PARTICULAR SPECIFICATION

APPENDIX AH

REQUIREMENTS FOR THE INSTALLATION OF NEW TEMPORARY TRAFFIC MONITORING SYSTEM

REQUIREMENTS FOR THE INSTALLATION OF NEW TEMPORARY TRAFFIC MONITORING SYSTEM

CONTENTS

1 INTRODUCTION

1.1 This section describes the scope of works and requirements for the Contractor to install temporary Traffic Monitoring System which includes the Portable Variable Message Sign Sub-System (PVMSSS) and Surveillance Camera Sub-System (SCSS).

1.2 All sections of this contract are to be read as complementary to each other and clauses occurring in one section shall be taken into consideration in another, whenever they are applicable.

2 GENERAL

2.1 All equipment shall have a useful life of at least eight (8) years throughout the Contract period. The equipment shall be designed to operate continuously 24 hours a day and 7 days a week.

2.2 The Contractor shall submit design document for the Authority's approval before procurement of all equipment. The proposed location of the new equipment shall be submitted to the Authority for approval.

2.3 The Contractor shall engage an approved subcontractor with relevant experience and track record to perform the installation of new Traffic Monitoring System. The engaged subcontractor shall be subjected to the approval of the Authority.

2.4 The Contractor shall ensure that all new surveillance cameras installed at the locations / junctions shall provide unobstructed coverage with minimum distance of approximately 100m from the stop line of these approaches.

2.5 The Contractor shall take into consideration in his planning of the new surveillance camera locations and the existing J-Eyes locations such that the new cameras would complement the existing J-Eyes cameras to meet the Authority's requirements.

2.6 All the necessary tools, equipment, vehicles, Trunk Mounted Attenuator (TMA), cherry pickers, manpower, lane closure equipment, etc. required for all works shall be provided by the Contractor. All cost shall deem to be included in the Contract Sum.

2.7 The Contractor shall design, supply and execute all related civil and electrical works in this Contract. All cost shall deem to be included in the Contract Sum.

2.8 The Authority shall have the right to stop all works if in the opinion of the Authority that the works are adversely affecting the traffic conditions at no additional cost and schedule impact to the Authority. The Contractor shall take into account the above requirement in the planning of the works schedule.

2.9 The Contractor shall ensure that there will be no disruption to the operation of the existing LTA's systems during the execution of the works.

2.10 The Contractor shall submit method statements for all works and these submissions shall be subjected to the approval of the Authority.

2.11 The Contractor shall prepare, review, endorse and submit to the Authority a detailed programmed schedule, inclusive of the time required to submit, obtain clearances and approvals from the relevant external authorities/agencies, material samples approval, material procurement delivery, fabrication and construction milestones.

2.12 All works shall strictly comply with latest edition Code of Practice for Traffic Control at Work Zone and Works on Public Streets.

2.13 The Contractor shall seek the approval of all relevant authorities/agencies (NParks, Telco, PUB, Singapore Power, etc) and/or owners before the commencement of any work. Subject to the requirements and approval of the relevant authorities and/or owners, the Contractor shall re-design and/or reinstate the affected part/s of the structures and/or equipment to the satisfaction of the relevant authorities. All conditions and requirements imposed by the relevant authorities and/or owners shall be complied with and all costs incurred shall be deemed to be included in the Contract Sum.

2.14 The Contractor shall provide rechargeable batteries and solar panels to ensure a continuous power supply for the PVMSSS and SCSS. The Contractor shall propose the rating of the battery and the size of the solar panel for continuous 24x7 (24 hours across 7 days) operation and the proposed setup shall be certified by QP as part of the scope of works. The Contractor shall also ensure that the fully charged batteries can last for at least 3 days in providing continuous power supply for the PVMSS and SCSS. All costs associated with these provisions shall be deemed to be included in the Contract Sum.

2.15 All equipment housings and cables shall be properly label tagged and laminated electrical single line drawing endorsed by Licensed Electrical Worker (LEW) shall be enclosed in the equipment housings. The costs associated with this provision shall be deemed to be included in the Contract Sum.

2.16 All design drawings, assumptions, calculations, schedules, patterns, models and other relevant information as may be called for in the Authority's requirements or as may be required by the Contractor for the execution of all works, or as the Authority may require for a full appreciation of the design and methods of manufacture, installation, operation and maintenance proposed by the Contractor shall be submitted to the Authority for acceptance prior to implementation. Any acceptance by the Authority shall not however relieve the Contractor of any of his responsibilities for the accuracy, suitability, adequacy, performance and practicality of his design and any subsequent amendment thereof.

2.17 The Contractor shall be responsible to safeguard and protect the System within the project work boundary to prevent damage at all times. Any damages to the System caused by the Contractor or by any operation carried out under this Contract shall be made good to the satisfaction of the Authority at the Contractor's own cost. In the event of any disputes, the Authority shall have the final decision.

2.18 The Contractor shall be responsible for any damage and repair charges incurred for the recovery of power and telecommunication services for the System due to negligence of the Contractor during the roadworks. In the event of any disputes, the Authority shall have the final decision.

2.19 The Contractor shall be responsible for any damage caused to any buildings, structures, bridges, drains, false ceiling, mechanical and electrical fixtures and other existing facilities during installation and removal. He shall make good, repair and reinstate all damages at his own cost within the Contract Period.

2.20 The cost of all necessary remedial works be it temporary or permanent ordered by the Authority as a result of any inaccuracy, inadequacy or impracticability in the Contractor's proposals and any subsequent amendments discovered at any time and after the execution of the works, shall be the entire responsibility of and shall be borne by the Contractor.

2.21 The Contractor shall ensure that the security requirements and appropriate procedures are in place for the frontend field equipment to minimise the potential for the introduction of malicious codes into the network and System. The security requirements for the frontend field equipment shall include but not limit to access/password control, authentication mechanisms (including remote changes from laptops), MAC address filtering for authorised access, system logging for all successful and unsuccessful login attempts and for all administrator activities with these logs to be timestamped using the time from the master clock. The costs associated with this provision shall be deemed to be included in the Contract Sum.

2.22 The Contractor shall provide full co-operation and assistance in any security review or audit that is performed by the Authority's IT Security team, Internal Audit or any third-party authorised by the Authority, at no additional cost to the Authority.

2.23 LTA shall own the administrator controls for all frontend field equipment. Portable media accessing the frontend field equipment shall only limit to authorised encrypted thumb drives.

2.24 The Contractor shall ensure that the Authority is granted all necessary copyright for all software and / or firmware developed or used by the new equipment for field equipment. Source code and / or copy of the software and / or firmware shall be made available to the Authority and provided upon request.

2.25 The Contractor shall ensure that the newly installed field equipment are in good working condition, based on latest technology and able to operate as intended which is subjected to the acceptance by the Authority. The Contractor shall complete the new equipment installation works on site as required by the Authority and other relevant authorities. All costs associated shall be deemed to be included in the Contract Sum.

2.26 The Contractor shall be responsible for all works related to the provision of power and electrical works, with the engagement of Professional Engineers (PEs) / Licensed Electrical Workers (LEWs) to be professionally responsible for the design of the power and electrical schemes and make all necessary submissions to relevant agencies. The qualified personnel shall certify that the installation of any electrical equipment has been designed, installed and supervised according to the relevant rules, regulations and standards.

2.27 In the case of any existing cables or other peripherals being damaged during the installation work, the Contractor shall replace with new cables or peripherals of the same type. No joint is allowed for any cables that are replaced. The costs associated with this provision shall be deemed to be included in the Contract Sum.

2.28 The schedule of the installation works shall be incorporated in the Contractor's programme. The Contractor shall give two months' notice to the Authority for the installation of new field equipment.

2.29 The Contractor shall provide Defect Liability Period (DLP) for one (1) year and be responsible for all recurring costs for the telecommunication and power services as well as any defects for the installed field equipment during this period. The Contractor shall carry out maintenance works during the one (1) year DLP period.

2.30 The Contractor shall provide an additional forty-eight (48) months of comprehensive maintenance including the payment of all recurring costs for the telecommunication and power services of the System. The Authority may at its sole discretion, extend the comprehensive maintenance of the System in blocks of calendar months.

2.31 The Contractor shall price for the forty-eight (48) months comprehensive maintenance in the Price Schedule. If the extension is exercised in blocks of calendar months, the price shall be pro-rated accordingly.

2.32 The Contractor shall provide 2% key equipment spares for handing over after implementation.

2.33 If the newly installed field equipment is obsolete during the DLP period, the Contractor shall replace with a new type of field equipment with equivalent technical specification subjected to the Authority's approval. All cost shall deem to be borne by the Contractor during the Contract period.

2.34 Any fine imposed by any authorities/agencies such as NEA due to water ponding or mosquito breeding that arises within the work areas, shall be borne by the Contractor.

2.35 The Contractor shall keep records of alternations, changes, omissions and additions in the structural works. One month before the completion of the structural works, the Contractor shall prepare and submit to the Authority one complete set of drawings endorsed by local certified PE registered under BCA which incorporates such alternations, changes, omissions and additions. The costs of such services are deemed to be included in the Contract Sum.

2.36 The Authority shall have the full power and authority to instruct the Contractor to amend or modify the design if he finds shortcomings in the design. Such instructions shall not however in any way relieve the Contractor of any of his responsibilities for the adequacy and practicality of the amended or modified design.

2.37 Any feedback from the public and motorists (noise pollution, dust pollution, vibration, etc) must be dealt with promptly by the Contractor. Any action taken shall be reported and approved by the Authority. All costs involved on the remedy action taken shall be included in the Contract Sum.

2.38 All test equipment that are used by the Contractor, PE, Surveyor, LEW, etc. shall be calibrated and calibration report shall be submitted before any commencement of work.

2.39 The Contractor shall note that all design, civil and installation works shall take into consideration the occupational health and safety of their workers and to adopt environment-friendly practices such as use of energy efficiency products as well as conservation of resources in the design. The Contractor shall also submit the risk assessment report to control the impact of their activities, products and services in accordance to SS ISO 45001 and SS ISO 14001 standards for the Authority’s review throughout the Contract period. If an event any safety, health and environmental incidents / violations occur, the Contractor shall take appropriate actions to correct them so as to avoid any recurrence. The results of evaluation and any necessary actions arising from the evaluation are maintained as records.

2.40 At the end of the Contract period, the Contractor shall remove all equipment on site with proper reinstatement to original condition, including the laptops unless otherwise specified by the Authority. The Contractor shall ensure all equipment are in good condition prior to returning these assets to the Authority.

3 PROJECT IMPLEMENTATION

3.1 The Contractor shall implement the Works in the following phases:

3.2 Project Key Dates

Key Activities	**Key Dates**
Completion of final design for PVMSSS and SCSS	4 months from the date of Letter of Acceptance
Completion of Works	6 months from the date of Letter of Acceptance
Completion of System Acceptance Test (SAT)	8 months from the date of Letter of Acceptance
Completion of the System	8 months from the date of Letter of Acceptance
Commencement of operation and maintenance of the System	1 day after the date of completion of the System
Completion of Defects Liability Period of System	12 months after the date of completion of the System
Completion of operation and maintenance of System	60 months from the commencement of operation and maintenance of the System

4 AUTHORITY FOR ROADWORKS

4.1 The Contractor shall be responsible to seek approval from the Authority and other agencies before any roadwork is allowed to be carried out.

