TEXAS DEPARTMENT OF TRANSPORTATION
DEPARTMENTAL SPECIFICATION
TO-4055
CLOSED LOOP SYSTEM ON-STREET MASTER UNIT

1.0 Scope

This specification sets forth the minimum requirements for a closed loop system on-street master unit. The on-street master shall implement patterns for the system, using time-of-day use or traffic responsive methods of choosing the system pattern, download patterns to the local controller via the primary communications link, accept patterns downloaded from the central control via the secondary communications link, collect status information from the local controllers, store this information and pattern information and upload this report information to the central control.

2.0 Hardware Design Requirements - On-Street Master Controller

2.1 The controller unit shall be completely solid state and digitally timed. All timing shall be referenced to the 60 Hz power line.

2.2 The dimensions of the controller unit shall not exceed 30.5 cm H, 44 cm W, 30.5 cm D.

2.3 The on-street master unit shall be supplied with 3 connectors, one FSK and two RS 232. Connectors are defined by the TS 2-1998 specification. One RS 232 will be used for systems communications purposes and one RS 232 will be used for laptop connection to run a version of the central control software.

2.4 The controller unit shall be built using one or more circuit boards. All printed circuit boards shall be designed to plug into or out of a mother board or harness within the unit. Power supply, transformers, capacitors, and heat dissipating components are excepted from the above requirements.

2.5 The design shall allow for removal or replacement of a circuit board without unplugging or removing other circuit boards.

2.6 The unit shall be designed so that one side of each board can be completely accessible for troubleshooting and testing the unit while it is still operating. This may be accomplished with extender boards or cables. This need apply to only one circuit board at a time.

2.7 No more than two circuit boards shall be attached to each other to constitute a circuit sub-assembly. Attaching hardware shall use captive nuts or other purchaser acceptable

method to secure the boards together. The boards shall be designed so that the purchaser can test and operate the controller unit with the boards separated.

2.8 No circuit cuts shall be allowed on circuit boards in any of the equipment supplied. Any wire jumpers included on circuit boards shall be placed in plated through holes that are specifically designed to contain them. Jumpers that are tack soldered to circuit traces or are added to correct board layout errors are not acceptable.

2.9 All IC's with 16 or more pins shall be mounted in machine tooled sockets. All sockets shall have two-piece, machined contacts and closed end construction to eliminate solder wicking. The outer sleeve shall be brass with tin or gold plating and tapered to allow easy IC insertion. The inner contact shall be beryllium copper sub-plated with nickel and plated with gold. All sockets shall have thermoplastic bodies meeting UL Specification 94V-0. Other high quality sockets may be acceptable but must have prior approval of the Traffic Operations Division Signal Operations Engineer. Sockets meeting alternate specifications shall be submitted in writing with the bids. Zero insertion force sockets will not be allowed.

2.10 User programmed entries shall be stored and maintained in non-volatile memory. Battery power will not be allowed for this application. Report data may utilize volatile memory.

2.11 The master unit shall be designed to operate properly with the logic ground isolated from the AC neutral (common).

2.12 A high quality keyboard with a rated lifetime of 1×10^6 operations /key shall be provided on the front panel of the controller unit. The keyboard shall be used for programming all user entered timings and settings.

2.13 A direct reading alphanumeric liquid crystal display with back lighting shall be provided on the front panel of the controller unit. The display shall be clearly readable in ambient light including the cabinet light, in full sunlight, or in the absence of light from a distance of 1.0 meters at a 45 angle. The display shall have an automatic time-out feature unless the display has an expected continuous life of 10 years or more, and shall have an operating temperature range of -34° C to +74° C. The display shall blank out approximately 10 minutes after the last keystroke is made.

2.14 The display shall be a minimum 40 character X 4 line display. The bidder may be required to supply literature which demonstrates that all display requirements of this specification are met prior to the awarding of the bid. (If an LCD contrast adjustment is required for visibility at temperature extremes, then the control shall be on the face of the controller unit, adjustable without the use of tools.)

