5.5 Specifications

5.5.1 General

(1) Power supply

The electrical power supply system for the VMS roadside equipment and center equipment shall consist of AC commercial power with Diesel Engine Generator (DEG) and Uninterruptible Power Supply (UPS) backup system which will be provided by other sub-system or other contract package. The VMS roadside equipment and center equipment shall operate with AC single-phase two-wire system 220 V $\pm 10\%$ 50Hz. Total power consumption of VMS at each location shall be 3KVA or less.

The Tenderer shall present the calculation of power consumption to be used for the VMS system.

(2) Communication

The data transmission of the VMS system shall be made through the fiber optic network provided by other sub-system. The media converter shall be provided in the VMS system to connect VMS roadside equipment with nearest Fiber Optic Node (FON) of the fiber optic network except the locations where media converter will be installed by the CCTV camera system.

5.5.2 System Functions

(1) Message indication function

Message to be displayed on the VMS shall be concise and clear as the road users have to read and understand the message in a short time. Messages shall have uniform structure and simple words shall be used. Messages on the VMS board shall be expressed in English and Vietnamese. In principle, a message to be displayed on the VMS board shall be composed of three parts, "location", "incident", and "event".

- Location

Location indicates the relationship between the VMS location and the incident location. They can be expressed as section (between interchange A to interchange B),

distance (ahead, xx km ahead), station number of expressway (KM xx + xxx) or specific location (near interchange A or the station number).

- Incident

Incident is a thing that has happened or taken place. It includes traffic conditions (accident, congestion), road condition (wet road surface, damaged pavement), and weather condition (fog, rain, strong wind).

- Event

Event includes traffic regulation (lane closure, road maintenance work) and the action is to be taken by the road users such as “slow down”, “cautious” and “use right/left lane”.

Three components are not necessarily required all the time. Messages consisting of one or two components described above or simple message will also be displayed.

The VMS system shall be also capable of displaying the graphic symbol marks. The sample symbol marks are listed below for reference only. The Contractor shall design and propose graphic symbol marks to be used on the variable message sign for approval by the Project Manager. The system shall be capable of having a maximum of twenty (20) graphic symbol marks. The graphic symbol marks shall be defined as dot matrix and editing of the symbol mark shall be possible. It shall be possible to combine text and graphic symbol marks in a message.





(2) Message creation and editing functions

Three message composition methods shall be provided; (1) manual input, (2) combination of pre-defined phrase, and (3) selection of ready-made message. The functions specified herein shall be possible in two languages i.e. in English and Vietnamese. In addition, a set of graphic symbol marks shall be provided to complement the text message.

- Manual composition

In the manual input, it shall be possible to display on the VMS any text message input by the system operator through the keyboard of the VMS center controller console in the MMC. There shall be no restriction as to the contents of message but the length of message is limited to the display capacity of the VMS board. If manual composition mode is selected, the console shall show the image of the VMS board and the message as it is input by the system operator.

- Combination of pre-defined phrase

In the case of combination of pre-defined phrase, frequently used words or phrases such as “accident”, “congestion”, “construction work”, “slow down” and so on are used to compose a message. It shall be possible to insert a word into the message composed by combination method. There shall be sets of pre-defined words. They shall contain words indicating location, incident and action. Each set shall have a capacity of 100 words in each language. In this mode, the operator console shall show the categories and the words or phrases in each category for the system operator to select. It shall be possible to alter the pre-defined words by the system operator.

- Ready-made message

Ready-made message selection method shall allow the system operator to choose one of the ready-made messages. If the ready-made message mode is selected, the operator console shall indicate the list of ready-made messages grouped into categories for the system operator to select. Message set shall have the capacity of 100 messages in each language.

- Graphic symbol marks

Graphic symbol marks that show typical incidents such as construction work and heavy rain graphically shall be provided to complement the text message. The sample graphic symbol marks are provided in these Employer’s Requirements for reference. The design of graphic symbol marks shall be subject to the Employer’s approval.

- Dot matrix pattern

The VMS system shall be provided with a function to create a display pattern by specifying the on/off status and color of each pixel comprising the display area of the VMS board. It shall be possible to mix the dot matrix pattern and character message on the board.

- Automatic message creation from incident information

If an adverse weather condition is detected by the MET system or any incidents are manually input in traffic event data console by system operator, these systems shall send an alarm to the VMS system via traffic management center system. The VMS system shall then create a warning message indicating the location, type of incident and action to be taken by road users. The message created shall not be displayed automatically on the VMS board. Instead, a recommendation shall be displayed on the VMS center controller console indicating the contents of the message and the location of VMS for which message is recommended. Upon confirmation of the recommendation, the message will be displayed on the specified message.

The VMS center controller console shall be provided with updating and editing functions of pre-defined word, phrase, message and symbol mark. Editing of symbol mark shall be possible on a pixel basis.

The console shall communicate with the operator through monitor and keyboard for message composition and operation monitoring. Message composition shall be made interactively with one of the methods described above. Graphic user interface shall be adopted in the interface as much as possible for user friendly operation and fail safe mechanism shall be incorporated to prevent VMS system from showing inadequate message. The system shall be equipped with a text input method in Vietnamese languages commonly used in the Project area through the standard keyboard.

The VMS system shall be provided with an automatic message selection function based on the priority or severity of the events and coefficient that represents the importance of event to each VMS. The function shall select and recommend the message to be shown separately for each VMS when there are two or more incidents to be informed to the road users.

Each message being displayed on the VMS shall be assigned with a time-to-live (TTL) value, during which message is displayed, to prevent inadvertently displaying false message after incident has been removed. Upon expiration of TTL, message shall be automatically extinguished, if no response is made to the warning within the preset time limit. A warning shall be issued to the operator console before TTL expires for operator to choose extension of TTL or termination of the display as scheduled.

The VMS system shall have an alternate display function, in which a maximum of two sets of message shall be displayed alternately. The function is intended to display a message in two different languages (English and Vietnamese) but not necessarily limited to the same message.

(3) Data transmitting function

Text and symbol mark messages to be displayed shall be converted to pixel image data to control display unit before transmitting to the variable message sign.

The VMS center controller shall communicate with the VMS control unit at roadside through the fiber optic network. It shall send out message converted to dot pattern for display. It shall also send out command data to control the VMS control unit and to confirm normal operation of the VMS board. In return, the center controller shall receive status data from the control unit.

(4) Operation monitoring and logging function

Operating status of the VMS shall be checked periodically. Status (message on, no message, fault, local control, test and switch off) shall be collected from the VMS control unit at roadside. If any abnormality is reported, an alarm shall be issued. The collected operation monitoring data shall be recorded as part of operation log. It shall be possible for the VMS center controller console to send a command to the control unit and collect the dot pattern data being displayed on the VMS board upon system operator's initiative.

Message displayed together with the starting and ending time shall be recorded as operation log. Status or malfunction of the VMS and the control unit shall also be recorded. Data retrieval software shall be provided and operation log can be retrieved for display on monitor and as printed report.

The Tenderer shall state in his Technical Proposal, the types of error and malfunction of the VMS system that can be diagnosed from the VMS center controller.

(5) Data storage function

- All data transmitted from the VMS roadside equipment and processed data in the MMC shall be recorded and stored in the VMS center controller for analysis and future usage. Data retrieval and presentation software shall be provided that can easily retrieve and show the recommended message automatically generated against event and message indicating on each VMS of the specified roadside equipment location at the hour or day.
- Status of roadside equipment (normal or malfunctioned) shall be recorded in the VMS center controller as operation log and for future reliability analysis together with error code and time stamp.

Data Sub-system	Storage Data	Type	Storage Period
VMS system	Recommended message automatically generated against event	Raw data	2 years
	Manual input operation record	Raw data	
	Equipment operational status	Raw data	
	Current message indicating on each VMS	Processed data	

(6) Display and reporting functions

- The VMS center controller shall be capable of showing the following screens.

Item	Contents
Route map	<ul style="list-style-type: none"> Schematic road map of DQE and access road Detailed VMS location map Name and station number of interchanges and toll barrier
Equipment location and status	<ul style="list-style-type: none"> Location of VMS and their condition (message / no message and normal / error)
Message	<ul style="list-style-type: none"> Message being displayed at selected VMS with starting time and scheduled end time Pre-defined words and phrases Pre-defined messages Graphic symbol marks
Operation	<ul style="list-style-type: none"> List of VMS currently not in operation Operation log and error record
Date and Time	<ul style="list-style-type: none"> Current date and time

- The VMS center controller shall produce the reports listed below. The reports shall be output according to the schedule or upon the system operator's request. It shall be possible to output the report as a file in portable document file format.

Item	Contents
VMS operation	<ul style="list-style-type: none"> Daily report summarizing VMS location, message displayed, start time, end time
Error log	<ul style="list-style-type: none"> List of VMS currently not in operation Error record

5.5.3 Technical Specifications

(1) VMS board

- Display Unit

High intensity LED (light emitting diode) shall be used as light source for the VMS. At least three color elements, blue, red and green, shall be provided and a total of seven (7) colors shall be displayed. Brightness and color shall be uniform throughout the surface.

Life of LED unit shall be long enough to withstand the severe environmental conditions in which the VMS operates. The Contractor shall submit the results of high temperature high moisture biased test to the satisfaction of the Project Manager. Display panel of VMS shall be of unit construction using LED matrix. The size of the LED matrix unit shall be as per the manufacturer's design. The unit shall be easily replaceable from backside without affecting other units. One pixel may be composed of multiple elements or LEDs for color presentations. The total number of pixels on the display panel shall be determined by the character size, pixel pitch,

number of character per line, and number of lines. Display unit shall be capable of detecting open circuit condition of each LED.

VMS designs, components, and enclosures primarily designed for commercial, advertising, billboard or other display purposes shall not be accepted.

- LED

The LED used for the display unit shall be from the reputable LED manufacture. All LEDs used shall be from the same manufacturer and shall have the same part number. The type of LED shall be as indicated below.

LED color	Type
Blue	InGaN (Indium-Gallium-Nitride)
Red	AlInGaP (Aluminium-Indium-Gallium-Phosphide)
Green	InGaN (Indium-Gallium-Nitride)

The Tender shall state the source, type and part number of LED used for VMS in his Technical Proposal.

- Character size

The character size of the VMS shall be 450 mm in height. The VMS shall be capable of displaying a total of 24 English characters or more of the standard width including space between words in one line. The standard width of character and number of pixels will be the value defined by the manufacturer. The width shall be adjusted proportionally for each character to display message in proportional font. The display panel shall be capable of displaying all characters used in two languages, English and Vietnamese.

A character shall be expressed by a matrix of pixels and on/off status of each pixel shall be independently controlled. The number of pixels comprising a character shall be determined by the character size and pixels spacing. Spacing between lines shall be at least 10% of the character height.

- Dimming

Dimming function shall be provided to VMS to reduce the brightness depending on the ambient light levels and prevent glaring during the dark hours. There shall be at least four (4) levels of brightness. Dimming control may be activated by photo electric cell attached to the VMS board, local timer or command from the MMC. A mechanism shall be provided to prevent chattering.

- Temperature monitoring

The VMS shall be equipped with a temperature sensor to measure the temperature inside the housing. The data shall be sent to the MMC as one of the monitoring data.

- Display off mode

The VMS shall be provided with display off mode, in which it operates normally but the display units shall be turned off for testing purpose.

- Housing

The VMS board shall be accommodated in the cabinet of suitable design made of cold rolled steel sheet or aluminum. Both VMS board and VMS control unit may be accommodated in one cabinet, or alternatively they will be accommodated in separate cabinets.

The cabinet shall be electrically and mechanically robust. The cabinet shall be either enclosure type without ventilation fan, or open type with ventilation fans. In both cases, the cabinet shall have the protection level of IP55 or higher.

The cabinet shall be finished with the anticorrosive treatment if steel is used. **The Tenderer shall state the details of the anticorrosive treatment and painting.**

VMS may or may not have front face panels covering the entire display surface. If front panel is used, it shall consist of perforated aluminum sheeting on the exterior and anti-glare polycarbonate sheeting on the interior. There shall be one and only one continuous polycarbonate sheet per front face panel. No lenses, individual pixel covers, or multiple polycarbonate sheet, buttons or plugs shall be allowed. Ventilation mechanism shall be provided for the space between LED display unit and front face panel, if front face panel is used.

- Minimum technical specifications of VMS board

The technical specifications mentioned hereunder are minimum guidelines. The contractor shall not deviate materially from the specifications.

The Tenderer shall submit the power consumption data of the VMS proposed for two cases; when all pixels are ON and when only 25% of the pixels are ON, in his Technical Proposal.

No.	Item	Specification
1.	Board size	9,680 mm (W) x 1,840 mm (H) or less
2.	Weight	2,500 kg or less
3.	Material	Cold rolled steel sheet (SPCC) 2.3 t, or aluminum 2.0 t
4.	Character size	450 mm in height
5.	Display pixel pitch	Not larger than 20 mm (vertical and horizontal)
6.	Number of pixels	16 pixels vertically for one character in both English and Vietnamese
7.	Display	24 English characters of standard width without graphic symbol per line.
8.	Display device	Light emitting device LED Luminescent color (blue , red , green)
9.	Power supply	220 V \pm 10% 50 Hz
10.	Power consumption	3,000 VA or less including power consumption of VMS control unit
11.	Operating temperature	0 to 50 degree Celsius
12.	Humidity	20 to 85 % (non-condensing)

13.	Wind	53 m/s
14.	Reliability and maintainability	MTBF: 10,000 hours MTTR: 1.0 hour

(2) VMS Control Unit

VMS controller shall have the following functions:

- Communication control
- Display control
- Monitoring
- Local operation

The VMS control unit shall communicate with the VMS center controller in the MMC through the fiber optic network using NTCIP or other equivalent international protocols. It shall receive display data from the VMS center controller and send back the operating status data to the center controller.

Display data received from the VMS center controller shall be stored in the buffer until all the data have been correctly received without error. Upon confirmation of correctness of data, display shall be changed to the new message. Changeover shall be fast and no irregular display shall be shown during the transition. Under any circumstances, the changeover of message shall be completed within 3 seconds after the system operator in the MMC has issued a message changeover command.

Several test pattern shall be provided to the VMS control unit, with which defect of LED can be tested by indicating one of them sequentially.

Operating condition of the VMS shall be monitored regularly by VMS itself and the control unit. If any abnormality is detected, error signal shall be issued to the VMS center controller together with the type of error.

It shall be possible to operate the control unit and the VMS board manually at the site. The manual control panel shall be provided to the VMS control unit. Alternatively, manual control shall be made with a notebook computer connected to the VMS control unit through serial port or network port.

(3) Network equipment (media converter)

No.	Item	Specifications
1.	LAN interface	10 BASE-T/100BASE-TX (RJ-45) x 4ports or more
2.	Network interface	100BASE-FX (SC) x 2ports or less
3.	Transmission speed	100Mbps
4.	Maximum segment length	10km (Single mode fibre) or more

5.	Power consumption	10VA or less
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(4) Supporting structure

The VMS board shall be fixed on either gantry type supporting structure or F-shaped cantilever structure. The construction of both gantry and cantilever support shall be included in the Contract.

Typical designs of the gantry and cantilever support are included in the **Employer's Requirement Part D: Drawing** as reference. The Contractor shall design the gantry and cantilever support and their foundations taking such factors as weight of VMS, bearing capacity of ground, wind load, fixing method of VMS board with the gantry and cantilever support, power receiving and network connecting points, and grounding method. The width of the gantry shall be adjusted to the road width at the installation location. The Contractor shall obtain the approval of above calculation sheet from the Project Manager.

A mechanism to adjust the tilting angle of VMS shall be provided to the VMS housing or fixture used to attach the VMS to the support. It shall be possible to adjust the tilting between 0 degree (vertical) and 10 degree (tilted forward).

If VMS is supported by a cantilever support on one side, the design of the support shall consider the tilting of support or arm extended from the cantilever support due to the weight of VMS.

The Contractor shall undertake foundation work for the gantry and cantilever support, communication cable and power cable works, protection against lightning, earthing and other works incidental to the installation of VMS.

(5) VMS Center Controller

The VMS center controller shall be standard models manufactured by organizations of international repute. Custom built or non-standard equipment shall not be acceptable.

The computer hardware shall be readily available in Vietnam. Full maintenance support services and ready availability of consumables, spare parts or replacement units shall also be assured from a third party, based in Vietnam; who is not connected with the Contractor and his agent.

The specifications in this section are provided as reference. The controller to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Project Manager.

No.	Item	Specifications
1.	Server configuration	<ul style="list-style-type: none"> • Latest redundant server with automatic failover ability • Prominent manufacturer • 10 years hardware supporting warranty • Readily available in Vietnam • Rack mount type enclosure • Low energy consumption
2.	Processor	<ul style="list-style-type: none"> • Latest stable multi core or CPU type processor • Having enough ability to process all required work without any delay.
3.	OS	<ul style="list-style-type: none"> • Latest LINUX stable operating system or latest Windows Server stable operating software • 10 years supporting warranty
4.	Memory	<ul style="list-style-type: none"> • ECC memory • Having enough ability to process all required work without any delay, and enough space in operation.
5.	Storage	<ul style="list-style-type: none"> • Having twice of sufficient volume to process all required work and store all required data including temporary data by OS and application in operation. • Having latest stable and high speed interface as for real-time operation. • Data recovery system like RAID5.
6.	Back-up	<ul style="list-style-type: none"> • High speed and large capacity device for periodical data backup • Software driven data mirroring mechanism to meet the availability criteria mentioned below in case of site outage
7.	Graphic card	<ul style="list-style-type: none"> • Two or more video interfaces as RGB Analogue, DVI-D or HMDI to connect display devices. • Video interface must support video switches and maintenance display monitor to display pixel to pixel matching full HD images.
8.	Peripheral	<ul style="list-style-type: none"> • DVD of high speed and high capacity multi drive supporting latest standard • High speed and large capacity device for periodical data backup
9.	Availability	<ul style="list-style-type: none"> • Hot-plug, redundant power supplies • Hot-plug, redundant FAN • Hot-plug drive bays
11.	Display monitor	<ul style="list-style-type: none"> • 21-inch or smaller size of LCD type monitor (Full HD) • RGB analogue, DVI-D or HMDI required as input interface that should be same as of video interface
11.	Network	<ul style="list-style-type: none"> • 1000/100M Base LAN interface • Dual LAN interface

No.	Item	Specifications
12.	Security	<ul style="list-style-type: none"> • Virus protection • Firewall
13.	Reliability	<ul style="list-style-type: none"> • MTBF > 5 years x 365 days x 24 hours = 43,800 hours as a redundant server • MTTR < 12 hours • Monitoring temperature of CPU & inside casing, FAN moving, HD status, Memory status, peripheral status • Alerting function when faults. • Latest SNMP supporting
14.	System availability	<ul style="list-style-type: none"> • Expected rate of operation as a redundant server > 99.97% $= \text{MTBF} / (\text{MTBF} + \text{MTTR})$
15.	Serviceability	<ul style="list-style-type: none"> • Onsite support service. • Automatically alert the service center without human intervention when the system experiences a system fault.
16.	Power supply	<ul style="list-style-type: none"> • Input voltage: 220 V \pm10% AC, 50Hz
17.	Power Consumption	<ul style="list-style-type: none"> • 2KVA or less as a whole redundant server
18.	Ambient operating temperature	<ul style="list-style-type: none"> • 10 - 35 degree Celsius
19.	Ambient operating humidity	<ul style="list-style-type: none"> • 70 % or less (non-condensing)
20.	Remark	<ul style="list-style-type: none"> • All equipment is mounted in 19-inch type server rack.

(6) VMS Center Controller Console

The Contractor shall provide the VMS center controller console. The console shall be the same model and shall have the same configuration with other consoles.

The specifications in this section are provided as reference. The VMS center controller console to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Project Manager.

No.	Item	Specifications
1.	PC configuration	<ul style="list-style-type: none"> • Latest PC • Prominent manufacturer • 5 years hardware supporting warranty • Readily available in Vietnam • Space saving type enclosure • Low energy consumption
2.	Processor	<ul style="list-style-type: none"> • Latest stable multi core or CPU type processor • Having enough ability to process all required work without any delay.

No.	Item	Specifications
3.	OS	<ul style="list-style-type: none"> • Latest Windows stable operating system • 5 years supporting warranty
4.	Memory	<ul style="list-style-type: none"> • Having enough ability to process all required work without any delay, and enough space in operation.
5.	Storage	<ul style="list-style-type: none"> • Having twice of sufficient volume to process all required work and store all required data including temporally data by OS and application in operation. • Having latest stable and high speed interface as for smooth operation.
6.	Graphic card	<ul style="list-style-type: none"> • Three or more video interface as RGB Analogue, DVI-D or HMDI to connect display device. • Video interface must support video switches and console display monitor to display pixel to pixel matching full HD images.
7.	Console Display Monitor	<ul style="list-style-type: none"> • Two or more monitors that are 24-inch or more size of LCD type widescreen monitor (Full HD) • RGB Analogue, DVI-D or HMDI required as input interface that should be same as of video interface.
8.	Peripheral	<ul style="list-style-type: none"> • DVD of high speed and high capacity multi drive supporting latest standard
9.	Network	<ul style="list-style-type: none"> • 1000/100M Base LAN interface
10.	Security	<ul style="list-style-type: none"> • Virus protection • Firewall
11.	Reliability	<ul style="list-style-type: none"> • MTBF > 3 years x 365 days x 24 hours = 26,280 hours • MTTR < 24 hours • Monitoring temperature of CPU & inside casing, HD status. • Alerting function when faults. • Latest SNMP supporting
12.	System availability	<ul style="list-style-type: none"> • Expected rate of operation > 99.90% =MTBF/(MTBF+MTTR)
13.	Serviceability	<ul style="list-style-type: none"> • Onsite support service.
14.	Power Consumption	<ul style="list-style-type: none"> • 500VA or less
15.	Ambient operating temperature	<ul style="list-style-type: none"> • 10 - 35 degree Celsius
16.	Ambient operating humidity	<ul style="list-style-type: none"> • 70 % or less (non-condensing)

6. Traffic Management Center System

6.1 General

This specification covers traffic management center system to be installed as a central monitoring and control system of the Intelligent Transport System (ITS) in the Da Nang – Quang Ngai Expressway (DQE). The ITS in this Project consists of many system components. The traffic management center system manages the total system, encourages data exchange between the system components in order to realize fully their functions and achieve the overall objectives of the traffic management system as follows;

- (1) To collect, manage and integrate all data related to road and traffic conditions, incidents, weather conditions and any other necessary data for expressway operation;
- (2) To process, store and record the necessary data for effective expressway operation and maintenance;
- (3) To display the above collected and processed information on real-time basis, and share the information among operators in Main Management Center (MMC), Management Office (MO) or other places;
- (4) To disseminate the information converted appropriate data to the road users in order to take notice of road conditions on the expressway; and
- (5) To totally manage the traffic management system operation in the MMC.

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

6.2 System Requirements

The system requirements of the traffic management center system are as follows.

- (1) The traffic management center system shall collect all necessary information from following each system component on real-time basis.
 - Closed Circuit Television (CCTV) Camera System
 - Vehicle Detection System
 - Meteorological Monitoring (MET) System
 - Overload Monitoring System
 - Variable Message Sign (VMS) System
 - Digital Transmission System

- Wireless Radio System
 - Internal Telephone System
 - Power Supply System
 - Tunnel Safety Facility System, Tunnel Lighting System, Others
- (2) The system shall automatically process the collected data into usable road traffic information including traffic flow data, weather alerting data, etc. Also, the system must have capability of event data management such as traffic accident.
 - (3) The collected and processed data shall be stored into database of the system for necessary period so that each data can be utilized as statistics.
 - (4) The system shall have function to provide the information collected and processed through VMS system to the road users, and internet, e-mail and/or SMS to the public.
 - (5) The collected and processed data shall be monitored on large display panel, operator consoles and monitoring PCs in the MMC and the MO to share the information with organizations related.
 - (6) The system shall have future expandability of data exchange with relevant organizations such as other expressway operating bodies to realize the flexible and interactive road information sharing each other.
 - (7) The system shall have future expandability to manage the ITS in whole central region of Vietnam.
 - (8) The system must have function to monitor and manage the operational status of all system components of the ITS. Also the system shall have a reporting function in which various reports can be prepared with printer.
 - (9) The system shall be able to operate continuously 24 hours a day and 7days a week with a redundant system configuration.

6.3 System Configuration

The traffic management center system shall consist of the following component;

- (1) Traffic Management System Server;
- (2) Facility Management Server;
- (3) Large Display Panel (LDP);
- (4) LDP Controller;
- (5) Traffic Event Data Console;

- (6) Traffic Analysis Console;
- (7) System Status Monitoring Console;
- (8) Monitoring PCs;
- (9) Web & Message (MSG) Server;
- (10) System Clock Server;
- (11) Printers;
- (12) Firewall and Network Equipment; and
- (13) Peripheral.

The traffic management center system would be configured as figure below.

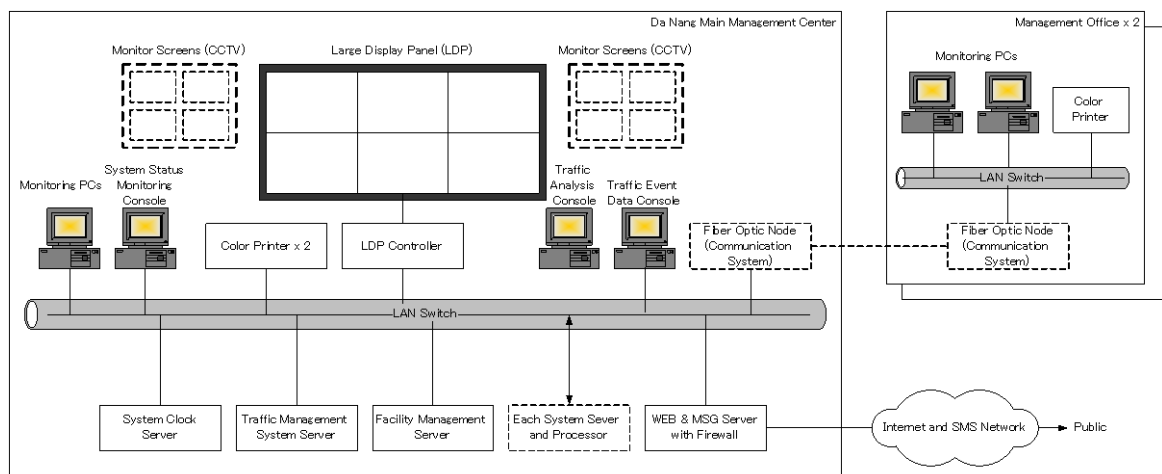


Figure 6-1 Traffic Management Center System Configuration

The traffic management center server, facility management server and Web & MSG server shall consist of an operating server and a standby server. In the event of a failure of the operating server, the standby server shall take over the operation automatically and there shall be no loss of data and abnormal operation of the system.

The traffic management center system shall consist of center servers and several operator consoles including monitoring PCs as specified herein. Each operator console shall have its own functions and perform the tasks assigned to it under normal conditions. In the event of unavailability of an operator console due to malfunction or maintenance, however, it shall be possible to use any other operator consoles as substitution to perform the same functions. Access privilege control shall be applied in the same manner when the operator console is being replaced.

The assignment of the functions to each operator console shall be as shown below.

No.	Operator console	Main functions
1.	Traffic event data console	<ul style="list-style-type: none"> • Input, editing and management of event data primarily • Having capability of access all contents of sub-systems
2.	Traffic analysis console	<ul style="list-style-type: none"> • Dedicated console for static data analysis • To be equipped with application software such as GIS, DB and traffic data analyser
3.	System status monitoring console	<ul style="list-style-type: none"> • Monitoring and management of the equipment and network primarily • Having capability of access all contents of sub-systems
4.	LDP controller	<ul style="list-style-type: none"> • Dedicated console for operation of LDP • To be equipped with application software to control LDP
5.	Monitoring PC	<ul style="list-style-type: none"> • Monitoring all contents of sub-systems excluding editing function by operators
6.	CCTV center controller console provided in the CCTV camera sub-system	<ul style="list-style-type: none"> • Observation of traffic conditions and operation of CCTV cameras primarily • Having capability of access all contents of sub-systems
7.	VMS center controller console provided in the VMS sub-system	<ul style="list-style-type: none"> • Creation and editing of VMS message to be displayed primarily • Control and monitoring of VMS primarily • Having capability of access all contents of sub-systems
8.	Maintenance consoles provided in each sub-system	<ul style="list-style-type: none"> • Dedicated console connecting each sub-system server directory for maintenance purpose

6.4 Installation Location

The traffic management center system will be placed in the traffic management room of MMC located near Tuy Loan toll barrier or in the office room of two (2) MOs which will be located in the same yard of MMC and near Quang Ngai north toll gate. The Contractor shall design the equipment installation layout of the traffic management room in MMC and the office room of MOs.

The layout shall be designed taking into consideration the function of the server and operator consoles to be placed in the room, the role of the staff and operators stationed in the room, position of large display panel, cable routes, viewing by visitors, relationships with other equipment procured by the other contract packages and other factors to establish a functional traffic management center system. The layout shall be approved by the Project Manager.

The Tenderer shall submit the layout plan of the traffic management room in MMC and office rooms in MO in the Tender for reference.

The Contractor shall also examine the interior works including wiring works for power and communication cable connections based on his own design and requirements of the equipment to be placed in the MMC and MO. All interior work designs shall be subject to the prior approval by the Project Manager.

6.5 Specifications

6.5.1 General

(1) System Capacity

The traffic management center system to be supplied under the Contract shall be designed to have the system capacity to operate the terminal equipment of the quantity specified below without adding hardware except the device related to data communication. The software shall be designed to function with the maximum capacity and actual number of equipment installed and connected to the system shall be specified as system parameter.

No.	Terminal Equipment	System capacity
1.	CCTV camera	Three (3) time of the quantity in the Contract
2.	Vehicle detection roadside equipment	Three (3) time of the quantity in the Contract
3.	MET observation station	Two (2) time of the quantity in the Contract
4.	Overload monitoring roadside equipment	Three (3) time of the quantity in the Contract
5.	Variable message sign	Three (3) time of the quantity in the Contract
6.	Others	Two (2) time of the quantity in the Contract

(2) Power Supply

The traffic management center system shall operate with AC single-phase two-wire system 220 V $\pm 10\%$ 50Hz. The electrical power supply system for the traffic management center system shall consist of AC commercial power with Uninterruptible Power Supply (UPS) and Diesel Engine Generator (DEG) backup power supply systems. The DEG will be provided by other contract package. The power supply facilities other than DEG such as UPS and power distribution board shall be procured in this Contract. The equipment to be supplied power from backup power supply systems is listed as table below.

Equipment	Voltages	UPS	DEG
Traffic management system server	1 ϕ - 2W - 220V, 50Hz	X	X
Facility management server		X	X
Large display panel		X	X
LDP controller		X	X
Traffic event data console		X	X
Traffic analysis console		X	X
System status monitoring console		X	X
Monitoring PC			X
Web & MSG server		X	X
System clock server		X	X
Printers			X
Firewall and network equipment		X	X
CCTV center controller and NVR		X	X

Equipment	Voltages	UPS	DEG
Traffic analysis processor		X	X
MET data processor		X	X
Overload monitoring data server		X	X
VMS center controller		X	X
CCTV center controller console		X	X
VMS center controller console		X	X
Maintenance consoles		X	X
Toll collection system equipment (server, etc.)		X	X
Fiber optic node		X	X
Wireless center station		X	X
IP-PBX		X	X

The UPS must be equipped with enough capacity of battery to supply power for a period of 10 minutes or longer in case of commercial power interruption. The UPS must have functions to send the power interruption signal to each equipment for safety system shut-down in case of commercial power failure, and the system shall automatically start-up when the commercial power recovers.

The Tenderer shall present the calculation of power consumption and capacity of UPS battery to be used for the traffic management center system.

(3) Communication

The communication network system shall connect the traffic management center system installed in the MMC and MO with each sub-system roadside equipment. The fiber optic network shall be utilized in this Project. The network equipment consists of Layer 3 Switch (L3-SW), Layer 2 Switch (L2-SW), Media Converter, Firewall etc. The network system configurations are indicated on the **Employer's Requirement Part D: Drawings**. The configurations shown on the **Employer's Requirement Part D: Drawings** are tentative and the Contractor shall examine and configure suitable network system and obtain the approval from the Project Manager.

The Tenderer shall present theoretical and physical network configurations and network security policy for this Project in his proposal.

6.5.2 System Functions

The traffic management center system shall have the functions listed below. These functions shall be integrated into a total intelligent transport system.

- Data collection
- Event data management
- Database management
- Facility management

- Network management and control
- Display and monitoring
- Parameter monitoring and management
- Information dissemination
- Human-machine interface
- System clock
- Operation log
- Report production

(1) Data collection

The traffic management center system shall collect the road and traffic conditions, incidents, weather conditions and any other necessary data from the respective sub-system components in certain periods as listed below.

Data Subsystem	Types of Data	Interval	Remarks
CCTV Camera System	CCTV video image	On real-time	Still image
	Equipment failure		
Vehicle Detection System	Traffic volume	1 minutes	every 1 minute data
	Large-sized vehicle traffic		every 1 minute data
	Time occupancy rate		every 1 minute data
	Vehicle average speed		every 1 minute data
	Equipment failure		
MET System	Instantaneous value of ambient temperature	1 minute	every 1 minute data
	Hourly cumulative value of rainfall in past 1 hour		
	Cumulative value of rainfall from start of rainfall		
	Instantaneous rainfall detection		every 1 minute data
	Maximum and minimum value of wind speed		every 1 minute data
	Wind direction at the max. and min. velocity		every 1 minute data
	Maximum and minimum value of visibility		every 1 minute data
	Equipment failure		
Overload Monitoring System	Axle and vehicle weight of vehicle	5 minutes	
	Plate number of overloaded vehicle		
	Video image of overloaded vehicle		Still image
	Equipment failure		
VMS System	Operation status	On real-time	
	Equipment failure		

The traffic management center system shall gather the road, traffic and weather data and equipment operational status from sub-system terminal equipment and their processed data via servers provided in each sub-system component. It shall also receive the still image data taken by CCTV camera.

(2) Event data management

The traffic management center system shall have data management functions of “event”

which includes events automatically generated in the each sub-system components such as adverse weather and traffic congestion, and incidents or traffic regulations that may be reported from expressway operator, traffic police and road users thorough verbal communications and input manually in the system. The system shall handle following event data as minimum requirement.

Event \ Data	Types of Data	Source	Remarks
Incident	Traffic Accident	Call Center / System	Manual
	Broken-down Vehicle	Call Center / System	Manual
	Left Obstacle	Call Center / System	Manual
	Natural Disaster	Call Center / System	Manual
Traffic Congestion	Heavy Congestion	System	Automatic
	Congestion	System	Automatic
Adverse Weather	Heavy Rain	System	Automatic
	Strong Wind	System	Automatic
	Dense Fog	System	Automatic
	Water Logging	System	Automatic
Construction Work	Construction Work	Road Operator	Manual
Traffic Regulation	Closure	Road Operator / Traffic Police	Manual
	Lane Closure	Road Operator / Traffic Police	Manual
	Max. Speed reduction	Road Operator / Traffic Police	Manual

(3) Database management

The traffic management system server shall store all data collected and processed within a system in an industry-standard database with the aim of statistics usage for future road planning, operation and maintenance. The system shall have one centralized database for managing the complete intelligent transport system. The facility management server shall store equipment operational status data into its database. Type, quantity and time period of data to be stored in each database shall be configurable. Each event shall be stored with necessary data timestamp. At least the following data and events shall be stored.