4.2 The Contractor is required to obtain information on the routes of existing utility or telecommunication services from the relevant authorities or online web link i.e. www.beforeudig.com.sg and all costs incurred in doing so shall be borne by the Contractor. Prior to the commencement of the works, the Contractor shall engage a licensed cable detection worker with the Power Grid Ltd to detect the presence of any underground cables prior to the commencement of any excavation work. The Contractor shall liaise closely with the respective utility or telecommunication services authorities if any of these utilities are affected and to keep the Authority informed of all the correspondences involved.

4.3 If there is a need for any diversion / realignment / relocation / raising / lowering /removal of any of the utility or telecommunication services affecting any part of the works, the Contractor shall note that the services diversion works shall be carried out by the utility / telecommunication services authorities or the assigned contractor. The Contractor shall co-operate fully and render assistance to the utility or telecommunication services authorities in carrying out the aforesaid work. If the Contractor is also required to perform such contractor's works and any costs involved shall be deemed to have been included in the Contract Sum. Due allowance must be made by the Contractor for all possible delays and / or inconvenience (arising out of the said works) in his tender, as no claims or compensation of any kind shall be entertained with regards to such delays and / or inconvenience.

4.4 The Contractor shall also liaise with the utility or telecommunication services authorities for the relocation / lowering / raising / removal of manholes, boxes, etc. along the road reserve if any of these structures / fixtures is going to affect the installation of the System. All costs associated in this connection are deemed to be included in the Contract Sum.

4.5 The Contractor shall also take due care to protect all utilities and telecommunication services which may not be affected directly but in close vicinity to the works. He shall provide adequate support and protection for these utilities and services to the entire satisfaction of the Authority and in compliance with the requirements of the relevant authorities. He shall submit details of the support / protection to the relevant authorities for approval prior to any construction. All works must be carried out with care and caution. No damage shall be caused to any existing wires, cables, service pipes and any part of the existing property. The Contractor shall note that it is an offence to damage any utility or telecommunication services and he shall report the damage immediately to the respective utility or telecommunication services authorities. All damage shall be made good at the Contractor's own cost and time.

4.6 The Contractor shall determine the exact route for lying of conduits, electro location techniques shall be used or trial-holes shall be dug to locate the presence of other services. The other services refer to water mains, gas mains, sewer pipes as well as electricity, telecommunications, traffic signal and street lighting cables, etc.

4.7 All underground cables shall be laid in at least 100mm galvanised iron pipes. Cable markers in legible lettering "Low Voltage Electrical Cables" showing the electrical cable routes shall be provided along the cable routes. If the Contractor wishes to propose alternative materials, approval must be sought from the Authority before commencement of work.

4.8 Conduits that are to be mounted on street lamppost shall be of 25mm galvanised iron pipes / flexible galvanised iron conduits using stainless steel (SS316) straps.

4.9 Unless otherwise approved, all conduits with cable slab under road carriageways shall be laid at a depth of at least one meter from finished road level to the top of conduit and on footpaths and side tables at a depth of at least 1.2 meters from the level of the finished ground to the top of conduit. The depths may be varied in certain circumstances due to close proximity of existing cables or other services, which the Contractor shall inform the Authority for approval.

4.10 Cable route markers shall be installed at changes of direction and at intervals on straight runs of cables.

4.11 Prior approval shall be obtained from the National Parks Board before commencement of any civil works near existing trees. All cost incurred for this scope of Work shall be deemed to be included in the Contract Sum.

4.12 If conduits are to be laid less than two and a half (2.5) meters away from existing sewage pipe, prior approval shall be obtained from the Public Utilities Board before commencement of any work.

4.13 Pull boxes, splice cabinets and manholes shall not be constructed within the side-table of the roads, junctions or intersections.

4.14 All trenching works across and along roads inclusive of kerbs, footpaths, drains, side-tables and other areas shall be reinstated by the Contractor responsible for such excavation. All works are to be reinstated to the satisfaction of the Authority.

4.15 Where required, the Contractor shall spread and tamp approved quality good loamy topsoil over and if necessary adjacent to any trench which passes through side tables, beams, slopes, etc.

4.16 The Contractor shall also, where required, provide and fix approved quality grass turfs over such areas in an uniform and continuous manner and it shall include pegging down as directed and required by the relevant authorities.

4.17 All materials from excavation shall not be stacked on the road carriageway or side-tables without the approval of the Authority.

4.18 The pedestrian movement shall not be channelled to the road carriageway even though the footpath is affected by the opening or reinstatement work without the approval of the Authority. Alternative access must be provided for the safety of the pedestrians and shall be included in the Contract Sum.

4.19 The Contractor shall cause as little obstruction as possible to the public during the execution of all works under this Contract and shall pay due regard to the interests and convenience of the public and of all private persons who have property or are residents in the neighbourhood area of the works.

4.20 No more than one trench along the same road at any one time shall be allowed without prior approval of the Authority.

4.21 The Contractor shall provide a Truck Mounted Attenuator (TMA) for roadworks on the arterial roads with a speed limit of 70 km/h and above. The requirements on TMA are as indicated in the Specification.

4.22 Total road closure is not allowed. The Contractor shall co-ordinate with the Authority on any requirement relating to lane closure.

4.23 The Contractor shall also provide the temporary traffic diversion schemes and proper traffic control plans for the Authority's approval at least three months before the commencement of any roadwork. Closure of any traffic lane or carriageway shall be implemented in accordance with approved traffic diversion scheme for all affected traffic movements. The Contractor shall also liaise with the Authority before work commences and comply with any security, safety and traffic arrangements necessary for the worksite as may be directed or required by the Authority. All requirements stated in the latest edition of the Code of Practice: Traffic Control at Work Zone must be strictly followed.

4.24 If requested by the Authority at any time, the Contractor shall immediately clear any lane of the entire road of any persons or materials to allow the movement of vehicles.

5 CONCURRENCE FROM OTHER AUTHORITIES

5.1 When trenching work falls within the reserves for the MRT system, approval shall be sought from LTA's Development and Building Control Division (Rail) before work commencement.

5.2 The Contractor shall be responsible to liaise closely with the relevant authorities e.g. SP PowerGrid, National Parks Board, building owners etc when executing the works. Approval must be sought from the relevant authorities before any work is carried out. All costs required for these approvals are deemed to be included in the Contract Sum and the Contractor shall not be entitled to any claim whatsoever.

6 CO-ORDINATIONS BETWEEN CONTRACTORS

6.1 The Contractor shall co-ordinate with the Authority's other contractors involved to ensure that the installation works are on schedule. The Authority reserves the rights to make the final decision should there be any dispute between contractors. Any cost incurred shall deem to be included in the Contract Sum.

7 PROTECTIVE AND ENVIRONMENT REQUIREMENTS

7.1.1 All equipment and materials shall be designed, constructed and installed so as to be able to withstand, without deterioration, the conditions of transport, storage, installation and operation to be met in the country of manufacture and in Singapore. They shall also satisfy the requirements of the environmental conditions in Singapore.

7.1.2 For security of his equipment and materials, the Contractor's attention is drawn to the need for scheduling this installation to minimise risk of theft. The Contractor shall note that until the handing over of the System, he is fully responsible for the security of his equipment and materials.

7.1.3 Upon completion of the works, the Contractor shall clear away and remove all surplus materials, rubbish and debris of every kind and leave the whole site clean to the Authority's satisfaction.

7.1.4 The equipment supplied by the Contractor shall be securely mounted on equipment racks and/or suitably housed and installed to ensure its functionality, compatibility and suitability to operate within the given environment and technical specifications. Installation of equipment and racks shall be subjected to the availability of space as well as the approval of the Authority.

7.1.5 The Contractor shall state the environmental limitations of all equipment supplied under this Contract. The environmental limitations shall include, but not be limited to, those for temperature, humidity, dust, thunder storm and vehicle exhaust. It shall be the Contractor's responsibility to determine the environmental conditions in which the materials equipment shall be placed and operated. The Contractor shall also determine the possible effects of solar radiation, heat, humidity, dust, vibration, pests, mould, corrosion, salt spray, lightning surges, electrical transients and other adverse conditions on all materials and equipment.

7.1.6 The system and all associated equipment installed shall be aesthetically pleasing to the eye. It implies that the equipment shall be strategically located such that there must be no obstruction visually to all motorists. It should also be easily accessible during system maintenance.

8 REINSTATEMENT/INSTALLATION WORK

8.1 Damages, directly or indirectly, caused to road carriageway, structures, kerbs, footpaths, drains, side tables etc. regardless of its existing condition, shall be reinstated / repaired by the Contractor at its own expense to the satisfaction of the Authority. Details of the footpath, kerb, drain, structure etc., if affected, shall be reinstated to conform to the current standard and practice of the Authority and not necessarily to the existing condition.

8.2 For all road-opening, installation and reinstatement works, the Contractor shall comply with the latest edition of LTA's Code of Practice for Works on Public Streets.

9 SURPLUS MATERIALS

9.1 All surplus materials and stains shall be removed and the site must be cleared up immediately after reinstatement and installation works are completed.

10 SPECIFICATION FOR TEMPORARY SIGNING

10.1 It is the responsibility of the Contractor to ensure public safety and safety of the workers during roadworks that require temporary lane closure. All roadworks and such temporary works shall have adequate signage, warning lights, warning cones etc as per the latest edition of the Code of Practice: Traffic Control at Work Zone. The temporary signing and other traffic control devices must be removed as soon as the hazard to which they apply no longer exists. The work and temporary signing must be identified by the Authority's logo.

10.2 Prior to the commencement of work, the Contractor shall prepare a plan showing the arrangements, types and numbers of each of the proposed temporary signing to be used for the roadworks. The proposal shall be submitted to the Authority for approval before sending to Traffic Police for their clearance, if necessary.

10.3 Signs, lights, barriers, and other traffic control devices shall be maintained in good conditions and in correct position by day and by night. Signs shall be kept neat, clear and legible at all times. Sidetracks shall be maintained in good order at all times.

10.4 All workman shall wear approved type of protective reflective vests, safety helmets, safety gloves, safety boots, safety harness and etc during all hours of the day and night when engaged in any type of work on the roads.

10.5 If the Contractor fails to conform to the above requirements, the Authority could take one or all of the following courses of action:

a. Suspend all works on the particular area until the above requirements are met; or

b. Provide equipment necessary to meet the above requirements and charge the cost to the Contractor.

10.6 The Contractor shall not be entitled to claim for extension of contract period caused by delay to the works, as a result of the Authority suspending works in accordance to above Clause 10.5.

10.7 The Contractor shall provide traffic barrier, cones and Truck Mounted Attenuator (TMA) for lane closing works where such are required under the Code of Practice for Traffic Control at Work Zone.

11 PERFORMANCE

11.1 The Contractor shall ensure that there is no compromise or down grading of any of the new field equipment after the completion of installation works to the acceptance of the Authority.

11.2 The Contractor shall follow all general guidelines set up by all other relevant authorities with regards to the installation of all new field equipment, controls and associated wiring.

11.3 All redesigns and installation shall be tested and re-commissioned to the acceptance of the Authority.

11.4 The Contractor shall engage competent personnel to test / modify / connect / disconnect etc of all field equipment.

12 ELECTRICAL POWER FOR SITE EQUIPMENT

12.1 GENERAL

12.1.1 This section sets out the general standards of electrical materials and equipment and the requirements of workmanship in relation to the installations and wiring of electrical equipment.

