STATE OF NEW JERSEY
DEPARTMENT OF TRANSPORTATION
TRENTON, NEW JERSEY 08625

METRIC SPECIFICATIONS FOR A CLOSED LOOP TRAFFIC SIGNAL CONTROL SYSTEM

N. J. Specification No. EBM-CL-2   Effective Date: July 1, 2001

New Jersey Department of Transportation Specifications for a Microprocessor Based Closed Loop Traffic Signal Control System.

The purpose of these specifications is to describe the minimum acceptable design and operating requirements for a microprocessor based closed loop traffic signal control system.

GENERAL - I

1-1   For the purpose of these specifications, a system is defined as a group of intersections under the control of an on-street master. However, in contracts to which these specifications apply which contain more than one on-street master, the word "system" will be used to describe the operation of each subsystem in the contract.

1-2   The system shall consist of the following:

   A.   An operator console, maintenance console, and engineering console in conformance with the current New Jersey Department of Transportation Specification No. EBM-OC-1, No. EBM-MC-1 and No. EBM-EC-1 respectively.

   B.   An on-street master in conformance with the current New Jersey Department of Transportation Specification No. EBM-OSM-1.

   C.   Local controller assembly in conformance with the current New Jersey Department of Transportation Specification No. EBM-TSC-8CL.

   D.   A communication server and a communication link from the operator console to the communications server shall be in conformance with these specifications.

   E.   A communication link from the on-street master to the Local controller assembly shall be in conformance with these specifications.

1-3   The system shall use the components specified in paragraph 1-2 in a "Building-Block" fashion that will allow future expansion of the system to its maximum capacity without modifications to the operator console, communications link or on-street master.

The capacity of the system is as follows:

A.   Each on-street master shall control a minimum of 30 local intersection controllers.

B.   Each operator console shall control a minimum of 8 communications servers. The operator console shall act as the system file server with the maintenance console and engineering consoles and workstations networked to the file server.

C.   Each communications server shall control a minimum of 8 on-street masters.

D.   The communication link between the on-street master and the local intersection controller shall be capable of providing the necessary two-way communications for a minimum of 30 local controllers. The communication link between the operator console and the communications server shall provide two-way communication for a minimum of 8 communications servers. The communication link between the operator console and the maintenance console shall provide two-way communication for maintenance reports. A communication link shall be provided between the operator console and engineering console and also between the workstations.

1-4   The system shall be capable of operation as traffic responsive, time of day (TOD), crossing arterial synchronization, contiguous systems or in a manual mode of operation. The system shall also be capable of incident management mode of operation.

1-5   The on-street master provides the computational power to provide traffic responsive operation. The on-street master, operator console, maintenance console and/or engineering console provide monitoring and data uploading/downloading capability and the local intersection controllers implement the selected traffic pattern.

1-6   The system shall include backup capabilities which will allow for a satisfactory level of system operation from stored timing plans should either the communication link or on-street master fail.

1-7   The system shall include all cabling, connectors, cards, and other ancillary equipment required for interconnection of the processors and peripheral equipment to perform the functions as required by these specifications.

SYSTEM CAPABILITIES - II

2-1   Cycles, Splits, Offset, Flash, Free - The system shall be capable of as a minimum, implementing any of four (4) cycles, four (4) splits and three (3) offsets for a total of 48 system timing plans.

The system shall have the capability of implementing system flash and system free operations. The commands to implement these modes of operation shall be transmitted to the local intersection controllers via the communications interface.

2-2   Intersections - The system shall have the capability of controlling a minimum of 30 intersections.

2-3   System Detectors - The system shall have the capability of accepting and processing data from a minimum of 30 system detectors via the TDM/FSK communications link. Each local intersection controller communications interface shall have the capability of transmitting the data from up to 16 system detectors.

2-4   Communication - The system shall have the capability of two-way communications through the operator console to the maintenance console, engineering console and/or the workstations to the field equipment in the following levels:

   A.   System wide - instructions and commands to be carried out by all intersections. It shall not be possible to place the system into a flash operation.

   B.   Subsystem wide - instructions and commands to be carried out by all intersections in a subsystem.

   C.   Local Intersection - instructions and commands to be carried out by an individual intersection.

   All information downloaded to the on-street master and local controllers shall be error checked by the communication system. A positive indication shall be returned to the console that the data was transmitted and received correctly.

2-5   Communication - The system shall have the capability of two-way 9 600 baud communications, minimum of 2 400 baud, from the operator console and the communications server. Also, the system shall have the capability of two-way 9 600 baud communication, minimum of 2 400 baud, from the operator console and the maintenance console, engineering console and/or workstations. The communications from the server to the on-street masters shall be a fiber optic network with fault tolerant system performance. The communication system shall be in conformance with the latest revision of New Jersey Department of Transportation Specification No. EBM-OC-1.

2-6   Downloading - The system shall have the capability of downloading all system information from the operator console to the maintenance console, engineering console, or workstations to the communications server and the on-street master and via the on-street master to each local intersection. The data shall be loaded into the operator, maintenance console, and/or workstations via a keyboard or mouse with CRT menu and prompt features. The maintenance console and workstations will communicate with the system through the operators console.

   The local controller shall acknowledge that all data downloaded has been correctly received. In the event that this acknowledgment is not received, the system shall automatically retransmitted this data. The system shall continue to re-transmitted data until either a successful transmission has occurred, or a programmable number of retries has been reached. If the maximum number of retries has occurred without a successful transmission, the system shall report this fact to the operator console.

2-7   Uploading - The systems shall have the capability of uploading to the operator via the communications server from on-street master, all subsystem data and intersection timing data stored in each local intersection controller. This data will available to the maintenance console, engineering console and workstations through the network.

