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PROJECT:

Consultancy Services for Detailed Feasibility Study and Framing up of Phasewise proposal (DPR) for construction of two tunnels at Z-Morh and at Zojila for all weather connectivity from Srinagar to Leh in Jammu & Kashmir State

Z-MORH TUNNEL

TITLE:

Phase II: Detailed Project Report - Preliminary Tunnel Design

Volume X: Technical Specifications - Fixed Operating Equipment

Index of Contents

Index of Addendums

1 PURPOSE OF THIS DOCUMENT

The purpose of this document is to provide product independent outline functional specification for Fixed Operating Equipment (FOE) for the Z-Morh Tunnel in the Republic of India.

1.1 Background

This document is the basic project specification for the design, construction, operation and maintenance of the Z-Morh Tunnel in India.

This document sets out the product independent comprehensive outline functional specification for Fixed Operating Equipment (FOE).

The FOE Contractor is required to design, supply and install the fixed operating equipment in full compliance to the Design Documentation.

1.2 Terms and Abbreviations

The following are the main terms and abbreviations used in this document.

CCTV Closed Circuit Television

ECC Emergency Call Column

ECS Emergency Call System

ECU Emergency Call Unit

ESC Energy Supply Company

FOE Fixed Operating Equipment

GUI Graphic User Interface

HGV Heavy Goods Vehicle

IDF Incident Detection Function

kph Kilometre per hour

LED Light Emitting Diode

MMI Man-Machine Interface

OMC Operation and Maintenance Centre

PLC	Programmable Logic Controller
PTZ	Pan, Tilt and Zoom (-camera)
SCADA	Supervisory Control and Data Acquisition
TLE	Traffic Logging Equipment
UPS	Uninterruptible Power Supply
VDF	Vehicle Detection Function
VIP	Video over Internet Protocol
VMS	Variable Message Sign
VoIP	Voice over Internet Protocol

2 STANDARDS AND NORMS

This section describes the general standardisation environment and operational circumstances of the FOE to be installed.

2.1 Standards Organizations

Where applicable the equipment should comply with the latest revision of the relevant standards from the following recognised Standards Bodies:

Table 1: References to sources of Standards, Guidelines and Recommendation

Abbreviation	Name
CENELEC	European Comittee for Electrotechnical Standardization, Avenue Marnix 17, B- 1000 Brussels
DIN	Deutsches Institut für Normung e.V. Beuth Verlag GmbH, Burggrafenstrasse 6 D-10787, Berlin, Germany.
EN, ENV	European Committee for Standardisation, Central Secretariat, Rue de Stassart 36 B-1050, Brussels.
IRC	The Indian Road Congress, Jamnagar House, Shahjahan Road, New Delhi-110011.
IS	Bureau of Indian Standards, Manak Bhavan, 9 Bahdur Shah Zafar Marg, New Delhi – 110002.
ISO	International Organization for Standardisation 1, rue de Varembé CP 56, CH-1211 Genéve 20, Switzerland.
ÖNORM:	Austrian Standard Institute, Heinestraße 38, 1020 Wien, Austria
RVS (Austrian Code for Road Construction)	Austrian Association on Road, Rail and Transport (FSV), Karlsgasse 5, 1040 Wien, Austria

In the case of any conflict between the standards of the above mentioned bodies, the prescriptions of the most specific one, which must also be compliant with the Indian law, shall apply.

2.2 Operating Temperature

The equipment to be supplied shall be able to operate under the following environmental conditions:

Externally installed equipment (for example ECCs, TLE):

- minimum temperature: -30°C
- maximum temperature: +60°C
- relative non-condensing humidity: up to 100%

Facility installed equipment (for example. computers, printers):

- minimum temperature: 5°C
- maximum temperature: +30°C
- relative non-condensing humidity: up to 80%

Should the external equipment proposed be unable to function under these conditions or under conditions anticipated at the installation site, protection to regulate the equipment operating environment must be provided. For internal equipment, the facility design will ensure that the temperature and humidity be kept at acceptable levels i.e. temperature > 5°C and humidity < 80%.

The temperature range specified is the ambient temperature that is defined as the temperature of the surrounding atmosphere as determined by an instrument shielded from direct or reflected rays of the sun.

2.3 Protection of FOE

The equipment to be supplied shall be installed in appropriate housings protecting against thermal, mechanical, etc. effects like direct rays of sun, dust, water, humidity, etc.

Cables shall be installed in appropriate ducting.

All protective structures shall be vermin proof.

3 PROJECT OVERVIEW

Open Road and Tunnel Fixed Operating Equipment (FOE) are provided to enhance the safety of journeys for motorists and to assist the operator in providing a cost effective, efficient operation and maintenance function.

The FOE systems are installed along the tunnel route and are located in positions that serve the intended function of the equipment and equipment access requirements best.

The corresponding civil engineering specifications relate to ducts and relevant structures for the protection of the communications cables and equipment, installation of roadside equipment and appropriate access provision for operation and maintenance.

3.1 Definition of Fixed Operating Equipment (FOE)

In the context of this document, FOE is equipment required to manage the day to day operations of the tunnel including alerting the traffic control centre of the occurrence of incidents and/or events on the Motorway such as:

- Traffic accidents
- Hazardous driving conditions
- Level of traffic flow

Tunnel and Open Road Fixed Operating Equipment Sub-Systems:

- Ventilation
- Traffic Control
- Closed Circuit Television (CCTV)
- Emergency Call System (ECS)
- Communication Systems
- Fire Safety System
- Lighting
- Tunnel Control System (SCADA)

3.2 Operation and Maintenance Centres (OMC)

Two Operation and Maintenance Centres (OMC) are to be constructed at the locations of West Portal and East Portal.

The OMCs shall, besides other maintenance activities, accommodate the central control and reporting centres for the Fixed Operating Equipment.

Open Road and Tunnel control operations, maintenance, control and recording functions will be managed from both OMCs.

The Main Control Centre will be located in the West Portal OMC, and the Slave Control Room will be located in the East Portal OMC.

The Operator administration and management functions shall be carried out at the OMCs, where the Traffic Control Room and Tunnel Control Room are located. The Traffic Control Room will coordinate all traffic management, maintenance, emergency response and other related activities on the Open Road.

The Tunnel Control Room shall be dedicated to the coordination of all traffic management, maintenance, and emergency response for the tunnel.

The main data storage and reporting points for the Open Road and Tunnel FOE shall be located at each of these locations.

The OMCs will be manned on a 24 hour a day basis by appropriately trained staff.

4 FIXED OPERATING EQUIPMENT

The FOE Contractor shall be required to manufacture, supply and install Open Road and Tunnel FOE in order to carry out the functional requirements of the system to the required performance criteria.

All components have to be provided, installed und put into operation.

4.1 Power Supply System

The FOE Contractor shall be required to design the power reticulation system for the tunnel, which shall include for the cabling, distribution boards, power supply units and equipment earthing system.

The detail for the design of equipment shall include for the equipment sizing, capacity, fault levels and operational requirements of the electrical equipment to be supplied by others and interfaced to the FOE and those electrical circuits to be supplied by the FOE Contractor.

The installation of the protective earthing system and the connection of equipment to the earthing system shall form part of the works.

4.1.1 High Voltage Power Supply

The power supply of the tunnel shall be adapted to the given network conditions of the energy supply company (ESC, 33kV-High voltage grid).

There shall be two separate power supplies (east portal and west portal) provided.

In the two OMCs, the voltage shall be stepped down from 33 kV to 11kV.

Further supply in the tunnel shall be via a 11 kV high voltage cable.

The transformers shall be situated in the OMCs, in the ventilation cavern and special power supply niches.

The following voltage levels shall be used:

- Energy Distribution: 400V / 50 Hz
- Ventilation: 690V / 50 Hz

4.1.2 Energy Distribution

The accommodation of the cabinets shall be done in the OMCs, in the ventilation cavern, in the power supply niches and in the emergency call niches.

The hydrant niches shall be supplied from the opposite emergency call niches.

The contractor will supply and install the power distribution cable networks from the utility power distribution board to the equipment installation at the OMCs and energy consumers in the tunnel.

4.1.3 Safety Power Supply

The FOE Contractor is required to specify the power requirements for the Uninterruptible Power Supply (UPS) system for the FOE.

The UPS units will be installed in the switch room of the OMCs and the tunnel ventilation cavern and these will be provided with their appropriate power distribution and systems.

The runtime of the UPS system must guarantee that the following plants can be supplied at least 1 hour of energy.