12.1.2 All works carried out and equipment supplied shall conform to the best principle of modern engineering practice and be completed for satisfactory operation, control and safety under all conditions of service.

12.1.3 The Contractor shall submit the QP’s calculations and drawings with endorsement to certify that the proposed installations shall not affect the structural integrity of the of the street lamp posts. No drilling, riveting and retrofitting is allowed on the lamp post.

12.1.4 The Contractor shall submit a separate drawing of the electrical routing from power source via the lamp post to the System with endorsement by authorised LEW to the Authority.

12.1.5 The electrical and installation works shall not block the pole ID and pole door which will hinder the maintenance work for the street lamp posts. The contractor shall ensure that protective measures are in place to prevent damage to the lamp post surface such as protective layer of rubber between lamp post surface and clamps.

12.1.6 All rechargeable batteries shall be suitable for outdoor usage and equipped with charge controllers for the charging and monitoring of each battery's charge level at regular intervals. Battery charge level and low voltage alert shall be triggered by the charge controllers to send back to the laptops supplied by the Contractor if the batteries are unable to hold charge.

12.1.7 The Contractor shall provide all the necessary support for maintaining the power supply to the PVMSSS and SCSS including replacement and charging of batteries, system functional testing and comprehensive maintenance during the Contract period.

12.1.8 The Contractor shall pay a deposit for the estimated utilities cost for a period of 2 years and top up the amount as and when requested by the Authority.

12.1.9 All electronics/electrical equipment supplied and installed shall be suitable for continuous operation up to a maximum temperature of 60°C unless otherwise stated for a 24-hour period.

12.1.10 All electrical installations shall be protected by Type-S Residual Current Circuit Breaker (Type-S RCCB) and power surge protection devices. The contractor shall measure the leakage current and submit the reading to the Authority.

12.1.11 The Contractor shall provide, unless otherwise specified, all materials, labour, plant, tools and everything necessary for the fulfilment and completion of the whole installation works.

12.2 RULES, REGULATIONS AND STANDARDS

12.2.1 The electrical installation including the materials used, equipment and fittings installed, method of wiring, workmanship, testing and commissioning shall comply but not be limited to the following Codes and Standards:

a. Singapore Power Regulations

b. SS 638: 2018 (formally CP5) – Code of Practice for Electrical installations

c. SS 551 – Code of Practice for Earthing

d. SS 535 (formally CP31: 1996) Installation, operation, maintenance, performance and constructional requirements of mains failure standby generating systems

e. SS 555 – Code of Practice for Protection against Lightning

f. SS 299: 1988 Specification for Fire Resistant Cables

g. SS 358: PVC insulated cables of rated voltages up to and including 450V/750V

h. The latest edition of IEE Regulations for Electrical Installation

i. BS EN 60529:1992 Specification for Degrees of protection provided by enclosures (IP code)

j. Regulations of other local authorities having jurisdiction over the installations

k. IEC 228 – Conductors of insulated cables

l. IEC 331 – Fire resisting characteristics of electric cables

m. IEC 332 – Tests on electric cables under fire conditions

n. IEC 502 – Extruded solid dielectric insulated power cables for rated voltages from 1 kV up to 30 kV

o. IEC 754 – Test on gases evolved during combustion of materials from cables

p. IEC 811 – Common test methods for insulating and sheathing materials of electric cables

q. IEC 1034 – Measurement of smoke density of electric cables burning under defined conditions

12.3 CIRCUIT BREAKERS

12.3.1 Miniature Circuit Breaker (MCB) shall comply with BS EN 60898 for use on AC 415V/230V 50Hz. All MCB shall have thermal and magnetic trip devices to protect against overload and short circuit. The operating mechanism shall be of quick make type irrespectively of the closing speed and should also be of quick break operation during overload or short circuit condition even if the handle is held at ‘on’ position.

12.3.2 The circuit breaker must remain open in the fault time for manual reset upon tripping.

12.3.3 When double and triple pole breakers are used, protection against single-phase faults shall be provided.

12.3.4 Surge arrestors shall be installed at the incoming power supply for the live and neutral wire and grounded to earth. Surge arrestors proposed shall have visual indicators to indicate the operating state. Surge arrestors proposed shall be able to protect against inrush current of 20kA and 600 volts.

12.3.5 Surge arrestors shall also be installed to protect all on site equipment from lightning surge and etc. Surge arrestors proposed shall have visual indicators to indicate the operating state.

12.4 RESIDUAL CURRENT CIRCUIT BREAKER (RCCB) – TYPE S

12.4.1 The RCCB – Type S shall be of PSB approved type and manufactured to BS 4293.

12.4.2 The Contractor shall install at least 2-pole RCCB – Type S with 100mA sensitivity with 0.25 seconds delay in all portable equipment housings. The RCCB – Type S shall perform automatic reclosing of the circuit in the event of residual current trip. The device shall comply with the following International Electrotechnical Commission Publications (IEC) or Singapore Standard:

a. IEC 61008 -1 - Residual current operated circuit breakers without integral over-current protection for household and similar uses (RCCBs);

b. IEC 60730 -1 - Automatic electrical controls for household and similar use; and

c. SS 97-1 - Residual current operated circuit breakers without integral over-current protection for household and similar uses (RCCBs).

12.4.3 The RCCB – Type S shall have an enclosed toggle-type of tripping switch to avoid accidental switching.

12.4.4 The ON and OFF position of the RCCB – Type S shall be indelibly marked and visible from the front of the RCCB – Type S in the installed position when fitted with the insulating case cover, if any. A separate mechanical indicator or contact position indicator, independent of the toggle, shall be provided to give a reliable indication of the contact position for isolation purposes. The RCCB – Type S shall have trip-free mechanism.

12.4.5 The RCCB – Type S shall have signaling LEDs on the front that enable the visualisation of the functioning state.

12.4.6 The RCCB – Type S shall be indelibly marked with particulars as stipulated in IEC 61008-1 or SS 97-1. The particulars shall be marked in a durable manner by transfer printing onto the body of the RCCB – Type S.

12.4.7 The terminal shall be of screw tightening type suitable for copper or aluminium conductor with cross sectional area up to 25mm^2. The terminal shall be tested according to IEC 61008-1 or SS 97.

12.4.8 The RCCB – Type S shall be suitable for snap-on-to DIN-rail EN50022, 35mm.

12.5 CABLE SUPPORTING SYSTEM AND INSTALLATION

12.5.1 Prior to installation, co-ordinated layout drawings of all mechanical and electrical services shall be produced so that no mechanical and electrical installation shall clash. All the necessary mechanical and electrical parameters must be clearly indicated in the proposed drawings. For example, dimension and type of the cable, cable slab, cable tray, trunking, conduit, ladder, structure and rating of the MCB, RCCB, surge arrestor and etc.

12.5.2 The Contractor shall submit detailed wiring plans for all the devices, indicating clearly the proposed location and cable route for each of these devices.

12.5.3 Site survey shall be conducted by the Contractor to confirm the exact location of the cable route for each of the devices.

12.5.4 All cables shall as far as practicable be fitted with the relevant proper connectors of plugs and sockets at both ends.

12.5.5 All cable connectors shall have suitable cable holding devices to prevent the cables from mechanical exhaustion and strain.

12.5.6 All cables shall be properly labelled in accordance to its relevant circuit. The cable-terminating points shall be labelled in conjunction with the equipment termination assembly so that any terminal may be readily identified. The cable labelling must remain legible after subjecting to continuous handling.

12.5.7 All cables carrying alternating current shall be separated from other cables carrying signal voltages. All such power cables and wires shall be insulated by high grade insulating materials. The termination of all power cables and wires shall be supported such that, in the event the copper wire is been exposed due to unforeseen incident, the conductor shall not come into contact with other cable or electronic module in the equipment.

12.5.8 The type and size of the wires used shall be selected with due consideration to the transmission requirement and protection against extraneous interference.

12.5.9 Underground cable should use the type designed for lying in buried underground ducts. The Contractor shall submit technical specifications of the cable to be drawn in ducts.

12.5.10 The cables size and type shall be selected so that the performance of each of the individual equipment is not affected.

12.5.11 Cables shall be delivered to site in manufacturer's standard packing with seals and labels intact. Only cables with manufacturer's identification clearly visible shall be used.

12.5.12 The Contractor shall be deemed to have, at the time of tendering, calculated and ascertained the actual quantity of all cables and cable slabs required upon the completion of the whole cabling works and ensure such quantity of cables and cable slabs are adequate.

12.5.13 All field cables shall be protected by weatherproof coating and shall be of heat resistance.

12.5.14 All new power and communication cables use shall be of armour type. The specifications shall be submitted to the Authority before commencement of any cable wiring work.

12.6 INSTALLATION OF CABLES

12.6.1 The cables shall not be pulled into cable conduits and ducts until the conduits system has been completely free from obstruction and sharp edges.

12.6.2 A clean rug or brush shall be drawn through each conduit before cable is drawn in. Cables shall be installed in such a manner that there shall be no cuts or abrasion in the insulation. There shall be no kinks in the cable conductors. All cables shall only be pulled through the cable conduits and underground ducts in the presence of the Authority and 24 hours advance notice is given.

12.6.3 Grease or other injurious lubricants shall not be used in pulling the cables. The use of talc or non-injurious lubricants shall be used.

12.6.4 Under no circumstances shall the cables be laid within 300mm (or other dimensions and requirements as imposed by the relevant utility services authorities) near the vicinity of high-tension cables, gas, water mains and / or telecommunication cables.

12.6.5 Cable that is damaged during installation shall be borne by the Contractor.

12.7 CABLING AND WIRING

12.7.1 All electrical cabling and wiring shall be carried out in galvanised iron conduit class B, in metal trunking or a cable tray.

12.7.2 Unless otherwise specified, all power and signal cabling from portable equipment housings to equipment shall be carried out in armour insulated, sheathed, and single or/and multiple core type of cable.

12.7.3 Wiring shall be carried out upon the “looping-in” principle with all joints being made at the switches, outlets, distribution boards and equipment housing only. No joint shall be made in joint boxes nor shall any through joint be allowed at any point of the cables.

12.7.4 All cables and wires shall follow the new cable colour code:

a. Active – brown (single phase) / brown, black, grey (three phase)

b. Neutral – blue

c. Earth - green / yellow.

12.7.5 All wires and cable conductors used in the Contract shall be identified at each end, using durable shrink-wrap or tag labels firmly fixed to the wire ends, with descriptive (functional purposes) nomenclature clearly and permanently marked. The shrink-wrap or tag labels shall also be numbered to identify the nearest vicinity.

12.7.6 For safety reasons, yellow warning notice (as shown below) shall be clearly affixed at each distribution board that controls circuit with cables in old and new colour codes.

CAUTION

"This installation has wiring colours to two versions of Code of Practice for electrical installations (SS638). Great care should be taken before undertaking extension, alternation or repair that all conductors are correctly identified. "

12.7.7 Solderless and screwless techniques shall be used as a means of terminating conductors where possible. Crimpling and other standard industry practice shall be used, subject to specific acceptance by the Authority. The Contractor shall provide a full description of terminating cables and wires.

12.7.8 All cable and wiring shall be terminated in accordance with industry standards for the system and duty being performed.

12.8 VOLTAGE CABLES

12.8.1 All cables shall be of 600/1000V grade with IEC 228, Class 2.

12.8.2 All cable supports shall be spaced and arranged to give adequate support and fixing to the cables. The spacing of supports for cables and the distance between cables shall comply with the requirements of SS CP5.