2-8   System Monitoring of Local Intersections - The operator, maintenance, and engineering consoles and/or workstations shall be capable of monitoring the operation, include monitoring of all functions and error conditions of each local intersection. The information needed to perform this function is transmitted from each local intersection to the on-street master and then to the consoles. The system shall be capable of monitoring at a minimum, the controller error status, the four controller special functions, the failure of a controller to respond to the system or consoles and the local flash mode caused by the conflict monitor.

2-9   System Monitoring of System Performance - The operator, maintenance, and/or engineering consoles shall have the capability of monitoring the system performance. System parameters shall be stored in the on-street master on a real-time basis. Periodically, this data shall be transmitted to the maintenance console for maintenance report generation and to the operator/engineering console for engineering report generation.

2-10   System Monitoring of Equipment - The operator, maintenance, and engineering consoles and/or workstations shall be capable of monitoring the operation of all equipment in the system. The system shall be capable of identifying malfunctions, and failures. Upon identification of a failure, the system shall update the system log, activate the visual and audible alarms and display the condition on the operators console. The failed equipment shall be taken off-line and the system operation adjusted if required.

2-11   System Monitoring of Communications - The operator, maintenance, and engineering consoles and/or workstations shall be capable of monitoring the operation of all communications in the system. The communications monitoring shall be performed on the entire system, from the local controllers to the operators console. This test is in addition to the testing performed in the communications server, although the system must recognize failures found in the server. The monitoring of bit error rates and performance test, such as throughput shall be for the entire system and include the fiber optic communications and equipment. The communications shall provide for an undetected error rate of less than 1 in 64 000. The monitoring as a minimum shall include the following;

        A.   Communications data errors shall be monitored by a continuous calculation of the bit error rate of each communications link. When the bit error rate is below a programmable system threshold value, the communications system shall be identified as marginal. Should the error rate fall below another programmable system threshold value it shall be identified as failed. Upon identification of a marginal or failed condition, the system shall update the system log and display the condition on the operators console. The log and display shall identify the nature of the as bit error rate.

B.   Communications failures shall also be identified through the failure of a controller communicating to a Master on a communications link. The system shall update the system log and display the condition on the operators and engineering console.

2-12   Traffic Analysis - The operator console shall have the capability of performing timing optimization and traffic analysis described in New Jersey Department of Transportation Specification No. EBM-OC-1. All data required to optimize the timing that is part of the system database shall be stored and/or translated into a format and file structure used by these programs. Translators shall be supplied to return the data to the closed loop system from the optimization programs. It shall not be necessary to manually reenter any data that is available in the closed loop system into the optimization programs. It shall also not be necessary to reenter the results of the optimization into the closed loop system.

TRAFFIC RESPONSIVE MODE - III

3-1   Traffic responsive operation of the system shall be controlled by the on-street master using traffic volume, speed and occupancy data from the system sampling detectors located throughout the system. The traffic responsive operation shall conform to the requirements of the current New Jersey Department of Transportation Specification No. EBM-OSM-1, For a Closed Loop On-street Master.

TIME OF DAY (TOD) MODE - IV

4-1   The system shall have capability of implementing time of day, day of week and week of year control using an internal clock that follows the AC line frequency. The time of day mode shall conform to the requirements of the current New Jersey Department of Transportation Specification No. EBM-OSM-1, For a Closed Loop On-street Master.

CONTIGUOUS SYSTEM CONTROL MODE - V

5-1   The system shall have an alternate mode of operation whereby coordination is established between contiguous systems. This feature shall be used to allow the coordination of a number of systems. Synchronization of the on-street masters shall be a function of software and not hardware. The contiguous system control mode shall conform to the requirements of the current New Jersey Department of Transportation Specification No. EBM-OSM-1, For a Closed Loop On-street Master.

CROSS ARTERIAL SYNCHRONIZATION - VI

6-1   The system shall have an alternate mode of operation whereby both the cycle selection and synch pulse originate from an external source to provide coordination between crossing arterial systems. The cross arterial synchronization shall conform to the requirements of the current New Jersey Department of Transportation Specification No. EBM-OSM-1, For a Closed Loop On-street Master.

MANUAL CONTROL MODE - VII

7-1   Manual control of the system shall be accomplished through the on-street master keypad. The manual control mode shall conform to the requirements of the current New Jersey Department of Transportation Specification No. EBM-OSM-1, For a Closed Loop On-street Master.

TRAFFIC INCIDENT MANAGEMENT CONTROL MODE - VIII

8-1   The system shall have an alternate mode of operation that allows for defining system criteria for implementation of system operation plans in response to traffic incidents. This operation shall conform to the requirements of the current New Jersey Department of Transportation Specification No. EBM-OSM-1, For a Closed Loop On-street Master.

SYSTEM CONTROL MODE - IX

9-1   The system shall provide for the control of the on-street master from the operator, maintenance, and/or engineering console via the communications link. The system control mode shall conform to the requirements of current the New Jersey Department of Transportation Specification No. EBM-OSM-1, For a Closed Loop On-street Master.

PREEMPTION CONTROL MODE - X

10-1   The system shall have capability of implementing preemption control of the system, subsystem or intersection. The control shall allow the system to receive a preemption status from a local controller and shall cause the system to implement a preemption timing plan. The preempt shall include a high level preempt for railroad and emergency vehicles. In addition a low level preempt shall be provided for bus and transit vehicles.

PRIORITY OF CONTROL - XI

11-1   The order of priority of control shall conform to the requirements of the current New Jersey Department of Transportation Specification No. EBM-OSM-1, For a Closed Loop On-street Master.