Data		Storage Data		Storage	Storage Period
CCTV camera system	CCTV still image		TMS		2 years
	Equipment operational status		FMS		
Vehicle Detection system	Equipment operational status		FMS		2 years
	1 minute spot (multiple lanes) data	Traffic volume		TMS	
		Large-sized vehicle traffic			
		Time occupancy rate			
		Vehicle average speed			
	1 minute sectional (single lane) data	Traffic volume		TMS	
		Large-sized vehicle traffic			
		Time occupancy rate			
		Vehicle average speed			
	1 minute sectional (multiple lanes) data	Traffic volume		TMS	
		Large-sized vehicle traffic			
		Time occupancy rate			
		Vehicle average speed			
“n” minutes sectional average speed		TMS			
Traffic congestion analysis results with parameters		TMS			
MET system	Equipment operational status		FMS		2 years
	Instantaneous temperature (1minute and 5minutes)		TMS		
	Moving total precipitation for previous 1hour		TMS		
	Total continuous precipitation		TMS		

Data Subsystem	Storage Data	Storage	Storage Period
	Instantaneous rainfall detection (1minute and 5minutes)	TMS	
	Maximum value of wind velocity for previous 1 minute	TMS	
	Direction at maximum wind during previous 1 minute	TMS	
	Instantaneous visibility (1minute and 5minutes)	TMS	
	Heavy rain analysis results with parameters	TMS	
	Strong wind analysis results with parameters	TMS	
	Poor visibility analysis results with parameters	TMS	
Overload monitoring system	Axle load of overloaded vehicles	TMS	2 years
	Weight of overloaded vehicles	TMS	
	Plate number of overloaded vehicles	TMS	
	CCTV still image of overloaded vehicles	TMS	
	Equipment operational status	FMS	
VMS system	Recommended message automatically generated against event	TMS	2 years
	Manual input operation record	TMS	
	Equipment operational status	FMS	
	Current message indicating on each VMS	TMS	
Traffic management center system	Input event data	Incident	2 years
		Construction work	
		Traffic regulation	
	Equipment operational status	FMS	
	E-mail and SMS subscriber information	TMS	
	Equipment operational status	TMS	
	Access history of Web	TMS	
	Transmitting history of e-mail and SMS	TMS	
Communication system	Digital transmission system operational status	FMS	2 years
	Wireless radio system operational status	FMS	
	Internal telephone system operational status	FMS	
Others	Tunnel safety facility operational status	FMS	2 years
	Tunnel lighting operational status	FMS	
	Other facilities' operational status	FMS	

Note TMS: Traffic management system server, FMS: Facility management server

(4) Facility management

The facility management function shall be provided to monitor the operational conditions of roadside equipment and traffic management center system equipment. The facility management server shall monitor the operation status of the all sub-system components listed below

- CCTV Camera System
- Vehicle Detection System
- MET System
- Overload Monitoring System
- VMS System
- Digital Transmission System
- Wireless Radio System
- Internal Telephone System
- Power Supply System
- Tunnel Safety Facility System, Tunnel Lighting System, Others

The role of this function is to consolidate the system operation status monitoring function undertaken by each sub-system component, present the status to operators and record the system operation. In case any abnormality or malfunction is detected, the facility

management server shall issue an alarm together with information regarding type and location of the failure so that remedial action can be taken smoothly.

(5) Network management and control

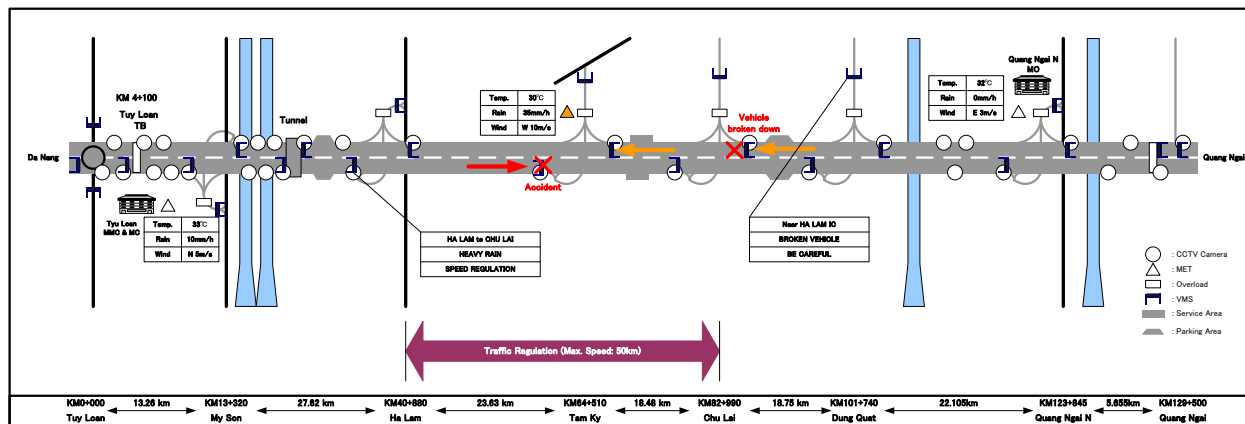
The network management function shall be provided to the traffic management center system. The function shall continuously monitor the conditions of Layer 2 switch and Layer 3 switch using simple network management protocol. In case a malfunction occurs, network management system shall issue an alarm to the system status monitoring console.

(6) Display and monitoring

The traffic management center system shall provide display and monitoring functions of schematic road map of the DQE with various kinds of static and dynamic information for the system operator to understand the current condition and to take necessary action. Such information to be displayed in the schematic map shall include but not limited to the followings.

Item	Contents
Route map	<ul style="list-style-type: none"> • Schematic road map of DQE • Name and station number of interchanges and toll barriers
Equipment location and status	<ul style="list-style-type: none"> • Location of CCTV camera • Location of vehicle detection and roadside equipment • Location of MET station • Location of overload monitoring roadside equipment • Location of variable message sign • Their operational status
Road, traffic and weather condition	<ul style="list-style-type: none"> • Traffic congestion • Weather condition (rain, wind velocity, wind direction, precipitation, visibility) • Incident (traffic accident, broken-down vehicle, left obstacle, natural disaster) • Regulation (lane closure, road closure)
CCTV video image	<ul style="list-style-type: none"> • Video image from the CCTV camera selected • Video image from the video recorder
Operator console monitor display	<ul style="list-style-type: none"> • Monitor display of operator console selected
Date and Time	<ul style="list-style-type: none"> • Current date and time

Figure below shows an example of schematic road map of the DQE.



The traffic management system server shall have function to generate the schematic road map to be monitored through display devices such as the operator consoles and large display panel. The server shall also generate following screens.

- Each sub-system equipment status with list and map
- Event data input screen with map

(7) Parameter monitoring and management

Some of sub-system components introduce a warning system to detect the traffic congestion or adverse weather condition based on the pre-defined threshold. The traffic management center system shall monitor and manage such parameters. The parameters to be monitored and changeable in the traffic management center system shall includes followings;

- Vehicle detection system: Two parameters of average speed judging for “heavy congestion” and “congestion”;
- MET system: Parameters detecting heavy rain, strong wind and poor visibility.

(8) Information dissemination

The road, traffic and weather condition information collected and processed in the traffic management center system will be provided to the road users through variable message sign, Internet, e-mail or SMS in the Project.

- Information dissemination through VMS

The VMS system provides road users with road, traffic and weather information through variable message sign boards at roadside in accordance with the data collected and processed in the traffic management center system. The control of VMS shall be made from VMS center controller console procured in the VMS sub-system while the traffic management center system shall provide VMS system with automatic message selection function based on the priority or severity of the events and coefficients that represent the importance of event. The function in the traffic management center system shall includes;

- Automatic message generation function that generates the recommended message

to be indicated on the VMS when any event occurs

- Zoning function that selects the VMS necessary for showing message when the event occurs at any place
- Information screening function that selects the prior event to be displayed on the VMS when several incidents occur at the same time.

Table below shows the priority schedule in VMS message selection function as reference.

Table 6-1 Priority Order of Cause and Event in VMS message

Cause \ Event		Cause										
		High ←			→ Low							
		Disaster or Flood	Traffic Accident	Fire	Broken Vehicle	Road Obstacle	Animal Invasion	O&M Work	Concentration	Dense Fog	Strong Wind	Heavy Rain
High ↑ Event ↓ Low	Road Closure	1	2	3	-	-	4	5	-	6	7	8
	Exit Closed	1	2	3	4	5	-	6	-	-	-	-
	Be Careful (Incident)	1	2	3	4	5	6	-	-	-	-	-
	Congestion 10km	-	1	2	-	-	-	3	4	-	-	-
	Congestion 5km	-	1	2	-	-	-	3	4	-	-	-
	Congestion	-	1	2	-	-	-	3	4	-	-	-
	Lane Control	1	2	3	-	-	-	4	-	-	-	-
	Speed Regulation	1	2	3	-	-	-	4	-	5	6	7
	Be Careful (O&M Work)	-	-	-	-	-	-	1	-	-	-	-
	Be Careful (Weather)	-	-	-	-	-	-	-	-	1	2	3

Event location	Next Section	2section Ahead	3section Ahead	4section Ahead	5section Ahead	6section or More
Road Closure	1	8	10	12	14	16
Exit Closed	2	9	11	13	15	17
Be Careful (Incident)	3	-	-	-	-	-
Congestion 10km	4	18	20	22	24	26
Congestion 5km	5	19	21	23	25	27
Congestion	6	28				
Lane Control	7	-	-	-	-	-
Speed Regulation	29	-	-	-	-	-
Be Careful (O&M Work)	30	-	-	-	-	-
Be Careful (Weather)	31	-	-	-	-	-

The Tenderer shall present his recommended priority schedule in VMS message indication in his proposal.

- Information dissemination through Internet and e-mail/SMS

Information dissemination system through Internet and e-mail/SMS shall consist of an Web & MSG server and a firewall and an application software. The basic information to be provided to the road users through those media shall include but not limited to the following:

[Internet]

- Traffic information on map
- Weather conditions on map
- Event and incident information on map
- Traffic regulation on map
- Overall schematic map indicating all information above

[e-mail/SMS]

- Weather conditions in text
- Event and incident in text
- Traffic regulation in text

The system shall have subscriber management function to register and deregister the e-mail and SMS users. Firewall shall be provided to protect the Internet server against the possible attack.

(9) Human-machine interface

Two kinds of display devices shall be provided as the human-machine interface, operator consoles including monitoring PC and large display panel. The large display panel shall have multiple screen display function in which display area will be divided into four or more small screen areas and each of them can display image from the different sources. Large display panel shall be capable of displaying any images from CCTV camera system and any operator consoles.

(10) System clock

The traffic management center system shall have a real-time clock that shall be used for the timing of monitoring, data transfer, device control, reports, and print-outs. The clock shall have an automatic adjustment function using GPS, Internet, mobile phone or any other references and the clock shall remain accurate within one second all the time. The real-time clock shall have an internal battery and shall maintain the correct time for at least 48 hours. All sub-systems, equipment and devices comprising the intelligent transport system in the DQE shall synchronize with the real-time clock.

(11) Operating log

All operations by the system operator through the operator consoles shall be recorded as operation log with the operator's ID and time. All malfunctions of the equipment comprising the system shall be recorded with time of occurrence, time of recovery and type of error.

(12) Report function

The traffic management center system shall have a reporting function in which various daily, monthly and annual reports can be prepared with printer. The types of report shall include but not limited to the followings:

- Traffic conditions and traffic analysis results
- Weather conditions (MET)
- Variable message sign operation
- Equipment malfunction and recovery

The report will be produced in two modes. In automatic mode, reports will be printed automatically at the timing specified for each report. In manual mode, report is printed when the operator requests it. All reports will be in English and Vietnamese.

6.5.3 Technical Specifications

(1) Traffic management system server and facility management server with storage

The traffic management system server and facility management server computer hardware shall be standard models manufactured by organizations of international repute. Custom built or non-standard equipment will not be acceptable.

The computer hardware including display terminals shall be readily available in Vietnam. Full maintenance support services and ready availability of consumables, spare parts or replacement units shall also be assured from a third party, based in Vietnam; who is not connected with the Contractor and his agent.

The specifications in this section are provided as reference. The servers to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Project Manager.

No.	Item	Specifications
1.	Server configuration	<ul style="list-style-type: none"> • Latest redundant server with automatic failover ability • Prominent manufacturer • 10 years hardware supporting warranty • Readily available in Vietnam • Rack mount type enclosure • Low energy consumption
2.	Processor	<ul style="list-style-type: none"> • Latest stable multi core or CPU type processor • Having enough ability to process all required work without any delay.
3.	OS	<ul style="list-style-type: none"> • Latest LINUX stable operating system or latest Windows Server stable operating system • 10 years supporting warranty

No.	Item	Specifications
4.	Memory	<ul style="list-style-type: none"> ECC memory Having enough ability to process all required work without any delay, and enough space in operation.
5.	Storage	<ul style="list-style-type: none"> Having twice of sufficient volume to process all required work and store all required data including temporary data by OS and application in operation. Having latest stable and high speed interface as for real-time operation. Data recovery system like RAID5.
6.	Back-up	<ul style="list-style-type: none"> High speed and large capacity device for periodical data backup Software driven data mirroring mechanism to meet the availability criteria mentioned below in case of site outage
7.	Graphic card	<ul style="list-style-type: none"> Five or more video interfaces as RGB Analogue, DVI-D or HMDI to connect display devices. Video interface must support video switches and maintenance display monitor to display pixel to pixel matching full HD images.
8.	Peripheral	<ul style="list-style-type: none"> DVD of high speed and high capacity multi drive supporting latest standard High speed and large capacity device for periodical data backup
9.	Availability	<ul style="list-style-type: none"> Hot-plug, redundant power supplies Hot-plug, redundant FAN Hot-plug drive bays
10.	Display monitor	<ul style="list-style-type: none"> 21-inch or smaller size of LCD type monitor (Full HD) RGB Analogue, DVI-D or HMDI required as input interface that should be same as of video interface
11.	Network	<ul style="list-style-type: none"> 1000/100M Base LAN interface Dual LAN interface
12.	Security	<ul style="list-style-type: none"> Virus protection Firewall
13.	Reliability	<ul style="list-style-type: none"> MTBF > 5 years x 365 days x 24 hours = 43,800 hours as a redundant server MTTR < 12 hours Monitoring temperature of CPU & inside casing, FAN moving, HD status, Memory status, peripheral status Alerting function when faults. Latest SNMP supporting
14.	System availability	<ul style="list-style-type: none"> Expected rate of operation as a redundant server > 99.97% $= \text{MTBF} / (\text{MTBF} + \text{MTTR})$

No.	Item	Specifications
15.	Serviceability	<ul style="list-style-type: none"> Onsite support service. Automatically alert the service center without human intervention when the system experiences a system fault.
16.	Power Consumption	<ul style="list-style-type: none"> 3.6KVA or less as a whole redundant server
17.	Remark	<ul style="list-style-type: none"> All equipment is mounted in 19-inch type server rack.

(2) Web & MSG server

No.	Item	Specifications
1.	Server configuration	<ul style="list-style-type: none"> Latest redundant server with automatic failover ability Prominent manufacturer 10 years hardware supporting warranty Readily available in Vietnam Rack mount type enclosure Low energy consumption
2.	Processor	<ul style="list-style-type: none"> Latest stable multi core or CPU type processor Having enough ability to process all required work without any delay.
3.	OS	<ul style="list-style-type: none"> Latest LINUX stable operating system or latest Windows Server stable operating system 10 years supporting warranty
4.	Memory	<ul style="list-style-type: none"> ECC memory Having enough ability to process all required work without any delay, and enough space in operation.
5.	Storage	<ul style="list-style-type: none"> Having twice of sufficient volume to process all required work and store all required data including temporary data by OS and application in operation. Having latest stable and high speed interface as for real-time operation. Data recovery system like RAID5.
6.	Back-up	<ul style="list-style-type: none"> High speed and large capacity device for periodical data backup Software driven data mirroring mechanism to meet the availability criteria mentioned below in case of site outage
7.	Graphic card	<ul style="list-style-type: none"> Two or more video interfaces as RGB Analogue, DVI-D or HMDI to connect display devices. Video interface must support video switches and maintenance display monitor to display pixel to pixel matching full HD images.
8.	Peripheral	<ul style="list-style-type: none"> DVD of high speed and high capacity multi drive supporting latest standard High speed and large capacity device for periodical

No.	Item	Specifications
		data backup
9.	Availability	<ul style="list-style-type: none"> Hot-plug, redundant power supplies Hot-plug, redundant FAN Hot-plug drive bays
10.	Display monitor	<ul style="list-style-type: none"> 21-inch or smaller size of LCD type monitor (Full HD) RGB Analogue, DVI-D or HMDI required as input interface that should be same as of video interface
11.	Network	<ul style="list-style-type: none"> 1000/100M Base LAN interface Dual LAN interface
12.	Security	<ul style="list-style-type: none"> Virus protection Firewall
13.	Reliability	<ul style="list-style-type: none"> MTBF > 5 years x 365 days x 24 hours = 43,800 hours as a redundant server MTTR < 12 hours Monitoring temperature of CPU & inside casing, FAN moving, HD status, Memory status, peripheral status Alerting function when faults. Latest SNMP supporting
14.	System availability	<ul style="list-style-type: none"> Expected rate of operation as a redundant server > 99.97% $= \text{MTBF} / (\text{MTBF} + \text{MTTR})$
15.	Serviceability	<ul style="list-style-type: none"> Onsite support service. Automatically alert the service center without human intervention when the system experiences a system fault.
16.	Power Consumption	<ul style="list-style-type: none"> 2KVA or less as a whole redundant server
17.	Remark	<ul style="list-style-type: none"> All equipment is mounted in 19-inch type server rack.

(3) Large display panel

The specifications in this section are provided as reference. The large display panel with video switches to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Project Manager.

No.	Item	Specifications
1.	Display Type	Color TFT LCD
2.	Display Size	55 inch or more
3.	Number of pixels	1920×1080 (full HD)
4.	Contrast Ratio	3500:1 or higher
5.	Bezel-to-Bezel Width	6.0mm or less

No.	Item	Specifications
6.	Input Signal	RGB Analogue, DVI-D or HMDI (Input interface shall be equivalent to output interface of Video Switches.)
7.	Video Switches	
(1)	Input Signal	RGB Analogue, DVI-D or HMDI x30 or more
(2)	Output Signal	RGB Analogue, DVI-D or HMDI x6 or more
(3)	Controllable Number of pixels	Equivalent to the number of pixels of Large display panel
(4)	Control Interface	10 BASE-T/100BASE-TX (RJ-45)

(4) Operator Consoles

The Contractor shall provide the operator consoles as listed hereunder. The operator consoles shall be the same model and shall have the same configuration.

- Traffic event data console
- Traffic analysis console
- System status monitoring console
- LDP controller
- Monitoring PCs

The specifications in this section are provided as reference. The operator consoles to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Project Manager.

No.	Item	Specifications
1.	PC configuration	<ul style="list-style-type: none"> • Latest PC • Prominent manufacturer • 5 years hardware supporting warranty • Readily available in Vietnam • Space saving type enclosure • Low energy consumption
2.	Processor	<ul style="list-style-type: none"> • Latest stable multi core or CPU type processor • Having enough ability to process all required work without any delay.
3.	OS	<ul style="list-style-type: none"> • Latest Windows stable operating system • 5 years supporting warranty
4.	Memory	<ul style="list-style-type: none"> • Having enough ability to process all required work without any delay, and enough space in operation.
5.	Storage	<ul style="list-style-type: none"> • Having twice of sufficient volume to process all required work and store all required data including temporally data by OS and application in operation. • Having latest stable and high speed interface as for smooth operation.

No.	Item	Specifications
6.	Graphic card	<ul style="list-style-type: none"> • RGB Analogue, DVI-D or HDMI video interface (Full HD), equivalent to video switches and console display monitor interface • Number of video interface shall be as follows: Traffic event data console: Three Traffic analysis console: Two System status monitoring console: Three LDP controller console: One Monitoring PCs: Three • Video interface must support video switches and console display monitor to display pixel to pixel matching full HD images.
7.	Console Display Monitor	<ul style="list-style-type: none"> • LCD widescreen monitor (Full HD), 24-inch or larger • Number of monitor shall be as follows: Traffic event data console: Two Traffic analysis console: Two System status monitoring console: Two LDP controller console: One Monitoring PCs: Two • RGB Analogue, DVI-D or HDMI input, equivalent to graphic card video interface
8.	Peripheral	<ul style="list-style-type: none"> • DVD of high speed and high capacity multi drive supporting latest standard
9.	Network	<ul style="list-style-type: none"> • 1000/100M Base LAN interface
10.	Security	<ul style="list-style-type: none"> • Virus protection • Firewall
11.	Reliability	<ul style="list-style-type: none"> • MTBF > 3 years x 365 days x 24 hours = 26,280hours • MTTR < 24 hours • Monitoring temperature of CPU & inside casing, HD status. • Alerting function when faults. • Latest SNMP supporting
12.	System availability	<ul style="list-style-type: none"> • Expected rate of operation > 99.90% =MTBF/(MTBF+MTTR)
13.	Serviceability	<ul style="list-style-type: none"> • Onsite support service.
14.	Power Consumption	<ul style="list-style-type: none"> • 500VA or less

(5) System clock server

Each system component will be equipped with a clock system for its operation. These clocks shall be synchronized to collect and process the data correctly. A system clock server will be provided to the traffic management center system as a reference clock. All clocks in the system component shall be synchronized with the clock provided by the server using network time protocol (NTP) or simple network time protocol (SNTP).

The Tenderer shall present his recommended server specifications in his proposal.

(6) Printers

The printer shall be a high-speed A3/A4 size color laser printer. The printers shall be connected to the LAN of traffic management center system.

No.	Item	Specifications
1.	Printing speed	30 ppm or higher (black, normal quality mode) 30 ppm or higher (colour, normal quality mode)
2.	First page out	Not more than 16 second (black, colour)
3.	Print resolution	600 dpi or higher (black) 600 dpi or higher (colour)
4.	Paper trays	2 (standard)
5.	Media size	A3 / A4
6.	Duplex (both sides) printing	Automatic
7.	Interface	100M Base LAN interface

(7) Firewall and network equipment

The network equipment consists of Layer 3 Switch (L3-SW), Layer 2 Switch (L2-SW), Media Converter, Firewall etc. Firewall shall also be provided to protect the Internet server against the possible attack.

The Tenderer shall present his recommended specifications for firewall and network equipment in his proposal.

(8) Software

• General

The Contractor shall provide a set of software to operate on the servers, operator consoles, terminal equipment, and other components and devices to be provided under the Contract. The software shall function as a system to provide end results required in the Contract.

The software will be either the software that the Contractor has, modification of the exiting software, or the new software to be developed for the Project. The copyright of the software specifically developed for the project shall remain with the Contractor.

The set of the software to be provided shall consist of those provided by third party and those specifically developed for the project. All third party software shall be legally licensed and there shall be no restriction on the use in the Intelligent Transport System in DQE. They shall be registered under the name of Employer and any supports and services provided by the software developer including update and revision shall be available to the Employer.

The software to be specifically developed for the Project shall be fully tested and shall be free from bugs. **The Tenderer shall state in the Technical Proposal of the Tender the software quality assurance program that he intends to adopt in developing the software.**

The programming of the applications shall be arranged in such a way that maximum flexibility is afforded by the design to allow the Employer to implement modifications or additional equipment which may become available or desirable during the working life of the system. Such future modifications or changes shall not be the part of the current scope of the contract and shall be estimated and paid time to time by the Employer if required but comprehensive documentation of the software and source codes shall be provided under the Contract to allow such changes to be implemented by the Employer without recourse to the Contractor.

The Employer may wish to implement additional software packages to run concurrently with the software provided under the Contract. These packages may include but will not be limited to the following:

- Programs allowing the traffic management center system to operate with other systems such as ITS developed in other expressway interfaced to the data network and involving bi-directional transfer of files.
- Analytical and statistical program to process the data collected by the system.
- Software that offers new service to the road users through Internet.

The Tenderer shall propose in the Technical Proposal of the Tender the feasibility and ease with which such applications might be implemented using the ITS proposed by him and shall advise the spare memory capacity and processing power which could be available, but not necessarily provided, within the proposed computer to allow such applications to be implemented.

- Third Party Software

The third party software to be provided shall include but not be limited to the following:

- Server operating system
- Storage device operating system
- Client operating system
- Database management software
- Firewall and antivirus program

All third party programs to be provided shall be widely used and suitable for the application of ITS in the DQE in terms of functions, capacity, speed, interface with other software, maintenance and user friendliness. **The Tenderer shall state in the Technical Proposal of the Tender, the third party software that he proposes. If the Tenderer proposes**

the third party program that is of limited use, he shall explain the reason for using it in the Technical Proposal of the Tender.

If the third party software is provided in CD or DVD, the original CD or DVD shall be submitted as part of documentation. The requirement is not applicable to the software preinstalled in the server or operator console.

If the cost of the operating system is included in the server and operator console hardware, the same may not be mentioned in the schedule of prices.

- ITS Software

The Contractor shall develop new software or modify the existing software to provide the ITS functions specified herein and as per the General Technical Specifications and Particular Technical Specifications.

The software to be provided as ITS software shall include but not be limited to the following:

- Traffic management center server software
- Facility management server software
- LDP control software
- Web & MSG generation software
- System clock software
- NVR application software (CCTV camera sub-system)
- CCTV control application software (CCTV camera sub-system)
- Traffic analysis processing software (Vehicle detection sub-system)
- MET data processing software (MET sub-system)
- Overload monitoring data processing software (Overload monitoring sub-system)
- VMS control application software (VMS sub-system)
- Network management software (communication system)
- Utility software
- Maintenance activity tracking and logging software

The actual configuration of software modules may not be necessarily as listed above; but it shall follow the General Technical Specifications and Particular Technical Specifications.

All software shall be of modular construction and the interaction between the modules

shall be kept minimum. They shall be designed to operate continuously and no periodical maintenance of the software shall be required.

All the display on the display monitor and printed report shall be capable of in both English and Vietnamese.

The utility software shall include but not be limited to the system backup and restoration, database backup and restoration, and access control and operation log functions. Usage of the server and operator consoles shall be controlled by log in/out procedure and different levels of access control shall be provided to restrict the use of certain software by unauthorized persons. All operations shall be recorded as log together with staff identification number.

The software that interacts with the system operator shall be provided with fault tolerant functions and access control functions. They shall be designed in such a way that any operation error shall not cause damage to the system, loss of data or system shut down.

All software shall be tested under the different conditions and cases including incorrect operation by the system operator and erroneous data to verify the sturdiness of the software.

7. Toll Collection System

7.1 Function of the Toll Collection System

7.1.1 System Configurations

The toll collection system shall be designed as “Closed System” in which the toll rate is determined by vehicle classification and vehicle running distance on the expressway. The vehicle will stop and get a toll ticket at entry point and pay a toll fee to a toll collector at exit point. After the ticket is handed over or toll fee is paid, the lane will be opened automatically for the vehicle to pass through the tollgate.

The Toll Collection System for the project shall be configured with, as mainly, four components as follows;

- ✓ Toll Lane System
- ✓ Toll Office System
- ✓ Toll Center System
- ✓ User Side Equipment

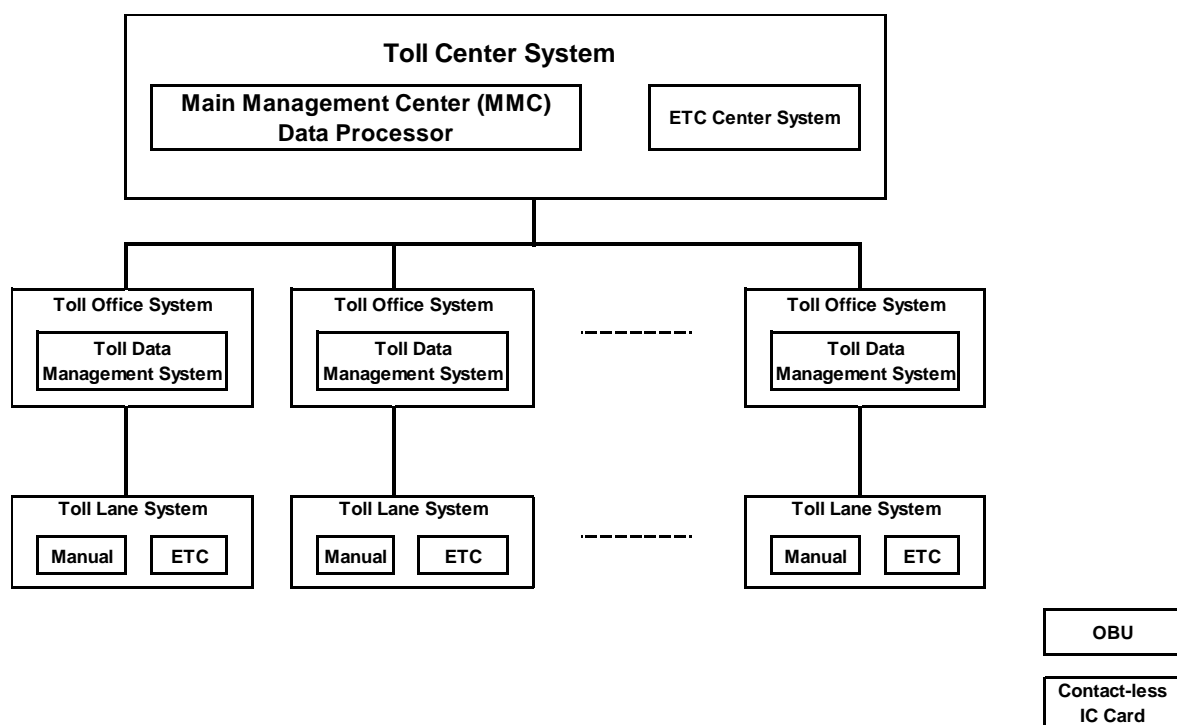


Figure 7-1 Overall Toll Collection System

7.1.2 Toll Lane System

The peripherals of toll lane system are installed both at the toll island and in the tollbooth. The Toll Lane Server (TLS) shall form the integrated core equipment to ensure the all lane functions and procedures, and all data of transaction are controlled and retrieved independently by the TLS.

(1) Toll island equipment

Toll island equipment shall be composed of, but not be limited to, following equipment, on the toll island.

- Lane Traffic Light (LTL)
- Canopy Traffic Light (CTL)
- Automatic License Number Plate Recognition Camera (ANPR-CAM)
- Lane Side Camera (LS-CAM)
- Vehicle Detector (VD)
- Lane Side Display (LSD)
- Automatic Lane Barrier (ALB)
- Manual Lane Barrier (MLB)
- Flashing Light for Traffic Safety (FLTS)
- Alarm Horn and Lamp (AHL)
- Roadside Antenna (RSA)

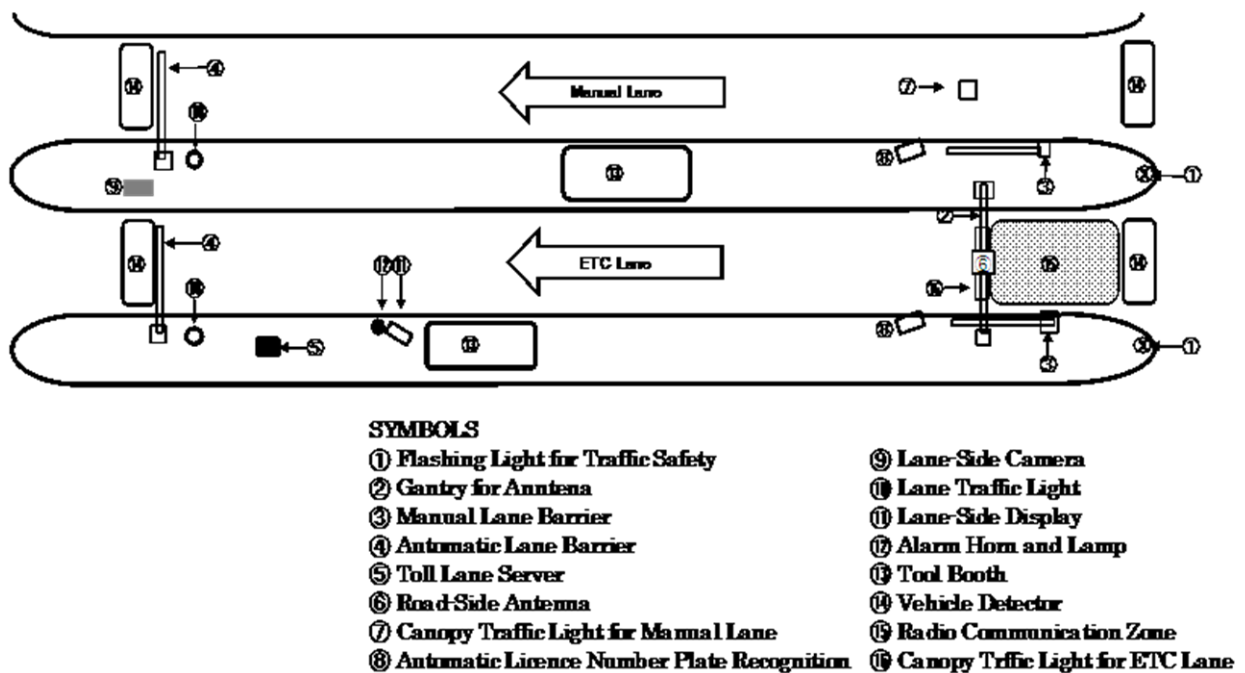


Figure 7-2 Toll Island Equipment Configuration

There shall be 4 kinds of signs associated with each set of tollbooth equipment, namely:

- ✓ Lane Traffic Light (LTL)
- ✓ Canopy Traffic Lights (CTL)
- ✓ Lane Side Display (LSD)
- ✓ Alarm Horn and Lamp (AHL)

The LTL shall be a traffic signal with a red “Stop” and green “Go” light, and located at the vehicle departure side of each toll lane to control passage of each toll vehicle. The

green “Go” light shall be for indicating a driver that the toll ticket has been issued at entry point or the toll fee has been paid at exit point and he is free to move on.

The CTL shall be mounted on the toll canopy above the entrance of each toll lane and shall indicate whether that lane is opened or closed for the driver.

The LSD shall be used to show the toll amount to be paid, vehicle classification registered by the toll collector, amount of value in prepaid card and other information related toll collection. The LSD shall be located where the driver can see it while he stopped at the tollbooth.

The AHL shall be used to indicate the warning or sign by sounds or visuals, when any incidents happen. The AHL shall be located where the driver can hear and see it while he stopped at the booth.

There shall be 2 sets of camera associated with tollbooth equipment or toll office system, namely:

- ✓ ANPR Camera (ANPR-CAM)
- ✓ Lane Side Camera (LS-CAM)

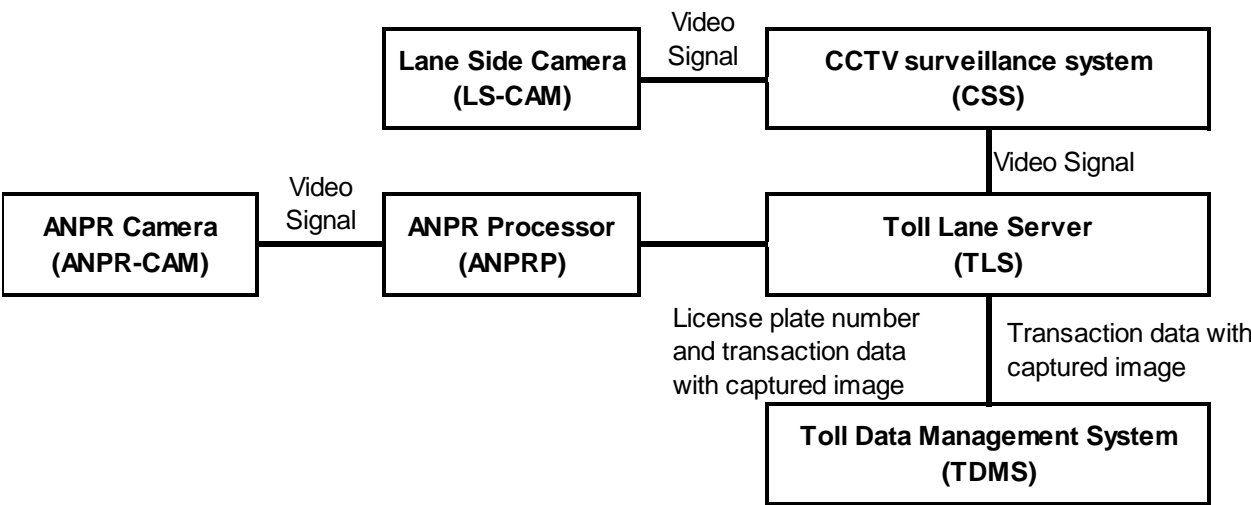


Figure 7-3 Configuration of Lane Side Camera and ANPR-Camera

The ANPR-CAM shall be used to recognize the license number of a vehicle connected with ANPR Processor (ANPRP) in the booth. The ANPR-CAM shall be located where it is the best position to take a shot the license number plate properly.