12.8.3 The turning radius of the various types of cables shall have the values not less than those specified in SS CP5 and in cable manufacturer's recommendation.

12.8.4 Where cables pass through walls and floor slabs, cable sealing certified to two-hour resistance rating shall be provided.

12.8.5 All cables and wires running in steel conduit or in metal trunking for general power and lighting shall have minimum rating of 600V unless otherwise specified.

12.9 NETWORK CABLES

12.9.1 Subject to the acceptance of the Authority, IEC or other international standards may also be used where they are equal to or more rigorous than the standards called for above and elsewhere. The Contractor shall indicate where deviations exist between the specified standards and his proposed standards.

12.9.2 Local Area Network (LAN) Cables

12.9.2.1 LAN cables are Foiled Twisted Pair (FTP) and conform to the performance requirements in ISO/IEC 11801. The minimum requirement is:

a) Category 6 Class E for 1000base-T Gigabit Ethernet.

12.9.2.2 FTP cable are shielded with aluminium foil screen and colour coded on the insulation throughout the length of the cable.

12.9.3 Signals and Control Cable

12.9.3.1 Conductors

a) The conductors are of stranded, high conductivity annealed copper wires complying with BS 6360;

b) Flexible Cables and cables for fixed installations have stranded conductors;

c) Conductors are smooth, uniform in quality, free from scale, spills, splits and any other defects. There shall be no joints in individual strands; and

d) All signal/control copper cable are rated at 600 / 1000V.

12.10 UNDERGROUND CABLES AND CONDUITS

12.10.1 All cables shall be of the armoured XLPE type unless otherwise stated by the Authority.

12.10.2 Underground cables shall be laid generally to a depth of at least 1000mm below the finished ground level in accordance with local cable laying practice. When trenches are backfilled, a layer of washed sand to 75mm deep shall be deposited throughout the length of the trench. Cables after being laid are to be covered with a depth of 300mm dry washed sand over which shall be placed length-wise one layer of red cable slabs to cover the cables throughout their length. Each cable slab shall have the words “DANGER LTA CABLES” embodied on the front surface.

12.10.3 Cables terminating above floor level shall be protected by galvanised iron pipe guards of adequate size and appropriate length. Cable bending shall be made in an easy sweep band method and in no case shall the cable be bent to a radius of less than 12 times the overall diameter of the cable.

12.10.4 The Contractor shall provide and fix in position suitable cable markers to indicate the route of cables after the trench being backfilled. Cable markers shall be provided one at every 50m along the straight and at every point of directional change.

12.10.5 All electrical cabling and wiring shall be run in galvanised iron conduits or cable trays or in reinforced concrete trenches or ducts.

12.10.6 All conduits under road pavements, footpaths, side-tables and carriageway shall be of 100mm, heavy duty class B galvanised iron pipe.

12.11 EARTH EXCAVATION AND BACKFILLING FOR CABLE LYING WORKS

12.11.1 The Contractor shall perform all earth excavation, trenching, mill & patching and backfilling work for outdoor cable lying and remove debris in connection with the cabling works.

12.11.2 The Contractor shall check for any underground existing service pipes / cabling as per SP PowerGrid Ltd or any other relevant authorities’ requirements before any excavation work is to be carried out. Patching and backfilling work shall be done with materials approved by the Authority or/and relevant authorities. All reinstatement works shall be thoroughly compacted.

12.11.3 All disturbed surfaces shall be restored to their original condition and properly reinstated to eliminate any settlement.

12.11.4 Before any earth excavation, the contractor must purchase the cable plans from SP Power Grid Ltd and engage Licensed Cable Detection Workers (LCDW) to detect the presence of underground electrical cables through trial holes using manual excavation.

12.11.5 If the vicinity of high voltage cables (6.6kV, 22kV, 230kV or 400kV) is detected, the Contractor shall submit Notice Commencement of Earthworks (NCE) form with (a) LCDW cable detection drawing(s), (b) Site plan indicating the proposed work area and (c) Schedule of planned earthworks activities to SP PowerGrid.

12.11.6 Excavation work can only be commenced with the presence of Registered Earthworks Supervisor (RES) after the Contractor has received the NCE approval from SP PowerGrid.

12.12 SHOP DRAWING

12.12.1 The Contractor shall submit shop drawings showing clearly the details of the structural, mechanical and electrical works and system and other related works. Shop drawings shall include, but not be limited to, the following:

a. Single line diagrams;

b. Dimensional drawings showing arrangement of busbars and all electrical devices;

c. Wiring diagrams;

d. Arrangements of components;

e. Sequence and details of fabrication;

f. Certification of the new equipment structure (eg. dedicated or special pole)

g. Installation of components and equipment and etc.

12.12.2 The shop drawings shall include instructions and explanatory details of the sequence of fabrication and installation of the various elements of the works. The Contractor shall be deemed to have verified all materials, site measurements and construction criteria thereof and have checked the shop drawings for complete dimensional accuracy. The drawings shall be approved by authorised LEW, PE and other authorised personnel.

12.13 EARTHING SYSTEM

12.13.1 All design and installation shall be in accordance with the latest edition of SS638 and SS CP16.

12.13.2 All earthing tape or bonding conductors shall be of fire retardant, high conductivity copper type with appropriate label. The colour of the insulation shall be green/yellow, which is in accordance to the latest cable colour code in stated in the relevant standards.

12.13.3 An earth mat shall be provided when deemed necessary by the Authority. The overall resistance to earth of each earth mat before bonding to any metal services shall be less than 1 ohm.

12.13.4 Any earth-continuity conductor from the exposed metal of equipment shall be connected to earth by one of the following as appropriate:

a. To the earth termination at the distribution board from which the earthen equipment is supplied by an earth continuity conductor of the appropriate size.

b. To any point on a sub-main or main earth-continuity conductor supplying the distribution board referred to the above.

c. To an earth leakage circuit breaker installed in accordance with the local authorities' requirements.

12.13.5 Wiring to equipment and measuring instruments in covers or doors shall be installed such that no mechanical damage shall occur as a result of movements of the door or cover.

12.13.6 Exposed metalwork of all electrical apparatus and wiring system including cable sheathes and armour, conduit, metal ducts, trunking, rack, tray, boxes, socket outlets, lighting fittings, metal-clad switches, structures, etc, shall be connected to the appropriate earth continuity conductors.

12.13.7 The use of conduit system itself as a sole means of earthling shall not be permitted. A separate earth continuity conductor cable of minimum cross sectional of 4-sq mm shall be used and run inside the conduit.

12.13.8 The Contractor shall install at least one earth pit and connect with earth cable to the portable equipment housing. The earth pit shall be pre-casted with hinged hot-dipped galvanised iron cover and at least two lengths of 1.8m 16mm diameter copper electrodes. The overall resistance to earth of the earth electrode system before bonding to any metal services or in the structure shall be less than 1 ohm. The reading obtained shall be endorsed and certified by LEW. In the event additional earth pit is required to achieve the less than 1 ohm requirement, the cost incurred shall be borne by the Contractor. The earth pit shall fill with sand to prevent water ponding.

12.14 LIGHTNING PROTECTION SYSTEM

12.14.1 The design and installation of the lightning protection system shall be in accordance with the latest edition of SS 555.

12.14.2 The lightning protection system shall be designed such that it can convey lightning discharges to ground without electrification of structure. The Contractor shall install the local earthing if it is not installed for the affected equipment.

12.14.3 The Contractor shall submit the design of the lightning protection system to the Authority for approval during the design phase.

12.15 DANGER WARNING NOTICE

12.15.1 A ‘Danger’ notice shall be pasted on all portable equipment housings. The ‘Danger’ sign stickers shall have yellow background with black wordings or graphics.

12.15.2 Under the latest SS638 specification, the colour of all the ‘Live’, ‘Neutral’, and ‘Earth’ cables that is used will be Brown; Black; Grey (Live), Blue (Neutral) and Green and Yellow (Earth). A sticker shall also be pasted on every portable equipment housings that consist of both the old and new conventional cable colour code under the CP5 specification. The sticker shall have a yellow background with black wordings that is specified by the Singapore PowerGrid.

13 PORTABLE EQUIPMENT HOUSING

13.1 The Contractor shall supply, deliver, install and commission the portable equipment housing with slanted top for all PVMSSS and SCSS. The costs for the new portable equipment housing shall be deemed to be included in the Contract Sum.

13.2 The Contractor shall incorporate in the design the Type-S Residual Current Circuit Breaker (Type-S RCCB) for all portable equipment housings of the PVMSSS and SCSS respectively to serve as lightning and power surge protection devices.

13.3 There shall be no looping of power supply that will cause power for all connected equipment to be down in the event of power failure at a single point.

13.4 All portable equipment housings shall be made of aluminium enclosed, factory built type corresponding IEC-Recommendations No. 60439, 60144 and 60157.

13.5 The Contractor shall provide engraving tags for label of cables and the housings. Equipment shall be properly secured in the portable equipment housings and the mounting method shall be submitted for approval by the Authority.

13.6 All portable equipment housings shall be labelled properly with reverse engraved name plate secured by stainless steel screws or aluminium blind rivets. The details of the labels are to be approved by the Authority before fabrication.

13.7 The Contractor shall submit the design of the portable equipment housing with slanted top for approval by the Authority before manufacturing. The submission shall include the specification of internal environmental conditions during normal operations, under external environmental extremes, layout of the equipment position, installation methods, materials used for the LTA’s label and interconnection of equipment modules.

13.8 The portable equipment housing located outdoors shall be weatherproof, 2.5mm thick aluminium cabinets of IP54 standard and shall be treated with powder coated material of minimum thickness 60 micron and shall be grey in colour. The equipment housing shall include proper ventilation and cooling system. The hinges for the doors shall be stainless steel or robust aluminium type.

13.9 The equipment housing shall contain all necessary power supply equipment, electrical components, communication equipment, protection system and Type-S Residual Current Circuit Breaker.

13.10 The Contractor shall make provision to raise the portable equipment housing above the ground level to prevent water seepage during rain or flood.

13.11 The portable equipment housing if mounted/attached to any existing infrastructure on site shall not cause any damage to the existing infrastructure and indirectly cause danger to the public.

13.12 The portable equipment housing shall not be embedded on the ground to allow easy relocation when required.

13.13 The portable equipment housing if mounted as a standalone structure shall be firmly mounted and shall not topple over, in the event of strong gusts of winds.

13.14 The Contractor shall provide metal pocket welded to the interior of the equipment housing for holding the logbook, electrical single line drawing, site as-built drawing and etc.

13.15 The portable equipment housing shall have sufficient space to house all site equipment, power sockets, mounting brackets with accessories, stainless steel 35mm DIN rail (if required) and all electrical components.

13.16 The Contractor shall provide common sets of locks and keys. All keys shall be handed over to the Authority upon commissioning of the equipment.

13.17 The Contractor shall ensure that all equipment installed in the portable equipment housing shall be properly arranged and mounted. The cables shall be properly tied, arranged neatly and shall be labelled accordingly. The Contractor shall take photographs of the housing after completing the works and submit to the Authority as part of the site installation and works submission.