SYSTEM REQUIREMENTS - XII

12-1   Security Code - A security code capability shall be included in the operator, maintenance, and engineering consoles. This code comprised of the operators name and a personal password shall prevent any change to the data or to the mode of operation unless the current security code is first entered. The security code access in the system shall be assigned to each user by a minimum of ten varying degrees of privileges. The lowest shall be no privileges followed by read and read and write. The highest privilege shall be the system administrator who shall have the capability to add, change, or delete user privileges.

A log shall be kept by the system of the time and date of all access to the system. The system shall provide a report when requested. The log shall be capable of storing, as a minimum, the last 100 persons to log in their access code.

12-2   <u>Programming Verification</u> - The system shall have the capability of automatically verifying all data contained in the memory of the on-street master or local controllers. The data shall be verified against the system data base resident in the disk files. This function shall be selectable from the operator, maintenance, or engineering console to verify the traffic coordination plans of the on-street master and the timing schedules of the local controllers.

12-3   <u>Coordinated Phase Control</u> - It shall be possible to change the coordinated phase(s). The command to do this shall originate in the operator, maintenance, and/or engineering console and be passed to local intersections via the on-street master.

DOWNLOADING CAPABILITY - XIII

13-1   The system shall have the capability of downloading system and timing data from the operator, maintenance, and/or engineering console to each local intersection controller assembly via the on-street master. The system operator using the console keyboard shall have the capability of entering the timing and system data via the keyboard into the RAM memory. Upon command, the console shall transfer this data to the selected controller assemblies. When in the download mode, normal interconnected operation shall not be required.

13-2   The information to be transmitted shall include all interval times as defined in the NEMA Standards TS1-1989, Section 14. The Min Green, Yellow, Red and Ped Clearance times shall be subject to predefined minimums.

13-3   In addition to the interval time, the following parameters shall also be capable of being downloaded.

        A.   Offset Times (3)
        B.   Force Off Associations and Times*
        C.   Permissive Phase Associations and Times*
        D.   Time Clock Information
        E.   Time, Day and Date
        F.   Security Code
        G.   Detector Delay
        H.   Initialization Phase(s) and Interval(s)
        I.   Last Car Passage Control
        J.   Dual Entry Operation
        K.   Offset Seeking Mode
        L.   Dwell Time*

        *If the controller has the capability of calculating the necessary parameters, the downloading is not required.

UPLOADING CAPABILITY - XIV

14-1   The system shall have the capability of uploading all of the data from each local
        controller unit to the operator, maintenance, and/or engineering console. The data that
        shall be available for uploading is specified in section 13. During the uploading
        operation, the normal interconnected operation may be suspended.

TIME CLOCK CORRECTION - XV

15-1   The operator and engineering console shall have a real time clock that maintains time to
        the nearest second, hour, day, date and year. It shall be used to set the clocks in the
        on-street master and the local intersections on command.

15-2   The operator and engineering console shall have the ability to be programmed to check
        and correct the clocks in the on-street master at regular intervals not less than once
        every 24 hours, provided the consoles are in a monitoring mode of operation. The on-
        street master shall backup the local intersection clocks at least every fifteen minutes.
        This function shall be altered to conform to the requirements of contiguous system
        control mode of operation.

OPERATOR INTERFACE - XVI

16-1   The operator, maintenance, and/or engineering console shall utilize the keyboard and
        monitor as the primary interface between the operator and the system. The interface
        displays shall include as a minimum the current time and date, and a reference to the
        report title and the data being displayed. The interface display shall also display a
        reference that designates the State Route, Municipality, system section, intersection 7
        digit number and intersection cross street.

        All terminology used in the system and the displays shall be in terms familiar to a
        person skilled in traffic engineering.

16-2   A graphical windows interface with pull-down menus approach shall be utilized with the
        appropriate prompts to allow a non-computer skilled operator using keyboard and
        mouse inputs to run the system. The menu shall allow the operator to select a menu
        option by pointing with the mouse or by entering the first letter of the selection. The
        menu may be at the top of the monitor or appear as a "side bar" menu on the right side
        of the monitor. The system shall provide for the operator to select additional windows,
        delete existing windows, and change the order in which windows are displayed. The
        operator shall also have the ability to shrink or expand the size of all windows.

16-3   SVGA graphics shall be used to display much of the information required for system
        operation. The graphics shall include as a minimum maps of the system, maps of
        sections of intersections that operate together, block diagrams, the fiber optic
        communication cable routing, schematics, plotted data and intersection plans as
        detailed as the contract plans. The graphic database shall be linked to the real time data
        and system status and displayed in or on the graphics.

16-4   Intersection and system parameters shall be displayed in a tabular form with forward
        and back paging capability. It shall be possible to highlight a particular parameter for

easy changing. It shall be possible to automatically calculate Permissive and Force Off times from the cycle and split times.

16-5   The interface shall provide for system control display and data entry within a single integrated environment. The operator shall not be required to exit one program and enter another to perform a different function. The system shall be capable of displaying multiple data windows in overlapping color displays, in a windows type display environment.

16-6   The interface shall provide menu selections that shall enable the operator to accomplish all changes to the database and to enter signal timing. The procedures for updating the database shall be the same for all types of data. The interface shall provide for an operator with appropriate privileges to access, view, modify, summarize, plot, and store every data element in the system database either in RAM or stored in the system files.

16-7   The interface shall provide the capability of generating, in addition to the graphic displays and map displays, spreadsheet displays. The data included in these displays shall be updated within two seconds of the receipt of new data values by the system database, except for the display of signal status and timing. The spreadsheet display shall be used to enter, review and edit numerical data.