- Tunnel Emergency Lighting
- Emergency Call System (ECS)
- CCTV Monitoring
- Variable Message Signs (VMS)
- Traffic Lights
- Overheight Vehicle Detection
- Traffic Logging Equipment
- Guidance System
- Tunnel Radio System
- Internal Telephone System
- Sound System
- Tunnel Physical Variables Measurement System

- Escape Route Lighting
- Integrated Tunnel Control System (SCADA)

In case of an outage of normal power supply, the electrical appliances in the OMCs, in the ventilation cavern and in the tunnel shall be powered from diesel generators.

To avoid the unwanted overload of the generator, the appliances shall be started one by one.

4.2 Tunnel Ventilation System

The purpose of the ventilation system is to ensure the safety of all persons who travel through the tunnel from harmful levels of vehicle emissions. Pollution measurement sensors will be installed throughout the tunnel, which will measure the intensity of gases present. The pollution level will determine when to activate the tunnel ventilation system to force out the harmful gases.

4.2.1 Tunnel Ventilation

The ventilation systems in road tunnel include two operating modes. These are:

- Normal mode of operation: Ventilation maintains the air quality in acceptable levels. That means that the ventilation system must be able to remove the engine vehicle emissions and also to maintain the air temperature in reasonable values.

- Emergency mode of operation: Ventilation provides a safety route of escape for the trapped users, and also facilitates the task of the fire brigade by controlling the fire smoke.

Therefore, the tunnel ventilation system has to be taken into account for the design of emergency protocols, and all the subsystems related with the air quality in tunnels (CO sensors, no further opacity meters, etc).

The threshold for CO concentration, and for the visibility loss shall be agreed later between the Client and the Independent Engineer.

4.2.1.1 Position

For the normal mode fans shall be installed in the ventilation buildings at both portals and in the ventilation cavern in the middle of the tunnel. The design defines 2 fans (one for fresh air and the other for exhaust air) in each ventilation building and 4 fans (for two ventilation sections) in the ventilation cavern.

For the emergency mode jet fans shall be installed. The pairs of jet fans shall be mounted in the tunnel in special jet fan niches at regular distances. The design defines 11 pairs (totally 22 units) of jet fans.

4.2.1.2 Function

The ventilation shall be monitored and controlled in the OMCs via the SCADA system.

The jet fans shall be fully reversible and might be activated from the tunnel control centre by means of the PLC in accordance with the functional protocols to be established.

Each fan and jet fan shall be connected to the SCADA system via a PLC. The SCADA system shall be programmed to identify each cable for all the fans.

The SCADA system shall monitor the data received from all the pollution measurement sensors. When the SCADA system detects values exceeding their defined limits, it shall then instruct the appropriate fan to switch on.

A data cable from the fan motor shall be wired back to the SCADA system via the PLC and this shall inform the SCADA system about the current status of the fan (for example motor run status, motor speed etc.)

The fans can be switched on as required from the PLC to adjust the system performance to the particular necessities for example light traffic hours, peak hours, emergency, etc.

4.2.1.3 Performance

In the event of a fire, the tunnel ventilation system shall be capable of controlling smoke and heated gasses in the main tunnel to allow the safe escape of people in opposite direction or the egress tunnel.

4.2.1.4 Interfaces

The jet fan system shall be controlled by the PLC, which shall be connected to the SCADA system. This aims to control remotely the following signals:

- Forward Start
- Reverse Start
- Stop

4.2.2 Tunnel Physical Variables Measurement System

The tunnel physical variables measurement system shall comprise the following elements:

- Visibility measurement (dust particle)
- CO measurement

- Air velocity and flow direction measurement
- Air temperature measurement

The visibility sensor shall work on an optical measuring principle. The sender emits light of a specific wavelength and the receiver determines, depending on the strength of the received light, the visibility conditions.

The CO Sensor shall be an electrochemical three electrode sensor for the continuous real-time monitoring of CO in the ambient air.

The air velocity and flow direction measuring device shall consist of two ultrasonic transducers, which will be fixed to the both tunnel walls and will be adjusted in an angle of 45° to the driving direction. The transducers shall work alternately as sender and receiver, so they will be able to determine air velocity and flow direction.

4.2.2.1 Position

The sensors shall be mounted on the tunnel wall two times in each ventilation section.

4.2.2.2 Function

The visibility sensor shall consist of a transmitter/receiver unit and a reflector. The transmitter emits light, which is reflected by the reflector to the receiver, next to the transmitter. The system shall determine the visibility conditions inside the tunnel by the amount of light that reaches the receiver. The light shall pass through the air twice, increasing the accuracy.

The air velocity and flow direction sensor system shall consist of two ultrasonic transducers and one evaluation unit. The two transducers shall work alternately as transmitter and receiver, so both transit times (with the flow, against the flow) will be determined. The evaluation unit shall calculate the air velocity and flow direction from the difference between the two transit times.

The measured physical variables shall be monitored and the sensors controlled in the OMCs via the SCADA system.

The sensors shall be powered by UPS.

4.2.2.3 Performance

The tunnel physical variables measurement system shall be designed to operate under the local technical parameters.

The threshold for CO concentration and for the visibility loss shall be agreed later between the Client and the Independent Engineer.

4.2.2.4 Housing and Fabrication

The tunnel physical variables measurement system shall be designed to operate under the following environmental parameters:

- Protection: IP-65
- Minimum temperature: -30°C
- Maximum temperature: +60°C
- Relative non-condensing humidity: up to 100%

4.2.2.5 Interfaces

The tunnel physical variables measurement system shall be connected via the PLC, which shall be connected to the SCADA system.

The whole measurement system shall be connected to the tunnel UPS network.

4.3 Traffic Control

The Traffic Control System shall cover the following needs

- Traffic Lights
- Overheight Vehicle Detection
- Traffic Logging Equipment
- Variable Message Signs (VMS)
- Guidance System

4.3.1 Traffic Lights

Traffic lights are located in the area before and after the tunnel, at the tunnel portals and inside the tunnel next to the lay-bys.

Traffic lights apply LED technology, brightness may be adjusted according to the time of the day and the weather conditions and must be connected to UPS system.

4.3.1.1 Position

Traffic lights in the tunnel shall be installed on the tunnel wall and in the area before and after the tunnel they are installed on poles.

4.3.1.2 Function

The traffic lights are controlled by their own monitoring module and report to SCADA the actual status of the lights.

The following conditions shall be possible:

- off
- yellow flashing
- red
- green

The operator in the OMC must be able to address the Traffic lights locations individually or in groups.

In the case of an event (for example fire alarm) the traffic lights shall be automatically switched to red.

When a lay-by is occupied, the traffic lights next to the lay-by shall automatically be switched to flashing yellow.

4.3.1.3 Housing and Fabrication

Traffic light equipment shall operate under the following ambient climatic conditions:

- Minimum temperature: -30°C
- Maximum temperature: +60°C
- Relative non-condensing humidity: up to 100%

4.3.2 Overheight Vehicle Detection

The optical height gate subsystem shall be designed to give alarm in case an over-height vehicle is moving towards the tunnel. Each site shall be covered with one infrared barrier or laser distance measurement product that is intended to monitor the height line of the lanes. If an over height vehicle breaks the beam, the system gives an alarm and initiates further actions. The sensors must be mounted at the predefined height, where detection of the over height vehicles shall be made.

For each installation site a holding pole or gantry shall be provided. The system shall be capable to identify the lane where the over height vehicle is moving (in case of laser product). Based on this information the system shall give an alarm to the SCADA which contains the location and lane number ID, the time where and when the system detected the incident. The system shall not be sensitive for occasional false alarms due to the built in software solution that continuously monitors the signal of the beam.

4.3.2.1 Position

The Over Height Gates shall be installed at the vicinity of the tunnelportals to detect over height vehicles, to activate visual and audible warnings and to instruct drivers to take appropriate action.

4.3.2.2 Function

For optical height measurement, laser devices or infrared beam devices and a detection system (inductive loops) can be placed at the roadside. The measuring

devices and an embedded industrial computer shall be placed on roadside poles or gantries in the required height where the detection takes place.

The computer shall analyze the received violation information and shall check if the alarm is real. False alarms shall be identified and not considered (e.g. a bird breaks the beam). To identify false alarms a loop sensor shall be installed in the traffic lane under the gantry.

When a real alarm is detected the system shall forward an alarm signal to the SCADA containing the location, the time where and when the system detected the incident.

The system shall work independently, locally or remotely controlled from the Control Centre. This system shall be connected to the closest controllers for communications with the Control Centre.

4.3.2.3 Performance

The Overheight Detection System shall be based on a market leader laser or infrared beam device, which is designed for outdoor measurement.

Performance requirements shall conform to the technical data sheets of the particular device.

4.3.2.4 Housing and Fabrication

Outdoor equipment shall operate under the following ambient climatic conditions:

- Minimum temperature: -30°C
- Maximum temperature: +60°C
- Relative non-condensing humidity: up to 100%.