The LS-CAM shall be used to observe the condition of toll collection activity on a lane. The video image shall be recorded in associated toll office system via the Toll Lane Server (TLS). The LS-CAM shall be located where it is possible to observe the vehicle fully while the driver stopped at the booth.

The **CCTV surveillance system (CSS)** shall be used to display state of vehicle passing through the toll lane via Lane Side Camera (LS-CAM), and send video signal to Toll

Lane Server (TLS).

The **Vehicle Detector (VD)** shall be used to detect the vehicle and retrieve the number of vehicles. The VD shall be used to detect whether the vehicle has existed/passed or NOT at the position where the VD is set. Also the VD shall be used as a kind of traffic counter to calculate the number of vehicle passing through the toll lane.

- ◆ The VD should be able to detect surely the vehicle running by per 80km/hour through the toll lane and to separate a vehicle which runs 1m by the distance between two vehicles.

The Roadside Antenna (RSA) shall be used to communicate with the On-Board Unit (OBU) installed in the user's vehicle in order to provide the Electric Toll Collection (ETC) service. The RSA shall be mounted on a gantry above the front side of both Ingress/Egress ETC operated lane (hereinafter referred as ETC lane).

- ◆ The communication area of RSA shall cover 4 m in the longitudinal (vehicle travel) direction and 3 m in the lateral direction, at a height of 1 m from the surface of toll lane.

There shall be 2 kinds of barrier which shall provide a physical obstruction to passage through each lane, namely a **Manual Lane Barrier (MLB)** and an **Automatic Lane Barrier (ALB)**. The MLB shall be located around the front of toll island to indicate the driver whether a toll lane is operated or NOT. The ALB shall be located at the tollbooth forward in order to control the “Stop” and “Go” of the vehicle.

Ancillary items of toll collection system equipment shall include, but not limited to, a **Flashing Light for Traffic Safety (FLTS)** which shall provide a warning to avoid the clash against the toll island.

- ◆ The FLTS shall be visually recognized from 100m distance from the toll island.
- ◆ The FLTS shall be a two light type, and emit light alternately.

Table 7-1 Number of Toll Island Equipment

Toll Island Equipment		Manual Lane		Manual & ETC Lane	
		Entry	Exit	Entry	Exit
Lane Traffic Light	LTL	1	1	1	1
Canopy Traffic Light	CTL	1	1	1	1
Automatic License Number Plate Recognition Camera	ANPR-CAM	1	1	1	1
Lane Side Camera	LS-CAM	1	1	1	1
Vehicle Detector	VD	2	2	2	2
Vehicle Detector Unit	VD-U	1/total lanes	1/total lanes	1/total lanes	1/total lanes
Lane Side Display	LSD	1	1	1	1
Automatic Lane Barrier	ALB	1	1	1	1
Manual Lane Barrier	MLB	1	1	1	1
Flashing Light for Traffic Safety	FLTS	1	1	1	1
Alarm Horn and Lamp	AHL	1	1	1	1
Roadside Antenna	RSA			1	1

(2) Tollbooth equipment

The tollbooth equipment shall be composed of following equipment, but not be limited to, in the tollbooth.

- Toll Lane Server (TLS)
- Toll Transaction Terminal (TTT)
- IC-Card Reader/Writer (ICCRW)
- Receipt Printer (R-PRT)
- ETC controller (ETCC)
- ANPR Processor (ANPRP)
- Booth Communication System (slave) (BCS-S)
- Emergency Caller (slave) (ECALL-S)
- LAN cable and necessary number of hubs and routers
- Power and switch boxes as necessary to meet the specification

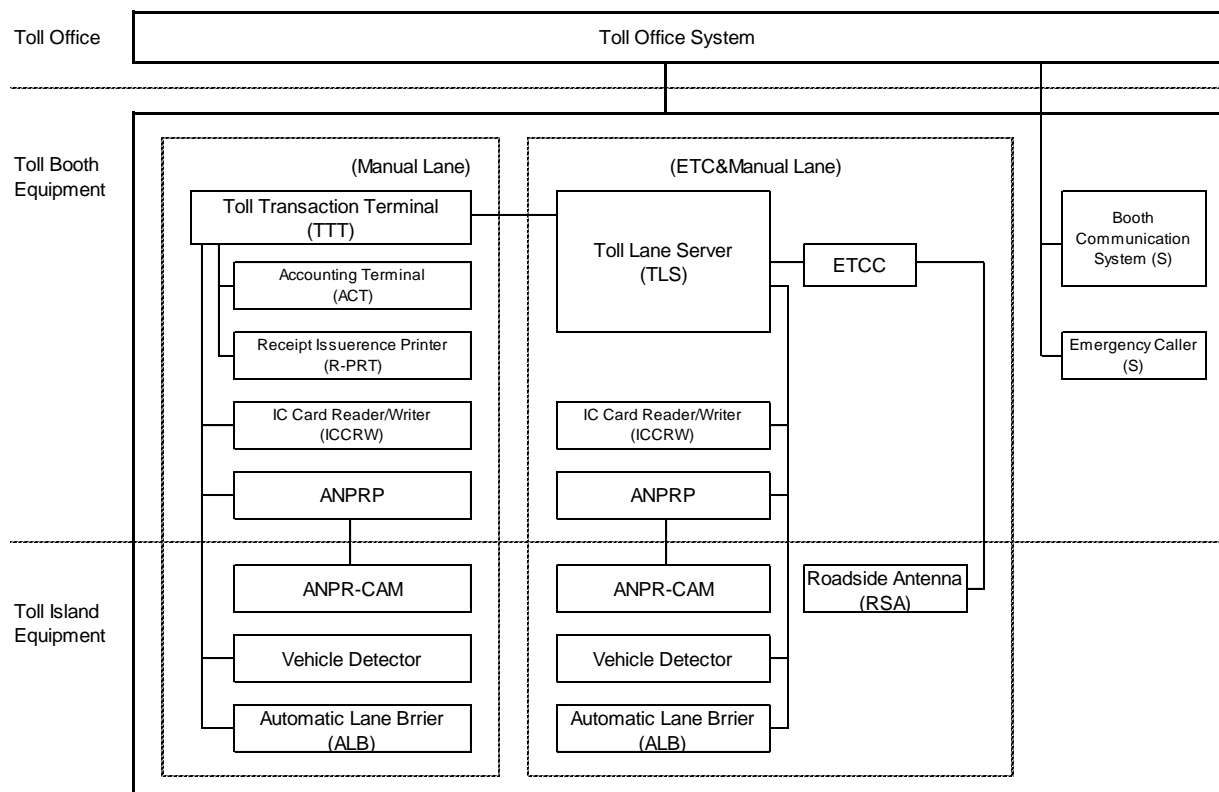


Figure 7-4 Tollbooth Equipment Configuration

The tollbooth equipment shall operate in an autonomous mode controlling all the lane peripherals, analyzing inputs from the Vehicle Detector (VD), the ETC Controller (ETCC), the IC-Card Reader/Writer (ICCRW) in conjunction with the toll collector's inputs made via a keyboard on the Toll Transaction Terminal (TTT) and other automatic and semi-automatic inputs provided by the equipment itself.

The **Toll Lane Server (TLS)** shall store and, under normal operating conditions, transmit

the individual data (including exceptional transactions data) of the toll collector's job to both the Toll Office System (TOS) for storing the data into the its database, in real time, confirming all events, individual transactions and alarms.

At the closing event of the lane, the TLS shall transmit the job and traffic data after summarizing all the toll transactions of the toll collector's job.

Each TLS shall have the capability of operating in the normal on-line mode and off-line mode. When the TOS failed, the TLS shall store data relating to at least 1 week operation under specified conditions and throughput, for later transmission to ensure no loss of audit or statistical data.

The TLS shall send a captured image from the LS-CAM with some retrieval keys to Toll Data Management System (TDMS) at each transaction. Required image storage period is of more than one (1) week. The size of image data shall be proposed by the contractor. One of retrieval keys to search the image shall be a transaction number. **Figure 7-6** shows the configuration.

The **Toll Transaction Terminal (TTT)** shall serves as the toll collector's input terminal. The TTT shall be connected by a plug and socket, arrange so that the connection is secure from unauthorized disconnection. The TTT shall be constructed to resist against split beverages, dust and exhaust pollutants.

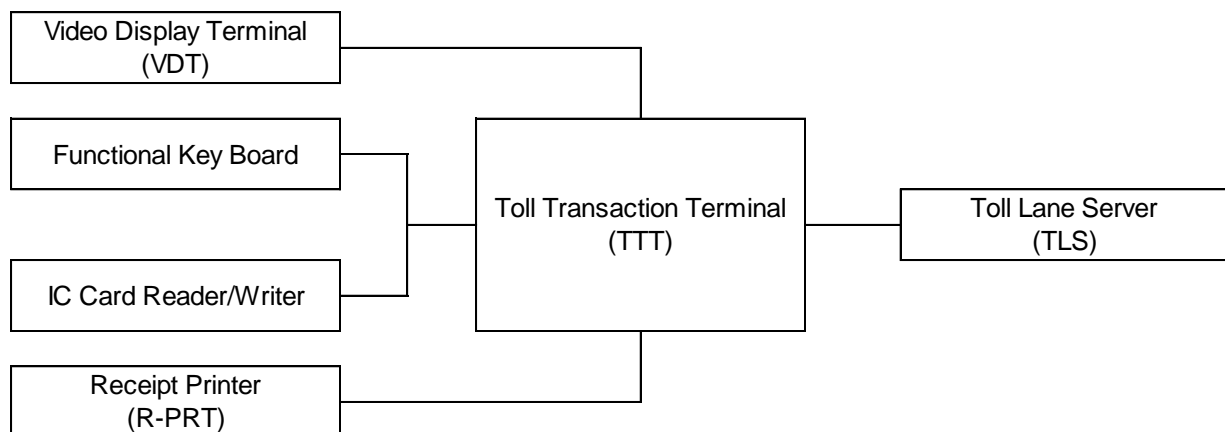


Figure 7-5 Configuration of Toll Transaction Terminal (TTT)

The following items of equipment shall be neatly fitted on or accommodated in the TTT or provided as separate unit as necessary for the proper registration of transactions:

- ◆ Functional keyboard or the touch screen as an input device.
- ◆ A digital time display.
- ◆ Compatible with an IC-Card Reader/Writer (ICCRW), able to read all IC-Card of the Project.
- ◆ An indication to show that booth equipment power is available.
- ◆ This indication shall only be extinguished for loss of a power supply to the

tollbooth equipment. It shall not be extinguished by faults in the processing and registration equipment.

- ◆ A “lane open” and “lane closed” control which shall switch display status of the Canopy Traffic Lights (CTL).
- ◆ A clear and easily distinguishable indication to show whether the “lane open” or “lane closed” aspects is currently displayed on the CTL.
- ◆ Vehicle classification selection keys function, at least five (5).
- ◆ A “Force Reset” key to allow reset of the equipment at the end of a transaction in the event of failure of the vehicle detection equipment.
- ◆ A “Cancel” key to allow correction of an erroneous input function.
- ◆ A “Manual Input” key function.
- ◆ A color monitor display with at least 14” screen with an appropriate resolution.
- ◆ An “Accept” key function to confirm receipt of payment.
- ◆ An “Enter” key function to confirm inputs.
- ◆ Allowance for at least four additional keys to be added to the keyboard for Future use.
- ◆ A Receipt Printer (RPR) with a receipt request key function.

The **IC-Card Reader/Writer (ICCRW)** shall be used to read and write the data in the contactless IC-Card. The ICCRW shall comply with the following requirements:

- ◆ The communication distance with contactless IC-Card shall be possible from the equipment exterior side by the range of about 5mm.

The frequency of the RF operating magnetic field shall be 13.56MHz.

- ◆ The ICCRW shall transfer power to the contactless IC-Card by producing RF operating magnetic field and make communications by magnetic field modulation.
- ◆ The bit rate between ICCRW and contactless IC-Card shall be 13.56 MHz/64 (approximately 212 k bit/s).
- ◆ ICCRW shall be equipped with high-security data management conforming to ISO/IEC 15408 EAL4.

The Receipt Printer (R-PRT) shall be installed in each tollbooth, located adjacent to TTT to issue receipts. A receipt shall be automatically printed, cut, and fed out when the collector depresses the key assigned for “CASH” transactions on TTT. The speed of issuing a receipt from the collector’s action shall be 1.5 second maximum.

The R-PRT shall use a well-proven durable print head mechanism which shall allow clear printing of receipts. The reliability of print head shall have a minimum of 80 million characters between failures of 5,000 hours, whichever is greater. The receipts shall be printed on a paper roll which shall have sufficient capacity for a minimum of 2,500 receipts.

The R-PRT shall use a dot matrix to form characters and symbols in the standard ASCII character set. The minimum dimension of printed characters and the minimum definition of dot matrix shall be as follows:

- ◆ Dimension : 1.8 mm (W)×2.7 mm (H)
- ◆ Definition : 7×7 dot matrix

A paper feed facility and a “Test Print” mode shall be provided to verify correct insertion and alignment of paper, and operation of the printer. Outputs of “Test Print” shall be identified easily as the output of test print.

The **ETC Controller (ETCC)** shall be used to communicate with the On-Board Unit (OBU). The ETCC shall comprise the part of radio transmitter/receiver connected with a Roadside Antenna (RSA), encoder/decoder for encryption and the other related processor. The ETCC shall be connected with the TLS to exchange the data of transaction.

- ◆ The ETCC shall allow the radio communication with OBU by using transceiver mode of Dedicated Short Range Communication (DSRC) complied with the active method requirements on Annex 1 on Recommendation ITU-R M.1453.

The **Automatic License Number Plate Recognition Processor (ANPRP)** shall be used to recognize the License Number Plate by scanning an image from an Automatic License Number Plate Recognition Camera (ANPR-CAM) when a vehicle approaches to the toll lane. The result of recognition shall be a formatted text data and transmitted to the Toll Lane Server (TLS). The ANPRP shall comply with the following requirements:

- ◆ The ANPRP shall capture an image of the license number plate of a vehicle passing the toll lane at a maximum speed of 80km/hr at any time day or night. Required image storage period is of more than one (1) week. The size of image data shall be proposed by the contractor.
- ◆ The ANPRP shall transmit a result of recognition combined with the captured image of license number, a time stamp and a transaction number to Toll Data Management System (TDMS).

The **Booth Communication System (BCS)** shall be installed to allow the direct inter-communication between master and slaves which are located in tollgate/plaza and tollbooth.

The BCS shall be composed of a Booth Communication System (Master) (BCS-M) on the supervisor’s desk in the **office room** of tollgate/plaza building and The Booth Communication System (Slave) (BCS-S) in each tollbooth, and other locations in the tollgate/plaza building. The BCS shall comply with the following requirements:

- ◆ The BCS system shall be designed to enable a communication between BCS-Ss and shall include an “all call” facility to allow the supervisor to broadcast messages to

all BCS-S simultaneously from the BCS-M.

- ◆ The BCS-M shall include, at least, the following parts:
 - Speaker/Microphone
 - Volume control for speaker
 - Call button for each BCS-S (with expansion to a maximum of 40)
 - “Press to talk” button
 - Station indicator lamp
 - “All call” button for simultaneous announcement to all BCS-S
 - Power on-off switch with “Power on” indicator
 - Lamp test button
- ◆ Communication shall be controlled from the BCS-M. The operation of the BCS shall be by “hands free” facilities.
- ◆ The BCS-S shall comprise a speaker/microphone and an illuminated call button. An audible tone and illuminated call button shall signify an incoming call. Operation of the BCS-S shall be independent of a toll collector being “logged in” to the TTT, or not.

The **Emergency Caller (ECALL)** shall provide an emergency call in each tollbooth and other locations in the tollgate/plaza building. The ECALL shall be composed of an Emergency Caller (Master) (ECALL-M) on the supervisor’s desk in the office room of tollgate/plaza building and an Emergency Caller –Slave (ECALL-S) in each tollbooth and other locations in the tollgate/plaza building.

The ECALL shall comply with the following requirements:

- ◆ An ECALL-S shall be provided in each tollbooth. The alarm shall be raised by pressing the button.
- ◆ The ECALL-S shall be installed in an agreed position within the tollbooth and toll office so as to be easily and discretely operated, but not being liable to accidental operation during normal collection activities.
- ◆ Once the ECALL is activated, alarm indications shall be given to ECALL-M at the Toll Supervisor's desk.

Table 7-2 Number of Tollbooth Equipment

Equipment		Manual Lane		Manual & ETC Lane	
		Entry	Exit	Entry	Exit
Toll Lane Server	TLS	1	1	1	1
Toll Transaction Terminal	TTT	1	1	1	1
IC-Card Reader/Write	ICCRW	1	1	1	1
Receipt Issuance Printer	R-PRT		1		1
ETC Controller	ETCC			1	1
ANPR Processor	ANPRP	1	1	1	1
Booth Communication System (slave)	BCS	1	1	1	1
Emergency Caller (slave)	E-CALL	1	1	1	1

7.1.3 Toll Office System

The Toll Office System (TOS) shall be provided in tollgate/plaza building. The TOS shall consist of management and data processing of toll collection transaction (hereinafter: TDMS, which is an abbreviation of Toll Data Management System) for each Toll Lane System. The TOS shall have the following two main functions:

- ✓ Transaction data acquisition/store from the Toll Lane System and provision of real time monitoring facilities via a visual display unit in the office room of toll office
- ✓ Data processing and toll office management via visual display units, printer terminals, auxiliary memory media and data transfer facilities.

The TOS shall be composed of following equipment, but not be limited to, in the office.

- Database Server for Toll Data Management System (TDMS)
- Supervisor and Operation Terminal (SOT): to supervise toll collection work
- Inspection and Post-check Terminal (IPT): to inspect toll collection work by image data
- Tollgate Server: to store and controls access of data of ETC vehicles passing tollgate, and transmit data to Toll Center System (TCS)
- Accounting Terminal (ACT): to manage toll account
- IC-Card/OBU Registration Terminal (ICORT)
- IC-Card Reader/Writer (ICCRW)
- LAN cable and necessary number of hubs or routers
- Booth Communication System (master)
- Emergency Caller (master)
- Operation Printer (O-PRT)
- Receipt Printer (R-PRT)
- IC-Card Issuance Printer (ICC-PRT)

- CCTV system
- Monitor/Controller: Color monitors and necessary number of multiplexer, digital video recorder and other related devices

The **Toll Data Management System (TDMS)** shall be located in the Equipment room for TCS of tollgate/plaza building. The TDMS shall be connected to all terminals of Toll Office System (TOS) and each Toll Lane Server (TLS) through Local Area Network (LAN) in order to carry out real time or fixed interval functions, such as data communication with lane equipment and data archiving.

The TDMS shall be a server to carry out real time functions, such as data communication with the TLS and data archiving including a captured image and a result of license number recognition to inspect and post-check the toll collection work. Visual display units and printer terminals for the TDMS shall be provided for control, selection and data input/output. Comprehensive back-up facilities shall be provided through the use of mass storage device or equivalent means to ensure that the loss of data or restrictions on operation must not occur as a result of TOS failure for a long term.

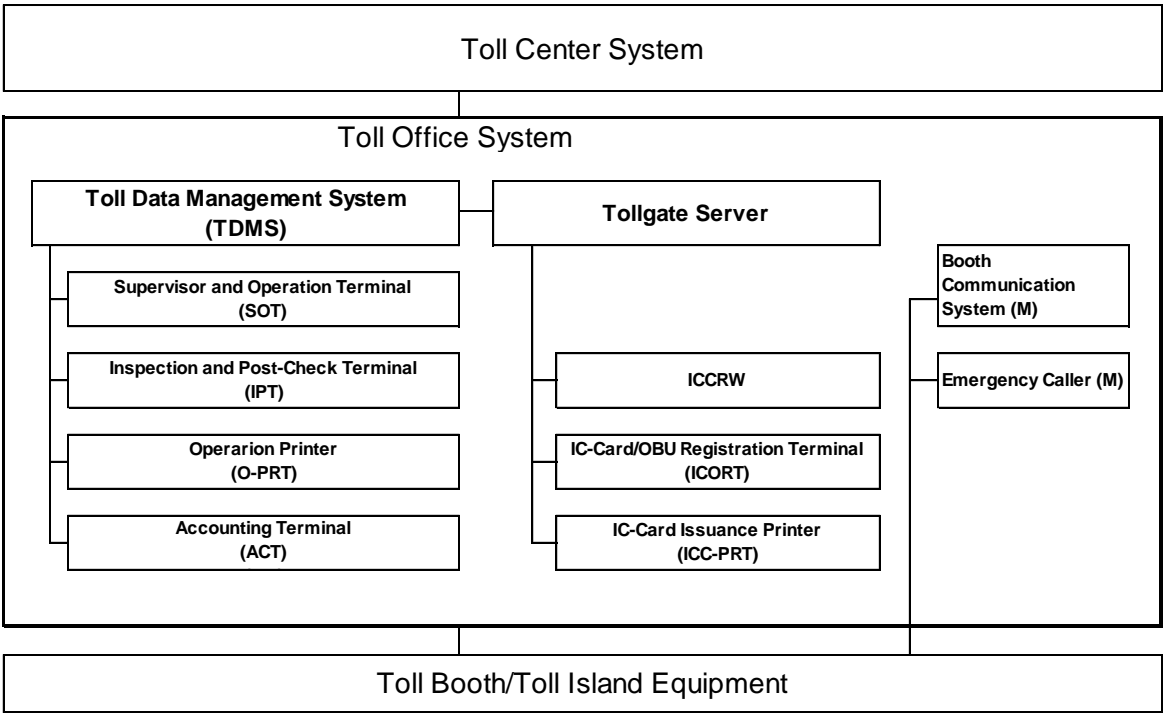


Figure 7-6 Toll Office System Configuration

In the event of power failure of the TOS, or a communication failure between the Toll Lane Server (TLS) and TOS, the TLS shall function as stand-alone equipment together with its all peripherals and maintain 1 week at least of data in the TLS.

When the link is restored, all data shall be automatically up-loaded.

The TDMS shall be linked to all lane equipment and shall receive details of data on the

individual transaction basis in real time and fixed interval, summary of a toll collector's job at each end of his job and hourly traffic data at each hour basis.

The disk capacity of the TDMS shall be calculated by taking account of the need to store the operating system, the application software and other software packages necessary for operation of the system and the data generated by the system to meet the requirements of the Specification.

The TDMS shall send, at intervals of not less than one hour, the current date and time of its real time clock to the TLSs and other terminals for their time synchronization purpose. The TDMS shall be provided its time synchronization from network time system of other system.

The TDMS shall treat necessary, but not limited to, data for toll transaction data and other related information as follows;

- Type of transaction
- The number of transaction
- Unique identification number for the IC-Card and OBU
- Status of authorization and/or validation
- Type of vehicle classification
- License number
- Name of interchange at entry
- Number of toll lane
- Name of toll collector at entry
- Transaction date at entry
- Transaction time at entry
- Name of interchange at exit
- Number of toll lane at exit
- Name of toll collector at exit
- Transaction date at exit
- Transaction time at exit
- Toll fee of a transaction
- Remaining value on prepaid value
- Charged value on prepaid value
- Personal identification number
- Job number for toll collector
- History of "Record of Use"
- Captured image of the LS-CAM and ANPR-CAM

- System Parameter
- Other related record

Some data/message shall be translated into a code in order to handle effectively on the data base system in advance.

There shall be 4 kinds of terminals associated with TDMS, namely a **Supervisor and Operation Terminal (SOT)**, **Inspection and Post-check Terminal (IPT)**, and an **Accounting Terminal (ACT)**.

A main purpose for a **Supervisor and Operation Terminal (SOT)** is to operate and monitor the Toll Lane System. The SOT shall be used by the “toll supervisor” to monitor particular aspects of the toll operation, to access the stored data in the TDMS for further data processing, and to conduct data backup procedure. The SOT shall receive the lane transaction and event data (including the status information of the lane equipment) directly from each TLS, and perform the detailed monitoring of lane equipment operation. The series of computer desks shall accommodate the SOT with an O-PRT. The desks shall be positioned in the office room so that toll supervisor shall have an unrestricted view of the plaza through the windows. The console arrangement shall be proposed by the Contractor to suit his equipment arrangement.

The **Inspection and Post-check Terminal (IPT)** shall be used to inspect and post-check the negative expression and activity of toll collection. Those inspections shall be implemented as Cross-check by staffs that Cashier (Officer) at each toll office (TO), Chief of Toll Management at each Management Office (MO) and by staff of Toll Management division at Main Management Center (MMC). The IPT shall be managed by transaction data and recordings from TDMS. In the TO, the series of computer desks shall accommodate two (2) IPTs with an O-PRT. The desks shall be positioned nearby staff in charge of toll inspection in the office room. In the MO, the series of computer desks shall accommodate two (2) IPTs with an O-PRT at office room. In the MMC, The console arrangement shall be proposed by the Contractor to suit his equipment arrangement.

The Accounting Terminal (ACT) shall be used for both toll collector and toll accountant at the tollgate/toll plaza. In order to register collected toll by a toll collector at each end of his job, an accounting room shall be established in the tollgate/toll plaza building. Two (2) ACTs shall be installed in the accounting room with an O-PRT, which shall form a part of the TOS and serve as a collected toll entry terminal.

The ACT shall have registration screens for the toll collector to enter collected numbers of banknotes for each denomination with his identity card number, job number and moneybag/box number. The ACT shall give a caution, if discrepancy between the registered amounts at the ACT and TTT exceeds the pre-defined allowance. The ACT shall be used to make proceedings of toll collector’s fee based on the shift of them and to make the report of general toll collection results corresponding to the regulations. The series of computer desks shall accommodate the ACT with an O-PRT. The desks shall be positioned in the accounting room so that toll collector and Accountants shall have a

restricted area in the toll office. The console arrangement shall be proposed by the Contractor to suit his equipment arrangement.

The **IC-Card/OBU Registration Terminal (ICORT)** shall be used to register the data of IC-Card and OBU. The ICORT shall record the data of IC-CARD and OBU, and transfer them to Customer Data Management System (CDMS) of Toll Center System at the MMC. An ACT shall be installed in the accounting room with an O-PRT and an ICC-PRT in order to issue/re-issue the ticket (toll ticket, commutation ticket and prepaid card) and OBU. The series of computer desks shall accommodate the ICORT with an O-PRT and ICC-PRT. The desks shall be positioned in the office room and ticket selling room. The console arrangement shall be proposed by the Contractor to suit his equipment arrangement.

The registration method of OBU shall be conducted by the specialized IC-Card for the purpose of initialization of the OBU.

The **Operation Printer (O-PRT)** shall be provided for production of audit, accounting and statistical reports. The O-PRT shall be connected to all terminals of Toll Office System (TOS) through Local Area Network (LAN) in order to produce audit, accounting and statistical reports such as operating logs, alarm messages, traffic statistics, details of “collected cash”, etc. The O-PRT shall be located in the convenient places with floor stands which incorporate accommodation units of printer papers. The specifications of the OPR shall be as follows:

- ◆ Printing Method : Monochrome laser printer
- ◆ Printing Speed : 24 pages per minute or more
- ◆ Printing Resolution : 1,200 dpi
- ◆ Connectivity : Ethernet with pre-installed network card
- ◆ Media Sizes : A5, A4, A3
- ◆ Media Handling : Multiple input trays

The **IC-Card Issuance Printer (ICC-PRT)** shall be installed with ICORT at the reception in the toll office in order to issue some kinds of the IC-Card. The ICC-PRT shall be provided for data recording and surface printing in/on some kinds of IC-Cards in order to issue the Commutation Ticket (CMT) and the Prepaid Card (PPC), which are with owner registration. The basic requirement of read/write function of ICC-PRT shall refer same as ICCRW.

- ◆ Type of IC-Card : IC-Card with Leuco dye surface
- ◆ Printing Method : Leuco dye type thermal rewritable printing
- ◆ Interface : USB / RS-232C/etc

The **Emergency Caller (ECALL)** shall provide an emergency call from each tollbooth and some rooms at tollgate/plaza building. An Emergency Caller (Master) (ECALL-M) shall be installed on the supervisor’s desk in the **office room** of tollgate/plaza building.

The ECALL-M shall function as main system for any Emergency Callers (Slave) (ECALL-S).

The ECALL-M/S shall be located in the following rooms, but not be limited to, at the toll office.

◆ Office room	1(M)
◆ Ticket Selling room	1(S)
◆ Equipment room for TCS	1(S)
◆ Accounting room	1(S)
◆ Sleeping room	1(S)
◆ Service Tunnel (Tuy Loan IC)	3(S) (Center and both ends of Tunnel)

The Booth Communication System (BCS) shall be installed to allow the direct inter-communication between master and slaves which are located in tollgate/plaza and tollbooth.

The BCS shall be composed of a Booth Communication System-Master, (BCS-M) on the supervisor's desk in the office room of tollgate/plaza building and The Booth Communication System -Slave (BCS-S) in each tollbooth, and other locations in the tollgate/plaza building.

The BCS-M/S shall be located in the following rooms, but not be limited to, at the toll office.

◆ Office room	1(M)
◆ Ticket Selling room	1(S)
◆ Equipment room for TCS	1(S)
◆ Accounting room	1(S)

Each Toll Office shall be equipped 2 **IC-Card Reader/Writer (ICCRW)** in order to login in the system and handle the data of IC-Card.

The **CCTV surveillance system** shall provide the visual image of the Lane Side Camera (LS-CAM) and toll collection work in the toll office. It is very useful for toll officer to observe visually the situation around/in the toll office.

The system shall consist of camera and video signal transmission system around/in the toll office and controller and display in the office room. General system configuration is shown in **Figure 7-7**.

As PAL (Phase Alternating Line) standards is used for TV broadcasting system in Vietnam, same PAL system shall be introduced for the surveillance system.

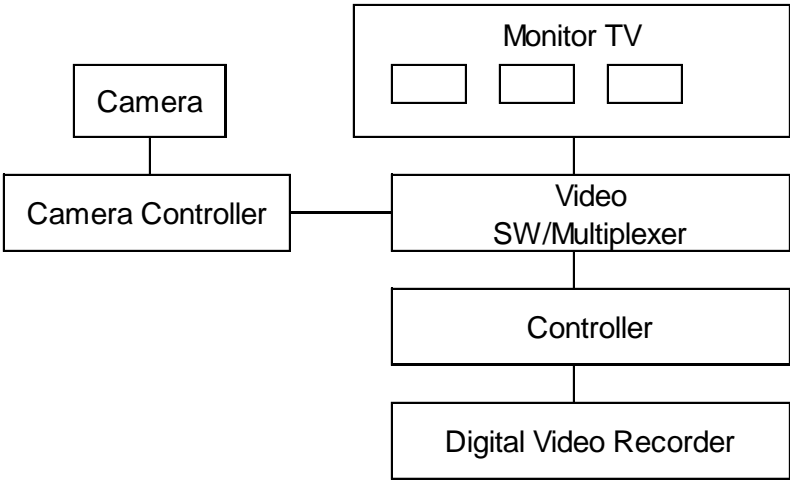


Figure 7-7 CCTV Surveillance System (CSS) Configuration

The CCTV surveillance system except the LS-CAM shall be located in the following points, but not be limited to, at the toll office. Two (2) cameras at least in the service tunnel shall be introduced to observe the condition of the tunnel. Additional two (2) cameras at least shall be located around the entrance of toll office in order to observe any persons who approach the entrance.

◆ Office room	1
◆ Ticket Selling room	1
◆ Equipment room for TCS	1
◆ Accounting room	1
◆ Service tunnel (Tuy Loan IC)	2
◆ Around the entrance	1

CCTV camera station shall installed at the location accommodates camera controller. It shall receive video image signal from the camera, and transfer it to office room. It shall receive control signals from office room, and shall control a zoom and focus of a camera, wiper of camera housing and movements of pan-tilt head.

CSS at office room shall consist of a video signal switcher/multiplexer, central controller and digital video recorder and sets of monitor TV.

Character generating function shall be provided to the central equipment to superimpose camera location/number overlaid video images.

Operator console shall have various control functions including camera control, pan-tilt head control and monitor TV control.

A total of 3 set of monitor TVs shall be provided and installed at office room.

The size of monitor TV must be 15 inch or larger. Connection between camera and monitor TV must be flexible and made through the video switcher. Each TV monitor

shall be utilized for 4 channels of video signal at least by multiplexer. The monitor TV shall be of LCD type.

A video switcher/multiplexer shall be provided to flexibly assign monitor TV to any camera. Video switcher/multiplexer shall have input terminal to receive video signal from the video recorders and other video sources. It must also have video signal outputs to provide video signal to other monitor TV or system.

Two sets of video recorder shall be provided to the office room to record video signal from any of the camera. Video recorder must be equipped with a hard disk unit of suitable storage capacity for temporary recording and a writable DVD unit to record video image permanently. It shall have time lapse recording function to record video image for longer period at reduced frame rate and date and time shall be superimposed on the recorded video image.

Each Toll office shall be equipped an **IC-Card Reader/Writer (ICCRW)** in order to login in the system and handle the data of IC-Card.

Table 7-3 shows the number of equipment of the Toll Office System (TOS).

Table 7-3 Number of Toll Office System Equipment

Equipment		Unit	Remarks
Database Server for Toll Data Management System	TDMS	1	Location of Toll Office 1. Tuy Loan 2. My Son 3. Ha Lam 4. Tam Ky 5. Chu Lai 6. Dung Quat 7. North Quang Ngai 8. Quang Ngai
Supervisor and Operation Terminal	SOT	1	
Inspection and Post-check Terminal	IPT	1	
Accounting Terminal	ACT	1	
IC-Card/OBU Registration Terminal	ICORT	1	
Operation Printer	O-PRT	1	
Receipt Issuance Printer	R-PRT	1	
IC-Card Issuance Printer	ICC-PRT	1	
Emergency Call (Master)	E-CALL(M)	1	
Booth Communication System (Master)	BCS(M)	1	
CCTV Surveillance System	CSS	1	
IC-Card Reader/Writer	ICCRW	2	

7.1.4 Toll Center System

The Toll Center System (TCS) shall be united system with each Toll Office System (TOS). Main function of this system shall be as follows:

- Operation and management for all of the Toll Lane System (TLS) and the Toll Office System (TOS)
- Administration system for all toll collection works
- Administration system for customer data (the toll ticket, the Commutation Ticket, the Prepaid Card and On-Board Unit (OBU))

The TOS shall be composed of following equipment, but not be limited to, in the toll

center.

