1.01 SECTION INCLUDES

A. This section specifies the safety and system assurance requirements applicable to the Communications Equipment. These requirements have been established to provide for the attainment of performance requirements for the project. The safety and system assurance requirements have been divided into quality assurance, system safety, reliability/availability, and maintainability, and are described under following specific sections.

1.02 RELATED SECTION (Not Used)

1.03 REFERENCES

2. Reliability Modeling and Prediction - MIL-STD 756B.
4. Maintainability Program Requirements (for Systems and Equipment) - MIL-STD-470A.

1.04 QUALITY ASSURANCE

A. The Contractor shall provide and maintain a Quality Assurance (QA) Program to regulate methods, procedures, and processes to ensure compliance with the Contract requirements. The QA Program, including QA written procedures, shall be submitted for approval.

B. The requirements of this QA Program shall apply to all activities related to quality of items, including designing, purchasing, inspecting, handling, assembling, fabricating, testing, storing, and shipping.

C. Organization

1. The QA organization shall be clearly defined. Management responsibility for the QA shall be set forth on the Contractor’s policy and organization chart.

D. Evidence of Compliance

1. The Contractor may use certificates of compliance for certain equipment or materials and products in lieu of the sampling and testing procedures. Certificates of
compliance shall be accompanied by certified documentation of test results or shall state that such test results are on file and will be furnished to Metro on request.

E. Calibration/Certification of Measuring Equipment and Tools

1. An effective time- or usage-cycled calibration/certification program shall be demonstrated. Validity of measurements and tests shall be ensured through the use of suitable inspection, measurement, and test equipment of the range and type necessary to determine conformance of items. Calibration certifications shall be recorded and be part of the QA records.

F. Quality Assurance Records

1. Adequate records shall be maintained in a readily retrievable manner to provide documented evidence of quality and accountability. These records shall be maintained, completed, and available to Metro at all times during the term of the Contract and for a 3-year retention period thereafter.

G. Verification

1. The QA operations shall be subject to Metro verification at any time, including: surveillance of the operations to determine that practices, methods, and procedures of the program are being properly applied; inspection to measure quality of items to be offered for acceptance; inspection of items awaiting release for shipment; and audits to ensure compliance with requirements of the Contract documents.

H. Qualification and Certification of Personnel

1. The QA personnel performing inspections and tests shall be qualified for such work by virtue of those skills with are obtained by experience or training. Manufacturing personnel performing special processes, such as welding and brazing, shall be certified for such work.

2. Records of personnel certifications shall be maintained and monitored by the QA personnel. These records shall be made available to Metro for review, upon request.

I. Special Processes

1. Processes that control or verify quality, such as heat treating, welding, plating, and nondestructive testing, shall be performed by certified personnel and in accordance with approved documented procedures.

J. Procurement Quality Assurance

1. The methods to be used for the selection and control of suppliers shall be defined.

1.05 SUBMITTALS

A. Reliability/Availability Program Plan

B. Reliability and Availability Analyses
C. Availability Demonstration Test Plan and Testing Data

D. Maintainability Program Plan

E. Maintenance Concept

F. Preventive Maintenance Plan

1.06 DEFINITIONS

1. ASSEMBLY: A number of parts or subassemblies or any combination thereof together to perform a specific function.

2. AVAILABILITY: The probability that a system or system element will be operational when required. Mathematically, the ratio of the mean time between failure and the sum of the mean time between failure and the mean down time.

3. AVAILABILITY, PERCENT: The Percent Availability is a measure of the degree to which a system, subsystem or equipment is operable and not in a failure condition. It represents the percentage of time that the system or subsystems are available to be used by the user.

4. FAILURE: A failure is defined as the event, or inoperable state, in which any item or part of an item does not, or would not perform as previously specified, regardless of the operational state of the subsystem.