4.3.2.5 Interfaces

Subsystem is interfaced with the SCADA system to provide an automatic alarm and has direct connection with the next Variable Message Sign .

4.3.2.6 Functional Requirements

Over height detection:

The over height detection shall monitor the traffic travelling towards the tunnel and shall detect any moving object/vehicle exceeding the nominal determined maximum permissible height above the surface of the road.

Warning function:

The OHD shall comprise a warning functionality that is activated when moving objects are exceeding the predetermined height passing the monitored points. This warning function shall activate the over height alarm function.

False alarms:

The warning functionality shall not provide false alarms in excess of the integrity requirement of the over height warning function. Automatic provisions to ensure this shall be provided.

Driver warning:

The over height alarm function shall alert the driver of the over height object/vehicle via message signs.

Traffic operator alarm:

The over height alarm function shall always be reported to the traffic operator. The alarm shall be visual and audible, readily recognizable and easily discernible above the ambient noise.

CCTV camera alarm action:

The over height alarm function shall automatically activate and present to the traffic operator images from the nearest CCTV camera showing the over height vehicle. The Tunnel Operator shall be able to monitor the movements of the offending vehicle, to ensure that it leaves the main lane correctly.

Tunnel entrance control alarm:

The over height alarm function shall automatically activate an alarm to the tunnel portal entrance control function (portal traffic lights).

4.3.3 Traffic Logging Equipment

Traffic Logging Equipment (TLE) is located to provide valuable data on vehicles using the tunnel, moving at speeds between 20 kph and 200 kph.

Traffic logging equipment consists of controllers, sensors and cabling.

4.3.3.1 Position

Sensors shall be installed at both portals of the tunnel to control traffic flow and in all lay-bys.

Controller units shall be installed in tunnel niches.

4.3.3.2 Installation

Loop sensor pairs and axle sensors shall be installed in the traffic lanes into the wearing surface.

The measurement of traffic volume is feasible using a single detector, whereas the measurement of vehicle speed, vehicle substitute electrical length and other parameters call for the installation of two induction loops installed one after another in the traffic flow direction together with an axle sensor.

The equipment shall be capable of determining and recording of length, speed, travelling direction, classification, following distance, axle count and spacing with time-stamps, under all anticipated environmental conditions, in respect of vehicles travelling at motorway speeds on the travelling lanes of each carriageway.

All vehicles larger than a motorcycle travelling within the lane must be detected by the installed road sensors.

Road sensors shall be connected to the controllers with copper interface cables.

Controllers shall interpret electrical data input from the sensors, and generate and process logical data from them.

Data and sensor cables shall be pulled into protective ducts.

4.3.3.3 Interface

Each station shall have a unique identity code used by the central control station for identification, control and data communication.

Communication between traffic logging sites and the central station shall be based on Ethernet-based IP communication.

TLE shall count and classify vehicles, report measurements to a central monitoring station; furthermore it shall also be capable of standalone operation in case of communication breakdown.

Data shall then be stored in the controller, and upon reestablishment of communication, without affecting regular actual real-time data traffic, transmitted to the central computer.

TLE shall have an automatic restart capability, without manual intervention and with appropriate safeguards to avoid data loss.

The TLE systems shall be designed to allow for diagnostic testing from either the roadside units or the central control station.

4.3.3.4 Performance

The traffic counter devices shall provide a continuous count of the total number of vehicles per hour in each direction with an accuracy of + or – 4% over every period of 24 hours 95% confidence interval, without bias to under-or over-recording. They shall provide a continuous count with the accuracy defined in the following table of the total number of vehicles per hour in each direction, classifying each vehicle into one of the following categories (using the EURO 6 classification definitions):

Class	Counting Accuracy
Class 1: Motorbike	Plus or minus 10%
Class 2: Cars/Vans	Plus or minus 3%
Class 3: Cars/Vans + Trailer	Plus or minus 10%
Class 4: Rigid HGV	Plus or minus 3%
Class 5: Articulated HGV	Plus or minus 3%
Class 6: Buses and Coaches	Plus or minus 5%

4.3.3.5 Housing and Fabrication

The units shall be installed in robust cabinets, which are resistant to environmental conditions and equipped with tamper protection and detection.

The TLE electronics and all other related electronic equipment shall be housed in the tunnel niches.

Control units shall control sensors of all traffic lanes at the given location, and shall also include the data storage and communication devices.

The cabinet shall be equipped with a security lock and unauthorized opening shall generate a door alarm at the Central Unit at the Traffic Control Room.

Cabinets are only accessible with the corresponding access key.

Access keys shall be applied in a master key per sub-system scheme. All cut-outs and openings shall be vermin proofed.

4.3.3.6 Functional Requirements

VDF (Vehicle Detection Function) detectors shall be installed to measure vehicles real-time and collect vehicle data from all lanes.

Measurement points:

Locations on the motorway are defined according to the drawings.

Ghost drivers:

The VDF shall be able to detect ghost drivers (vehicles moving in the direction opposite to the regular traffic) in the whole tunnel.

Traffic database:

Vehicle data shall be communicated to and stored in a central traffic database.This collected data shall be sent to the control centre into the OMC.

Vehicle data delay:

Vehicle data shall be transmitted and processed timely without impairing the VDF reaction time significantly.

Integrity monitoring:

The system implementation of the VDF function shall perform continuous system monitoring of it self and associated equipment and interfaces.

Any malfunction shall be automatically identified and logged without any delay.

VDF traffic data:

As a minimum the traffic database shall continuously record and retain the latest 60 days of traffic data and provide the means to extract any selected subset of these data.

4.3.3.7 Operator Functions

The operator shall be able to continuously view a graphical presentation of near real time traffic conditions of the whole tunnel.

Ghost driver alarm:

It shall be possible for the operator to receive an audible and a visible ghost driver alarm detected by the VDF function.

4.3.4 Variable Message Signs (VMS)

Variable Message Signs are located in the area before and after the tunnel and inside the tunnel. Variable Message Signs support drivers on the motorway with traffic control and other information. VMS located in front of and inside the tunnel must be connected to UPS system.

4.3.4.1 Position

Icon VMS consists of an alphanumeric zone full color to show images (speed restrictions, warning on weather conditions, road works, accidents, all necessary traffic pictograms).

Icon type VMS in the tunnel shall be installed on the tunnel wall and in the area before and after the tunnel they are installed on a pole.

4.3.4.2 Equipment

The control unit consists of a computer and a communication unit for storing sign pictures, to control the displays and communicate with the centre. The power supply of the control unit is shall be uninterruptible (UPS).

Potential malfunction is warned by an automatic alarm system. The communication module consists of a network connection of the control computer and a suitable branch of the adjacent LAN switch. There is an IP based network connection between the centre and the individual VMS units.

4.3.4.3 Installation

The VMS which are installed on a pole shall be protected by H2 type guard rails.

The H2 guard rail shall be connected to any potential guard rail existing or to be installed within 50 metres otherwise it shall be installed with a flare end.

4.3.4.4 Housing and Fabrication

VMS equipment shall operate under the following ambient climatic conditions:

- Minimum temperature: -30°C
- Maximum temperature: +60°C
- Relative non-condensing humidity: up to 100%

4.3.4.5 Specifications

The signboards shall be able to display the appropriate icons and text messages.

The signboards apply LED technology; brightness may be adjusted according to the time of the day and the weather conditions.

4.3.4.6 Interfaces

The VMS subsystem shallbe directly interfaced with the SCADA system.

4.3.4.7 Central Unit

The Central Unit shall be located in the technical room at the OMCs.

The decision support system (SCADA) for VMS runs on the central computer, the input data is provided by the central traffic management system. This decision support system is partly automatic; in certain traffic and weather circumstances it shall alarm the operator and automatically send display command to the particular VMS units.

Further more it shall provide functionality for the operator to manually set icon messages on particular signboards.

The user interface to be developed on the central computer shall allow for:

- All-time monitoring of the system with testing function
- Displaying all signal pictures actually set on any signboard
- Archiving all processes and retrievable

4.3.4.8 General VMS Functions

VMS remote control:

All signs and signals shall be remotely controllable from the traffic operators panel, and it shall be possible to individually turn all signs and signals on and off within the specified response times.

Override control:

It shall be possible for the operator to manually override any automatic control of the signs.

Control responsibility:

All VMS in a road segment shall only be controlled from a single traffic operator panel at a time. The operator ID, operator panel road segment, date/time etc. shall be logged.

Light Intensity Control:

Each VMS sign and signal shall be able to automatically adjust its display intensity in order to provide optimum visual effect under changing light and visibility conditions.

VMS response time:

Time delay between the command that the operator has issued to set or change the setting of a VMS sign and the system has changed, the status and reports the new condition, shall not exceed 3 seconds.

