



TENDER NO. 25G/2009/10

CONTRACT DOCUMENT

FOR THE

**DESIGN, SUPPLY, DELIVERY, INSTALLATION,
TESTING, COMMISSIONING AND MAINTENANCE OF
THE IRT CONTROL CENTRE HARDWARE AND
SOFTWARE SYSTEMS**

VOLUME 2B

(NON-RETURNABLE DOCUMENT)

SCOPE OF WORK, TECHNICAL REQUIREMENTS and SITE INFORMATION

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CITY OF CAPE TOWN

TRANSPORT ROADS & STORMWATER

CONTRACT NO. 25G/2009/10

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CONTROL CENTRE HARDWARE AND SOFTWARE SYSTEMS**

General Tender Information

This **Volume 2B** constitutes the balance of the Tender Documentation in accordance with F1.2 in Part T1.2 Tender Data on pages 4 and 5 of Volume 2, and is not returnable as stated in the foregoing clause and in F2.13.2 on page 7 of Volume 2.

This **Volume 2B** contains 107 pages numbered i to v and 1 to 107 in consecutive order (refer to Declaration in Part C2.2 Schedules of Quantities in Volume 2). These pages numbers exclude the Appendices and Drawings attached to the Volume.

DESIGN, SUPPLY, DELIVERY, INSTALLATION, TESTING, COMMISSIONING AND MAINTENANCE OF THE IRT CONTROL CENTRE HARDWARE AND SOFTWARE SYSTEMS

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Volume 2B	Scope of Work, Detailed Specifications & Drawings (non-returnable document)

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PART C3: SCOPE OF WORK

C3.1 DESCRIPTION OF WORKS

C3.1.1 Purpose and Objective of the Project

The objective of this project is to supply, install, commission/test, train, integrate and maintain an Integrated Rapid Transit (IRT) vehicle management system including fixed-route and feeder Computer Aided Scheduling and Dispatching (CASD) system, an Automatic Vehicle Location (AVL) systems, a Vehicle Weight Measurement (VWM) system, Advanced Traveller Information (ATI) and Communication systems, Security and Surveillance Systems (CCTV and Emergency Phones), a Data Management System, and bus (transit) signal priority (TSP) system.

The high level scope of work for the project includes the following specific work elements:

- (1) Deployment of an on-board system on the entire IRT fleet. The fleet of vehicles is in the process of being purchased by the City of Cape Town. The control centre company will be required to provide most of the on-board ITS related hardware (computer, intercom, GPRS modem, GPS device, Mobile Data Terminal (MDT), etc) and the rest of the on-board equipment will be provided and installed under the vehicle tender. The Control Centre Company is responsible for the integration of all hardware supplied on the buses with the operations in the Traffic Management Centre (TMC). This tender includes interfacing with the technology on the IRT fleet at the following levels:
 - Tracking of vehicles in the control centre using GPS coordinates transmitted by all vehicles via 2G/3G wireless communications.
 - Managing of the bus fleet in real time utilizing the schedules developed.
 - Communicating with the on-board passenger information system, infotainment system, driver MDT, and driver radio/phone link.
 - Providing information to the on-board transponder/tag device which will be used to activate traffic signals to provide bus priority at the traffic signals.
 - Uploading and management of on-board video recordings, offline.
 - Uploading of mechanical information stored on the bus.
 - Vehicle Weight Measurement (VWM) system
- (2) Deployment of a Central Control System with the necessary software (Scheduling and Dispatching), central data servers, work stations and large screen displays for use by the ITS Entity (system operators and managers).
- (3) Deployment of a video control system in the TMC from where activities in the stations and along the route can be monitored in real time as well as reviewing of off-line video material from the buses.
- (4) Implementation of an Advanced Traveller Information System (ATIS) providing real-time public transport information via electronic next bus signs at the stations and on the buses, an interactive web site.
- (5) Deployment of a communication system integrating the on-board systems and the Central Control System via 2G/3G communications, Wireless Networks in the Depots (WLAN), last mile fibre optic communication near the stations and at the depots, all the necessary data links within the stations, depots and in the control centre by single mode backbone fibre and other communication links.
- (6) Deployment of the necessary infrastructure (software and hardware) in the control centre, on the buses and at the relevant traffic signals to provide traffic signal priority for buses on a selective basis when needed.

These items must operate in a fully integrated manner, and must provide for external interfaces to other systems as described herein. In addition, the deployment shall allow for expansion over time, including increases in the number of vehicles or operators, and the addition of enhanced or improved functionality.

It shall be the responsibility of the Contractor to bid a complete system and provide all equipment, hardware, software and services necessary to ensure a fully functioning system as described by this specification. This requirement includes any permits, authorizations, inspections, designs, licenses, way leaves and/or other activities necessary to install any equipment on vehicles or at City of Cape Town facilities. The City of Cape Town will reasonably assist the contractor in

obtaining the required clearances, and approvals but this will not in any way absolve the Contractor from providing a complete and operational system that meets the requirements identified in this document.

C3.1.2 Overview of the works

Refer to **Figure 21** in Section C4.

C3.1.2.1 Description

The ITS elements that need to be provided as part of this contract can be categorised as follows:

- On-board systems (By Control Centre Company)
- Station systems
- Control Centre systems
 - Operations and Control
 - Safety and Security
- Communications systems
- Traffic signal pre-emption systems

Advanced Public Transportation Management System (APTMS) equipment shall be installed on the entire CoCT IRT bus fleet, including trunk buses and feeder buses.

The objective of this project is to supply, install, commission/test, train, integrate and maintain an IRT vehicle management system including fixed-route and feeder CASD/AVL systems, an VWM system, Advanced Traveller Information and Communication systems, Security and Surveillance Systems and data management and export systems.

Work elements shall include.

- (1) Deployment of an On-Board System on the entire IRT fleet, including trunk and feeder vehicles.
- (2) Deployment of a Central Control System with central data servers, work stations and large screens for use by the ITS Entity.
- (3) Implementation of an Advanced Traveller Information System providing real-time public transport information via electronic next bus signs, an interactive web site, and an optional.
- (4) Deployment of a communication system integrating the on-board systems and the Central Control System via 2G/3G wireless communications, Wireless Networks in the Depots (WLAN-802.11), and other communication links.
- (5) Implementation of security CCTV cameras including alarms, recording and video management.

These items must operate in a fully integrated manner, and must have external interfaces to other systems as described herein. In addition, the deployment shall allow for expansion over time, including increases in the number of vehicles or operators, and the addition of enhanced or improved functionality.

It shall be the responsibility of the Contractor to bid a complete system and provide all equipment, hardware, software and services necessary to ensure a fully functioning system as described by this specification. This requirement includes any permits, authorizations, inspections, designs, licenses, way leaves and/or other activities necessary to install any equipment on vehicles or at City of Cape Town facilities. The City of Cape Town will reasonably assist the contractor in obtaining the required clearances, and approvals but this will not in any way absolve the Contractor from providing a complete and operational system that meets the requirements identified in this document.

C3.1.2.2 Programme

One of the main drivers behind the implementation of the first phase of the IRT is the preparation of transport systems for the hosting of the 2010 FIFA Soccer World Cup. The IRT project programmes must ensure that Milestone 1, which includes limited sections of the works, is achieved before the start of the 2010 FIFA Soccer World Cup events.

With this in mind, the contractor's project programme must clearly illustrated phases and milestones for the different elements and/or tasks that will result in successful completion of the works within the contract period. Refer to Sub-Clause 8.2 of the Particular conditions in Volume 2A

The installation of the equipment could extend over the 2009 December holiday period. The contractor must allow to work during the holiday periods, except possibly for the week between 24 December 2009 and 1 January 2010.

For Milestone 2 only those vehicles, trunk stations and the TMC, which will be made accessible to the Contractor prior to Milestone 1, are at minimum required to be completed on or before 1 September 2010.

For Milestone 3 the remainder of the works shall be completed on or before 16 February 2011.

It is envisaged that the contract will be awarded in during October 2009, with a site handover (contract commencement) some time during that month. The contract completion date will be 16 February 2011 with the milestones as defined in Sub-Clause 8.2 of the Particular Conditions.

Tenderers shall state in their tenders their ability to meet this programme and shall submit in their tenders their proposed programme of works. The programme shall highlight the critical path, all long lead items and indicate delivery dates for all long lead items.

The Contractor shall be responsible for co-ordination of the programme between himself and any subcontractors which he may appoint as described in the FIDC general conditions of contract.

The contractor's programme will be impacted significantly by other contracts such as the construction of the IRT stations, the IRT depots, the Transport Management Centre (TMC) and the delivery of the vehicles. It is the contractor's responsibility to liaise with the relevant parties to ensure realistic planning of activities.

Milestone 1: 2010 tournament – on or before 2010-05-05

- (i) Installation of all components and software systems on the trunk and feeder vehicles (which will be used for the Soccer World Cup Tournament) as required to deliver a functional basic vehicle tracking system and a functional communication system to communicate with the drivers on the vehicles; and
- (ii) Installation of a functional control system in the newly constructed Transport Management Center in Goodwood, Cape Town. The City needs to be in a position to manage and control the fleet of vehicles that will be used for the Soccer World Cup to undertake vehicle tracking and monitoring and controlling drivers.
- (iii) The above requirements are minimum requirements. Any additional functionality which can be provided in the available time should be installed to enhance to system as much as possible.

Milestone 2: on or before 2010-09-01

- (i) Installation of all the remaining system components and software on vehicles which was partially equipped under Milestone 1, as required under the Contract and the Detailed Specifications;
- (ii) Installation of all hardware and software systems to deliver a fully functional control centre in the TMC in Goodwood, Cape Town; and
- (iii) Installation of all systems and software in trunk and feeder stations to which access is given to the Contractor for Milestone 1. The stations that will be completed by May 2010 need to be fully equipped in Milestone 2. These stations will not be equipped during Milestone 1.

Milestone 3: on or before 2011-02-16

Completion of the remaining installation on all vehicles, stations, TMC and depots.

C3.1.2.3 Site Offices and site facilities available

There are no facilities available for the contractor. If the contractor has no premises in or around Cape Town to operate from, the premises will have to be rented. Allowances are made for the payment of office rental. The rented office space, must be within 10 kilometers of the City Centre and preferable along the proposed IRT route or close to the TMC building in Goodwood.

C3.1.2.4 Environmental requirements

The contractor will be responsible for construction according to an approved environmental management plan. The contractor must take the utmost care to minimise the impact of any site establishment and other construction activities on the environment and must adhere to the requirements as set out in the approved environmental management plan.

C3.1.2.5 Schedules of information

All the schedules applicable to this contract are to be found in the tender documentation

Note in particular the following information to be **provided with tenders**:

- Completed Tender Offer Part C1.1 (Signed)
- Completed Pricing Schedules Part C2.2 (Signed)

- Completed Returnable Schedules Part T2, with supporting documentation
- Completed Technical Schedules Part T2.2, with supporting documentation
- Programme of Works
- Project References
- Company Profile and Previous Work Experience including Value of Works

Tenders are also required to provide a covering letter and executive summary of their tender, with emphasis on how they plan to resource the project and achieve the project milestones.

C3.1.2.6 Subcontractors

The diverse nature of this contract may necessitate the involvement of one or more subcontractors. Tenderers shall ensure that their subcontractors have the necessary experience and have the capabilities and resources available to execute their portion of the works within the programmed dates.

Tenderers shall indicate in the schedules provided in Schedule 6 "Schedule of Subcontractors" in part T2.2, the names of subcontractors they wish to employ in the works, and shall define their duties and outline their experience.

Once the successful tenderer has been appointed, subcontractors may not be changed without the prior approval of the Engineer.

C3.1.2.7 Delivery of materials and equipment

It is the responsibility of the Contractor to take delivery, off-load, store and move into their permanent position all equipment and material covered under this contract.

C3.1.2.8 Changes to scope of work

It is a condition of this contract that the employer reserves the right to limit the total expenditure on the Works due to possible budget constraints. Should the tender sum exceed the budgeted amount, the scope of works may be reduced at any time before or during the contract period to ensure that the final contract amount does not exceed the budgeted amount.

The Employer also reserves the right to increase the scope of the Works by at least 15 % of the contract value.

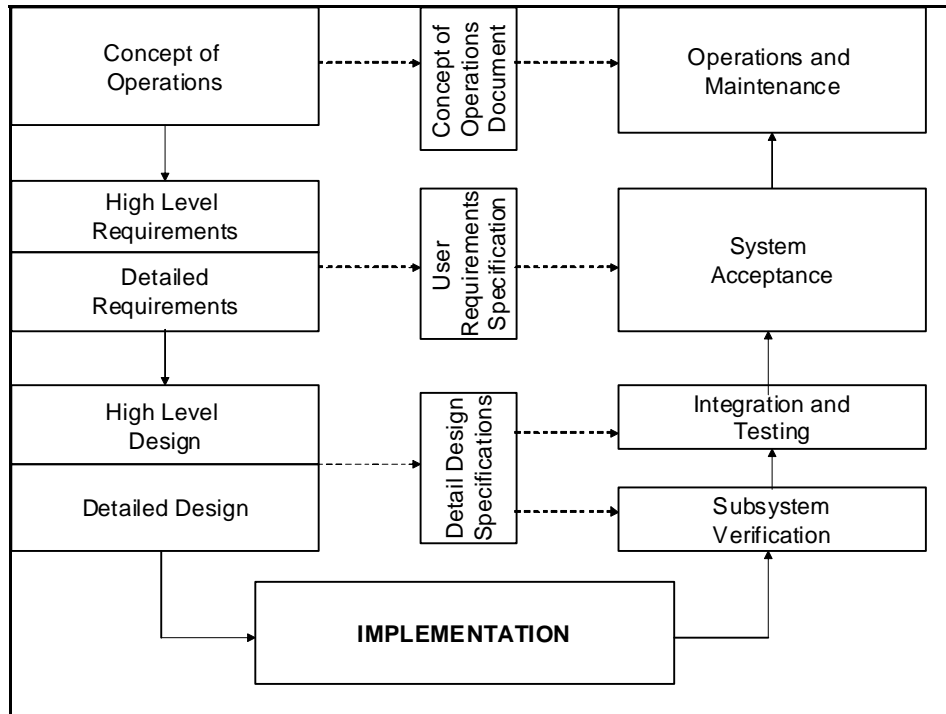
C3.1.2.9 Requirements of the occupational health and safety act and regulations

Tenderers should note that some of the works (at the stations) will be carried along routes which carry high traffic volumes, and this should be taken into account in the development of a Health and Safety plan.

C3.2 ENGINEERING DESIGN

C3.2.1 System Design Process

The system engineering process is being followed for the specification, design, and implementation and testing of the electronic systems for the Cape Town IRT project. This is illustrated in the following figure.



Each of the stages of systems engineering is shown.

The cross-relationship between Concept of Operations and Operations and Maintenance stages, and between User Requirements Specification and System Acceptance should be noted.

Figure 1: Systems Engineering Process

Based on the figure above, this specification provides the tenderer with the User Requirements Specification. It shall be the responsibility of the contractor to implement the other steps in the Systems Engineering Process. More detail with regards to these steps is described in paragraphs C3.2.1.1 to C3.2.3 below.

The Contractor shall conduct two formal design review meetings (with each extending over multiple days as needed) namely High Level Design and Detail Design. These reviews shall be conducted to evaluate the progress and technical adequacy of the design and compatibility with the requirements of the contract.

The Contractor shall establish a design review schedule. The initial schedule shall be tentative and shall be updated as necessary to provide a minimum notice of 14 calendar days for each scheduled review.

At least 14 calendar days prior to a scheduled review, the Contractor shall submit a System Design Document (SDD). The Contractor may submit design review material incrementally, however a complete listing and submittal of each section of the System Design Document shall be provided at least twenty-one days in advance of the meeting. Each section of the System Design Document shall contain version control numbers and revision dates.

The review shall be conducted on mutually agreeable dates at City of Cape Town offices in Cape Town on Hertzog Boulevard. The Contractor shall provide design review personnel with technical competency and knowledge in all subject areas reviewed.

The Contractor shall employ human factors and industrial design principles for equipment and user interface design.

C3.2.1.1 High level design (HLD)

The preliminary design review shall be held approximately four (4) weeks after Contract Award. The initial review will focus on the deliverables for Milestone 1. Subsequent design reviews must be programmed by the contractor to ensure sufficient time for manufacturing, delivering and installation to meet the other milestone dates.

The preliminary design review shall be held to confirm basic system functionality and conformance with the contract. The preliminary design review shall also be used to solicit City of Cape Town input on system engineering and design.

The preliminary design review shall represent approximately 50-70% completion of the total engineering work. Documentation shall be provided at a first draft or preliminary level.

The System Design Document issued in both hard copy and electronic format at PDF shall include at a minimum:

- (1) Schedule compliance and discussion of variances or delays.
- (2) An overall system architecture identifying functional blocks, distribution of major processes, and data and information flows.
- (3) ITS Architecture diagrams to the equipment package level.
- (4) Flowcharts, diagrams, and supporting text describing major system processes. Major software applications shall be described in detail, especially where custom processing algorithms are to be provided.
- (5) Functional and physical descriptions of all proposed hardware elements.
- (6) Preliminary user interface information and drawings, flow charts, messages and menus.
- (7) Description of all system security features.
- (8) Preliminary equipment mounting arrangements, dimensions and installation requirements. The Contractor shall include with this initial estimates of installation time.
- (9) Preliminary data model describing entities, attributes, data dictionary and meta data
- (10) Communications system architecture described graphically and in text, along with descriptions of the transmission mediums to be used, capacity utilization, speed, and expected reliability and availability.
- (11) Hardware and software interfaces with other City of Cape Town systems, as well as a complete description of the inter-relationships of Contractor supplied hardware and that of City of Cape Town.
- (12) Listing of special tools and software requirements.
- (13) Summary of human factors and industrial engineering results.
- (14) System backup and recovery procedures.
- (15) Software design descriptions (top level of software documentation) for microprocessor-based or programmable equipment.
- (16) Preliminary report structure and content.

Preliminary design review material shall also include annotated outlines of all manuals, training materials and other system and operational documentation

Within seven days of the preliminary design review, the Contractor shall prepare and issue a summary of all design review items arising from the meeting. The summary shall also include any items transmitted by City of Cape Town separately up to three days after the meeting. The Contractor shall indicate proposed actions to resolve outstanding design items. Such actions may include:

- (1) No further action required. This shall be accompanied either by a note that this was agreed to at the meeting, or by an explanation/justification by the Contractor.
- (2) To be revised for Final Design Review.
- (3) Outstanding issue for resolution. This shall be accompanied by a description of the issues, options for resolution, and process for resolution.

All issues and proposed actions/resolution are subject to approval by the City of Cape Town.

C3.2.1.2 Detail Design

The final design review for specifically Milestone 1 shall be held approximately three to four weeks after the summary of the Preliminary Design Review has been issued.

For the final design review, the Contractor shall furnish the City of Cape Town with updated (from the preliminary design review) and complete written documentation describing the system to be delivered including all equipment and software to be furnished. The System Design Document (SDD) shall include, as a minimum, the following information:

- (1) Overall system schematic and architecture;
- (2) Major assumptions and risks;
- (3) Detailed description of all sub-systems and equipment and hardware, including functional description, interface descriptions, communications loading details, material specifications (i.e. environmental, electrical etc), Material Selection Documentation (MSD), configuration details and installation details;
- (4) Description of how the system deals with a loss of communication, including Interface) for the software;
- (5) Details on all network, data, power/electrical or other requirements provided by a third party;
- (6) Detailed description of all software, including functional description, system interface descriptions, Graphical User Interface descriptions, hardware specifications, availability and reliability figures and configuration details;
- (7) Detailed description of the information style and content that will be disseminated to the public, including but not limited to, VMS (Variable Message Sign) message sets, structure and content, web site style, content and organization, and how the web site shall address requirements for universal accessibility;
- (8) Detailed descriptions of information, materials, and timing required by the Contractor of other parties; and

The final design review shall be conducted when the design for the system is substantially complete, just prior to production drawing and software specification release. This shall represent approximately 90% completion of the engineering work.

The final design review shall determine that the detail design of the subsystem under review will satisfy the design requirements and establish the exact interface relationships between the subsystem and equipment or facilities.

Final design review materials shall include in both hard copy and electronic format a draft final (90% complete) version of the Systems Design Specification, including at a minimum:

- (1) Schedule compliance and discussion of variances or delays.
- (2) Final system architecture identifying functional blocks, distribution of major processes, and data and information flows.
- (3) Final flowcharts, diagrams, and supporting text describing major system processes. Major software applications shall be described in detail, especially where custom processing algorithms are to be provided.
- (4) Listing of all third party software to be provided including version number and license information.
- (5) Detailed hardware functional and physical descriptions including dimensions, weight, power and environmental requirements.
- (6) Detailed user interface information and drawings, flow charts, messages and menus.
- (7) Updated description of all system security features.
- (8) Final equipment mounting arrangements, dimensions and installation requirements including all brackets and mounting hardware design. Design work related to this will require input and review from, and coordination with, City of Cape Town Vehicle Maintenance. The Contractor, with input from Vehicle Maintenance and OEM's (Original Equipment Manufacturers), shall provide final estimates of installation time and shall prepare detailed installation procedures.
- (9) Final data model describing entities, attributes, data dictionary and meta data.

- (10) Final communications system architecture described graphically and in text, along with descriptions of the transmission mediums to be used, capacity utilization, speed, and expected reliability and availability.
- (11) Final hardware and software interfaces with other City of Cape Town systems. Each interface shall be described in a unique interface control document (ICD) describing all associated electrical, data and security elements and structure of the interface.
- (12) Final listing of special tools and software requirements.
- (13) Updated summary of human factors and industrial engineering results.
- (14) Final system backup and recovery procedures.
- (15) Final report structure, content and format.

Final design review material shall also include draft versions of all manuals, training materials and other system and operational documentation. Final versions shall be submitted as part of "as-built" documentation.

Within fourteen days of the final design review, the Contractor shall prepare and issue a summary of all design review items arising from the meeting. The summary shall also include any items transmitted by City of Cape Town separately up to seven days after the meeting. The Contractor shall indicate proposed actions to resolve outstanding design items. Such actions may include:

- (1) No further action required. This shall be accompanied either by a note that this was agreed to at the meeting, or by an explanation/justification by the Contractor.
- (2) To be revised prior to system production and/or software development.
- (3) Outstanding issue for resolution. This shall be accompanied by a description of the issues, options for resolution, and process for resolution.

All issues and proposed actions/resolution are subject to approval by the City of Cape Town

C3.2.1.3 Implementation and Testing (I & T)

Prototype (unit) or sub system testing. A prototype test of a component or components of the system will be conducted to demonstrate the agreed conformance, functionality and performance of that component/components of the system. The following prototype testing shall be carried out:

- (1) Functional testing of all the onboard systems with the control centre systems. This will be done with a test vehicle equipped with all the relevant onboard equipment and driving along the proposed route.
- (2) Functional testing of the wireless docking in the depots and successful uploading/downloading of all the relevant data.

Only on approval of the prototype test results by the Engineer, shall full system deployment of these components commence.

Factory Acceptance Tests (FAT's). Factory acceptance testing shall be carried out on all manufactured or pre-assembled components of the system such as display modules, controllers, power supplies and associated enclosures.

System and Software Configuration, testing and commissioning The system and software shall be developed and configured based on the User Requirements and Technical Specifications (URTS), and approved detail design specifications as the design inputs.

- (1) During preparation of the detail design specification and prototype testing the contractor shall highlight any features available in the hardware and software packages which may enhance the functionality and ease of operation of the system.
- (2) The contractor shall be responsible for the full integration of all components of the system.
- (3) The contractor shall carry out his own testing of the system in such a way as to guarantee the equipment to meet the claimed functionality, performance and compliance. These tests shall simulate normal operating conditions for the components being tested. The contractor shall supply to the Engineer a certificate that each item of equipment has been tested and is in correct working order and complies with the URTS and detail design specifications.

- (4) The Engineer may at any stage call for witnessing of some or all of these tests and shall therefore be notified of their taking place.
- (5) All software shall be setup and configured for the system to perform the required functionality.

Site Acceptance Tests (SAT's). This includes the final commissioning, site acceptance testing, and operational handover to ensure that user requirements are met. The contractor shall prepare comprehensive test and acceptance schedules which list every item and sub-item described in the URTS and detail design specifications. These schedules shall be completed and signed by the contractor during his own testing, and then presented to the Engineer for signature at the time of witness testing where all items shall be demonstrated to the Engineer for acceptance. The Engineer shall be informed of SAT's at least 7 days in advance.

C3.2.2 Submittals

C3.2.2.1 General

Unless otherwise indicated, five (5) paper copies and one (1) CD-ROM or DVD-ROM copy of all submittals shall be provided. The City of Cape Town shall have the right to reproduce all submittals as required for internal and consultant distribution and system operation.

C3.2.2.2 Material Selection Documentation (MSD)

For custom-manufactured equipment, the Contractor shall submit a set of comprehensive shop drawings and specifications as part of the MSD. The comprehensive shop drawings shall include the general arrangement, layout, wiring details, mounting bolt requirements, location for conduit entry and any physical or electrical requirements.

For standard off-the-shelf items, the Contractor shall submit detailed manufacturer product specifications, drawings on mounting requirement, location of conduit entry and any other physical or electrical requirements.

The Contractor shall provide certification and compliance statements for all standards that apply to the manufacturing of the equipment, whether custom manufactured or off-the-shelf.