5. FAILURE, CHARGEABLE: A “Chargeable” failure of an item is defined as a failure that results in a loss of function of that item caused by any of the following:
   a. A fault in the item while operating within its design and environmental specification limits.
   b. Improper operation, maintenance or testing of the item as a result of Contractor-supplied documentation.
   c. Repair or replacement of any subsystem component, which is an approved consumable but has not achieved its design service life shall be considered as chargeable failure.

6. FAILURE, NON-CHARGEABLE: Any failure or condition of an item not included in the definition of chargeable failure, such as the following:
   a. A failure caused by malfunction of another system or sub-system.
   b. A failure caused by not performing the recommended preventative or service maintenance actions.
   c. Vandalism or physical mistreatment at a human interface.
   d. A failure caused by operating the item outside of design or environmental specification limits.
   e. A failure caused by human error, except as noted in definition of chargeable failure.
f. An accident.

7. FAILURE RATE: Rate at which failures occur as a function of time. If the failure rate is constant, it is frequently expressed as the reciprocal of mean-time between-failures (MTBF). Calculated for an article, it is the ratio of the total number of independent article failures to the total article operating hours.

8. MAINTAINABILITY: The quality of the combined features of equipment design and installation that facilitates the accomplishment of inspection, test, checkout, servicing, repair, and overhaul with a minimum of time, skill, and resources in the planned maintenance environments.

9. MAINTENANCE, CORRECTIVE: The action taken to restore a failed item of equipment to an operable state.

10. MAINTENANCE, PREVENTIVE: The actions performed in an attempt to retain an item in a specified condition by providing systematic inspection, detection, and prevention of incipient failures.

11. MEAN CYCLES BETWEEN FAILURES (MCBF): The arithmetic mean of the number of cycles between successive failures of a repairable device.

12. MEAN DOWN TIME (MDT): The arithmetic mean of the time the device remains in an inoperable state after it has failed.

13. MEAN TIME BETWEEN FAILURE (MTBF): The item MTBF is defined as the total operating time (t) accumulated by the total population of identical items divided by the total number of failures occurring within the population of identical items during time (t).

14. MEAN TIME TO REPAIR (MTTR): The mean active repair time required, after arrival of the maintenance team, to locate and isolate the fault, make repairs, and perform a functional checkout to verify that the equipment has been restored to operational status. The MTTR is the ratio of the total active corrective maintenance time expended during a specific period of time to the total number of relevant failures occurred during that same time period.

15. OPERATING TIME: The time period between turn-on and turn-off of a system, subsystem, component, or part during which time operation is as specified. Total operating time is the summation of all operating time periods.

16. RELIABILITY: The probability that the system or subsystem will perform satisfactorily for a given period of time when used under stated conditions.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Inspection and Test

1. Inspect and physically or functionally test all items to be delivered. Inspection and testing instructions shall provide for reporting nonconformance or questionable conditions to Metro.

2. Inspection shall occur at appropriate points in the manufacturing and installation sequence to ensure compliance with drawings, test specifications, process
specifications, and quality standards. Metro may designate inspection hold points into the manufacturing, installation, or inspection planning, upon review of Contractor’s efforts.

3. In-process tests, including tests of raw materials, shall be performed and documented.

B. Receiving Inspection

1. The receiving inspection activity shall provide for the inspection of incoming materials. These inspection measures shall be used to preclude the use of nonconforming materials and to ensure that only correct and accepted items are used and installed.

C. Production Operations

1. Machining, wiring, batching, shaping, and other basic production operations of any type, together with all processing, fabricating and installation of any type, shall be accomplished under controlled conditions. Documented work instructions shall be the criteria for all production, processing, and fabrication work. The QA program shall effectively monitor the issuance of and compliance with work instructions. Quality inspection procedures shall be used where applicable. Criteria for approval and rejection shall be established and shall be subject to approval.

D. Shipping Inspection

1. The QA program shall provide and enforce procedures for the proper inspection of all products deliverable to Metro, to assure completion and conformance prior to shipment.

E. Statistical Sampling Plans

1. Statistical sampling used in inspection shall be fully documented and based on generally recognized and accepted statistical practices and shall be approved.