Status:

It shall be possible for the operator to view real-time operational status of the VMS systems and all its components. VMS and signals without control/command connection shall default to blank display.

Error handling:

If the control link between the central site and a sign is broken, the sign shall automatically display a blank screen.

4.3.4.9 Speed Control Function (SCF)

Speed control:

The speed control function (SCF) shall be implemented through the use of SCF signs capable of posting variable speed limit in kph.

Properties:

Each of the SCF signs shall generally have the ability to assume the following visual properties: 30, 40, 50, 60, 70, 80, 90 and 100 kph.

Cancellation of speed limit:

SCF signs for cancellation of the speed limit shall be provided. The cancellation signs shall display the cancelled speed limit and only be operational when a speed limit is in effect.

Signal control:

The SCF signs shall be controllable by the operator based on current traffic conditions.

Blanking:

It has to be possible to completely blank the signs.

Safety functions:

The SCF shall not allow the operator to set the SCF sign in a configuration which is not permissible by the approved general traffic control scheme in accordance with the Traffic Management Plan.

Predefined settings:

It shall be possible for the operator to define minimum 10 predefined settings involving all individual SCF signs settings and manually enforce these setting with a keystroke.

Safety lock:

If the control link between the central site and a sign is broken, the sign shall autonomously display a blank face.

4.3.5 Guidance System

The edges of the sidewalks shall be equipped with self-illuminating light modules for optimal detection of the road course.

The guidance system applies LED technology and the brightness may be adjusted according to the time of the day and the weather conditions.

4.3.5.1 Position

The light modules on the left sidewalk shall be provided with red LEDs and the light modules on the right sidewalk with white LEDs.

In the area of the entrance lighting the light modules shall be located in distances of 15 m each to other.

In the area of the interior lighting the light modules shall be located in distances of 25 m each to other. In the lay-bys no light modules shall be located.

4.3.5.2 Function

The light modules of the guidance system shall work normally in continuous operation.

In the case of an event (for example fire alarm or an accident) the guidance system shall be automatically switched to flashing mode.

For services in the tunnel the operator in the OMC shall also be able to switch the guidance system to flashing mode.

4.3.5.3 Housing and Fabrication

The covers and mechanical parts of the light modules must be resistant against the aggressive tunnel environment and must be passable by a truck tire.

4.4 CCTV Monitoring

The remote camera monitoring system constitutes a basic visual aid to operators located in the Control Centre in order to take the appropriate measures against incidents that may happen in the tunnel and in the area before and after the tunnel.

This system also allows the recording of different situations so it is possible to make a later analysis to prevent future incidents and give a better response.

The possibilities that a system with these characteristics offers are varied and of vital importance:

- To allow traffic monitoring: the vision of the traffic in the accesses serves as support for the operators to verify the real state of the traffic, either by direct observation, or like means of verification of possible erroneous information of other systems (automatic detection of incidents, etc.)

- To allow meteorological conditions monitoring: the vision of the surrounding area serves as support for the operators to verify visually the climatic conditions of the zone and their possible influence in the security of the drivers.

- To serve as support for the operators in operation conditions. In this sense, the direct vision is the only possible way of verifying certain circumstance (correct operation of a part of the system, validation of phases in a determined protocol of performance as closing of tracks, etc).

- To serve as support in the management of incidents. The video surveillance systems constitute one of the key elements in the control and pursuit of the different phases that follow one another when an incident happens: detection, verification, information, answer, works in field and cleaning.

4.4.1 CCTV-Cameras

4.4.1.1 Position

The surveillance cameras into the tunnel shall be installed on the tunnel wall and the cameras in the area before and after the tunnel are installed on a pole.

Data and video image shall be transmitted through the communications lines. To achieve this, transceivers and media converter shall be employed.

The Automatic Incident Detection cameras shall be fixed type located at distances less than 200 m each to other in the tunnel, providing 100% coverage of the carriageways.

As well inside the tunnel, PTZ cameras (pan, tilt, zoom) shall be provided to monitor the portals, lay-bys, emergency areas, tunnel ECUs and emergency exits, with a resulting image at the control centres of adequate size and resolution to enable the operator to correctly observe vehicles and people.

4.4.1.2 Interface

Video signal from the cameras shall be sent to concentration points using coaxial copper cables.

The connection between the camera and the control enclosure shall be a unique cable that will carry power, video signals and the data to position the camera.

Outgoing coaxial cable from the camera shall be changed to FO single mode cable in a pair of receiver-transmitter of Video and Data before being encoded by a MPEG4 encoder at the OMC.

4.4.1.3 Function

CCTV cameras shall be as follows:

- The cameras shall be equipped with colour CCD, and motorized zoom lense
- Cameras shall automatically switch over to black and white under poor lighting conditions
- The surveillance cameras shall be PTZ (pan, tilt, zoom)
- The system equipment shall be able to control the PTZ movement of cameras individually
- 24 hours automatic recording of video of all camera images
- The recorded camera images can be searched at any time together with the possibility of printing the selected image
- Saving must be in digital form in the central storage system
- Time display, single and multiple camera images with identification on a single monitor. The number of camera images displayed on the monitor and on the video walls shall be adjustable.
- The cameras shall be of tough, heavy-duty construction, with increased optical clarity.

4.4.1.4 Housing and Fabrication

- The video camera installations shall be easily identifiable
- The video camera installations shall be easily accessible for maintenance purposes
- The mounting and equipment housing shall be able to withstand adverse weather conditions and the video cameras shall be capable of working satisfactorily under worst case weather conditions
- Cameras shall have waterproof housing with heater
- Cameras and associated units shall be protected against water ingress and dust proof
- All cables and connections to the lense should be weatherproof
- The equipment cabinets must be located for ease of access for maintenance purposes. They must also be weatherproof.

Outdoor equipment shall operate under the following ambient climatic conditions:

- Minimum temperature: -30°C
- Maximum temperature: +60°C
- Relative non-condensing humidity: up to 100%.

4.4.2 Central Unit

4.4.2.1 Position

The Central CCTV system shall be located in the Control Room at the OMCs.

4.4.2.2 Function

The Control Room systems shall consist of a video wall, keyboard, joystick and a mouse as well as the digital recorder and viewing workstation. The video wall shall be configured to be capable of displaying multiple separate or individual camera outputs. Recorded images shall be stored on the digital recorder for at least 14 days. System shall be capable of archiving the recorded images to hard disk drive or DVD.

The CCTV control system shall provide the following reporting functions.

- Multiple camera displays for live viewing or playback while recording
- High-speed searching (date, time and alarm)
- Playback by date, time, and camera

4.4.2.3 Housing and Fabrication

Indoor cameras shall operate at the following ambient conditions:

- Temperature; +5°C to +30°C
- Relative humidity: up to 80%

4.4.3 CCTV Operator Functions

Viewing facility:

A viewing facility to allow the operator to simultaneously view the same camera images from at least two separate locations shall be supplied. This facility shall be installed in the control room and the emergency control room.

Selection of camera:

It shall be possible for the operator on duty at any time to select a view from any CCTV camera to be displayed on any selected viewing facility.

CCTV response time:

The time, from an operator has issued a command to view the images from a specific location until these images are provided on the viewing facility, shall not exceed 2 seconds. The same response time shall apply when an automated system requests images from a certain camera to be presented.

Control delay:

The camera function shall be interactively, remotely controlled by the operator on the basis of the monitor view in such a way, that tuning can take place quickly and safely. For example delays shall not have detrimental effects on the control.

Images ID:

Images shall automatically be supplied with camera ID, operator ID, location name/viewing direction, day, month, year, hour, minute and seconds, and this information shall be visible on the images. The operator shall be able to remove this information during viewing.

Automatic camera selection function, inside the tunnel:

The CCTV function shall be automatically activated upon the occurrence of any of the following events in the tunnel, and shall automatically record and show on the viewing facility the images of the activated area from the two nearest CCTV cameras:

- Opening of any emergency door
- Operation of a fire alarm push button
- Operation of an emergency push button
- Removal of fire fighting equipment
- Incident detected by Vehicle Detection Function (VDF) and Incident Detection Function (IDF)

This control function shall have certain priority functions related to the normal camera and image control.

The occurrence of any of the above events shall also activate a visual and audible alarm to the operator.