13.18 The portable equipment housing shall meet the following requirements:

a. Weatherproof;

b. Corrosion resistance;

c. Solar radiation resistant;

d. Prevent moisture condensation;

e. Fully resistant against fungus growth;

f. Complete with all necessary equipment, electrical components;

g. Insect and vermin resistant;

h. All incoming and outgoing wires shall be properly sealed in order to meet the above requirements; and

i. Proper warning signs indicating danger and voltage level on the external equipment housing.

13.19 All portable equipment housings shall be located within sight and 2m from the proposed equipment and their locations shall be subjected to the Authority's approval.

13.20 All portable equipment housings shall not cause any obstructions to the smooth flow of the pedestrian traffic or pose any hazard and danger to the passing pedestrians.

13.21 The Contractor shall take appropriate measures to protect all portable equipment housings as well as the equipment cables it houses against any damage by over-voltage, power surge and lightning surge with appropriate lightning and surge protectors.

13.22 The Contractor shall ensure that all portable equipment housings shall be adequately protected against any external coastal and environment influences found in local environment that might affect the performance or aesthetic of the equipment housing.

13.23 The Contractor shall take appropriate measures to ensure that the temperature inside all housings shall not exceed 60ºC or the internal equipment temperature rating whichever is lower. The Contractor shall demonstrate the compliance of the above requirement to the Authority. The Contractor shall provide temperature monitoring system, if required, to activate the environmental system at no extra cost for this contract.

13.24 The Contractor shall provide all the necessary environmental system (eg. force ventilation), if required, to mitigate the effects of dust ingress, providing air movement, thermal cooling and thermal equalisation to mitigate the accumulation of condensation, excessive heat built-up and formation of “hot spots” as to maintain the internal environment of the portable equipment housing within the operating range of all the internal components.

13.25 The Contractor shall ensure that all portable equipment housings shall be of a sufficient size to accommodate all necessary components without overcrowding for the provision of the ease of maintenance, testing and future hardware add-ons.

13.26 The housing shall be properly sealed around on all incoming or outgoing cables holes using stainless steel cable glands and silicon.

13.27 The Contractor shall provide at least 2 spare metal 13 ampere outlet power points in each portable equipment housing.

13.28 No holes are to be drilled on all parts of the portable equipment housing to prevent water seepage.

13.29 The portable equipment housing shall be supplied complete with bottom removable galvanised steel gland plates that shall be drilled to suit cable glands or conduit entry.

13.30 The portable equipment housing shall be fitted with an earth stud located in an accessible position on the inside of the box. All metal parts of the box except current carrying parts shall be bonded together electrically and to the earth bar.

13.31 As-built single line diagram, control circuit and layout plan endorsed by LEW shall be inserted in a permanent pocket on the inner side of the panel door of each portable equipment housing.

13.32 All portable equipment housings shall be totally enclosed, metal clad, cubicle type, insulated for up to 500V and be manufactured to withstand the electrical, mechanical and thermal stresses.

13.33 All portable equipment housings shall be factory type-tested assembly as defined in BS, IEC, SS or any equivalent standard requirements.

13.34 All portable equipment housings shall be supplied complete with all accessories such as circuit breakers, fuse-switches, ammeters, voltmeters, switches, current transformers, potential transformers, double sockets and so forth, and be constructed to the requirements of this Contract.

13.35 The material and finish of the portable equipment housing shall be subjected to the Authority's approval. Product(s) brochure of the proposed housings shall be submitted to the Authority during the design phase.

13.36 All connecting cables attached/connected to the portable equipment housings shall be terminated with weatherproof sockets to facilitate easy access for maintenance purposes.

13.37 The door of the portable equipment housings shall offer complete access to the interior of the housings and shall encompass substantially of the full area of the front of the housings. The door hinges and the pins shall be made of stainless steel. The door of the housings shall be equipped with a lock. The locks shall be identical for all main doors of the equipment housings.

13.38 All portable equipment housings may be back or front connected. No joint shall be located at the corners.

13.39 All doors of the portable equipment housings shall be individually bonded to earth with panels they attach in. The panels shall be fixed by Philips head pattern, nickel or chromium plated screws.

13.40 Any defective portable equipment housing detected before handing over shall be rejected by the Authority and the replacement of it shall be borne by the Contractor.

13.41 The portable equipment housings shall be designed to ensure that when the components are carrying their rated normal currents, thermal interaction does not unduly affect the performance of any other components within the housings. The temperature rise of the cable terminals when tested with links of the appropriate current rating fitted shall not exceed 60°C relative to the ambient temperature. Contractor shall make good to the performance of the equipment if the above scenario occurs on site. All the cost of the rectification work shall be borne by the Contractor.

13.42 The Contractor shall provide the necessary wiring and cabling works from each portable equipment housing to the equipment locations for the proper functioning of the System. The Contractor shall liaise with the relevant authorities for the necessary wire cabling details. All costs associated with the work are deemed to be included in the Contract.

13.43 Cable trunking or conduit shall be in place till the cable has entered to the base of the housing where it is sealed by galvanized steel plate.

14 SURVEILLANCE CAMERA SUB-SYSTEM

14.1 The surveillance camera shall enable the Authority to monitor traffic conditions and confirm the nature of the incidents along the arterial traffic junctions. These surveillance cameras shall termed as Surveillance Camera Sub-System (SCSS) along the arterial roads.

14.2 The Contractor shall ensure the surveillance cameras provide optimal coverage along the existing arterial roads. The location of the camera shall be proposed by the Contractor and submit to the Authority for approval.

14.3 Surveillance Camera Sub-System

14.3.1 The SCSS is a network of surveillance cameras mounted on either the existing lampposts or new dedicated poles (supplied by the Contractor) along both bounds of the arterial roads.

14.4 DESIGN REQUIREMENTS

14.4.1 The SCSS shall interface with the laptops (supplied by the Contractor) to enable viewing and control of the SCSS. The proposed cameras shall be ONVIF compliant.

14.4.2 The Contractor shall position all surveillance cameras at strategic locations such that the views of the traffic are not blocked by trees, shrubs, buildings, new and existing beams and supports of the flyovers and bridges etc.

14.4.3 The Contractor shall ensure that the surveillance camera is able to capture and transmit real time video images back to the laptops. All interfacing equipment provided by the Contractor shall be fully compatible with the SCSS.

14.4.4 The Contractor shall provide rechargeable batteries and solar panels equipped with charge controllers for the monitoring and charging of the rechargeable batteries to ensure a continuous power supply for the SCSS.

14.4.5 All utilities fees and costs incurred for the supply of power shall be borne by the Contractor during the DLP and comprehensive maintenance period and included in the Contract Sum.

14.4.6 The Contractor shall directly engage the Telecommunication Service Provider (TSP) for the subscription of wireless 4G or equivalent service from site to exchange and coordinate with them closely on the interface with the laptops.

14.4.7 The Contractor shall bear all one-time setup, monthly recurring costs and any other miscellaneous fees incurred for providing the wireless service during the DLP and comprehensive maintenance period.

14.4.8 The Contractor shall ensure a central control software is installed in each laptop provided for the remote viewing and control of all SCSS installed on site.

14.4.9 All field equipment health status alarms shall be sent to the laptops via the wireless service.

14.4.10 The Contractor shall appoint a qualified surveyor to provide exact positions and co-ordinates of the proposed SCSS in terms of Global Positioning System (GPS) coordinates (in WGS84 coordinate system) with location descriptions. The information shall be updated whenever there are changes made to the location of the SCSS.

14.4.11 The Contractor shall incorporate in the design lightning and power surge protection devices for the SCSS both at the camera end and equipment housing end.

14.4.12 The SCSS shall include but not limited to the following:

a. Surveillance camera(s);

b. Mounting infrastructure(s);

c. Portable equipment housing(s);

d. Transmission medium;

e. Tunnelling router(s);

f. Rechargeable batteries;

g. Solar Panels

h. Charge controller; and

i. Network Switch (For multi-camera locations).

14.5 SURVEILLANCE CAMERA

14.5.1 The Contractor shall provide a minimum of **10 Digital (HD) IP surveillance cameras** during the Contract period. In proposing the camera locations for the Authority's approval, the Contractor shall submit video recordings of all camera views from the proposed camera locations. In addition, upon the Authority's request, the Contractor shall arrange a site demonstration using a proposed camera mounted at the required height for recording.

14.5.2 The cameras complete with accessories shall be installed at locations that provide unobstructed coverage of all approaches at each location / junction with a minimum distance of 100m from the stop line of these approaches.

14.5.3 The proposed Digital (HD) IP cameras shall meet or exceed, but not limited to, the following requirements:

(a)	Signal Format	: Digital
(b)	Video Quality	: High Definition (HD)
(c)	Pan travel	: 0° to 360° continuous movement in horizontal plane
(d)	Pan speed	: 0.1° up to 80°/sec (manual operation)
(e)	Tilt travel	: +2° to -90°
(f)	Tilt speed	: 0.1° up to 40°/sec (manual operation)
(g)	Zooming	: Minimum 25x optical zoom
(h)	PTZ Option	: With pre-set option
(i)	Power	: 70 VA (nominal)
(j)	Max Sensitivity	: 0.02 lux at 1/1.5 sec
(k)	Resolution	: Up to 1920 x 1080
(l)	Aspect Ratio	: 16:9 aspect ratio
(m)	Video Output	: Compressed Video
(n)	Video Compression	: H.264
(o)	Frame Rate	: Up to 30 FPS
(p)	Video Recording Storage Duration	: 14 days
(q)	Network Interface	: RJ45 Connector
(r)	IP Rating	: IP 66
(s)	Housing	: Yes
(t)	Type	: Dome or Bullet Shape

14.5.4 The proposed cameras shall include a built-in codec unit which shall output a digital format suitable for transmission via the telecommunication network back to the laptops (supplied by the Contractor). They should also output a digital format suitable for transmission over the Internet (e.g. RTSP or SRTP format)

14.5.5 The proposed camera shall be IP addressable and support all data communications between the camera and the laptops.

14.5.6 The Contractor shall provision for the storage hardware required to allow video recording of 14 days for each surveillance camera. The location of the housing the video storage hardware shall be advised by the Authority.

14.5.7 The colour of the cameras together with the wire conduits and brackets shall be similar to the colour of the mounting poles, lampposts, overhead bridges, traffic light poles or neighbouring building façade, where possible.

14.5.8 The Contractor shall provision for the Authority's logo to be imprinted or pasted onto the dome housing of all cameras for camera identification purposes. The logo size shall be of minimum 80mm x 80mm. The Contractor shall ensure that the imprinted logo is weather-proof and shall not fade or fall off over time.

14.5.9 The Contractor shall implement appropriate measures to protect the cameras against any damage caused by lightning surge and power surge.

14.5.10 The cameras and related equipment shall be rated IP 66 and be adequately protected against moisture, condensation, ingress of dust, dirt, exhaust fumes, corrosion and any other external coastal and environmental influence.

14.5.11 The Contractor shall provide the camera information (field equipment co-ordinates, camera IDs, etc.) in a format required by the Authority for the purpose of updating the SCSS locations in the laptops.

14.6 MOUNTING INFRASTRUCTURE

14.6.1 The cameras shall be mounted on existing infrastructures such as lampposts, smart poles or traffic light poles using galvanised conduits from lead-in pipes above ground to the cameras. In the event, there is no suitable existing infrastructure can be found, the Contractor shall design, supply and erect new galvanised mounting poles with foundation to mount the cameras. The design of the mounting pole and mounting details shall be endorsed by a certified PE and be submitted to the Authority for approval. Where applicable, the pole shall be designed to blend in with the existing infrastructures.