F. Identification of Inspection Status

1. A system for identifying the progressive inspection status of equipment, materials, components, subassemblies, and assemblies as to their acceptance, rejection, or noninspection shall be maintained.

G. Identification and Control of Items

1. Item identification and traceability control shall be provided. Where specified, items having limited calendar or operating life or cycles shall be identified and controlled to preclude use of items whose shelf life or operating life has expired.

H. Handling, Storage, and Delivery

1. Provide for adequate work, surveillance, and inspection instructions for handling, storing, preserving, packaging, packing, marking, and shipping.

I. Corrective Action
1. Ensure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, and defects in equipment and material shall be promptly identified and corrected.

J. Nonconformances

1. Establish, document, and maintain an effective and positive system for controlling nonconforming material including procedures for its identification, segregation, and disposition. Dispositions for the use or repair of nonconforming material shall require approval.

1.08 SYSTEM SAFETY

A. Scope

1. This section specifies the requirements for System Safety. These requirements shall apply to all suppliers and subsuppliers, for all phases of the contract, including in-service support, warranty, retrofits, and field modifications.

B. System Safety Principles

The following safety principles shall be followed in the design and operations of systems, subsystems, components, and parts.

1. The system shall be designed such that there shall be no single-point failures in the system that can result in an unacceptable or undesirable hazard condition.

2. When the system is operating normally there shall be no unacceptable or undesirable hazard conditions.

3. The system design shall require positive actions to be taken in a prescribed manner to either begin or continue system operation.

4. The safety of the system in the normal automatic operating mode shall not depend on the correctness of actions or procedures used by operating personnel.

5. If one failure combined with a second failure can cause an unacceptable or undesirable hazard condition, the first failure shall be detected and the system shall achieve a known safe state before the second failure can occur.

6. Software faults shall not cause an unacceptable or undesirable hazard condition.

7. Unacceptable hazards shall be eliminated by design.

8. The criteria for accepting a hazard risk level shall be in accordance with Reference E, Hazard Analysis Guidelines for Transit Projects.

9. Maintenance activities required to preserve or achieve acceptable risk levels shall be performed. Personnel qualifications required to adequately implement these activities shall also be identified.
1.09 RELIABILITY/AVAILABILITY

A. Reliability/Availability Program Plan: Prepare a detailed Reliability/Availability Program Plan in accordance with the provisions specified herein:

1. Task listing and time phasing for each task.
2. Organization and responsibilities of key personnel.
3. Techniques for allocation of quantitative requirements to lower level functional elements.
4. Interfaces between reliability/availability and other closely related programs, and support to efforts such as:
   a. Design.
   b. Quality assurance and quality control.
   c. Standardization.
5. Methods for assuring that subcontractors' reliability/availability efforts are consistent with overall system requirements.
6. Provision for first article inspection, and surveillance of subcontractors' reliability/availability activities.
7. Analytical methods to be used during design and development for demonstrating compliance with reliability/availability requirements and goals.
8. Procedures and controls, including piece part selection and screening, manufacturing process controls, procurement controls and test procedures to be utilized during production to ensure achievement of reliability/availability requirements.
9. Provisions to evaluate design changes for possible effects upon subsystem and functional level requirements and goals.

B. Reliability and Availability Analyses

1. Perform reliability/availability analyses for items identified in Table 1 up to the point of interface with other Project elements/subsystems or assemblies. The Contractor shall submit preliminary reliability/availability predictions within 60 days of NTP. The Contractor shall then refine these predictions in its reliability/availability analyses. The accepted reliability/availability values in the reliability/availability analyses shall not differ from those in the preliminary predictions by more than 5%. The accepted availability/MTBF/MTTR values shall be used as the requirements for the reliability/availability testing. The subsystems may be composed of a number of components, some of which will not be supplied by the Contractor. For reliability/availability calculations and actual performance measurements the
equipment not furnished by the Contractor shall have an assumed reliability/availability of 100%.