C3.2.2.3 Installation and User Manuals

The Contractor shall provide five (5) installation and User manuals for each type of unit provided unless specified otherwise. The manuals shall provide sufficient detailed installation and maintenance instructions to allow City of Cape Town or its representative to properly and safely install, connect and commission the equipment supplied.

The Contractor shall also provide all details of connectors and interconnect cables to City of Cape Town or its representative.

C3.2.2.4 Training Manuals

Training manuals shall be provided for each training participant, in addition six (6) additional copies shall be provided. The manuals shall provide information on all of the topics covered during each of the training sessions and include exercises and screen captures. The Training Manual shall include space for the users to take notes during the training sessions.

The Training Manuals shall be provided at the initiation of each training session.

C3.2.2.5 Test Documentation

Testing documentation shall be submitted as described in Section 3.4.3

C3.2.2.6 As-Built Documentation

The Contractor shall provide sufficient documentation to reflect "as supplied" conditions and to facilitate operation, maintenance, modification and expansion of the equipment or any of its individual components to the satisfaction of the City of Cape Town or its representative.

The SDD shall be updated to include the as-built conditions.

The as-built documentation shall be provided three weeks after the System Acceptance Test (SAT), and updated documentation will be required at any time the Contractor provides software or hardware upgrades.

C3.2.2.7 Operation and Maintenance Documentation – General

The operation and maintenance documentation shall be comprised of the Operation and Maintenance (O&M) manuals, User Manuals and System Administration Manuals.

The operation and maintenance documentation shall be developed interactively with City of Cape Town staff, and the Contractor should expect multiple iterations.

As part of the Preliminary Design Review, the Contractor shall provide example operation and maintenance documentation from other, similar projects, indicating elements that are or are not applicable to City of Cape Town, and indicating areas of the operation and maintenance documentation that require creation or substantial revision to reflect the City of Cape Town requirements.

At the Preliminary Design Review, the Contractor shall conduct interactive workshops using demonstration equipment to “walk through” operation using the information provided. The Contractor shall also further develop operation and maintenance documentation to meet the City of Cape Town needs for operations, training and maintenance.

At the Final Design Review, updated operation and maintenance documentation shall be provided, and further workshops conducted to revise and update the documents.

Final operation and maintenance documentation shall be submitted to the City of Cape Town no later than seventy-five (75) days prior to deployment of the system in revenue service to support training requirements.

The Contractor shall deliver fifteen (15) complete sets of operation and maintenance documentation.

C3.2.2.8 O&M Manuals

The O&M manuals shall be a detailed presentation and shall include illustrations where applicable. For each unit, it shall include, but shall not be limited to:

- (1) General description;
- (2) Functional descriptions;
- (3) Functional block diagram;
- (4) Operating instructions;
- (5) Maintenance and repair procedures;
- (6) Test procedures;
- (7) Schematic drawings and circuit diagrams; and
- (8) Parts list;

Each type of maintenance manual shall contain but not be limited to:

- (1) Description of operation including start-up, shut-down and emergency procedures;
- (2) Installation procedures;
- (3) Complete parts identification diagram and list;
- (4) Troubleshooting procedures;
- (5) Inspection procedures;
- (6) Preventive maintenance procedures and program;
- (7) Repair procedures;
- (8) Diagnostic procedures including criteria for equipment swap-out;
- (9) Wiring diagrams;
- (10) Electrical schematics with board and cable identification;
- (11) Adjustment procedures;
- (12) Seasonal maintenance requirements;
- (13) Equipment arrangement and drawings;

- (14) Names and schedules of all lubricants and cleaners used; and
- (15) Other consumable materials for the equipment stating where used, quantity, service intervals and annual consumption.

The Contractor shall provide a subassembly list for each piece of equipment supplied. The subassembly list shall identify the manufacturer(s), model/part number, address and contact information.

The Contractor may use manufacturer's data and handbooks for individual items of the equipment that are a sub-component of the overall system. All such documentation shall be contained in similar binders.

Where an equipment component is of such a nature that local repairs cannot be made and it must be returned to the factory as a unit for overhaul, specific information concerning its repair and breakdown into component parts shall be provided.

C3.2.2.9 User Manuals

A User Manual shall be provided for each software application. The User Manual shall include screen captures and easy to follow instructions to assist the users through all of the tasks that they may need to complete. The User Manual shall include an index.

As a minimum, the User Manual shall include all information that is available through the context-sensitive help system.

Fault procedures shall be described, as well as procedures for dealing with problems.

C3.2.2.10 System Administration Manual

System Administration Manual shall be provided for each software application. The System Administration Manual shall outline all of the configuration parameters, details on how to configure the parameters, back up and recovery process, trouble shooting techniques and technical support information.

Fault procedures shall be described, as well as procedures for dealing with problems.

C3.2.3 Review and Acceptance

Unless otherwise approved by the City of Cape Town Project Manager, all submittals shall be complete when issued. Incomplete or substantially under-developed submittals will be rejected, and shall not be considered as either a draft or final document.

The Contractor shall include three (3) weeks in their schedule for City of Cape Town review of each documentation submission, and shall include the necessary time and resources to modify the documentation to incorporate comments from the City of Cape Town.

All pages of the documentation shall carry a title, version number and issue date, and all documents shall contain a complete subject index. The Contractor shall be responsible for fully coordinating and cross referencing all interfaces and areas associated with interconnecting equipment and systems.

Documentation shall require re-issues if any change or modification is made to the equipment or functions supplied. Through the course of the contract the Contractor may re-issue individual sheets or portions of the documentation that are affected by the change or modification. Each re-issue or revision shall carry the same title as the original, with a change in version number and issue date.

Final versions of all documents must be submitted prior to System Acceptance, incorporating all changes incurred through the course of the Contract.

Equipment installation drawings shall be prepared using AutoCAD and Adobe Acrobat.

As-built drawings shall be supplied to show engineering changes made to any component or module up to the end of the warranty period of the system supplied.

Each volume shall have a binder (stiff cover and spine), and drawings shall be protected by clear plastic to withstand frequent handling. The binding arrangement shall permit the manual to be laid flat when opened.

The paper used shall be of good quality and adequate thickness for frequent handling.

C3.3 INSTALLATION OF WORKS

Unless otherwise specified, the Contractor shall provide all materials, parts, interconnect cables and connectors, software, documentation, installation instructions, and commissioning instructions. This includes mounting brackets, stanchion extensions, hardware, cable labels, grommets, cable clamps and harnesses, and other materials required to install the equipment.

C3.3.1 On-Board Equipment Installation (By Control Centre Company)

These requirements are also included in the specifications for the bus manufacturer/suppliers. Some of the on-board equipment will be supplied and installed by the vehicle manufacturer. The remainder of the equipment on the buses, unless otherwise indicated, will be provided and installed by the control centre company. Tenderers must ensure that their hardware can fit into the different buses to be supplied. A prototype will be required to illustrate successful integration.

The Contractor shall be responsible for preparing all power requirements, design plans, installation plans and instructions, fabrication plans, wiring diagrams, connection instructions, bills of materials, and commissioning and testing instructions for all buses and individual configurations. Such information shall be provided at or before the Preliminary Design Review submission and will be provided to the bus supplier to assist with their design, manufacture and configuration of the IRT buses.

The Contractor shall be responsible for vehicle preparation and the installation, commissioning and testing and final integration of all onboard APTMS components for all vehicles.

The Contractor shall provide installation information as noted above, shall provide and install all equipment at the OEM vehicle supplier's site or approved alternative, and shall be responsible for providing coordination and oversight required to certify that all equipment have been installed and tested correctly. In the event that the IRT OEM supplier wishes to use their own forces to install the equipment, the Contractor shall provide all equipment, wiring, tools, hardware, mountings, instructions, and training required, and shall remain responsible for certifying the installation.

All equipment shall be installed in a manner that allows for simple replacement by City of Cape Town maintenance personnel in the event of failure.

Equipment shall allow for easy installation/removal in PT vehicles through the doors without requiring door disassembly.

In-vehicle system devices shall be identical in installation characteristics across each bus type and model.

Equipment shall not pose a hazard to operators or passengers when operated in accordance with manufacturers' recommendations.

Individual equipment components to be installed shall be capable of being carried by a single person, and as such, shall not exceed 40 kg.

Equipment shall be able to be replaced in a vehicle in five minutes or less when the proper tools and a spare unit are available. Unless otherwise approved by City of Cape Town, all connectors, fasteners and connection shall be water-tight and solvent-resistant.

All cables shall be fully labelled at both ends.

During the installation period of the on-board equipment, the contractor could be required to provide own 24 hour security. The level of security could include fencing, surveillance and/or security guards to the extent required by the contractor and to the satisfaction of their insurer. The contractor will be responsible for the security of all equipment until the final taking over certificate is issued.

C3.3.2 Central Computer System Installation

The Contractor shall be responsible for the installation, local configuration, network configuration, commissioning and testing of all central computer system equipment.

The Contractor, as part of the design phase, shall confirm the preferred locations for all central computer system equipment installation.

The Contractor, as part of the design phase, shall prepare design drawings, elevations and wiring connection diagrams illustrating the location of all central computer system and related components and their interconnection.

City of Cape Town will provide power and a network demarcation point at all central computer system sites. The Contractor shall be responsible for any local cabling requirements to connect to the demarcation points.

Central Computer Aided Operator workstations, monitors and other related hardware shall be installed at:

- (1) The Transport Management Centre in Goodwood (Phase 1A)
- (2) The CBD Depot (Phase 1A)
- (3) The Potsdam Depot (Phase 1A)
- (4) (Possible future Depots in future Phases)

All servers and associated racks and other hardware shall be installed at a designated location in the TMC.

City of Cape Town will provide access during normal business hours for installation work that does not disrupt normal operations. All installation and cutover work that disrupts normal operation shall be conducted at night, weekends or other off-hours per City of Cape Town approval.

C3.3.3 Station/Stop Equipment Installation

It shall be the responsibility of the Contractor to develop installation requirements for all station/stop equipment including VMS, communications equipment, power supplies, enclosures, etc. The Contractor shall be responsible for the installation, local configuration, network configuration, commissioning and testing of all station/stop equipment.

The Contractor shall coordinate the installation of all station/stop equipment with City of Cape Town. The Contractor shall also coordinate the design and installation of VMS signs with the designer and Contractor responsible for construction of the IRT stations and stops.

The Contractor, as part of the design phase, shall prepare stop/station design drawings, elevations and wiring connection diagrams illustrating the installation of all station/stop components and their interconnection.

Power will be available in the stations and feeders, although some of the feeder stops might not have power and the contractor will be responsible for powering the equipment. All electrical points in the stations and feeder stops will be provided under another contract, but it remains the responsibility of the contractor to ensure the availability of electrical points where needed.

The Contractor shall be responsible for providing all wireless and fibre optic communications and connections. All station/stop components shall be designed and installed to resist normal vandalism. Station/stop components shall be identical in mounting characteristics so that a specific piece of equipment shall be installable with minimal modification at any of the stops at which it might be used.

Equipment shall not pose a hazard to pedestrians and passengers when operated in accordance with the manufacturers recommendations. All installation work shall be per electrical code.

C3.4 TESTING AND COMMISSIONING

C3.4.1 General Requirements

The Contractor shall be responsible for conducting all testing as described herein. Work under this section shall include all labour, materials, and support services required to completely test all hardware and software.

If a type of equipment does not meet the specifications or requirements as stated in these Specifications or the System Design Document, it shall be the Contractor's responsibility to correct the problem in all units of that equipment furnished, at no additional cost to City of Cape Town.

All of the components, subsystems, interfaces and systems processes constituting the APTMS shall be tested individually and together to demonstrate that they meet the contract requirements and provide a system that functions in accordance with the contract.

The Contractor shall be responsible for the performance of all of the tests described below to satisfy the objectives of each testing phase as determined by City of Cape Town.

City of Cape Town shall have the right to witness any and all tests.

Test plans shall be submitted to City of Cape Town a minimum twenty-one (21) days prior to the planned start of testing. Testing shall not commence until the plans have been approved.

Unless otherwise specified, all test plans shall include at a minimum the following:

- (1) Overview of test including test objectives
- (2) Pass/fail criteria
- (3) Traceability matrix listing of all requirements and specifications from the Contract that are included/to be verified in the test and their cross-reference to the Specifications and System Design Document.
- (4) Test setup and test measuring equipment (including descriptive diagrams)
- (5) Listing of tools, test applications, simulators, etc. required to perform the test
- (6) Entry/startup conditions
- (7) Exit/closing conditions
- (8) Test procedures and scripts to be executed
- (9) Test recording form
- (10) Test comments form
- (11) Signatures and verification form

City of Cape Town reserves the right to direct, at no additional cost, the following changes to the test plans:

- (1) The addition of procedural changes and other reasonable tests to reasonably assure System performance and conformance;
- (2) Investigation into any apparent troubles or anomalies with respect to the System;
- (3) An audit of all test reports and verification of any or all previous tests and Measurements.

The Contractor shall provide written notification of readiness to test for all required test stages a minimum of two (2) weeks in advance of the testing.

Upon successful completion of any test, the Contractor shall prepare and submit within two (2) weeks a report summarizing the results with relevant test records appended. All such test reports will be reviewed by City of Cape Town.

With each vehicle installation, and immediately upon completion of the installation work, the Contractor shall test and demonstrate that the onboard system is fully functional.

C3.4.2 Test Suspension Criteria and Defect Resolution

All test failures, system defects, system errors, or missing functionality shall be recorded by the Contractor and assigned a "Defect Severity" rating as follows:

- (1) Severity 1: Required functionality is substantially not available; normal in-service operation of the device or subsystem cannot be maintained; or City of Cape Town PT operations are disrupted.
- (2) Severity 2: Functionality is substantially available however one or more subfunctions are not operating as specified; full functionality is available but performance is not within specifications. Normal in-service operation can be maintained via a workaround.
- (3) Severity 3: Minor software defect or usability problem for which there is a workaround.

The Contractor shall maintain a database of and shall track the status of all defects.

City of Cape Town reserves the right to re-classify a defect severity based on the impact to system operation or PT operations.

Test continuation, suspension or restart shall be as follows:

- (4) Severity 1 Defect: Applicable test(s) shall be halted and restarted from time zero upon rectification of the Severity 1 defect. In the event that City of Cape Town operations are disrupted, all testing shall be suspended until the defect can be rectified.
- (5) Severity 2 Defect: Applicable test(s) shall be suspended and restarted upon rectification of the Severity 2 defect.
- (6) Severity 3 Defect: Testing may continue. Defect shall be noted in the comments section of the report.

All Severity 1 and 2 defects shall be corrected prior to completion of the stage of testing where they were identified. Test results for that stage shall not be accepted until such time as the Contractor demonstrates that all Severity 1 and 2 defects have been resolved and tested.

Severity 3 defects may be carried forward into software or system modifications in the next stage of the project, and shall be demonstrated to be corrected in the next planned testing stage.

The Contractor shall develop and maintain a standard set of regression tests for each device or subsystem. Regression tests shall be run for any affected device or subsystem in the event that any testing is halted and restarted in accordance with the requirements of Severity 1 defect resolution.

C3.4.3 Test Stages

C3.4.3.1 Testing Stage 1: Factory Acceptance Testing (FAT)

Factory Acceptance Testing shall be performed to ensure that the supplied and equipment is functional and acceptable prior to transit. A City of Cape Town representative will be present during the FAT.

The Contractor shall develop a comprehensive FAT program consisting, at a minimum, of the following individual test programs:

- (1) Hardware test to test the operating parameters of all equipment are per the Specifications of this Contract, OEM specifications, and System Design Document.
- (2) Functional test to demonstrate that all functional and operational requirements and specifications applicable to the device/subsystem have been delivered.
- (3) Environmental, electrical and electromagnetic tests demonstrating compliance with Contract and regulating agency requirements.
- (4) Human factors test for all devices/subsystems with a user interface.

All equipment types shall be tested. A minimum of one (1) unit of each equipment type, identically configured to all other units of that same equipment type, shall be subject to the FAT unless waived by the City of Cape Town Project Manager.

Any device certifications required by regulatory agencies shall be the responsibility of the Contractor.

All required certifications shall be submitted with each shipment of devices or subsystems.

Any changes to the hardware configuration shall require a FAT retest.

C3.4.3.2 Testing Stage 2: System Integration Test (SIT)

A System Integration Test (SIT) shall be conducted to verify that subsystem components, when integrated together, meet the system level functional requirements and specifications. SIT shall be completed prior to onsite installation of the system.

The Contractor shall be responsible for the provision of any SIT test beds or bench test facilities, including any power supplies, simulators, or other components and software required to conduct the test.

The SIT configuration shall include all dispatch equipment and all other local and remote console equipment, all servers and all communication control equipment, a complete set of on-board vehicle equipment for at least three (3) vehicles. The SIT shall include all equipment and interfaces supplied by the Contractor under the APTMS project, including any optional equipment selected by City of Cape Town for inclusion under this project. The SIT configuration shall also include all test equipment required to simulate data signals to and from devices noted in this Contract such as wheelchair lift/ramps, destination sign, bicycle rack, emergency alarm, etc.

The Contractor shall develop a comprehensive SIT program consisting, at a minimum, of the following individual test programs:

- (1) System configuration
- (2) Integrated operation of all devices and subsystems
- (3) End-to-end connectivity and correct processing/handling of data and messages
- (4) Scenario or use-case testing to demonstrate that all system-level functional and operational requirements and specifications have been delivered.
- (5) As applicable, environmental, electrical and electromagnetic tests demonstrating compliance with Contract and regulating agency requirement in the integrated form of the system

The SIT shall include time and provisions for City of Cape Town staff to conduct independent system integration testing using their own or ad-hoc script and test cases. Contractor support during these tests shall be provided.

C3.4.3.3 Testing Stage 3: Onsite Integration Testing (OIT)

Upon completion of the SIT, the Contractor shall demonstrate the integrated operation of all system components when installed at City of Cape Town.

The Contractor shall identify a subset of the System Integration Tests to be re-run at City of Cape Town once a limited number of vehicles have been equipped.

The OIT shall include time and provisions for City of Cape Town staff to conduct independent system integration testing using their own or ad-hoc script and test cases. Contractor support during these tests shall be provided.

C3.4.3.4 Testing Stage 4: System Acceptance Testing (SAT)

The SAT is the final test to be completed and can only be initiated once all of the system elements have been installed and configured and all other tests have been successfully completed. The SAT looks at the entire system, and tests are completed to ensure that the overall functional requirements are met.

Each requirement listed in the specification shall be tested or, in case it may not be feasible to test certain functions in the operational environment, evidence for correct function is to be provided.

Acceptance testing shall be performed on all equipment and services placed into service to demonstrate the performance of the system as a whole.

The Contractor shall develop a System Acceptance Testing plan, which shall be submitted to City of Cape Town for review and acceptance at least twenty one (21) days prior to commencement of System Acceptance Testing. The acceptance plan shall include any tests necessary to document that the system is performing in compliance with the Contract requirements.

System Acceptance Testing shall be conducted over a minimum four month period. During the system acceptance testing period, the Contractor shall measure and report system and subsystem performance, defects and failures, and report same on a weekly basis.

System Acceptance will be granted when:

- (1) All System Acceptance Testing requirements have been met.
- (2) All data radio coverage testing has been completed and accepted.
- (3) All training has been completed and accepted.
- (4) All as-built and final documentation has been delivered and accepted

C3.5 TRAINING

C3.5.1 General

The Contractor shall be responsible to train City of Cape Town-designated personnel according to the requirements specified herein. The Contractor shall be responsible for the supply of all training materials including, at a minimum:

- (1) Training setups of equipment, including mounting and all power supplies and simulators required to simulate normal operation.
- (2) Instructor guides.
- (3) Student guides.
- (4) Operations manuals.
- (5) Training presentations.
- (6) Training handouts.
- (7) Quick reference guides.
- (8) Interactive videos or demonstrations.
- (9) Course and instructor comments sheets

A Training Program shall be developed and submitted a minimum forty-five (45) days before delivery of training materials that describes:

- (1) Each course to be conducted.
- (2) An overview of delivery methods for each course, including hands-on and group work experience.
- (3) The course objectives for trainees.
- (4) An evaluation plan, including criteria for success of the course, based upon the goals and objectives, and evaluation steps and instruments to be employed.
- (5) A proposed schedule for each class, keyed to the installation process and constrained by availability of trainees away from regular duties.
- (6) A plan for developing or customizing course material.
- (7) Resumes of personnel proposed to be trainers for each class, demonstrating that they are experienced, effective training professionals.

Training shall include course development, providing instructors, and supplying all handouts, materials, classroom aids, etc. required to conduct the training. Training shall take place at City of Cape Town-designated facilities. Practical training on equipment shall occupy a significant portion of all training Classes. The training presentations and material shall be in English.

Instruction shall cover equipment familiarization and systems operation. The minimum training is that which is necessary to bring those employees designated to the level of proficiency required for performing their respective duties.

The Contractor shall provide experienced and qualified instructors to conduct all training sessions. The Contractor is responsible for ensuring that the instructors teaching these courses are not only familiar with technical information but are able to utilize proper methods of instruction, training aids, audiovisuals and other materials to provide for effective training. The Contractor is responsible for providing all training aids, audiovisual equipment and visual aids for the conduct of these courses. At least one session of each different training course shall be videotaped by the Contractor onto DVD. All training materials are to become the property of City of Cape Town at the conclusion of training. Maintenance training shall commence during the time when equipment is installed on the buses. The Contractor shall submit the training curricula, for review and approval by City of Cape Town.

Training curricula, presentations, and materials shall be provided to City of Cape Town for review a minimum sixty (60) days prior to commencement of equipment installation. No training shall commence until these items have been approved by City of Cape Town.

C3.5.2 Training Sessions

C3.5.2.1 General Requirements

The Contractor shall be responsible for training City of Cape Town trainers and senior staff in the operation and maintenance of the APTMS.

The Contractor shall assume up to ten (10) persons per class. The Contractor shall identify the training hours required for each class. All classes shall be a minimum of four (4) hours. The following training sessions shall be provided by the Contractor:

Class	Number of Classes	Subject
Onboard Operations	2	Train-the-trainer on the operation of onboard equipment
Operations	2	Train dispatch/operator staff on system operation
Maintenance	2	Train maintenance personnel in the following: - First line maintenance (troubleshooting, diagnostics, configuration and remove and replace). - Second line maintenance (subassembly or board-level troubleshooting, diagnostics, configuration, and replacement).
System Administration	2	Train senior staff on the configuration and administration of the system
Radio System	2	Train senior staff and contracted maintenance staff on the configuration, operation and maintenance of the radio system
Reporting	2	Train senior staff on the reporting capabilities of the system and on the mechanics of creating reports and/or developing ad hoc reports.
IT Training	2	Train city staff to maintain the system and to get an understanding of the system configuration.
Follow-up	2	Follow-up training and consultation between 30 and 60 days after the initial training to ensure best use of the systems by the users

C3.5.2.2 Information Technology Training

Training shall be provided to fully familiarize IT personnel with all aspects of the system software including the structure of the applications, tables utilized, network connections and settings, plus other similar information.

The trainer for this course shall be technical in background as this training will be highly technical "back end" information and not end-user type training.

At the conclusion of training, the City of Cape Town personnel involved, including the following as applicable:

- (1) Applications' architectures
- (2) Data flows
- (3) Interfaces
- (4) Development tools used
- (5) Development assumptions

- (6) Directory structures
- (7) Processing scripts
- (8) Data dictionaries
- (9) System flows
- (10) Table relationships
- (11) Table growth
- (12) Data conversion methods
- (13) Recommended backup strategies
- (14) Application programs

Data diagrams shall be developed using the latest version of Microsoft Visio or similar software.

All programs shall be defined and described fully, showing all inputs/outputs, samples of reports, logic flows and major functions described.

C3.6 PROJECT MANAGEMENT

C3.6.1 Project Management and Staffing

The selected Contractor shall provide staff and Key Personnel as identified:

All on-site Contractor staff and Subcontractors shall report to the Project Manager who shall have full control over all schedules, staff and on-site decisions.

The Contractor Project Manager shall be present at all project meetings and shall be fully responsible for the management of the project from inception to completion.

The Contractor Project Engineer shall be available, in person or by teleconference, for all project meetings and specialty technical meetings.

Contractor key technical, documentation, training and other staff shall be available in person or by teleconference, as appropriate, to discuss specific items as needed.

Project management shall be an ongoing and continuous service provided by the Contractor to ensure that City of Cape Town requirements are met in terms of functionality, schedule and within the proposed cost.

C3.6.2 Coordination of Work

The Contractor shall coordinate all work done by Subcontractors. Any communication between City of Cape Town and the Subcontractors shall be done through the Contractor.

The Contractor shall coordinate all on-site work and access with City of Cape Town. All access is subject to approval by City of Cape Town.

The Contractor shall minimize downtime to existing resources, prevent any negative impacts on the existing operating systems, and provide for a smooth and secure transition to use City of Cape Town equipment.

The Contractor shall ensure that all points of interface have been investigated well, and all technical risks addressed. The Contractor shall ensure that operators, vehicle operators, system maintainers, and planning staff and system administration staff have been trained on the operation of the systems, as well as briefed on how the systems will change their job responsibilities and enhance their ability to perform their jobs efficiently.