Automatic camera select function outside the tunnel:

The CCTV function shall be automatically activated by the occurrence of any of the following events outside the tunnel, accompanied by a visual and an audible alarm to the traffic operator, and automatically record and show on the viewing facility the images of the activated area from the two nearest cameras:

- Alarm from the over height vehicle detection function
- Operation of an emergency push button of an emergency call column (ECC) on the tunnel approach ramps

4.4.4 Incident Detection Function (IDF)

Incident:

The IDF shall continuously and automatically detect anything out of standard situation, i.e. vehicles on hard shoulder, stopped vehicles or objects in lane and transverse or inverse moving objects (ghost drivers, persons, leaves, debris etc.) occurring in or near the tunnel, on the specified road segment and on the associated hard shoulder areas, and automatically alert the operators of such incidents.

4.4.4.1 Functional Requirements

Object definition:

An object to IDF identification is any object, which may cause dangerous situations involving personal injury or damage to property.

Incident detection:

The IDF shall be able to continuously identify the following conditions on the applicable segments:

- Any new objects on a hard shoulder. New is identified as an object that was not previously accepted by an operator
- Slow moving objects in lanes (V < 15 kph)
- Queues of objects in lanes (V< 5 kph)
- Stationary objects on lanes (V=0 kph min. time 3 seconds)
- Inverse moving direction of objects (Ghost drivers)
- Smoke or fog presence in the tunnel

Location data:

Such incidents shall be reported to the operator, with information of incident location and camera identification.

Reaction times:

Reaction times for the IDF shall be adjustable and decided upon during operational trials, but the IDF shall generally react within:

- 5 seconds for stopped objects and vehicles
- 30 seconds for queues and slow moving vehicles
- 30 seconds for smoke or fog detection
- Less than 3 second for ghost drivers

4.4.4.2 IDF Operator Functions

Presentation of incidents:

The IDF shall perform the detection and where an incident is detected the operators shall automatically be presented with real time CCTV images of the area of the incident.

4.5 Emergency Call System (ECS)

The Emergency Call System shall consist of roadside units (emergency call columns ECC) installed on both portals and tunnel units, providing two-way communications between the ECCs and the Central Monitoring Unit located at the Traffic Control Rooms at the OMCs.

All components have to be provided, installed und put into operation.

4.5.1 Emergency Call Column (ECC), Open Road Unit

The emergency call columns (ECC) shall provide hands free communications activated by a single push button for ease and simplicity of operation by the road user. Clear operating instructions shall be affixed to the ECC housing by means of pictograms.

4.5.1.1 Position

ECCs are required at the beginning and end of the tunnel.

The ECC sites shall be suitable for use and access by disabled wheelchair users.

ECC sites shall be protected by road-side guard rails, which shall be opened for Motorway users for proper access to the call box.

A hard standing shall be provided around the ECC, which shall be provided by the Construction Contractor.

The call boxes shall be additionally equipped with shields to protect both the ECC and the user from snow clearing operations and materials thrown up by passing vehicles on the Motorway.

The microphone and speaker of the ECC shall be placed on the call box side opposite to the carriageway in order to provide the user with more security, and to provide clearer sound.

4.5.1.2 Function

The ECC shall provide full duplex voice communication between Motorway users and the operator located at premises of the Motorway Police Station.

The ECC shall provide for clear, full duplex communications with effective suppression of background noise at the call box.

Each call box shall have a unique site identity code both visible for the Motorway user and displayed on the Central Monitoring Unit GUI.

The ECC unit shall be designed to provide the following functions:

- A motorist pushes the call button to initiate a call at the ECC.
- The motorist hears a ring tone if the call is successfully initiated. Otherwise an out of order tone/voice must be generated.
- A ringing tone at the operator handset shall indicate that the call has been received.
- The call shall be received and indicated at the Central Monitoring and Control Unit (also referred to as Central Unit) by an audible tone and simultaneously on the Graphical User Interface (GUI) display, with the calling ECC icon changing its colour. Depending on the scale a zoom-in on call location is provided, the system shall zoom in on a zone where a call has been made.
- The connection shall be established once the operator lifts the telephone handset at the Central Unit. The operator can then converse with the caller.
- Simultaneous calls shall be displayed on the GUI by flashing icons of the new calling station. The operator can put the current call on hold by a simple mouse click on the GUI, or the current call can be terminated and the next call handled.
- Upon completion of the call, the operator disconnects the call and classifies the call in one of several options available on the GUI.
- The ECC shall allow the operator to transfer the call to a public switched telephone network line.

The ECCs shall be equipped with the following:

- Weatherproof speakers installed inside the call box, mechanically protected by the grating on the ECC housing. The user will hear the operator’s voice from this speaker.
- A microphone installed inside the call box, mechanically protected by the grating on the ECC housing. The microphone shall be installed near the speaker to provide the user with comfort and support him talking at the same position, where the operator can be best heard.

- A push button installed in the close proximity of the microphone and speaker. The button shall be pushed once, and the call control and conversation will be carried on in a hands-free manner.
- Pictograms describing the usage of the ECC.
- The ECC shall house the call control and communication module. It shall handle the speaker, push button and microphone, and shall also manage communication with the Central Monitoring and Control Unit.

4.5.1.3 Housing and Fabrication

- The ECCs shall be resistant to environmental conditions, robust, vandal proof and tamper protected.
- The colour of ECCs shall be maintained for the period of the life cycle of the equipment.
- The system shall be designed to provide for diagnostic interrogation of the remote ECC units.
- The housings are designed to provide for ease of access for physical maintenance procedures.
- The equipment housings are provided with secure fasteners and locks to prevent unauthorised access.
- The design of the system is modular enabling ease of access to carry out maintenance.

4.5.2 Emergency Call Unit (ECU), Tunnel Unit

The manufacturer of the tunnel ECUs equipment is recommended to be the same as that of the Open Road ECCs.

4.5.2.1 Position

The tunnel ECUs shall be installed in tunnel niches to enable the motorists to speak to an operator at any OM-centre.

Locations of the niches will be on the side of the cross passages at 125-meter distances.

Additonal ECUs are located at the lay-bys on the other side at 750-meter distances.

Illuminated signs (or pennant signs) will indicate the locations of the emergency phones for the motorists.

4.5.2.2 Function

Emergency calls shall beinitiated by pressing the push button of the ECU. Pressing the emergency call button will cause:

- the indicator LED to flash in order to confirm the call
- issuing of an appeasement message
- an automatic dial-up the operators phone at the assigned OM-centre (no need for the user to dial a number manually)
- audible and visible warning for the operator by means of ECS GUI and loudspeakers
- identification of the location of the call on the synoptic layout of the tunnel
- optionally, interfacing with the CCTV for automatically displaying camera images to predefined screens (monitors and GUI)

Opening the door of the booth (door open contact) shall trigger an alarm at ECS GUI for the operator.

Handling of calls and operators interaction is the same as it is described in the Open Road section.

4.5.2.3 Performance

The ECU shall allow for immediate call initiation upon pressing the push-button. The call shall then be answered or put on the waiting calls list by the operator according to the current status of the ECS.

All ECS equipment (central and peripheral) shall be connected to uninterruptible power supplies (Tunnel-UPS).

4.5.2.4 Housing and Fabrication

The tunnel ECUs shall be constructed as hands free equipment that provides a speaker, a microphone near the speaker, and operating instruction labels for the user.

All user-accessible equipment shall be of a rugged design, vandal resistant and includes tamper detection and alerting.

Secure fasteners and locks shall prevent unauthorized access to the electronic equipment.

Components shall be clearly identified and labelled (approval prior to labelling).

The emergency call system shall be based upon VoIP communication protocol.

Emergency phones shall have the capability of self-diagnostics based upon continuous periodic interrogation of the phones (checking of loopback test-signals).

Phones shall be designed to enable intelligible conversation at the prevailing noise levels by means of:

- automatic active noise reduction
- automatic active echo cancellation
- automatic digital voice amplification
- noise suppression algorithms

The ECBs shall operate under the following ambient climatic conditions:

- Minimum temperature: -30°C
- Maximum temperature: +60°C
- Relative non-condensing humidity: up to 100%

4.5.3 Emergency Push Buttons

The emergency push buttons are shall be installed into all emergency call units (tunnel niches).

They provide potential free alarm contacts (opening contacts) and are monitored according to the principle of quiescent power.

The buttons are also illuminated (continuous light). In case of alarm the devices must be switched to a flashing light. After acknowledgment by the operatore the lights must be switched back to continuous light.

4.5.4 Central Monitoring and Control Unit

A central monitoring unit shall manage the full ECS network. The software (source code) has to be provided for future changes.

4.5.4.1 Position

Two operator positions shall be provided for the use of the Motorway Operator at each OMC. Any operator can answer a call.

Central Monitoring and Control Unit shall be composed of active equipment such as appropriate communication gateways, operator workstations and telephone sets. These shall be located at the OMCs.

Operator stations, printers and telephone sets shall be located in the Traffic Control Room at the OMC.