C. Quantitative Requirements

1. The availability requirements for each subsystem/equipment are listed at the installation level in Table 1 below.

<table>
<thead>
<tr>
<th>Item</th>
<th>Availability</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPS</td>
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<td>CTS</td>
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<tr>
<td>Fire Alarm System</td>
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<tr>
<td>Facilities Emergency Management System</td>
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<td>Percent</td>
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<tr>
<td>Intrusion Detection System</td>
<td>99.99</td>
<td>Percent</td>
</tr>
<tr>
<td>CCTV</td>
<td>99.99</td>
<td>Percent</td>
</tr>
</tbody>
</table>

D. Reliability/Availability Demonstration Testing Data

1. The Contractor shall perform demonstration testing for verification of compliance with specified reliability/availability requirements. A reliability/availability demonstration test plan shall be prepared before the start of the test. The test results shall be submitted in a report for approval. Subject to the Metro or its Designee's approval, existing demonstration data which are properly documented and verifiable may be submitted in support of the required submittals, for equipment and applications which are identical or manifestly similar to those required under this Contract.

1.10 MAINTAINABILITY PROGRAM

A. General

1. The Contractor shall establish and maintain a maintainability program in support of the specified requirements. Features shall be incorporated into the design of equipment to minimize the Mean Time to Repair (MTTR) and preventive maintenance time. The subsystems and components shall incorporate the following design features:

2. Accessibility: All routinely serviced subsystems and components shall be readily accessible for service and inspection. Accessibility of components shall be proportional to frequency of maintenance and repair. No active electrical or mechanical components that can foreseeably require maintenance shall be structurally embedded to preclude convenient access for repair or replacement.

3. Modular Design: Modular design principles shall be employed to the greatest extent practicable. Components shall be packaged together in replaceable subassemblies according to the logical function that they perform. Components or subassemblies requiring occasional removal shall preferably be plug-in units.
4. Interchangeability: Assemblies or components that are functionally interchangeable shall be physically interchangeable. Assemblies or components that are not functionally interchangeable shall not be physically interchangeable.

5. Adjustments: The need for adjustments shall be avoided. Where adjustment points cannot be avoided, they shall be readily accessible, adequately identified, and self-locking to prevent inadvertent adjustment or drift.

6. Special Tools: The number of special tools required for maintenance and repair shall be minimized. However, if they are required, they shall be defined and furnished in a quantity determined as part of the Work of this Contract.

7. Panels and Openings: Panels and openings shall be of sufficient quantity, size, and placement to permit ready access from normal work areas and positions. Adjustment controls, fittings, and such, shall be directly accessible through panels and openings. Self-retaining fasteners shall be used wherever possible. Special access opening tools shall not be used unless considered necessary to prevent vandalism.

8. Cable Connections: Cable connectors shall be spaced far enough apart so that they can be grasped firmly for connecting and disconnecting. Connectors shall be properly labeled and keyed so that they cannot be interchanged or improperly installed. Signal and power pins shall not be adjacent.

9. Lifting Assists: Handles, lifting lugs, or reviewed functional equivalents shall be provided on components of 18 kg (40 lbs) or more.


11. Test Points: Built-in test points shall be provided and marked. Major components having test panels or test points shall be located for easy accessibility and shall permit external monitoring of critical functions. Test points shall be protected against environmental damage and human error.

12. Fault Isolation: Failure indicators shall be provided and identified. Systematic fault isolation procedures shall be developed and included in the maintenance manuals.

13. Labeling: All test points, fault indicators, modules, wire junctions, pipes, tubes, wires, etc., shall be identified by name plates, color coding, number coding, or other means to assist maintenance personnel. All ROMs, PROMs, andEPROMs shall be labeled with the version and date of stored software.