2.15 If used in the design, the vendor shall provide one spare set of all proprietary components including displays, IC's, and PROM's for every ten master units purchased or portion thereof.

2.16 The on-street master shall meet the environmental requirements set forth in Section 2 of the NEMA TS2-1998 standard.

3.0 Program Requirements

3.1 Programming of the master unit shall be by the use of a keyboard and display on the front of the master unit. Programming shall require only simple keystrokes aided by full menu displays.

3.2 Ease of programming through a well organized menu structure and ease in interpreting the display shall be required for acceptance. The menu structure shall contain a main menu which contains options for all sections of the controller on one screen. Each option shall be selectable by a numeric entry. Each subsequent menu shall be a detailed breakdown of one of the previous menu options. Each menu option shall be a descriptive name to prompt the user to the desired section for programming. All entries shall be displayed and entered in plain English. Toggle type entries shall be set by entering YES/NO or ON/OFF responses. Non-alphanumeric symbols and abbreviations used to display information shall be clear and unambiguous in their meaning. Numeric entries shall be in the Base 10 (decimal) number system. Entries in other number bases such as hexadecimal or binary are not acceptable.

3.3 A user selectable four digit (minimum) code shall be available to secure access to timing and configuration of the unit. Display features shall be available without the need to access the unit. The controller units shall be supplied with the code preset to be all zeros (0000). Internal DIP switches may be used to establish codes.

3.4 Instructions for use of the access code shall **not** be provided on the face of the unit.

3.5 A keyboard entered coded command (a series of commands or entries, not a single entry) shall be provided which will set <u>all</u> controller and TBC timings and entries to a default or inactive value. This coded command shall allow new values to be entered without first deleting prior entries.

4.0 Time Clock

4.1 The clock shall use the sixty (60) Hz power line frequency as time base when power is present. The clock operating voltage range shall be 89 to 135 VAC over the temperature range of -34° C to +74° C. A 10-year lithium battery shall maintain the time-of-day clock and digital data during a power outage lasting up to 30 days. Lead-acid, nickel-cadmium, or alkaline batteries are not acceptable.

4.2 The Time Base clock shall be maintained to within ± 0.005 % at 20° C and to within a ± 0.02 % over the specified operating temperature range as compared to Coordinated

Universal Time (WWV) standard for a period of thirty days during periods when AC power is not applied.

4.3 Local time clocks shall be updated, at least once per hour, with a minimum of the following current information: year, month, day of month, day of week, hour and minute.

5.0 Clock/Calendar (Event Schedule) Programming Requirements

5.1 The event schedule is a database at the on-street master which schedules the patterns and modes of operation of the subsystem based on the time of the day, the day of the week, and the week of the year. The possible modes are isolated or free operation, time-of-day operation, and traffic responsive operation.

5.2 The event schedule shall be overridden by a command from central control or the on-street master to force a mode of operation.

5.3 The clock shall be easily set to the year, month, day of month, day of week, hour, minute, and second.

5.4 Automatic Daylight Savings Time shall be available by keyboard entry.

5.5 The dates for fixed and floating holidays and special events shall be keyboard programmable by the user.

5.6 Calendar adjustments for leap years shall be automatic.

5.7 The clock shall store sequences of operations with a minimum of 255 entries and 15 day plans.

Global Time Base Schedule					Actuated Traffic Signal Schedule
entry	months	dates of month	days of week	day plan	Time Base Actions
1	1-12	1-31	1-7	1-15	entry 1 actions
:	"	"	"	"	:
255	"	"	"	"	Entry 255 actions

5.8 The structure and interrelationships of each type of program shall be in accordance with the following paragraphs.

5.8.1 A day plan shall consist of the following:

Hour : Minute Action 1 (time to implement: action to implement)
: : :
Hour : Minute Action 10 (time to implement: action to implement)
where each action is unique. There shall be a minimum of ten actions per day plan.