14.6.2 The Contractor shall seek and liaise with all relevant authorities and agencies at his own costs, for approval to place the cameras and mounting poles at the proposed locations. All electrical, civil and structural works required shall be performed by the Contractor at no additional cost to the Authority.

14.6.3 The Contractor shall ensure that the mounting mechanism used for installing the camera to the infrastructures such as lampposts and traffic light poles is certified and approved by the PE. The Contractor shall provide detailed specification to the Authority’s for approval before installing it.

14.6.4 The Contractor shall use stainless steel (SS316) straps to secure the galvanised conduit or equipment to the mounting infrastructure.

14.6.5 In the event the proposed mounting mechanism of the camera to be installed onto any infrastructure is rejected by the Authority, the Contractor shall engage a certified PE to design and endorse with a new mounting mechanism, subjected to the approval from the Authority. All costs shall deem to be included in the Contract Sum.

14.6.6 The Contractor shall keep a record of the galvanised mounting poles inventory list together with the equipment list with equipment ID, location description and pole number. These mounting poles supplied shall be part of the assets under this Contract.

15 PORTABLE VARIABLE MESSAGE SIGN SUB-SYSTEM

15.1 The Portable Message Sign Sub-System (PVMSSS) comprises a network of full-matrix message signs located at strategic locations along the arterial roads to provide real-time traffic information to motorists.

15.2 The Contractor shall provide a minimum of **17PVMSSS** for the dissemination of traffic information to the motorists during the Contract period. The dimension of the mobile VMS shall be of a minimum of 2m x 2m and shall be able to remotely control from the laptops supplied by the Contractor. The design of the PVMSSS shall be submitted to the Authority for approval.

15.3 The Contractor shall be responsible for all coordination of the exact locations of the PVMSSS and shall be required to adhere to any conditions and / or restrictions imposed by any relevant authorities. All proposed PVMSSS shall be located along the turf areas within the road reserves and clear from obstruction for the Authority's approval.

15.4 The Contractor shall be responsible to liaise closely with the relevant authorities e.g. PowerGrid, National Parks Board, building owners, etc. when executing the works. Approval must be sought from the relevant authorities before any work is carried out.

15.5 The Contractor shall appoint a qualified surveyor to provide exact positions and co-ordinates of the proposed PVMSSS in terms of Global Positioning System (GPS) coordinates (in WGS84 coordinate system) and location descriptions. The information shall be updated whenever there are changes made to the location of the PVMSSS.

15.6 The structure and installation methodology of the PVMSSS shall be reviewed and endorsed by the authorised PE.

15.7 The Contractor shall provide rechargeable batteries and solar panels equipped with charge controllers for the monitoring and charging of the rechargeable batteries to ensure a continuous power supply for the PVMSSS.

15.8 All utilities fees and costs incurred for the supply of power shall be borne by the Contractor during the DLP and comprehensive maintenance period and included in the Contract Sum.

15.9 The Contractor shall directly engage the TSP for the subscription of wireless 4G or equivalent service from site to exchange and coordinate with them closely on the interface with the laptops.

15.10 The Contractor shall bear all one-time setup, monthly recurring costs and any other miscellaneous fees incurred for providing the 4G service during the DLP and comprehensive maintenance period.

15.11 The Contractor shall ensure a central control software is installed in each laptop provided for the remote viewing and control of all PVMSSS installed on site.

15.12 All field equipment health status alarms shall be sent to the laptops via the 4G service.

15.13 The PVMSSS shall include, but not limited to, the following:

a. LED full matrix display(s);

b. Local controller(s);

c. Transmission router(s);

d. Mounting structure(s);

e. Portable equipment housing(s);

f. Rechargeable batteries;

g. Solar Panels; and

h. Charge controller(s)

15.14 The proposed display sign shall meet or exceed, but not limited to, the following requirements:

(a) LED Type : Super brightness LED chip

(b) Display Colour : Amber

(c) Screen : Non-glare UV polycarbonate

(d) Intensity : Amber 9,200 cd/m^2

(e) Dimming Control : Up to 10 levels by automatic and remote control

(f) Viewing Angle : 30 degrees

(g) Pixel Pitch : 20mm

(h) Character Height : 216mm

(i) Character Spacing : Minimum 1 pixel and configurable up to 2 pixels remotely

(j) Line Spacing : Minimum 2 pixels and configurable up to 5 pixels remotely

(k) Memory : Store up to 100 messages

(l) Toggling : Up to 10 pages

(m) Toggling Speed : Minimum 2 seconds and configurable up to 60 seconds remotely

(n) Display Capabilities : 6 lines of 12 characters, full matrix, graphic and text display

(o) Communication : Local : RS485 / RS232 / RJ45
Remote wireless : WIFI / GPRS / 4G

(p) Operating Temperature : -20 ^{0}C ~ +60 ^{0}C

(q) Protection Level : IP 66 for front and rear

16 TRANSMISSION MEDIUM

16.1 The Contractor shall propose wireless transmission medium of 4G network or equivalent for transmitting digital video images from site back to Telecommunication Service Provider (TSP) exchange as well as the transmitting and receiving both of data and control signals from site to the laptops supplied by the Contractor.

16.2 The Contractor shall be responsible for engaging and liaising with TSP for all matters regarding the TSP's network for the site equipment.

16.3 The Contractor shall apply the TSP's services on behalf of the Authority. All costs incurred shall be deemed to be included in the Contract Sum and the activation dates shall be subjected to the Authority's approval.

16.4 The bandwidth of the transmission medium for each surveillance camera shall be minimum 2Mbps from site to TSP's network or other equal and approved network.

16.5 The Contractor shall submit a detailed proposal on the transmission medium. Addition information on the quality of service, bandwidth usage, performance calculation and security issues shall be addressed. The Contractor shall be responsible to work with the TSP on the details of the design such that it meets the Authority's requirements.

16.6 The Contractor shall be responsible for conducting site surveys and all coordination work with TSP for the installation, testing and commissioning of transmission medium. All costs involved shall be deemed to be included in the Contract Sum.

16.7 The Contractor shall be responsible for liaising with TSP directly on all matters pertaining to the restoration of TSP's network in the event of failures.

16.8 TRANSMISSION ROUTER

16.8.1 The transmission router or equivalent shall be used to create secured tunnels through the TSP's network via 4G or equivalent wireless service.

16.8.2 The transmission router or equivalent shall meet or exceed, but not limited to the following requirements:

a. Utilise established standard Transmission Control Protocol / Internet Protocol (TCP/IP) methods which do not require additional protocols such as Encapsulating Security Payload / Generic Routing Encapsulation (ESP/GRE) which can "break when used with Network Address Translation (NAT), or some stateful firewalls;

b. Designed to provide an end point which is compatible and able to create a secured tunnel across the TSP's network;

c. IP addressable and support all data communications among the cameras;

d. Built-in SIM card slot with fast speed connectivity of minimum 100Mbps;

e. Operating temperature of 0 to 60 degree Celsius (outdoor);

f. Suitable and certified for use in outdoor environment; and

g. Support Internet Protocol V4 and Internet Protocol V6.

16.9 NETWORK SWITCH

16.9.1 The Contractor shall provision for new network switch(s) which is / are required for locations with multiple surveillance cameras in order for the cameras to be connected to the transmission router.

16.9.2 The network switches shall be suitable and certified for outdoor use.

16.9.3 The network switches shall be IP addressable and support all data communications among the proposed cameras and any other equipment.

16.9.4 The network switches or equivalent shall meet or exceed, but not limited to, the following requirements:

a. Operating Temperature : 0 °C to +55 °C

b. Network Interface : RJ45 connector

c. Number of RJ45 Ports : Minimum of 4

17 INTERFACE WITH LAPTOPS (SUPPLIED BY CONTRACTOR)

17.1 The Contractor shall propose, design, furnish, install, implement and test the complete integration of the site equipment to the laptops. The Contractor shall lead in testing the interface between the site equipment and the laptops to allow smooth data and video transfer between them.

17.2 The Contractor shall provide a common Graphical User Interface (GUI) map to integrate both PVMSSS and SCSS for control and monitoring. The design of the GUI map shall be subjected to the Authority's approval.

17.3 The Contractor shall provide all materials, labour, cables, hardware equipment and other peripheral devices required for the integration of the site equipment to the laptops. All costs incurred shall be included in the Contract Sum.

17.4 The Contractor shall have the necessary skills and expertise to ensure that all the works involved in the interfacing of the site equipment to the laptops are done accurately.

17.5 The Contractor shall liaise and coordinate with the TSP to determine the interface requirements and ensure a seamless integration for all data (video and control data) to be exchanged between the site equipment and the laptops. The proposed interface shall be subjected to the Authority's approval.

17.6 The Contractor shall cooperate fully and provide all the necessary information required by the TSP for the purpose of linking the site equipment to the laptops.

17.7 DATA COMMUNICATION

17.7.1 The Contractor shall ensure that the data which is sent from the site equipment to the laptops shall include the following:

a. Field equipment health status (includes cameras, LED, local controller, router, battery charge level etc); and

b. Digital Video Images in HD quality, with the latest video compression standard.

17.7.2 The Contractor shall ensure that the data and command, which are sent from the laptops to the site equipment, shall include the following:

a. Pan, Tilt, Zoom (PTZ) command;

b. Display message command;

c. Polling of field equipment health status (includes cameras, encoder, battery charge level etc); and

d. Field equipment configuration settings.

17.7.3 All data and command transmission between the site equipment and laptops shall come with date and time-stamp.

18 PROJECT PROCURED LAPTOPS

18.1 The Contractor shall purchase three (3) laptops for this Contract and these laptops shall be part of the Authority's asset. The laptops are to be returned to the Authority at the end of the Contract in good working condition subject to the acceptance by the Authority.

18.2 The Contractor shall be responsible for the purchased laptops, including maintenance upkeep for the Contract period. The Contractor shall replace the laptops, with the same laptop or of higher specifications, that is caused by any damage or if found missing. The cost shall be deemed included in the Contract Price and the replacement shall be subject to the approval of the Authority.

18.3 The proposed laptops shall meet at least, but not limited to, the following:

Specification	Recommendation
Usage	Operational and Maintenance Works
Operating System	Windows 10 Professional or above
Processor	Core i7 Processor or equivalent
RAM	32GB or above
Interface Port	USB3.0 or above
Monitor	21 inch-Resolution: 1920x1080
Hard Disk	1 TB
Software	Latest version of web browsers including Chrome, Internet Explorer and Firefox Latest Java Plug-in Anti-virus software with updated virus definitions.

Table 1-1

18.4 The Contractor shall note that the purchased laptops shall only be used for the purpose of operational and maintenance works.

18.5 The Authority will assume the administrative rights of the purchased laptops for the whole Contract period. The Contractor shall work with the Authority to set up different user accounts for the various operational and maintenance teams who will use the laptops.

18.6 The Contractor shall work with the Authority to install the necessary software to carry out the operational and maintenance works. No other software is allowed to be installed in the laptops unless approved by the Authority.

18.7 The Contractor shall ensure that the laptops are not connected to the internet at all times.

18.8 The Contractor shall ensure that the laptops adhere to the IT security policies and guidelines issued by the Authority from time to time.

18.9 The Authority may, from time to time, at his own discretion inspect the laptops to ensure that the laptops are well maintained and free from any security risk. The Contractor shall facilitate and schedule for the inspection by the Authority.