4.5.4.2 Function

A computerised visual schematic of the installed units shall indicate the current status of each remote ECU i.e. active, standby or faulty. The central unit shall instantly detect the call box from which a call or alarm originated, and allow the call to be answered immediately if no other calls are in progress. It shall be capable of handling multiple calls and provide for call holding and call queuing.

The central monitoring unit shall be provided with administrative functions in terms of system configuration, fault notification and audible alarms, message traffic and statistical information. It shall output all incidents and events to an audit printer. Self-test diagnostics features shall be applied to test call boxes for correct operation.

Two-way communications between the traffic controller and each roadside unit shall be recorded digitally and retained for at least 6 months on a data storage device suitable for selecting and replaying any recorded conversation. The date and time of calls, faults and incidents are to be registered on the central monitoring unit. All calls and general alarm conditions shall be logged in a database.

The system diagnostic utilities are designed to check the operational functionality of any individual emergency call box in the system at a regular defined interval or as a deliberate query.

When an ECU is to be checked, the central monitoring unit shall initiate a call to that unit. After establishing the call, it shall send various queries to the ECU to check its health status. The ECU shall receive the query, decode it and send the appropriate reply to the central monitoring unit based on its present status. These replies from the ECU are stored in the central database with time, date and ECU ID stamp. If an

ECU fails to respond to the query or the call could not be established to the ECU, then that particular ECU is marked as faulty. The appropriate message is displayed on the console and the database is updated with the status of the ECU.

The diagnostic test for each ECU in the system is performed automatically at a defined time, normally twice a day. In addition, the operator at the Central Monitoring Unit using the system GUI can also perform these interrogations as an ad hoc on-demand enquiry.

General system failure is reported if a central unit initiated call is not responded to.

The real-time software of the operator station:

- Manages calls from the ECUs: talking to an ECU that is already involved in a call, placing on hold, call release
- Permits to manage several simultaneous calls by means of placing the call on hold
- Calls an ECU
- Tests an ECU: phone quality and status of the battery
- Displays alarms from the various components of the ECS (gateways, ECU, etc.).

The operator station comprises:

- 1 PC, which acts as the main ECS Server and includes a GUI for the Operator Station.
- 1 monitor screen
- 1 keyboard
- 1 mouse
- 1 telephone set on IP network
- 1 loudspeaker connected to the sound card of the PC
- 1 printer connected to the parallel port of the PC
- 1SWITCH/HUB (IP local Ethernet network) for interconnecting the operator station, the gateway and IP phone.

4.5.4.3 Performance

The ECS Central Monitoring and Control Station shall manage an arbitrary number of concurrent calls by means of immediately answering incoming calls and setting up lists of waiting calls put to hold. The voice communication and voice recording shall be performed in real-time (so that human users cannot experience any delay in voice processing).

4.5.4.4 Housing and Fabrication

Gateways of the ECS shall be standard 19” rack mountable units to be placed in the rack cabinet located at the Server Room of the OMCs.

Operator station elements shall be manufactured by a reputable manufacturer and shall be installed on the built-in operator desk/counter.

4.6 Communication Systems

The following communication systems shall be installed:

- Tunnel Radio System
- Internal Telephone System
- Sound System

4.6.1 Tunnel Radio System

The maintenance radio equipment shall be located at the OMC server rooms, as well in the tunnel niches.

Radio towers shall be erected near the OMC buildings; they shall hold the necessary antennas to cover the Open Road communications.

In the tunnels leaky cables shall be provided mounted on the top of the tunnel bore.

The maintenance radio system shall cover the tunnel project and additional 5 km distances at the end of the sections.

The radio system shall cover the following needs:

- Maintenance Radio
- Emergency Service Radio
- Public Radio
- Cellular Phone

4.6.1.1 Maintenance Radio

The maintenance radio system shall cover the whole tunnel, all rooms in the service buildings, and the two control centres (main control centre and the reserve control centre). In the two control centres fixed radio equipment shall be installed.

Terminal portables (transmitter-receiver) shall be provided for maintenance workers who shall be on the highway, in the tunnel or in the service buildings.

4.6.1.2 Emergency Service Radio

The radio system shall re-broadcast all the frequencies for the emergency services in the tunnel.

The radio communication for emergency services shall also cover the control centre and the service buildings.

The emergency services concern the fire brigade, the ambulance and the police.

Contact and coordination with the concerned services and compliance with their requirements will be made during the Design and Construction phase.

4.6.1.3 Public Radio

A public radio broadcast breakthrough system and a public address system shall be provided in the tunnel.

In the two control centres, a system to insert messages on the FM band shall be installed.

This system shall allow the operator to break-in the FM re-broadcast and to send safety messages.

The operator shall be able to announce a specific message or a pre-recorded message.

The radio system shall be able to re-broadcast up to 5 radio channels.

Radio frequencies shall be determined later during the Design and Construction phase with the relevant authorities.

4.6.1.4 Cellular Phone

Facilities for re-transmission of signals for at least 4 (four) cellular telephone service providers shall be included.

It concerns the prerequisites for installation of re-transmission equipment to the service providers.

This shall include but is not limited to mounting facilities for antennas, cable paths and furnished equipment rooms with electricity supply, air conditioning and other required installations. The costs of re-transmission equipment -including electricity costs –are not included in our scope of work, so these shall be covered by each service provider respectively.

4.6.2 Internal Telephone System

An internal telephone system, based on VoIP technology, shall be employed to ensure reliable, cost effective communications for staff at all locations.

Each control centre shall be provided with telephone system that enables telephone communication between each control centre including the tunnel control centres.

It shall also enable operators to access the public switched telephone network and provide direct dial facilities to emergency services and other key numbers.

4.6.3 Sound System

The sound system (amplifier and speaker system) is used for transmitting signals and announcements in the driving area, in the egress tunnel and in the area of the tunnel portals.

4.6.3.1 Position

Speakers in the tunnel shall be installed on the tunnel wall and the in the area before and after the tunnel are installed on poles. The amplifiers shall be situated in tunnel niches.

Speakers shall be situated:

- at each lay-by
- at the tunnel portals
- in the egress tunnel
- in the open field next to the over height vehicle detection

4.6.3.2 Function

In the two control centres a system to generate signals and announcements for the sound system shall be installed.

The system shall be able to address the speaker locations individually or in groups.

4.6.3.3 Housing and Fabrication

Components of the sound system shall be standard 19” rack mountable units to be placed in the rack cabinet located at the Server Room of the OMCs or in the tunnel niches.

Sound system equipment shall operate under the following ambient climatic conditions:

- Minimum temperature: -30°C

- Maximum temperature: +60°C
- Relative non-condensing humidity: up to 100%

4.7 Fire Safety Equipment

All tunnel services buildings, buildings with control room and rooms with electrotechnical equipment shall be equipped with a fire detection system.

The following equipment shall be provided in the tunnel:

- Linear heat detection (main and egress tunnel)
- Manual call point fire alarm according to the EU standard

All these fire detection systems shall be connected to the fire alarm centre . As soon as a fire is detected, an alarm and location information shall be sent to the operator.

For the tunnel, linear heat detection system shall provide the location of the fire, a relevant scenario shall be automatically proposed to the operator.

4.7.1 Fire Alarm System in buildings

In OMCs, in the ventilation cavern and in rooms with electrotechnical equipment there shall be ionisation smoke detectors installed.

In addition manuel fire alarm push buttons shall be installed at all exits of this buildings.

The fire alarm centre should be situated in the OMC and connected to the SCADA system.

4.7.2 Automatic Fire Detection System in the tunnel

For the Linear heat detection in the tunnel there shall be a linear fire detection cabling mounted on the ceiling of the tunnel. The maximum measuring point distance in the tunnel longitudinal direction shall not exceed 10m. The sensors shall be summarized in reporting sections. Controller units and amplifiers shall be installed in the tunnel niches.

In the case of a line break or failure of a control unit a maximum of 1000m length monitoring is allowed to fail.

The same system shall be installed in the main tunnel and the egress tunnel.

The linear heat detection systems shall be connected the SCADA system through its own control system. Specific views on the SCADA system shall be developed to assume a complete monitoring and remote controls.

4.7.3 Emergency Telephone Niches

Emergency call niches shall be located according to the EU standard in the tunnel at distances less than 125 m each to other in the tunnel and in all lay-bys.

The emergency points shall have the following equipments:

- Fire Alarm Push Buttons
- Fire extinguisher

Manual Fire Alarm Push Buttons and portable fire extinguishers shall be at the drivers' disposal. This equipment shall be monitored by the SCADA through the Fire System Control Unit.

A telephone shall be also installed at the emergency call niches (see description in the relevant chapter).

4.7.4 Hydrants and Hydrant Niches

Hydrants with firefighting water shall be installed on both portals and in the hydrant niches in the tunnel.