There shall be a minimum of 15 day plans.

5.8.2 Each action in a day plan shall, as a minimum, consist of a group of the following objects:

pattern (consisting of):
- cycle length
- offset
- split
- MUTCD flash (on/off)
- free operation

special functions 1-8 (on/off)

Any or all of these may be selected within a single action.

5.8.3 An Entry shall consist of time period implemented: day plan, month(s), date(s) of month, and day(s) of week.

5.8.4 A minimum of 255 Entries shall be programmable.

5.8.5 There shall be a copy feature that allows the transfer of entries between day plans.

5.8.6 Other programming schemes that meet the functional intent are acceptable but require approval by the Traffic Operations Division Signal Operations Engineer.

6.0 Subsystem Size

Each on-street master shall control a minimum of twenty-four (24) local controllers. Addition or deletion of an intersection to the subsystem shall be easy to accomplish both at the on-street master and the central control and will not require additional hardware at the central control or the on-street master. The software shall not require any modification for system expansion, except for database modifications.

7.0 System Detectors

7.1 Each on-street master shall access a minimum of forty eight (48) system detectors. These detectors shall be used to select the proper traffic responsive pattern and to create reports at central control. Sufficient diagnostics shall be provided for each system detector input to determine if failure has occurred. A method which could be used may consist of user-defined minimum and maximum occupancy values for the detectors, where any detector with an occupancy value outside of this range is considered to have failed.

7.2 The system shall report volume and occupancy counts based on a user-selectable time period for each detector. As a minimum, the system shall be able to store 15 minutes values for a period of seven (7) continuous days. Storage of these counts may take place

at either the local controller or on-street master. Allowances shall be made for a minimum of 8 system detectors at any local controller, in addition to any local detectors.

8.0 Traffic Responsive Operation

8.1 Each system detector may be assigned to function as a cycle-length, an offset set, or a split set detector. An alternate method may use inbound, outbound, and cross street detectors in the selection of cycle length, offset set, and split set. Each assigned system detector shall have weighting factors for cycle-length, offset set, and split set. A pattern selection parameter combining volume and occupancy shall incorporate a user-selectable time period from 3 to 15 minutes. These pattern selection parameters shall be compared to threshold tables to determine the appropriate pattern. These threshold tables shall include hysteresis effects to minimize pattern oscillation.

8.2 In the event of detector failure, a minimum of one of the following methods of alternative operation shall be employed:

A. Each subsystem detector shall have three default pattern selection parameters to be used if the detector has failed. The particular default pattern selection parameters shall be determined by the time-of-day.

B. A failed detector shall be removed from the pattern selection process and when a user-specified number of detectors fail, the subsystem will go to either isolated or time based coordination mode.

C. A backup detector shall be user-assignable from available functioning detectors.

The minimum time between pattern changes shall be user selectable between 3 and 15 minutes.

9.0 Upload - Download and Monitoring

9.1 The monitoring, downloading, and uploading of data from the on-street master and the local controller will not interrupt the normal operation of these units. The software will include safeguards against the subsystem changing patterns while pattern data is being downloaded.

9.2 A standard DB-9 to DB-25 pin null modem cable shall be supplied to direct connect the controller to a PC or other peripheral device (PDA's) and cable in order to upload and download data as well as monitor the controller operation.

9.3 Downloading Pattern Information

After a pattern is selected, the on-street master shall download the information to the

local controllers necessary to implement the pattern. After the local controller has received the pattern information, it shall verify that the data was transmitted correctly and transmit an appropriate message back to the on-street master. The on-street master shall repeat the transmission data if a data failure occurs. After the second data failure, a data transmission error shall be logged and the system shall continue to operate under the last pattern called for.

9.2 Local Monitoring

For monitoring the operation of the subsystem and the local controllers while at the on-street master the manufacturer shall furnish the necessary hardware and software as required herein to provide for a fully functional system.