DATABASE - XVII

17-1   The System shall include a graphic database for all intersection and system maps. The maps shall be prepared by utilizing Micro-Station Drafting software as provided for in the operators and engineering console specification. The system may translate the drawings for it's use, however all drawings shall be provided to the system and must be exported from the system in a .dgn format.

17-2   The graphic database shall also contain as-builts of all wiring diagrams, cabinet layout plan and intersection construction plan for all intersections contained in the contract to which this specification applies.

17-3   The System shall include a database for all maintenance activities at each intersection. The database shall provide data fields for all normal and emergency maintenance and will include pop-up windows for default values. The maintenance Repair Log report shall include as a minimum the intersection, type of call, equipment type, equipment ID, start date and time, end day and time, technician name, trouble reported, trouble found, and comment.

17-4   The System database shall also include an inventory control database software with an SQL interface. The software shall through bar codes on all traffic signal equipment provide for inventory control. The database shall provide reports indicating the location of all equipment and the stock levels. The system shall reference the Department's 7 digit intersection number whenever the intersection is referenced. Inventory report to include as a minimum the intersection, inventory number, equipment type, manufacturer, model, serial number, equipment status, price, purchase date, install date, and warranty length.

17-5   The System database shall be managed by database software with an SQL interface. This format will be required for all data files including but not limited to all controller data, maintenance data, records of all significant system activities and traffic data. The system shall be capable of generating, structuring and reporting key information in a user defined format which indicates the system performance. This information shall be displayed on the maps and in system reports.

COMMUNICATIONS LINK - XVIII

18-1   Intersection Communication - The system shall have the capability of communicating with up to 30 intersections via a single mode fiber optic interconnect utilizing Time Division Multiplex/Frequency Shift Keying techniques (TDM/FSK). Each intersection shall be equipped with a TDM/FSK communications module capable of receiving commands and data from the on-street master and transmitting system detector data and local controller status to the on-street master.

18-2   Master Communication - The on-street master shall have the capability of two-way communications with the operator console and the networked maintenance and engineering consoles by means of a single mode fiber optic communications server. An RS 232 port on the on-street master shall be used as the connection to the server.

18-3   Detector Communication - The system shall have the capability of accepting and processing data from up to a total of 30 system and counting detectors via the TDM/FSK communications link. The system detectors shall be connected to the Communications Module at any twelve of the local intersection controllers. Each local intersection controller communications module shall have the capability of transmitting the data from up to 16 detectors.

REPORTS - XIX

19-1   Maintenance Reports - The system shall have the capability of providing from the maintenance console reports of all maintenance related system operations. The reports shall be presented in a format that identifies the intersection or location of a failure. The Department's 7 digit number assigned to the location shall also be included in the report along with the time and date. All data from these reports must be available in an "SQL" file format.

19-2   The system shall provide as a minimum maintenance reports for the following:

A.   Loss of Communications
B.   Communication Reestablished or Repaired
C.   Controller Malfunction
D.   Special Function Failure
E.   Detector Failure
F.   Cabinet Door Open
G.   Monitor Flash - Voltage or Conflict

     H.   Monitor Status Changes
     I.   Manual Flash
     J.   Loss of Cabinet Ventilation
     K.   Change of Operation Due to Detector Failure
     L.   Manual Control Enabled

19-3   The system shall provide maintenance repair log reports which can be sorted by the failure location, equipment type, start & end date and time, technician name, trouble found, trouble reported, and comment.

19-4   The system shall provide a maintenance and an engineering Pager Alarm. The system shall be capable of a pager alarm which shall dial a pager numbers to notify a maintenance technician and the system manager, of the failure.

19-5   The maintenance report for controller malfunction will be provided as a minimum for the following conditions:

     A.   When the controller fails to respond to cross street demand.

     B.   When the controller fails to conform to the current coordination plan in effect.

19-6   <u>Failure Log and Display</u> - The system shall automatically maintain a log of all system failures. The log shall record the time, date, and type of failures and marginal operating conditions. The log shall also record the time at which the failure is acknowledged and the time of its repair. A display of the system status shall be displayed indicating the operation status of all equipment by exception.

19-7   <u>System Log</u> - The system shall automatically maintain a log of all system events associated with operator activities including all failures, changes in the system operating mode and database changes.

19-8   <u>Engineering Reports</u> - The system shall provide from the operators and engineering console reports of all maintenance functions as required in paragraph 19-2 and in addition all traffic data reports.   These reports shall include reports of the system detectors and counting detectors. The reports shall consist of the actual volume counts at each location for an operator defined time period in 15 minute increments.

19-9   The system shall provide engineering reports of the thresholds and computed values when the system is in traffic responsive mode.

19-10 The system shall provide an engineering report whenever a coordination plan is changed in traffic responsive mode.

19-11 The system shall provide an engineering report whenever the mode of operation is changed, i.e. from traffic responsive to time of day.

19-12 The system shall provide an engineering and maintenance report for all data stored in the random access memory of the on-street master and the local intersection controller.

A report will automatically be issued with this information each time the RAM memory is changed from the consoles. The report will contain the time, date, and operator's name.

TRAINING - XX

20-1   As part of the closed loop system and prior to the observation period, training shall be provided for the Department's engineering and maintenance staff, at a facility provided by the Department, as follows:

A.   Maintenance Training - The training shall be provided for a minimum of 32 hours for a minimum of 5 maintenance personnel. The training shall include the operation of the system, maintenance and repair of on-street master, etc.

B.   Engineering Training - The training shall be provided for a minimum of 8 hours for a minimum of 20 engineering personnel. The training shall include a complete demonstration of the system, emergency procedures, operation, trouble procedures and equipment operation.

C.   Operation Training - The training shall be provided for a minimum of 32 hours for a minimum of five (5) operation personnel. The training shall include the operation of the system and subsystem.