The firefighting water will be provided by a water reservoir building at the east portal of the tunnel. The water level shall be monitored by the SCADA system. If the water level falls below the minimum level an alarm is displayed in the OMC.

Hydrant niches shall be located according to the EU standard in the tunnel opposite the emergency call niches also at distances less than 125 m each to other in the tunnel and in all lay-bys.

The Hydrant niches shall have the following equipments:

- a connection for the water hose
- Lighting (switched by a door opening contact)
- sockets combination for power supply

4.7.5 Fire Extinguishers

Portable fire extinguishers shall be installed in the tunnel at each emergency niches. Removal of a fire extinguisher at the emergency niches shall trigger an alarm to the SCADA system.

Additional extinguishers shall be provided in the service and control buildings, in the medium voltage cell rooms and in the transformer rooms. Portable extinguishers shall be suitable for use on all types of fire.

4.8 Tunnel Lighting Systems

The Tunnel Lighting System shall cover the following needs

- Entrance Lighting
- Interior Lighting
- Lay-bys Lighting
- Egress tunnel Lighting
- Street Lighting
- Luminance Measurement
- Escape Direction Lamps
- Evacuation Route Lamps
- Evacuation Route Signs

The lamps of all lighting segments except the street lighting are installed into the inner area of the tunnel.

All covers and mechanical parts should be resistant against the aggressive tunnel environment.

4.8.1 Entrance Lighting

The adaptable lighting serves the driver in entering the inner area of the tunnel without a drastically change of lighting intensity on the cross border between open area highway and the first part of the tunnel.

The calculation of the intensity of lighting should be calculated for the maximum projected speed inside the tunnel (80kph).

The entrance lamps shall be situated centered above each lane driveway.

The entrance lighting shall be regulated in 9 steps:

Step 1	100%
Step 2	87,5%
Step 3	75%
Step 4	62,5%
Step 5	50%
Step 6	37,5%
Step 7	25%
Step 8	12,5%
OFF	0%

The adaptable lighting sections are symmetrical on both entry parts of the tunnel.

4.8.2 Interior Lighting

The interior lighting or main lighting covers the internal area of the tunnel between two sections of entrance lighting near both entries.

The calculation of the intensity of lighting depends on the tunnel profile and the projected speed in the tunnel.

The interior lighting is 0.5 m away from the center of two lanes on the second lane, located at the tunnel ceiling.

The interior lighting together with all additional lighting segments are controlled by their own Lighting Control System and report to SCADA the actual status of the lighting module of the tunnel.

In the tunnel, Emergency and Fire lighting support the drivers when the main lighting system is not in operation.

In these situations, the speed of the traffic is limited and the lighting intensity will be lower.

4.8.3 Lay-bys Lighting

The lay-bys shall be provided with lighting. There shall be the same lights as the interior lighting.

To increase the attention of the driver in the lay-bys the light density level shall be elevated (different luminous color and stronger bulbs).

4.8.4 Egress Tunnel Lighting

The egress tunnel and the cross passages shall be provided with lighting. There shall be the same lights as the interior lighting.

The calculation of the intensity of lighting shall be determined later during the Design and Construction phase with the relevant authorities.

The interior lighting is 1.0 m away from the center of the lanes located at the tunnel ceiling.

4.8.5 Street Lighting

The street lighting shall be build over a length of 200m before and after the portals of the tunnel.

The calculation of the intensity of lighting shall be determined later during the Design and Construction phase with the relevant authorities.

The street lighting is provided with pole lamps. The lights are mounted on 10m high poles.

The control of the street lighting is via the external luminance measurement and a time program. The actual status of the street lighting shall be reported to the SCADA system.

4.8.6 Luminance Measurement

The interior lighting together with the entrance lighting are controlled by their own Lighting Control System. The control of the lighting depends on the external luminance and the luminance in the tunnel.

For detecting the luminance luminance cameras shall be used. The luminance cameras in the tunnel shall be installed on the tunnel wall and the cameras in the area before and after the tunnel are installed on poles.

In the event of a failure of a luminance camera the value from the luminance camera from the other tunnel portal shall be used. If both luminance cameras fail, the lighting is controlled via a time program.

The actual status of the street lighting shall be reported to the SCADA system.

4.8.7 Escape Direction Lamps

At every cross passage internally illuminated escape direction lamps shall be installed on the tunnel wall above the exit.

The escape direction lamps shall be powered by UPS.

4.8.8 Evacuation Route Lamps

Internally illuminated evacuation route lamps shall be installed on the tunnel wall on the side of the emergency call niches.

Evacuation route lamps shall be located in distances less than 50 m each to other or to the next emergency call niche. The mounting height of the lamps is 1.0 m above the sidewalk.

The evacuation route lamps shall be powered by UPS.

4.8.9 Evacuation Route Signs

Evacuation route signs shall be located according to the EU standard in the tunnel opposite the evacuation route lamps also at distances less than 50 m each to other.

The mounting height of the signs is also 1.0 m above the sidewalk.

4.9 Integrated Tunnel Control System - SCADA

The Traffic Control and Monitoring System – SCADA (Supervisory Control and Data Acquisition) shall be able to interact with all Open Road and Tunnel FOE.

4.9.1 Monitoring System Configuration

The Control Monitoring System (CMS) will offer the operators the means to control and monitor Open Road and Tunnel Technology equipment (ITS and M&E systems) from the control rooms and locally (automatically) in the tunnel.

The SCADA will help the operators to control and monitor all technology on the highway including the tunnel technology by showing the status of equipment, giving the possibility to control them and also by proposing automatic functions.

The overall TCS system shall be provided with a video wall which makes it possible to carry out all the monitoring and control functions required for safe traffic conditions on operated motorway route in case of a total failure of the SCADA system.

This video wall shall be located in both Control Rooms at the east portal and the west portal so that the monitoring and control function can be carried out in a safe and ergonomically acceptable manner.

The Main Control Centre shall be located in the west portal OMC, and the secondary Control Room shall be located east portal OMC.

4.9.1.1 Monitoring Requirements to the SCADA System

The system shall enable operators to monitor the tunnel and receive information that enables decisions to be taken and actions made for controlling and influencing traffic behaviour or mobilising appropriate responses in order to increase safety and efficiency in the operation of the tunnel.

Monitoring of the tunnel shall be achieved using a variety of information sources including the use of traffic monitoring outstations (Overheight Vehicle Detection), CCTV cameras and emergency roadside columns).

The monitoring shall be used to support the identification of a range of situations that potentially reduce safety where action may need to be taken including:

- Accidents or other incidents on the carriageway
- Recurrent or non-recurrent congestion

- Broken down vehicles on the hard shoulder
- Adverse weather or visibility conditions
- Debris, animals or other unusual objects on the road
- Damage to road infrastructure
- Other unusual or unexpected events

Decision making shall be based on the information gathered from these sources. The system shall support both manual decision processes and semi automatic and automatic processes. Safety functionality, commensurate with the type of support systems provided, shall be included in the decision support facilities to ensure that consistent and safe responses are made. The decision support process shall as far as possible determine the scope of the event identified, the effect on road capacity, the expected duration of the event.

4.9.1.2 Functional Requirements to the SCADA System

The SCADA system shall as a minimum be provided with the following Man-Machine Interface (MMI) equipment at the Control Centres:

- Two operator stations equipped with the technology required. The two operator stations shall function independently of each other so that two operators can work concurrently. It shall be possible to carry out all monitoring and control functions by means of one operator station.
- Event log printer to provide a hard copy of all events and commands issued.

4.9.1.3 Availability of the SCADA System

In general, any switching or reconfiguration that is required in order to uphold the functionality of the SCADA system in case of a fault shall be executed automatically with no noticeable effect to the operator.

No data shall be lost in case of a sudden failure.

4.9.1.1 SCADA System Interfaces

The SCADA System shall be able to interact with external systems and organizations:

- ITS-subsystem and M&E-subsystem

- ITS / M&E-operator
- Police and Fire Brigade
- Vehicle Drivers
- Emergency Call System

4.9.2 Performance and Requirements of IT-equipment

Operation shall be straightforward and easily understandable by suitably trained, non-technical personnel with “help” frames for guidance of operators.

The system shall be able to restart automatically after a power failure without the need for specialist operator intervention provided that the system shut down procedure has been performed successfully.

It shall be safeguarded against accidental loss of data.

All systems access shall be controlled with a login and password for every user.

The central unit shall be based on a redundant server with multiple workstations and multitasking operating systems.

4.10 Doors and Gates

All doors and gates in the buildings and in the tunnel shall be delivered and installed.