9.3 The on-street master software shall also provide a display of real-time subsystem status information on the front panel. This information shall include the display of pattern selection parameters, pattern in effect and mode of operation.

9.4 Monitoring and Reports

9.4.1 The on-street master shall monitor the operation of itself, the local controllers, the primary communications link and the system detectors.

9.4.2 The on-street master shall provide a daily report to central control which shall contain all failures, all preemptions, patterns in effect during the day with the time each started, and an indication of whether the pattern was selected by time-of-day operation, manual operation, isolated or free operation, or traffic responsive operation, and evidence of any password modifications. This report shall be retrievable or automatically forwarded according to a user-selectable schedule.

9.5 Dial-Up Operation

9.5.1 If a failure occurs, the on-street master shall call the central control and report the failure. This report shall include the type of failure, location of failure, date and time of failure. Failures shall include: coordination failure, data transmission error, local intersection off-line, intersection conflict flash, intersection manual flash, local controller failure, system detector failure, cabinet door open, local detector failure, and a minimum of two user-defined alarms based on NEMA outputs. The user shall preselect for each type of failure whether the subsystem will continue to operate in a coordinated manner or revert to isolated operation.

9.5.2 All alarms shall be prioritized for reporting purposes to a minimum of three levels of user-selected priority. The levels of priority may be defined as, but is not restricted to, immediate response, response associated with a higher priority alarm, and no response

9.5.3 If the phone number is busy, the on-street master will continue to dial the number on an

automatic preassigned schedule until it gets through or dial another number as specified by the operator.

9.6 NTCIP Compliance

9.6.1 The on-street master must either be capable of implementing the National Transportation Controller ITS Protocol (NTCIP) and be downward compatible to closed loop systems supplied by the same manufacturer since January 1992 and provide all necessary components to upgrade to NTCIP, as specified by the plans. PROMs or programs to upgrade the master controllers to NTCIP compliance shall be provided at no cost to the purchaser at the time of the request.

9.6.2 The master software shall comply with the referenced National Transportation Communications for ITS Protocol (NTCIP) Standards when installed. The software shall comply with the versions of the relevant NTCIP standards that are current at the date of this document, or a later version.

9.6.3 The software shall comply with NEMA Standard Publication TS 3.2-1996 (TS 3.2), the Simple Transportation Management Framework, and shall meet the requirements for Conformance Level 2. The software shall comply with NEMA Standard Publication TS 3.3-1996 (TS 3.3), the Class B Profile, and shall include both an EIA/TIA 232-E and an FSK modem interface for NTCIP based communications.

9.6.4 The software shall implement all *mandatory objects* of all *mandatory conformance groups* as defined in Global Object Definitions, NEMA Standard Publication TS 3.4-1996 (TS 3.4);

- Configuration Conformance Group and Actuated Signal Controller Object Definitions, NEMA Standard Publication TS 3.5-1996 (TS 3.5).
- Phase Conformance Group
- Detector Conformance Group

9.6.5 The software shall implement all *mandatory objects* of all *optional conformance groups* as defined in Global Object Definitions, TS 3.4;

- Database Management Conformance Group
- Time Management Conformance Group
- Time Base Event Schedule Conformance Group
- Report Conformance Group
- STMF Conformance Group
- PMPP Conformance Group

and Actuated Signal Controller Object Definitions, TS 3.5.