14. Hardware: Standard, commercially available industrial components and hardware shall be used wherever possible.

15. Vandalism: The use of vandal and damage resistant materials shall be used whenever possible.

B. Maintainability Program Plan

1. Prepare a detailed Maintainability Program Plan including the following:
   a. Task listing and time phasing for each task.
b. Organization and responsibilities of key personnel.

c. Interfaces and input from maintainability to efforts such as:

1) Logistic support and maintenance planning.
2) Design.
3) Standardization.
4) Systems engineering.
5) Personnel subsystem program (human engineering, training, and manuals).
6) Methods for ensuring that subcontractors' and suppliers' maintainability efforts are consistent with overall plan.
7) Provisions for early fault detection and rapid fault isolation to the proper service level to minimize costs and MTTR.
8) Provisions for simplification of fault detection, isolation, and repair to minimize the skill levels and training requirements for maintenance personnel.
9) Provisions for accessibility for maintenance tasks.
10) Provisions for reduction of the following: complexity of maintenance, design-dictated maintenance activities and related costs, maintenance down-time and effects on system operation, maintenance costs, potential for maintenance error, and man/machine interface problems.
11) Provisions to evaluate operational and design changes for possible effects upon maintainability requirements.

C. Maintenance Concept

1. Develop a maintenance concept taking the following into consideration:

   a. System parameters as specified above.

   b. Maintenance Assumptions

1) Troubleshooting and repair will be done by a high school graduate who has had 2 years of relevant qualifying technical school training and 2 years of experience; has attended the required training programs, has available printed maintenance documents furnished by the Contractor; and has use of the test equipment recommended by the Contractor.

2) Spare parts recommended by the Contractor will be available.

3) Maintenance will be performed at three discrete levels: on-line, off-line, and bench.
4) On-line maintenance is that performed on an in-place and operational equipment element. Test points or built-in Indicators shall facilitate identification of interfaces with other system elements. On-line maintenance shall not disrupt service.

5) Off-line maintenance is that performed on in-place but out-of-service equipment elements.

6) Bench maintenance is that which is performed on out-of-place and service equipment elements. This maintenance is to be performed in a shop area where standard test equipment and fixtures are available. Test equipment and procedures shall allow maintenance to the lowest pluggable component part level.

c. The maintenance concept shall define the repair, corrective, and preventive maintenance program plans, policies, and support requirements for all equipment supplied under this Contract. It shall:

1) Minimize each level of maintenance consistent with the specification.

2) Recommend policies and practices that ensure, at the time of a failure, qualified maintenance personnel will be promptly notified and will have the necessary documentation, tools, test equipment, and spare parts to affect the repair in a minimum of time.

d. The maintainability concept shall develop recommendations for:

1) Depth and frequency of maintenance requirements at each level.

2) Facilities required.

3) Support equipment and tools required.

4) Skill levels and numbers of personnel required.

5) Subsystem, component, and piece part repair policy.

6) Detailed fault isolation and troubleshooting procedures, diagnostic equipment, and special test equipment.

D. Preventive Maintenance Plan

1. The Contractor shall develop and submit within 18 months of NTP, a detailed Preventive Maintenance (PM) plan based upon the maintenance concepts and established maintainability requirements. The PM plan shall provide all preventive maintenance tasks needed to maintain each subsystem/equipment, supplied under this Contract, as close as possible to new condition. The PM task analysis shall include all servicing, inspections, scheduled overhaul, or any task required on a scheduled basis. The elapsed time to perform specific tasks shall be defined in the analysis, and in maintenance and servicing manuals. All tasks will be sorted and grouped by time interval (ex. daily, weekly, monthly, etc.), as well as by subsystem.
2. In addition to PM tasks recommended by equipment manufacturers to enhance the reliability/availability of their equipment, many Safety-Critical Preventive Maintenance (SCPM) tasks will be required as a means of detecting safety-significant latent failures, which would otherwise remain latent until another subsequent failure resulted in a potentially hazardous event. The SCPM tasks are a direct result of performing safety analyses on all required subsystems. The Contractor shall use a clear and deliberate method to identify all SCPM tasks in the PM plan.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION - NOT USED

END OF SECTION 27 05 56