- Database Server for Toll Collection Administration System (TCAS)
- Database Server for Customer Data Management System (CDMS)
- Supervisor and Operation Terminal (SOT): to supervise toll collection work
- IC-Card/OBU Registration Terminal (ICORT)
- LAN cable and necessary number of hubs or routers
- IC-Card Reader/Writer (ICCRW)
- Operation Printer (O-PRT)

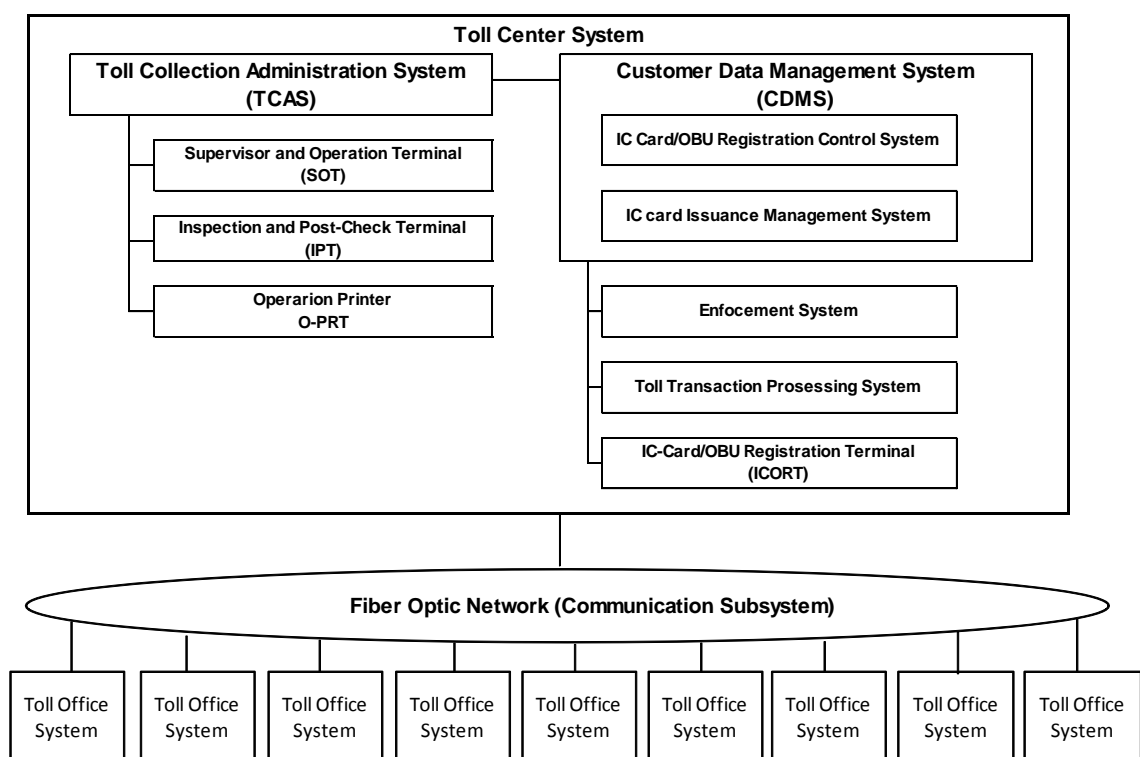


Figure 7-8 Toll Center System Configuration

The TCAS shall be a server to carry out real time functions in order to administrate and manage all of toll related information, such as data communication with the Toll Office System. The CDMS shall be also a server to carry out real time and fixed interval functions in order to administrate and manage all of customer related information, such as the registered data of Toll Ticket, the Commutation Ticket (CMT), Prepaid Card (PPC) and On-Board Unit (OBU). Visual display units and printer terminals for them shall be provided for control, selection and data input and output. Comprehensive back-up facilities shall be provided through the use of mass storage device or equivalent means to ensure that the loss of data or restrictions on operation shall not occur as a result of the Toll Center System (TCS) failure for a long term. The TCAS and CDMS can be

expanded effectively to be interoperable with the Bank system in the future.

The following total report summarized from each toll office shall be available on the TCAS, but not limited to:

- ◆ Traffic Volume (Weekly, Monthly, Quarterly and Annually)
 - Traffic volume by class
 - Histogram of traffic volume
 - Lane traffic volume
- ◆ Management (Weekly, Monthly, Quarterly and Annually)
 - Plaza Performance Evaluation
 - Staff Checkout
- ◆ Financial (Weekly, Monthly, Quarterly and Annually)
 - Cash Collection Report and Summary
 - Traffic and Revenue
- ◆ Maintenance (Weekly, Monthly, Quarterly and Annually)
 - Log of Equipment Alarms
 - Alarm Activity Summary

The following function shall be available on the TCAS, but not limited to:

- ◆ Operational Parameter Tables
 - System Constant Table (plaza identity code, lane identity code, operational day closing time, automatic/manual issue of receipt, allowable variance of toll collector's input to TTT, etc)
 - Toll Fare Tables (Current and Future)
 - Personnel Identification Card Number Tables (8 digits, 500 staff)
 - Access Control List
 - Currency Denomination Table
 - Payment Type Tables
 - Access Level Edit
 - Table Revision Number
- ◆ Filing
 - Parameter download (using memory device)
 - Parameter transfer for TLS (using memory device)
 - Off-line data transfer from TLS (using memory device)

- Data/parameter backup onto a removable media such as DAT (Digital Audio Tape, etc).
- Data/parameter restore from a removable media such as DAT, etc.

The following function and related report shall be available on the CDMS, but not limited to:

- ◆ Toll Ticket Registration and Administration
- ◆ Commutation Ticket Registration and Administration
- ◆ Prepaid Card Registration and Administration
- ◆ On-Board Unit Registration and Administration

The series of computer desks shall accommodate each server with an Operation Printer (O-PRT). The desks shall be positioned in the Equipment room for TCS. The console arrangement shall be proposed by the Contractor to suit his equipment arrangement.

In the event of power failure of the Toll Center System (TCS), or a communication failure among the Toll Office System (TOS), the TOS shall function as stand-alone equipment together with its all peripherals lane equipment and maintain 1 week at least of data in the TOS. When the link is restored, all data shall be automatically up-loaded.

There shall be a client terminal associated with each server system, namely a Supervisor and Operation Terminal (SOT).

The SOT shall be used to supervise and operate the all of toll information. The series of computer desks shall accommodate the three (3) SOTs with an Operation Printer (O-PRT). One (1) SOT shall be in the MMC, one (1) SOT shall be in the Da Nang MO and one (1) SOT shall be in the Quang Ngai MO. The desks shall be positioned in the office room. The console arrangement shall be proposed by the Contractor to suit his equipment arrangement.

IC-Card/OBU Registration Terminal (ICORT) shall be used to register the data of Personnel Identification Card into the ID Card. 3 ICORT shall be installed. One (1) ICORT shall be in the MMC, one (1) ICORT shall be in the Da Nang MO and one (1) ICORT shall be in the Quang Ngai MO. The ICORT shall record the data of IC-Card and transfer them to Toll Collection Administration System (TCAS).

The series of computer desks shall accommodate the ICORT with an Operation Printer (O-PRT). The desks shall be positioned in office room and reception in the MMC and at office room in each MO. The console arrangement shall be proposed by the Contractor to suit his equipment arrangement.

Each terminal shall be equipped ICCRW in order to login in the system and handle the data of IC-Card.

Table 7-4 shows the number of equipment of the Toll Center System (TCS).

Table 7-4 Number of Toll Center System Equipment

Equipment Unit		Unit	Remarks
Database Server for Toll Collection Administration System	TCAS	1	MMC
Database Server for Customer Data Management System	CDMS	1	MMC
Supervisor and Operation Terminal	SOT	3	MMC(1) + 2MO(1)
IC-Card/OBU Registration Terminal	ICORT	3	MMC(1) + 2MO(1)
IC-Card Reader/Writer	ICCRW	5	MMC(1) + 2MO(2)
Operation Printer	O-PRT	4	MMC(2) + 2MO(1)

7.1.5 User Side Equipment

The User Side Equipment is a part of the Toll Collection System. The User Side Equipment is used not only for a Road Operator but also for a driver.

(1) Toll Ticket

As discussed in subsection 13.1.3, the toll collection system of the Project shall be the “Closed System.” In the Closed System, the toll ticket is essential because the toll due is depend upon the vehicle classification and running distance that is calculated based on toll ticket information recorded at entry point.

In addition to the normal toll ticket, cards of the Commutation Ticket (CMT), the Prepaid Card (PPC), and the Personnel Identification Card are used with the Toll Collection System in this Project.

(a) Functional Requirement of the Card

Functional and common requirement of the entire card on the Project shall be satisfied with, but not limited to, the following aspects:

- Anti tamper: for high secure data management
- Reliability: to perform and maintain its functions in routine circumstances
- Durability: applicable for long time or repeated use in certain term
- Data Capacity: to be enough data size
- Operability: multi-purpose, user-friendly, operation speed,
- Expandability: applicable for new or future function
- Environment friendly: applicable for re-cycling, not harmful for environment, and
- Cost: cost effectiveness through Operation and Maintenance

Required number of IC cards to be provided in this project shall be 625,000 based on traffic volume. **Table 7-5** shows number of IC-Cards. And **Table 7-6** shows Traffic Volume at Tollgate.

Table 7-5 Number of IC-Cards

Type of IC Card	unit	Quantity	Remarks
IC-Card for a Personal Identification	set	1,000	Number of Staff(448) X 2
IC-Card for a Toll Ticket (ICT)	set	546,000	Total traffic volume of all Tollgates in 2 weeks on DQE
IC-Card for a Commutation Ticket	set	23,000	About 2% of Total traffic volume of all Tollgates in 1month on DQE
IC-Card for a Prepaid Valued Payment	set	55,000	About 10% of Total traffic volume of all Tollgates in 2 weeks on DQE
Total	set	625,000	

Table 7-6 Traffic Volume at Tollgate

Tollgate	Assumed traffic volume on Enter (ADT) (Y2025)	Assumed traffic volume on Exit (ADT) (Y2025)
Tuy Loan	13,742	15,624
My Son	1,245	762
Ha Lam	2,619	2,285
Tam Ky	3,755	4,680
Chu Lai	2,112	1,654
Dung Quat	2,906	1,957
North Quang Ngai	5,355	4,898
Quang Ngai	7,254	7,128
Total	38,988	38,988

The Contactless IC-Card has an advantage in the LCC per one card, although the cost per one card is the most expensive, because durability of a contactless type IC-Card is superior to any other kinds of card.

Therefore, “Contactless type IC-Card” (hereinafter referred as IC-Card) should be adopted as a Toll Ticket which shall be a common platform on the Project because it is able to keep secured data management, to operate easily and rapidly, and to reduce the cost of toll collection work through Operation and Maintenance.

(b) Functional Requirement of the IC-Card

The IC-Card shall be referred to the requirements of ISO/IEC specifications number 18092 or ISO/IEC14443, and shall conform to the following minimum functions.

◆ Flexible File System:

Each toll collection service using various cards inclusive an ID card, Toll Ticket, Commuter Card, or Prepaid Card, shall assigned an area in the card’s memory space for registering services in block units. A single area shall be divided hierarchically into multiple areas. Total number of available blocks is 154 (one block is 16bytes), including those used for registering areas and services.

◆ File Access Control:

With the IC-Card, up to 8 user blocks should be written simultaneously, while up to 12 user blocks should be read at a time. As to these block read/write operations, it should be possible to group different services for access control by the use of keys synthesized from the keys set for individual areas and services.

◆ **High-Speed Transaction:**

The IC-Card shall provide high processing speed at minimum power consumption. This should owe a great deal to the incorporation of a high-performance microprocessor, which combines with dedicated encoding/decoding hardware to speed the enormous amount of calculations necessary for data encryption/decryption and mutual authentication. With its capability to read or write 8 blocks of data in only 100ms including the time required for mutual authentication, the IC-Card should meet perfectly with the performance requirements of automatic toll collection systems.

◆ **Transaction Reliability:**

The card should be powered by electromagnetic waves from the Reader/Writer. That is, data becomes incomplete due to power failure if the card is moved out of the communication range before writing into the non-volatile memory is finished. In this case, the IC-Card should automatically discard incomplete data and restores the previous state.

◆ **Wireless Communication Security:**

All data should be encrypted using encryption keys in order to prevent illicit operations during wireless transmission, such as skimming, falsification and reuse of data.

The card shall obtain ISO/IEC 15408 EAL4 both card chip and card Operating Software (OS) for security assurance.

(c) Required Physical Characteristics of the IC-Card

The General Physical Characteristics of the IC CARD should be conformed the card type ID-1 in ISO/IEC 7810 specifications.

The Physical Characteristics of the IC CARD should be followed:

◆ **Dimensions:**

The nominal dimensions of the Card shall satisfy the specification in ISO/IEC 7810 as the card type ID-1.

◆ **Surface conditions:**

The card surface shall be flat and smooth to allow the Card to be carried, etc.

◆ **Substrate material:**

The substrate material of the Card shall be made of PET (poly-ethylene terephthalate) or material having equal or better performance.

◆ Static electricity:

The Card shall continue to operate after testing in accordance with the test methods specified in ISO/IEC 10373-6, where the test voltage is 6kV. Any information recorded in the Card shall not be altered; besides, data shall be able to be re-written.

◆ Static magnetic field:

The Card shall continue to operate after having been exposed to a static 640 kA/m magnetic fields.

◆ Operating temperature:

The Card shall continue to operate under the environmental temperature of -5°C to 50°C.

◆ Moisture proof:

After having been left for 48 hours in an environmental of 40°C temperature and 90% relative humidity, the Card shall continue to operate and satisfy the warpage specification.

◆ Cyclic thermal proof:

The Card shall continue to operate after having been applied ten thermal test cycles, each consisting of 30 minutes at -25°C, 5 minutes at room temperature and humidity (23°C±3°C, relatively humidity: 40% to 60%), 30 minutes at +85°C and 5 minutes at room temperature and humidity.

◆ Drop impact proof:

The Card shall continue to operate after having been dropped twice in three directions (longitudinal, lateral and surface directions) from the height of 1.5 m onto a concrete surface

◆ Bending pressure stiffness:

The Card shall continue to operate after having been applied a load of 0.7N for 1 minute in accordance with the method of specified in ISO/IEC 10373-1.

◆ Point pressure stiffness:

The Card shall continue to operate after a pressure, generated by applying a force of 1.5N to a φ1mm steel ball, is applied to the position of the IC chip.

◆ De-lamination:

The Card shall possess the minimum peel strength of a least 6N/cm when tested by the method specified in ISO/IEC 10373-1.

◆ Storage temperature:

The Card shall continue to operate after having been stored in -35°C and +85°C temperature for 60 minutes each.

◆ Environment protection:

The Card shall not cause toxic hazard in the normal use. The Card shall not cause toxic gas when it is disposed or incinerated.

◆ Curl, burr and chipped particles:

The Card shall not cause any malfunction of the issuing or processing machine by curl, burr or chipped particles.

(d) Communication Interface

The General Communication Interface of the IC-Card should be conformed the specification defined in ISO/IEC 7810.

The Communication Interface of the IC-Card shall follow:

◆ Power Transmission:

The IC-Card Reader/Writer (ICCRW) shall transfer power to the Card by producing RF operating magnetic field and make communications by magnetic field modulation.

◆ Frequency:

The frequency of the RF operating magnetic field shall be 13.56MHz.

◆ Tolerance deviation of frequency:

The tolerance deviation of frequency shall be ± 50 ppm or under.

◆ Leakage electric field strength:

The leakage electric field strength shall conform to the regulations of the Radio related Low in Vietnam.

◆ Bit rate:

The bit rate between ICCRW and Card shall be 13.56 MHz / 64 (approximately 212 k bit/s)

(e) Serial Number

The serial number is laser-laminated on the rear surface of each IC card, together with the model name, making it possible to identify when is produced.

◆ Printed items:

Serial number (12-digit alphanumerical characters) Model name

As a basic specification, a unique serial number, which is enough space for 12-digit alphanumerical characters, shall be laser-printed on the rear surface of each IC-Card

together with the model name, making it possible to identify when and where it was produced. Additionally, an area for identification number, which is enough space for 16-digit alphanumerical characters, shall be reserved to be laser-printed on the rear surface of each IC-Card. A sample image is given in **Figure 7-9**.

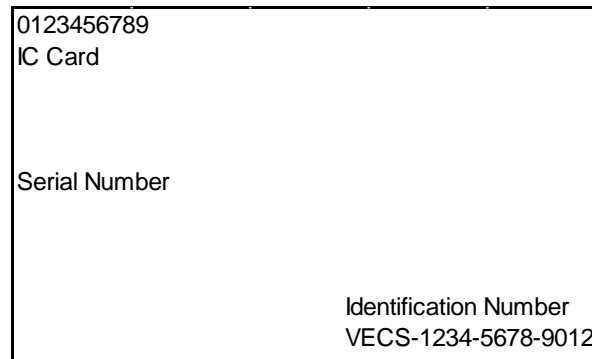


Figure 7-9 Serial Number and Identification Number

The IC-Card shall be furnished with the term of validation and shall be recorded an attribute of validation and/or a data of validation. The Contractor shall propose the format of data, encoded in the cards, to the Employer for approval.

(f) IC-Card Service

IC-Card service is necessary to achieve various functions on the IC-Card. The service is used to define the method of accessing the memory in the IC-Card. The IC-Card shall make it possible to set multiple access modes, such as read/write, read only and authentication necessary or unnecessary, to the same memory area in order to actualize the multi function on the Project.

◆ **Random Service:**

Random Service means general-purpose service that allows random access to any desired memory block.

◆ **Cyclic Service:**

Cyclic service is based on a log of write operation. With the reference made to the record of the sequence the blocks were written in the pre-assigned user area, new data is written automatically in the empty block next to the last-written block.

◆ **Purse Service:**

Designated specifically for such application as deducting fees or charges, the purse service additionally offers a subtraction function.

(g) IC-Card for a Personal Identification

The Personnel Identification Card (ID-Card) shall be used to identify all of toll personnel by coupling through an IC-Card Reader/Writer (ICCRW) at the beginning of their job.

The ID-Cards shall be pre-encoded and embossed with identification numbers.

The ID-Cards shall be printed a portrait image of a person on the ID-Card. The Contractor shall propose the printing method of image on the IC-Card to the Employer for approval.

The ID-Card shall be provided for following six categories.

- Toll collector's identity card
- Toll Supervisor's identity card
- Toll Technician's identity card
- Toll Accountant's identity card
- Toll Officer's identity card
- Visitor's/Guest's identity card

The front or backside surface of the ID-Card shall be pre-printed with at least the following information as shown in **Figure 7-10**.

- Name of a Road Operator
- Category name of the identity card
- Description of important points for instruction

The ID-Card shall be used to access various functions and facilities. A unique number for all of toll personnel shall be allocated and encoded on the IC-Card.

The ID number shall be provided to identify the authorized access control level of individuals. It should be noted that the access level is not encoded on the card to enable the quick redeployment of the personnel. The access level number shall be defined in an access control list (ACL) which forms a part of the operational parameters in the toll system.

The Contractor shall provide 1000 sets of ID-Cards per one tollgate/plaza in the Contract. The detailed design, layout and samples shall be submitted to the Employer for approval, prior to the system test. The design and layout shall comprise embossing arrangement of ID number and coloring.

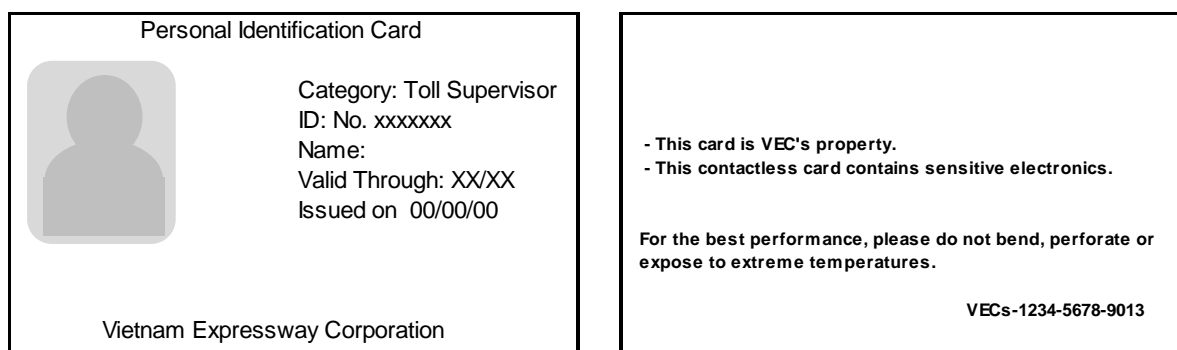


Figure 7-10 Sample of Personnel Identification Card

(h) IC-Card for a Toll Ticket

The IC-Card Toll Ticket (ICT) shall be used to identify both the name of entry point and exit point by scanning through an IC-Card Reader/Writer (ICCRW) in the tollbooth. The ICT shall be pre-encoded and printed with some information.

The Contractor shall propose the printing method on the IC-Card to the Employer for approval.

The front or backside surface of the ICT shall be pre-printed with at least the following information as shown in **Figure 7-11**:

- ✓ Name of a Road Operator
- ✓ Category name of IC-Card Toll Ticket (ICT)
- ✓ Description of important points for instruction

The Contractor shall provide 546,000 sets of the IC-Card Toll Ticket (ICT) in the Contract. ICT detailed design layout and samples shall be submitted to the Employer for approval, prior to the system test. The design and layout shall comprise printing/embossing arrangement of information and coloring.

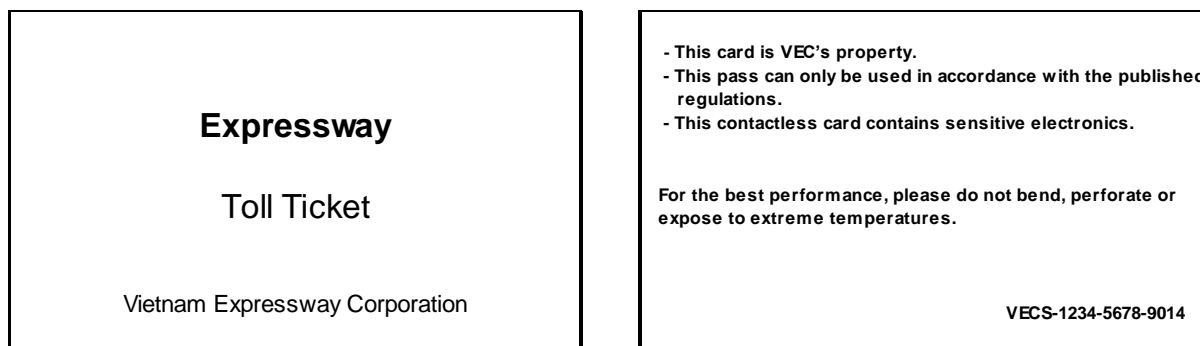


Figure 7-11 Sample of the IC-Card Toll Ticket

(i) IC-Card for a Commutation Ticket

A commutation ticket, which is defined as a monthly ticket or quarterly ticket in the

Circular, No.90/2004/TT-BTC, Ministry of Finance, shall be provided with function improvement of both the IC-Card Toll Ticket (ICT) and Prepaid Card.

The IC-Card for a Commutation Ticket (hereinafter referred as Commuter Card) shall be used to confirm the section and terms of the card by coupling through an IC-Card Reader/Writer or with On-Board Unit (OBU) through Electric Toll Collection (ETC) at the tollbooth or toll lane.

As a Commuter Card, an available section and a term of validity shall be decided previously. These items are the difference from a Prepaid Card.

Basic terms of use of Commuter Card on the Project shall be satisfied with, but not necessarily limited to, the following aspects:

- All users shall pay deposit (such as rental fee) to road operator for the card issuance.
- The deposit shall be returned when the card is returned to road operator.
- The available section for a Commuter Card should be decided prior to operation.
- The function of both IC-Card Toll Ticket and Prepaid Card shall be realized in the function of a Commuter Card.

The Commuter Card shall be pre-encoded and printed/embossed with some information including an available section and terms. The Commuter Card shall be printed an available section, terms, vehicle classification and vehicle license number on the card at every time of issuance. The Contractor shall propose the printing method on the Card to the Employer for approval. The Commuter Card shall be provided with registration.

The front or backside surface of the Commuter Card shall be pre-printed with at least the following information as shown in **Figure 7-12**.

- Name of a Road Operator
- Category name of the card
- Description of important points for instruction

The Contractor shall provide 23,000 sets of the Commuter Card in the Contract.

The Commuter Card detailed design layout and samples shall be submitted to the Employer for approval, prior to the system test. The design and layout shall comprise printing/ embossing arrangement of information and coloring.

<h2 style="margin: 0;">Commutation Ticket</h2> <p style="margin: 0;">With Prepaid Value Card</p> <div style="margin: 10px 0;"> <div style="display: flex; justify-content: space-between; border-bottom: 1px solid black; width: 80%; margin: 0 auto;"> From: To: </div> <div style="display: flex; justify-content: space-between; border-bottom: 1px solid black; width: 80%; margin: 0 auto;"> Class: LPN: </div> </div> <p style="margin: 0;">From: Day/Month/Year To: Day/Month/Year</p> <p style="margin: 10px 0 0 0;">Vietnam Expressway Corporation</p>	<ul style="list-style-type: none"> - This card is VEC's property. - This pass can only be used in accordance with the published regulations. - This pass is valid for 5 years from the date of issue. - Stored value is valid for 2 years from the date of first use or the last refill or when the last use of travel, after which any remaining value cannot be refunded or exchanged for other values. - This contactless card contains sensitive electronics. <p style="margin: 10px 0 0 0;">For the best performance, please do not bend, perforate or expose to extreme temperatures.</p> <p style="text-align: right; margin: 0;">VECS-XXXX-XXXX-XXXX</p>
--	---

Figure 7-12 Sample of the Commutation Ticket

(j) IC-Card for a Prepaid Valued Payment

The prepaid valued payment card (hereinafter referred as Prepaid Card) shall be used to pay the toll by coupling through an IC-Card Reader/Writer (ICCRW) or with On-Board Unit (OBU) through Electric Toll Collection (ETC) at the tollbooth or toll lane.

Basic terms of use of Prepaid Card on the project shall be satisfied with, but not necessarily limited to, the following aspects:

- All users shall pay deposit (such as rental fee) to road operator for the issuance of the card.
- The deposit shall be returned when the card is returned to road operator.
- The minimum amount and maximum amount of deposit in the card per a payment shall be decided prior to the operation.
- Remaining value in the card shall be recorded in both the card itself and Toll Center System.
- The function of IC-Card Toll Ticket shall be realized in the function of a Prepaid Card.

The Prepaid Card shall be pre-encoded and printed/embossed with some information. The Contractor shall propose the printing methods on the IC-Card to the Employer for approval.

The front or backside surface of the Prepaid Card shall be pre-printed with at least the following information as shown in **Figure 7-13**:

- Name of a Road Operator
- Category name of Prepaid Card
- Description of important points for instruction

The Contractor shall provide 55,000 sets of the Prepaid Card in the Contract. The detailed design, layout and samples shall be submitted to the Employer for approval, prior to the

system test. The design and layout shall comprise printing/embossing arrangement of information and coloring.

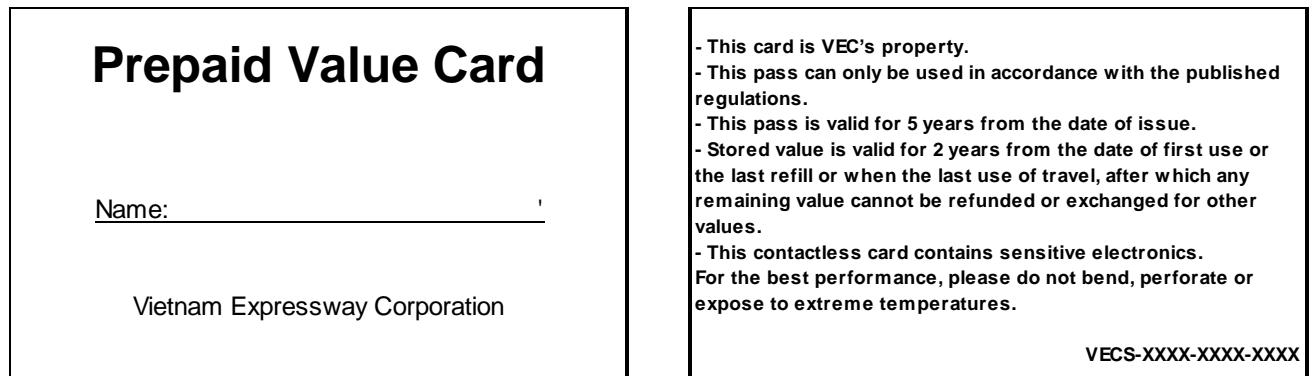


Figure 7-13 Sample of the Prepaid Card

(2) On-Board Unit (OBU)

(a) Conceptual Requirement

The On-Board Unit (OBU) shall be used to communicate with the Roadside Antenna (RSA) in order to provide the service of Electric Toll Collection (ETC) system.

The OBU shall be introduced as a two-piece type, which consists of 1) On-Board Unit, and 2) IC-Card. The IC-Card is used as a payment means of toll due.

For sophisticated ETC service to reduce transaction time, conceptual requirement of the OBU shall be satisfied with, but not limited to, the following:

- Toll collection without stopping both at entry and exit point
- Harmonization with existing toll collection system or other systems commonly used in Vietnam
- Toll collection with quickness, accuracy and reliability
- Support for enforcement of toll collection (The enforcement of OBU will be made of OBU unique number for road users and by auditing system for road operator)
- To be capable of both prepaid & postpaid method
- To be available for all vehicle classification
- To be available for both “Open System” and “Closed System.”
- To be capable of confirmation of “Record of Use” by a user oneself
- To be available for secured transaction
- To be available for personally identifiable information
- To be capable of common usage among different road operators
- To be capable of various toll policy (such as road pricing or VDM, free flow)

Basic terms of use of OBU on the project shall be satisfied with, but not necessarily limited to, the following aspects:

- An OBU shall be applicable for all tollgates/plazas.
- The OBU shall be installed in a vehicle prior to use.
- Ownership of all OBU shall belong to a Road Operator.
- Ownership of all OBU shall be registered in name as a Road Operator.
- All users shall pay deposit (such as rental fee) to borrow an OBU from the Road Operator.
- The deposit shall be returned when the OBU is returned to road operator.
- A unique number shall be recorded on the OBU as carved seal and in the memory area of the OBU as a data.
- The vehicle classification and valid terms of use shall be recorded in the memory area of OBU when a driver borrows it. This information shall be easily read and recognized by convenient way, but shall not be rewritten easily by any way.
- The function of payment on ETC shall be realized in the same way of a Prepaid Card.

A communication method to be actualized high reliability, tough, authenticity and high speed transaction within very short time and limited area around Toll-island between ETC Controller (ETCC) and OBU even under special surroundings of toll lane must need following functional requirements.

- To be capable of stable communication without any affection by any surroundings
- To be capable of high reliable communication for all OBU within a limited communication zone provided on the ETC lane
- To be capable of authenticity of transaction which is processed into OBU, IC-Card and ETCC

Figure 7-14 presents the outline of the data flow of the ETC system data including OBU.

The unique number of the OBU shall be pre-encoded and printed/laser-printed with some information. The Contractor shall propose the methods of encoding/printing the number on the OBU to the Employer for approval.

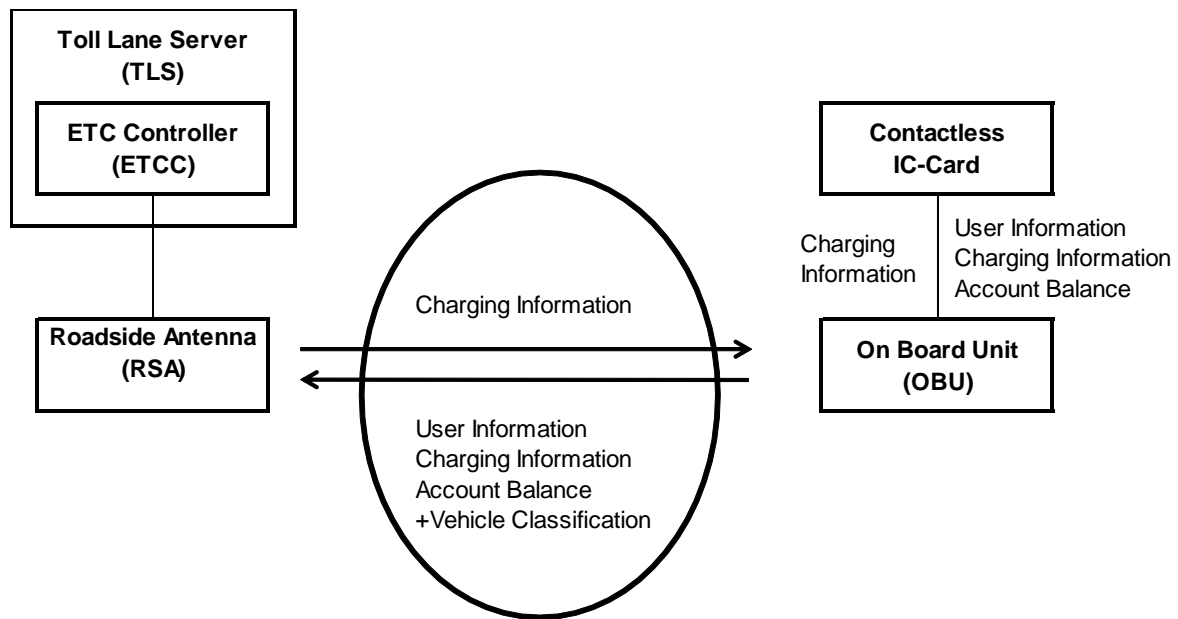


Figure 7-14 Outline of Data Flow of ETC

The front or backside surface of the OBU shall be pre-printed with the information of, at least, the followings:

- Name of a manufacture
- Name of a model of OBU
- Number of registered type
- Number of a unique identification
- Coloring space for vehicle classification
- Description of important points for instruction

The OBU shall be referred to the requirements of ISO/IEC and other international standards, and shall conform to the following minimum requirement.

◆ **Communication:**

The OBU shall comply with the Active method requirements of Annex 1 on Recommendation ITU-R M.1453.

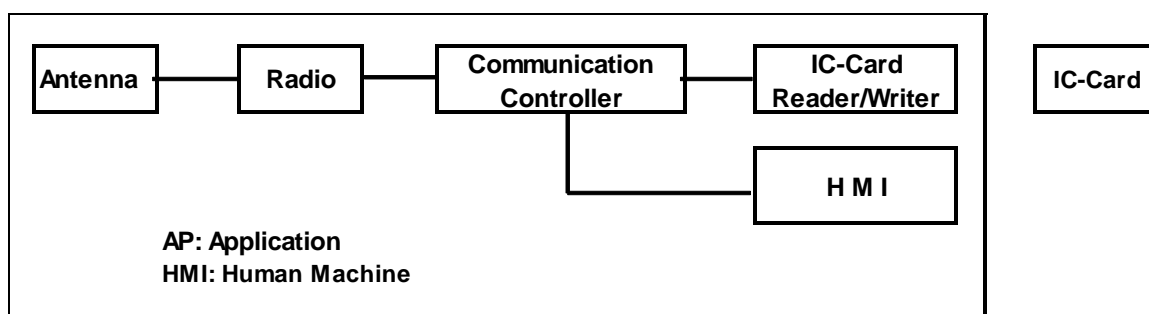
◆ **Reliability:**

Minimum number of communication per year: 2,000 MTBF (Mean Time between Failures): 0.5×10⁵ hours Minimum service life: 5 years

The Contractor shall provide 50,000 sets of the OBU in the Contract. The detailed design, layout and samples shall be submitted to the Employer for approval, prior to the system test. The design and layout shall comprise printing/embossing arrangement of information and coloring.

(b) OBU Specifications

- 1) DSRC should comply with the Active method requirements of Annex 1 on Recommendation ITU-R M. 1453.
- 2) The OBU shall be a two-piece type. One-piece type would be a possible option that needs the Employer for approval.
- 3) For the two-piece type OBU, the IC-Card shall be a contactless IC-Card conforming to this Specification.

**Figure 7-15 Configuration of On-board Unit**

- 4) A single channel shall be used and communication method is based on a simplex system.