C3.6.3 Schedule and Progress Monitoring

C3.6.3.1 Schedule/programme

The Contractor shall prepare a master programme of work within the requirements of the general and particular conditions of contract. The schedule shall include milestone dates for all interfaces, availability and requirements that are to be delivered by or to a third party. For example, the timing for all data requirements for facility availability, power/communication availability, training etc. should be clearly identified.

The schedule shall be updated by the Contractor on a monthly basis to reflect the progress attained in the previous month and the anticipated changes in the future.

C3.6.3.2 Progress Reports

The Contractor shall provide monthly status reports during system installation and system testing, detailing current progress, percent of project completion, any Subcontractor work, and problems encountered.

C3.6.4 Quality Assurance and Control

The Contractor shall provide a quality plan identifying their internal processes for the creation and review of deliverables including parties responsible and the respective time frames.

C3.7 MAINTENANCE, UPGRADES AND WARRANTIES

C3.7.1 Warranty Requirements

C3.7.1.1 General Requirements

The Contractor shall provide a statement of warranty that describes the system warranty coverage, in accordance with the requirements defined herein.

The Contractor warrants that it has good title to the system and the right to sell to City of Cape Town free of any proprietary rights of any manufacturer (if the Contractor is not the manufacturer) or other party, and free of any lien or encumbrance.

Contractor warrants that it has good title to all system software or that it has the right to license the use of such software, or both, free of any proprietary rights of any other party and free of any other lien or encumbrance.

Contractor warrants that all equipment furnished is guaranteed to be free from fleet and related defects for the warranty period. A fleet defect is defined as the failure of identical items covered by the warranty period in proportion to the equipment for each contractual requirement. The portion shall be 10%.

Contractor shall also warrant that all installation work and system hardware shall perform according to the specifications for the guarantee period. All equipment shall be guaranteed against defects and failures for a minimum period of 1 year from date of acceptance of the system.

All warranties and guarantees of Subcontractors, suppliers and manufacturers with respect to any such work and system hardware shall be obtained by the Contractor for the benefit of City of Cape Town regardless of whether or not such warranties and guarantees have been assigned or transferred to City of Cape Town by separate agreement. The Contractor shall fully enforce such warranties and guarantees on behalf of City of Cape Town.

The contractor shall guarantee that the proposed technologies will be supported for at least 5 years after installation and that spare parts will be available for at least 10 years.

C3.7.1.2 Warranty Period (Defects Liability Period)

Contractor agrees that the system and all related installation work shall be subject to the warranties and obligations set forth in this section. Warranties shall commence upon issuing of the Taking over Certificate and end after the period as specified in the Appendix to the Tender. The warranty period is similar to the Defects and Notification Period defined in Clause 11 of the General Condition of Contract.

C3.7.1.3 Hardware Warranty

During the Warranty Period, the Contractor using stock from the spare parts inventory will replace defective hardware. For each defective part, the Contractor shall provide repaired or new replacement units to replenish the spare parts inventory. The replacement units shall be fully tested and certified compliant with the original part.

The cost of all transportation and insurance charges for shipping defective and replacement parts to and from the Contractor shall be borne by the Contractor.

Replacement parts shall be provided within fourteen (14) days of the defective part being received by the Contractor.

C3.7.1.4 Software Warranty

The Contractor warrants that all software is free of defects in design and workmanship, and will perform according to the specifications.

The Contractor warrants that all software does not contain any timers, counters, or pre-programmed devices that will cause the software to be erased, inoperable, or incapable of performing as specified.

The Contractor warrants that all software contains an appropriate security and control system for protecting the software and the data from unauthorized use.

The Contractor warrants that all software shall be free of "back doors" and all other known methods of software access that bypass the normal system security features.

The Contractor shall develop, test, provide and install all applicable software “patches” or upgrades that become necessary to remedy system software faults or “bugs” identified during the warranty period.

Through the Warranty Period, the Contractor shall provide at no additional cost, all version updates, software patches and error corrections available for the system software provided.

C3.7.2 System Maintenance

C3.7.2.1 General Responsibilities

This should be read together with Section 24 Maintenance Agreement of the Additional Conditions of Contract (Volume 2A) and Section 3.16 of this Volume 2B.

The Contractor shall be responsible for providing all maintenance during the Defects Liability period and shall be responsible for all transport costs of equipment. The contractor will also be responsible for removing and replacing defective equipment.

Post-warranty, the contractor will be responsible for the maintenance of all installed equipment and software. Payment for these tasks will be based on the tendered equipment rates subject to contract price adjustment and exchange rate variation. Adequate training shall be provided for City of Cape Town if the City wishes to take over these responsibilities.

The Contractor shall provide a Maintenance & Operations Support Plan that describes routine maintenance measures, response for repairs, communications service, and operations support during the Defects Liability period and after the Defects Liability Period according to the requirements outlined in Section 3.16.

The Contractor shall respond and attend to maintenance requirements within the times as stipulated in Section C3.16. The Contractor shall provide a reliable method for telephone problem notification.

C3.7.2.2 Test Bench

If required by the City of Cape Town, the Contractor shall supply a fully-configured onboard equipment test bench that includes at a minimum the following:

- (1) A work bench with sufficient space, power distribution, etc. to troubleshoot and dismantle malfunctioning equipment removed from a bus.
- (2) A minimum one (1) unit of all onboard equipment.
- (3) A wireless LAN access point to be used for testing purposes.
- (4) A complete set of tools, test equipment, computer software, computer hardware and simulators as needed to conduct troubleshooting, diagnostics and configuration of equipment.

C3.8 DETAILED SPECIFICATION: GENERAL

This specification defines the User Requirements (Employer Requirements) and applicable Technical Specifications for the electrical and electronic systems forming part of the Intelligent Transport Systems (ITS) technologies that will be rolled out by the Control Centre Company (CCC) as part of the implementation of the Cape Town Integrated Rapid Transit (IRT) system.

C3.8.1 Scope of the Specifications

The scope of the specifications covers the employer requirements and where applicable the required technical specifications for the ITS elements that must be provided as part of this contract and these can be categorised as follows:

- On-board systems (Mostly Provided by Control Centre Company)
- Station systems
- Control Centre Systems
 - Operations and Control
 - Safety and Security
- Communications systems
- Traffic signal pre-emption systems

Notwithstanding the details of the technical specifications, the tender evaluation could include a demonstration of a “benchmark system” during the tender evaluation period at the cost of the tenderer.

C3.8.2 Physical and Materials Requirements

C3.8.2.1 General

These requirements apply to all subsystems, unless more specific requirements are defined in the subsequent sections. In case of any apparent conflict, the subsystem requirements take precedence over General Requirements.

The on-board equipment shall be designed to provide a usable life of not less than fifteen years.

All equipment shall be designed for use in the transit industry, with specific attention to ergonomics, reliability, efficiency, and safety for passengers, operators, maintenance personnel and other system users.

Equipment furnished under these specifications shall be the latest model in current production, as offered to commercial trade, and shall conform to quality workmanship standards and use materials consistent with public transport industry requirements.

The successful Contractor shall represent that all equipment offered under these specifications is new.

Used, shopworn, demonstrator, prototype, re-manufactured, reconditioned, or discontinued models are not acceptable for supply under this contract.

Onboard equipment shall be capable of being disassembled to fit through a standard vehicle door.

All components of the CAD/AVL system shall be built in accordance with best commercial practice. As a minimum, the design and construction shall provide for:

- (1) Reliable and stable operation.
- (2) Minimum maintenance and alignment procedures.
- (3) Minimum number and variety of assemblies and spare parts.
- (4) Maximum attention to human engineering.
- (5) Simplified design and rapid fault isolation to reduce the requirement for highly skilled maintenance personnel.

The Contractor shall make required site improvements and provide all required structures, hardware, brackets, cabling, wiring, and services for equipment or elements to be installed at all sites. Unless otherwise noted, City of Cape Town will

in general be responsible for making sites ready for installation work, including the provision of power, network communications drops, and equipment boxes on buses for the installation of onboard equipment.

All external screws, nuts, and locking washers shall be stainless steel or an approved alternate non-corrosive material; no self-tapping screws shall be used unless specifically approved.

All parts shall be made of corrosive resistant material, such as plastic, stainless steel, anodized aluminium or brass.

Equipment shall be designed to prevent unauthorized access, and to facilitate authorized access.

The Contractor shall utilize modular design throughout.

Standard, commercially available components shall be used wherever possible.

All functionally identical modules, assemblies and components shall be fully interchangeable between like modules for all equipment acquired under this contract.

Unless otherwise approved, all modules and assemblies shall be connected using standardized durable, positive-locking, indexed quick disconnect fasteners.

All external connectors shall be weathertight and designed for use in a mobile environment subjected to dirt, water, oil and cleaning solvents.

Contractor shall include reasonable provisions to protect all equipment and components from common vandalism and physical abuse as may be expected on buses and at stops.

System components must be identical in mounting characteristics and inter-unit cabling across the entire fleet, so that a replacement piece of equipment is installable without modification in any of the vehicle for which it might be used.

Any retrofit or post-delivery change to one item of one type of equipment, shall be reviewed with the City Project Manager and upon approval, changes shall be made identically to all units (except modifications that are clearly understood by the Contractor and City of Cape Town to be experimental and applied to less than five units).

Equipment and sub-components shall be identified by a part number and/or serial number, permanently and legibly affixed directly to the surface of the unit.

Unless otherwise specified in the sub-system specifications, all onboard equipment shall have a minimum 25 000 hours MTBF (Mean Time Between Failures).

Unless otherwise specified in the sub-system specifications, all central site equipment shall have a minimum 10 000 hours MTBF.

C3.8.2.2 Electrical Requirements

All device enclosures shall contain an easily accessible master circuit breaker that will remove power from the equipment when tripped.

Circuit breakers shall clearly indicate when they have been tripped.

All enclosures, chassis, assemblies, panels, switch boxes, terminal boxes, and similar enclosures or structures shall be grounded.

Protective grounding shall be provided to ensure that all exposed metal equipment and metal fixtures are connected to a common ground point in the electrical cabinet.

Conductors that have the potential of operating at 50 volts or more shall not be bundled with any other lower voltage conductors.

Wire dress shall allow sufficient slack for three additional "re-terminations" without excess tension.

Wire splices are not permitted.

Wire and cable ties shall not be so tight as to cause indentation and damage to the insulation.

Adhesive-mounted bases shall not be used to support wire ties or cable supports.

All conductors within each enclosure shall be installed free from metal edges, bolt heads, and other sharp or interfering points.

All conductors providing connections between components shall be provided with strain-relief, and be clear of moving objects that could damage either the conductor or the object.

All terminations and cables shall be clearly indexed, labelled and schematically identifiable.

All wire labels shall be non-metallic and shall resist standard lubricants and cleaning solvents.

When components must be connected to each other through individual wires, the wiring shall be incorporated into a wiring "harness," where each branch of each circuit can be separated from others for troubleshooting.

Protection shall be provided against radio frequency interference (RFI) and electromagnetic interference (EMI) emission sources, as well as internal conductive or inductive emissions.

The Contractor shall certify through the Contractor's expense the electromagnetic compatibility of equipment to be furnished.

C3.8.2.3 Software Requirements

All software shall be written in a common and well-known, modern, high-level, highly structured language.

All software shall be the current version in production at the time of installation (software versions to be approved by the City of Cape Town).

All software shall contain version control numbers.

Features shall be provided to identify the software version on each device, and verify that it is the correct or most recent version for that device.

Software shall be organized in a modular, configurable manner to the extent reasonable.

Adjustable, Cape Town-specific, and configurable parameters shall not be hard-coded onto the source-code. They shall be user-modifiable.

Application software (both user and system) shall be portable, i.e., the source code shall be transferable to other computers using the same hardware and operating system without any modifications or use of hardware key.

The application software shall be reasonably scaleable to newer, higher performance hardware or operating systems.

Passwords shall not be displayed unencrypted on displays.

All application software shall be self-diagnostic.

All central system user interfaces shall have online help features.

The system date and time shall adjust automatically for possible daylight savings, leap year, and holidays.

The system date and time shall provide the same date for service times associated with a complete "Public Transport Day", where number of hours in one day is based on start and end of service regardless of service extending past midnight.

The system shall maintain both 24-hour timestamps and 30-hour timestamps matching the 30-hour clock used by some scheduling software if that is proposed by the tenderer.

Data transferred from a device or system shall not be purged or written over until at least one successful transfer is confirmed.

Features shall be provided to ensure that all system-created files are uniquely identified, and that no files are lost or missed during data transfer.

Verification features shall be provided to confirm that there have been no losses of data at any point in the system.

The system shall be capable of remote paging of software alarms, with an escalation process.

The Contractor shall provide a comprehensive data backup and recovery plan.

The Contractor shall provide a data backup system for data archiving and recovery

The data backup system shall include capabilities for the City of Cape Town to back up data through network-wide backup.

It shall be possible to recover and transfer data files in the event of a primary data storage failure through a secondary standardized PC interface such as an RS-232 port. An alternate process for initiating data extraction and/or alternate means of removing data records may be provided which shall be subject to Cape Town Project Manager review and approval.

C3.8.3 System Security Requirements

The Contractor shall develop a comprehensive System Security Plan which identifies the system elements which require protection, and identifies mechanisms, procedures and processes to counter security threats to those elements.

The System Security Plan shall describe the intended functionality for each of the procedures, functions and systems for detecting and mitigating those threats

The System Security Plan shall identify system users, and describe rules that govern how those users will have access to system data, resources and processes.

The System Security Plan shall identify methods of detecting security breaches regardless of whether there is a detectable change in the performance of the system.

The Contractor shall implement system security services to achieve the approved System Security Plan.

The Contractor shall coordinate with the Agency to develop system security elements and procedures that function with existing Agency firewalls.

All AVL/CAD/VWM systems, subsystems and devices shall allow only authorized users access.

The system shall provide access control based on the establishment of groups, users and roles:

- (1) Groups, users and roles shall be assigned during system implementation as directed by the Agency Project Manager.
- (2) A minimum of ten groups shall be provided for.
- (3) It shall be possible to assign each user a unique identification and password, or assign a unique identification and password for each group, at the City's discretion.
- (4) The system shall include flexibility to add new groups, roles and users, redefine groups and roles, and reassign access permission as part of normal system operations.
- (5) Access permission shall be assigned by the System Administrator.

All system access shall be recorded.

The system security shall include features to limit the propagation of access permission.

As a minimum, the system shall provide the following alarms, and shall notify the appropriate users in the event an alarm is triggered:

- (1) Detection of invalid data or incomplete data packets
- (2) Detection of a security breach
- (3) Detection of a device or system fault

All alarms shall be recorded and stored in a database, along with a history of corrective actions.

C3.9 DETAILED SPECIFICATION: ONBOARD SYSTEMS

Refer to Figures 4 and 6 in Section C4

For clarity, these requirements are also included in the specifications for the bus manufacturer/suppliers. **Some of the hardware specified in this section will be provided and installed by the bus manufacturer. The rest of the on-board equipment will be supplied and installed by the contractor. It is therefore the responsibility of the control centre company to guarantee systems integration of all onboard systems. Liaison between the control centre company and bus manufacturer is important to guarantee sufficient allowance for space, security and electrical requirements of all equipment to be installed on the bus(es). A prototype will be required to illustrate successful integration.**

The following hardware will be provided and installed by the bus manufacturer/supplier:

- Vehicle performance monitoring
- Vehicle weight measurement system
- External variable messaging display
- Internal variable messaging display
- Internal infotainment display
- Audio system
- Door opening and door synchronisation unit
- Driver Display Unit
- On-Board CCTV cameras
- Emergency alarm

Details of the extent of the hardware to be provided and installed by the bus manufacturer can be found in Annexure B

C3.9.1 High Level Requirements

The ITS/APTMS related hardware required on the buses will be provided and installed by the control centre company and the bus manufacturer. The Control Centre Company will be responsible for using the hardware, providing the appropriate software to work with the hardware, integrate the bus-systems with the station-systems, the depot-systems and the control centre systems. It is the intention to run the tender and the contract periods for the supply of the buses and the supply of the ITS equipment concurrently. Tenderers must liaise with bus manufacturers to fully understand related installation of the hardware, inter alia, to ensure that enough space is allowed for, devices are secure and the electrical system of the bus can accommodate the additional power required (the **Form of Correspondence** in Schedule 23 shall be completed by both tenderers to confirm liaison regarding these and any other related issues. More detail is provided on the form). Working prototypes will be necessary. The tenderer will be required to provide a complete and operational system satisfying the following high-level requirements. This also includes the integration of the hardware supplied and installed by the vehicle manufacturer with the onboard systems to fully accomplish these high-level requirements.

- | | |
|---|---|
| • GPS Tracking and AVL at all times communicated to control centre | • Radio communication with traffic signals to implement Bus Priority. Activation of traffic signal link to be controlled from central control |
| • On-board PA for driver to address passengers | • Monitoring of vehicle mechanics and driver performance (recorded) |
| • Dynamic route displays on front of bus | • Communication with driver, visual and/or audible |
| • Vehicle weight measurement system | • Dynamic information to passengers: audio and video of "Next Station" and "Time to Next Station" |
| • CCTV cameras and on-board recording equipment | • Wireless Docking in Depot – download of recorded info, upload infotainment |
| • Infotainment | • The opening of the passenger doors must also activate stations doors and must be synchronized. |
| • Driver "panic button" | |
| • GPRS links to control centre for AVL, tracking and CCTV images, text messages to driver | |
| • High bandwidth wireless LAN links to network in depots. Wireless docking in depots | |

- GSM link to bus for voice communications to TMC and other predefined numbers
- Scheduling of buses

C3.9.2 General

Each vehicle deployed as a part of the system shall be equipped by the Contractor and bus manufacturer with **at least** the following:

No	Item	Trunk buses	Feeder buses
1	Machinery Monitoring	YES	YES
2	Mobile Wireless Router (GSM/UMTS)	YES	YES
3	Automatic Vehicle Location (AVL)	YES	YES
4	Wireless LAN (Wi-Fi)	YES	YES
5	Panic Alarm	YES	YES
6	Public Address (PA) System	YES	YES
7	Security CCTV	YES	YES
8	Digital Video Recorder (DVR)	YES	YES
9	Passenger Information Displays	YES	YES
10	Passenger Infotainment Display (Flat panel displays)	YES	NO
11	Mobile Data Terminal (MDT)	YES	YES
12	Vehicle Logic Unit (VLU)	YES	YES
13	Bus Priority Transponder – Traffic Signals	YES	NO
14	Vehicle Weight Measurement System	YES	YES
15	Automatic Next Stop Announcement	YES	YES
16	Tetra Radios	YES	YES

It shall be the responsibility of the Contractor to properly locate all vehicle equipment, prepare all shop drawings, installation drawings, material fabrication drawings, and wiring drawings, and provide installation services. This shall be done during and after liaison with the bus manufacturer.

The installation method for all equipment must permit simple replacement (i.e. remove and replace) in the event of a device failure.

All vehicle equipment shall be “hot swappable”, and shall not require manual configuration on the bus in order to be fully operational.

All new Onboard System components deployed as part of APTMS shall be universal serial bus (USB) or Ethernet as required to support onboard networking.

Close coordination will be required between the suppliers of the different components on the buses and the rest of the IRT ITS suppliers to guarantee equipment integration and compatibility on all levels. This includes but is not limited to communications, storage and management of CCTV and IRT incident management software and bus scheduling software.

C3.9.3 Electrical

In-vehicle devices shall meet accepted SABS/SANS and/or international rules and regulations related to generation of and susceptibility to radio frequency interference (RFI). Unless otherwise approved, all devices, cables and connectors shall be shielded and grounded.

Onboard components shall be able to withstand sustained voltage levels of up to 48 VDC for up to ten (10) minutes.

Onboard components shall not suffer corruption of data when the power dips below 9 VDC.

Onboard components shall not be damaged by very high (twenty [20] times nominal voltage) short duration (up to ten [10] milliseconds) peak voltage.

Contractor shall indicate full operational and quiescent power drain for each on-board component proposed.

Contractor shall provide effective power regulators/conditioners/filters for all in-vehicle equipment. Specific tests shall be accomplished in each type of vehicle, by electrical system configuration, to assure that an effective filtering system has been identified, before installation in the remainder of the fleet.

Wiring/installation diagrams for in-vehicle systems shall be provided by the Contractor for each make/model of both service and supervisory (manager) vehicle.

Operation of equipment shall not be affected by electromagnetic effects present during normal public transport operations.

Operation of equipment shall not affect or be affected by vehicle components, such as engine ignition, or other on-board equipment including vehicle power supplies, radios, automatic vehicle identification systems, fare collection systems, and onboard data collection and processing equipment.

Operation of equipment shall not be affected by the electromagnetic fields generated by electrical transmission lines, by an overhead catenary at distances as close as 7 metres, or by local power distribution lines at distances as close as 15 metres.

It is the responsibility of the contractor to determine if the bus will require an upgrade of its electrical system (i.e. batteries and alternator) to support the additional on-board electrical equipment, including data exchange.

C3.9.4 Environmental

Mobile equipment must meet or exceed the following minimum conditions:

- (1) Operating Temperatures between -10° and +70°C
- (2) Storage Temperatures between – 20° and +75°C
- (3) Humidity: 98%
- (4) Shock: 30g of 6 milliseconds
- (5) Operating Vibration: 1.5g RMS, 5 to 150 Hz
- (6) Endurance Vibration: 8g RMS, 100 to 1,100 Hz
- (7) Dust and Water Ingress: Protected to IP (Ingress Protection) 54 for all equipment inside the bus.
- (8) Inclination: 0 to 10 deg off vertical
- (9) Water Solvents: Water spray on equipment from cleaning floors and walls, industrial solvents, rain, mud, snow and slush may come in contact with equipment

If the Contractor's equipment has been tested to different specifications than those defined above, the Contractor shall identify the environmental testing requirements utilized and results that were obtained. Such alternatives are subject to approval by the City of Cape Town.

All exterior mobile equipment must be sealed and weatherproof to a rating of IP 65.

All components shall maintain specified performance when operated from mean sea level to at least 40 000 feet above sea level in an unpressurized cargo compartment.

C3.9.5 Vehicle Logic Unit (VLU)

C3.9.5.1 Requirements

The Vehicle Logic Unit (VLU) shall be designed for installation and operation in a public transport environment. Specifically, the VLU shall include provisions to protect against vibration, water ingress, vandalism, and corrosion.

The Contractor in liaison with the vehicle supplier, shall be responsible for determining the final location of VLU installation on each different bus type and configuration, subject to approval from City of Cape Town.

The on-board processing unit shall store the Automatic Vehicle Location (AVL) and vehicle weight measurement data in a non-volatile memory with sufficient capacity to hold thirty (30) days of data assuming up to 20 revenue round trips per day.

The VLU shall be an integrate unit with at least 9 x 10/100Mb/s Ethernet copper ports and 2 x USB ports. It shall either have integrated GPRS, GSM, GPS and WLAN communications or it shall be possible to interface with all of these communications devices.

The tenderer will research and propose the best suited communication medium (GSM/UMTS, TETRA, WLAN) to utilise by taking reliability, coverage and operating costs into account. The final proposal is subject to approval by the City of Cape Town.

The vehicle supplier will supply and install infotainment displays on the vehicles. The tenderer will supply a VLU with integrated media storage and playback capabilities or separate media server. The media integrated VLU or separate media server will drive the infotainment displays and the tenderer must complete the final integration of the infotainment display with the media system. The contractor must ensure that the input ports on the infotainment display are compatible with the output ports on the media device.

For trunk buses, the VLU shall process data received from the vehicle weight measurement system, GPS and secondary position systems, and shall correlate it with date, time (both 24-hour system clock and 30-hour clock which some scheduling systems use), route, block, trip, stop ID, timepoint association, latitude/longitude, door open and door closed and wheelchair lift or ramp to provide stop-level passenger count estimates.

The VLU shall act as the central processor, data storage, and device manager for all onboard systems supplied by the control centre company and the bus manufacturer including:

- The Mobile Data Terminal (MDT)
- Vehicle Weight Measurement (VWM)
- Transit Signal Priority (TSP)
- Automatic Vehicle Location (AVL)
- Passenger Information Display (PID)
- Automatic Voice Annunciation (AVA)
- CCTV System and DVR
- Voice and text messages

It shall be possible to load and store a minimum of 2 schedules onto the VLU.

The VLU shall reconcile discrepancies between GPS and secondary position systems to provide the most accurate vehicle location information.

The VLU shall store all the data collected from other on-board components, with the exception of the smart card fare collection system components supplied by others until it can be transmitted to the central system.

The VLU shall be configured such that collected route data may be send via its communications system to the central application(s) database. The reporting rate shall be customisable for both specific time and distance interval. The reports shall also be capable of being communicated on an exception basis including schedule adherence. It shall be capable of sending a configurable data packet that could span single or multiple polling intervals. Configuration data elements should include:

- Un-reported locations (recent).

- Schedule adherence
- TSP activities/ status
- PDU status
- VWM status
- CCTV status.

Real time data exchange between the bus and the TMC is required as follows:

- Text messages and voice calls
- Sending of emergency status
- VWM data
- Update of schedules including messages for PDU's and AVA.
- Send and accept TSP requests from TMC.
- AVL data
- Data logs

The VLU shall include the monitoring of machinery including but not limited to status of the brakes, the electrical system and bus maximum and average speeds.

All data between the VLU and the TMC shall be transferred to the central control system via wireless LAN at the depot once the vehicle docks in any of the City Bus Depots.