- Volume Occupancy Report Conformance Group
- Unit Conformance Group
- Special Function Conformance Group
- Coordination Conformance Group
- Time Base Conformance Group

- Preempt Conformance Group
- Ring Conformance Group
- Channel Conformance Group
- Overlap Conformance Group
- TS 2 Port 1 Conformance Group

9.6.6 The software shall also implement the following *optional objects* as defined in the Global Object Definitions, TS 3.4;

- globalSetIDParameter
- dbMakeID
- eventLogOID
- eventConfigAction
- eventClassDescription

9.6.7 The software shall also implement the following *optional objects* as defined in the Actuated Signal Controller Object Definitions, TS 3.5;

- unitRedRevert
- phaseDynamicMaxLimit
- phaseDynamicMaxStep
- phaseControlGroupTable
- ringControlGroupForceOff
- vehicleDetectorQueueLimit
- vehicleDetectorFailTime
- vehicleDetectorReportedAlarms
- alarmGroupTable
- specialFunctionOutputTable
- preemptMinimumGreen
- preemptMinimumWalk
- preemptEnterPedClear
- preemptState
- preemptControlTable
- ringControlGroupMax2
- ringControlGroupMaxInhibit

9.6.8 All objects required by these procurement specifications shall support all values within its standardized range, unless otherwise approved by the Traffic Operations Division Signal Operations Engineer. The standardized range is defined by a size, range, or enumerated listing indicated in the object's SYNTAX field and/or through descriptive text in the object's DESCRIPTION field of the relevant standard. The following provides the current listing of known variances for this project:

TABLE 2.1 OBJECT RANGE VALUES FOR ACTUATED SIGNAL CONTROLLERS

OBJECT	MINIMUM PROJECT REQUIREMENTS
TS 3.4-1996	
moduleType	Value 3
dbCreateTransaction	All Values
dbErrorType	All Values
globalDaylightSaving	Values 2 & 3
maxTimeBaseScheduleEntries	255
maxDayPlans	15
maxDayPlanEvents	10
maxEventLogConfigs	255
eventConfigMode	Values 2 thru 5
eventConfigAction	Values 2 & 3
maxEventLogSize	255
maxEventClasses	7
maxGroupAddress	2
TS 3.5-1996	
maxPhases	16
phaseStartup	Values 2 thru 6
phaseOptions	All Values
maxPhaseGroups	2
maxVehicleDetectors	32
vehicleDetectorOptions	All Values
maxPedestrianDetectors	8
unitAutoPedestrianClear	All Values
unitControlStatus	All Values
unitFlashStatus	All Values
unitControl	All Values
maxAlarmGroups	1
maxSpecialFunctionOutputs	8
coordCorrectionMode	Values 2 thru 4
coordMaximumMode	Values 2 thru 4
coordForceMode	Values 2 & 3
maxPatterns	48
patternTableType	Either 2 or 3
maxSplits	16
splitMode	Values 2 thru 7
localFreeStatus	Values 2 thru 11
maxTimebaseASCActions	255
maxPreempts	6
preemptControl	All Values
preemptState	Values 2 thru 9
maxRings	4

OBJECT	MINIMUM PROJECT REQUIREMENTS
maxSequences	16
maxChannels	16
channelControlType	Values 2 thru 4
channelFlash	All Values
channelDim	All Values
maxChannelStatusGroups	16
maxOverlaps	8
overlapType	Values 2 & 3
maxOverlapStatusGroups	8
maxPort1Addresses	255
port1Status	Values 2 & 3

9.6.9 The controller shall be able to implement all NTCIP messages called for in the specification without any additional vendor specific / proprietary statements.

9.6.10 The controller software shall be supplied with full documentation, including a 3.5in. floppy disk(s) and/or CD-ROM containing ASCII versions of the following MIB files in ASN.1 format:

- the relevant version of each official NEMA Standard MIB Module referenced by the device functionality; and
- if the device does not support the full range of any given object within a NEMA Standard MIB Module, a manufacturer specific version of the official NEMA Standard MIB Module with the supported range indicated in ASN.1 format in the SYNTAX field of the OBJECT-TYPE macro. The filename of this file shall be the same as the standard MIB filename with the extension ".man".