Table 7-7 On-board Unit Specifications

	Item	Specifications
Layer 1	Radio frequency bands Number of Channel Operating method and multiple access Access method Modulation method Transmission data rate Communication zone	5.8GHz bands 2 Simplex TDMA-FDD ASK 1,024kbps 3m×4m
Layer 2	Association Point to point communication Retransmission control Duplication check Scramble / Descramble	Available Available Available Available Available
Layer 7	Link Address Normal association Release timer ASN.1 encoding / decoding ACTION primitives EVENT-REPORT primitives	Random number Available Available Available Available Available
Application	Application interface Vehicle data registration	Conformity to ISO/IEC 14906 (EFC) Vehicle classification and License Plate Number

- 5) HMI for displaying account balance and passage history information is offered as an optional feature. However, as it is considered necessary to notify users of the situations listed in **Table 7-8** somehow at least, minimum levels of HMI, such as LED or buzzer, should be available.

Table 7-8 HMI Functions

No.	Situation	Notification to user
1	Power ON	Results of on-board unit Power ON self-test
2	IC card insertion	Results of on-board unit / IC card self-test
3	Communication with roadside equipment	Roadside commands to on-board unit or communication error
4	Completion of toll transaction	Amount of toll to be paid
5	On-board unit error	Detection of on-board unit error

- 6) A registered vehicle classification should be able to be distinguished easily with the color plate attached on the OBU. A number of the color should be seven (5) at least. The Contractor should propose the methods of installation of its color plate for OBU.
- 7) A vehicle data registration in the OBU such a vehicle classification number and a vehicle license number should be easily available to read out in order to inspect it.
- 8) OBU should comply with the following environmental conditions.
- IEC60721-3-5 5K3/5B1/5C1/5S1/5F1/5M2 or above

Section 5 of 60721-3 is related to “Ground vehicle installations” and this standard classifies the environmental conditions to which a product not forming part of the vehicle is subjected. Such products are for example radios, communication systems, fare meters, flow meters.

Where, K: Weather conditions, B: Microbial conditions,

C: Chemically active substances, S: Mechanically active substances,

F: Fouling liquids, M: Mechanical conditions

7.1.6 Authorization and Validation

To prevent the improper and/or illegal use of toll ticket, including the Toll Ticket, the Prepaid Card, and the OBU, authorization and/or validation must be forced effectually in the following aspects;

- ✓ Authorization : check whether it is genuine or NOT, available for toll road or NOT and other confirmation of the card
- ✓ Validation : check the effective date

The negative result of authorization and validation are called “Negative Data”.

The negative data must be administered at Toll Center System (TCS) and must be transferred to Toll Office System at fixed interval in order to check the card and OBU. The negative data shall be preserved at least 10,000 data in each Toll Lane Server (TLS).

7.1.7 Data Communication

All the Toll Lane Server (TLS) shall be linked to the Toll Office System (TOS) installed in the tollgate/plaza building. Data stored by the TLS shall be transmitted to the TOS at various times during collection activities so as to allow compilation of audit and statistical data and monitoring of lane operation and equipment status.

The following information, but not limited to, shall be both stored by the TLS on an individual event basis and transmitted to the TOS in real time under normal operation conditions.

- ✓ System status and operational status including alarms
- ✓ Start of toll collector’s job including allocated job number
- ✓ End of toll collector’s job data
- ✓ Individual transactions
- ✓ Exceptional transactions (Emergency, Violation, etc.)

The data storage available within the TLS shall be sufficient to store the above data for a minimum period of 14 days based on the relevant designing parameter stated in the Specification. The data shall be sufficient to allow all requirements of the Specification to be met with respect to monitoring, report generation, data transfer and the like.

The TLS shall include comprehensive automatic testing routines which shall be implemented on a frequent basis to the toll equipment. Any detected fault condition shall be reported to the TOS as soon as possible from the detection.

There would be occasions either the TOS is off-line or data communication between one or more lane equipments and the TOS is not available. Under such condition the TLS shall continue to store data for later transmission to the TOS.

Means shall be provided to extract the data from the TLS by external data storage device and directly load to the TOS in consideration of such occasions.

Each toll collector’s job shall be allocated a job number. The job number together with the data of operational day shall uniquely identify the job at the tollgate/toll plaza.

The TLS shall receive operational parameters from the TOS. These shall include, but not limited to:

- ✓ “Current” toll fare data for each vehicle classification, and “Future” toll fare data with date and time of implementation.

- ✓ Validation data for IC-Card and OBU (called Negative Data)
- ✓ Other various system constants deemed to be necessary for the control, data acquisition and processing for the toll lane equipment (to be suggested by the Contractor).

Downloading of the operating parameters shall be completed within 3 seconds for each toll lane and not exceed 60 seconds for all toll lanes.

The data communication cables between the TLS and the TOS shall be of metallic cable or optical fiber cable to avoid a magnetic or electric interference. The data communication shall be of a secured Local Area Network (LAN) on 100-BASE Fast Ethernet to fulfill the requirements of the System.

Operating parameters received from the TOS shall be stored in secured read-write memory modules which allow the integrity of stored data to be maintained for a minimum of five days under power failure conditions.

Two toll fare tables for each vehicle classification shall be provided, one for current toll fares and the other for future toll fares with a date and time for implementation. In case no future toll fares are defined, both tables shall contain the same current toll fares data for security. Routines in the lane equipment shall ensure that once a change in toll fares has been implemented, data relating to the previous fares is deleted from memory.

7.1.8 Report and Documentation

The Toll Office System (TOS) shall produce reports for the purpose of management and monitoring of toll collection activities, including toll collector's End of Job report, summarized daily activity reports as well as traffic related reports.

In addition to the audit reports of toll collection activities, the TOS shall produce printouts relating to warning messages, alarm messages, toll equipment failures and other maintenance events. These shall be printed by an Operational Printer (O-PRT) on demand through SOT.

The followings present some kinds of tentatively proposed audit reports. These reports shall be also provided on the visual display of Supervisor and Operation Terminal's (SOT) Console. The exact details of these audit reports on paper and on display shall be proposed by the Contractor for approval by the Employer.

- ✓ Transaction Related Reports retrieval on line for 6 month
- ✓ Traffic Related Reports retrieval on line for 3 month
- ✓ Equipment Maintenance Related Reports retrieval on line for 3 month
- ✓ System Parameter Related Reports retrieval on line for 6 month
- ✓ Enforcement Related Reports retrieval on line for 3 month
- ✓ Registration Related Reports retrieval on line for 6 month
- ✓ Negative Data Related Reports retrieval on line for 6 month

- ✓ Filing Related Reports (On visual display only)

7.2 Operational Procedure and Function

The operational procedures and the functions of various items of equipment are described below. The description assume that all power is correctly available, the toll equipment is switched on ready for used, the lane is exclusive use for one way and is initially not in use. Reference as necessarily is made to other items of equipment which are described elsewhere in the Specification.

(1) Normal Closed State of a Lane

In the normal closed state of a lane both at entry and exit, the following conditions shall prevail:

- Canopy Traffic Light (CTL) is “Red”.
- Manual Lane Barrier (MLB) is in the closed position.
- Lane Traffic Light (LTL) is “Red”.
- Automatic Lane Barrier (ALB) is in the closed position.
- Automatic Lane Barrier (ALB) is in the closed position.
- Toll Transaction Terminal (TTT) is deactivated (except for the internal clock and the function to detect and register the unauthorized vehicle passing through the lane using the Vehicle Detector (VD)).
- Lane Side Display (LSD) is blank.

(2) Lane Opening Procedures

Lane operating procedures shall be as follows:

- ✓ To commence the job, the toll collector shall unlock the booth.
- ✓ The toll collector shall couple his personal Identity (ID) Card through the IC-Card Reader/Writer (ICCRW). The toll collector’s ID number will be registered and displayed on the TTT screen, and the toll collector should be deemed to have logged in. The toll collector’s identity code, the lane number, the time and the date shall be recorded.
- ✓ The toll collector shall turn manually the arm of the MLB to its fully open position and lock it to the position.
- ✓ The collector shall turn the lane open control switch to ‘ON’ position. This shall cause:
 - The lane closed aspect of the CTL to change “Green”.
 - The lane closed indication on the TTT to be turned “Off”.

- The lane opened indication on the TTT to be turned “On”.
- The “Red” indication on the LTL remains on.
- ✓ The ALB shall have a manual locking mechanism to fix the arm to full open position. Judging from the traffic volume, when the automatic operation of ALB is not required, the toll collector shall lock the ALB in the full open position.
- ✓ In the event the ICCRW is not able to read the ID card, the collector shall be able to enter manually his ID number and a password. The manual entry key will be used to correct erroneous entries and the “Enter” key will be used to confirm correct input. Suitable prompts shall be shown on the TTT display and confirmation of ID inputs shall also be displayed. Once the toll collector’s ID number and the password were verified and accepted, the collector shall be deemed to have logged in.
- ✓ The lane opening procedure for service personnel using a maintenance ID card is identical to the toll collector’s procedure stated above, except the CTL is not changed from “Red” to “Green”.

7.2.1 Procedure for Cash Transaction

(1) Process at Entry

When the approaching vehicle enters the lane at entry, the ANPR sends information of Number of the vehicle to ANPRP for processing captured image. The ANPRP transmits a result of recognition combined with the captured image of license number plate, a time stamp and a transaction number to the TDMS via the TTT. And vehicle stops abreast of the booth, then, the toll collector scans an IC-Card Toll Ticket (ICT), which is prepared inside the tollbooth, over the IC-Card Reader/Writer (ICCRW) to record the information of entry. The data which is read from and recorded into the ICT is transferred to the Toll Office System (TOS) through the Toll Lane Server (TLS) and recorded into the server.

Whenever the toll collector scans an ICT, the validity of ICT is checked by TOS through TTT.

After the toll collector scans the IC-Card Toll Ticket (ICT), the toll collector hands over the IC-Card Toll Ticket (ICT) to the driver whereupon:

- The Lane Traffic Light (LTL) shall be changed from “RED” to “Green”.
- The Lane Side Display (LSD) shall be changed from “STOP” to “Passing through, Please”.
- The Automatic Lane Barrier (ALB) shall be fully opened automatically, when it is under the automatic mode.

- The Toll Transaction Terminal (TTT) shall be restricted to issue the IC-Card Toll Ticket (ICT) until the next procedure below has been finished completely.

When the vehicle moves forward and crosses the traffic detection area of the Vehicle Detector (VD) for ALB, the following shall occur:

- The Vehicle Detector (VD) for ALB shall detect a vehicle precisely. The detection signal from the VD for ALB shall be used to judge whether a vehicle has passed by the position of the ALB or NOT.

As the vehicle leaves the lane beyond the ALB, the following shall occur:

- The Lane Traffic Light (LTL) shall be changed from “GREEN” to “RED”.
- The Lane Side Display (LSD) shall be changed from “Passing through, Please” to “STOP”.
- The Automatic Lane Barrier (ALB) shall be fully closed automatically, when it is under the automatic mode.
- The Toll Transaction Terminal (TTT) shall be prepared to issue the IC-Card Toll Ticket (ICT) for a next vehicle.

(2) Process at Exit

When the approaching vehicle enters the lane at exit, the ANPR sends information of Number of the vehicle to ANPRP for processing captured image. The ANPRP transmits a result of recognition combined with the captured image of license number plate, a time stamp and a transaction number to the TDMS via the TTT. And vehicle stops abreast of the booth, then, the toll collector received the IC-Card Toll Ticket (ICT) from the driver and scans an ICT over the IC-Card Reader/Writer (ICCRW) to read the entry information in order to calculate exact toll. The toll collector shall make the visual recognition of the vehicle classification and input the identified vehicle classification through the TTT. The selected classification shall be shown on the display on the TTT and LSD. The toll due shall also be displayed on the TTT and LSD.

After the toll collector collects the toll fare in cash, the toll collector shall press the “Accept” key whereupon:

- A receipt shall be issued automatically by a Receipt Issuance Printer (R-PRT)
- The Lane Traffic Light (LTL) shall be changed from “RED” to “Green”.
- The Lane Side Display (LSD) shall be changed from the contents of toll to “Passing through, Please”.

- The Automatic Lane Barrier (ALB) shall be fully opened automatically, when it is under the automatic mode.

While the transaction activities between the toll collector and a driver take place before the receipt is issued, the Automatic License Number Plate Recognition (ANPR) shall be activated and the image from the Lane Camera (L-CAM) shall be captured. The result of recognition and the image are sent to the TOS and recorded with a transaction number. The data which is read from and recorded into the ICT is transferred to the Toll Center System (TCS) through the Toll Office System (TOS) and recorded into the server.

When the vehicle moves forward into the traffic detection area of the Vehicle Detector (VD) for ALB, the following shall occur:

- The Vehicle Detector (VD) for ALB shall detect a vehicle precisely. The detection signal from the VD for ALB shall be used to judge whether a vehicle has passed over the position of the ALB or NOT.

When the vehicle leaves the lane beyond the ALB, the following shall occur:

- The Lane Traffic Light (LTL) shall be changed from “GREEN” to “RED”.
- The Lane Side Display (LSD) shall be changed from “Passing through, Please” to “STOP”.
- The Automatic Lane Barrier (ALB) shall be fully closed automatically, when it is under the automatic mode.
- The Toll Transaction Terminal (TTT) shall be prepared to treat the IC-Card Toll Ticket (ICT) for a next vehicle.

Prior to pressing the “Accept” key, the collector may use the “Cancel” key to abort the current transaction. On pressing this key:

- The information on the TTT and LSD relating to the previous classification or toll shall be canceled.
- The keyboard shall be ready to accept correct information of input manually.

Unlawful vehicle passage through the ALB activates an Alarm Horn and Lamp (AHL), which operates for a pre-determined time.

The information of invalidated card shall be sent to the Toll Lane Server (TLS) periodically from the Toll Center System (TCS). By using this information, the process of certification is executed prior to every transaction.

7.2.2 Procedure for Prepaid Card Transaction

A driver will make a deposit for a Prepaid Card (PPC) with a returnable warranty deposit at toll office or exit of tollgate/plaza. The amount of deposit shall be decided in regulation of PPC payment. The driver stops at tollbooth of entry then hands his PPC over toll collector to be recorded information requires at entry point in the PPC. At the time of this transaction, toll data on its PPC will be simultaneously recorded to the Toll Office System (TOS) with a unique ID number of card. It will be possible to record a data of license number in the PPC or to the center system.

In case of insufficient balance of PPC for the toll calculated based upon the running distance and vehicle classification automatically, warning message shall be displayed on the Lane Side Display (LSD) and the Alarm Horn and Lamps (AHL) shall be activated. The driver stops at tollbooth of exit point because the Automatic Lane Barrier (ALB) does not open at the exit. At this situation, the driver hands a Prepaid Card (PPC) and cash for insufficient balance of deposit to the toll collector. And then, after receiving them, the toll collector shall recharge the amount to the PPC account and then withdraw amount of toll from the PPC. The toll collector returns card to a driver when all transaction is completed.

When a Prepaid Card (PPC) is lost or in theft, it is possible for registered user to be re-issued a new PPC after a confirmation both registration and deposit through inquiring from the Toll Center System (TOS). Invalidation process for the PPC is carried out to ban the further use of missing PPC.

Non-registered card is never re-issued because there is no way to confirm the owner of the card. Registered card will be issued only when a user submits an application form with picture at the same time as he/she shows ID with photo.

In the case the card is judged in an abnormal condition, a new card shall be re-issued instead of an old card after some of evidences, including the card number or the owner of the card, are confirmed with the data archived in center system.

The information of invalidated card shall be sent to the Toll Lane Server (TLS) periodically from the Toll Center System (TCS). By using this information, the process of certification is executed prior to every transaction.

(1) Process at Entry

When the approaching vehicle enters the lane at entry, and stops abreast of the booth, the toll collector receives a Prepaid Card (PPC) from the driver, and the toll collector scans the PPC over the IC-Card Reader/Writer (ICCRW) to read and record the information of entry point. The data, which is read from and recorded into the PPC, shall be transferred to the Toll Center System (TCS) through the Toll Office System (TOS) and recorded into the server.

Whenever the toll collector scans the PPC, the validity of PPC is checked by the Toll

Lane Server (TLS).

After the toll collector scans the PPC, and the toll collector hands over the PPC to the driver whereupon:

- ✓ The Lane Traffic Light (LTL) shall be changed from “RED” to “Green”.
- ✓ The Lane Side Display (LSD) shall be changed from “STOP” to “amount of value” and “Passing through, Please.”
- ✓ The Automatic Lane Barrier (ALB) shall be fully opened automatically, when it is under the automatic mode.
- ✓ The Toll Transaction Terminal (TTT) shall be restricted a next transaction until the next procedure below has been finished completely.

When the vehicle moves forward into the traffic detection area of the Vehicle Detector (VD) for ALB, the following shall occur:

- ✓ The Vehicle Detector (VD) for ALB shall detect a vehicle precisely. The detection signal from the VD for ALB shall be used to judge whether a vehicle has passed over the position of the ALB or NOT.

In case that short balance of Prepaid deposit, warning message shall be displayed in a Lane Side Display (LSD), whereupon the following shall occur at that case:

- ✓ The AHL are activated for a pre-determined time. The tone and illumination of AHL is separated from other event.
- ✓ The marginal amount of balance deposit to activate the warning is pre-decided and defined in system parameter.

As the vehicle leaves the lane over the ALB, the following shall occur:

- ✓ The Lane Traffic Light (LTL) shall be changed from “GREEN” to “RED”.
- ✓ The Lane Side Display (LSD) shall be changed from “amount of value” and “Passing through, Please” to “STOP”.
- ✓ The Automatic Lane Barrier (ALB) shall be fully closed automatically, when it is under the automatic mode.
- ✓ The Toll Transaction Terminal (TTT) shall be prepared to issue the IC-Card Toll Ticket (ICT) for a next vehicle.

(2) Process at Exit

When the approaching vehicle enters the exit lane, and stops at tollbooth, the toll

collector receives a Prepaid Card (PPC) from a driver and places it on the IC-Card Reader/Writer (ICCRW) to read the entry information in order to calculate and charge an exact toll fee. The toll collector is informed the entry point in of toll payer by the Video Display Terminal (VDT) of TTT. The toll amount is displayed on the LSD, too. This action shall cause to prepare the next function from the toll collector.

The toll collector shall make the visual recognition of the vehicle classification and input the identified vehicle classification through the TTT. The identified classification shall be shown on the display on the TTT and LSD. The toll due shall also be displayed on the TTT and LSD.

The toll collector shall press the “Accept” key whereupon:

- ✓ A calculated toll shall be automatically deducted from the user’s deposit in the PPC.
- ✓ A “Record of Use” shall be issued on demand basis by a Receipt Printer (R-PRT)
- ✓ The Lane Traffic Light (LTL) shall be changed from “RED” to “Green”.
- ✓ The Lane Side Display (LSD) shall be changed from the contents of toll to “Passing through, Please”.
- ✓ The Automatic Lane Barrier (ALB) shall be fully opened automatically, when it is under the automatic mode.

While the transaction between the toll collector and the driver is under progress, the Automatic License Number Plate Recognition (ANPR) shall be activated and the image from the Lane Camera (L-CAM) shall be captured. The result of recognition and the image are sent to the TOS and recorded with a transaction number. The data, which is read from and recorded into the ICT, is transferred to the Toll Center System (TCS) through the Toll Office System (TOS) and recorded into the server.

When the vehicle moves forward into the traffic detection area of the Vehicle Detector (VD) for ALB, the following shall occur:

- ✓ The Vehicle Detector (VD) for ALB shall detect a vehicle precisely. The detection signal from the VD for ALB shall be used to judge whether a vehicle has passed by the position over the ALB or NOT.

When the vehicle leaves the lane beyond the ALB, the following shall occur:

- ✓ The Lane Traffic Light (LTL) shall be changed from “GREEN” to “RED”.
- ✓ The Lane Side Display (LSD) shall be changed from “Passing through, Please” to “STOP”.
- ✓ The Automatic Lane Barrier (ALB) shall be fully closed automatically, when it is

under the automatic mode.

- ✓ The Toll Transaction Terminal (TTT) shall be prepared to next transaction.

Prior to pressing the “Accept” key, the toll collector may use the “Cancel” key to abort the current transaction. On pressing this key:

- ✓ The information on the TTT and LSD relating to the previous classification or toll shall be canceled.
- ✓ The keyboard shall be ready to accept correct information of input manually.

(3) Procedure in case of insufficient deposit

In case of lack of insufficient balance deposit amount at the tollbooth, the warning message shall be displayed on the Lane Side Display (LSD). The following shall occur at that case:

- ✓ The Alarm Horn and Lamp (AHL) shall be activated for a pre-determined time. The tone color and illumination of AHL shall be separated from each incident.
- ✓ The condition of insufficient balance amount in the PPC is displayed on the TTT and the LSD.
- ✓ The transition of transaction mode which is additional recharge or cash payment shall be guided on the TTT
- ✓ A driver chose to pay the toll by cash or recharging additional deposit to the PPC by cash.
- ✓ The toll collector shall select the transaction mode on the TTT.

As an additional deposit is recharged at the tollbooth, the toll collector shall depress the key for recharging. Then the following shall occur:

- ✓ The choice of additional deposit is displayed on the TTT. This choice shall be defined as system parameter in the Toll Office System (TOS).

The toll collector selects one of choices which is designated by a driver in order to add the deposit to a current PPC placed on ICCRW of TTT.

- ✓ An amount of additional deposit is displayed on the TTT and the LSD.

After the toll collector receives it by cash from the driver, the toll collector shall press the “Charging” key whereupon:

- ✓ A Receipt shall be issued automatically by a Receipt Printer (R-PRT)
- ✓ The transition of transaction is guided from “charging” mode to “payment by PPC”

mode on the TTT

- ✓ A calculated toll due shall be automatically deducted from his deposit.
- ✓ A “Record of Use” shall be issued on demand by the Receipt Printer (R-PRT)
- ✓ The Lane Traffic Light (LTL) shall be changed from “RED” to “Green”.
- ✓ The Lane Side Display (LSD) shall be changed from the contents of toll to “Passing through, Please”.
- ✓ The Automatic Lane Barrier (ALB) shall be fully opened automatically, when it is under the automatic mode.

Unlawful vehicle passage through the ALB shall activate an Alarm Horn and Lamp (AHL), which operates for a pre-determined time.

7.2.3 Procedure for Commuter Card Transaction

The Commuter Card (CMC) will be issued the information including an available section, a contract term and designated vehicle license number. A driver will buy a CMC with a returnable warranty deposit at toll office. The CMC shall have the function of prepaid payment because of toll fee adjustment discussed in further paragraph.

The driver stops at the entry point then hands his CMC over the toll collector to record information into the CMC. At the time of this transaction, toll data on CMC will be read and be recorded simultaneously to the Toll Office System (TOS) with a unique ID number of card. It will be possible to record a data of license number in the card or to the Toll Center System (TCS).

The driver stops at the exit point then hands his Commuter Card (CMC) to the toll collector. The validity confirmation of the CMC (running path on designated section only and conforming contract term) will be automatically executed, whereupon the toll collector returns the CMC to a driver when all transaction is complete.

In case the driver uses the expressway section exceeding the designated section recorded in the CMC, it is necessary to adjust the toll fee. At the time of toll adjustment, the prepaid card is effective method for toll adjustment in order to reduce the transaction time. In case of toll adjustment, the payment is changed from the Commuter Card transaction to the Prepaid Card Transaction. The toll fee for outside section in the CMC is conducted from the deposit amount of the CMC.

The residual procedure is described in as same as the Prepaid Card Transaction.

When a Commuter Card is lost or in theft, it is possible for registered user to be re-issued a new Prepaid Card as same procedure as in the Prepaid Card Transaction

In the case the card is judged in an abnormal condition, a new card shall be re-issued

instead of an old card after some evidences, including the card number or the owner of the card, are confirmed with the data archived in center system.

The information of invalidated card shall be sent to the Toll Lane Server (TLS) periodically from the Toll Center System (TCS). By using this information, the process of certification is executed prior to every transaction.

(1) Process at Entry

When the approaching vehicle enters the lane at entry, and stops abreast of the booth, the toll collector receives a Commuter Card (CMC) from a driver, and the toll collector scans the CMC over the IC-Card Reader/Writer (ICCRW) to read and record the information of entry point. The data, which is read from and recorded into the PPC, shall be transferred to the Toll Center System (TCS) through the Toll Office System (TOS) and recorded into the server.

Whenever the toll collector scans the CMC, the validity of the card is confirmed by the Toll Lane Server (TLS) at every transaction.

After the toll collector scans the CMC and the toll collector hands over the CMC to the driver whereupon:

- ✓ The Lane Traffic Light (LTL) shall be changed from “RED” to “Green”.
- ✓ The Lane Side Display (LSD) shall be changed from “STOP” to a kind of ticket such as a monthly or quarterly ticket and “Passing through, Please”.
- ✓ The Automatic Lane Barrier (ALB) shall be fully opened automatically, when it is under the automatic mode.
- ✓ The Toll Transaction Terminal (TTT) shall be restricted a next transaction until the next procedure below has been finished completely.

When the vehicle moves forward into the traffic detection area of the Vehicle Detector (VD) for ALB, the following shall occur:

- ✓ The Vehicle Detector (VD) for ALB shall detect a vehicle precisely. The detection signal from the VD for ALB shall be used to judge whether a vehicle has passed by the position of the ALB or NOT.

In case of expired ticket, warning message shall be displayed on the Lane Side Display (LSD). The following shall occur at that case:

- ✓ An Alarm Horn and Lamp (AHL) are activated for a pre-determined time. The tone color and illumination of AHL is separated from each incident.
- ✓ The Lane Side Display (LSD) shall be changed from “STOP” to “Expired Ticket”.

- ✓ Then the transaction is migrated to the Prepaid Card Transaction

As the vehicle leaves the lane beyond the ALB, the following shall occur:

- ✓ The Lane Traffic Light (LTL) shall be changed from “GREEN” to “RED”.
- ✓ The Lane Side Display (LSD) shall be changed to “STOP”.
- ✓ The Automatic Lane Barrier (ALB) shall be fully closed automatically, when it is under the automatic mode.
- ✓ The Toll Transaction Terminal (TTT) shall be prepared to next transaction.

(2) Process at Exit

When the approaching vehicle enters the lane at exit, and stops abreast of the booth, the toll collector receives the Commuter Card (CMC) from the driver and places it on the IC-Card Reader/Writer (ICCRW) to read the entry information and the designated vehicle license number. After the validation check of the CMC, a calculated toll due, if necessary adjusted toll due also, and designated vehicle license number are displayed in the Lane Side Display (LSD). The toll collector can understand the validation of the card, whether a section use of this driver is inside or outside from designated section and the adjusted toll by the VDT of TTT. This action shall cause to prepare the next function from the toll collector.

The toll collector shall make the visual recognition of the vehicle license number plate by reading the number written on the side of the vehicle. The toll collector shall realize validation of the CMC by sound from TTT. After validation is complete and the designated vehicle is correct use, the procedure of the Commuter Card is almost finished. Then following shall occur:

- ✓ The toll collector shall press “Accept”.
- ✓ A “Record of Use” shall be issued on demand by a Receipt Printer (R-PRT)
- ✓ The Lane Traffic Light (LTL) shall be changed from “RED” to “Green”.
- ✓ The Lane Side Display (LSD) shall be changed from “STOP” to a kind of ticket such as a monthly or quarterly ticket and “Passing through, Please.”
- ✓ The Automatic Lane Barrier (ALB) shall be fully opened automatically, when it is under the automatic mode.

While the transaction activities between the toll collector and a driver take place before confirmation of the card, the Automatic License Number Plate Recognition (ANPR) shall be conducted and the image from the Lane Camera (L-CAM) shall be captured. The result of recognition and the image are sent to the TOS and recorded with a transaction number. The data which is read from and recorded into the CMC is transferred to the Toll

Center System (TCS) through the Toll Office System (TOS) and recorded into the server.

When the vehicle moves forward into the traffic detection area of the Vehicle Detector (VD) for ALB, the following shall occur:

- ✓ The Vehicle Detector (VD) for ALB shall detect a vehicle precisely. The detection signal from the VD for ALB shall be used to judge whether a vehicle has passed over the position of the ALB or NOT.

When the vehicle leaves the lane beyond the ALB, the following shall occur:

- ✓ The Lane Traffic Light (LTL) shall be changed from “GREEN” to “RED”.
- ✓ The Lane Side Display (LSD) shall be changed from “Passing through, Please” to “STOP”.
- ✓ The Automatic Lane Barrier (ALB) shall be fully closed automatically, when it is under the automatic mode.
- ✓ The Toll Transaction Terminal (TTT) shall be prepared to next transaction for a next vehicle.

(3) Procedure of invalid term and outside section usage

In case of a use of outside term, the payment had been already changed to the Prepaid Card Transaction from the entry point because of validation checking. Therefore, the remained transaction is as same as the Prepaid Card Transaction.

In case of a use of outside section, the payment is changed to the Prepaid Card Transaction at the time of toll adjustment. The toll operator shall define the rule of toll adjustment. There are mainly three cases regarding a use of outside section as shown:

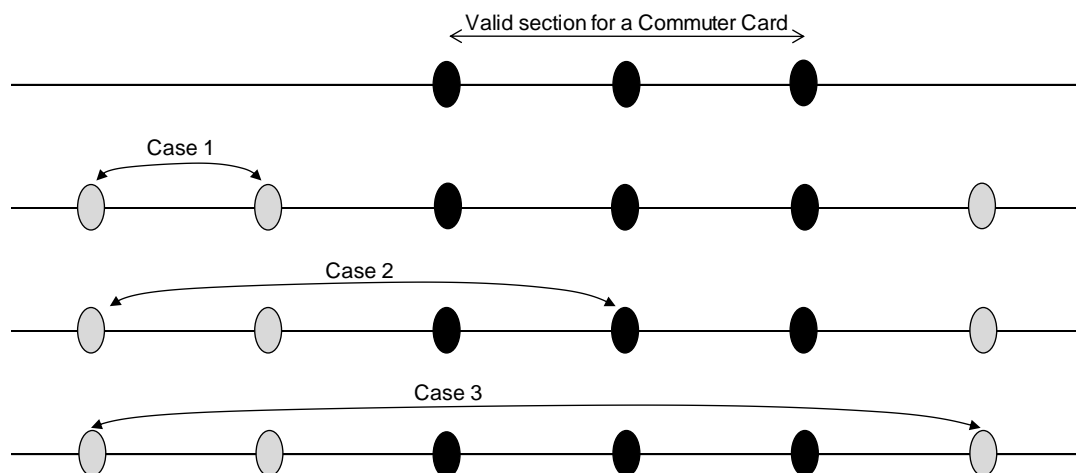


Figure 7-16 Image of Outside Use of Commuter Card

- ✓ CASE 1 a use of section which is no relationship with a section of commutation
- ✓ CASE 2 a use of section which is including a section of commutation

- ✓ CASE 3 a use of section which is exceeded a section of commutation

For each case of toll adjustment, the payment of outside section shall be changed to the Prepaid Card transaction. The remained transaction is as same as the Prepaid Card Transaction.

In case of a different vehicle license number plate use, the payment is changed to the Prepaid Card Transaction for all section of use. Therefore, the remained transaction is as same as the Prepaid Card Transaction. After the toll collector inputs a vehicle classification and realize a difference from pre-defined classification.

- ✓ The toll collector shall press the “Invalid Vehicle” key.
- ✓ An Alarm Horn and Lamp (AHL) are activated for a pre-determined time. The tone color and illumination of AHL is separated from each incident.
- ✓ The Lane Side Display (LSD) shall be changed from “STOP” to “Invalid Vehicle”.
- ✓ The toll due shall be automatically calculated and displayed on the TTT and LSD.
- ✓ Then the transaction is migrated to the Prepaid Card Transaction

While the transaction activities between the toll collector and a driver take place before the acceptance of the toll collector, the Automatic License Number Plate Recognition (ANPR) shall be activated and the image from the Lane Camera (L-CAM) shall be captured. The result of recognition and the image are sent to the TOS and recorded with a transaction number. The data, which is read from and recorded into the CMC is transferred to the Toll Center System (TCS) through the Toll Office System (TOS) and recorded into the server.

When the vehicle moves forward into the traffic detection area of the Vehicle Detector (VD) for ALB, the following shall occur:

- ✓ The Vehicle Detector (VD) for ALB shall detect a vehicle precisely. The detection signal from the VD for ALB shall be used to judge whether a vehicle has passed by the position of the ALB or NOT.

When the vehicle leaves the lane beyond the ALB, the following shall occur:

- ✓ The Lane Traffic Light (LTL) shall be changed from “GREEN” to “RED”.
- ✓ The Lane Side Display (LSD) shall be changed from “Passing through, Please” to “STOP”.
- ✓ The Automatic Lane Barrier (ALB) shall be fully closed automatically, when it is under the automatic mode.
- ✓ The Toll Transaction Terminal (TTT) shall be prepared to next transaction for a

next vehicle.

7.2.4 Procedure for Electric Toll Collection (ETC) Transaction

The Electric Toll Collection System (hereinafter referred as ETC) shall be consisted of three components namely, a Roadside Equipment (RSE), On-Board Unit (OBU) and the IC-Card.

The ETC shall be used to pay the toll through a communication between a RSE and an OBU. The payment means of ETC shall be the same as a Prepaid Card.

(1) Procedure of toll collection through ETC

A driver who wants to use ETC borrows OBU from a Road Operator and pay returnable warranty deposit for its OBU at the toll office. Then the OBU is installed in a vehicle by the way of authorized method and position. Of course, a driver also purchases a Prepaid Card in advance.

The Road Operator registers information of ownership, classification of the vehicle, license number of the vehicle, a unique number of the OBU which is originally recorded in the OBU at the time of manufacturing and others to database of the Toll Center System (TCS). Especially, a classification of the vehicle and a license number of the vehicle are simultaneously recorded in the OBU completely. It shall be possible easily to read or recognize that information by a convenient ways.

A driver checks the activity of OBU before entering the expressway. The Prepaid Card (PPC) is inserted to the OBU prior to proceeding to the entry point. The ETC service will be never provided, in case of incomplete use of card.

The driver approaches to the ETC lane after confirming whether ETC service is operating or NOT by looking the Canopy Traffic Light (CTL) and keeps safe speed to avoid any unexpected events.

The driver keeps safe speed and passes through the lane after confirmation whether transaction is completed or NOT by checking the status of OBU and viewing of the Lane Side Display (LSD). Additionally, by confirming the operation of the Automatic Lane Barrier (ALB), the driver finishes to pass through the lane.

Same transaction with the Prepaid Card as described in 13.3.2 is simultaneously completed while an ETC user runs the ETC lane. At the same time, some toll data in addition to the record of OBU is sent to the Toll Center System (TOS) as the same process as the Prepaid Card. These data is prepared for the transaction at exit point and in case of unexpected eventuality.

The driver approaches to ETC lane at exit point after confirming whether ETC service is operating or NOT by looking the CTL and keeps safe speed in case of unexpected eventuality. The card must be inserted to OBU prior to proceeding to the exit point. The

ETC service is never provided in case of incomplete use of the card.

The driver keeps safe speed and passes through the lane after confirmation whether transaction is completed or NOT by checking the activity of the OBU and viewing of the Lane Side Display (LSD). Additionally, by confirming the operation of the Automatic Lane Barrier (ALB), the driver finishes to pass through the lane.

Same transaction including the process of withdrawing the charge from deposit balance for the PPC as described in 13.3.2 is simultaneously completed while the ETC user runs the lane. At the same time, the toll data with OBU data is sent to the Toll Center System (TCS) as the same process as the Prepaid Card.

On the other hand, it is necessary for driver to pay toll manually by cash or recharge to toll collector in the event of insufficient amount of the prepaid value and in the case that automatic barrier does not open.

(2) Arrangement of ETC lane

If an ETC lane is NOT set up appropriately, it will be possible to be exerted on some kinds of obstruction which may cause interference with both ETC and non-ETC user because the lane which is available for ETC service and which is NOT applicable for ETC coexist at tollgate/toll plaza.

The ETC lane on the project shall be set up as one lane for each entry and exit because of rate of spread at initial stage and shall be set up at the most left side of lane because of consideration which is based on weaving problem around tollgate/toll plaza.