The VLU shall be responsible for initiating and verifying the complete transmission of data through the wireless LAN at the depots, and shall not delete or remove data until a successful transfer has been recorded or if removed by a systems administrator.

The VLU shall include functionality and external interfaces to provide GPS position and time information to future devices/subsystems by others.

The VLU shall provide an interface to and support the Fare Collection System (FCS), to be provided by others.

The VLU shall enable remote vehicle immobilisation once specific criteria is met.

The VLU shall be equipped with a lithium battery that would maintain system time for more than 5 years. The VLU shall run diagnostics and report any problems with on-board APTMS components (including the VLU itself).

The VLU shall automatically recognize any system process failure or lock-up and log the problem and attempt a restart. If restart of the process fails, notification shall be sent to the operator via the MDT and logged in the VLU for download at the end of the day.

The VLU shall manage power to all onboard devices supplied under this Contract, and shall have two "power-down" timers as follows:

- (1) One power-down timer that will keep the equipment operational for a configurable period of time (0-120 minutes) when the vehicle master switch is turned to "off", "lights" or "night park". This will allow the equipment to remain operational at a layover or extended stop.
- (2) A second power-down timer that will gracefully log-off and shutdown the onboard equipment after a configurable period of time (0-120 minutes) after the first timer has expired. This will allow data transfers to be completed when the bus returns to the depot.

Data shall not be corrupted as a result of short-term power interruptions (e.g. vehicle startup) or power down.

The VLU shall include functionality to verify the successful transmission of data to the central system before purging any data records or buffers.

The VLU shall include functionality to re-transmit data in the event of an unsuccessful transmission.

C3.9.6 Automatic Vehicle Location (AVL)

C3.9.6.1 Requirements

All trunk and feeder buses shall be equipped with Automatic Vehicle Location (AVL) system.

The AVL system shall include at a minimum the following hardware elements:

- (1) A GPS receiver, integrated with the vehicle logic unit.
- (2) A secondary position system consisting of an odometer interface or other dead-reckoning device. Such a system may use stochastic probable position and odometer assisted location estimation to supplement the accuracy of vehicle location GPS and in case of loss of GPS reception. The combined AVL accuracy shall be within 5 metres. Bids' shall state its equipment functionality in this respect
- (3) Exterior mounted, watertight GPS and Wireless LAN antennas to be mounted on the roof of the bus for standard height buses and feeder vehicles. A combined GPS/Wireless LAN antenna is preferred to minimize the number of roof penetrations, but will accept separate antennas if required by the Contractor's design. The Contractor is advised that on some vehicles, the antennas may be mounted underneath a fiberglass cowling. This should be considered in the selection of appropriate antennas.
- (4) All cables, wiring, connectors and labels.
- (5) All mounting brackets, mounting hardware, sealant, and associated installation materials.
- (6) Antenna ground planes for any and all vehicles with fiberglass roofs or where the vehicle chassis cannot be used as a ground plane.
- (7) GPS polling intervals shall be decreased when the vehicle is stationary or switched off to save power and bandwidth requirements.

The Contractor shall provide evidence that the proposed GPS antenna has been identified by the GPS receiver manufacturer as compatible.

The automatic vehicle location (AVL) system shall provide real-time position (latitude/longitude), speed, time and compass direction data to the VLU.

The AVL system shall be designed for operation in urban, suburban, and rural areas, including the ability to continue logical vehicle position tracking when a GPS signal is not available or a position fix is not possible (dead reckoning functionality). This could include, but is not limited to environments such as mountainous areas, heavily forested areas, office tower "canyons", tunnels, and multimodal public transport centres located in buildings.

The AVL system shall provide GPS time sync to other onboard devices supplied under this Contract.

Location data shall be sufficiently precise to accurately and reliably identify the location of each bus on the street network.

Location data shall identify the location of each bus in the parking lot at the depot. The Contractor shall indicate the expected accuracy of this information. Location data shall possibly be provided to the Depot Management software enabling the parking location to be automatically recorded.

The AVL system shall provide an arrival and departure time each time the bus stops. The AVL shall be integrated into a remote Computer Aided Dispatch (CAD) system. The CAD system shall be web based and managed by transit operation personnel. The CAD system shall aid dispatchers to manage the fleet and shall include GIS mapping, historical reports and real time alerts. The dispatcher shall be able to select and view one or multiple vehicles in real-time. Upon selection the following information shall be available; date, time, speed direction, route, schedule information and vehicle and driver identification.

The AVL shall provide a positional accuracy of +/- 15 meters, 95% of the time.

The GPS position shall be updated every 5 seconds or less.

The AVL system shall provide multiple geo-fences polygons of a minimum resolution of 5m by 5m suitable for lane based identification of the vehicle to support central TSP.

Vehicle location computation lag time shall not exceed two (2) seconds in the vehicle (lag time is defined as the time it takes to compute position information, correct it, and update the onboard systems).

C3.9.7 Trunk Vehicle Mobile Data Terminal (MDT)

C3.9.7.1 Requirements

The Mobile Data Terminal (MDT) shall be a rugged computing device designed for operation in a public transport environment and shall be managed and controlled by the VLU.

The MDT shall be equipped with a colour, liquid crystal display (LCD) touchscreen display.

The MDT touchscreen shall provide VGA (640 x 480) resolution. Proposed use of any lower-resolution screens will be contemplated by the City.

The MDT display shall include functionality to display different font sizes and styles on the same screen.

The MDT display shall include functionality to display both text and icon-based messages and key labels.

The MDT display must be readable in direct sunlight and must offer a low-glare setting for night time operation.

The MDT shall contain a small speaker and tone generator to be used to provide audio alerts.

Mobile Data Terminals (MDT) shall be installed in each bus, and shall act as the user interface between the operator/bus driver and all in-vehicle devices connected to the VLU and to the TMC, including providing the interface for the functions of initialization, operation, and configuration.

The MDT shall control settings for internal public address (PA) system, for both automatic announcements and ad hoc announcements by the driver. It shall also enable the driver to communicate confidentially with the control room or emergency services.

The MDT shall incorporate a graphical schedule adherence display including alarms/warning if the driver is behind or in front of schedule.

The MDT shall control settings for the activation or deactivation of automated voice annunciation (AVA) messages.

The MDT shall be designed for simple and intuitive use by operators from varied educational backgrounds. The MDT shall not be configured in such a way as to require computer literacy from the operators.

The MDT shall be provided with a "quick reference card" summarizing basic operational processes and functions, to be included in the operators' book. The design of the MDT shall not require that the operator reference this card or other documentation for normal daily use; it is intended as a supplemental reference only.

The MDT shall automatically configure and initialize itself for operation when the power is turned on with the default screen being the operator log-on screen.

The MDT shall initialize all in-vehicle devices integrated with the VLU in a single action as the operator enters the log-on information.

The interface and menu structure of the MDT shall be programmable through configuration data.

The MDT shall utilize a hierarchical multi-page menu structure. The MDT shall include functionality to scroll through a page and switch between pages.

The MDT shall provide simple access to pre-programmed text messages that are configurable by the City of Cape Town.

Message selection, variable inputs, and interpretation of received messages shall be from menus and pop-ups that may change based on context.

The MDT display shall include default backlight, brightness, contrast, audio and tone settings.

The MDT shall include functionality to set audio tone types, frequencies, volume and duration through configuration data.

The MDT shall include functionality to set default display backlight, brightness and contrast settings through configuration data.

The MDT display shall have controls to allow the bus operator to adjust backlight, brightness, contrast, and volume settings within configurable limits. In no event shall such controls allow the screen to be set to all bright or all dark such that the text is unreadable.

Upon start-up and log-on the system shall revert to default settings for all configurable parameters.

The MDT shall include operator log-on and log-out functions. The log-on function of the MDT shall permit the operator to initialize the system with an ID number that associates their name and background information with the vehicle for dispatch purposes for the duration of their scheduled block/run/route/route variant/trip.

The MDT shall validate log-on and trip change entries against an internal database of valid trips. In the event of an erroneous entry, the MDT shall sound and display an alert for the operator.

The MDT shall include functionality to send pre-defined messages to central control. Such messages shall be established through configuration data. The Contractor shall define a comprehensive set of messages that shall include at a minimum the following:

- (1) Log on/log out/system test/maintenance
- (2) Critical messages (including silent alarms)
- (3) Vehicle status report
- (4) On-route
- (5) Out-of-service
- (6) Call for a field supervisor
- (7) Vehicle mechanical problem
- (8) Minimum of five other pre-programmed messages

The MDT shall display at a minimum, current system wide transit time, vehicle status (in/out of service), block/run/route/route variant /trip, data messages, and schedule adherence status.

The MDT shall indicate that there are unread messages in the incoming message queue and how many messages are in that queue. The MDT shall also indicate when there are no more messages to be read.

The MDT shall move priority messages received to the front of the queue and provide visual and audible indications that a priority message has been received.

The MDT shall include functionality to skip a message in the queue, delete a message from the queue only after it has been displayed, or save a message to memory for long-term storage (until MDT shutdown).

All data messages entered or selected by the operator shall activate the data communications for transmission to dispatch. Emergency alerts/silent alarms shall be transmitted immediately to dispatch as a high priority data communication.

Except for silent alarms, the MDT shall indicate to the operator that the operator received a critical message.

The MDT shall include a minimum three levels of critical messages including:

- (1) Overt/Covert Alarm (highest priority - level 0)
- (2) Emergency Services Requested (high priority - level 1)
- (3) Non-Emergency Assistance Requested (priority - level 2)

The MDT shall be configurable on a system-wide basis to provide non-priority messaging functions to the operator either at any time or only when the vehicle is below a customizable speed threshold.

The MDT shall be able to receive and display a minimum of sixty-four characters in a message consisting of ASCII (American Standard Code for Information Interchange) coded numbers and letters. The MDT shall allow scrolling through the message at sixty-four characters or more per scroll action. The MDT shall be able to display multiple text sizes and multiple lines of text

Messages displayed to the user shall be in a large font (approximately eighteen point) that is readable by a user with 20/20 eyesight from a distance of three feet. Summary lists, tables of data, etc. may be displayed at a smaller font.

The MDT shall provide maintenance personnel with a maintenance and test function device diagnostics, and default configuration values for the MDT.

If no operator logout has occurred, the MDT shall remain active until the expiration of the first power down timer in the event the vehicle master switch has been turned to "off", "night run" or "lights". Once the second power down timer has triggered, the MDT shall automatically logout and shut down.

Data shall not be corrupted or operation disrupted as a result of short term power interruptions (e.g. vehicle startup) or power down.

The MDT shall not “freeze up” in the event that power is applied in the incorrect order (ignition sense versus continuous power on the load side of the master switch), or power is interrupted/drops during startup (e.g. from activating the vehicle ignition).

C3.9.8 Vehicle Weight Measurement System (VWM)

These systems will be supplied and installed by the vehicle supplier and only final integration of the VWM system with the VLU shall be required of the control centre company. The control centre company must liaise with the vehicle supplier to ensure system compatibility with the VLU.

C3.9.8.1 Requirements

The VWM shall measure the vehicle weight at different points of time and store the data on the VLU. The data recorded will include the total weight of the vehicle. Preferably, this data will also include the distribution of the weight, and in particular, the axle loads.

There are at least two general uses for the data collected.

First, this data can be correlated to GPS position to estimate the number of passengers on board the vehicle at different segments of the route. The weight values will thus be used to estimate the boardings and alightings at each station.

Second, the axle load data will help ensure compliance to the legal load-carrying limits of the vehicle.

Data from the vehicle weight device shall be recorded onto the Vehicle Logic Unit (VLU).

The VWM system shall detect and track door openings correlating to actual bus stops. It shall be possible to account for sitting of temporary stops, or temporary bus stop closures and re-routes. Actual bus stops may include flag stops on detours or other non-permanent locations. If the bus goes off-route, the system shall continue to log the longitude and latitude of all locations where the doors open/close.

VWM data and reports shall be associated with Cape Town stop, route, route variant, and trip identifiers.

The VWM system shall provide real-time data for each bus through the system so current VWM data is immediately available to Operators in the TMC. The preference is that such data is continuously available, however if data loading is a constraint, “on-demand” access to this information will be considered.

The VWM system shall provide high-level analysis tools to analyze archived data.

C3.9.9 Automatic Stop Annunciation (ASA)

The audio system consisting of the speakers, amplifier and accompanying wires shall be supplied and installed by the vehicle supplier. All of the LED displays and accompanying wiring utilised by the ASA system will also be supplied and installed by the vehicle supplier. The control centre company should ensure the proper functional operation of the ASA system as specified in this section. The control centre company will be responsible for the control logic and communications required on the VLU to ensure the proper operation of the ASA components.

C3.9.9.1 Requirements

The Automated Stop Annunciation system shall include:

- (1) Onboard signs to provide a visual next stop announcement display.
- (2) An interface with the bus PA system to provide audio next stop or route identification announcements on the bus, as appropriate.

Through configuration data, City of Cape Town shall be provided with functionality to identify the stops be announced visually only, and that some stops be announced both visually and audibly. As part of the final design process, City of Cape Town will make a final determination of whether to announce all stops with both technologies, or have some stops announced visually only.

The onboard signs shall utilize high brightness, wide viewing angle, amber Light Emitting Diode (LED) technology.

Signs shall consist of a 1-line Amber LED matrix with a minimum of 16 characters. Characters shall be approximately 38mm high to support a viewing distance of at least 20m.

Messages on the signs shall be legible during any time of day and from any designated passenger position on the bus. If this is not possible another sign shall be installed.

LED brightness shall be controlled by photocells installed as part of the sign.

Each sign shall be provided with its own integrated controller. The controller shall communicate with the on-bus VLU. It shall also be possible to override messages directly from the control centre under emergency conditions.

The time display shall be outside of the message display area, and may be provided either through additional dot-width on the display or through a separate display module integrated into the sign housing.

The signs shall be capable of displaying upper and lower case characters with proportional fonts. Characters shall be between three (3) and five (5) dot-width, with an average (mode) of four (4) dot-width.

The sign shall be capable of displaying double stroke width (bold) fonts.

The front face of the sign shall be designed to minimize glare.

The background shall be black, and the sign housing shall include a black border.

The position of the sign shall not block the viewing area of onboard video cameras.

The ASA system shall provide visual and audio next-stop announcement acceptable to people with disabilities. Message being played shall be displayed on the MDT.

The ASA system shall include functionality for:

- (1) Automated operation that requires no interaction by the operator to trigger announcements (all triggering to be set as configuration data). This may be required to work as follows: The VLU shall store bus stop and route information and compare that to the actual coordinates. At predetermined distances from the next stop an announcement shall be triggered. These trigger distances shall be configurable. If a bus travels off-route the system shall mute all announcements until the bus returns to the route.
- (2) Manual override to allow an operator to cancel or manually activate an announcement.

The ASA system shall announce transfer point and connecting route information.

The onboard systems shall include functionality to generate and display the following types of next stop and related messages:

- (1) Audio location-based announcements onboard the bus (next stop, customer service, transfers, etc).
- (2) Visual display in the interior of the bus of the route number and final destination of the bus.
- (3) Visual next stop messages onboard the bus giving the location or name of the next stop.
- (4) Visual display of the current, exact time (shall be shown with scrolling or alternating display).
- (5) Time-based audio and textual customer service announcements onboard the bus.
- (6) Announcements initiated by the TMC.
- (7) Pre-recorded audio customer service announcements.

All message content shall be configurable by City of Cape Town.

The ASA system shall be supplied with an automated process to import stop and other configuration data.

Onboard systems and devices shall include functionality to comply with requirements for people with disabilities. Requirements include but are not limited to:

- (1) All stops shall be clearly and automatically announced throughout the inside of the bus
- (2) Major intersections shall be announced whether the bus stops or not
- (3) Major destinations shall be announced
- (4) Major transfer points shall be announced

Automated internal announcements shall be triggered by the AVL system (through the VLU).

The volume of the internal announcements shall be adjustable to a standard level through configuration data. The system shall include a minimum of three volume level settings that can be selected by the bus operator through the MDT.

The volume setting shall revert to its default value when the AVA is logged off or logged on.

The ASA shall receive its time synchronization from the VLU.

The system shall include an automatic gain control to automatically adjust interior volumes depending on interior ambient noise levels.

The signs shall have the functionality to display time and messages in the following modes, set through configuration data:

- (1) A single, non-scrolling or changing message.
- (2) A right to left scrolling message.
- (3) An alternating (between two states) message.

Through configuration data, it shall be possible to set the arrival message to play once, play twice, or repeat in a loop while the door is open. If on a repeating loop, it shall be possible to set the repeat interval through configuration data.

The announcement shall be repeated automatically if the front door remains open for greater than a pre-determined time. It shall be possible to set this time through configuration data.

The AVA system shall include self-diagnostic capabilities, and shall provide diagnostic information to the AVL system.

The AVA shall provide maintenance technicians with a means of testing and setting the internal audio default volume and ambient noise sensor circuit.

The system shall be designed for continuous operation without the need to manually "reboot" computers or devices.

LED's used in the onboard signs shall have a minimum service life of 80 000 hours in their installed configuration.

Both audible and visible messages shall begin playing within one (1) second of being triggered.

The ASA time-sync shall be updated at least once per day. A clock accuracy of +/- 20 seconds per day is sufficient for all ASA system components.

C3.9.10 Emergency Alarm

Emergency alarm (EA) switches and associated, hardware, cabling and appurtenances shall be supplied by the vehicle manufacturer for all vehicles. The control centre company shall be responsible for the integration of the EA switch and associated cabling and hardware with the VLU and other onboard systems.

C3.9.10.1 Requirements

The EA activation switch shall be installed in a location easily accessible to the bus operator, and positioned such that activation can be done without visibly alerting a customer on the bus or in the boarding area.

In the event of EA activation, the bus operator shall be notified covertly, such that the indication is identifiable only by a trained bus operator.

Activation of the overt/covert alarm shall initiate continuous tracking of the vehicle with highest priority being given to the vehicle for data communications.

The EA circuit shall be monitored continuously for continuity, and any faults shall be reported on the MDT and provided to dispatch.

The Control Centre shall be notified of EA activation within 10 seconds of alarm activation.

In the event of EA activation, the bus operator shall be notified within 10 seconds of the alarm being acknowledged by a operator.

C3.9.11 Video Surveillance System (VSS)

The vehicle supplier will supply and install the following components:

- (1) All on-board CCTV cameras
- (2) All wiring to/from cameras to/from digital video recorder
- (3) Digital display units for the driver. The display units will be utilised by the driver to view onboard camera footage.
- (4) All wiring to/from digital display unit to/from control units and to/from cameras such as the rear view camera
- (5) Housing for all the on-board ITS equipment to be supplied by others (designs to be submitted to and approved by the City of Cape Town)
- (6) Power supplies to equipment supplied by others (designs to be submitted to and approved by the City of Cape Town)

The control centre company should provide pricing for the DVR unit. Installation and setup of the DVR and the connections to the DVR will be done by the control centre company.

C3.9.11.1 Requirements

Analogue cameras shall be installed inside the bus from the ceiling. All cameras shall be fixed cameras positioned to provide full coverage of the bus interior, including the driver.

A digital video recorder (DVR) shall be installed to record up to four cameras footage. The DVR shall be connected to the VLU for management purposes.

Upon docking stored video footage will be downloaded via WLAN and fibre optic backbone to the control centre if required.

The DVR shall be installed such that it is tamper proof and only authorised personnel can gain access to it.

The DVR must be robust and be able to withstand the vibrations and impacts associated with poor road conditions without losing recorded video footage.

The CCTV system shall be protected from electrical fluctuations typically present in transit buses, including, but not limited to, over voltage, under voltage, transient, power dip/surge during engine or other bus equipment start up, alternator noise, etc.

The Contractor shall provide an impact sensor. Events will be triggered by either activation of the Covert Panic alarm button or impact sensor activation. Although the system shall record at all times, an event trigger will cause the system to protect a customisable time segment before and after the event from automatic overwriting until a systems administrator overwrites it. During an event, the resolution and frame rate shall automatically increase to the maximum on all cameras. The impact sensor shall be configurable to minimise false alarms.

The surveillance system must assist validation that buses are running with closed doors.

Cameras shall be configured and installed to achieve optimum coverage inside the bus focused on passenger and driver safety. Clear unobstructed coverage of the following areas shall be provided:

- a. Over driver's head, all doors and AFC System validators.
- b. Driving view from front of bus.
- c. Front of bus looking towards rear
- d. Back of bus looking towards front.

Cameras shall at least record video at 15 frames per second at CIF resolution.

The DVR shall have enough storage capacity to record 18 hours per day for 3 days at the stated frame rate and resolution for up to four cameras.

C3.9.12 Bus Priority (BP)

C3.9.12.1 Introduction

Bus Priority (BP) is an operational strategy that facilitates the movement of transit buses through traffic signal controlled intersections. This is accomplished through the modification of the normal signal operation by extending green times to better accommodate transit buses, without changing signal cycle length and taking the signal system out of coordination. The objectives of BP include improved schedule adherence and improved transit travel times while minimizing impacts to normal traffic operations.

BP systems consists of three components: the priority request generator (detection device), the priority request server (signal controllers and embedded priority logic), and the support systems that allow the agencies access to data for management of the system (transit monitoring system).

C3.9.12.2 Requirements

BP transponders shall be positioned secure, unobtrusive to passengers and operation of the bus and operate at optimum efficiency. The rest of the BP system shall be integrated with the Automatic Vehicle Location (AVL) system, Scheduling System and the Vehicle Logic Unit (VLU).

The BP will be implemented on buses that service a wide geographical area which utilise different controller types, software and firmware. It is therefore crucial during the implementation stages, that the BP detection and operating systems are tested to ensure proper interface with these signal system elements in the region.

Communications between the transponder on the bus and the traffic signal controller shall be by the 802.11 (WLAN) standards. Wireless detection may require custom software to interface with different controller types.

The bus priority system where possible, should make use of commercially available, off-the-shelf components, with well-established records of reliability and performance, within the region. It will be preferred if the components are compliant with the latest National Transportation Communications for ITS Protocol (NTCIP) and Society of Automotive Engineers (SAE) standards, and should be cost-competitive when compared to other similar functioning components.

A distributed priority system is envisaged where the priority signal is generated on the bus by the priority request generator (PRG) and is detected and served at the local traffic controller by the priority request server (PRS). The PRS makes the decision to grant the priority request and priority treatment for the approaching bus is implemented. **In order to implement this system successfully, the integration of the AVL and scheduling system with the BP is a fundamental requirement.** This system is independent of communications by the traffic signal controller to the traffic control centre.

The system shall operate on the concept that the bus contains all the required information to request priority. The following minimum conditions shall be considered when requesting priority: location, schedule adherence and if the doors closed. Once the bus is behind its schedule by a predetermined threshold, it activates the priority request system.

The priority message would be transmitted from the wireless antenna on the bus to the signal cabinet, where the priority request is processed and if allowed, the signal timing parameters are adjusted.

Logging of BP requests and activities will be required for future analysis and statistical purposes. Logging of BP activities is preferred to be done at the local traffic control centre, but may be done locally on the controller.

The AVL systems must receive information from scheduling software/databases to compare actual bus location to the bus's schedule. This is a key portion of the conditional priority system, because only late buses should receive signal priority. This will create a more efficient use of the signal priority modifications at the intersection.

Signal priority logic should be connected to the bus doors or speedometer to ensure priority is requested only when doors are closed and/or bus is in motion. Logic should also incorporate the ability to recognize that a bus is sitting in queue at a red signal and delay the request until the bus is in a closer position to the intersection to take full advantage of the priority request. Optional logic connections would be on the vehicle weight measurement system (VWM), to prioritize multiple requests for priority at an intersection based on ridership; or to connect the priority logic to the stop request (pull) cord on-board the bus. The priority request would cease when the pull cord is activated on-board the bus if approaching a near-side stop.

The following should be characteristics of the transit signal priority detection (communication) system:

- Shall be integrated with other on-board systems, using relevant standards.

- Shall not result in an installation of equipment that will create redundant processes.
- Shall detect and distinguish transit and emergency vehicles from each other and the general traveling public.
- Shall transmit relevant bus information that will be used to prioritize conflicting priority requests. The message shall be user defined and changeable as needed.
 - Bus Status (one to two bytes)
 - Direction
 - Priority request
 - Check in/check out
 - Position update
 - Bus Estimated time of arrival in seconds (one bit)
- Shall communicate wirelessly (IEEE 802.11).
- Shall validate the data transmitted from the approaching vehicle and identify whether the vehicle in question is authorized in the TSP system or not.
- Shall be able to determine whether or not a detected vehicle has departed or cleared the priority intersection, and prompt the intersection to return to normal operations once the vehicle has cleared.
- Shall enable preemption/priority requests automatically. No driver activations shall be required or allowed.
- Shall request limited or no priority at near-side stops.

The following shall be characteristics of the transit signal priority request server.

- Shall be compatible with the agencies' traffic signal systems and traffic management system.
- Shall process data from priority detection system and conditional priority logic to determine if and how much priority should be granted at the local intersection.
- Shall be capable of processing and prioritizing multiple requests for both priority and preemption, and prompting the local controller to carry out the most critical function.
- Shall override all priority requests, when a preemption request is registered.
- Shall be able to log all priority/preemption activities.
- Shall be able to develop an optimized priority/preemption solution based on signal priority inputs and logic. Optimal plan should minimize impacts to side-street traffic, while allowing needed benefit to priority/preemption vehicle in question.
- Shall transition back to normal signal operations as soon as possible once priority/preemption vehicle has left the intersection.
- Shall process signal priority requests and deliver functional commands to the signal system at either a centralized or local traffic operations level.
- Transit signal priority equipment in the field shall be able to communicate with a laptop or handheld computer for maintenance and monitoring activities in the field.