20-2   Training shall also be provided for all software. The training will be given to a minimum of ten (10) engineering personnel and will provide for a minimum of 40 hours of training each. The engineer will approve the training.

20-3   The schedule and the content of all training shall be submitted for approval.

TESTING - XXI

21-1   The equipment shall demonstrate in the presence of the Manager (as defined in section 22), to insure that the equipment supplied and installed functions in full compliance with this specification and the specifications to which this maybe part. For this purpose, a requirement for a program of testing at the unit, sub system, and system levels to be performed is defined. The tests can be separated into factory test, system function test, on-site, overall operational function test, an observation period, and a final system test.

A.   All test procedures and equipment other than standard factory production shall be furnished and maintained by the manufacturer. The manufacturer shall submit all generated test documentation containing proposed test requirements, test procedures, test equipment, report forms and expected results to the Manager for review at least 30 days prior to performing any tests. The Manager shall have the sole authority to determine the acceptability of proposed tests. Rejected test procedures shall be revised and resubmitted.

B   Tests shall be performed only on conditionally approved equipment using approved test procedures. The Manager shall be notify at least 30 days in advance of the time and place (within the 48 contiguous states) at which the tests will take place to enable the Manager or his representative to witness them. If

requested by the Manager, any given test shall be postponed for a period of up to seven (7) calendar days for each occurrence in order to accommodate the schedule of the Manager. Such requests for postponements shall be expected by and shall not be grounds for extensions of the completion times. A certified copy of each test report shall be submitted to the Manager within 2 weeks following completion of the test. Satisfactory completion of a test shall not relieve the Manufacturer of the obligation to correct defects in design, materials or workmanship which may be detected during subsequent tests or at any time prior to final acceptance.

21-2   FACTORY TESTS. - The Manager will witness this test. No working drawings on the digital microprocessor unit will be approved until this test has been satisfactorily completed.

A.   OPERATOR AND MAINTENANCE CONSOLE TESTS. The operator and maintenance consoles are to be demonstrated to insure they are capable of executing the required software. This demonstration shall consist of running, as a minimum, the working version of the communication and traffic responsive subroutines of the system. These portions or closed loop traffic control system program shall be loaded and executed in the digital microprocessor unit in such a manner that the results of the demonstration indicate worst case processing time of the digital microprocessor unit. In addition, the test shall demonstrate that all other off-system software required by the specifications is fully operational and performs all the required functions. The test shall also demonstrate all the network software, communication server software, the long term data storage, printers and standby power system are fully operational and in compliance.

B.   VOLTAGE AND ENVIRONMENTAL TESTS. These tests are intended to demonstrate that the equipment units and subsystems have been designed and manufactured in accordance with the specifications. Design tests shall be performed only on representative samples selected at random to prove compliance with required variations in temperature, humidity, and input voltage.

1.   Manufacturing tests using factory test requirements shall be performed on all units and subsystems at normal temperature, humidity and voltage to detect faulty components and to verify that no errors have occurred during manufacture. This will demonstrate the manufacturing tests and the quality control procedures.

2.   The Manager will select at least one of each or 10 percent of the total field equipment supplied, whichever is greater, for non-destructive temperature, humidity and voltage design tests. Field equipment shall be defined as all equipment which will be installed in the controller cabinet at each intersection. The field equipment shall consist of but is not limited to, controllers, on street master, modems, monitors, and loop sensors. These test units shall operate properly for two hours under the minimum specified temperature, humidity and voltage (i.e., -34 °C, 10 percent relative humidity, 98 volts) having been stabilized at these conditions. Following this test, they shall operate properly for two hours under the

maximum specified temperature, humidity and voltage (i.e., 74 °C, 95 percent relative humidity, 132 volts) having been stabilized at these conditions. Following such tests, they shall operate properly for two hours at 21 °C with an input voltage of 115 volts AC.

3.   The Manager will select either the operator or maintenance console for nondestructive input voltage design tests. These units include but are not limited to the digital microprocessor unit, monitors, keyboard, printer, disk drives, communication equipment and standby power system. The test units shall operate properly using factory test requirements for two hours at the extreme ranges of 115 volts plus or minus 19 percent input voltage. Following these tests, the units shall operate properly using factory test requirements for two (2) hours at the specified nominal input voltage. All of these tests shall be conducted at 29 °C.

4.   Every unit of equipment furnished for the project shall be individually tested in the factory for proper operation at normal temperature and voltage using factory test requirements.

C.   COMMUNICATION TEST. A factory communication test for message security (throughput and undetected erroneous messages) shall be performed.

1.   This test shall be performed at the on-street master manufacturer's facility or elsewhere as approved by the Manager. During this demonstration, at least two on-street masters shall communicate with a minimum of four local intersection controllers. The message security test shall be performed using twisted pair cable upon which has been introduced the maximum attenuation and noise level specified in the Bell System Technical reference entitled, "Transmission Specification For Voice Grade Private Line Data Channels" for unconditioned voice grade circuits 16 kilometers or less in length.

2.   The manufacturer shall furnish special test devices which, when connected to an on-street master, will cause a received message to be retransmitted to the local intersection controller without changes. In this way, the test devices shall verify by a minimum of 5 million round-trip transmissions that the messages transmitted to the on street master are returned from the local intersection controller correctly. The rate of undetected erroneous messages shall not exceed 1 in 64 000 and the throughput of valid messages shall amount to at least 99.9 percent.

3.   The software necessary for the computer to execute this test will be supplied prior to utilization.

4.   The test shall then be repeated utilizing single mode fiber optic cable again the system will be tested with the maximum allowable loss on the cable.

D.   SYSTEM TEST. The manufacturer shall perform a factory test of the closed loop traffic control system. The manufacturer shall demonstrate the operation of the operator's console with two on street masters and four controllers.