This includes:

- doors and gates in the control centres
- doors and gates in the ventilation buildings and in the ventilation cavern
- doors to the emergency call niches
- doors to the hydrant niches
- doors to the power supply niches
- doors and gates to the cross passages
- doors and gates to the egress tunnel

All doors and gates in the tunnel shall be equipped with a door opening contact. Opening any door shall trigger an alarm to the SCADA system.

Larger doors shall be fitted with an electrical drive. These gates shall be operated with a key switch on the spot or by the operator from then OMC.

All doors and gates in the tunnel shall be resistant against the aggressive tunnel environment (stainless steel).

4.11 Building Installation and Equipment

In the control centres, in the ventilation buildings and in the niches in the tunnel the electrical installation has to be made and the equipment has to be delivered.

These services include:

- lighting installation
- emergency lighting
- outlets installation
- air conditioning and ventilation
- computer cabling
- lightning protection system
- cable trays, raised floor
- furnishing

In the control rooms the lighting must be suitable for computer workstations.

5 INSTALLATION REQUIREMENTS

This section covers the minimum requirements of the works with respect to the manufacture, supply, installation, jointing, terminating and connecting of power, control, instrumentation, communications and earthing cables, the supporting and support materials required for the cabling and equipment installation in the tunnel and in the buildings.

5.1 Installation Drawing Design Approvals

All installation drawings are required to be submitted to the client for their comment.

These shall include but not be limited to all electrical and network installation designs and aboveground structures.

Notwithstanding these comments, which shall be taken into account, the FOE contractor shall be required to ensure that all designs for any part of the installation and equipment have met with all the requirements for approvals by the regulatory authorities of India and any comments given by the client shall not relieve the FOE contractor of any obligations in terms of the statutory and regulatory requirements.

5.2 Electrical Design Requirement

The FOE contractor shall be required to design the power reticulation system for the tunnel management system, which shall include for the cabling, distribution boards, power supply units and equipment earthing system.

The detail for the design of equipment shall include for the equipment sizing, capacity, fault levels and operational requirements of the electrical equipment to be supplied by others and interfaced to the FOE.

5.3 Network and Communications Design Requirement

The FOE contractor shall be required to design the data communications network for the entire FOE and TCE system at the LAN level, and on the communication backbone.

The design shall cover the data communications systems, video signals, control signals and voice communications.

The design shall include for the sizing capacity of the network and communications equipment to meet the performance and operational requirements.

5.4 Cables and Cabling Materials

The FOE contractor shall be required to design the cable installation for the system to meet the performance criteria of the system and to comply with all local and national regulations and legislation.

As a minimum requirement the cables shall comply with the following.

5.4.1 Low voltage P.V.C. Insulated Copper Cables

All P.V.C. insulated cables shall be multicore P.V.C. insulated, P.V.C. sheathed, galvanized steel wire-armoured and P.V.C. covered 660 V graded cables of Heavy Duty or General Purpose type.

5.4.2 Low voltage P.V.C. Insulated Aluminium Cables

The cable supplied and installed shall be of solid aluminium conductor, P.V.C. insulated, P.V.C. bedded, aluminium strip armoured and black P.V.C. overall sheathed.

5.4.3 Instrument Cables

All instrument cables required for data communications shall be of P.V.C. insulated stranded or solid copper wire (as specified) in twisted pairs with surface printing on one core of each pair for circuit identification, tinned stranded copper drain wire per pair and each pair and drain wire screened with a helically applied metal-polyester laminate tape (Aluminium-Mylar).

Single pair cables shall be given an outer jacket of P.V.C. for mechanical protection and multi-pair cables shall be given an overall Mylar screen and an outer PVC jacket.

Where cables are installed on open cable tray/racks or are buried in cable earth trenches, the cable shall be given a steel wire armouring and P.V.C. outer jacket.

All instrument cables shall be provided with a stripping cord between the outer Mylar screen and the jacket to facilitate removal of the jacket.

5.4.4 Communication Cables

Communications cables shall be in accordance with the applicable national standards for telecommunications with the added requirement of steel wire armouring and P.V.C. outer jacket when specified for direct burial in earth cable trenches or installed on open cable tray/racks.

5.4.5 Data Communication Cables

Communication cables for local area networks will be category 7, standard Unshielded Twisted Pair (UTP) fordistances of less than 100 m. Category 7 certification and testing shall be required. For connection lengths of greater than 100 m or where the connection points are not within the same civil structure, fibre optic cable shall be used.

5.4.6 Fibre Optic Cables

All data, voice and video communications shall be via fibre optic cables.

For cable lengths of less than 1500m (one thousand five hundred metres) the fibre optic cable may be of the multi mode format having a core diameter of 50 micron and a cladding diameter of 125 micron with a tolerance of 3 micron.

The core shall be manufactured of Silicon Oxide. Where the cable lengths exceed the limits for multimode cables, the FOE contractor shall design for single mode cables and associated equipment. The FOE contractor shall ensure that all fibre optic cables have 100% spare cores.

Where the fibre optic cable is to be installed in earth trenches, the FOE contractor shall supply and install a suitably sized high density polyethylene (HDPE) duct with draw wire and shall install the cable in the duct.

Where draw pits are required, these shall be prior-approved by the FOE Contractor and shall conform to all requirements dictated by the main civil and structural engineering requirements for the plaza.

5.5 Cable lugs and ferrules

All cable lugs and ferrules shall be correctly sized to contain each and every strand of the cable conductor to be connected or terminated.

5.6 Cable Supports

The FOE contractor shall be required to provide and install all cable supports for all cables required for the system.

5.6.1 Cable tray

The FOE contractor shall provide perforated cable tray fabricated from a minimum thickness of 1.2 mm mild steel sheets and having a minimum turn up at the sides of

60 mm. The perforations shall run lengthwise and the fabricated tray shall be hot dipped galvanized.

Any inter-section of a section of the cable tray shall be made with prefabricated transition sections only, i.e. right/left hand bends, vertical bends or tee-sections.

Any damage to the galvanising shall be restored by an approved method and no sharp edges shall be permitted that could damage cables or injure persons.

The cable tray sections shall be bonded together with appropriately sized earthing straps of suitable material to prevent any galvanic or electrolytic action.

5.6.2 Cable racks

Cable racking shall be fabricated from rolled strip mild steel welded to form a ladder configuration.

The construction shall ensure adequate rigidity of the racking under full loading conditions and shall not permit any noticeable deflection of the installed racking to exist. The fabricated sections shall be hot dipped galvanized.

The transitions to different planes or intersections with runs of racking shall be by means of prefabricated transition sections of correct radius for right/left hand bends, vertical bends, tee-sections or changes in racking width.

5.7 Earthing

The FOE contractor shall be responsible for the design, supply and installation of the earthing of all electrical and electronic components of the supplied FOE.

5.8 Cable numbering

All cables installed by the FOE contractor shall be numbered in accordance with the universal cable numbering system.

5.9 Cable testing

All cables shall be tested to the relevant and applicable specification, before connecting up and before backfilling of cable earth trenches commence.

5.10 Cable Installation

Cables are to be installed in pipes or ducts and in cable saddles or cable trays.

Each end of all cables shall be provided with a cable tag as specified. All cables shall be run off drums such that the cables are always laid head to tail.

All drawing of cables shall be carried out in accordance with good practice using rollers, winches, etc., and all precautions taken to prevent damage to the cables.

Temporary provisions shall be made to all sharp edges to prevent any damage to the cables.

5.11 Cable Joints and Terminations

The jointing of cables throughout the installation shall not be permitted unless the length of the cable between two consecutive termination points of the cable is greater than the manufactures standard drum length.

Where cables are damaged or become faulty, these cables shall be removed and new cables laid.

6 ACCEPTANCE TESTING AND APPROVALS

This section covers the minimum requirements for system functional and performance testing, mechanical, electrical, electronic testing of hardware, and computer software testing.

The FOE contractor shall be required to submit a number of documents that record the status for the process relating to equipment and system interfaces, approvals, drawings, prototypes and system developed reports to the client for their comment.

The FOE contractor shall be also required to supply all test equipment necessary to prove compliance of the system to the requirements of the specifications. In addition, the FOE contractor shall supply all site test equipment and tools.

7 DOCUMENTATION

The FOE contractor is required to supply and develop the following general types of documents:

- As-Built documentation
- Functional Analysis
- Installation Method Statements
- Technical Specification
- Acceptance Tests Procedures
- User Manuals
- Maintenance Manuals

The FOE contractor shall develop the documentation in English language.

The documentation shall be in the Microsoft Word ® and PDF printed format.

8 MAINTENANCE AND SPARE PARTS

The FOE contractor is required to ensure that the system is maintainable throughout its useful life.

Therefore it is required to supply a sufficient stock of spare parts to support the system. The FOE contractor shall be fully responsible for the repair and replacement of all equipment.