C3.10 DETAILED SPECIFICATION: CONTROL CENTRE

C3.10.1 High Level Requirements

The tenderer will be required to provide a complete and operational system. The systems will be managed, controlled and monitored from the Control Centre, which will be located in Goodwood, Cape Town. Floor space and server rooms will be made available to the contractor for installing the necessary hardware. The tenderer must ensure that all systems are integrated with the onboard systems, the systems in the stations and the systems in the depots. The following high-level requirements must be met in terms of **operations**:

- Software/hardware should allow scheduling of buses (scheduling software)
- Tracking of all buses, including scheduling adherence must be possible
- The management and control of passenger and other information should include:
 - Onboard information
 - Stations information
 - Media (web etc)
- Incident management along the IRT corridors
- Emergency calls and dispatching of assistance
- Visual surveillance of stations and network for control and security
- Develop/control signal priority strategies and signal operations to assist buses
- Will required high bandwidth communication links to buses, stations, other control centres and depots.
- Radio links to security personnel, bus drivers, station attendants, field inspectors and bus operators.

The following high-level requirements must be met in terms of **system security and surveillance**:

- Automatic and manual scanning of all video feeds from stations, depots and corridors.
- Identification of incidents and crimes, automated where possible through video analytics
- Dispatching of police and emergency services
- Dispatching of maintenance and clean-up teams

C3.10.2 General

Monitors used to display AVL maps shall be large enough, have adequate resolution, and colour definition for strain free viewing during normal operation.

System control shall be achieved with as few operator separate steps for commonly performed functions as possible, or by operator created macros.

Human factors shall be addressed such that repetitive stress injury (RSI) risk is low or none.

A large video wall will be fitted in the operational room. This video wall will consist of a large DLP screen by either combining 4 x 50" DLP screens or using one 100" DLP screen. Barco, Mitsibushi or similiary approved make based on DLP technology shall be fitted on the wall. The DLP screen shall be surrounded by at least 12 x 40" LCD screens. These screens and monitors should be of the latest available technology. The design of the video wall will be to the approval of the City of Cape Town.

C3.10.3 Network

The APTMS central site equipment (dispatch consoles, servers, WLAN, etc.) will reside on a dedicated network in the TMC to be provided by the Contractor.

All servers/services provided by the Contractor shall be integrated with, and shall be part of, City of Cape Towns existing security infrastructure. In the event that the Contractor is unable to meet this requirement, the Contractor shall supply any required servers and software to provide an equivalent level of security at no additional cost. City of Cape Town will be responsible for all network security management including any new servers provided by the Contractor.

Central site servers shall be installed in a designated location at the City's TMC.

The Contractor shall provide fault monitoring systems for all network components supplied under this Contract. All fault notifications shall be forwarded to the City's network monitoring and management system. Such notifications shall be independent of any specific network monitoring and management software. The Contractor will be responsible for fixing all faults within two working days

C3.10.4 Electrical

All Equipment installed in Agency or third-party offices or facilities (with the exception of any on-board equipment) shall operate from a nominal line voltage of 220 VAC, within voltage tolerances of +10% to -10%, and a frequency range of 57 Hz to 63 Hz.

C3.10.5 Environmental

The Contractor shall survey the TMC environmental conditions and confirm that it is adequate to the requirements of all.

Equipment shall maintain specified performance while operating in a controlled environment of +5°C to +33°C (+41°F to +92°F), relative humidity (non-condensing) less than 90% at 33°C (+92°F) for both intermittent and continuous periods.

Equipment shall maintain specified performance after being stored, non-operating, in a temperature environment of -10°C to +50°C (+14°F to +122°F) and shall maintain specified performance after storage exposed to a relative humidity of 90%, non-condensing, at +50°C (+122°F) for both intermittent and continuous periods.

C3.10.6 Hardware Requirements

C3.10.6.1 Operator Consoles

The final number and types of operator consoles and their flexibilities will depend on the functionality of the supplier's software and will be determined through the final design process. The following operator consoles are envisaged for the TMC:

- System Operator Workstations: Vehicle Tracking, Vehicle Management, Driver Information System, Communications with Driver, etc.
- Emergency and Information Call Workstation. Workstations for receiving emergency calls and information calls and for communications with the public via the IP intercom network.
- Maintenance Manager Workstation. For receiving, recording, dispatching and management of all maintenance related activities.
- Surveillance Workstations: For surveillance of CCTV video feeds in stations, stops and along the route. These workstations will be differently equipped with large LCD screen displays (approximate size 40" displays) that can display up to 16 separate video feeds. Dedicated CCTV keyboards and surveillance joysticks will be used to control the remote cameras and the surveillance workstation. The layout and design of the workstation will be approved by the City of Cape Town.

The system shall be supplied with all required hardware and operating system software. Hardware shall include at a minimum computer processing devices, keyboards and navigation devices, and displays.

All displays shall utilize LCD technology and have a minimum 20" diagonal measure (except displays for surveillance workstations that need to be larger). At least 3 (three) displays per console should be provided.

The user interface shall utilize MS-Windows standard navigation, icons and shortcut keys.

All workstation software shall operate on the Microsoft Vista operating system or alternative Microsoft OS (Operating System) as approved by City of Cape Town.

The final number of workstations for operators of the APTMS system will depend on the extent of the system, the number of buses and the functionality of the software provided by the contractor. This will be determined during the design phase of the project.

C3.10.6.2 Hardware and Software Standards

All hardware and software supplied under this Contract shall be per City of Cape Town hardware and software standards as listed below. The Contractor shall identify in its design any proposed alternatives to these standards.

All servers shall be RAID (Redundant Array of Independent Disks) Level 1 or better.

All servers shall be supplied with a built-in Remote Access Card (RAC) – one per server.

All workstations shall be current generation Dell, Hewlett-Packard or approved equivalent with processing, storage and video capabilities.

All network devices, including WLAN devices, shall be current generation Cisco devices or approved equivalent.

All additional support office equipment required for the optimal operation of the TMC will be provided. This includes but is not limited to the following:

- All printers
- All plotters
- All fax machines
- All scanners
- Any other equipment required for basic office operations

All software supplied shall be compliant with the following operating system and application software standards:

- (1) Operating Systems and Databases: MS Windows 2003, MS Exchange 2007 Server, MS SQL 2005 Server, MS SharePoint 2007 Server and Oracle 9 Enterprise/Standard DBMS.
- (2) Desktop Applications: MS Office 2007 and Internet Explorer 7.
- (3) Other Applications (as applicable): Financials, HCM, TrackIT Development Tools, Cold Fusion, and MS Visual Studio.

All the software used for management and surveillance in the Control Centre will be fully functional via a web interface that is accessible from any remote location.

City of Cape Town hardware and software standards will be updated to reflect current generation at the time of Preliminary Design. All APTMS central site components shall be based on the generation identified at that time.

There will be a central server to handle all e-mail and other related basic infrastructure services required for an efficient working environment.

Backup storage media, drives, and software shall be provided for the management servers. This media shall be Network Attached Storage (NAS) architecture tape or other suitable storage media, subject to approval by City of Cape Town.

The Contractor shall provide sufficient media for storing sixty (60) months of data. The Contractor shall provide all required hardware and software for accessing archived or backed up data.

Disk capacity shall be sufficient to store the applications, maps, data and associated files required for the operation with 100% expansion capacity.

All computer equipment shall have a minimum 10 000 hours mean time between failures (MTBF).

The Contractor shall supply and install enclosed equipment racks for all rack mounted equipment. All racks shall be standard EIA (Electronics Industry Alliance) 19" (inch).

All servers, wiring, network, back-up power/filtering units shall fit within the racks, and all wiring shall be clearly labelled and physically supported using support devices that are compatible with the supplied racks. Plans for rack layout shall be submitted in advance for approval by City of Cape Town.

C3.10.7 Functional Requirements

C3.10.7.1 Central Processing System

The system shall include central application software and hardware as required to process VWM data, process AVL data, manage configuration data, manage and log incidents and events, and report diagnostic information.

Expansion of the central processing system to include other typical transport management functions such as Freeway Management, Arterial Management, Incident and Emergency Management will be an advantage and tenderers must indicate the ability of the software to do that or the options available to expand to that.

The central processing system shall provide the following functionality:

- (1) Manage the communications with all VWM/AVL equipped vehicles
- (2) Import schedule and operator data from the proposed scheduling and CAD systems
- (3) Create and manage all VWM and AVL configuration data
- (4) Create and manage VWM reports by City of Cape Town.
- (5) Create diagnostic and system performance reports
- (6) Provide a real-time AVL interface to external systems to provide the location of all VWM/AVL and AVL-only equipped buses.
- (7) Be sensitive to and react to any alarms activated by bus drivers, station attendants, CCTV cameras or intruder detection alarms.
- (8) Interface with the information displays located on the stations and busses allowing for the update of schedule information.
- (9) Interface with the infotainment displays located on the trunk stations allowing for the update of infotainment content.

The AVL map system shall be based on standard digital GIS data provided by the City of Cape Town. Digital data may include City of Cape Town bus routes, route-stop-sequences, bus stop points, park & ride/depots, landmarks, and street network lines (with attributes).

The AVL shall include functionality to import City of Cape Town GIS data in ESRI (Environmental Systems Research Institute) shapefile format, with a relevant local projection/coordinate system.

The AVL stop and station database shall utilize a stop identification numbering system as assigned by City of Cape Town (up to six alphanumeric characters per stop).

The AVL shall automatically reconcile VWM data with route, trip and stop information provided by City of Cape Town scheduling systems.

City of Cape Town's preference is that VWM data reconciliation be conducted on the bus through automatic association of recorded stop data with route, trip, and stop information. Alternatively, the Contractor shall provide software and features on the Central Processing System to associate and reconcile VWM data with route, trip, and stop information provided by the scheduling systems.

The Contractor shall identify their proposed approach to reconciling VWM data with route variant, trip, and stop information, and shall identify any expectations or assumptions with respect to activities to be carried out by City of Cape Town staff in support of such reconciliation.

The AVL interface shall also supply current route variant and block/run/route/trip ID.

The central processing system shall be used to generate and manage device configuration, generate reports, and manage device fault reporting and logs.

The central processing system shall maintain an inventory of all onboard devices in use, and shall identify devices that have not reported in after a period of time (this time period shall be configurable).

The system shall utilize a commercial off-the-shelf reporting utility capable of producing standardized or regular reports, as well as custom reports. The utility shall include ASCII, delimited text file, XML (eXtensible Markup Language), and DBF (dBase file extension) table export capabilities.

The system shall provide for the import of stop and route mapping data using common or industry standard file formats and City of Cape Town standard formats.

The system shall have the capability of hardware and software extension to include new or additional features.

The system shall be designed to migrate to updated versions of hardware and software operating systems.

Disk mirroring and other techniques shall be utilized to minimize loss of data in the current configuration data.

It shall be possible to navigate with keystrokes in lieu of mouse action. A library of keystrokes and short cuts shall be provided.

The Central System shall provide XML feeds of fixed route schedules and real-time status data for integration with current and future external systems.

The Central System will be able to communicate with all the information displays located on the trunk and feeder stations and on the trunk and feeder vehicles. This system will allow for the update of the scheduling information displayed on these information displays. The scheduling system will interface with this information display update system and be able to send new schedules to all the information displays in a batch process.

It will be possible to update the infotainment content of the infotainment displays located in the trunk station, remotely from the TMC. The content update of the displays will be possible via a batch update command.

Any faults or errors that occur during the automatic conversion or transfer of data either within internal subcomponents of the central system, or from external data sources to internal subcomponents, shall be logged and critical operational items automatically emailed to a predefined City of Cape Town email distribution list.

C3.10.7.2 Computer Aided Operations/Dispatch and Scheduling

The Contractor shall supply a full-featured (by industry standards) monitoring, Computer Aided Dispatching (CAD) and scheduling functionality that has been previously proven in public transport operations. This should preferably be a single software application with different modules for monitoring, dispatching and scheduling or it could be different software applications. However, if different applications are proposed then their must be complete and simple integration between the applications.

The CAD system shall be integrated with the data communications system.

The CAD system shall allow for multiple operators at multiple locations over the LAN/WAN (Wide Area Network).

CAD functional capabilities shall be the same across all operator workstations provided for the system.

The CAD system shall provide representation and management of fixed route service by the following:

- (1) Block. This refers to the complete piece of work for the vehicle, which may include multiple routes/interlined trips.
- (2) Run. This refers to the complete piece of work for an operator (duties) that may include bus changes during the course of the day.
- (3) Route: This refers to the overall route identifier, under which there would be a series of route variants.
- (4) Route Variant: This refers to the series of points that designate a particular path or paths that define the route variant or pattern.
- (5) Trip: This refers to a specific one-way trip for the vehicle related to start/end times and points.

The CAD system shall allow for the distribution of work amongst operators by routes, vehicle types, or vehicles or by geographic area.

The CAD system shall allow for operators to modify bus or operator work distribution throughout the day as required by staff and workstation availability.

The system shall include the distribution of operator workload by configurable groups of blocks, routes or trips, with all data associated with a block, route or trips on that route being directed to particular operators. The workload assignment shall be such that no route can remain unassigned. Regardless of route assignments, all operators must have the ability to see and monitor all buses in the system at all times.

The scheduling and routing software should allow for:

- Scheduling of typical IRT trunk and feeder services where the trunk vehicles will run along fixed routes.
- Easy and efficient scheduling of subscription and demand-response trips
- Detail explanation of how the software handles scheduling and routing functions and how reports and manifests are generated and printed.
- Dispatching of demand-response trips: - The dispatcher must be able to easily toggle between different screens while a customer is on the telephone.
- Dispatching tools just be simple to use and efficient to enter and retrieve information.
- Description all of the tools available to the dispatcher and how they work.

The number of licenses provided for operator workstations shall be a minimum of 12, with the option to procure up to an additional 4 licenses to accommodate future growth.

User access levels shall be configurable such that different people and positions have access only to the features that they need.

The CAD software shall utilize typical Windows style graphical user interface conventions such as resizable windows, point and click, right click context menus, drop-down menus, toolbars, colour displays, icons, drag and drop, scroll bars, scroll wheel mouse, status bars, etc.

The system shall include a user interface that is user-friendly, accessible, and intuitive for all users.

The CAD system shall support mouse and keyboard inputs with all key features supported by keyboard shortcuts.

The CAD system shall provide for enlarged fonts and have easy to read displays when operators are situated a standard distance from the display.

The CAD software shall allow individual operators to log-on with an appropriate password and log-off.

A minimum of two levels of CAD access shall be allowed including:

- (1) Supervising operator/system administrator – with the ability to adjust all CAD software preferences.
- (2) Standard operator – without the ability to adjust preferences (such as vehicle status colour indications or icons).

Access to the CAD software shall be secured by standard passwords managed and controlled by system administrator functions through a standard operating environment.

The system shall support three separate displays per workstation position.

The system shall provide two-way text messaging between bus and operators. Dispatch shall have the capacity to send a text message to a single bus, a specific group of buses, a specific operator, or all buses.

The CAD system shall include “canned” (pre-defined) and free form text messaging functionality.

The CAD system shall provide for a minimum 20 canned message types that may be broadcast from vehicles with MDTs to dispatch.

Canned text message types shall be determined by City of Cape Town and configured into the appropriate MDTs and CAD software. Where appropriate, canned responses to canned messages shall be available to both the vehicle and operator, and responses will also be determined by City of Cape Town.

The CAD system shall support free form messages typed by the operator up to 255 characters in length.

The operator shall be able to initiate text message communications by:

- (1) Selecting a message from the queue
- (2) Selecting a vehicle from a list.
- (3) Entering an operator ID, vehicle ID or group ID.
- (4) Entering a route ID, trip ID or block ID

The operator shall be able to reply to a text message in the queue in either a canned response or free-form text message by clicking on the appropriate message.

When an operator receives a text message from a bus operator, the system shall display the operator's name, employee number, trip number, bus number, route number, route variant, route direction, vehicle location, and the time of the message.

The system shall provide an incident and message queue containing all text communications, vehicle status changes, etc. with priority of the messages displayed being configurable.

The CAD system shall provide the following basic views in addition to the message queues:

- (1) Map displays (allowing for multiple map windows and zoom settings).
- (2) Route displays indicating vehicles in relation to stops along a route.
- (3) Vehicle lists of all vehicles active in the system.
- (4) Driver lists of all operators logged into the system.
- (5) Trip lists of all trips logged into the system.
- (6) Incident or event lists (for work assigned to operator or bus-specific) which shows all actions conducted through the CAD.

The performance and output of the CAD/AVL data and mapping software must be accurate, correctly reconciling to stop locations and the centerline of the street.

The map system shall be compatible with City of Cape Town's ESRI based GIS system.

The digital mapping system must be able to import City of Cape Town's GIS data on a periodic basis.

The operator shall be able to open, close, tile, or resize map windows.

The map display shall be capable of displaying a variety of geographic features. It shall be possible to independently set features to be visible or hidden by map layer without limitations on the numbers of layers. The map display shall display these features:

- (1) Freeways & highways (with appropriate shields)
- (2) Major and minor streets (with appropriate names)
- (3) Rail track
- (4) Depots
- (5) Transfer points
- (6) Bus stops and stations
- (7) Rivers, lakes, and other major bodies of water
- (8) Parks
- (9) Agency maintenance yards
- (10) Airports, hospitals, police stations, fire stations, and schools

The map view shall include functionality for pan, zoom in/out, window zoom, and multiple map displays. The map display shall be configurable to display different levels of detail (such as street names) at different zoom levels.

Operators and supervisors shall have the ability to filter the bus location display by the following options. It shall be possible for routes to be assigned to multiple groups simultaneously by some or all of the following criteria:

- (1) Route number
- (2) Route variant
- (3) Trip
- (4) Groups of routes
- (5) Operating base

- (6) Vehicle type
- (7) Bus number
- (8) In-service and on-schedule (by a configurable period)
- (9) Behind schedule (by a configurable period)
- (10) Running early (by a configurable period)
- (11) Out-of-service
- (12) Not logged in
- (13) Emergency/panic alarm activated. Note that as there will be no direct integration with the fixed route vehicle emergency alarms, the central systems must include the ability for an operator to manually set a vehicle into EA mode from the dispatch console.
- (14) Off-route (by a configurable distance)
- (15) Communications interruption

The operator shall be able to centre a map view on a vehicle or track a vehicle by:

- (1) Selecting the vehicle on the map display
- (2) Entering the vehicle, operator ID or trip
- (3) Selecting the vehicle from a list of vehicles

Views for “tracked” vehicles shall automatically update each time the position or status changes.

The base polling frequency for updates to the location of each bus shall be no longer than every 60 seconds, or as frequently as the capacity of the Communication System permits, but in no event greater than every 90 seconds. The Contractor shall identify its recommended polling frequency based on the data radio system proposed and City of Cape Town’s current fleet size. The Contractor shall also identify if more frequent polling of the IRT vehicles can be provided.

The system shall indicate any vehicle that is not reporting back on regular intervals and/or over multiple polling cycles.

The CAD system shall display vehicles via icons displayed in a map view (as well as vehicles indicated in a list). Icons shall be configured in the system and standard across CAD workstations. Icons shall clearly indicate position in relation to the map and direction of travel. A minimum of 10 vehicle icon types shall be available for configuration. Operators shall be able to call up “flags” noting vehicle IDs, operator name, trip number, bus number, and route number.

Icons shall allow for the display of vehicle status such as:

- (1) In-service and on-schedule (by a configurable period)
- (2) Behind schedule (by a configurable period)
- (3) Running early (by a configurable period)
- (4) Out-of-service
- (5) Not logged in
- (6) Emergency/panic alarm activated. Note that as there will be no direct integration with the fixed route vehicle emergency alarms, the central systems must include the ability for a operator to manually set a vehicle into EA mode from the dispatch console.
- (7) Off-route (by a configurable distance)
- (8) Communications interruption

The following types of vehicle status shall be flagged as exceptions, through the use of a different colour or other means. They shall also trigger an alert directed at the operators:

- (1) Behind schedule (by a configurable period)
- (2) Running early (by a configurable period)
- (3) Not logged in

- (4) Off-route (by a configurable distance)
- (5) Emergency/panic alarm activated

The system shall distinguish between normal and estimated time points. It shall be possible to set “running early” and “running late” thresholds for estimated time points.

Vehicles that are “in service” shall be displayed in a different colour than vehicles that are “out of service” on the CAD display. Also, vehicles deadheading back to base, “pull-out” (non-revenue trips departing base) and “pull-in” (non-revenue trips returning to base) trips shall be in different colours.

The system shall display the number of passengers aboard each bus, updated in real time as bus locations are polled.

The system shall alert operators when a bus is operating over its capacity. Capacity thresholds shall be configurable by City of Cape Town by bus type and route type. For City of Cape Town local services, standing capacity will most commonly be used. City of Cape Town may wish to use seated capacity. This data shall be archived for planning purposes.

The system shall display the average speed of the vehicle along the route.

Operators shall have an option to query a list of all bus operators currently driving a route, including at least the following information:

- (1) Operator name
- (2) Employee number
- (3) Route number
- (4) Bus number
- (5) Trip number
- (6) Time bus departed base
- (7) Time operator due back to base
- (8) Whether the operator is returning the bus to base or being relieved in the field

The system shall notify City of Cape Town Customer Service automatically of significant service disruptions, such as unusual delays, incidents, reroutes, or missed trips. The criteria to determine “significant” shall be configurable by City of Cape Town.

The CAD screens shall provide access to a line display showing the locations of all buses in service along a specified route, including:

- (1) Headways
- (2) Gapping
- (3) Schedule status
- (4) Layover time
- (5) Original route
- (6) Interlining route
- (7) Dispatch action (short-turn, added trip, etc.)

The system shall provide a service summary display that summarizes schedule adherence, gapping/bunching, headways, and status by route. Routes displayed for each operator shall be filtered to include either all routes or only those routes for which they are responsible. This service summary data shall be captured in a reportable format.

The CAD system shall provide tables displaying all current schedules by route, block, and pattern.

The CAD module/software shall link directly to the scheduling module or alternative schedule software. The integrations should be simple, easy and complete. Automatic data transfers should occur between the scheduling software/module and the CAD software/module. Automatic transfers will occur from a set file directory where only the appropriate and current schedules will be hosted. The integration between the modules should allow for:

- (1) There shall be full or partial updates of schedule information between the modules.
- (2) The CAD module shall only activate schedule transfers during periods that will not impact operations.
- (3) The Contractor shall be responsible for ensuring all data required for the CAD software/module from the scheduling software/module is properly imported and vice versa.
- (4) The Contractor shall be responsible for ensuring all necessary network configurations are in place to allow for schedule data transfers to take place.
- (5) The Contractor may provide for direct integration between the CAD software/module and the scheduling module/software.

The CAD system shall support and provide displays of operator trip and vehicle rosters/lists.

The CAD system shall provide for operator information such as name, employee number, vehicle assignment, block/trip assignment, safety record rating.

The CAD system shall allow operators to add, delete, or temporarily replace/reassign operators by vehicle and block trip. Operator assignments shall be automatically updated as operators sign-in/out of their vehicle MDT's.

The CAD system shall allow operators to view vehicle details such as vehicle type, make/model, garage assignment, route assignment, schedule adherence, block/trip, and vehicle identification (ID) number.

The CAD system shall create an incident message when a vehicle or operator reports a serious mechanical problem.

The CAD system shall provide an audible and visual alert to Dispatch, Radio Supervisor, and others using the system when an emergency alarm is activated and the CAD/AVL system shall monitor that bus continuously until otherwise specified by Dispatch.

The CAD system shall support both covert alarms and overt alarms. When receiving an alarm the CAD system shall zoom and centre the map display on the alarming vehicle at the discretion of the operator.

The CAD system shall allow covert alarms to be downgraded to overt alarms. The CAD system shall allow all alarms to be cancelled at the discretion of the operator, and all cancelled alarms shall be logged and stored in the incident log.

The CAD system shall provide an in-system response plan that will be configured by City of Cape Town and the Contractor during system development. This response plan will contain a list of steps, list of emergency contacts, and additional emergency information.

The CAD system shall be capable of indicating schedule adherence for all in-service fixed route vehicles.

Schedule adherence shall be visible to the operator via a minimum of these methods:

- (1) Colour or style of vehicle icons displayed in the map display.
- (2) List or table of vehicles noting schedule adherence.
- (3) List or route diagram noting schedule adherence by vehicle on that route.
- (4) System wide summary of schedule adherence by route.
- (5) Block list of schedule adherence in tabular format.
- (6) System wide summary of schedule adherence by trip

The CAD system shall allow the operator or dispatch supervisor to adjust the thresholds under which a vehicle is considered:

- (1) Running "hot" or early – by number of minutes
- (2) Running late – by number of minutes

The default criteria for "running late" shall be configurable in minutes behind schedule. In addition, the CAD shall provide a separate configurable "late" parameter specifically to support public transport and other needs.

Schedule adherence shall be determined on the vehicles and communicated to the central system for display on the CAD workstations.