1.   The test shall demonstrate the graphic user interface and the SVGA representation of graphics of a minimum of four intersections, these shall be typical, unless these specifications are part of the contract, then they will be from that contract.

2.   The graphic representation of a subsystem shall also be demonstrated.

3.   The test shall demonstrate and provide documentation of all reports generated by the system.

21-3   ON-SITE TESTS. These tests are intended to demonstrate that the equipment, units and subsystems have been transported to the installation sites without damage and have been properly installed and interconnected to form a fully integrated, functional system. Where feasible, two or more tests may be conducted simultaneously.
All test devices necessary to conduct these tests shall be furnished and shall become the property of the State.

A.   The following specific tests shall be performed at the installation sites:

1.   Operator Console Tests. Following successful completion of the factory tests, all of the operator console equipment shall be shipped to site in Newark where the operator console tests shall be conducted. At this facility, the equipment shall be connected together as a system. Using this setup, tests shall perform to demonstrate that the digital microprocessor unit and its peripheral equipment function properly, utilizing manufacturer's supplied diagnostic software.

2.   Maintenance Console Tests. Following successful completion of the factory tests, all of the maintenance console equipment shall be shipped to the traffic signal maintenance shop site in Newark.   At this facility, the equipment shall be connected together as a system. Using this setup, tests shall perform to demonstrate that the digital microprocessor unit and its peripheral equipment function properly, utilizing manufacturer's supplied diagnostic software.

3.   Engineering Console Tests. Following successful completion of the factory tests, all of the engineering console equipment shall be shipped to site in Trenton where the engineering console tests shall be conducted. At this facility, the equipment shall be connected together as a system. Using this setup, tests shall perform to demonstrate that the digital microprocessor unit and its peripheral equipment function properly, utilizing manufacturer's supplied diagnostic software.

4.   Local Equipment Test. Counting and System Detector Test. in addition to standard tests conducted by the State, the contractor shall conduct tests

to demonstrate that these detectors have been installed and are operating in accordance with the requirements of these supplementary specifications. For this purpose, a 100 cubic centimeters motorcycle furnished and driven by the contractor shall be used to test a 25 percent sample of detectors as selected by the Manager. as a minimum, the tests shall demonstrate the following:

a.   Inductance - The Manager will verify the inductance of all loop detectors. For this purpose, the contractor will provide two (2) induction meters which will become the property of the State. The meters shall be mounted in a heavy duty portable case. The unit shall be battery operated, and be capable of measuring an embedded induction loop having an inductance between 20 and 2 000 microhenries. The meter shall provide a means of checking the frequency of and operating the detector's electronic unit. The meter shall be capable of reading directly frequencies of 25 kilohertz to 100 kilohertz. There shall be a battery test pushbutton. The meter shall be complete with all test probes and an A.C. adapter.

b.   Sensitivity - The detector shall detect a motorcycle passing over the loop at approximately 8 kilometers per hour.

c.   Hold - Roll the motorcycle into the center of one of the loops at approximately 8 kilometers per hour and initiate timing. The detector shall hold the detection for 3.5 minutes or longer.

d.   Long Detection and Recovery - Using a sensitivity setting that will consistently detect a motorcycle, park an automobile over the test loop for 40 minutes. The automobile shall be detected throughout this period. At the end of the 40 minute test interval, drive the automobile away. The detector shall drop out as the vehicle clears the loop. Immediately after the automobile departs, roll a motorcycle into the center of the test loop. The motorcycle shall be detected and held for at least 3.5 minutes.

e.   Adjacent Lane Rejection - Using the lowest sensitivity that produces detection, rapidly push a motorcycle into the center of the test loop. wait about 10 seconds, then carefully park an automobile 900 millimeters as measured from the loop wires to the nearest point of the tire track. immediately remove the motorcycle. The detection shall drop out as the motorcycle is pulled away.

B.   Controller test. -The contractor shall demonstrate to the Manager that each controller has been correctly installed and operates in accordance with the requirements of these supplementary specifications and this section of the standard specifications.

As a minimum, the contractor shall test the following signals (if available) at the appropriate cabinet terminal block:

	Per Controller	Per Ring	Per Phase
inputs	Call to non act 1 & 2	Max inhibit	Veh det
	Test a & b	Stop time	Ped det
	Minimum recall	Force off	Hold
	Walk rest modifier	Red rest	Phase omit
	Manual advance	Omit all red	Ped omit
	Manual control enable		Ped recycle
	Lamps off	Max 2	
	External start		
outputs	flashing logic	Status bits	red, yellow, green
	Voltage monitor		Walk, don't walk
	5 spares		Phase on
	Overlap A B C D		Phase next
			Phase check

1.   The contractor shall test the conflict monitor by introducing a conflicting indication. All conflicting indications shall be tested, also absence of red indication.

2.   The contractor shall demonstrate controller start-up and initialization.

3.   The contractor shall also demonstrate that the local controller is capable of uploading and downloading the required data to an on-street master prior to assumption of maintenance.

C.   On-Street Master Test. Completing the above test on all controllers in a subsystem, the contractor shall perform the following test:

1.   The contractor shall demonstrate that the on street master has been correctly installed and operates in accordance with the requirements of the specifications. The test shall demonstrate that on street master is capable of uploading and downloading the required data to the local controllers in its subsystem. The test shall also demonstrate the operation of the on street master with respect to the accumulation of traffic data.

21-4   SYSTEM FUNCTION TESTS.