By comparison of lane operation for ETC and corresponding method for unusual situation as shown in **Figure 7-17**, the Manual & ETC lane shall be basically managed for ETC user.

ICCRW, as a kind of back-up system, shall be set up in order to prevent long time transaction in case of unusual use that non-ETC user proceed to ETC lane and some anomaly happens at ETC lane.

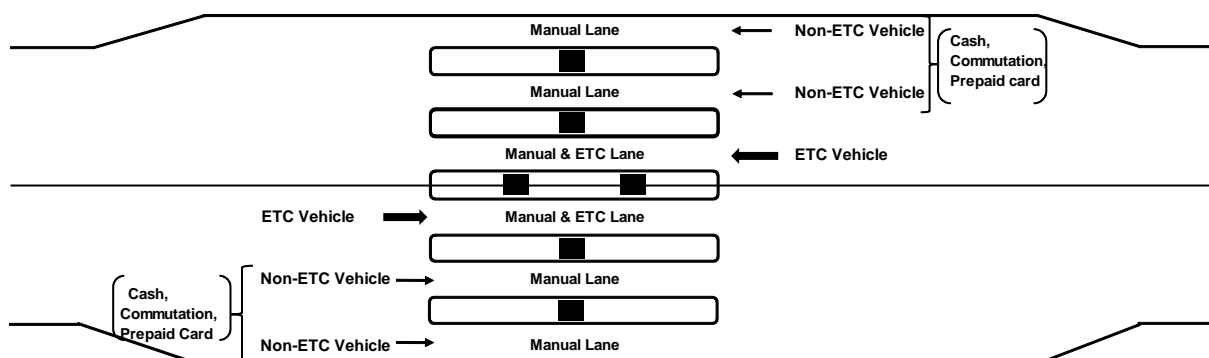


Figure 7-17 Lane Arrangement at Toll Plaza

(3) Design Speed for ETC service

A driver passes through an ETC lane without stopping abreast of the tollbooth. In the case of that a non-ETC user trespasses to an ETC lane, the amount of value on the Prepaid Card is insufficient for the toll due, the CARD or OBU is expired to be available, or the Toll System is not in operation by some reasons, the Automatic Lane Barrier (ALB) is not opened. Therefore the driver must reduce the speed and stops in front of the ALB.

The ETC system shall be designed properly to convey the information of system status to the driver even in case of mentioned above. The location of each equipments in the ETC system shall be decided effectually. To decide the location, the design speed for the ETC lane shall be defined firstly. The design speed for the ETC lane shall 40km/h with following conditions;

- Regulated speed at the front and beyond of tollgate
- Lane width
- Safe speed to reduce calmly
- Safe speed to recognize a content of the Lane Side Display (LSD) and a status of the Automatic Lane Barrier (ALB) in visible

The design speed is quite not the requirement for the system, but defined from view point of safe for driver.

(4) Basic arrangement of main equipments of ETC lane

Basic configuration of equipment of ETC lane shall be as follows;

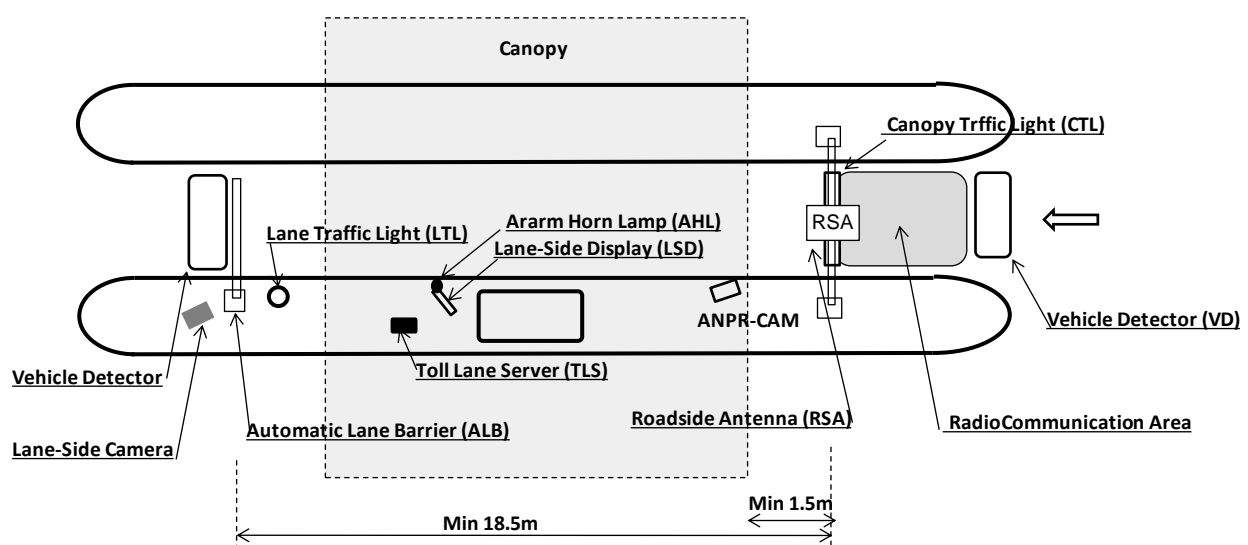


Figure 7-18 Arrangement of Equipments at ETC Lane

When an approaching OBU mounted vehicle enters the lane, Vehicle Detector (VD)

detects the Vehicle, radio communication through a Road side Antenna (RSA) of Roadside Equipment (RSE) and an On-Board Unit (OBU) is executed in a radio communication area at both Entry and Exit toll lane. And Automatic License Number Plate Recognition (ANPR) sends information of Number of the vehicle to RSE for verifying registered Number Plate and Vehicle Classification on OBU. When the communication is complete appropriately, the result of transaction is displayed on the Lane Side Display (LSD). Simultaneously, the Automatic Lane Barrier (ALB) is fully opened automatically when it is under the automatic mode. The driver can recognize the contents of the LSD. And then, the driver can leave the lane thoroughly.

On the other hand, if an approaching vehicle, which is not equipped the OBU, enters the lane, a communication between a Roadside Equipment (RSE) and an On-Board Unit (OBU) is failed in the Radio Communication Area at both Entry and Exit toll lane. And then, LSD displays the failure and the ALB keep close.

The configuration of the major equipments of ETC lane should be designed correctly to keep enough distance. **Figure 7-18** and the following shows required distance which is cited from Japanese Standard.

- For all drivers to recognize the status of the LSD and the ALB after passing the communication area and to stop safely just before of the Automatic Lane Barrier (ALB), minimum 18.5 m distance is required between communication area and ALB.
- For prevention of radio communication failure, take into consideration radio wave reflection from Canopy, minimum 1.5 m distance is required between Roadside Antenna (RSA) and Canopy.

(5) Process at Entry

When the vehicle equipped the On-Board Unit (OBU) enters the ETC lane at communication area, a radio communication with the Roadside Equipment (RSE) and the OBU is executed in the communication area located at the front of the toll island. The information of the entry point is recorded into the Prepaid Card through the OBU via a result of the communication. The data which is read from and recorded into the Prepaid Card is transferred to the Toll Center System (TCS) through the Toll Office System (TOS) and recorded into the server.

The validity of the OBU and the Prepaid Card is checked by TOS through TTT average time.

After the communication is complete successfully, the followings shall occur:

- The Lane Traffic Light (LTL) shall be changed from “RED” to “Green”.

- The Lane Side Display (LSD) shall be changed from “STOP” to “Passing through, Please.”
- The Automatic Lane Barrier (ALB) shall be fully opened automatically, when it is under the automatic mode.

If the vehicle non-equipped the OBU moves forward into the communication area after passing through VD, ETC System judges that the vehicle is non-OBU equipped vehicle because of the communication failure. At that time, some warnings are activated. The following shall occur at that case:

- An Alarm Horn and Lamp (AHL) are activated for a pre-determined time. The tone color and illumination of AHL is separated from each incident.
- The Lane Traffic Light (LTL) shall be kept “RED”.
- The Lane Side Display (LSD) shall be changed “STOP” and “Communication Failure”.

At that situation, the toll collector, who is waiting in a tollbooth on ETC lane, shall operate manually after checking whether a driver has valid Prepaid Card or not. If the driver has a valid Prepaid Card, the rest of transaction shall be followed as Prepaid Transaction, otherwise as Toll Ticket Transaction by the toll collector.

(6) Process at Exit

When an OBU equipped vehicle entered into the communication area of exit lane, radio communication between the Roadside Equipment (RSE) and the On-Board Unit (OBU) is executed in the communication area. The entry point information recorded in the OBU is read by this communication. The toll due is calculated automatically and withdrawn from the deposit amount of the Prepaid Card in this communication. The data which is read from and recorded into the Prepaid Card is transferred to the Toll Center System (TCS) through the Toll Office System (TOS) and recorded into the server.

The vehicle classification is decided by the information of OBU. The classification shall be shown on the display on the TTT and LSD. The toll due shall also be displayed on the TTT and LSD.

After the communication is successful completely, the followings shall occur:

- The Lane Traffic Light (LTL) shall be changed from “RED” to “Green”.
- The Lane Side Display (LSD) shall be changed from “STOP” to “Passing through, Please.”

- The Automatic Lane Barrier (ALB) shall be fully opened automatically, when it is under the automatic mode.

When the vehicle non-equipped the OBU enters the communication area after passing through VD, ETC System judges that the vehicle is non-OBU equipped vehicle because of the communication failure. At that time, some warnings are activated. The following shall occur at that case:

- An Alarm Horn and Lamp (AHL) are activated for a pre-determined time. The tone color and illumination of AHL is separated from each event.
- The Lane Traffic Light (LTL) shall be kept “RED”.
- The Lane Side Display (LSD) shall be changed “STOP” and “Communication Failure”.

The toll collector shall operate manually depend whether a driver has valid Prepaid Card or NOT. If a driver has a valid Prepaid Card, the toll collector, who is waiting in a tollbooth on the ETC lane, shall take the transaction procedure for the Prepaid Card. If a diver doesn't have a valid Prepaid Card, the transaction procedure for the Toll Ticket Transaction shall be taken by the toll collector.

The same shall occur in case that recognized Number Plate by ANPR differs from the registered Number on OBU. Also, in case that if OBU is not installed on the registered vehicle and its vehicle classification is different, the above same activation shall occur, and toll collector shall do appropriate operation manually.

7.3 General Technical Requirements

7.3.1 Introduction and Approvals

The requirements detailed below shall be regarded as being supplemental and/or additional to those given in other applicable Specification requirements. In the event that the requirements given herein conflict with requirements provided elsewhere in the Contract documents, the requirements herein shall prevail.

The Contractor's attention is drawn to the fact that all equipment and systems provided shall require type approval by the Employer. Tests associated with the type approval will be necessary for all equipment which has not been previously approved and may include environmental tests by an approved independent testing body.

7.3.2 Quality Assurance

The Contractor shall establish and maintain the Quality Assurance System in accordance with the requirements in respect to all elements of the works. A quality plan to be prepared by the Contractor shall be submitted to the Employer and shall comprise the following parts:

- ✓ The Management Quality Plan
- ✓ The Design Quality Plan
- ✓ The Construction and Installation Quality Plan
- ✓ The Software Development Quality Plan.

The Management Quality Plan shall define the Management Structure for the development and implementation of the quality system and include, but not limited to, the following sections:

- Organization and Responsibility
- Correspondence
- Oral communications
- Records
- Change Control
- Sub-Contract Services
- Audit and Report
- Quality Plan Review and Revision
- Inspection, Measuring and Test Equipment
- Archives
- Training.

The Contractor shall prepare a separate Design Quality Plan for his design work.

The Design Quality shall cover the following subject headings:

- Design and Performance
- Handling, Storage, Packaging and Delivery
- Construction and Installation Control
- Inspection and Testing
- Non Conforming Material and Construction

The Contractor shall prepare a separate Software Development Quality Plan for the software development associated with the works.

7.3.3 Design Submission and Approval

The Contractor shall prepare a Functional Specification as a part of the overall design and approval process. The Contractor is advised to make reference to “Guidelines for the documentation of software in industrial computer systems” published by the Institution of Electrical Engineers, for the preparation of Functional Specification. These guidelines

will be used by the Project Manager in assessing the suitability of documents submitted by the Contractor.

The Functional Specification shall provide comprehensive details of the manner in which the Contractor intends to meet all requirements in this Specification. The document shall include a description of each item of plant, outline operating procedures of the facilities and services provided and an indication of maintenance arrangements.

As a minimum, the Functional Specification shall include the following:

- ◆ System Overview: in the form of block diagram accompanied by descriptive text.
- ◆ Functions and Facilities: describing how the equipment proposed will meet the objectives of the technical specification. This section shall include all equipment specifications and outlines, display and report formats, outline operating procedures, alarms and security measures.
- ◆ Interfaces: details of all inputs and outputs to the equipment and communication links between the various items including hardware, protocol and data content.
- ◆ Attributes: details of the adaptability, availability, maintainability and usability of the equipment together with information on training and documentation to be provided.
- ◆ Design development and test factors: specifying broad details of software design, development procedures and proposals for on-site testing.

The Contractor shall submit the draft Functional Specification to the Employer not later than 1 month from The Effective Date. The Functional Specification shall be finalized within 2 months from The Effective Date, incorporating the Employer's comments.

The Contractor shall submit a Software Specification within 1 month from the issuance date of completion certificate after the reliability tests for the Toll Collection System.

The Software Specification shall describe the functions, structures and content of the software system. The summary of Software Specification shall present the overall descriptions of system, covering the followings:

- The structure of the software and its breakdown into subsystems.
- The breakdown of subsystems into programs and program modules.
- Data input and output to and from the system.
- The functions and interrelationship of the various parts of the software system.

7.3.4 Equipment Practice and Procedures

All electrical and mechanical equipment shall be properly finished for the ambient

conditions and circumstances of use.

All equipment and systems shall be entirely suitable for operation in the environmental conditions at the project site. The Contractor shall either, arrange for environmental tests to be performed on the equipment giving the Employer at least ten days notice of such tests, or submit test certificates in respect of similar equipment that has been subjected to a suitable testing program.

The Employer from the manufacture's range of available colors and styles shall select the color and style of all finished items.

All surfaces or features which become damaged or broken prior to the commencement of the maintenance period shall be repaired and refinished to the satisfaction of the Employer in such manner so as to be indistinguishable from the original finish.

All proprietary items shall be to the approval of the Employer. The Contractor shall be responsible for delays caused by the submission of unacceptable details in connection with such approval.

The Contractor shall ensure that the manufacture(s) requirements and recommendation for handling, storage installation testing, commissioning and operation of proprietary equipment are observed.

All mechanical and electrical parts shall be adequately guarded to ensure the safety of persons in their vicinity.

In the areas accessible to the public, equipment shall be completely enclosed. Such enclosures shall be strongly made to resist intentional damage and shall have smooth exteriors free from avoidable irregularities and crevices where dust and damp may accumulate.

Doors shall have locks with special keys to open them. They shall not be capable of being opened by common articles such as screwdrivers, knife blades, square keys and such "Allen" wrenches. Keys shall not have common and easily identified and manufactured shapes. Similar enclosures for equipment in the same system shall use identical locks. Two keys shall be provided for each lock with a minimum of keys for each type of lock.

The average life of indicating lamps and LEDs shall not be less than 5,000 hours.

Means shall be provided to test the lamp/LED without interference on the normal operation of other circuits. Fault lamps shall be reset only after its fault has been cleared.

The Contractor shall submit schematic block diagrams of all equipment showing the manner in which the functional requirements of the Specifications will be met and a general cabling arrangement with estimated cable sizes.

7.3.5 Installation Instructions

A draft of the installation instructions which will eventually be included in the operating and maintenance manuals, shall be submitted to the Employer no later than 4 (four) weeks prior to commencement of a unit's installation.

The installation instructions shall clearly show the required sequence of installation, testing and commission for all parts of the equipment. They shall be described in detail any special action to be taken to ensure correct functioning or prevent damage to equipment, or danger to life. Any special techniques to facilitate cabling, connecting and testing shall be clearly described using suitable sketches.

The Contractor shall be responsible for checking and verifying dimension of all doors and exits to assure that equipment can be properly, transported, positioned and installed. Any modifications shall be minimal and not effective the operation and functionality of equipment. Any and all changes to the standard operation and the design shall be submitted to the Employer for approval.

7.3.6 Testing

No later than one month after the Commencement of Works date the Contractor shall submit to the Employer for review and approval his proposed acceptance and reliability testing program. The program shall include a summary of all testing and inspection for all equipment and operations as well as proposed formats of records for recording testing, and inspection requirements and procedures.

The Contractor shall submit the detailed testing and commissioning procedures with appropriate inspection records for all system and equipment tests to the Employer for review and approval no later than one month prior to the commencement of testing. Any testing or commissioning delays due to submission of unacceptable or inadequate procedures shall be the responsibility of Contractor.

In addition to the operation testing required for acceptance and hand over, the functioning of all interlocks, sequences and protection not utilized in normal operation shall be tested as required by the Employer.

The cost of all the testing equipment, associated documentation software and manpower shall be deemed to be included in the Contract.

Any equipment, cables, spares or tools supplied under the Contract, which do not meet the test requirements, will be rejected. The Contractor shall clear the fault after which the failed equipment will be resubmitted for retest as required by the Employer. Any further tests required by the Employer shall be deemed to be included in the Tender sum.

7.3.7 Maintenance and Spare Parts

All equipment shall be designed to facilitate inspection, cleaning, replacement and repair

of individual components without the need for unnecessary removal of other components. Identical items of equipment shall have interchangeable parts or matched sets forming interchangeable units. This condition shall be recorded and described in the operating and maintenance manuals and instructions.

All principal items of equipment down to the level of printed circuit boards shall be clearly identified with assembly number, serial number and modification levels.

On completion of acceptance tests, the Contractor shall provide the Employer with a record of which assemblies are installed in the various equipment locations. Such records shall be considered part of the “as built” drawings and will be used as base data for maintenance logs and long term reliability assessment.

The facilities shall be provided for proper isolation of equipment for maintenance work without affecting the working of other parts of the systems. Protection from “live parts” shall be given by the use of interlocks, isolators, shrouding or by combination of these. There shall be warning labels to show when parts remain live and when an isolator is opened. These parts shall be properly secured against inadvertent contact.

The Contractor shall state in his submittals, the mean time between failures (MTBF) for all items of equipment and for systems as a whole. No item of equipment shall be provided for which the MTBF is less than 5,000 hours and in certain instances, as detailed hereunder, equipment shall have an MTBF considerably in excess of this figure.

Unless otherwise agreed, no equipment shall be used for which the manufacture’s recommended periodic maintenance attention is at intervals of less than 2,500 hours nor requiring shut down for more than four hours at such intervals. Certain items of equipment, as stated hereunder, shall require periodic maintenance to be performed at intervals considerably in excess of this minimum figure.

The Contractor shall arrange to make available during the reasonable life of the equipment and for not less than ten (10) years, such spares and replacements as will ensure continued satisfactory working without need for replacement of substantial parts of the equipment. Such spares and replacements shall be suitable to ensure the continued satisfactory operation of the equipment without degradation of performance or reliability. Should any spares or replacements not be available in the period sated above or for a further period of not less than five (5) years, the Contractor shall use his best endeavors to ensure that similar parts or modules, which may be used in direct substitution will be available to ensure that ongoing operation of the system is maintained.

The Contractor shall provide a priced schedule of recommended spare parts in accordance with requirements noted for Operation and Maintenance Manuals. Capital, breakdown, overhaul and consumable spares shall be fully considered and included in quantities recommended by the Contractor. The schedule shall take account of the Employer’s included policy of repairing components wherever possible and should cover piece part spares, noting standard commercial items and sources of supply where

appropriate. Full details shall be provided where it is recommended that the Employer enter into a servicing Contract with a manufacturer or his agent for particular items of equipment and systems such as proprietary processor systems.

It is recognized that it may not be possible to detail certain spare parts such as individual components until the design work is well advanced. The Contractor shall include a lump sum provision in respect of such spares.

The Contractor shall provide a priced schedule of all special tool and test equipment required for initial set up, maintenance, overhaul and repair of the electrical and mechanical equipment so as to ensure efficient operation of project. The equipment detailed shall take into account the condition in which the electrical and mechanical equipment will operate and the Employer's intended policy of carrying out all post warrantee period maintenance.

A listing of spares and special tools and test equipment shall also be included in the Contractor's Tender.

The Contractor shall be responsible for the availability of spares on site during installation and commissioning. Unused spares from the Contractor's stock, which are additional to those provided under the Contract may be taken over by the Employer, by prior arrangement with the Contractor.

All special tools and test equipment, which are likely to be used away from a workshop, shall include protective carrying cases as may be appropriate for the storage and use of each item. Such carrying cases shall be subject to the approval of the Project Manager.

7.3.8 Cabling and Wiring

All cables shall employ extruded, reduced flame propagation, low smoke and low fume and zero halogen gas emission compound outer sheaths.

Spare conductors will not be required for cables carrying power, but all other cables shall have not less than 10% (minimum two) spare conductors after completion of the installation.

Cable and wire ends shall be repaired using only approved means, which avoid damage to conductors. They shall be clearly and indelibly marked in accordance with relevant diagrams for wiring up and circuit checking. Each cable shall be an indelible label securely fixed near each end, giving its reference number in the "as constructed" cable records. Details of the proposed cable numbering shall be submitted to the Employer for approval.

Wiring entries to all enclosures shall generally be made through compression type glands with all wires neatly arranged, securely located, preventing the access of vermin to the enclosure and relieving all terminals of the weight of cables. Spare gland holes with blanking plugs shall be provided for each enclosure.

Terminals shall be coded and identified according to the diagrams and the cable and wire marking to assist in providing correct connections. Terminals shall be of the anti-vibration type, using non-tracking-molded insulation, made by specialist manufacturer and having current ratings not lower than that of the cable or wire, which they will receive. Live metal shall be recessed or protected to avoid accidental contact. Terminals used in control, alarm and communication cubicles and in associated cable junction boxes shall be bolted or clipped to carrier rails. Carrier rails shall be sufficiently long to permit the addition of extra terminals at a later date.

All equipment and junction boxes shall have a separate terminal for each wire including spare cores. Link type terminals shall be provided at the end of long control, alarm and communication cable runs to facilitate the testing of cables. Throughout the installation, the arrangement of wire and terminal identities shall be consistently followed and shall be as agreed with the Employer.

Jumper leads and transition terminals shall be provided to avoid along runs of cable tails within ducts and cubicles. Flexible cable harnesses shall be properly located and protected from “chafing”, “pinching” and tension where they pass from doors or other moveable positions.

All trunking, conduit, wiring and earth conductors shall (except when laid in trenches or in ducts), be secured throughout their length and shall be supported on cleats, hangers, trays or racks. No permanent cabling, wiring or conductor shall be left lying loose in or on any part of the structure or buildings. Cables shall be fixed with purpose made fixing clamps of the correct size for the cable.

Joints in cables shall be avoided unless approved by the Employer. Cable terminations and joints shall be made by methods and with such materials as are recommended by the makers of the cables.

The installation of non-protected cables on any structure will not be permitted. All means used for making attachments to any structure shall be to the approval of the Employer.

Cable ducts and conduits will be provided to extent shown in the Drawings and as otherwise required or necessary to properly construct and complete the Works

The Contractor shall supply erect cable trays, hangers, brackets and supports for and his cables inside buildings. Trays shall be made from perforated sheet steel and all trays, supports and clamps shall be hot dipped galvanized after manufacture. Lengths of tray shall be bolt together with approved fish-plates and webs. The arrangement of cables on trays shall prevent electrostatic and electromagnetic interference between power cables and communication/data cables.

All cables shall be delivered on robust cable drums with cable ends treated to form an effective seal. When a cable is cut from a drum the cable end left on the drum shall be immediately sealed in an approved manner to prevent the entry of moisture. All cables,

once they have been cut, shall be either terminated in their final position immediately or effectively sealed in an approved manner.

Details of all methods of winching cables into ducts shall be submitted to the Employer for approval. A cable pulling eye attached to the conductor or cable stocking, as appropriate, may be employed on cables for direct laying of short lengths. Care shall be taken that no damaging stress shall occur to the cable sheaths.

Where cables pass through the cable holes, ducts and the like they shall be sealed to prevent vermin and water access to other parts of the installation.

Cables shall be of approved manufacturer and shall be delivered to site with maker's seal intact bearing the maker's original guarantee. Seals shall be retained for inspection and record in case of later faults. Short lengths of cable may be delivered out of seals, provided they are suitably packed and the Employer's approval is obtained beforehand. Unless agreed by the Employer cable shall have been manufactured not more than 18 months before delivery to site and the date of manufacture shall be indicated on all consignments. The permission of the Employer shall be obtained before any cables are installed or wrapping removed. Manufacturers test certificates shall be submitted for all cables.

No damaged or repaired sections of cables shall be used unless agreed by the Employer.

All cables shall be chosen to suit the ambient conditions and rated for the conditions of installation. Cables laid in trunking and on tray shall be rated for multiple runs appropriate. No cable of less than 1.5 square millimeters core section shall be used for power purposes.

The "as built" record drawing shall show the spacing, location and identification of each cable at all major sections of trays, racks, and trunkings.

7.3.9 Miscellaneous Items

All equipment and installation material shall be chosen and designed to minimize the risk of outbreak and spread of fire and damage due to fire.

Equipment cubicles, desks, boxes and the like shall be of high quality strongly braced folded sheet steel construction. Access doors and covers shall have properly turned and formed edges for rigidity. All burrs shall be removed and all welds shall be neat, clean and smooth.

External fittings of cubicles and boxes shall be chrome plated or to an agreed finish to withstand frequent usage. Hinges and fixing posts shall be strongly constructed to withstand hard usage and shall preferably also allow larger doors to be lifted off for easy access to interiors. Door stays and stops shall be incorporated.

Removable chassis and panels shall be carried on proper rollers or low friction slides so

that no damage occurs to finished surfaces in use. Suitable end of travel stops shall be fitted for all movements, with restraints to ensure that drawers and chassis do not move or open due to vibration.

All cubicles, boxes, posts and other electric equipment for outdoor installation shall be weatherproofed and protected by approved finishes. Details of these finishes shall be submitted to the Employer for approval.

The use of “self tapping” screws shall be avoided wherever possible and they shall not be used to secure protective covers or guards for equipment which have to be removed for maintenance purposes.

Printed circuit boards shall be formed on stable insulating materials with permanent adhesion of the circuit to the board under all conditions. The board and circuit shall be protected from climatic conditions, dirt and moisture by an approved finishing technique. Plug-in boards shall be “coded” and “keyed” to ensure correct alignment of contacts and to prevent a board being plugged into a wrong location. The contact materials shall be chosen to ensure correct operation after long periods of in-operation or storage. The component identity code shall be prominent in the inserted position.

Indicating lamp shall have an average life of not less than 10,000 hours. The circuit shall incorporate means local to the lamp of regular and speedy testing of lamps without disturbing the operational circuit. Fault lamps shall be maintained unit reset.

All semi-conductor and rectifier power circuit shall be adequately rated and protected for the normal duty and for over-voltage and over-current.

The type and sizes of delays and switches shall be kept to a minimum. Plug-in relays shall be coded and “keyed” to ensure insertion of relays into correct bases and correct alignment of contacts and shall be located by spring clips to prevent loosening by vibration and shock. Contacts of differing voltages on the same relay shall be arranged in voltage groups, one for each voltage, mechanically and electrically separated.

The magnet faces of relays, contactors and the like shall be non-rusting or coated with a thin film of suitable grease. Contacts shall be arranged to collect the minimum amount of dust, in use and to minimize dust falling onto the contacts when relays and contactor covers are removed. Sealed relays other than reed type shall have a transparent enclosure to allow operation of the relay contacts to be observed.

Throughout the Contract Works all items of equipment, including connection boxes, interface boxes and other parts shall bear labels as described below to facilitate identification and maintenance. All labels shall clearly inscribed, indelible and attached by screws or other approved permanent fixing. All legends shall in both Vietnamese and English.

Fuses and miniature Circuit-breakers:

- These shall be numbered and a chart giving the function and rating of each shall be fixed inside the door of the enclosure. These charts shall be prepared in an approved manner, clearly drawn in ink and protected by clear plastic material.

Components:

- When an equipment case or cubicle contains more than one item of similar link, each shall have an engraved plastic label stating its function.

Distribution Boards:

- Each distribution board and fuse board shall have an external engraved plastic label stating its function, identify code and the highest working voltage within.

All equipment shall have radio interference suppression, as necessary, to prevent interference with satisfactory operation of other equipment whether the interference shall be due to radiation, induction or conduction.

All danger and warning plates shall be of permanent materials securely fitted by approved permanent fixings and clearly and indelibly worked and located. The word “danger” shall be prominent and have larger characters than the other parts of the inscription. The size of characters and the nature of the warning shall be to the approval of the Employer. All legends shall be given in both Vietnamese and English characters.

Identical components within sets of equipment shall be interchangeable. Should the Employer require, the Contractor shall prove the interchangeability during testing by exchanging certain parts selected by the Employer.

Contact materials shall be chosen to give long life and reliable operation with regard to switching duty, current and voltage in the circuit. The Employer may require evidence, when approving drawings that all contacts are suitable for the circuits that they serve.

All equipment shall have correct sequence interlocks to ensure that only the correct switching and operating procedures are followed. Failure or interlocks and sequence shall not lead to improper operation of the equipment from correct operation in sequence.

7.3.10 Earthing (Grounding) and Bonding

The design of the Toll Collection System shall include protection against all effects of stray current, lightning and faults in adjacent circuits that may cause damage or incorrect performance of the equipment. The Contractor shall describe in his submittal the means he proposes to use to prevent damage by lightning whether by direct strike or by induced effects or charging. The means shall include not less than effective screening and/or separation of all light current conductors from power cables, bonding cabling, fluid carrying pipes and the like and the fitting of suitable surge suppression or isolating devices where screening or separation is not practicable.

8. Digital Transmission System and Cable Works

8.1 Digital Transmission System

The Intelligent Transport System (the ITS) in the Da Nang – Quang Ngai expressway (the DQE) deploys various devices such as CCTV camera, vehicle detector and variable message sign along the roadside. These devices are connected with the central equipment at the Main Management Center (MMC) and data and voice are exchanged between them. Digital transmission system is required to perform the service of data and voice communication. IP based digital transmission system over fiber optic cable shall be introduced for this purpose.

The Contractor shall design, supply, install and test a digital transmission system that satisfies the needs of the component systems in terms of speed, bandwidth and reliability.

8.1.1 System Configuration

Digital transmission system shall consist of local line transmission system and access line transmission system. The former connects between fiber optic nodes (FON) established at locations listed in table below and uses optical fiber cable while the latter connects roadside equipment to the FON using media converter provided in other sub-systems and fiber optic cable.

Table 8-1 Location of Fiber Optic Node

No.	Location	Remarks	No.	Location	Remarks
1	Tuy Loan IC	KM0+000	6	Tam Ky Toll Office	KM64+510
2	Da Nang Main Management Center	KM4+100	7	Chu Lai Toll Office	KM82+990
3	My Son Toll Office	KM13+260	8	Dung Quat Toll Office	KM101+740
4	Tunnel (north side)	KM22+485	9	Quang Ngai North Management Office	KM123+845
5	Ha Lam Toll Office	KM40+880	10	Quang Ngai Toll Office	KM129+500

It is specifically noted that when the Expressway is extended, trunk line transmission system will be introduced for long distance data transmission between the Da Nang Main Management Center and other MMCs. Digital transmission equipment for trunk line transmission system will not be installed under this Project. However, the local line transmission system to be provided in the Contract shall be compatible with the standard digital transmission system commonly used in trunk line transmission. The fiber optic cable to be installed along the DQE shall have the sufficient number of cores to accommodate trunk line system.

All transmission cables shall be fiber optic cable having suitable number of cores.

8.1.2 System Design

The Contractor shall undertake the detailed design of the digital transmission system. The design work shall include but not be limited to transmission protocol, network and transmission equipment, type and size of cable, cable splicing, conduit and cable installation work, manhole and pull box at bridge and earth sections. It is noted that cable conduit, manhole and pull box installed along the expressway will be provided by other contract packages. The Contractor shall provide and install the cable conduit from nearest manhole or pull box to each ITS equipment and additional manhole and pull box, if required.

Digital transmission system shall adopt IP based system. Suitable media and transmission protocol at Layers 1 and 2 and type of digital station equipment shall be selected. In developing the design, various factors such as amount and type of data, transmission distance, quality of service (QoS), reliability, latency, and changeover time to backup route shall be considered. Type of fiber optic cable shall also be considered in the design. Packet based transmission system will be preferred than circuit based transmission system such as Gigabit Ethernet.

Loop topology based on resilient packet ring (RPR) shall be adopted for local line transmission system for redundant operation. A cut of communication at a point in the loop shall not affect the normal operation of the communication system.

Physically separate fiber optic cables shall be used to for a ring topology and for back up route in the local line transmission system. Compressed image data, toll collection system data and data from other devices must be separately allocated by theoretical methods in the communication system.

Layer 3 switch will be used at each node to connect local network or device to the local line network. Layer 2 switch will also be used to connect devices to the local network.

In addition to the equipment listed above, the system requires fiber optic termination, surge arrester or similar surge protection device to protect the equipment from the lightning, and accessories necessary for cable installation. The Contractor shall supply and install these devices and accessories.

8.1.3 Reliability

Digital transmission system shall have high reliability to ensure continuous operation of the system. Bit error rate for the end to end data communication must be 1×10^{-6} or better.

8.1.4 Capacity and Quality of Service

The digital transmission shall have a sufficient capacity in terms of speed and bandwidth

to meet the demands to be decided based on the estimated amount of data including digitized voice data at each facility such as the MMC, the Management Offices (MO) and the Toll Offices (TO). Video signal from the CCTV camera shall be transmitted in MPEG 4/H.264 or Motion-JPEG format and the digital transmission system shall provide sufficient capacity for it. The Contractor shall estimate the type, amount and location of data transmission need and design the system, equipment and cables that satisfy the demand.

Quality of service (QoS) capability shall be provided to the digital transmission system to ensure smooth and uninterrupted delivery of data for voice and video image transmission required for internal telephone system and CCTV camera system.

8.1.5 Specifications

The specifications in this section are provided as reference. The digital transmission system equipment to be provided by the Contractor shall materially comply with these specifications and shall be subject to the approval by the Project Manager.

(1) Fiber Optic Node (FON)

The FON shall have enough capacity and interface, QoS control function, fail-over function and any other required functions. Followings are reference specifications of the FON.

a. Standards:	Gigabit Ethernet
b. Capacity:	1 Gbps or more
c. Interface:	Fiber Optic Interface: 8 cores or more LAN Interface: 20 ports or more
d. Applied Topology:	Ring, Star
e. Fail-Over Function:	Resilient Packet Ring (RPR)
f. Transmission Distance:	60km or more
g. Changeover Time:	50msec or less
h. Network Management:	SNMP or equivalent
i. Reliability:	1×10^{-6} or better

(2) Layer 3 Switch

a. Switching Bus Speed:	20 Gbps or equivalent
b. WAN Interface:	10BASE-T/100BASE-TX x 8 ports or more
c. LAN Interface:	10BASE-T/100BASE-TX x 20 ports or more
d. LAN Protocol:	TCP/IP, IP multi-cast, etc
e. Layer 3 Switching:	Shall be Provided
f. Maximum VLAN:	Approx. 200

- | | |
|------------------------|------------------------|
| g. VLAN Trunk: | Shall be provided |
| h. Spanning Tree: | Shall be provided |
| i. Routing Protocol: | RIP, RIPv2, OSPF, etc. |
| j. Multicast: | IGMP, etc. |
| h. Network Management: | SNMP |

(3) Layer 2 Switch

- | | |
|------------------------|--|
| a. LAN Interface: | 10BASE-T/100BASE-TX x 20 ports or more |
| b. LAN Protocol: | TCP/IP, IP multi-cast, etc |
| c. Layer 2 Switching: | Shall be provided |
| d. Maximum VLAN: | Approx. 200 |
| e. VLAN Trunk: | Shall be provided |
| f. Spanning Tree: | Shall be provided |
| g. Multicast: | IGMP, etc. |
| h. Connector: | RJ-45 jacks |
| i. Network Management: | SNMP |

(4) Fiber Optic Termination

Fiber optic termination shall be installed in the Da Nang MMC, the MOs or other fiber optic connection points, where the FON will be located, and used to connect fiber optic cable with the ITS equipment smoothly by using suitable connectors.