The CAD system shall provide operators with real-time access to VWM load count data for each bus. Configurable VWM data alerts shall be provided for situations such as the following:

- (1) Bus is operating over capacity (configurable as seated or standing capacity by individual route).
- (2) Number of passengers on a bus at the time an emergency notification has been given.

The CAD system shall generate an off-route alarm for vehicles deviating from routes by a configurable distance.

The CAD system shall include functionality for adjustments to service including as a minimum:

- (1) Modifications to time points.
- (2) Cancel or add blocks/trips.
- (3) Adjust for temporary detours.
- (4) Reassign or remove vehicles from certain routes or blocks (such as may be required by a mechanical issue).

The system shall include entry and management of a series of standard dispatch and service restoration/correction functions including:

- (1) Detour – Activate predefined detours for service routes.
- (2) Ad-hoc Detour – Create short-term detours to avoid construction activity or respond to special events.
- (3) Short-Turn – Short-turn a bus to restore schedule adherence/headways.
- (4) Delete/Add a Trip – Delete or add trip to a block to adjust service levels.
- (5) Replace a Bus/Operator – Assign a replacement vehicle and/or operator to take over service from a scheduled trip that cannot continue due to a disabled bus (or any other reason).
- (6) Skip Stop – Notify an operator to bypass a series of stops to restore headways with the ability to identify the starting and stopping point for the skip stop measure.

Operators shall have the option to see a list of routes and/or vehicles that are currently affected by a detour.

All dispatch functions shall be supported by automatic messaging to trips/vehicles/operators and confirmation messages to dispatch, and shall be logged in the CAD/AVL database.

The system shall include a function that allows for the identification of supervisor and support vehicles closest to an individual bus trip selected by the operator. Once these resources are identified, the operator shall be able to assign a response to the closest available support vehicles. This will automatically forward a message to these supervisor vehicles and highlight the location of the bus in question.

A manager or other authorised personnel shall be provided with remote dispatch functionality similar to the dispatch workstations. The system shall also support expansion of this functionality to other users and City of Cape Town's Mobile Operations Centre.

Remote dispatch functionality shall include, at minimum:

- (1) Text messaging
- (2) Service summary displays
- (3) AVL map/vehicle status displays
- (4) Ability to enter and update incident reports
- (5) Ability to display incident/message queues
- (6) Performance summary information/ladder displays for tracking route performance
- (7) Transfer protection information
- (8) Access to trip card information
- (9) Ability to filter route display by assignment to a particular Road Supervisor (this feature shall not limit each supervisor's ability to monitor all buses as needed)
- (10) Access to Trip Planning Data (this may be accomplished by providing Road Supervisors with Internet access to the City of Cape Town web site)

- (11) Access to trespass information and photos
- (12) Access to Customer Service data
- (13) System wide timetables
- (14) Stop servicing display indicating schedule adherence and next bus arrival by stop.

The CAD system shall be capable of displaying timed transfer points, associated vehicles, and associated routes/trips.

The CAD system shall include the ability to alert operators when a timed transfer will be missed and a decision is needed.

The CAD system shall automatically forward an operator's request for a "hold" for a timed transfer to await arrival of another vehicle. The amount of hold time shall be configurable within the system. The CAD shall forward this hold to the appropriate vehicle at the transfer point with the approval of the operator.

The CAD system shall allow system administrators to add, modify, or cancel timed transfer holds.

The CAD system shall include functionality for the display of multiple screens from multiple dispatch workstations on a large screen or video wall display.

The CAD system shall enable operators to monitor platform hours in real-time. This data shall be captured and archived.

The CAD system shall enable operators to monitor revenue hours in real-time. This data shall be captured and archived.

The CAD system shall provide dispatch with automated information regarding the coordinates of vehicles parked at the yard. This information shall be accurately & automatically communicated to possibly the depot Yard Management software or equivalent, which will convert GPS coordinates to specific information such as parking space number.

The CAD system shall include a data interface for public transport traveller information systems including next bus arrival information signs at stops, Internet-based real-time bus arrival and display systems, and interactive voice response systems keyed to specific stops. The interface shall supply data in an XML format which shall include at a minimum:

- (1) Real-time vehicle location information (absolute or relative to stops) along with bus ID, route number, trip number, and trip number
- (2) Real-time schedule variance
- (3) PT system time
- (4) Service changes, re-routes and suspensions
- (5) Delays or disruptions noted by operators.

The Contractor shall supply an Interface Control Document describing the data and message format, content ranges the agency with details of the format and structure of this data for integration with other systems. City of Cape Town shall have full rights to release this information to third party Contractors.

The Contractor shall also supply Interface Control Documents for the following:

- (1) All proposed interfaces and integration with scheduling software and systems
- (2) Interfaces to the current PT signal priority system
- (3) All proposed or required interfaces with existing reporting and management systems.

The Contractor shall supply database structures and format documentation for the CAD system.

The CAD shall allow for routes or route variants to be designated as PT signal priority "allowed" or not "allowed" with the ability to set separate "late" thresholds by each route or route variant.

In addition to mechanical incident forms, the CAD shall support up to five other incident or event form types that shall be custom developed or configured to match City of Cape Town's operational needs.

The design of incident forms (draft and final) shall be prepared during the Preliminary and Final Design stages, and refined following initial operations based on actual experience and feedback from City of Cape Town dispatch staff.

The CAD shall include functionality to create forms either automatically through a system event or message, or by an operator by selecting a vehicle from a map, route, or block-based view.

The CAD shall include functionality to re-open forms to add additional information regarding an incident or event. Each form shall contain a time/date/user stamp to note such information related for creation and with each set of edits.

Operators shall be able to view forms based on type, time period, vehicle association, or route with a quick view list for forms that have been active for that operating day.

The scheduling and routing software must be seamlessly integrated with an industry standard GIS engine.

- (1) The City of Cape Town will provide the street network/centreline data for use in the scheduling and routing software in ArcView format.
- (2) Any conversion required of the base data set to other industry standard GIS formats, is the responsibility of the selected respondent.
- (3) The application of GIS should provide the ability to optimize routes in an expedient and regular manner.
- (4) The scheduling and routing program must have the ability to easily export data generated for use in other mapping applications.

Compliance:

- (1) The proposed system shall be a client/server application based on an ODBC or OLD-DB compliant relational database engine with the potential for import/export to a GIS system.
- (2) The client platform shall be Windows Vista, 32-bit design, incorporating a common graphical interface.
- (3) Supported protocols should include the National (USA) Transportation Communication/ITS protocol (NTCIP), and the open system (vendor independent) standard that is used for communication on the Internet, (Transmission Control Protocol/Internet Protocol, TCP/IP).

C3.10.7.3 Reports

The Database and Reporting Subsystem (DRS) shall provide data to assist in required reporting:

- (1) DRS shall store and provide information required for reporting from contract operators to City of Cape Town.

DRS shall provide predefined reports enabling City of Cape Town to compare system performance against standard industry benchmarks.

DRS shall generate reports including, but not limited to:

- (1) Stop-, trip-, variant-, and route-level passenger estimates by location, specifying timestamp, trip number, and latitude/longitude for stop-level boardings
- (2) Run times and stop- and segment-level load counts by trip
- (3) Schedule performance exceptions
- (4) Headway exceptions
- (5) Transfer coordination performance
- (6) Stops passed with no passenger activity on each trip
- (7) Missed trips, including: time of missed trip, in-service miles and hours lost, and the cause of the missed trip
- (8) Buses operating off-route in the absence of a prescribed detour
- (9) Accidents, incidents, and mechanical failures
- (10) Platform hours
- (11) Revenue hours, including in-service, loading, and layover hours
- (12) Trip-level passenger-miles, schedule recovery time, and schedule deviation (on-time performance)
- (13) Cumulative stop-to-stop and total trip-level mileage for revenue trips

DRS shall provide geographic related data that is compatible with City of Cape Town's ESRI based GIS.

DRS shall have the capability to export data at the lowest level through an Open Database Connectivity (ODBC) compliant query interface.

The parameters defining an "exception" (minutes early or late, minimum and maximum interval between buses) shall be configurable by City of Cape Town personnel each time the report is generated.

The transfer coordination performance report shall track when timed transfers are met or missed. This report shall include transfers for all City of Cape Town routes.

Off-route exception data shall include, at minimum:

- (1) Route number, route variant number and trip number.
- (2) Beginning and end date and time of the off-route condition
- (3) Route mileage missed while off-route
- (4) Bus stop locations missed while off- route
- (5) Bus Operator ID

City of Cape Town shall have the capacity to query off-route exception data by ranges of dates/times, day of week, route, route variant and trip number, bus operator, etc.

The system shall provide supervisors and operators with the capacity to prepare electronic reports of accidents, incidents, and mechanical failures.

Accident, incident, and mechanical failure data shall include at a minimum:

- (1) Route, route variant number and, trip number.
- (2) Date and time of incident
- (3) Type of incident
- (4) Bus Operator ID
- (5) Vehicle number

The DRS shall provide a means for City of Cape Town staff to develop and generate customized reports. It shall be possible for City of Cape Town staff to develop daily, weekly, monthly, quarterly, and annual customized reports. Contractor involvement shall not be required to generate new, customized reports. However, during training on reports development, the contractor shall assist City of Cape Town in the development of up to ten (10) custom reports (not duplicative of reports already provided).

The DRS shall provide a means for City of Cape Town staff to develop and generate customized database queries and exports. Contractor involvement shall not be required to generate new, customized reports and database queries and exports. These exports and queries shall provide access to all data collected by on-board systems thru DRS.

The system shall include the ability to record actual bus pull out times compared to the route's scheduled pull out time, and actual bus pull in time (at the end of the route variant and trip) compared to the route's scheduled pull in time. The system shall also document bus number, assigned route/route variant number, trip number, and bus operator name and run linked to the record of pull out and pull in times.

The CAD system shall provide report generation, analysis, viewing, file management, printing, canned reports, and ad-hoc queries.

Reporting functions shall be supported from all system workstations up to a minimum of 30 workstations.

All standard reports shall be easily accessed, viewed, and printed from workstations with reporting software by selecting the reports from a list, menu, or other standard windows method.

The CAD system shall include functionality for report generation in Microsoft Office format that allows a non-SQL (structured query language) trained PT staff person to:

- (1) Generate new reports using CAD data
- (2) Perform basic statistical analysis

- (3) Analyze report data
- (4) Develop graphs displaying information summaries from CAD
- (5) Print reports

In addition to the reports noted in the requirements of the subsections below the Contractor shall assume that they will be required to develop 15 additional standard reports from the CAD data with information and formats to be defined by City of Cape Town.

The reporting function of the CAD system shall provide operator reports (set by start/end dates) to summarize:

- (1) Operator assignments
- (2) Vehicle assignments
- (3) Block/route/route variant and trip assignments
- (4) Any incidents and incident types
- (5) On-time schedule performance

The reporting function of the CAD system shall provide vehicle reports (set by start/end dates) to summarize:

- (1) Vehicle assignment
- (2) Mechanical failures
- (3) Block/run/route/route variant/trip assignments
- (4) Any incidents and incident types

The reporting function of the CAD system shall provide performance reports that summarize on-time performance by:

- (1) Block, route, route variant and trip.
- (2) Operator
- (3) Geographic sub area
- (4) Time of day, day of week, month of year, service or calendar day, and schedule day time (e.g. weekday, Saturday, Sunday, holiday)
- (5) Stop, depot, or other specific locations, including time points not located at stops or PT centres

The reporting function of the CAD system shall provide reports on all historic emergencies and text messages developed in the CAD system.

The reporting function for radio and text messages shall summarize and display all fields for all incidents within a selected time period.

The reporting function for radio and text messages shall allow separate views and summaries for reports by message types (including emergency calls) noting the start time, end time, and resolution.

The reporting function of radio and text messages shall indicate time from initiation of the message by a operator to the response to that message by the operator – separated by operator.

The reporting function of the CAD system shall include diagnostic reports on system performance for each server and application process comprising the CAD system.

The reporting function of the CAD system shall log and summarize system faults by type, time of day, and duration.

The reporting function of the CAD system shall log and summarize communications activities and interruptions between the CAD system and the vehicles.

The system shall provide the ability for operators, supervisors, and managers to “replay” stored CAD/AVL data. Replay shall include selection and replay of multiple vehicles simultaneously and shall provide all status, incident reports, and location data associated with the vehicles for the replay period.

The system shall record a minimum of 90 days of stop level detailed vehicle location and schedule performance data for queries, analysis, and replay of recorded AVL data to investigate complaints or reported incidents. Recorded data must include the route, route variant, trip number, time, date, calendar and service day, bus ID, operator name, bus number,

arrival and departure times, miles travelled, any deviations from normal routing, the speed of the bus, and passenger load count data. Data shall be archived no earlier than 90 days.

The system shall record the pull-out and pull-in times, and the deviation from the scheduled times, of all trips departing or arriving at bases and layover points.

The system shall be capable of storing at least five years of archived summary and reporting data on route and system performance. The archived data shall be stored in an ODBC compliant database. Required summary data include:

- (1) Bus number
- (2) Operator ID
- (3) Operator name
- (4) Arrival and departure info at the start and end of each trip
- (5) Total passenger load count and peak loading for each trip
- (6) Pull-out and pull-in time at the depot
- (7) Number of miles travelled (disaggregated by in-service, deadhead, pull-in, and pull-out miles)
- (8) Route and Trip

The DRS shall provide functionality for the prescheduled “running” and conversion (to HTML format) of selected reports provided thru the CAD.

The DRS shall provide functionality for the email distribution of selected reports in HTML format to a predefined email list of City of Cape Town staff.

C3.10.7.4 Traveller Information Website

The Traveller Information System shall include an interactive web site for fixed-route services.

The design and development of the web site shall be coordinated with City of Cape Town marketing and customer service representatives, and shall have a consistent look and feel with other City of Cape Town web sites.

The web site shall be designed to be “windowed” in an existing City of Cape Town web site, or linked to as a separate series of pages from an external web site.

The web site shall include the capability to display a system map showing bus routes and the real-time locations of buses along these routes.

The web site shall be fully compliant with open standards for compatibility and accessibility. The web site shall be accessible to persons with disabilities.

The web site shall have the capacity to display the expected arrival time, based on real-time AVL data, of the next two buses on each route, at any published time point and at any stop along a route.

- (1) This feature shall be accessible to XHTML (eXtensible HyperText Markup Language)-based mobile web browsing devices (such as wireless phones and PDAs) in addition to desktop and laptop computers.
- (2) This feature shall be accessible via a simple URL (Uniform Resource Locator, for example, tracker.commtrans.org).
- (3) Customers who have the Stop ID number available shall be able to look up bus arrival times using a single step.

A prototype or mockup of the web site shall be provided at final design review. The Contractor should anticipate multiple iterations of changes (minimum four iterations) to the look and feel of the website both before and after it goes live.

C3.10.7.5 Digital Video Management System (DVMS)

The DVMS system shall display real-time video images to all operators.

The system shall provide operator control of PTZ drives and camera selection, as well as automated sequences and alarm responses.

The Network Video Recording System (NVRS) shall be a distributed recording network with the individual Network Video Recorders (NVR's) situated throughout the IRT routes at selected stations.

The NVRS shall provide continuous, time scheduled and alarm recording of all cameras connected to the network and fast and easy to use video retrieval.

The NVRS shall support video analytics located either locally or remotely on the cameras or video encoders.

H.264 video encoding will be preferred above MPEG 4 and the NVRS should be compatible with both types of video streams.

A further requirement is for the provision of real-time video feeds to other EMS and enforcement centres or agencies.

The newly installed NVR's shall be configured and setup to include setup of zones, alarms, alarm recording and any other parameters that may benefit the client. Such parameters may still be identified during the contract.

The DVMS and NVRS shall be fully configured for all cameras supplied under this contract. Configuration shall include but not be limited to:

1. Presets and tours for PTZ cameras
2. Camera and preset captions/titles
3. Continuous and alarm recording per camera
4. Alarms for all network I/O inputs listed in this specification and video analytics alarms.
5. Alarm responses to all alarms including alarm message/log, display switching and recording start
6. Display combinations and views
7. Display sequences
8. Windows and antivirus software

Video storage of all cameras shall be for at least 3 days.

C3.10.7.6 Communications and Ethernet Network Equipment

The primary communication medium from the Control Centre to the stations and depots shall be via a redundant fibre optic network.

The secondary communications medium shall be via an ADSL line (See section C3.15.4).

The contractor will be required to provide an ADSL line in the TMC unless otherwise specified by the CoCT.

The following minimum requirements shall be met for ADSL:

- At least 4 Mb/s
- Firewall
- Virtual Private Network (VPN)

The connections to be provided by the ethernet network system shall include but not be limited to:

- a. Multiple Mpeg 4/H.264 video streams and Jpeg images from cameras/encoders
- b. Variable Message Signage
- c. Voice over IP communication
- d. Traffic Monitoring and Logging Equipment
- e. Other data producing field devices

The network shall support common IP protocols such as UDP/IP, TCP/IP. As a minimum the following requirements must be met for the network switch design in the TMC:

- Layer 3 routing switches
- Switch redundancy
- Redundant power supplies
- Provision for edge and core routing
- Distributed switches

Provision must be made for connecting the switching infrastructure in the TMC to the fibre optic backbone entering the TMC. This includes all media modules, splicing, pigtailed and all other sundry material for a complete installation

Full configuration of the network switches must be done by the contractor. This includes the allocation of IP addresses and VLAN's as required for a fully working IRT network.

The physical installation shall be neat and with cable guides.

C3.10.8 Performance Requirements

The system shall be designed for continuous operation without the need to manually "reboot" computers or devices. Scheduled automated reboots are acceptable, provided that such reboots shall not be required more than once in a 24 hour period.

System availability shall be 97% or better. For central systems, availability shall be determined by dividing total out-of-service time by total operating time. Out of service time shall include system maintenance that occurs outside of the normal maintenance window.

The central system and all CAD/AVL subsystems shall automatically recognize any stoppage, failure, or lock-up of a system process and automatically log the problem, attempt a restart, and notify dispatch.

Emergency Alarms/intruder detection alarm/etc should be detected within 2 second and streaming video of the affected area must be immediately available.

Video storage of all cameras shall be for at least 3 days.

C3.11 DETAILED SPECIFICATION: SMART TRUNK STATIONS

C3.11.1 Requirements

The tenderer will be required to provide a complete and operational system. The trunk stations are located along the major trunk routes and are all closed stations of varying widths and lengths. The tenderer must ensure that all the systems in the trunk stations are integrated and that the systems are integrated with that in the control centre. The following high-level requirements must be met:

- Ticket Sales will be available at the stations in kiosks or vending machines, both to be provided by others.
- The entrances will be controlled by ticket validators (by others)
- Exits controlled by ticket validators (by others)
- On-station server PC and required software
- IP based CCTV cameras must be installed inside the station
- The cameras must be tamper proof with the necessary alarms and video analytics
- Network Video Recorder (NVR) located at some trunk stations
- All video feeds to be streaming video to control centre
- The ticket kiosk must be provided with one video monitor to display video feed from cameras
- Dynamic electronic arrival times displayed on a LCD/LED VMS with audio alarm to announce bus arrival. The City wished to receive proposals on the options and prices of the VMS's.
- PA system to allow communication with passengers if required (by others)
- Emergency and information intercom to be provided per station platform
- An IP intercom must be provided in the kiosk for the operator
- Infotainment LCD Screen and infotainment server (if infotainment is not managed remotely from TMC) to be provided (Optional).
- High bandwidth communication links to control centre via fibre where available, WLAN or GPRS/3G
- Layer 2 network switch in the kiosk server space to connect to the fibre optic backbone and also the additional robust switches on every platform
- Network switch in the kiosk server space to connect to the fibre optic backbone and the additional switches on every platform
- Intruder detection system linked to control centre
- TETRA handsets provided for the station surveillance personnel
- A 19" server rack to be installed in the server area of the kiosk

All equipment installed at stops/terminals shall operate from a nominal line voltage of 220 VAC, within voltage tolerances of +10% to -20%, and a frequency range of 47 Hz to 53 Hz without equipment damage.

Electrical supply will be provided by the client centrally in each station. Further electrical supply point will be distributed throughout the station platform. The contractor must liaise with the client to ensure the provision of electrical supply points where required.

All outdoor equipment shall be designed for and suitably protected against exposure conditions prevalent in the City of Cape Town.

Enclosures shall include any provisions necessary to maintain the internal equipment at the manufacturer's specified temperature and humidity.

Enclosures shall be designed to prevent entry of moisture during a driving rainstorm and to minimize entry of dust. The Contractor shall indicate if housings that do not meet these requirements, and shall identify any alternative provisions incorporated to protect against moisture and dust, as well as requirements for installation.

The Traveller Information System shall include Smart Bus Stops (SBS) located at all trunk stations.

SBS components shall include all components necessary to provide a fully functional system, including at a minimum:

- (1) On-station server PC to service the CCTV monitor in the kiosk and control other trunk station devices as required by the contractor's design
- (2) Layer 2 network switch in the kiosk server space to connect to the fibre optic backbone and also the additional robust switches on every platform
- (3) Variable message signs (VMS) to display bus arrival and other information.
- (4) A speaker and tone generator, built into the variable message sign to provide an alert to passengers waiting at the stop that a bus will be arriving soon.
- (5) Wireless data communications modems as backup communication medium with the central system.
- (6) All electrical power supplies, cabinets, server rack, conduit, mounting hardware, mounting brackets, etc. required for installation and operation.
- (7) IP CCTV Cameras, NVR, tamper proof cameras with alarms to Control Center
- (8) Infrared intruder detection alarms wired to IP I/O device with communication to Control Centre
- (9) LCD/LED Monitors (at least 4 per station) for displaying of passenger information and infotainment.
- (10) Infotainment server if the infotainment displays are not managed from the TMC (Optional)
- (11) Emergency and Information intercom on each station platform for passengers
- (12) Intercom in kiosk for communication with the TMC
- (13) LCD monitor in ticket kiosk with live feed of all CCTV cameras.
- (14) TETRA handsets for the station surveillance personnel

The VMS shall include functionality to display pre-set messages and/or real-time dynamic information including next bus arrivals to PT users.

The VMS shall be of a standard size and look at each stop, with the number of lines varying depending on the application.

The VMS shall have the following technical features:

- (1) Capability to display messages composed of any combination of alphanumeric character fonts, punctuation symbols and full graphics
- (2) Inclusion of clock functionality
- (3) Clearly legible under full range of ambient illumination conditions at full intensity from any viewing distance within 1 meter to 25 meters.
- (4) Adequate line length (or size and font size) to indicate service (ST or CT), route, and predicted arrival time for a single bus on a single line of the sign.

SBS components shall be designed to resist outdoor weather and vandalism.

It is envisioned that the main network switch in the kiosk server space will connect to the fibre optic backbone and also to the additional switches located on the different platforms of the station. The network link between the main switch in the kiosk and the secondary switches on the platforms will either be via multi mode fibre optic or CAT5E/6 cabling. This will be determined during the design phase and is subject to approval by the engineer.

The supplied network switches shall be sufficiently robust for the operating conditions in the station platforms. Layer 2 switches will be used with enough ports for all the IP devices required in the stations. The contractor will also make available three (3) additional ports per station to be used by others. There will be sufficient open ports for later expansions and upgrades of the stations.

Full configuration of the network switches must be done by the contractor. This includes the allocation of IP addresses and VLAN's as required for a fully working IRT network.

A Digital Video Surveillance System (DVSS) shall provide the operators in the trunk station kiosk and Control Centre with the means to survey the entire trunk station. Fixed IP cameras shall be used, but this is still dependent on the final design of the contractor during the design phase. Footage of the inside of the station kiosk shall be provided.

The cameras on the stations shall comply with the following requirements. These requirements are subject to approval during the final design stage.

- Fixed Varifocal lenses
- Day/Night Wide Dynamic Range (DNR)
- Mini dome enclosure
- Rugged, high-impact, vandal resistant and puncture proof domes
- IP based with POE
- Onboard video analytics

Recording of the footage shall be at selected trunk stations and management of the footage shall be at the TMC. Network Video Recorders (NVR's) shall be used in a distributed recording network design. The number of stations catered for by each NVR and the number of channels per NVR shall be determined during the design phase.

The NVR shall have at least 32 recording channels, a RAID 5 storage configuration and preferably support H.264 video streams.

Combined emergency and information IP intercoms shall be installed per platform. The intercom will have 2 buttons, one for emergencies and one for information. The intercom will connect the passenger directly to the Control Centre by the push of one button. The call will be routed to a call servicing desk in the TMC.

Inside the kiosk there will also be an IP intercom for communication between the kiosk operator and the TMC.

There will be an infrared intruder detection system covering all of the station. The groupings of infrared detectors at each station platform will be wired to an IP based I/O device located on each platform. These IP devices on the different platforms will be linked together to the network switch located in the kiosk server room. It will be the responsibility of the contractor to design a fully working intruder detection system for all the different station types during the design period.

The VMS shall receive as input from the central system on an as-required basis:

- (1) System management commands (e.g. system status requests, etc.)
- (2) Static display information (e.g. hours of operation, bus routes, schedule, etc.)
- (3) Real-time display information (e.g. schedule, next bus, etc.)
- (4) Ad hoc information (e.g. time clock or advertisements, etc.).

The SBS shall have the capacity to display freeform alert messages entered by operators (or, potentially, automatically generated by the Central System) to advise riders of service disruptions or reroutes. Such messages shall alternate or otherwise be displayed in concert with predicted arrival times, and shall not pre-empt the arrival time display unless there has been a complete disruption in service to the SBS location.