After the contractor has successfully completed all of the above tests on all subsystems, the contractor will incorporate the closed loop traffic control system software package into the system and will conduct the system function tests to verify that the system can perform all its required functions. The contractor shall have a qualified representative on-site during these tests to correct any equipment failures which may occur. The system function tests will be conducted using the test controller housing and display unit and one fully-loaded communication line.

A.   Traffic Control Operations. The contractor will conduct a multi-part test to verify that the system properly affects traffic control operations. The term "test controller" herein refers to a complete controller which the contractor will supply and temporarily install at an intersection with an on street master. The test controller will include a display unit to simulate eight phase operation. This test controller and display unit will become the property of the state. The contractor will be compensated under the item closed loop traffic control system for furnishing the controller and display unit. The contractor shall connect the test controller to the interconnected cable system. The contractor shall temporarily connect the interconnect cables at the furthest intersection from the on street master to the "spare" interconnect cables. The connection shall form a loop from the on street master to the furthest intersection and back to the "test controller" at the on-street master intersection. These tests are as follows:

1.   Monitoring: The contractor will initiate monitoring of local controller operations. This portion of the test is intended to demonstrate the system's ability to monitor the complete intersection feedback functions including those that indicate phase green, local preempt conditions, flashing operation, vehicle actuations, special functions, pedestrian calls and walk indications.

2.   Standby: The contractor will command the system to place the test controller in the standby mode and will verify that this command has been effected.

3.   On-line: The contractor will command the test controller to the on-line state and will verify that it is brought on line through a pickup and transition sequence and operates according to the timing plan selected.

4.   Communications failure: The contractor will disconnect the field communication line to the test controller and will verify that this malfunction is properly sensed, responded to and reported by the system. The contractor will also verify that the test controller has reverted to time of day mode.

5.   Acknowledge: The contractor will acknowledge the reported communications failure and will verify that the system has changed the status of the equipment.

6.   Repair: The contractor will repair the reported communications failure and will confirm that the corresponding status change has occurred.

7.   On-line operation: The contractor will reestablish on-line operation of the test controller in the operator console in response to commands issued by the system.

8.   Timing plan change: The contractor will direct the system to change the timing plan of the test controller from the one in operation to another

timing plan and will confirm that the resultant command has been implemented.

9.   Special function command and monitoring: The contractor will activate the special function command(s) and will verify that the auxiliary device is controlled properly by the special function. The contractor will verify the activation of the special function command(s). the contractor will also actuate the special controller functions and verify the system response.

10.   Controller malfunction: The contractor will locally disable the controller's ability to respond to on street master. The closed loop traffic control system will sense the controller's inability to obey commands and report a controller malfunction.

B.   Detector Processing Operations. The contractor will conduct tests to demonstrate that the detector equipment is properly integrated into the closed loop traffic control system and that the detector data sensed in the field is properly transmitted, processed and reported by the system. To accomplish this the detector simulator furnished by the contractor will be connected to the local intersection controller system loop input at the test location to provide a controllable source of data. The detector simulator shall become the property of the State.

The detector simulator will be set to simulate eight traffic volumes with corresponding occupancies and this data will be input to the eight circuits of the controller unit designated for detector information. The simulator will be permitted to run for 30 minutes and the resultant data will be output to monitor and printed on a report.

1.   Detector malfunction: The detector data for three of the detectors will be set to zero. This condition will be permitted to exist for 30 minutes and the closed loop traffic control system will be set up to report suspected malfunction at these three locations.

2.   Threshold checking: The threshold checking capability of the system will be verified by resetting the threshold in increasing increments from 0 to 1 800 vehicles per hour while observing the resultant state changes that occur to the system and the resultant reports generated.

C.   Closed loop traffic control system data operations. In order to establish that the closed loop traffic control system operates properly and permits the operator or maintenance staff to examine, modify and restore system data on the disk drive, the following tests will be conducted:

1.   Data modification: The closed loop traffic control system will be commanded to display the menu to make the modification and the local controller option will be selected. The contractor will load, using this option, the data for one local controller whose number shall be selected by the Manager. This data will be examined and one or more elements will be identified for modification. The modified data will be saved on the disk

file and reloaded for subsequent examination. The process will confirm that the data base modification package provides the capability to load, modify, save and reload the closed loop traffic control system data. This will be repeated for up to two additional elements of data.

2.   Printer output: The contractor will direct the closed loop traffic control system to output data on the line printer and will direct the system to print the following data:

    a.   volume counts for all system loops in 15 minute increments.
    b.   volume graphic counts for all system loops in 15 minute increments.
    c.   intersection timing data.
    d.   threshold levels.
    e.   threshold level change points.
    f.   smoothing factors.
    g.   a day timing plan.
    h.   a week timing plan.

3.   Timing plan loading: An optimized time plan provided by the state will be loaded into the closed loop traffic control system. The result of this command is the placement of the timing plan into the system. The contractor will examine this data and exhibit the result to the Manager.

4.   Timing plan implementation: The contractor will direct the closed loop traffic control system to implement the new timing plan in the street. This operation will be observed from the operator console using system reports and from field observations.

5.   Monitoring: The contractor will initiate monitoring of a local intersection controller. The controller shall not be under system control. It is intended that this test be performed at a time of day when the controller changes state under control of the closed loop traffic control system, in order to demonstrate that the system properly monitors the state change.

6.   Transition from balanced to directional state: The contractor will initiate the closed loop traffic control system control and command a subsystem to transition from the balanced state to either the inbound or outbound directional state. The contractor will verify that the transition takes place in an orderly and satisfactory manner, in accordance with the time specified.

7.   Transition from directional to balanced state: The contractor will initiate the closed loop traffic control system control and command a subsystem to transition from the directional state to the balanced state. The contractor will verify that the transition takes place in accordance with the time specified.