- | | |
|-----------------------------|--------------------|
| a. Splicing Number of Core: | 100C x 2 or more |
| b. Connector: | SC or FC Connector |

(5) Network Supervisory Equipment

The digital transmission system shall be equipped with a supervisory function which continuously monitors the system operation and issues an alarm in case malfunction is found. The network supervisory equipment shall have the following functions:

- a. Management of occurrence and recovery of malfunction
- b. Registration and modification of system configuration
- c. Registration and modification of network configuration
- d. Testing of equipment and circuit
- e. Logging of equipment operation and cable
- f. Changeover between primary and backup routes

8.1.6 Communication Cable

The type of cable for digital transmission system shall be as stipulated below. The cable having suitable number of fiber optic cores and pairs for metallic cable, if used, shall be selected.

Table 8-2 Type of Communication Cable

Application	Cable Type
Outdoor Cable	
Trunk Line System	Fiber Optic Cable (Dispersion-Shifted Fiber: DSF)
Local Line System	Fiber Optic Cable (Single Mode Fiber: SMF)
Access Line System	Fiber Optic Cable (SMF) or CCP cable if required
Cable of Network Management	Fiber Optic Cable (Single Mode Fiber: SMF)
Indoor Cable	
Data/ Voice	Ethernet Cable or SWVP

Fiber optic cable to be installed along the expressway shall have a minimum of 100 cores. Branching of fiber optic cable shall be made in such a way that only the cores connected to the equipment are taken into the equipment and other cores will be bypassed. Splicing of optical fiber cable shall be made with the method that allows re-opening of splicing housing and change of connection. The connection of core shall be made with fusion splicing.

8.1.7 Conduit and Cable Works

Conduit work includes cable conduit from nearest manhole or pull box, which will be provided in other contract packages, to each ITS equipment, additional manhole and pull box if required, associated accessories necessary for cable installation.

The Contractor shall undertake the detailed design of conduit and cable work including preparation of plain plan of conduit and cable route showing type and length of conduit, type and length of cable, and type of manhole and pull box. The detailed design shall be submitted to the Project Manager for his approval.

For the section where electromagnetic induction or electrostatic induction caused by high power transmission line is expected, countermeasures such as use of aluminum sheath cable shall be taken.

Two types of cable conduit for fiber optic cable and power cable to feed power to equipment shall be provided in this Contract.

(1) Type and Size of Conduit

HDPE pipe shall be used for underground conduit and conduit must be protected by concrete at the section where conduit is exposed or underground conduit does not keep

enough depth from the top of base. The conduit shall be buried at least 60 cm from the top of base. Inner diameter of conduit shall be about 1.5 times of the cable to be installed and conduit having inner diameter of 90 mm for fiber optic cable or 50mm for power cable shall be used as standard. Conduit of same size must be used throughout a section and change of size shall not be allowed without manhole or pull box.

(2) Conduit attached to wall

Conduit attached to wall, box culvert or other structure shall be designed taking weight, vibration, expansion and contraction into consideration. Flexible joint shall be used at proper location to compensate for the expansion and contraction by temperature.

(3) Manhole and Pull Box

Manhole and pull box shall be used for cable installation, cable splicing and cable branching. They shall have suitable dimensions for its use. Fixture shall be provided to hold cable splicing if manhole is used for cable splicing.

Manhole and pull box shall be placed at the proper location. Spacing of manhole shall not exceed 250 meter.

9. Wireless Radio System

9.1 General

The Contractor shall provide a wireless radio system to be used for communications with personnel engaged in the expressway operation and maintenance. The system shall cover the entire Da Nang – Quang Ngai Expressway (DQE) section with high quality of voice and data communication. The system shall conform to the existing laws and regulations regarding radio wave transmission.

9.2 System Configuration

The wireless radio system shall consist of control center station to be established at Main Management Center (MMC), four (4) wireless base stations located at tunnel (south portal), Ha Lam toll office, Chu Lai toll office and KM112+410, and mobile units.

Additional base stations may be established to ensure the coverage area. The mobile unit shall be installed in the vehicles used for expressway operation and maintenance or accompanied with the staff engaged in the operation and maintenance work.

The base stations will be connected to the control center station through digital transmission system to be constructed under this Project.

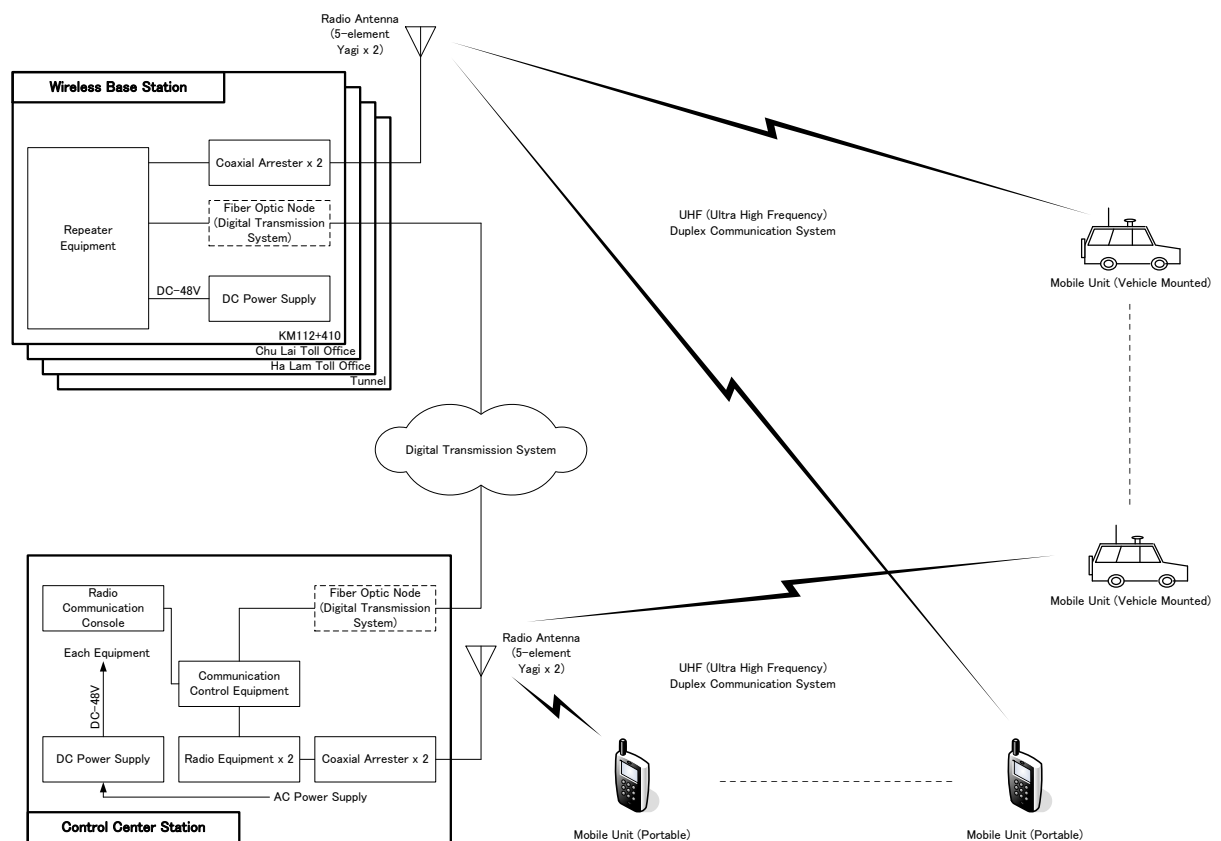


Figure 9-1 Wireless Radio System Configuration

9.3 Frequency

The wireless radio system shall use 400 MHz band frequency. The exact frequency allocation will be specified and approved by the Agency managing of the radio frequency, and notified to the Contractor. The Contractor shall take necessary actions and assistances for the frequency allocations.

9.4 System Design and Link Budget Analysis

In order for the system to cover the entire DQE section with good quality of voice and data communication, proper design of the system components including transmitter, antenna and receiver shall be made. A link budget analysis shall be conducted for this purpose. Received power will be calculated based on the planned or assumed transmit power, pigtail loss, cable loss, connector loss, transmit antenna gain, free space loss, miscellaneous losses including fading, receive antenna gain, pig tail loss, cable loss, and connector loss. Design shall be modified and parameters shall be adjusted until the required received power is obtained.

Propagation loss shall be first estimated by calculation and later measured by field test during the detailed design. The results of field test shall be reflected to the link budget analysis.

The Contractor shall under take the detailed design of the system including link budge analysis and measurement at field, and submit the design to Project Manager for his approval.

9.5 Transmission Technology

Digital type wireless communication system shall be used for its advantages over the conventional analogue type. Communication shall be scrambled for privacy.

9.6 Function and Features

The wireless communication system shall have the following functions and features:

- Quality of communication indicated by the received power level shall be better than -103 dBm.
- One-to-one, one-to-many communications shall be possible as minimum.
- ID data shall be automatically transmitted every time call is made.
- Mobile units both vehicle mounted type and portable type shall be equipped with GPS and the system has a vehicle tracking function.
- Portable units shall be rain proof.

9.7 System Components

(1) Control center station

The control center station shall consist of, but not limited to, radio equipment (transmitter and receiver), antenna, coaxial arrester, communication control equipment and radio communication console. Two sets of transmitter and receiver shall be installed as hot standby system.

The radio communication console equipped with microphone shall have such functions as to select and communicate with any mobile unit or mobile unit group to be preset, select transmitter and receiver (No.1 / No.2) to be used, control the base station equipment, track vehicle location, and log operation record through the communication control equipment.

8-element Yagi type antenna or equivalent shall be used to transmit the radio signal effectively. The coaxial arrester shall be installed to protect the equipment from lightning surge.

The power supply to the each equipment shall be made from DC power supply or Uninterruptible Power Supply (UPS) with battery having enough capacity to supply power until the emergency generator starts.

(2) Base station

The base station shall consist of, but not limited to, repeater equipment including two sets of transmitter and receiver, control equipment, antenna (5-element Yagi type or equivalent) and coaxial arrester. The base station shall have following functions.

- To connect and communicate with control center station and mobile units
- To receive control signal from control center station or mobile units and initiate repeater equipment
- To change over No.1/No.2 transmitter or receiver based on the control signal from control center station
- To detect transmitter and receiver failure, and have automatic radio changeover function
- To send operating status in compliance with control signal from control center station

The power supply to the each equipment shall be made from DC power supply or UPS with battery having enough capacity to supply power until the emergency generator starts.

(3) Mobile Unit

Both vehicle mounted type unit and portable type mobile unit with cradle type battery charger shall be provided. The mobile unit shall be of compact size and light in weight in consideration of the usability. The number of equipment to be provided in the Contract is shown below.

Table 9-1 Number of Mobile Units

No.	Mobile Units	Quantity	Remarks
1.	Vehicle mounted type mobile unit	30	
2.	Portable type mobile unit	50	
3.	Battery charger	50	

10. Internal Telephone System

10.1 General

The Contractor shall provide an internal telephone system using VoIP technology and packet switching for voice communication between the personnel at the office along the expressway such as Main Management Center (MMC), Management Offices (MO) and Toll Offices (TO). The system shall be connected to the public switched telephone network for the communication with the public and other organizations.

10.2 System Configuration

The internal telephone system shall consist of the specified number of IP telephone sets to be installed at each office along the expressway and an IP based private branch exchange (IP-PBX) at the MMC. IP-PBX shall be capable of controlling centrally all telephone sets installed along the expressway regardless of the location. The internal telephone system will be made through the digital transmission system to be constructed under the Project.

10.3 Capacity

The telephone exchange must have the capacity to handle the number of telephone sets shown below. The number of telephone sets to be provided under the contract shall be 170 sets.

Table 10-1 Telephone Exchange Capacity

No.	Location	Number of Telephone Sets	Telephone Exchange Capacity
1	Da Nang Main Management Center	50	200
2	Management Offices	20 x 2	50 x 2
3	Toll Offices	10 x 8	30 x 8
Total		170	540

Connection to public switched telephone network shall be possible. The system shall have the capacity of 20 PSTN lines or more. Type of connection shall be discussed with the local telephone company. Each telephone set shall be assigned with an access class and connection to outside public switched telephone network, long distance call and overseas call shall be restricted according to the class.

10.4 Function

The PBX shall perform the basic call processing functions of establishment of connection, maintaining connection, terminating connection, and providing information for accounting purpose.

In addition to the basic functions listed above, the PBX shall have at least the following functions:

- Call forward
- Call transfer
- Call hold
- Call park
- Call waiting
- Camp on
- Conference call
- Speed dialing
- Busy override
- Do not disturb
- Follow me

10.4.1 Firewall and DMZ

Demilitarized zone (DMZ) shall be created by firewall between inner network and outer network and IP-PBX shall be placed at DMZ to protect the inner network from the outer network access.

10.4.2 Quality of Service Control

IP-PBX shall support virtual local area network (VLAN) and quality of service (QoS) control to ensure uninterrupted and smooth calls. Quality of service shall adopt VLAN tag and voice priority tag embedded in type of service (TOS) and differentiated services code point (DSCP) to allow the network to process packets by priority.

10.4.3 Session Initiation Protocol

IP-PBX shall support session initiation protocol (SIP) to allow communication with users in the third-part VoIP system.

10.5 Installation

The Contractor shall install the IP-PBX and telephones sets at the specified location in the MMC, the MO and the TO and connect them with network. The Contractor shall also provide network cable, router and layer switch if necessary, connector, and other parts and accessories to construct a functioning telephone system. Power shall be supplied to the IP-PBX, telephone set and other devices. Power of Ethernet (PoE) technology specified in IEEE 802.3af shall be applied as much as possible to reduce the power cable installation works.

The Contractor shall undertake the initial setting of the system parameters, registration of account, and other works necessary for the operation of the system.

11. Power Supply Work

11.1 General

11.1.1 Scope of Work

The power supply work shall include the designing, manufacturing, supplying, factory testing, finishing, painting, export packing, insuring, shipping, delivering to the site storage yard designated by the Employer, supervision for installation and erection, field testing and co-operation in the commissioning (the trial operation). The operating service to the Employer's staff at the site shall also be included.

In order to avoid any defects under interface between this Contract work and other contract work under other contract packages, and to establish effective site work progress, the Contractor shall make good co-operation with the other Contractor whenever the Project Manager confirms such requirements.

The Contractor shall provide all labor, materials, equipment and incidentals to furnish and install the complete electrical system as shown on the drawings and/or specified herein.

It is the intent of these specifications, that when completed, the electrical systems shall be suitable in every respect for the service intended, and the Contractor shall, at no extra cost, supply all the materials and do all the work which may be reasonably implied as being incidental to the work.

The Contractor shall be responsible for all wiring and connections, testing and placing in satisfactory operation the complete electrical system to the approval of the Project Manager.

(1) The planned electrical facilities in this Contract will be located at following places;

- Da Nang Main Management Center (MMC)
- Tuy Loan Interchange
- My Son Toll Office
- Tunnel portal site (north side)
- Ha Lam Toll Office
- Tam Ky Toll Office
- Chu Lai Toll Office
- Dung Quat Toll Office
- Quang Ngai North Management Office
- Quang Ngai Toll Office

(2) The work shall include, but not limited to, the followings;

- 10 Uninterruptible Power Supply (UPS) systems
- 10 low voltage distribution panels
- All required cablings and wirings
- Lighting protection systems
- Grounding systems

It is noted that power receiving system including 22kV distribution line, 22kV CB panel, 22kV/400V transformer, diesel engine generator (DEG) with fuel tank and automatic transfer switch (ATS), etc. will be provided by other contract package. The Contractor shall provide and install the cables and conduit systems from DEG distribution panel to low voltage distribution panel, UPS and ITS equipment. The lighting protection systems and grounding systems for ITS equipment shall also be provided in this Contract

11.1.2 Rules and Regulations

All equipment and works under this Contract shall be provided in accordance with the requirements of local jurisdiction. The Contractor shall file the required notice with any Municipal Department having jurisdiction over such permits and obtain and pay for all permits required.

11.1.3 Standards

All electrical equipment, design, materials, manufacture, testing, inspection and performance shall, unless otherwise specifically mentioned in this Specification, conform to the authorized latest Standards by International Electrotechnical Commission (IEC) and Vietnamese Standard (TCVN).

Other internationally acceptable national standards equivalent to IEC or TCVN may be considered. In case that IEC or TCVN Recommendations do not exist, the other national standards may be applied.

If offers, materials or equipment which conform to standards other than the IEC and TCVN those stipulated in this Specification, full details including copies in English of such standards, grade and class, shall be submitted for approval. Such standards, if approved, shall be incorporated in the Contract, otherwise the IEC, TCVN and the specified standards shall be applied.

11.1.4 Photographs

The Contractor shall keep photographic records of the equipment manufacturing, the factory testing and the progress of the site work.

Upon completion of the Works, the Contractor shall submit three (3) sets of recorded photographs adequately edited in a book with explanations to the Project Manager. The

Contractor shall provide himself necessary access to the Work and temporary facilities to photograph any parts of the Work at any stage of installation or manufacture.

11.1.5 Interpretation of Drawings

The Contractor shall verify with the Project Manager the exact locations and mounting heights of equipment, lighting fixtures, switches, and receptacles prior to installation.

Any work installed contrary to or without approval by the Project Manager shall be subject to change as directed by the Project Manager, and no extra compensation will be allowed the contractor for making these changes.

The locations of equipment, fixtures, outlets and similar devices shown on the drawings are approximate only. Exact locations shall be as approved during detailed design. The Contractor shall obtain in the field all information relevant to the placing of electrical work and in case of any interference with other work, shall proceed as instructed by the Project Manager, and shall furnish all labor and materials necessary to complete the work in an approved manner.

Surface mounted panels, boxes, junction boxes, conduit, etc., shall be supported by spacers to provide a clearance between walls and equipment.

The drawings are diagrammatic and functional only and are not intended to show exact circuit layouts, number of fittings, or other installation details. The Contractor shall furnish all labor and materials necessary to install and place in satisfactory operation all power and other electrical systems shown. Additional circuits shall be installed by the Contractor wherever needed to conform to the specific requirements of the equipment.

The ratings of motors and other electrically operated devices, together with the size shown for their branch circuit conductors and conduits, are approximate only and are indicative of the probable power requirements insofar as they can be determined in advance of the purchase of equipment. The ratings shown for motor branch circuit protective devices are the maximum ratings permitted. Lower ratings may be used where approved as being proper for the dynamic characteristics of the motor and its connected load.

Unless otherwise specified, all conduits, wires, cables and the support systems for the conduits and cables that are required to make the electrical connections to equipment shall be furnished and installed by the Contractor. All connections to equipment shall be made as shown, specified, and directed and in accordance with the approved shop drawings.

11.1.6 Size of Equipment

The Contractor shall investigate each space in the building through which equipment must pass to reach its final location. If necessary, the manufacturer shall be required to ship his material in sections sized to permit passing through such restricted areas in the

building.

11.1.7 Materials

The materials used in all systems shall be new, unused, and as hereinafter specified. All materials where not specified shall be of the best of their respective kinds. Samples of materials or manufacturer's specifications shall be submitted for approval.

Electrical equipment shall at all times during construction be adequately protected against mechanical injury or damage by water. If any apparatus has been damaged, such damage shall be repaired by the Contractor at his own cost and expenses.

11.1.8 Enclosed Type

Unless otherwise specified in the Specifications, all equipment enclosures are to be designed and manufactured in accordance with the following protection degrees classified in IEC 529.

- | | |
|----------------------------------|-------------|
| • Outdoor Control Cubicle | IP54 |
| • Outdoor/(Indoor) Instruments | IP65/(IP60) |
| • Outdoor/(Indoor) Motor | IP54/(IP50) |
| • Indoor Control Cubicles/Panels | IP40 |

Minimum thickness of steel plate for the panel shall be 2.3 mm. Panels shall be bolted at the bottom to suitable steel channel sill.

11.1.9 Drawings

Shop drawings shall be submitted in the required number of copies for approval of all materials, equipment, installation and wiring.

All shop drawings shall be checked by the Contractor for accuracy and Contract requirements before submittal. Shop drawings, not so checked and noted by the Contractor shall be returned to him without approval.

The Project Manager's check shall be only for conformity with the design concept of the Project and compliance with the Specifications and Contract drawings. Should any modification is required, the Project Manager may instruct the Contractor to do so, and the drawings so modified shall be resubmitted for approval.

It shall be understood, however, that approval of the drawings by the Project Manager shall not exonerate the Contractor from any of his liabilities under the Contract.

All drawings submitted for approval to the Employer and the Project Manager for any other reasons shall be sent by registered mail with quickest possible mean.

All drawings or documents submitted to the Employer and the Project Manager shall bear the Contractor's stamp of approval and the date of submission.

After approval of drawings by the Project Manager, the Contractor shall supply the approved drawings to the Employer and the Project Manager within one (1) month of the receipt.

The title of the drawing, the signature of the Contractor's responsible engineer, the date prepared, the number of the drawing, etc., shall appear in the bottom right-hand corner of the drawing. The drawings shall be printed in principle on A3 size sheet.

The Contractor shall be responsible for all dimensions to be confirmed and correlated to the job site and for co-ordination of his work with the work of all other trades.

No material shall be ordered or shop work started until the Project Manager's approval of shop drawings has been given.

After all items of the equipment have been manufactured and erected, the Contractor shall submit two (2) printed copies of as built plans and drawings to the Project Manager prior to the commencement of the Test on Completion for a portion of Works for the Works to be tested. In addition, the Contractor shall submit three (3) printed copies of as-built drawings and one (1) set of soft copy of all as-built drawings to the Project Manager prior to the issuance of the taking-over.

11.1.10 Painting

All outside panel surfaces shall be primed, filed where necessary, and given not less than two coats of synthetic undercoat. The finishing coat for the outdoor installations shall be a gloss paint and for the indoor installations shall be a semi-gloss paint.

The inside surface of the enclosures shall have two prime coats and one finishing coat of light cream color (5Y 7/1) unless otherwise specified.

The color scheme for the finishing coats of all equipment, frames for meters and relays, and switch handle shall be proposed by the Contractor with presentation of color samples or color chips and shall be subject to the Project Manager's approval.

The humid and tropical conditions shall be taken into account on selection of the paints and painting procedure.

11.1.11 Wiring

(1) General

All wiring shall be done with PVC or XLPE insulated wire not less than 2.5 sq.mm except for electronics devices. A suitable wiring duct system shall be installed for all inter panel. As far as possible all wiring shall be installed in wiring ducts.

All wiring from hinged door panels to the fixed panels shall be done with flexible conductor of equivalent size.

Wiring between terminals of the various devices shall be point to point. Splices or tee connection will not be acceptable. Wire runs shall be neatly trunked or clamped.

Exposed wiring shall be kept to a minimum, but where used shall be formed into compact groups suitably bound together and properly supported.

Cable supports and clamp type terminal lugs shall be provided for all incoming power wiring terminating at each cubicle. All wire shall be marked near each terminal end with circuit or wire designation. These markers shall be of an approved type and permanently attached to the conductor insulation.

(2) Terminal block

Terminal Blocks for control wiring shall be rated not less than 600-volt with cover and be of the molded type with barriers.

White or other light-colored marking strips, fastened by screws to the molded sections at each block, shall be provided for circuit designation.

Each connected terminal of each block shall have the circuit designation placed on the marking strip with permanent marking fluid. The terminal arrangement shall be subject to the Project Manager's approval. Spare marking strips shall be furnished with each block.

(3) Phased arrangement

The standard phase arrangement when facing the front of the panel shall be R-S-T-N, and R-N-S from left to right, from top to bottom, and front to back for A.C three-phase and single-phase circuits and N-P from left to right, P-N from top to bottom and front to back for D.C polarity. All relays, instruments, other devices, buses and equipment involving three-phase circuit shall be arranged and connected in accordance with the standard phase arrangement where possible.

(4) Wiring color code

All wires shall be colored as follows, unless otherwise specified:

<u>Circuit</u>	<u>Color</u>
Voltage transformers	Red
Current transformers	Black
A.C circuit	Yellow
D.C circuit	Blue
Grounding circuit	Green with yellow stripe

(5) Phase and polarity color code

Following colored ferrules shall be provided on each wire in order to identify phase and polarity, unless otherwise specified.

<u>Phase and Polarity</u>			<u>Color</u>
A.C.,	Three-phase,	First Phase	Red
		Second Phase	Yellow
		Third Phase	Blue
A.C.,	Single-phase,	First Line	Red
		Second Line	Yellow
Neutral			Black
Grounded			Green with Yellow stripe
D.C.,	Positive		Red
	Negative		Blue

11.1.12 Accessories, Spare Parts and Tools

(1) Accessories

For all equipment and panels, all essential and desirable accessories for an installation, operation and maintenance shall be furnished and installed, which shall include but not be limited to the each item specified in the Specifications.

(2) Spare parts

A list of spare parts shall be furnished as specified in each section.

(3) Tools

The Contractor shall furnish all standard and special tools that may be required for the installation, testing, maintenance and servicing of the equipment. These tools shall be properly packed in a suitable steel box with the contents listed on the outside in neat lettering in contrasting color, in English. Each tool box shall be provided with a lock and keys. Hinges for the tool box shall be of the continuous hinge type.

11.1.13 Electrical Requirements

(1) System connection

Unless otherwise specified, the following will be applied:

380V/220 V:	3-phase, 4-wire, 50 Hz, wye-connected system with effective grounded neutral.
220 V:	1-phase, 2-wire, 50 Hz, voltage variation: +/- 10%, frequency variation: +/- 5%

(2) Interlock

For maintaining safe operation of the power circuit, necessary electrical or mechanical interlocks shall be provided for switching of circuit breakers and disconnecting switches

and other operation.

The interlock shall be fail-safe type for preventing any accident or damage for persons and equipment.

(3) Consideration of high temperature

In the designing and manufacturing all the equipment and facilities under the Contract, due consideration shall be given so as not to affect the life under high average temperature at the Site.

(4) Adiabatic effect and moisture prevention

Provision shall be made for protecting outdoor equipment from harmful effects of heat resulting from direct sunshine. Panels, control boxes shall be provided with adequate space heaters for the prevention of moisture condensation.

(5) Protective relay settings

The Contractor shall take good co-ordination for selection of the protection system and setting of the protective relays.

Recommendable settings with its calculation sheet for the protective relays and calculation sheets to determine expected fault currents and voltages on the whole electrical system shall be submitted to the Project Manager for approval.

11.1.14 Installation Supervisor

The Contractor shall dispatch the manufacturer's supervisor to the site for instructing proper installation and site tests of the UPS, at least.

11.1.15 Coordination

The Contractor shall coordinate the following works between all trades.

- Cable trench in the floor
- Embedded conduit in the floors and walls.
- Walls and floors opening for cables/wirings.
- Equipment fixing to floors and wall.
- All other necessary coordination between Civil/Building/Electrical/Mechanical works.

11.2 Uninterrupted Power Supply System (UPS)

11.2.1 General

(1) General

The Contractor shall furnish and install all UPS as hereinafter specified and as shown on the drawings.

(2) Standards

The following standards are referred to:

- IEC 896 Pb battery
- SBA 6001 Determining the capacity of stationary batteries
- JIS C 8707 Stationary sealed lead-acid battery

11.2.2 Schedule

The UPS which shall be furnished and installed under this Contract, are summarized in the following Table:

Table 11-1 Schedule of UPS

No.	Location	UPS		
		20kVA	50kVA	100kVA
1	Da Nang Main Management Center			X
2	Tuy Loan Interchange	X		
3	My Son Toll Office		X	
4	Tunnel Portal Site (north side)	X		
5	Ha Lam Toll Office		X	
6	Tam Ky Toll Office		X	
7	Chu Lai Toll Office		X	
8	Dung Quat Toll Office		X	
9	Quang Ngai North Management Office		X	
10	Quang Ngai Toll Office		X	
Total		2	7	1

11.2.3 Type, Rating and Characteristics

The type, ratings and characteristics of UPS shall be as follows:

(1) Type

- | | |
|-----------------------|-------------------------------------|
| • Capacity | As shown in Table 11-1 above |
| • Compensation period | 10 minutes |
| • Rating | Continuous duty |
| • Cooling system | Forced air-cooling |
| • System | Synchronized AC line (By-pass) |
| • Rectifier/Charger | Full wave rectifier |
| • Inverter | Transistor bridge |

(2) AC input

- | | |
|-----------------------------|---------------------|
| • Phase & Wiring | three phase 3 wires |
| • Rated voltage | 380V |
| • Voltage variation range | Within +/- 10% |
| • Rated frequency | 50 Hz |
| • Frequency variation range | Within +/- 5% |

(3) DC line

- | | |
|----------------------|----------------------------------|
| • Floating voltage | to be selected by the Contractor |
| • Equalizing voltage | to be selected by the Contractor |

(4) AC output

- | | |
|-------------------------------------|--|
| • Rated capacity | As shown in Table 11-1 above |
| • Frequency | 50 Hz |
| • Phase & Wiring | single phase 2 wires |
| • Rated voltage | 220V |
| • Voltage variation range | Within +/-2% |
| • Transient voltage variation range | Within +/-2% |
| • Frequency stability | Within 50Hz +/-0.1% (at asynchronous) |
| • Harmonic distortion | Within 5% (at non linear load) |
| • Available load power factor range | 0.7 (lag) ~ 1.0 |
| • Recovery time | Within 0.1 sec |
| • Over load rating | 120 % 1 minute |
| • Efficiency | More than 85 % (at rated input and output) |

(5) Alarm signals

- Power suspension signal to be equipped for supply signals to equipment

(6) Battery

- Type Sealed lead acid battery
- Backup time Minimum period 10 minutes at +25°C for maximum load power

(7) Audible noise

- Audible noise 60 dB or less

11.2.4 Construction**(1) Construction**

The UPS shall be complete with all equipment, components and accessories necessary, and all parts shall be mutually compatible and properly integrated to provide functions and operated as intended.

The UPS shall be consist of rectifier/charger, batteries, inverter, static and electromechanical bypass, synchronizing equipment, protective devices and accessories that automatically effect continuity of electric power to a load within specified tolerances, without interruption upon failure of deterioration of the normal power supply. In case of commercial power failure, the UPS shall supply alarm signals for safety operation to connected equipment, and so on traffic management system, toll collection system and communication system.

The panel shall be provided with lockable hinged front door and removable panels of adequate thickness on rear and bottom.

Provisions shall be made for bottom plate for bottom entry of power and control cable.

For safety of operating personnel, it is essential that should an arc develop in any one of the compartments, it shall be confined to that compartment without affecting the other compartments.

The panel shall be equipped with a space heater, a lamp.

The panel shall be furnished as a completely factory-assembled unit where transportation facilities and installation requirements permit.

UPS panel shall be self-supporting, indoor installation, metal enclosed cubicle type of robust construction. The degree of protection for enclosure shall be IP50 conforming to IEC 144.

The panel shall include the molded case circuit breakers. The panel shall be provided with transparent front door consisting of transparent plate (glass plate, etc.) and suitable steel frame in order to avoid undesirable operation of the molded case circuit breakers by personnel touch, etc., and to make easy watch for the breakers' switching status. The door shall be provided with suitable lockable handle.

(2) Accessories

The following accessories shall be supplied:

• Maintenance tools	1 set
• Portable DC voltmeter (1.0 class)	1 set
• Syringe hydrometer	1 set
• Vent mounted thermometer (0-100 deg.C)	3 sets
• Funnel (made of synthetic resin)	3 sets
• Bottle (made of synthetic resin)	3 sets
• Requisite quantity of potassium hydroxide with 10% extra	1 set
• Sufficient quantity of distilled water first filling up	1 set
• Steel box for containing accessories	1 set

(3) Spare parts

The list of spare parts to be furnished by the Contractor shall include but not be limited to the followings:

- Two (2) cells in seal
- 500% of actual use of indicating lamps and fuses
- Other spare parts recommended by the manufacturer*

**Note: The Tenderer shall give a list of recommended spare parts together with the price of each item, based on the quantity needed 10 years operation. Whether the recommended spare parts are purchased or not will be decided by the Employer before signing of the Contract.*

11.2.5 Tests

(1) Factory Tests

The battery and charge panels shall be completely assembled at the factory. The panels shall be subject, unless otherwise noted, to the following tests by the Contractor:

- Construction check
- Power frequency voltage withstand test
- Measurement of insulation resistance

- Operation tests including sequence check
- Characteristic test
- Efficiency test (Certificate of the type test with test report may be acceptable).

(2) Field Tests

After installation, the following tests shall be executed before energizing:

- Construction check
- Electrical operation tests
- Operation test
- Measurement of insulation resistance.

11.2.6 Installation

The UPS panel shall be mounted on steel channels, which are installed on the concrete floor or free access floor. The channels shall cover full length of the panel and shall be installed at level in all directions.

It may be required to install the channels (base) at the time of flooring work, prior to panel installation, depend on site work schedule.

Installation work shall be made so as to maintain the panels in an upright position, and required their shifting shall also be done by means of their lifting or rolling of suitable roll bars inserted under them. Lifting eye bolts shall be mounted on the top of the panel.

The panel shall be protected against any damage during its installation. Any damage for the paint shall be carefully repaired using touch-up paint furnished by the panel manufacturer.

11.3 Low Voltage Panel

11.3.1 General

(1) General

The Contractor shall furnish and install all low voltage panels hereinafter specified and as shown on the drawings.

(2) References

The following standards are referred to:

- IEC 144 Degrees of protection of enclosures for low-voltage switchgear and control gear.
- IEC 439 Factory-built assemblies of low-voltage switchgear and control gear

- IEC 529 Classification of degree of protection provided by enclosures

11.3.2 Schedule

The low voltage panels, which shall be furnished and installed under the Contract, are summarized after detail design by the Contractor.

11.3.3 Type, Rating and Characteristics

The type, ratings and characteristics of panel boards shall be as follows:

Type:	Metal-enclosed, self-supported or wall mounted type
Number of phases:	Three (3) Phase, four(4) wire
Rated frequency(Hz):	50
Rated insulation voltage	
- Main circuit V (r.m.s)	600 AC
- Control circuit V (r.m.s)	250 AC
Rated operation voltage	
- Main circuit V	380/220 AC
- Control circuit V	220 AC
Power frequency withstand voltage	
- Main circuit V (r.m.s)	2500 AC
- Control circuit V (r.m.s)	1500 AC
Rated operation and control voltage V (r.m.s)	220V + 10% - 15% (IEC 694 Clause 4.8)

11.3.4 Construction

All interiors shall be completely factory assembled with circuit breakers, busbars and wire connectors. All wire connectors, except screw terminals, shall be of the anti-turn solderless type and shall be suitable for copper wire of the sizes indicated.

Interiors shall be so designed that circuit breakers can be replaced without disturbing adjacent units and without removing the main bus connectors and shall be so designed that circuits may be changed without machining, drilling, or tapping.

Branch circuits shall be arranged using double row construction except when narrow column panels are indicated. Branch circuits shall be numbered by the manufacturer.

The trim shall be fabricated from steel. All exterior and interior steel surfaces of the panel boards shall be properly cleaned and finished with Muncell paint over a rust inhibiting phosphatized coating.

11.3.5 Busbars

Busbars for the mains shall be copper. Full size neutral bars shall be included. Busbar

taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices.

Busing shall be braced throughout to conform to industrial standard practice governing short circuit stresses in panel boards.

Phase busing shall be full height without reduction. Cross connectors shall be copper.