The system shall have capacity to store static messages in the VMS controller.

The sign controller shall allow a laptop computer to be connected locally through a dedicated external serial or similar communication method.

The SBS shall be able to display the predicted times of the next bus on each route serving the stop based on information transmitted from the central system.

When the bus arrival is within a designated number of minutes (to be a configurable parameter), the SBS shall emit a tone or chime indicating that arrival is imminent.

The volume of the tone shall be settable on a stop-by-stop basis through configuration data transmitted from the central system, with a minimum volume of zero or "off".

At a minimum, day and night settings for tone volume shall be included in the configuration data and the change shall occur automatically based on time of day.

Clock functionality shall be synchronized to the central system time, and shall be updated on a daily basis (minimum). Between update cycles, the clock shall have a cumulative drift of no more than 10 seconds.

City of Cape Town is interested in the ability of the SBS to display the predicted times of the next two buses on each route serving the stop. The Contractor shall indicate if this capability can be provided.

The SBS shall support up to four line electronic message signs.

Static information or a clock display shall be shown if communication link is lost.

The DVSS shall be networked IP based CCTV system and it is preferred that the video streams from the cameras will be in H.264 format.

Video analytics capabilities is required for incident detection

The video analytics shall provide alarms based on the following:

- Crowd congestion monitoring
- Loitering
- Unattended luggage
- Human presence
- Emergency phone activation
- Each of the functions shall be configurable for multiple zones per camera

One of the following communication options shall be implemented to connect the trunk station to the central system:

- Connecting to the fibre optic backbone and using GSM: GPRS,EDGE and UMTS: 3G, HSPDA and HSUPA as backup communication medium.
- Connecting to the fibre optic network of another commercial fibre optic provider and using GSM: GPRS,EDGE and UMTS: 3G, HSPDA and HSUPA as backup communication medium.
- Using a wireless point to point link to connect to a point on the fibre optic backbone and using GSM: GPRS,EDGE and UMTS: 3G, HSPDA and HSUPA as backup communication medium.
- Using only GSM: GPRS,EDGE and UMTS: 3G, HSPDA and HSUPA as communication medium.

It is envisioned that every trunk station will be connected to the fibre optic backbone, but if there is no possibility of connecting to the fibre optic backbone, a wireless link to the network will be required.

The Contractor shall be responsible for providing the wireless communications infrastructure if required. The Contractor shall describe the proposed communications methodology and costs (capital and operating).

The physical installation shall be neat and with cable guides.

Bus arrival times shall countdown in one (1) minute increments.

All cameras shall always provide streaming images to the TMC and station kiosk at a reduced frame rate and resolution. However when an incident triggers an alarm cameras shall stream video footage at maximum frame rate and resolution, which as a minimum shall be 25 frames per second and CIF resolution. During the alarm state, recording shall also be at the increased frame rate and resolution. Alarm recording shall continue for a configurable time period after which it shall revert back to the lower frame rate and resolution.

Cameras shall cover the entire station area including:

- All station doors
- The inside of the kiosk
- All turnstiles

C3.12 DETAILED SPECIFICATION: SMART FEEDER STATIONS

C3.12.1 Requirements

The tenderer will be required to provide a complete and operational system. The feeder stations are located throughout the neighbourhoods and not on the major bus routes. There will be different types of feeders stations/stops and they will vary from a typical bus stop to a larger open structure and even closed structures. The tenderer must ensure that all the systems in or at the feeder stations are integrated and that the systems are integrated with that in the control centre.

The following high-level requirements must be met for the open structure feeder stops:

- CCTV coverage of feeder stops
- CCTV Video feed: video streamed to control centre on demand
- Encoder with SD/SDHC memory card or equivalent to be used with CCTV camera as local recording medium.
- Integrated emergency and information intercom at selected stops
- Where possible dynamic VMS should be provided, these must be tamper and vandal proof
- At the open structure stops, VMS and CCTV requirements will be built into a single, vandal and tamper proof box

The requirements for the closed structure feeder stations are the same as for the Smart Trunk Stations as shown in section C3.1

C3.12.2 Open Structure Feeder Stop

All equipment installed at stops shall operate from a nominal line voltage of 220 VAC, within voltage tolerances of +10% to –20%, and a frequency range of 47 Hz to 53 Hz without equipment damage.

All outdoor equipment shall be designed for and suitably protected against exposure conditions prevalent in the City of Cape Town.

Enclosures shall include any provisions necessary to maintain the internal equipment at the manufacturer's specified temperature and humidity.

The dimensions for the enclosure will be 1250mm wide x 240mm high x 150mm deep. The enclosure with the single or double sided VMS will be fabricated to fit within the above stated dimensions. Refer to Figure 10 and Figure 11 of Part C4 of Volume 2B.

Enclosures shall be designed to prevent entry of moisture during a driving rainstorm and to minimize entry of dust. The Contractor shall indicate if housings that do not meet these requirements, and shall identify any alternative provisions incorporated to protect against moisture and dust, as well as requirements for installation.

Open structure feeder stops shall be equipped with a small camera and encoder with SD/SDHC memory card or equivalent as local recoding medium. Video footage will be streamed to the control centre on request or when the emergency intercom is activated. Video footage will be continually recorded on the local SD/SDHC memory card for later retrieval if required. The SD/SDHC memory card will have sufficient capacity to store at least 24 hours of video footage. Recording of video footage will also occur at the control centre if required.

An integrated emergency and information IP intercom shall also be installed and it will provide a direct connection to the control centre. The IP intercom will be installed into the structure of the feeder stop and be rated as vandal and tamper proof.

The open structure feeder stations will also include a dynamic display sign (VMS) providing the time of arrival of the next bus and also the current time.

The VMS will employ ultra bright amber text utilising high-performance wide-angle LED's, with a vandal-resistant screen. The entire surface of the VMS will be evenly illuminated with a minimum viewing angle of 110 degrees.

The VMS, CCTV camera and 2G/3G communication device will be housed in a vandal and tamper proof enclosure to be built into the structure of the feeder stop. The integrated emergency and information IP intercom will be installed separately into the structure of the feeder stop.

The enclosure will be rated as IP65 and the fasteners and screws in or on the enclosure shall be stainless steel. The material and the appearance of the enclosure will be the same as that of the open structure feeder stop to ensure an appealing integration with the existing structure.

A prototype of the enclosure will be fabricated for approval by the CoCT. Full production of the enclosure will only commence after approval from the CoCT.

Communications may be with either last mile fibre optic to the closest trunk station, WLAN or 2G/3G

The 2G/3G Communications system shall have an interface that supports common IP protocols such as UDP/IP and TCP/IP.

The Mobile Wireless Router (MWR) to be supplied shall be a cellular access platform designed to transport mixed generation Radio Access Network (RAN) traffic. This includes GSM: GPRS,EDGE and UMTS: 3G, HSPDA and HSUPA.

Where wireless last mile links are used for last mile connection to the backbone (e.g. bus depot(s) or trunk stations) a point-to-multipoint wireless network base station (BS) or access unit (AU) shall be installed at each of the base station sites (BS). The point-to-multipoint BS/AU equipment shall meet or exceed the specification as described in Section C3.15.

Wireless subscriber units shall be installed at camera sites where last mile fibre optic is not possible and shall meet or exceed the minimum specifications given in Section C3.15.

All WLAN units shall be fully configured with the agreed IP addresses. Installation shall include but not be limited to configuration of:

- Quality of Service (QoS)
- Latency
- Modulation
- Security
- Transmit Power
- Channel assignment
- Antenna alignment for optimum power transfer

C3.13 DETAILED SPECIFICATION: BUS DEPOTS

C3.13.1 Requirements

The tenderer will be required to provide a complete and operational system. Bus depots are located at strategic locations based on access to the transport corridors, relative location to the communications network and available space, Bus depots will serve as the storage facility for buses not in operation and incoming buses will go through a docking procedure. The docking procedure involves the transfer of stored video and data onto the communications network by a broadband wireless connection. The video and data is then transferred and stored at the control centre.

The tenderer must ensure that all the systems in or at the depots are integrated with that in the control centre. In addition the following high-level requirements must be met:

- CCTV coverage of bus depots.
- CCTV Video feed: streaming video to control centre
- Infotainment will be uploaded via the WLAN to the vehicles on-board media server
- Network Video Recorder (NVR) for local recording of CCTV footage
- Alarm monitoring of CCTV and security fencing.
- Broadband Wireless LAN (WLAN) access points (AP's) for on demand transfer of video and data from buses.
- APTMS server
- Scheduling server/link to control centre.

All equipment installed at depots shall operate from a nominal line voltage of 220 VAC, within voltage tolerances of +10% to -20%, and a frequency range of 47 Hz to 53 Hz without equipment damage.

All outdoor equipment shall be designed for and suitably protected against exposure conditions prevalent in the City of Cape Town.

Enclosures shall include any provisions necessary to maintain the internal equipment at the manufacturer's specified temperature and humidity.

Enclosures shall be designed to prevent entry of moisture during a driving rainstorm and to minimize entry of dust. The tenderer shall indicate it housings that do not meet these requirements, and shall identify any alternative provisions incorporated to protect against moisture and dust, as well as requirements for installation.

Depots shall be equipped with tamper proof, IP, CCTV cameras at each site to provide coverage of the whole site. Footage shall be recorded at the Control Centre.

An emergency IP telephone shall also be installed and it will provide a direct connection to the control centre.

A WLAN access point shall also be installed for transfer of video and data from the bus onto the communications network.

An ADSL modem may also be required if there is no fibre link to the TMC.

Operation of the CCTV may be in severe wind and rain conditions.

Video analytics capabilities is required for incident detection

The video analytics shall provide the following functionality:

- Loitering
- Human presence

Each of the functions shall be configurable for multiple zones per camera.

Where wireless last mile links are used for last mile connection to the backbone (e.g. bus depot(s) or trunk stations) a point-to-multipoint wireless network base station (BS) or access unit (AU) shall be installed at each of the base station sites (BS). The point-to-multipoint BS/AU equipment shall meet or exceed the specification as described in section C3.15.

Wireless subscriber units shall be installed at camera sites where last mile fibre optic is not possible and shall meet or exceed the minimum specifications given in section C3.15:

The Contractor shall provide fixed wireless LAN access points at the following facilities:

- (1) DEPOT 1: Du Noon
- (2) DEPOT 2: CBD

The wireless LAN access points shall be based on 802.11g technology, and shall be compatible with the wireless LAN cards on the buses.

A sufficient number of wireless LAN access points shall be provided to provide a minimum 10Mbps coverage throughout all bus parking areas and driveways. The Contractor shall be responsible for conducting wireless site surveys to confirm the number of access points required, and shall assume for the purpose of the tender that two access points will be required at each site.

The Contractor shall be responsible for locating, installing and configuring the wireless LAN access points to provide required coverage and minimize interference. Channel selection shall be coordinated with the existing wireless LAN access points installed at City of Cape Town facilities.

All WLAN units shall be fully configured with the agreed IP addresses. Installation shall include but not be limited to configuration of:

- Quality of Service (QoS)
- Latency
- Modulation
- Security
- Transmit Power
- Channel assignment
- Antenna alignment for optimum power transfer

The complete docking procedure for buses shall not exceed 10 minutes from the time of arrival in the depot.

Recorded on-board CCTV footage will only be transferred from the vehicle via the WLAN to the TMC on request.

C3.14 DETAILED SPECIFICATION: STATION - NETWORK DESIGN

C3.14.1 Requirements

A fibre optic backbone shall connect all trunk bus stations in a logic network-ring layout, providing redundant communications to the other stations in the network-ring, should communications to any one of the stations fail. Inside the stations a combination of multimode fibre and CAT 5E/6 copper cable shall supply last mile communications to all devices installed inside the station on the different station platforms (inter alia, CCTV cameras, LCD display screens, IP intercoms and burglar alarms). Managed Ethernet network switches shall connect the devices to the fibre optic backbone. If subcontractors are used for the execution of the fibre optics or network works, the main contractor shall be responsible for coordination of all activities of the subcontractor to ensure that this work is done in accordance with specifications and programme dates. The general physical station layout is illustrated in the drawings attached to this volume.

The hardware shall consist of the following equipment:

- 19" Server cabinet to be installed in station kiosk
- Gigabit backbone network switches to be installed in server cabinet
- Managed Fast Ethernet network switches to be installed with equipment
- Splice trays, dome joints, pigtails, midcouplers, patch leads
- Multimode fibre optic cable
- CAT5E/6 network cable

All stations and related equipment shall be installed on the same fibre optic Ethernet network and shall be setup with relevant IP addresses and VLAN configurations. The VLAN configuration shall be as follows:

VLAN 1: Management

VLAN 2: Voice

VLAN 3: Video

VLAN 4: Future Video

VLAN 5: Future Data

VLAN 6 – 8: Spare

All ports shall be locked-down and activated only for the MAC addresses of the connected devices. The network switches shall be securely mounted in equipment enclosures; power supplies connected and patch cables installed. The installation shall include the supply and installation of all power supplies, cables connectors, bonding conductors, mounting brackets and other sundry installation material.

The kiosk network switches shall be modular Gigabit Industrial Ethernet switches complete with backplane and dual power supplies. The switches shall have modular slots for at least 7 media modules. All stations and related equipment shall have continuous and reliable communications to the TMC.

The connections to be provided by the Ethernet network system shall include but not be limited to:

- Multiple H.264 or MPEG4 video streams and Jpeg images from cameras and/or encoders
- Voice data from IP intercoms and phones
- Management data to installed devices
- Data to be displayed on information screens
- Other data producing field devices

The network shall support common IP protocols such as UDP/IP and TCP/IP.

C3.15 DETAILED SPECIFICATIONS: COMMUNICATION

C3.15.1 High Level Requirements

The communications requirements specified in this section are relevant to all the different components of the system, e.g. trunk stations, feeder stations and depots as specified in those sections. The different communications systems are described below, but in general the standard requirement is to establish fast, secure and reliable communications between components of the system.

C3.15.2 Wireless Local Area Network (WLAN) Communications

Where wireless last mile links are used for last mile connection to the backbone (e.g. bus depot(s) or remote stations) a point-to-multipoint wireless network base station or access unit (AU) shall be installed at each of the base station sites (BS). The point-to-multipoint AU equipment shall meet or exceed the following specification:

Radio Technology	
RF Band	5.470 – 5.725 GHz and 5.725 – 5.850 GHz
Channel Size	<= 20 MHz
Transmit Power Control	Adaptive
Encoding Method	OFDM
Antenna	Directional 12°
Aggregate Capacity	36 Mbps
Ethernet	
Protocol	Ethernet IEEE 802.11
Primary Interface	10/100 Base T/F auto sensing/auto polarity
Security & Management	
Security	Scrambling, WOP and Encryption
Status Indicators	LED's for Power, Link, Ethernet
System Management	SNMP, HTTP, external alarm input
Physical and Environmental	
Format	Discrete with external antenna
Lightning Protection	Integrated lightning/surge arrestors
Operating Temperatures	-20°C to +60°C

Wireless subscriber units shall be installed at bus depots or stations if it is not linked by last mile fibre optic connection. The subscriber units shall meet or exceed the following minimum specification:

Radio Technology	
RF Band	5.470 – 5.725 GHz and 5.725 – 5.850 GHz
Channel Size	<= 20 MHz
Transmit Power Control	Adaptive
Encoding Method	OFDM
Antenna	Directional 12°
Aggregate Capacity	>=3 Mbps
Ethernet	
Protocol	Ethernet IEEE 802.11
Primary Interface	10/100 Base T/F auto sensing/auto polarity
Security & Management	
Security	Scrambling, WOP and Encryption
Status Indicators	LED's for Power, Link, Ethernet

System Management	SNMP,HTTP, external alarm input
Physical and Environmental	
Format	Integrated antenna
Lightning Protection	Integrated lightning/surge arrestors
Operating Temperatures	-20°C to +60°C

C3.15.3 2G/3G COMMUNICATIONS

The connections to be provided by the 2G/3G Wireless Communications system shall include but not be limited to:

- Motion JPEG images and H.264 or MPEG4 low frame rate, streaming video bursts from cameras and/or encoders.
- Voice data from IP intercoms and phones
- Management data to installed devices
- Data to be displayed on information screens
- Other data producing field devices

The 2G/3G Communications system shall have an interface that supports common IP protocols such as UDP/IP and TCP/IP.

The Mobile Wireless Router (MWR) to be supplied shall be a cellular access platform designed to transport mixed generation Radio Access Network (RAN) traffic. This includes GSM: GPRS,EDGE and UMTS: 3G, HSPDA and HSUPA.

The routers on the buses and at the bus stations shall have the following minimum specifications.

Quantity	Mobile Wireless Router (MWR) Minimum Specifications
1	Ethernet Port
1	RS232 Port
2	SIM slots
1	2dBi Dual Band Antenna GSM 900 and GSM 1800:
1	10 to 30V power connection
	DIN Rail mounted
	Power and communications status LED's
	Built in VPN client and firewall
	Supports SNMP
	Layer 3 Routing
	DHCP Server/Client
	NTP time server
	Firmware upgradeable via FTP or serial
	ICASA Certified
	Password protected
	Multiple simultaneous connections
	Real Time Clock (RTC)
	IP Masquerading (NAT)
	Device management via a web interface

The required data transfer per router shall be determined by cost, the equipment it supports and by available RAN services. Upon award of the contract, the contractor shall do a design to determine the requirements for the router(s) inside the TMC. The basic requirements for this router(s) shall be to provide a secure interface, sufficient bandwidth to download images and all field data simultaneously and to connect to the Ethernet network inside the TMC and it must be possible to fully integrate this system into the existing network.

The design for the TMC router(s) shall take the above into account and be submitted for approval by the Engineer and after approval and signature by the Engineer the contractor shall order the router(s) and other equipment required for the installation. The Engineer may also request a redesign until he is satisfied that the minimum requirements are met.

Although 3G coverage of most of the route is expected, this service cannot be guaranteed at every site and along every bus route. At some sites/routes only GPRS coverage may be available. All different mobile service providers shall be considered for this solution. However, one network service provider shall be used for the complete installation as the primary communications.

Before installation of devices that communicate by MWR the contractor shall submit a report per site per service provider including inter alia; RAN services available, bit rate up and download speeds and consistency of connection.

C3.15.4 ADSL

An ADSL fixed line shall be installed at the TMC to connect this centre via a VPN to the Wireless routers on the vehicles and stations if so required.

At the time of installation the contractor shall negotiate with the service provider to provide the best router to meet the following minimum specifications:

- At least 4 Mb/s
- Firewall
- Virtual Private Network (VPN)

The contractor is to ensure that the available bandwidth on the installed line is sufficient to enable reliable and fast connections to the field devices. The bonding of two or more ADSL lines should be considered if the currently maximum available transfer speed of 4Mb/s is not sufficient.

C3.15.5 Fibre Optic Links

The contractor will be required to install multimode fibre between the platforms on larger stations. The installation of the fibre will be into pre installed sleeves or ducts either by blowing or installing Corrugated Steel Tape Armour (CST) cable. The fibre design is to be done by the contractor during the design period and is subject to approval by the engineer and the CoCT.

The fibres shall comply with the following Optical Characteristics:

Attenuation	1310 nm	≤ 0.50 dB/km
	1550 nm	≤ 0.25 dB/km
	1290 nm – 1330 nm	≤ 3.0 ps/(nm.km)
	1525 nm– 1575 nm	18.0 ps/(nm.km)
Chronic Dispersion	Zero Dispersion Wavelength	$1300\text{nm} \leq \lambda_0 \leq 1322$ nm
	Slope	≤ 0.092 ps/nm ² .km
Polarisation Mode Dispersion (PMD)		≤ 0.20 ps/ $\sqrt{\text{km}}$
Cut Off Wavelength (Fibre)		$1150\text{nm} \leq \lambda_{\text{cf}} \leq 1330\text{nm}$
Cut Off Wavelength (Cable)		$\lambda_{\text{cc}} \leq 1250\text{nm}$
Index of Refraction @ 1550nm (IOR)		1.4681

The contractor shall provide samples of all tubes, breakouts, connectors and cables for approval prior to placing of orders. The cables shall be spliced to pigtails installed in patching trays at each of these locations (to allow easy patching-in of alternative links in the event of fibre failure), or through spliced (to limit attenuation) in accordance with the splicing and patching plan to be provided by the Engineer. Where splicing is done, pigtails shall be fitted with the following types of connectors:

- Single mode fibres: LSH APC 8°
- Multimode fibres: ST or SC

C3.15.6 Tetra Radio Services

C3.15.6.1 Functional Requirements

The tenderer will ensure that devices integrate onto the City's TETRA network functions according to this specification on the existing Motorola Dimetra - IP, version 6.1 and 6.2 infrastructure.

The tenderer will ensure that developed interfaces to the current City's TETRA database switch, connected to the TETRA infrastructure, functions according to the TETRA specifications.

The City has existing approved tenders for the provision of TETRA radio subscribers and data devices which shall be utilized.

The TETRA radio communication devices shall be used for all radio voice communication requirements.

The TETRA data communication devices shall be utilized wherever possible and the narrow data bandwidths available allow the effective use of the TETRA network.

Tenderers shall be responsible to ensure that the overall functionality shall be at least that as specified in the tenders for TETRA subscribers and data devices.

Tenderers shall be responsible to ensure that the end to end reliability of the data services shall be at least that as specified in the TETRA data tender.

The radio units offered are required to operate on a Motorola Dimetra - P ETSI TETRA infrastructure version 6.1 or higher.

All the equipment offered shall interface into the existing TETRA database switch installed on the radio trunking network with the interface specifications as per **Annexure A**.

Except where otherwise specified or implied, the following standards shall apply:

- Wherever relevant, even if not directly requested within this tender, all radio equipment must comply to all applicable ETSI specifications for ETSI TETRA subscriber equipment including ETS 300 392, ETS 300 394, ETS 300 395, ETS 300 396.
- The data equipment offered shall fully integrate to the existing Data Server and shall comply to the specifications as per Annexure C.
- Wherever relevant, even if not directly requested within this tender, all equipment must comply to all applicable ETSI specifications for ETSI GSM, including ETSI TS 100 559, 100 585, 101 344, 101 348, 101 356, GSM 03 04, GSM 07 07
- All equipment and accessories shall for safety aspects be compliant with EN 60950.

C3.15.6.2 Hardware Requirements

TETRA radio subscribers. Radio subscribers shall be purchased of the existing approved City of Cape Town tender number 160G/2008/2009, awarded to Alcom-Matomo. All the costs for these devices shall be included in the tender.

TETRA On Board Computers (OBC's). Data devices shall be purchased of the existing approved City of Cape Town tender number 159G/2008/2008 awarded to Alcom-Matomo. All the costs for these devices shall be included in the tender.

C3.16 DETAIL SPECIFICATION: MAINTENANCE

C3.16.1 DEFINITIONS AND CONCEPTS OF MAINTENANCE

All maintenance on the system shall be based on the definitions and methodologies provided in this section.

C3.16.1.1 Acronyms

- CBP: Current Best Practice
- CCTV: Closed Circuit Television
- ECCM: Essential Care and Condition Monitoring
- PM: Preventive Maintenance
- RCA: Root Cause Analysis

C3.16.1.2 Key terms

- a) **Maintenance Plan:** A documented plan defining a detailed approach to system maintenance. It describes application of the maintenance program to a specific system or set of systems. It typically identifies the maintenance activities, priorities, timetables, and resource commitments and expenditures.
- b) **Maintenance Program:** Identifies the City of Cape Town's (CoCT) general approach to system maintenance. It includes the organizational structure and funding support needed to implement the program.
- c) **Maintenance Activity:** The sequence of actions needed to conduct preventive, periodic, or repair maintenance on a device or subsystem. Typically refers to a specific component (e.g., camera) or subsystem (e.g., network infrastructure).
- d) **Operational Concept:** Also known as "concept of operations" (or ConOps), it defines the environment in which the TMC will operate. The environment includes the relationship between the system and CoCT's responsibilities, the physical environment, and expectations (performance and life).
- e) **Maintenance Concept:** Defines the level-of-effort necessary to maintain system availability, reliability, and the functionality necessary to fulfil the operational concept.
- f) **Responsive Maintenance:** The repair or replacement of failed equipment and its restoration to safe, normal operation. Typically unscheduled, it is in response to an unexpected failure or damage.
- g) **Preventive Maintenance:** Also called "routine" maintenance, it is the activity performed at regularly scheduled intervals for the upkeep of equipment. It includes but is not limited to checking, testing and inspecting, recordkeeping, cleaning, and periodic replacement when called for in the preventive maintenance schedule.
- h) **Emergency Maintenance:** Emergency maintenance is similar to responsive maintenance in that it is initiated by a fault or trouble report. However, in this case, the fault is more serious and requires immediate action. Events such as traffic accidents, exposed electrical wires, network interruptions, theft or damaged equipment etc. are examples of event reports that may require emergency maintenance.
- i) **Continuous Maintenance:** Continuous maintenance refers to the continuous improvement of existing practices resulting in improved performance. For this contract continuous improvement is categorized into Root Cause Analysis and Current Best Practice Assessment and is shown in the following figure with its sub-items.