8.   System monitor tests. The contractor will conduct the following tests to demonstrate the proper operation of the system monitor unit:

9.   Intersection test: The contractor will command the closed loop traffic control system to display an intersection selected by the Manager.

10.   Subsystem test: The contractor will command the closed loop traffic control system to display a subsystem selected by the Manager.

11.   Threshold display test: The contractor will request that the system exhibit all detectors with the volume below a threshold of xxx vehicles per hour. The Engineer will identify at the time of testing the numerical value to be inserted for xxx and the resultant display will be observed on the monitor.

12.   Intersection data display: The Engineer will select a single intersection status category from the menu and the corresponding data will be displayed on the monitor. This test will establish that the monitor display functions to exhibit intersection-related data.

13.   Detector data display: The Engineer will select one of the detector data displays available from the menu and request a corresponding monitor display. This will verify that detector data can be displayed on the monitor.

21-5   Overall Operational Function Test.

After the successful completion of the system function tests, an operational function test shall be conducted by the Engineer and the contractor to validate the integrated operational characteristics of the system. In this test, the traffic signal system shall be operated continuously for a period of two weeks, as deemed by the Manager, without failure of any major subsystem component. for purposes of this test, the following shall be considered to be major subsystem components:

    engineering console
    operator console
    maintenance console
    computer software
    video monitors
    disk drives
    printer
    1 on street master
    5 percent of the contractor-supplied control equipment
    5 percent of the contractor-supplied detector equipment
    total communative failure of the above two (2) categories
            shall not exceed 7 percent

A.   During this test, the contractor's personnel shall be permitted to replace defective equipment using available spare parts. The operator and maintenance consoles shall accumulate no more than one hour of downtime and the average availability of the peripheral equipment shall exceed 99.5 percent. In the event that equipment failures occur which reduce the availability of individual subsystems below that specified, or more than one repair is required for the digital

microprocessor unit or the peripheral equipment, the contractor shall be required to repeat the test. The Engineer may reinitiate this test whenever the intent of the test is violated. The contractor may initiate a new test whenever he considers it desirable to do so; however, he must have the consent of the Engineer prior to starting the clock for the new period. This test shall be witnessed by the Manager.

21-6   Observation Period.

Upon successful completion of the overall system operational test and the correction of all known deficiencies including minor construction items, a 90-day observation period shall commence. The purpose of this period is to insure that all components of the system function in accordance with the specifications over an extended length of time.

System or component failures that occur during the observation period shall be responded to within 24 hours and corrected as soon as possible by the contractor. Failures which affect any of the major system components defined above for more than 72 hours shall suspend the timing of the observation period beginning at the time of the failure. After the cause of the excessive failures has been corrected, timing shall resume. Any equipment whose infant mortality rate within the first 2 000 hours of operation exceeds 15 percent as determined by the Engineer shall be removed from service and returned to the factory for redesign and retesting at the contractor's expense. Redesigned equipment returned to service shall be accompanied by a manufacturer's report detailing the cause of the failures and the corrective action taken. System or component failures which necessitate a redesign of any component and three or more failures in any one major system component within any 30-day period shall end the timing of the observation period and shall cause the period to be reinitiated when the redesigned component has been installed or the failure corrected. Final acceptance of the work shall not take place until the observation period has been successfully completed and all other aspects of these specifications have been satisfied.

21-7   Final System Test.

The Engineer will be conducting a final system test during the overall operational function test to evaluate the effectiveness of the closed loop traffic control system. This test will not affect the operation of the contractor's equipment.

SYSTEM START-UP AND OBSERVATION - XXII

22-1   As part of the closed loop system during the observation period, traffic data shall be collected in order to provide with the system the following timing plans and patterns:

A.   Weekday and Weekend TOD AM Peak

B.   Weekday and Weekend TOD PM Peak

C.   Weekday and Weekend TOD Off Peak

D.   Weekday and Weekend Traffic Responsive AM Peak

E.   Weekday and Weekend Traffic Responsive PM Peak

F.   Weekday and weekend Traffic Responsive Off Peak

*All timing plans shall be approved by the Bureau of Traffic Engineering

22-2   Also as part of the closed loop system during the observation period, all graphics and data required for the system data base and operation shall be prepared and entered into the system.

DOCUMENTATION AND GUARANTEES - XXIII

23-1   No changes or substitutions in these requirements will be acceptable unless authorized in writing. Inquiries regarding this equipment shall be addressed to the Manager, Office of ITS Engineering, New Jersey Department of Transportation, P.O. Box 613, 1035 Parkway Avenue, Trenton, New Jersey 08625.

23-2   The complete system shall carry a Two (2) year guarantee from the date of operation and acceptance against any imperfections in workmanship or materials.

23-3   The company agrees upon the request of the Manager, Office of ITS Engineering to deliver to the Office, a sample of the equipment to be supplied in compliance with these specifications for inspection and test before acceptance.

23-4   The company shall furnish any and all equipment which they deem necessary for safe and reliable field operation of the system.

23-5   The company shall furnish any and all revisions to the system software for a five (5) year period from the date of delivery. Revisions shall include complete documentation and an explanation of any changes. Revisions shall be submitted with three (3) copies of the software resident on disk.

23-6   All equipment under this specification must be current production equipment and of recent manufacturer, identical models of which are field operational. Untried or prototype units shall not be considered for acceptance.

23-7   Any repairs made by a manufacturer or representative shall be documented and returned with units when warranty repaired. This documentation shall include an explanation of the exact repairs made and identification of parts replaced by part number and circuit number. All warranty repairs must be made within thirty days upon receiving equipment.

23-8   Complete system documentation shall be provided, and shall include as a minimum:

Four (4) complete system operating manuals

Three (3) copies of the operating software resident on disk