19 TEST REQUIREMENTS

19.1 GENERAL

19.1.1 The system tests shall be carried out in stages as follows:

a. Factory Acceptance Test (FAT);

b. Field Test (FT); and

c. System Acceptance Test (SAT)

19.1.2 The Contractor shall prepare detailed test procedures to demonstrate all aspects of the System compliance with the Specification for the above stages of testing.

19.1.3 The Contractor shall ensure that the test plan and procedures shall be comprehensive to test all aspects of the System according to the Specification. The Contractor shall submit the test schedules, test plans, test procedures to the Authority for approval prior to the testing.

19.1.4 In addition to allowing verification of normal operating conditions, unusual occurrences such as equipment failures or the effect of incorrect operating procedures shall also be addressed.

19.2 FACTORY ACCEPTANCE TEST (FAT)

19.2.1 The Contractor shall arrange for the inspection and test of the manufactured equipment and materials including cables and accessories at the Contractor's local premises prior to its release to site.

19.2.2 The scope of the FAT shall include but not limited to the following:-

a. Diagnostic tests for each component in the Sub-Systems including all peripherals, controllers, interfaces, displays and terminals;

b. Visual inspection;

c. Test of electronic modules or cards;

d. All communication protocol tests including other contractors' equipment or gateway to the system; and

e. Demonstration of all utility software, database and graphics generator/editor functions.

19.2.3 The FAT shall be 100% covered and completed prior to the commencement of FT and SAT.

19.2.4 Where required, the Contractor shall furnish the Authority with factory test certificates for the machinery, equipment, software and other things intended to form or forming part of the works, duly certified as complying with the Specification. Records of tests, including examinations and inspections, shall be recorded and kept complete by the Contractor and made available to the Authority.

19.2.5 The FAT shall be conducted under the direction of an experienced professional who has had considerable experience in the relevant field and who has been extensively involved in the design and manufacture of the system.

19.3 FIELD TEST (FT)

19.3.1 All Sub-Systems shall be tested at the site to verify correct operation of individual components, such as cameras, LED displays, controllers and other ancillary items, where various items are interconnected in a similar manner to the actual installation on site. FT shall be carried out on individual and combination of equipment.

19.3.2 The Contractor shall be responsible to arrange all facilities and equipment which is necessary for the FT. Where it is required, overseas representative or specialist from the Contractor shall carry out or supervise the FT.

19.3.3 The FT shall be completed prior to the commencement of SAT. After the completion of the FT, there shall be a period of test operation for all Sub-Systems. The Contractor shall propose the period of test running for the acceptance of the Authority.

19.3.4 The FT involves testing of each Sub-System in terms of its full functionality and performance on site. The Contractor shall include full functional tests of the Sub-Systems with the integration of all hardware and software.

19.3.5 Anytime during the FT, if bugs in any Sub-System are discovered or if any aspect of the Specification is not met, the Contractor shall make good, within three days, the Sub-Systems to comply with the Specification and the test period shall be automatically extended for re-testing. Under no circumstances shall the Contractor be entitled for any claims whatsoever.

19.3.6 The Contractor shall carry out the FT and any subsequent re-testing of the FT to the satisfaction of the Authority.

19.3.7 The FT shall include, but not limited to, the following:

a. Local Test;

b. Communication Test; and

c. Sub-System Functional Test.

19.4 LOCAL TEST

19.4.1 The Local Test activities shall include but not limited to:

a. Sub-system hardware inspection and test;

b. Installation and wiring test; and

c. Point to point test.

19.4.2 The hardware test shall include the correctness of the points' physical addresses in the Sub-Systems.

19.4.3 The insulation and continuity of cables between the remote site equipment shall be measured during the wiring test. The Contractor shall establish the passing criteria prior to the Local Test.

19.4.4 Communication Test

19.4.5 The Contractor shall be responsible to test all communication links of the Sub-Systems.

19.4.6 Sub-System Functional Test

19.4.7 The Contractor shall simulate external inputs and Sub-System outputs to allow full functional tests to be conducted prior to the SAT.

19.4.8 A 100% input / output check shall be performed on real data if possible, otherwise simulated data may be used if real data is impossible or impractical to achieve. The use of simulated data shall be subject to the acceptance of the Authority.

19.4.9 The Contractor shall perform full functionality tests of the Sub-Systems which shall include but not limited to the following:

a. Each component including local controllers, all field equipment and servers shall be functionally tested;

b. Test all Sub-System functions to demonstrate compliance with the requirements in the Specification. These shall include performance measures and all software, database and graphics/editor functions; and

c. Test on exceptional cases

19.5 SYSTEM ACCEPTANCE TEST (SAT)

19.5.1 The SAT shall be conducted by the Contractor with the supervision of the Authority on all newly installed equipment to ensure it is functioning as required.

19.5.2 The Contractor shall provide all necessary support (manpower, vehicles, etc) to carry out a complete SAT which meets the functional and operation as a whole of all Sub-Systems.

19.5.3 All testing and other works that interfere with the existing operations shall be scheduled during off-peak hours, at night or weekends (Saturday and Sunday), as required by the Authority. The testing shall have minimal impact and shall not disrupt the existing operations.

19.5.4 The finalised details of the test plan and procedures for each test shall be submitted to the Authority for approval at least two (2) weeks in advance prior to the commencement of each test.

19.5.5 The Contractor shall ensure that the test plan and procedures shall be comprehensive to test all aspects of the Sub-Systems according to the Specification.

19.5.6 The Contractor shall submit all necessary documents and as-built drawings of all newly installed field equipment. The as-built drawing shall include the GPS co-ordinates for all the newly installed equipment location, cable routes drawing, electrical line drawings, structure and foundation dimension, etc. The documents and as-built drawings shall be endorsed, certified by authorised personnel, Professional Engineer, Registered Surveyor, Licensed Electrical Workers (LEWs) accordingly.

20 DEFECTS LIABILITY PERIOD

20.1 Please refer to Clause 21 on the maintenance standards to comply during the one (1) year Defects Liability Period.

21 MAINTENANCE

21.1 SCOPE OF MAINTENANCE

21.1.1 This contract shall include comprehensive maintenance of the System and analysis of the site observations and operational issues encountered during the Contract period.

21.1.2 The scope of works for maintenance shall include the following:

(a) Preventive Maintenance (PM)

(b) Corrective Maintenance (CM)

21.2 MAINTENANCE REQUIREMENT

21.2.1 General

21.2.1.1 The Contract Price shall be deemed to have covered all costs to perform the works required in this Contract including all labour, spare parts, consumables, vehicles, lane closure equipment, tools and other materials, documentation, insurance (except those provided by the Authority), test equipment, car park charges and all other necessary items.

21.2.1.2 All works carried out by the Contractor shall be in accordance with good engineering practices, relevant Acts and Regulations, relevant Codes of Practice (COP) and Standards, manufacturer's recommendations, Ministry of Manpower (MOM), Building and Construction Authority (BCA) and Authority’s policies and procedures.

21.2.1.3 The Contractor shall comply with latest edition Code of Practice for Traffic Control at Work Zone and Works on Public Streets.

21.2.1.4 The Contractor shall provide and supply all replacement parts, spares, consumable materials including batteries, manpower, tools, equipment, data cable, power cables, software, patches and all other incidentals necessary for carrying out the works.

21.2.1.5 The Contractor shall liaise and coordinate his work with all external agencies (e.g. Town Councils, Telecommunication Service Providers, Traffic Police, Power Utility Agency, National Parks Board etc.). The Contractor shall also attend to related matters which are in connection to the fulfillment of the responsibilities and obligations in this Contract.

21.2.1.6 Any software or equipment of any kind used by the Contractor to carry out his obligations under the maintenance shall not interfere with the normal operations of the System.

21.2.1.7 The Authority reserves the right to inspect any works at any time or carry out site survey with the Contractor. The Contractor shall facilitate the inspections or survey by providing transportation, traffic cones, TMA and all other necessary tools and equipment at no additional cost.

21.2.1.8 The Contractor shall perform regular checking, periodical inspections and monitoring of the System's condition to ensure optimum working condition and to prevent catastrophic failure of any of the hardware, software and other peripherals.

21.2.1.9 The Contractor shall use GPS equipment to capture the locations of field equipment when required by the Authority for updating GPS information of the equipment. The GPS equipment used shall be able to collect attribute information in both numeric and alphanumeric. Raw data from the GPS equipment shall be provided so that data verification can be done.

21.2.1.10 The Contractor shall maintain and update all maintenance activities in a maintenance log book kept at site.

21.2.2 Preventive Maintenance (PM)

21.2.2.1 PM shall include all scheduled or planned works consisting of at least, established or recommended periodic inspections of the equipment, condition monitoring, critical parts replacements, adjustment, calibrations, lubrication, cleaning, housekeeping, application of OS and software patches/updates, antivirus updates, backups.

21.2.2.2 The following PM works shall be carried out:

(a) PM once every three (3) months

(b) Electrical testing once every year

(c) Batteries replacement minimum once every year

21.2.2.3 The PM frequency shall be any period which is recommended by the manufacturer or supplier which is shorter than the frequency required by the Authority.

21.2.2.4 The Contractor shall plan and propose the PM schedule and submit to the Authority for acceptance. Any changes to the schedules shall be submitted to the Authority for approval.

21.2.2.5 Contractor shall take digital photographs of the condition of the equipment; including defects found during maintenance works and submit to the Authority the digital copies in CD or DVD media as part of the maintenance report.

21.2.2.6 Any PM work carried out shall not cause any disruption to the operation of System and all the communication links. In the event that shutdown of the field equipment is required during PM work, the Contractor shall seek the Authority's approval prior to carrying out the PM. The Contractor shall inform the Authority in writing at least two (2) calendar weeks in advance.

21.2.2.7 Electrical testing includes insulation testing resistance test, earth continuity test, polarity test, earth loop impedance, RCCB test and supply voltage measurement. All tests reports shall be properly documented and endorsed by LEW and submitted to the Authority.

21.2.2.8 The Contractor shall indicate on each of the battery the date of first use.

21.2.2.9 PM shall include at least, the following:

(a) Inspect, lubricate, test, align, adjust, measure and calibrate the hardware.

(b) Replacement of worn out equipment housing rubber gasket, door locks and hinges.

(c) Carry out housekeeping of all the equipment housing and surrounding areas.

(d) Replacement of consumables and parts of such frequency and duration as recommended by the hardware manufacturers.

(e) Visual inspection on the structure of all equipment. Visually check for any cracks on the foundation, structure, bolts, nuts, lock pins, adverse displacement of the structure, corrosion, wear and tear of mounting supporting brackets, etc. The Contractor shall highlight such defects in the PM check list. The Contractor shall replace or reinstate any of the components when necessary. The replacement of washers, bolts, nuts and cable straps shall be of stainless steel.

(f) Repair any cracks found and touch up with concrete and paint where applicable.

(g) Check for water stagnation inside equipment housing, camera housing and portable message signs.

(h) Cleaning of equipment housing, camera housing and portable message signs.

(i) Equipment alignment / adjustment if is necessary to achieve the optimal position / field of view for the equipment / camera if it is found that the equipment is not in the correct position.

(j) Checking and tightening of the cable mounting support on the mounting infrastructure. The cable ties and / or straps shall be replaced when worn out or rusty.