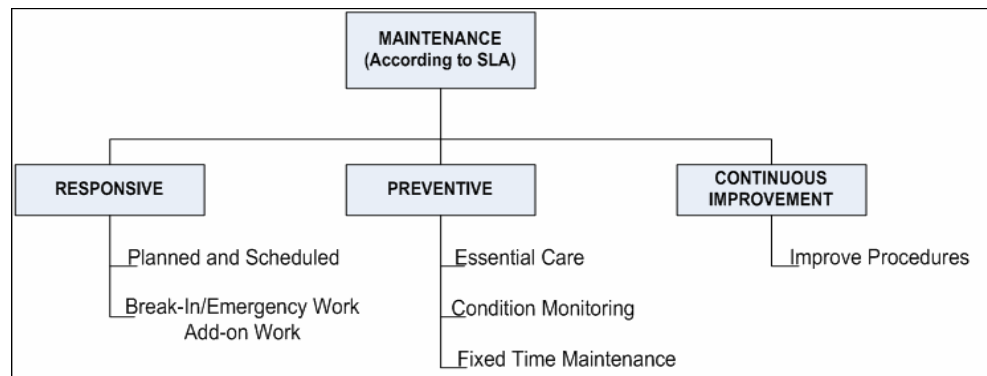


Figure 2: Definition of maintenance

C3.16.1.3 Responsive Maintenance

- a) **Responsive Maintenance** refers to operations that are initiated by a fault or trouble report. The report can come either:
 - from a person or
 - from software monitoring parts of the system.
- b) Most general faults fall into the responsive maintenance category. Most of these calls are responded to by the maintenance crews within the parameters of the applicable service level agreement. However, some faults can require days or weeks to repair. Problems can occur in securing new parts, e.g. when new power connections are needed from the local utility authority, etc.
- c) Responsive Maintenance is generally performed to correct a breakdown (when equipment ceases to function) or failure (when equipment condition reaches an unacceptable level, even though it may be functioning).
- d) For failure modes which lend themselves to condition monitoring (see section below), Responsive Maintenance should be the result of a regular inspection which identifies the failure in time for Responsive maintenance to be planned and scheduled.
- e) When Responsive Maintenance is done, the equipment shall be inspected to identify the reason for the failure and to allow action to be taken to eliminate or reduce the frequency of future similar failures. These inspections shall be documented and included as part of Responsive Maintenance.
- f) Responsive Maintenance can be divided into
 - 'Planned and Scheduled Maintenance' and
 - 'Break-In/Emergency Work' ('Unscheduled Maintenance') as shown in the following figure.

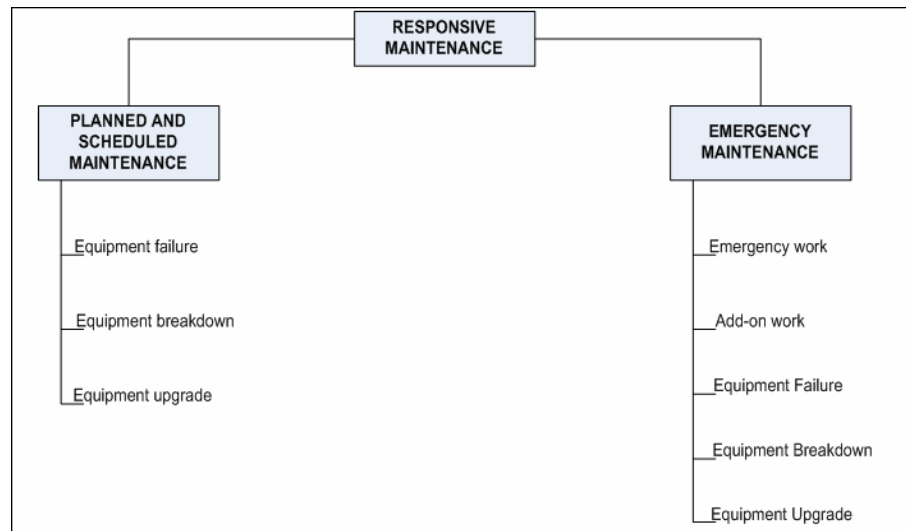


Figure 3: Responsive maintenance

Responsive Maintenance shall include but is not limited to the following components:

- On-Board System
- Central Control System
- Advanced Traveller Information System
- Data and Video Transmission System
- Visual Surveillance System

C3.16.1.4 Planned Maintenance

Planned Maintenance includes but is not limited to the following:

- The person planning the job verifies the scope of the job.
- Equipment, tools, parts, material and personal to do the job are identified and allocated.
- Skills needed are identified.
- A description of job steps is documented.
- Safety requirements are identified.
- Necessary technical documentation is available.
- Crafts people are part of the planning process.
- Estimated job duration by skills and the number of people needed for the job.
- Required permits available.
- The cost of each job is estimated.
- Define physical and environmental constraints.

C3.16.1.5 Emergency maintenance

Emergency maintenance is part of Responsive Maintenance, similar in that it is initiated by a fault or trouble report. However, in this case, the fault is more serious and requires immediate action. Events such as knockdowns, spills, exposed power supplies or communications failures, are clear examples of reports that may require emergency maintenance. These sorts of conditions often constitute emergencies that need to be dealt with quickly in order to alleviate hazards.

C3.16.1.6 Work Requests, Work Orders, Planning and Scheduling

Responsive Maintenance shall require a Work Request to be filled in by the maintenance contractor. This shall be done regardless if it is requested by the TMC or if it originates internally to document all work orders. The work request shall be submitted to the maintenance planner who shall review the work request. After approval of the Work Request it shall become a Work Order. Planning for all work orders are then done by the maintenance planner.

Faults may be reported by the client either telephonically or by email. In each case the contractor shall supply the client with a unique set of contact detail for fault reporting to their Operating Support Centre. As far as possible an accurate description of the fault shall be given to aid proper planning of preventive maintenance. However it shall remain the responsibility of the contractor to plan the maintenance as described in this document. Each work request shall have a unique reference number.

The Work Request shall indicate the priority of the job. Only after a job is planned it is scheduled. The purpose of scheduling is to determine when a job is done and by who based on the priority and resource/equipment availability. For a scheduled job specific people and the start time and end time of the job shall be documented. Scheduled jobs shall have a cut-off time for scheduling based on the current best practice for cut-off time, see Table 1.

Any work that changes a set schedule or an agreed cut-off time is categorized as a break-in job or unscheduled maintenance.

As part of the planning for a job the maintenance planner shall have a checklist to complete; this shall include but is not limited to the following:

- Is this a duplicate work order, or will it affect any other work orders?
- Is the work location clearly identified?
- Is special access required, e.g. scaffolding?
- Is the description accurate and professional?
- Is there a standard work order for this job?
- Are all materials/spares/equipment required for the work included in the work order?
- Is there a standard work kit for this work order?
- Is the availability of each item of material/components clearly indicated?
- Are all safety issues adequately covered?

- Are all environmental issues adequately covered?
- Are all trades/skills required to complete the work included on the work order?
- Is there any work which may conflict with this job?
- Are there other work orders in the backlog which should be done in conjunction with this work order?

If there is any uncertainty by the maintenance planner about any of these questions he shall request it from the person who placed the work request and/or he or his representative shall do a site visit to assist him with the proper planning.

C3.16.1.7 Preventive Maintenance / Essential Care and Condition Monitoring (PM/ECCM)

- Preventive Maintenance** consists of scheduled operations performed to keep systems operating. This includes simple operations, such as cleaning camera housing faces. In some cases, Preventive Maintenance requires sophisticated technology, such as optical testing equipment to ensure that the fibre-optic used in the communications system is operating within acceptable parameters.
- Preventive Maintenance is initiated by a schedule.
- Preventive Maintenance is also defined as the care and servicing by personnel for the purpose of maintaining equipment in satisfactory operating condition by providing for systematic inspection and detection, and correction of incipient failures either before they occur or before they develop into major defects.
- The purpose of Preventive Maintenance is to ensure peak efficiency of equipment and minimize deterioration. Preventive Maintenance shall be a planned and controlled program of systematic inspection, adjustment and replacement of components and include performance testing and analysis.
- PM/ECCM consists of three components (Refer to the following figure):
 - Essential Care
 - Fixed Time Maintenance
 - Condition Monitoring.

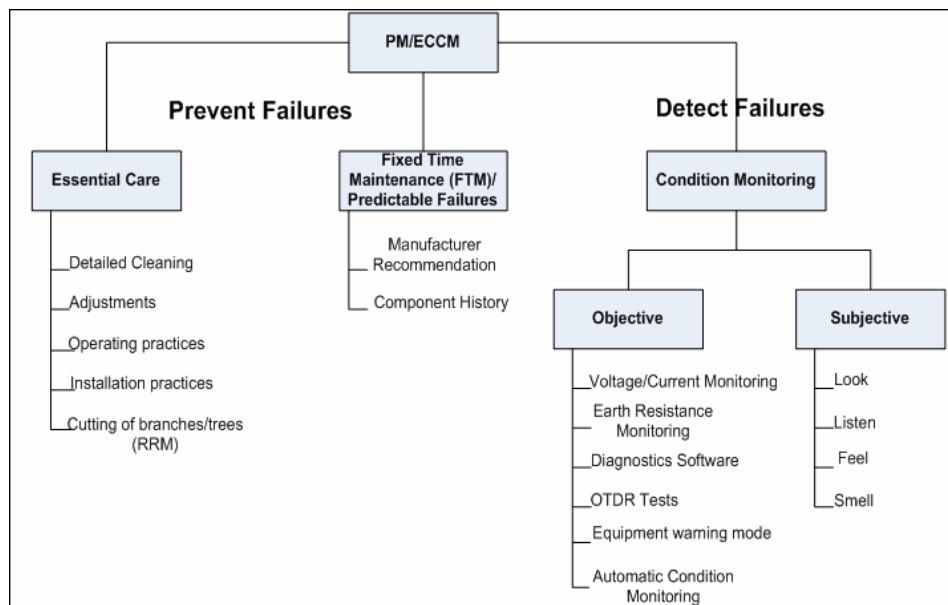


Figure 4: Preventive Maintenance/Essential Care and Condition Monitoring (PM/ECCM)

C3.16.1.8 Essential Care

Essential Care shall include but is not limited to the following items:

- Detailed cleaning:** Camera lenses/enclosures,
- Replace/renew:** labelling of enclosures and cabling
- Adjustments:** Camera inside housing, wireless antenna
- Operating practices:** From historical data determine better operating practices

- e) **Installation practices:** From historical data determine better installation practices

C3.16.1.9 Fixed Time Maintenance (FTM) / Predictable Failures

Fixed Time Maintenance (FTM)/Predictable Failures shall include but is not limited to the following items:

- Manufacturer Recommendations:** Take into account specified Mean Time Between Failures (MTBF) and any other specified recommendations according to the installation/user manual.
- Component History:** Anticipate component failure from **recorded** history

C3.16.1.10 Condition Monitoring

- Condition monitoring is categorized into objective and subjective condition monitoring, as shown in Figure 4 above. Condition monitoring shall be done using the Essential Care and Condition Monitoring Standards (ECCMS). These standards shall be discussed after award of the contract in order to make them more efficient and they shall only serve as a guideline for the tenderer. The updated standards shall then be recorded as a new revision. The continuous improvement of these standards shall be practiced during the duration of the contract.
- A full record of all condition monitoring carried out shall be kept and recorded, both as a hard copy and electronically for future reference.

C3.16.1.11 Continuous Improvement

Continuous Improvement refers to the continuous improvement of existing practices resulting in improved performance. For this contract continuous improvement is categorised into

- Root Cause Analysis and
- Current Best Practice Assessment

and is shown in the following figure with its sub-items.

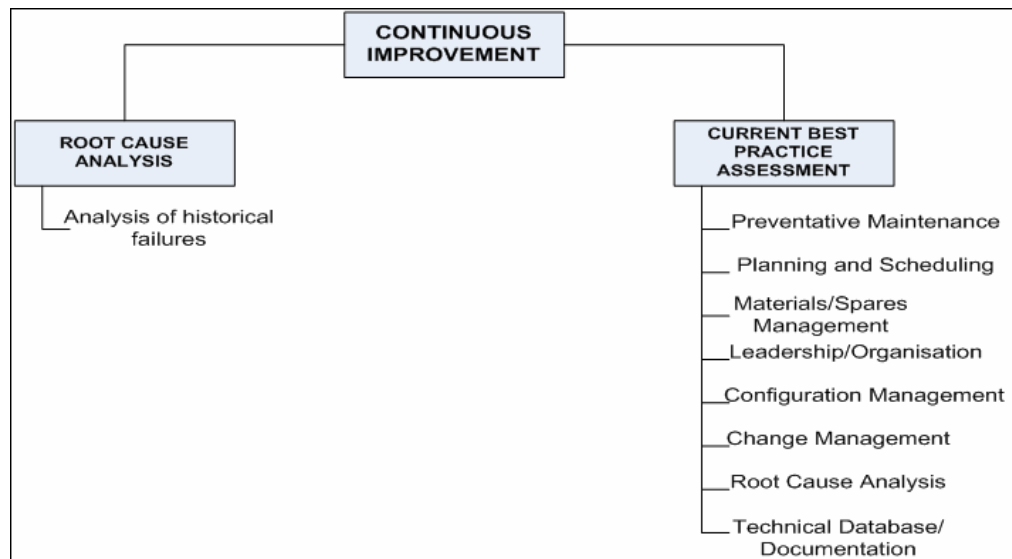


Figure 5: Continuous Improvement

C3.16.1.12 Root Cause Analysis

Root Cause Analysis (RCA) is a systematic approach to collect, select and analyse data about equipment failure / breakdown in order to solve, eliminate and prevent problems.

In this contract, RCA is considered to be an iterative process: Initially, RCA is a reactive method of problem solving. This means that the analysis is done *after* an event has occurred. By gaining expertise in RCA, it shall become a pro-active method. That is, the tenderer, by means of RCA, should be able to *forecast* the possibility of an event.

Therefore, the maintenance tenderer shall apply generally accepted Root Cause Analysis Techniques. The environment of the IRT including the TMC implies *Failure-based* and *System-based* RCA approaches.

Root Cause Analysis shall be documented, showing analysis technique, including conclusions and recommendations to improve responsive and preventive maintenance.

The maintenance tenderer is responsible for the implementation and observation of the recommended solutions to ensure effectiveness.

C3.16.1.13 Current Best Practice (CBP) Assessment

Current best practice assessment is the critical assessment of current practices to improve them. The key processes for assessment shall include but is not limited to those shown in the Figure above.

As an **example**, the CBP for cut-off time (from Table 1) may change based on a review of the effectiveness of planning and scheduling.

SCHEDULE	NO OF DEVICES AFFECTED	DOWNTIME	CUT-OFF TIME
Daily			20h before start of job
Weekly			72h before start of week
Shutdown	More than 10	Less than 12 hours	1 week before start of shutdown
Shutdown	More than 10	More than 12 hours	4 weeks before start of shutdown

Table 1: Example of a current best practice (CBP) for cut-off time

Current best practice assessment shall be done continuously throughout the contract and shall be documented for future reference. The maintenance tenderer shall develop their own sets of procedures based on the device manufacturer guidelines, previous experience and Continuous Improvement as described in this section upon award of the contract. Keeping documentation of the procedures and when they are performed will put the client in a better position in the case of disputes concerning warranties and in providing the MTBF data discussed earlier.

C3.16.2 Maintenance and Repair

The scope of the maintenance contract is for the maintenance as defined in the previous section for all equipment and software to be installed under this contract.

Maintenance on the installed system shall be for 6 years from the date of taking over certificate. The scope of maintenance and repair shall include but not be limited to:

- a) Scheduled maintenance of all items supplied and installed under this contract
This includes the cleaning, adjustment, re-configuration, testing and replacement of equipment or parts in order to keep the system fully operational and optimised.
- b) Set up of maintenance schedules for all items of equipment.
This includes the setting up and implementation of a maintenance plan and procedures for all components of the system. The maintenance plan shall include detailed maintenance schedules which provide for servicing of all roadside equipment on at least a 3-monthly cycle.
The maintenance procedures shall be based on manufacturers' guidelines and installers' maintenance experience.
- c) Unscheduled maintenance or repair including emergency repairs
This includes carrying out of all maintenance and repairs necessitated by equipment failure, accident damage or theft.
- d) Set up of an equipment register database, and tracking of all equipment removed for repair and spares used

Cables and electrical and electronics equipment shall be captured in this database. The tracking of equipment used shall extend to all equipment sent to the manufacturers for repair.

- e) Set up and implementation of a fault reporting, logging and job card tracking system.

This system shall provide at least features for the following:

- Reporting of the fault via phone, radio, e-mail or fax
- Acknowledgement of receipt and expected response time via e-mail and/or SMS
- Feedback on initial assessment by e-mail
- Feedback on repair work carried out and close-out of the fault report
- Initiation, tracking and close-out a job card for the repair
- Escalation of problem when response times are exceeded
- Automatic opening of fault reports in instances of alarms generated by the system e.g. UPS fault
- The system shall be based on a commercially available maintenance management software package such as Maximo or approved equivalent.

- f) Provision of breakdown/fault response capabilities with response times as detailed below:

This includes the provision of all resources (manpower, tools, equipment & plant) to carry the scheduled maintenance, unscheduled maintenance and emergency repairs. The resources shall include technical staff. Response times apply to unscheduled maintenance or emergency repairs and not planned maintenance. The minimum response times associated with three defined priority levels are as follows:

Priority Level	Condition	Response Time Calls logged between 06:00 and 18:00	Response Time Calls logged between 18:00 and 06:00
One (1) (Example – failure of any TMC core system, interfaces or communication to VLU or depot).	Critical - Failures seriously affecting the operational effectiveness of the IRT system.	Respond within 1 hour of receipt of call, investigate and restore or provide temporary service immediately.	Respond within 4 hours of receipt of call, investigate and restore or provide temporary service immediately.
Two (2) (Example – failure of any bus components that inhibits the use of the bus).	Important - Failures that partially impact the operational effectiveness of the IRT system.	Respond within 4 hours of receipt of call, investigate and restore or provide temporary service immediately.	Respond within 8 hours of receipt of call, investigate and restore or provide temporary service immediately.
Three (3) (Example - non-critical failure of a component of the system e.g. a single workstation).	Non-critical - Failures that have limited or no effect on the operational effectiveness of the IRT system.	Investigate within 24 hours of receipt of call and repair as soon as possible.	Investigate within 24 hours of receipt of call and repair as soon as possible.

Table 2: Minimum maintenance response times

- g) Spares

This includes the initial supply of a spares stock and the replenishment of the spares stock as these are used, as well as management of the return of repaired items to the spares stock. The spares stock shall provide for change out of failed items to be sent for repair. The Contractor shall propose for consideration of City of Cape Town a list of spare parts (Spare Parts List) to be provided. This list shall include replacement parts, components or sub-assemblies for all items of equipment provided, in sufficient quantities to meet the estimated need for warranty and maintenance purposes for a period of two years. A spare ratio of 10% or greater is preferred.

The Spare Parts List shall contain all specialized tools and equipment necessary to install, calibrate, test and maintain the system. All wiring, cabling and adapters shall also be provided.

The Spare Parts shall be placed into the spare parts inventory and become the property of City of Cape Town upon acceptance.

C3.16.3 Pricing and Payment

Pricing shall be provided for Maintenance and Repair as follows:

- Year 1: Defects liability period (note obligations in terms of FIDIC)
- Year 2 and subsequent years: Post defects liability period – Maintenance Agreement

Payment for maintenance, repairs and spares shall be effected as follows (Refer to Section C3.16.2):

- Payment for items a, b, d, e, and f shall be included in a monthly maintenance fee.
- Payment for item c shall be made as follows:
 - Response, repair, replacement of a failed item still under guarantee during the defects liability period: No payment
 - Response, repair, replacement of an item no longer under guarantee during the defects liability period, or damaged by accident or theft: Payment for material and labour at tendered rates plus escalation
- Payment for item g shall be made as follows:
 - Initial spares stock: Tendered rates plus escalation against Provisional Sum in Bill of Quantity.
 - Spares replenishment: Tendered rates plus escalation

C3.17 DETAIL SPECIFICATION: OPERATIONS

The City of Cape Town might require the contractor to operate the IRT system for a period of time of between 12 months and 3 years. The operating of the system will form part of this contract and are outlined in the Operations Agreement included in “Additional Conditions of Contract” (Section C1.2 Contract Data, Subsection 23). The Operations Agreement shall commence on the date of the issue of the Taking-Over certificate for Milestone 1.

It is envisaged that the Contractor will employ an Operations Manager and an additional 6 (six) operator staff which will operate the system in shifts. The expected operating hours of the IRT systems is between 5 a.m. and 11 p.m. (18 hours), seven days a week. The operators will have to work in shifts and the number of operators present at any one time will depend on the actual work load. The Operations Manager must have at least five (5) years related experience with managing of similar systems.

The Operations Manager and his supporting staff shall operate the Control Centre systems, and maintain a high level of service compliance. The operations will be housed in the new TMC under construction in Goodwood, Cape Town.

Payment for the operations will be based on monthly cost of employment per staff member. The contractor will have to illustrate to the Engineer the number of staff members actively involved per month in the operations.

C3.18 GLOSSARY

AC	Alternating Current
AGL	Above ground level
AMSL	Above mean sea level
APTMS	Advanced Public Transportation Management System
ASA	Automatic Stop Annunciation
ASCII	American Standard Code for Information Interchange
ATP	Used as "HASTUS-ATP runtime analysis module"
AutoCAD	Computer Aided Design software from Autodesk
AVL	Automatic Vehicle Location
BNC	Bayonet Neill-Concelman: connector for coaxial cable
Bps	Bits per second
BRT	Bus Rapid Transit
C	Celsius
CAD	Computer Aided Dispatch
CADM	Computer Aided Dispatch and Monitoring
CCTV	Closed circuit television
CDMA	Code Division Multiple Access
CD-ROM	Compact Disc read-only memory
CFR	Code of Federal Regulations
CPC	Coverage Performance Criteria
CTCSS	Continuous Tone-Controlled Squelch System
DART	Dial-a-Ride-Transportation
dB	Decibel
dBc	Decibels relative to carrier
DBF	dBase file extension
DDU	Driver Display Unit
DIN	Deutsches Institut für Normung: German institute for Standardization
DLP	Digital Light Processing
DRS	Database Reporting System
DVD	Digital Versatile Disk (formerly Digital Video Disk)
EA	Emergency Alarm
EIA	Electronic Industries Alliance
EMI	Electromagnetic Interference
ERP	Effective Radiated Power
ESRI	Environmental Systems Research Institute
F	Fahrenheit
FAT	Factory Acceptance Testing

FCC	Federal Communications Commission
FDR	Final Design Review
FIPS	Federal Information Processing Standards
GIS	Global Information System
GPRS	Generalized Packet Radio Service
GPS	Global Positioning System
GSM	Global Systems for Mobile Communications systems
GUI	Graphical User Interface
HLD	High Level Design
HP	Hewlett Packard
HVAC	Heating, Ventilation, and Air Conditioning
Hz	Hertz
IBM	International Business Machines
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
EMS	Emergency Management Services
IP	Ingress Protection (i.e. IP 66)
IP	Internet Protocol (i.e. IP addressing)
IT	Information Technology
ITS	Intelligent Transportation System
IVR	Interactive Voice Response
kg	kilograms
LAN	Local Area Network
lbs	pounds
LCD	Liquid crystal display
MDT	Mobile Data Terminal
MIL-STD	Military Standard
mph	Miles per hour
MS	Microsoft
MSD	Material Selection Documentation
MTBF	Mean time between failures
N	Newton
NEC	National Electrical Code
NEMA	National Electrical Manufacturer's Association
O&M	Operation and Maintenance
ODBC	Open Database Connectivity
OEM	Original Equipment Manufacturer
OIT	Onsite Integration Testing

OS	Operating System
OSHA	Occupational Safety and Health Administration
PA	Public address
PC	Personal Computer
PCMCIA	Personal Computer Memory Card International Association
PDA	Personal Digital Assistant
PDR	Preliminary Design Review
PT	Public Transport
MDT	Feeder Mobile Data Terminal
ppm	Parts per million
RAID	Redundant Array of Independent Disks
RAN	Radio Access Network
RF	Radio Frequency
RFI	Radio Frequency Interference
RMS	Root mean square
RSI	Repetitive Stress Injury
RX	Receive
SAE	Society of Automotive Engineers
SAT	System Acceptance Test
SAT	Standard Acceptance Test
SBS	Smart Bus Stops
SDD	System Design Document
SINAD	Signal including noise and distortion
SIT	System Integration Test
SQL	Structured Query Language
TCIP	Transit Communications Interface Protocol
TETRA	Terrestrial Trunked Radio
TIA	Telecommunications Industry Association
TSB	Telecommunications Systems Bulletin
TSP	Transit Signal Priority
TX	Transmit
UL	Underwriters Laboratories Incorporated
URL	Uniform Resource Locator
URTS	User Requirements and Technical Specifications.
USB	Universal Serial Bus
V	Volts
VDC	Volts of continuous current (direct current (DC))
VGA	Video graphics array

VLU	Vehicle Logic Unit
VMS	Variable Message Sign
VPN	Virtual Private Network
VSWR	Voltage Standing Wave Ratio
VWM	Vehicle Weight Measurement
WAAS	Wide Area Augmentation System
WAN	Wide Area Network
WDOLS	Wireless Data On-Off Load System
WLAN	Wireless local area network
XHTML	eXtensible HyperText Markup Language
XML	eXtensible Markup Language