Neutral busing shall have a suitable lug for each outgoing feeder requiring a neutral connection.

Spaces for future circuit breakers shall be bussed for the maximum device that can be fitted into them.

11.3.6 Tests

(1) Factory tests

The panel boards shall be completely assembled at the factory. The panel boards shall be subject, unless otherwise noted, to the following tests by the Contractor:

- Verification of construction
- Mechanical operation tests
- Electrical operation tests
- Withstanding voltage tests
- Measurement of insulation resistance.

(2) Field tests

After installation, the following tests shall be executed before energizing:

- Verification of construction
- Electrical operation tests
- Withstanding voltage tests
- Measurement of insulation resistance.

11.3.7 Equipment Included

The panel boards shall include circuit breakers as shown on the Drawings. The circuit breakers shall be the molded case type with auxiliary switch built in. The circuit breakers shall have suitable interrupting current value.

11.4 Wires and Cables

11.4.1 General

(1) General

The Contractor shall furnish and install all wires and cables as hereinafter specified and as shown on the drawings.

(2) Reference

The following standards are referred to:

- IEC 228 600V PVC Insulated Wire (IV)
- JISC 3307 600V PVC Insulated Wire (IV)
- JISC 3342 600V Vinyl Insulated Vinyl Sheath Cable (VV, CVV)
- JISC 3605 600V Polyethylene Insulated Cables and 600V Cross Linked Polyethylene Insulated Cables
- JISC 3401 Control Cables
- JISC 2811 Terminal Blocks for Industrial and Similar Use
- IEC60947 Terminal Blocks for Industrial and Similar Use
- JISC 2804 Compression Terminals
- JISC 2805 Crimp-type Terminal Lugs for Copper Conductors

11.4.2 Wires and Cables

The wires and cables used shall be as hereinafter specified.

- 600V PVC insulated wire (IV)
- 600V Vinyl insulated vinyl sheath cable (CVV)
- 600V vinyl insulated vinyl sheath cable with shield (CVVS)
- 600V cross-linked polyethylene insulated vinyl sheath cable (XLPE)

11.4.3 Drum

The cables and wires shall tightly and firmly be rolled on the drums and applied with damp-preventing measure. Each cable shall completely be sealed.

The drum shall be made of wood or steel or robust construction and be provided with anti-termite and anti-rodent protection.

11.4.4 Tests

(1) Factory tests

The following tests shall be carried out:

- Construction test
- Resistance measuring
- Withstand voltage test
- Insulation resistance test
- High temperature insulation resistance test
- Tensile strength test
- Coiling test
- Thermal shrinkage test
- Oil proof test
- Non-inflammability test
- Shield conductivity test
- Impulse breakdown voltage test
- AC breakdown voltage test
- Chlorine gas measurement

11.4.5 Installation

(1) General

Power cable shall have an ample current carrying capacity and shall duly withstand the maximum prospective fault current for a duration time approved by the Project Manager.

All cables shall be fitted with approved type of terminations at both ends.

No cable manufactured more than twelve months prior to installation shall be used in the Works.

All cables shall be designed for continuous operation at full circuit load, and shall be of the type and rating to suit the application and environmental conditions of the installation.

The rated voltage of the cable shall not be less than the operating voltage.

All cables shall be fitted with engraved PVC identification labels/tags at each end of termination points, such as distribution boards, panels, connection boxes, mechanical equipment, etc.

The Contractor shall design and prepare the cable schedules showing all power and

control cabling within the Project. The cable schedules shall include the following information:

- Cable identification
- Termination points (e.g., cubicle designations).
- Cable construction, number of cores and rated voltage.
- Route length.

All fixings shall be spaced in accordance with the manufacturer's recommendations and size to allow for expansion and contraction of the cables.

Through joints shall only be permitted within accessible positions and where the length of cable required exceeds the manufacturer's maximum manufacture length for any particular size of cable and only when particularly approved by the Project Manager.

All through joints shall be made in accordance with the manufacturer's instructions using materials supplied or approved by the cable manufacturer such that the properties of the cable are not compromised in any way.

Cable terminations shall be direct into clamp type terminals where cable size permits or be of the crimped type using purpose made crimps.

Hydraulic tools shall incorporate pressure release features to ensure that the crimp is successful before the pressure is released.

(2) Cable size

All cable shall be sized shall meet the following conditions unless otherwise indicated:

- Capacity not less than maximum load
- Size in accordance with the standards and codes applicable to the installation

Overall voltage drop shall be not more than:

- 5% for motor at full load
- 20% for motor at the starting

(3) Cable layout

Power and control wiring shall be carried out in the following manner to minimize transient induction:

- Incoming and return wires for each device shall be run in the same cable.

Cables in trenches and trays shall be segregated in the following groups:

- AC power cable, current and voltage transformer lead and battery main cables.

- Control and indication cables.
- Low voltage analogue signal cables.

(4) Underground cable protection

Underground power and control wiring shall be protected by steel or PVC conduit. Conduit size shall be selected so that total cable area is not exceeded 40% of the conduit area.

(5) Manhole and pull box

Manhole and/or pull box shall be provided at both end of the conduit duct run and a maximum of 50m interval, at all changes of direction of more than 45 degrees.

The size of manhole and pull box shall be enough space for cable installation or maintenance.

The Contractor shall submit all manholes and pull boxes arrangement plan showing the incoming pipe size and numbers for Project Manager's approval.

11.4.6 Conduit

(1) Materials

(i) Rigid steel conduit

Rigid steel conduit shall be heavy gauge welded with matching screwed accessories, of minimum 20 mm diameter or 2.5 times the total cross-sectional area of the cables.

The conduit and all accessories shall be internally and externally galvanized for all installations. Conduit accessories shall be manufactured from galvanized steel or malleable iron.

All conduit fittings, couplings and elbows shall be the same type as the steel conduit. All conduit and boxes shall be sealed to prevent the ingress of dust and water by the suitable use of sealing compound and gasket as applicable.

(ii) Flexible steel conduit

Flexible conduit shall be used at all equipment connections or where vibration or expansion and contraction, prohibits the use of rigid conduit.

Flexible conduit shall be liquid tight, of interlocked flexible galvanized steel core construction, twine packed with a fire resistant outer sheath for all general applications.

The glands shall be of two parts construction manufactured from brass complete with sealing ring.

Flameproof glands shall be used within all areas designated as a hazardous area.

The interior of the conduit shall be free from burrs and sharp edges.

Flexible conduits shall be of sufficient size to permit the easy withdrawal and replacement of cables and shall be a minimum of 20mm diameter.

Each flexible conduit shall not be more than 500mm long, without the written approval of the Project Manager, and shall be complete with a separate 2.5 mm² circuit protective conductor run internally and connected to an appropriate earthing terminal at each end.

(iii) HDPE conduit

HDPE conduits and fittings shall be heavy gauge high density polyethylene.

The sectional area of the conduit shall be, at least, 2.5 times the total cross-sectional area of cables to be installed.

All HDPE conduit bends shall be pre-formed.

(iv) Corrugated hard polyethylene pipes (FEP pipe)

FEP pipes may be used with the approval of the Project Manager at no additional cost.

(v) Cable racks

Horizontal support spacing of cable rack shall not more than 2.0m for steel. The vertical support spacing shall be not more than 3.0m. Metal fittings for cable rack support shall be of galvanized steel with sufficient strength and be rigidly fixed against swings.

(2) Conduit installation

Where the conduit installation is wholly or partly of a non-metallic material, then a separate ground continuity conductor shall be supplied to ensure complete electrical continuity of the conduit system.

An adequate number of pull boxes shall be included in the conduit installation to facilitate wiring without undue strain or damage to the cables.

Conduit threads shall be cleanly cut to a finished length which leaves the minimum amount of thread exposed when the conduit installation is completed.

All edges of conduits shall be smoothed and internal bores of steel conduit edges shall be taper reamed to prevent damage to wires and insulation.

All exposed metals shall be cleaned and protected against corrosion by the use of materials compatible to the original protective coating.

Any bends in the conduit run shall be made in a manner that does not cause any damage or indents in the conduit section. The radius of bends shall not be less than the minimum values provided in relevant codes of practice and wiring regulations. Not more than two

right angle bends shall be installed between pull boxes.

Embedded conduits shall be located in the walls, ceilings and floors to a sufficient depth which will enable a minimum required depth of the concrete, mortar or plaster covering over the conduit to be installed. Where possibility of puncture exists, cover plates shall be provided to embedded PVC conduits or rigid steel conduit used instead.

Exposed conduit shall be routed on walls, ceilings and other concrete structure either horizontally or vertically and shall be supported every 1,500 mm by saddles or suitable means, and 250 mm on either side of any box or bend. Exposed conduits shall be finished with the same color paints as the finished color of the wall or ceiling against which the conduits are placed.

Where conduits cross expansion joints of buildings, expansion couplers shall be fitted across the joint and at right angles to it. A 4 mm² insulated wire for grounding purpose shall be installed between the two conduit boxes either side of the expansion joint.

Conduits to be directly buried in the ground will be installed not less than 600 mm below the ground surface with suitable protection against the heavy load imposed on the conduits. The buried conduit system will be provided with suitable manholes where required.

Conduit runs to motors shall terminate 250 mm short of the terminal boxes and the final connections shall be completed by the use of flexible conduit with PVC sheathing.

Where conduits terminate in the cable trenches or openings not provided with the tapped holes or threaded spouts, the end of conduits shall be provided with suitable bushings and locknuts.

Only threaded joints shall be used.

Conduit which has been crushed or deformed shall not be used in the Works.

All joints and terminations shall comply with the weatherproof or explosion proof requirements as applicable.

All exposed threads will be given two coats of zinc based paint of approved type after installation.

Where conduits are required to pass from the inside to the outside of buildings or in any position where a considerable variation in temperature exists between different sections of the building, free circulation of air must be prevented between the conduit system of each section by inserting a conduit box in an approved position, filled with plastic compound (after the cables have been drawn in) to seal off the conduit system at that point.

The box lid shall be fitted with a label to indicate the presence of a "Thermal Seal".

Conduit ends shall be reamed and cleaned internally prior to assembly; open ends must be plugged after installation to prevent ingress of foreign matter or water.

For all surface work conduit shall be fixed using splayed distance (hospital) saddles fixed directly to walls. Where conduit is required to be fixed to any structural steelwork the saddles shall be affixed to the steelwork using purpose made girder clamps.

Drilling of the structural steelwork will not be permitted. Boxes must be fixed independently of conduit, and fixings must be capable of supporting any intended fittings and withstanding mechanical forces required to operate such fittings.

Conduits shall be screwed into threaded apertures or terminated using flanged conduit couplers with lead washer and brass bush with a hexagonal head.

The bush shall be tightened using a purpose-designed spanner.

All conduits shall have a separate earth continuity conductor installed throughout. Throughout the installation the conduit, draw-in boxes, angle boxes, looping-in boxes etc. shall be arranged and be of sufficiently large section, to allow for both an easy "draw-in" and "out" of any one or all of the cables in the conduit during or subsequent to the installation. Conduit sets through walls will not be permitted.

When change of direction is required immediately after passing through a wall an appropriate back outlet box shall be fitted. All runs shall be installed neatly in straight and symmetrical lines to minimize bends and sets.

All bends shall be made on site with an approved type of bending machine, and all sets shall be neatly made without restriction of the bore. Where large radius bends are required a bending block of approved type may be used providing the conduit is not deformed.

Not more than four sets or two right angle bends shall be installed between draw boxes at a maximum spacing of 10 meters along any conduit run. Running thread connectors with milled edge lock-nuts may be provided in difficult situations to facilitate erection, but these shall be kept to an absolute minimum.

The ends of fittings, conduits, etc. in such cases shall be filed to permit good mechanical contact throughout the circumference.

Only couplings having smooth even bearing faces shall be used. All vice marks, exposed sections of screwed threads, abrasions and other damage to the galvanizing caused during installation or storing shall be made good by painting with a calcium plum bate primer immediately after erection followed by two coats of aluminium paint.

Conduit, which in the Project Manager's opinion is badly damaged or has poor threads will not be acceptable and shall be replaced by the Contractor.

Where conduit is or may be in contact with any other metal work, of any description, an efficient and permanent metallic bond, to the Project Manager's approval, shall be made between the conduit and the metal work.

Conduits shall not be installed within ducts. Where two or more conduits are installed side-by-side the minimum distance apart shall be 12mm and conduits shall not cross.

Where a diversion occurs, and segregation of cables is not required, then an adaptable box shall be installed so that all cross-over of conduit are eliminated.

Where conduits of different services are run together and require to cross-over than an adaptable box shall be installed proud of the wall to allow the conduits to cross using double sets only.

The routes of all surface conduits shall be subject to the Project Manager's approval before the installation.

A galvanized pull wire shall be installed in all conduits that are to receive future conductors. At least 60 cm of pull wire shall be doubled back into the conduit at each termination.

Conduits (and pipe ducts) shall be sealed where entering chambers or buildings with an expanding polyurethane foam sealant to prevent entry of water, insects or vermin.

11.4.7 Cable Tray

Cable trays shall be of heavy duty aluminum, or manufactured from perforated hot rolled steel, hot dipped galvanized after manufacture.

Cable tray shall all be from the same range of one manufacturer.

Cable tray shall be supplied and installed with all necessary fittings and supports, fully in compliance with the manufacturer's recommendations.

The tray shall be run in straight lengths and any changes of direction or size shall be made using bends, offsets, reducers etc. Connections between lengths of cable tray shall be made using coupling pieces.

Bends, offsets, coupling pieces, reducers etc. shall be manufactured and supplied by the manufacturer of the cable tray, complete with earth bonding connections. Site made items are not acceptable.

Cable tray runs shall fit closely to the structure, and all necessary bends, etc. shall be provided.

The minimum thickness of the tray shall be as follows:

- -Up to 300mm in width 1.5mm

- -Above 300mm in width 2.0mm

The minimum flange height for the tray shall be 38mm.

The minimum width of cable tray shall be 150mm, but in all cases the width shall be 200mm greater than necessary for the cables being installed thereon.

All cable trays shall be supported at a maximum of 1500mm from changes in direction or termination and at a maximum spacing of 2000mm. Brackets shall support the full width of the tray.

All bolts, nuts, washers, etc. shall be galvanized or sheradised. Where trays are attached directly to a building surface, stand-off brackets shall be used to give a minimum clearance of 25mm.

Fire barriers of an approved proprietary manufacture shall be provided wherever cable tray passes through a wall or floor, or elsewhere where indicated. The barrier shall not be less than the thickness of the wall or floor through which the tray passes.

11.5 Lightning and Grounding System

11.5.1 General

(1) General

The Contractor shall furnish and install all lightning and grounding systems as hereinafter specified and as shown on the drawings.

(2) Reference

The following standards are referred to:

- IEC61643 Low voltage surge protective device and referring standards
- IEC 228 600V Vinyl Insulated Wire (IV)
- JISC 3307 600V Vinyl Insulated Wire (IV)
- JISC 2806 Non-insulated Crimp-type Sleeves for Copper Conductors
- JISH 3100 Copper and Copper alloy-Sheets, Plates, Strip and Coiled Sheets.

11.5.2 Wire

The wire used for the wiring shall be as hereinafter specified.

- 600V Vinyl Insulated Wire (IV)
- Soft annealed Copper Stranded Bare Conductor

11.5.3 Materials

Wire shall be of soft drawn annealed, 98% conductivity, stranded copper and bare

conductor.

SPD (Surge Protection Device) shall be discharge the lightning current and protect electrical equipment from surge lightning.

11.5.4 Ground Plates

Ground plates shall be copper plate of 1.5 mm or more thickness and 1000 mm x 1000 mm square or equal.

The connections between the ground plates and grounding wires shall comply connected by brass-welding with electrolytic corrosion-proof treatment.

11.5.5 Ground Rods

Grounding rods shall be copper clad steel rods or galvanized steel rods, 10 mm or more in diameter, 1.5 meter long and with pointed and chamfered tops. Grounding rods shall be equipped with couplings and driven bolts, and shall be driven to the depths and number of rods needed to obtain the desired resistance.

Grounding rod clamps shall be cast copper alloy, and shall tightly grip the rod and cable.

11.5.6 Grounding Connectors

Grounding connectors shall be made by compression type. Grounding connectors shall be corrosion resistant and provided for cable to flat surface connections on equipment and structural steel.

11.5.7 Ground Electrode Markers

The marker for buried ground plates and rods shall be installed to construction wall near each electrode.

Each marker shall be made of brass or stainless steel, and shall have written down the bury position, depth, resistance and date, etc.

11.5.8 Installation

The surge protection system shall conform to latest IEC standard, JIS and Vietnamese standard. Ground system for all electrical equipment in the buildings shall be grounded to common ground by bonding the earthing bus sive for avoiding the voltage differences in the lightning.

SPD shall be installed for all electrical wire of equipment at the entrance to building.

In case of various ground works shall be grounded independently of and separately far from the common ground. Grounds of the following equipment shall be done separately from the common ground, in addition to the electrical equipment grounding.

If acceptable and specified ground resistance value cannot be actually measured, suitable countermeasures such as addition of grounding rods including grounding plates, extension of grounding system and considerable others shall be made so as to satisfy its target value specified in the Specifications.

The ground electrode shall be separated 2.0 m or more from other steel frames and pipes as far as possible.

For the above measurement, a grounding terminal board shall be installed.

All electrical equipment shall be connected to the nearest available grounding rods. The protecting conduits shall be bonded to the grounding conductor at both ends.

The Contractor shall not allow the grounding connections to be painted. If the connections are painted, they shall be disassembled and remade with new fittings.

All equipment enclosures, panel, motor, transformer and conduit systems, exposed structural steel and similar items shall be grounded.

A grounding wire and cable shall be run in all electric power conduits. The cable rack shall be grounded by a separate green colored, insulated, grounding conductor.

Although all metallic conduits shall be grounded, they shall not be used to provide grounding for motors or other electrical equipment.

The Contractor shall exercise care to ensure good ground continuity, in particular, between the conduit system and equipment frames and enclosures. Where necessary, jumper wires shall be installed.

11.5.9 Tests and Others

The Contractor shall test the ground resistance of the system. All test equipment shall be provided by the Contractor and approved by the Project Manager. Dry season resistance of the system shall not exceed ten (10) ohms. If such resistance cannot be obtained with the system as shown, the Contractor shall provide additional grounding as instructed by the Project Manager, without additional payment.

It shall be noted that in any case the Contractor shall be responsible for any defects and failures for the grounding system to establish complete it.

12. Tunnel Safety Facility

12.1 General

The Contractor shall provide tunnel safety facility to be used for detecting incidents occurred inside tunnel and providing incident information to road users and road operator.

The scope of work shall include the designing, manufacturing, supplying, factory testing, finishing, painting, export packing, insuring, shipping, delivering to the site storage yard designated by the Employer, supervision for installation and erection, field testing and co-operation in the commissioning (the trial operation). The operating service to the Employer's staff at the site shall also be included.

In order to avoid any defects under interface between this Contract work and other contract work under other contract packages, and to establish effective site work progress, the Contractor shall make good co-operation with the other Contractor whenever the Project Manager confirms such requirements.

The Contractor shall provide all labor, materials, equipment and incidentals to furnish and install the complete tunnel safety facility system as shown on the drawings and/or specified herein.

The Contractor shall be responsible for all wiring and connections, testing and placing in satisfactory operation the complete electrical system to the approval of the Project Manager.

12.2 System Configuration

The tunnel safety facility shall consist of the specified number of information push buttons, fire extinguisher, tunnel telephones and indication boards to be installed inside tunnel, master controller to receive the push button signal or voice information from tunnel telephone and transmit them to the Main Management Center (MMC), and tunnel information board to inform the tunnel incident to the road users who are intending to enter the tunnel. Information board will be provided in the scope of VMS system.

The number of tunnel safety facilities to be provided under the contract shall be as follows.

- Information Push Button: 21 sets
- Fire Extinguisher: 21 sets
- Tunnel Telephone: 6 sets
- Indication Board: 10 sets
- Master Controller: 1 set

12.3 Functions and Specifications

(1) Information Push Button

Information push button shall provide information of tunnel incident location to the MMC. An emergency signal from each push button shall be integrated into defined observation division separated by certain interval so that the operator can understand the location of incident. The marker lamp shall be put into the cabinet of information push button. For convenience of regular maintenance works in tunnel, telephone jack for handset shall be provided in the cabinet to communicate with staff in substation located at tunnel north portal or the MMC.

Information push button consists of following equipment and materials.

- Push button switch
- Indication lamp
- Telephone Jack
- Marker lamp

These are installed in cabinet of information push button structured by stainless steel plate.

When push button switch is pressed, emergency signal shall be sent to master controller. The push button switch shall be of water jet proofing type specified in JISC0920 or equivalent. Push button switch shall be installed in front panel of information push button cabinet.

After signal is sent from push button switch, indication lamp shall be turned on to confirm signal received. The lamp shall be LED lamp (red color) and operating with DC48V, 20mA or equivalent.

The telephone jack is provided for communication between maintenance worker at tunnel inside and operator in substation or in the MMC. The telephone jack should be plug-in type with water and dust proof system.

Marker lamp shall indicate presence of information push button to person in emergency. The lamp should be with conical shape appearance of red color.

(2) Fire Extinguisher

Two (2) units of fire extinguisher with cylindrical casing shall be provided in fire extinguisher box. This box shall be made by stainless steel and have door with handle for security. In this box, information push button shall be built in together. Class, type and capacity of fire extinguisher shall be ABC class powder type with 6 kg weight capacity at least or recommendations of local authorities. Class ABC type fire extinguisher shall be effective against ordinary combustible (class A), flammable liquids (class B) and

flammable gases (class C).

(3) Tunnel Telephone

Tunnel telephone system shall be provided to inform the condition and location of tunnel incident by the person in emergency to road operator at the MMC and receive proper advices from the operator. The tunnel telephone shall be connected directly to the MMC without any exchange. The tunnel telephone must be equipped with swing door to avoid disturbance conversation due to noise from high speed traffic. Marker lamp for the telephone shall be installed above telephone box in order to find out telephone box easily inside tunnel.

Tunnel telephone consists of telephone body and handset. When handset is picked up from the body, telephone line shall be connected automatically to the MMC. The swing door shall be with automatic close system. The material of swing door should be of aluminum flame structure.

(4) Master Controller

The master control installed in substation house at north tunnel portal site shall be connected to the VMS boards located near the tunnel to inform the incident occurred inside tunnel to the road users who are intending to enter the tunnel. The controller shall also be connected to facility management server through fiber optic network to manage tunnel safety facilities such as tunnel telephone, information push button, etc. The controller supplies power to safety facilities in tunnel and relays signal from information push button to the VMS board and server.

Appendix-4 Cost Estimate Report

Summary of ITS Implementation Cost

No	Item	Amount		Amount Equivalent in USD	Remarks
		VND	USD		
1	Traffic Management System	11,529,000,000	8,818,000	9,367,000	
1-1	CCTV Camera system	2,520,000,000	516,000	636,000	
1-2	Vehicle Detector System	1,176,000,000	544,000	600,000	
1-3	MET System	315,000,000	509,000	524,000	
1-4	Overload Monitoring System	1,848,000,000	1,236,000	1,324,000	
1-5	Variable Message Sign System	5,460,000,000	3,570,000	3,830,000	
1-6	Traffic Management Center System	210,000,000	2,443,000	2,453,000	
2	Toll Collection System	6,930,000,000	14,669,000	14,999,000	
2-1	Toll Center System	0	3,500,000	3,500,000	
2-2	Toll Lane System	5,250,000,000	3,530,000	3,780,000	
2-3	Toll Office System	1,680,000,000	3,264,000	3,344,000	
2-4	User Side Equipment	0	4,375,000	4,375,000	
3	Communication System	7,003,500,000	5,398,950	5,732,450	
3-1	Digital Transmission System	6,268,500,000	4,342,450	4,640,950	
3-2	Wireless Radio System	525,000,000	787,000	812,000	
3-3	Internal telephone system	210,000,000	269,500	279,500	
4	Power Supply Work	6,919,500,000	700,000	1,029,500	
5	Tunnel Safety Facility	420,000,000	397,600	417,600	
6	General Requirements	14,238,000,000	4,131,000	4,809,000	
7	Detailed Design	0	1,500,000	1,500,000	
8	Overhead, Others (15%)	7,056,000,000	5,342,000	5,678,000	
	Total	54,096,000,000	40,956,550	43,532,550	

Note Exchange Rate: 1USD=21,000VND

CCTV Camera System

Item	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Central equipment and software						
CCTV center controller with application software	set	1		80,000		80,000
Network video recorder (NVR) with application	set	1		50,000		50,000
CCTV center control console	set	1		20,000		20,000
Monitor screens	set	8		2,000		16,000
Installation of central equipment and wiring	LS	1		20,000		20,000
Terminal equipment						
PTZ camera with controller	set	33		5,000		165,000
Media converter with power supply	set	33		3,000		99,000
Steel pole	no.	18	63,000,000		1,134,000,000	0
Installation of pole, pan-tilt head, camera, camera housing, controller cabinet, and wiring	no.	33	42,000,000	2,000	1,386,000,000	66,000
Sub-total					2,520,000,000	516,000

Vehicle Detector System

Item	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Central equipment and software						
Vehicle detector center system equipment	set	1		40,000		40,000
Traffic analysis processing application	LS	1		200,000		200,000
Installation of data gathering processor	LS	1		10,000		10,000
Terminal equipment						
Vehicle detector sensor	set	28		1,000		28,000
Vehicle detection unit	set	14		10,000		140,000
Cabinet with power supply, terminal, others	set	14		5,000		70,000
Installation	set	28	42,000,000	2,000	1,176,000,000	56,000
Sub-total					1,176,000,000	544,000

MET System

Item	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Central equipment and software						
MET data processor	set	1		40,000		40,000
MET data processing application	LS	1		60,000		60,000
Installation of central equipment and wiring	LS	1		10,000		10,000
Terminal equipment						
Thermometer with converter	set	3		4,000		12,000
Anemometer with converter	set	3		8,000		24,000
Rain gauge with converter	set	3		4,000		12,000
Rainfall detector with converter	set	3		5,000		15,000
Visibility meter with converter	set	3		20,000		60,000
Data logger with media converter	set	3		15,000		45,000
Cabinet for converter and interface with power supply	set	3		5,000		15,000
Pole	no.	3		3,000		9,000
Installation of terminal equipment and pole and wiring	no.	3	105,000,000	5,000	315,000,000	15,000
Sub-total					315,000,000	192,000
						509,000

Overload Monitoring System

Item	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Central equipment and software						
Overload monitoring data server	set	1		80,000		80,000
Overload monitoring data processing application	LS	1		150,000		150,000
Portable weigh station	set	1		50,000		50,000
Installation of central equipment and wiring	LS	1		10,000		10,000
Terminal equipment						
Roadside panel with media converter	set	11		20,000		220,000
WIM type axle load scale	set	11		50,000		550,000
Vehicle detector (*)	set	11				0
Lane monitoring camera (*)	set	11				0
ANPR camera (*)	set	11				0
Overweight warning display	set	11		8,000		88,000
Installation including cable, conduit, connector and accessories	set	11	168,000,000	8,000	1,848,000,000	88,000
Sub-total					1,848,000,000	1,236,000

(*) included in toll collection system

Variable Message Sign System

Items	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Central equipment						
VMS center controller with console	set	1		100,000		100,000
VMS control application software	LS	1		200,000		200,000
Installation of central equipment and wiring	LS	1		20,000		20,000
Terminal equipment						
VMS board	set	26		80,000		2,080,000
VMS control unit with media converter, power supply and terminal board	set	26		15,000		390,000
Support	set	26		20,000		520,000
Installation of signboard, support, and controller and wiring	set	26	210,000,000	10,000	5,460,000,000	260,000
Sub-total					5,460,000,000	3,570,000

Traffic Management Center System

Item	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Hardware						
Traffic management system server	set	2		50,000		100,000
Facility management server	set	2		30,000		60,000
Operator console	set	3		15,000		45,000
Large display panel (LDP) with controller	set	1		200,000		200,000
Database server with external storage device	set	1		50,000		50,000
WEB&MSG server with firewall and associated devices	set	2		50,000		100,000
System clock server	set	1		30,000		30,000
Monitoring PC	set	6		10,000		60,000
Laser printer	set	4		2,000		8,000
Network equipment (L3-SW, L2-SW, etc.)	LS	1		50,000		50,000
Installation of equipment and wiring	LS	1	210,000,000	40,000	210,000,000	40,000
Software						
Traffic management system software	LS	1		800,000		800,000
Facility management system software	LS	1		600,000		600,000
LDP control software	LS	1		100,000		100,000
WEB & MSG generating application	LS	1		150,000		150,000
System clock software	LS	1		50,000		50,000
Sub-total					210,000,000	2,443,000

Toll Collection System

Item	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Toll Center System						
Toll center system with software	LS	1		3,000,000		3,000,000
Installation of toll center system including testing, commissioning and training	LS	1		500,000		500,000
Subtotal					0	3,500,000
Toll Lane System						
Manual lane equipment	set	34		48,000		1,632,000
ETC lane equipment	pc	16		98,000		1,568,000
Installation of toll lane system including testing, commissioning and training (50 lanes)	LS	1	5,250,000,000	330,000	5,250,000,000	330,000
Subtotal					5,250,000,000	3,530,000
Toll Office System						
Toll office system with software	LS	8		388,000		3,104,000
Installation of toll office system including testing, commissioning and training	LS	1	1,680,000,000	160,000	1,680,000,000	160,000
Subtotal					1,680,000,000	3,264,000
User Side Equipment						
IC card	pc	625,000		3		1,875,000
On board unit	set	50,000		50		2,500,000
Subtotal					0	4,375,000
Total of Center System					6,930,000,000	14,669,000

Digital Transmission System

Item	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Digital transmission equipment						
Fiber optic node with Layer 3 and Layer 2 switch	set	10		40,000		400,000
Network monitoring server with software	set	1		150,000		150,000
Installation of equipment, network configuration and wiring	LS	1	1,050,000,000	50,000	1,050,000,000	50,000
Cable						
Fiber optic cable	km	288		12,000		3,456,000
Fiber optic terminal	pc	10		6,000		60,000
Fiber optic closure	pc	647		350		226,450
Conduit						
Supply of HDPE conduit	m	7,100	210,000	10	1,491,000,000	
Manhole	pc	71	21,000,000	1,000	1,491,000,000	
Installation of conduit at earth section	m	3,550	630,000	30	2,236,500,000	
Sub-total					6,268,500,000	4,342,450

Wireless Radio System

Item	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Central equipment						
Communication control equipment with transmitter/receiver	set	1		150,000		150,000
Radio communication console	set	1		30,000		30,000
Antenna	set	2		3,000		6,000
Cable, connector and miscellaneous	set	1		5,000		5,000
Installation of equipment	LS	1	105,000,000	5,000	105,000,000	5,000
Antenna pole (material and construction)	set	1		5,000		5,000
Base station equipment						
Repeater equipment with transmitter/receiver	set	4		80,000		320,000
Antenna	set	8		3,000		24,000
Cable, connector and miscellaneous	set	4		3,000		12,000
Installation of equipment	LS	4	105,000,000	5,000	420,000,000	20,000
Antenna pole (material and construction)	set	4		5,000		20,000
Terminal equipment						
Mobile unit including installation	set	30		3,000		90,000
Portable unit with charger	set	50		2,000		100,000
Sub-total					525,000,000	787,000

Internal telephone system

Item	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Central equipment						
IP-PBX including software	set	1		200,000		200,000
Installation	LS	1	210,000,000	10,000	210,000,000	10,000
Terminal equipment						
Telephone set (supply and installation)	set	170		350		59,500
Sub-total					210,000,000	269,500

Power Supply Work

Class	Particular	Unit	Q'ty	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
[Equipment]							
UPS							
	UPS 20kVA (equipment and installation)	set	2		45,000		90,000
	UPS 50kVA (equipment and installation)	set	7		70,000		490,000
	UPS 100kVA (equipment and installation)	set	1		120,000		120,000
Low Voltage Distribution Panel							
	Low Voltage Distribution Panel (MMC)	lot	1				
	Low Voltage Distribution Panel (MO and TO)	set	1	210,000,000		210,000,000	0
	Low Voltage Distribution Panel (Tuy Loan IC/Tunnel)	set	7	168,000,000		1,176,000,000	0
		set	2	105,000,000		210,000,000	0
Low Voltage Cable and Wire							
		lot	1	840,000,000		840,000,000	0
Grounding system							
	Earthing rod	lot	1	3,202,500,000		3,202,500,000	0
	Earthing wire	lot	1	896,700,000		896,700,000	0
	connector	lot	1	384,300,000		384,300,000	0
Sub-total						6,919,500,000	700,000

Tunnel Safety Facility

Item	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Tunnel Safety Facility						
Fire extinguisher with information push button	set	21		6,000		126,000
Tunnel telephone box	set	6		10,000		60,000
Master controller	set	1		150,000		150,000
Installation of equipment and wiring	LS	1	420,000,000	20,000	420,000,000	20,000
Cable						
Communication and power cable	LS	1		41,600		41,600
Sub-total					420,000,000	397,600

General Requirements

	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Mobilization & de-mobilization	LS	1	630,000,000	30,000	630,000,000	30,000
Project Management	month	24	567,000,000	45,000	13,608,000,000	1,080,000
Acceptance test						
Factory test	LS	1		30,000		30,000
Test on completion	LS	1		50,000		50,000
Work area safety and traffic control	LS	1		5,000		5,000
Documentation						
System design manual	LS	1		6,000		6,000
Operation's manual	LS	1		10,000		10,000
Software manual	LS	1		40,000		40,000
Hardware manual	LS	1		40,000		40,000
Maintenance manual	LS	1		20,000		20,000
As-built drawing	LS	1		40,000		40,000
Training						
Management training	LS	1		20,000		20,000
Operator training	LS	1		30,000		30,000
Maintenance training	LS	1		30,000		30,000
Spare parts and maintenance equipment						
Spare parts	LS	1		1,500,000		1,500,000
Maintenance equipment	LS	1		200,000		200,000
Warranty						
Warranty for two year	LS	1		1,000,000		1,000,000
Sub-total					14,238,000,000	4,131,000

Project Management

	Unit	Quantity	(VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Personnel						
Project manager (foreign)	month	24		25,000		600,000
Deputy project manager (local)	month	24	105,000,000		2,520,000,000	
Engineer (foreign)	month	24		20,000		480,000
Engineer (local)	month	72	63,000,000		4,536,000,000	
Administrative staff	month	96	21,000,000		2,016,000,000	
Office & equipment						
Office rental	month	24	63,000,000		1,512,000,000	
Equipment (computer, printer, copying machine. Etc.)	month	24	42,000,000		1,008,000,000	
Vehicle						
Vehicle rent	month	96	21,000,000		2,016,000,000	
					13,608,000,000	1,080,000
Sub-total					567,000,000	45,000
Monthly average		24				
Documentation						
System design manual	page	300		20		6,000
Operation's manual	page	500		20		10,000
Software manual	page	2,000		20		40,000
Hardware manual	page	2,000		20		40,000
Maintenance manual	page	1,000		20		20,000
As-built drawing	sheet	800		50		40,000

Detailed design

	Unit	Quantity	Unit Price (VND)	Unit Price (US\$)	(VND)	Amount (US\$)
Personnel						
Vehicle detector system	month	3		25,000		75,000
CCTV camera system	month	3		25,000		75,000
MET system	month	2		25,000		50,000
Overload monitoring system	month	4		25,000		100,000
VMS system	month	5		25,000		125,000
Traffic management system	month	10		25,000		250,000
Toll collection system	month	12		25,000		300,000
Digital transmission system	month	3		25,000		75,000
Internal telephone system	month	2		25,000		50,000
Wireless radio system	month	4		25,000		100,000
Power supply system	month	3		25,000		75,000
Tunnel safety system	month	3		25,000		75,000
Cable and conduit work	month	6		25,000		150,000
		60				1,500,000