9.6.11 The controller software shall be supplied with full documentation, including 3.5in. floppy disk(s) and/or CD-ROM containing ASCII versions of any and all manufacturer-specific objects supported by the device in ASN.1 format in a manufacturer-specific MIB with accurate and meaningful DESCRIPTION fields and supported ranges indicated in the SYNTAX field of the OBJECT-TYPE macros.

9.6.12 The Manufacturer shall not place any restrictions as to the use and passage of any and all of this documentation to any of TxDOT personnel.

10.0 Security

When the on-street master is called by central control, an alpha-numeric (either numbers, letters, or any combination thereof) password shall be required before any parameters may be modified. This password may be changed at central control. If the password is

modified, this will be reported on the daily status report. A minimum of three security levels shall be provided to restrict user-access.

11.0 Documentation

Each on-street master unit shall be provided with the following documentation:

A. One service manual per unit which includes description of master unit, description of its operation, and basic maintenance and troubleshooting information.
B. Two complete, accurate, and readable schematic diagrams for all circuitry in the master unit. One set of these diagrams may be included in the service manual.
C. Complete parts list including names of vendors for parts not identified by universal part numbers such as JEDEC, RETMA, or EIA. This may be included in the service manual.

D. Pictorial of components layout for each circuit board or individual component identification permanently printed on each circuit board. Regardless of which of the above is provided, each electronic component on the board will need to be clearly identified or labeled. This may be included in the service manual.

12.0 Bid Requirements

The supplier's facilities shall be of sufficient size and staffing that any and all warranty repairs to the cabinet assembly provided can be made on a timely basis. Timely return of equipment is interpreted as a period of time no longer than 18 calendar days from the date of receipt by the supplier to the return receipt of the equipment at the specified location. This requirement may be met by field service. Failure to meet these requirements may result in rejection of future bids.

13.0 Test And Acceptance of On-Street Master Unit

13.1 The supplier shall burn in each controller cabinet assembly for a period of 48 hours at a temperature of 60° C and for a period of 96 hours at a temperature of 23° C. A certification shall be included with or attached to each controller cabinet indicating the dates of the burn in period, number of hours, and the burn in temperature.

13.2 The controller cabinet assembly may be run under load in a shop environment for a period of at least 120 hours. During this time the entire controller cabinet assembly will be inspected for compliance with the specifications.

13.3 The purchaser may then perform any or all tests described in NEMA Standard Publication TS 2-1998 on two or more complete controller cabinet assemblies on a

random sample basis. Environmental sampling and testing shall be in accordance with the Traffic Operations Division, Test Method TEX-1170-T. If any of the assemblies fail any of the tests, the supplier will be permitted to make one complete repair of the order on a timely basis which will be determined by the purchaser and the testing will be redone. The supplier shall reimburse TxDOT for any retesting required during acceptance. The cost for each retest will be based on time and charges and is estimated at $1500.00 per test.

12.4 Minor discrepancies noted in sampling and test of this item received shall be corrected within a maximum of 30 days of written notice of the discrepancies or as stated in the notice. Major discrepancies that in the opinion of the purchaser will substantially delay receipt and acceptance of the item will be cause for cancellation of the purchase order. Discrepancies found in partial shipments shall be corrected prior to the delivery of subsequent shipments.

12.5 All on-street masters supplied to TxDOT shall be identical to the approved pre-shipment sample. Any deviations from the approved sample shall be submitted for evaluation and approval before any shipment is accepted for payment.

12.6 Deviations from the approved sample after shipment of any parts of the order shall be cause for rejection and non-payment of the remainder of the order. Excessive delays or noncompliance by the vendor at any point in the approval process may be cause for cancellation and non-payment.

12.7 Date of acceptance will be date that the on-street master is approved by Traffic Operations Division.

13.0 Measurement

13.1 Measurement shall be made of each controller cabinet assembly with components required to make a complete assembly as specified in Invitation for Bids.

14.0 Warranty

14.1 The on-street master unit shall be fully warranted for parts and labor for a minimum of five (5) years from the date of acceptance.