(k) The Contractor shall change the label tag on the equipment housing if the label is no longer valid, fazed/defaced or missing.

(l) Relocating and adjustment of the portable message signs.

(m) Shutdown and restart of frontend equipment and laptops if is necessary. The Contractor to inform the Authority at least two (2) weeks in advance for such work.

(n) Check resource utilization of all equipment to ensure the utilization is below defined threshold.

(o) Installation, reconfiguration, testing and implementation of standard corrections, patches and updates of operating systems, application software and firmware. This shall include the supply, installation of newer versions and newer releases of the software, updating of related documentation and materials. The Authority shall have the rights to test the new patches, updates and releases.

(p) Keep the antivirus definition up to date as and when it is available on all laptops.

(q) Perform laptops' housekeeping, checking of available hard disk space, CPU and memory usage etc.

(r) Perform antivirus scan on all laptops.

(s) Perform backup including configuration files, hard-disk image and database, and test to ensure the backup can be used for system recovery.

(t) Perform connection checks to all the field equipment.

21.2.2.10 The Authority has the right to make changes to the maintenance checklist to improve the maintenance work carried out. The Contractor may suggest improvement to the maintenance work subjected to the Authority' approval.

21.2.2.11 The Contractor shall report to the Authority immediately of any abnormalities found during PM. Description and photograph(s) of the abnormalities are to be submitted to the Authority. This includes any illegal tapping of power from any of the equipment power source. The Contractor shall lodge police reports on the same day that the equipment or parts are found stolen, damaged or vandalized and submit a copy of the police reports to the Authority.

21.2.2.12 The Contractor shall ensure that all equipment shall be pest-free, including if there is a report of dangerous pests such as bees hive; the Contractor shall activate a licensed pest control company to eradicate it immediately as part of maintenance.

21.2.2.13 The Contractor shall submit a PM report within one (1) calendar week upon the completion of the PM. The report shall include:

a. Maintenance checklists at all locations

b. Service report for the System at all locations.

21.2.3 Corrective Maintenance (CM)

21.2.3.1 CM shall include all unscheduled works performed to restore the System after occurrence of any fault condition including cyber-attacks. The corrective maintenance cycle shall include fault localisation and isolation, power-tripped recovery, disassembly, checkout and condition verification, system recovery and restoration after a virus/malware infection or a cyber-attack, urgent software patching or update, etc. Also, unscheduled servicing may occur as a result of a suspected or intermittent failure, even if further investigation indicates that no actual failure has occurred.

21.2.3.2 All CM shall include all actions to diagnose and rectify malfunctions of the System by repair or replacement so that it can operate at its optimal condition and perform as specified.

21.2.3.3 Any equipment damaged due to power surges induced by lightning or other causes, the Contractor shall make good the damages.

21.2.3.4 Any repair and replacement of the damaged equipment that arises from accident, vandalism or damage by other parties during the operation and maintenance period shall constitute a variation to the Contract.

21.2.3.5 The Contractor shall notify the Authority in the event a replacement of any equipment can only be carried out with an alternative equivalent design, for reasons beyond the control of the Contractor. Replacement of any part shall only be carried out after obtaining approval from the Authority.

21.2.3.6 The Contractor shall be responsible to rectify any breakdown, defect or malfunction to any part of the equipment. All repair or replacement shall be carried out at the Contractor's own expense including airfreight and other transport charges, if any. The Contractor shall also be responsible for fault isolation and removal of any faulty items.

21.2.3.7 For each reported fault, the Contractor shall submit to the Authority a fault report for each corrective maintenance work stating the cause of failure and rectification actions taken within two (2) working days upon completion of fault resolution. The report shall include the following:

a. Date and time the Contractor is notified of any defect or malfunction

b. Time of arrival of the Contractor to the site

c. Item or part of the software or hardware subject to investigation

d. Total time the System or part thereof is made unavailable to the Authority

e. Description of defect(s), including cause(s)

f. Corrective action taken, including temporary corrections, bypasses, etc. and the date and time it was resolved

g. Name of the Authority acknowledging the completion of the corrective work

h. Date and time of the completion of corrective work as verified and acknowledged by the Authority

i. Preventive action to be taken

j. Tests performed and results

k. Any spares used

l. Supporting activity logs

m. Other related supporting documents

21.2.3.8 The Contractor shall make good any graffiti found on any surface or the equipment and remove illegal posters pasted including their residues as part of the PM and CM or when informed by the Authority.

21.2.3.9 The Contractor shall replace the battery(s) if battery(s) is low in voltage during CM.

21.2.4 FAULT CLASSIFICATION

21.2.4.1 Fault refers to when a component, a part, a portion or all of the System is faulty, not fully operational or not performing its designated purpose. It can be a malfunction, breakdown or defect.

21.2.4.2 The System's equipment fault shall be classified into three (3) categories:

a. Critical

Faults which adversely affect the operation of the System, or are life threatening and/or affect safety.

Examples are:

i. Malfunction of an entire Sub Systems;

ii. Malfunction of field equipment (cameras, message signs, controllers, routers and switches, etc) and laptops;

iii. Unsafe tilting of portable message sign structure;

iv. Accident cases and the damaged equipment is affecting road safety;

v. Failure of more than two consecutive PVMSSS or SCSS in the same direction of an arterial road at any one time;

b. Major

Faults that are not critical but can lead to a critical situation when a second failure occurs or in combination of some other conditions.

Examples are:

i. Malfunction of any part of the Sub-Systems that partially or fully hinders or disrupts the traffic operation and monitoring functions;

ii. Degraded performance (such as but not limited to system hanged, lagging, LED pixel failure etc) that will affect the normal System functions; and

iii. Garbage display on any portable message sign.

c. Minor

Any other faults which are of routine nature and are not defined as Critical or Major.

Examples are:

i. Failure of other peripherals that have minimal or no effect on functionality and operation of the System; and

ii. Spider web or scratches on camera housing lens.

21.2.5 FAULT REPORTING AND MANAGEMENT

21.2.5.1 The Contractor shall be contactable and be available 24 hours a day, 7 days a week including public holidays to attend to all maintenance issues pertaining to the System.

21.2.5.2 The Contractor shall propose a fault escalation plan and submit to the Authority for approval. The Authority shall provide the Contractor with a list of personnel and contact numbers for this purpose.

21.2.5.3 The Contractor shall provide short message service (SMS) alerts to the Authority within five (5) minutes from fault occurrence and update the Authority within five (5) minutes following the rectification / resolution of the fault. Additional means of alerts via electronic mails or any other means via mobile devices through internet or mobile broadband transmission shall be proposed and implemented upon Authority's request.

21.2.5.4 The Contractor shall submit a summary and log files of fault alerts with the fault occurrence, response and rectification time with corresponding SMS alerts sent.

21.2.6 MAINTENANCE STANDARDS

21.2.6.1 Response Time is defined as the period of time which commences from the time the Contractor is notified of a fault, breakdown, defect, damage, accident or incident, whether verbally or in writing or through fax or through text message or through fault reporting system, to the time when qualified maintenance personnel arrive at the site where the equipment is located and start the troubleshooting and commence of the rectification works. In the event that the Contractor could not be contacted, the time delayed shall be computed into the Response Time, up to the Resolution Time.

21.2.6.2 Resolution Time is defined as the period of time which commences from the time a fault the Contractor is notified of a fault, breakdown, defect, damage, accident or incident, whether verbally or in writing or through fax or through text message or through fault reporting system, to the time the fault, breakdown or defect is fully rectified and tested and the affected item, System or equipment is restored to its normal functioning condition or to condition agreeable with / instructed by the Authority for damage, accident or incident cases.

21.2.6.3 The maintenance standards for Response Time and Resolution Time are:

Fault Types	**Allowable Response Time (Hours)**	**Allowable Resolution Time (Hours)**
Critical	1	3
Major	1	6
Minor	12	24

21.2.6.4 If the Contractor is unable to rectify the fault within the Allowable Resolution Time, the Contractor shall inform the Authority immediately. The Contractor shall continue to rectify the fault and update the Authority on the progress of the rectification works until the completion of the rectification works. Upon completion of the rectification works, the Contractor shall explain in writing to the Authority the cause of the delay in the rectification works.

21.2.6.5 System Operational Availability (SOA) is defined as:

$$SOA = \frac{\text{Total Serviceable Time}}{\text{Total Available Operational hours}} \times 100\%$$

21.2.6.6 Serviceable Time shall be the time that the System is fully operational. This is equivalent to Total Available Operational hours minus total Resolution Time.

21.2.6.7 Total Available Operational Hours shall be the total number of operating System multiplied by their respective operating hours.

21.2.6.8 The System shall operate 24 hours a day, 7 days a week.

21.2.6.9 Hardware and / or software which malfunctioned and affect the normal operations and performance of the System to meet all requirements specified in the Specification shall be considered as “operationally down”. The duration and the number of equipment that are “operationally down” shall be the downtime for the computation of the monthly SOA.

21.2.6.10 The period of time during which the System is running on temporary, standby, or bypass measures shall be considered as Resolution Time unless it is a planned PM activity to run the System in the manner.

21.2.6.11 The computation of the SOA shall be presented in the monthly maintenance report. The Contractor shall submit the SOA report for the month on the first working day of the following month.

21.2.6.12 The maintenance standards for monthly SOA are:

Equipment	Monthly SOA
PVMSSS and SCSS	98.5%

21.2.7 ADMINISTRATIVE CHARGES (AC) FOR NON-PERFORMANCE

21.2.7.1 If the Contractor fails to meet the maintenance standards for the Response Time and Resolution Time, the following AC shall be imposed:

Fault Types	**Administrative Charges**	
	Exceeded Allowable Response Time (R1)	**Exceeded Allowable Resolution Time (R2)**
Critical	$150/- per hour for every hour or part thereof (up to the Allowable Resolution Time) that exceeds the Allowable Response Time of 1 hr.	$150/- per hour for every hour or part thereof that exceeds the Allowable Resolution Time of 3 hrs.
Major	$120/- per hour for every hour or part thereof (up to the Allowable Resolution Time) that exceeds the Allowable Response Time of 1 hr.	$120/- per hour for every hour or part thereof that exceeds the Allowable Resolution Time of 6 hrs.
Minor	$20/- per hour for every hour or part thereof (up to the Allowable Resolution Time) that exceeds the Allowable Response Time of 12 hrs.	$20/- per hour for every hour or part thereof that exceeds the Allowable Resolution Time of 24 hrs.

21.2.7.2 The Contractor shall pay to the Authority or shall allow the Authority to deduct the AC from any sums due or shall become due to the Contractor under the Contract.

21.2.7.3 The total AC to be paid by the Contractor and / or deducted by the Authority pursuant to Clause 21.2.7 of the Specification shall be capped at **$31,550/-** per month.

21.2.8 FAULT MONITORING AND ANALYSIS

21.2.8.1 The Contractor shall capture the fault details throughout the whole month and perform trend analysis e.g. equipment with highest failure rate, highest failure type, etc. For the top highest three faults, the Contractor has to analyze these faults to find out the root causes. The Contractor shall carry out preventive measure approved by the Authority to prevent the same failure from happening and to reduce the failure rate. This report shall be submitted monthly.

21.2.8.2 The Contractor shall monitor and capture the battery charge level throughout the entire month and perform analysis on the charging and battery(s) performance. The Contractor shall carry out preventive measure such as replace the battery(s) when it is observed that the battery(s) is starting to be unable to hold charge.