SPECIAL SPECIFICATION

A9003

Traffic Control System

1.0 Description

This Item shall govern the minimum requirements for a distributed traffic signal control system consisting of all labor, supplies, equipment and services necessary to provide the operation and functions described herein. This Advanced Traffic Management System (ATMS) shall have the capability of selecting and implementing traffic signal timing plans based on real-time traffic conditions, preset time events, and operator commands. The system shall feature a "building-block" design which enables future system expansion to its maximum capacity without major modifications to the central control system.

The system configuration consists of three (3) principal elements, namely, the local controller assembly, the spread-spectrum radio communications link, and the distributed traffic control system. The local controller assembly and the spread-spectrum radio communications requirements are detailed in other special specifications. The functional requirements of the distributed traffic control system are described herein.

2.0 Required Features and Functionality

The following sections provided the minimum requirements for the new ATMS.

2.1 Graphical User Interface. The ATMS graphical user interface (GUI) software shall provide the operator with a graphical operating environment of the type commonly found on today's desktop computers. The GUI shall be easy to use while providing a fast and efficient way to control and monitor the ATMS in real time. The GUI shall allow the operator to intuitively select objects on the screen by point-and-click manipulation with the mouse, thereby minimizing typing and the need to memorize lengthy commands. The system shall also provide hot keys for commonly used functions. The GUI shall incorporate the following:

- Pop-up multiple display objects and windows;
- Menu icons and controls;
- Dialog boxes;
- Rollovers with automatic pop-ups
- Push button and other active commands;
- Visual and audio alarms; and
- Use of object characteristics such as colors, highlighting, and flashing to alert operators of status changes

The GUI interface shall be oriented around graphic tools and based on the principle of

direct manipulation. Several windows may be active at the same time and may overlap on the screen. The operator shall be able to easily switch from one window to another, such as by pointing with the mouse cursor to the uncovered part of another window. The operator shall be able to move any window on the screen, to change window size, and to collapse a window to an icon. When an exception condition (such as a device failure) exists, an inactive window shall attract the operator's attention by beeping and/or flashing its icon or title bar.

2.2 System Access

2.2.1 Multi-user Access Required

The Contractor-furnished operating system and ATMS software shall support a multi-terminal, multi-user interface and the ATMS software shall allow access to multiple levels of the system simultaneously. A minimum of six (6) users, each one of who can be assigned a specific level of access privilege, shall be able to access the system concurrently.

2.2.2 System Security

The ATMS software shall provide and maintain a security system to prevent unauthorized access to the system. This shall apply to executable files as well as text and database files. Operator privileges shall be definable on a functional level. Each operator shall have a privilege level mask defined for him/her by the system administrator. The mask shall define the specific functions that the particular operator is authorized to perform. For example, a particular operator may be given the ability to view all reports, but not to modify some or all levels of the database. This shall allow for any number of different levels of operator access capability. The system administrator level shall have full access to the system as well as the responsibility for maintaining account passwords and privilege level masks.

Before gaining access to the ATMS, the operator shall be required to enter an operator identification code. The ATMS software shall validate the code against an encrypted database of authorized operators. Successful completion of the log-in shall result in execution of a session start-up procedure. The start-up procedure shall establish the privileges, object menu options, windows, and tools the operator may utilize. Any functions that a particular operator is not authorized to access shall either not be shown or shall be grayed out so that the operator can easily distinguish the functions to which he/she has access.

LAN access shall be limited to those activities that support the ATMS. Any activity that hinders or does not directly support the operation of the ATMS shall be restricted or eliminated. Any executable files that are not needed in support of the ATMS shall be eliminated from the system or otherwise protected from access, thus minimizing any risk associated with unauthorized access. Operating system tasks that impede system response shall also be eliminated (i.e. clock, calendar manager, file manager, etc.).

Unsuccessful log-in attempts shall be logged to the system log.

2.2.3 Remote Access

The ATMS software shall have the capability of providing access to the system for remote operators. The remote access capability shall include workstations which are physically connected to the LAN as well as computers connected by dial-up telephone modem or the internet. All connected computers, including those connected remotely, shall be capable of concurrent operation.

The system administrator shall have the capability to reduce the access capabilities of operators while they are logged into the ATMS software from a remote computer. For example, someone who would normally have full access privileges while inside the TMC might be granted lesser capabilities if using a computer connected by means of dial-in modem.

2.2.4 Remote Computer Software

The Contractor shall furnish a version of ATMS software that runs on portable computers. Such software shall be capable of performing all operator-allowed command and monitoring functions available to operators within the TMC.

The ATMS shall provide dial-in security features designed to protect the system from unauthorized access by computer hackers capable of breaking sign-on password protection.

It will be acceptable for remote-access computers to have a scaled down version of the graphics capability. For example, generic intersection graphics would be acceptable at a remote computer even though a precise graphical file may be available within the ATMS graphic database. Each remote computer shall have any generic graphics files resident. All other database items shall reside only on the ATMS software. The remote computers shall be able to monitor real-time operations of a minimum of six intersections.

2.2.5 Direct-Connect Access to Local Controllers

The Contractor-furnished portable computer software shall enable a portable computer to be connected directly to the local intersection controller. Field technicians shall thereby have the ability to access and modify the local controller database without directly accessing the ATMS central software. This shall give the field technicians the ability to directly upload/download controller timing parameters and to set the time and date.

Field technicians shall also have remote access to the ATMS by means of a dial-up connection. This function shall allow the technician to:

- Download the current ATMS parameters for any controller to a controller or portable computer;
- Upload newly established local controller parameters to the ATMS.

2.2.6 Automatic Paging

The ATMS system software shall support report alarming events via pop-up user-based messages, pages, or emails to individuals or groups. Events that trigger the alarm pop-up, page, or email shall be set by the user. The pop-up or heads-up alarms are routed to a specific user, based on login of that user. To clear the heads-up alarm display, the user must acknowledge the alarm. The ATMS message system shall support individual or group paging/emailing as well as TOD control for each individual or group. The paging function shall be implemented using a dial-up line to connect to a local paging service that supports alphanumeric messaging. The emailing function shall be implemented to allow the system to send an email to a user's PDA device through a local email network server.

2.3 Time/Date Synchronization

2.3.1 Synchronization with Universal Time

The Contractor shall provide the means by which the system's central time clock is automatically synchronized with universal time, either through the WWV radio broadcast or by other approved means. Such automatic synchronization shall occur at least once per hour. The capability shall also be provided for the operator to disable and re-enable this function.

2.3.2 System-wide Clock Updates

The system shall provide for the automatic downloading of clock updates to each field clock. The frequency of such updates shall be operator-programmable within a minimum range of once per day to once per hour. Additionally, unless the feature has been disabled by the operator, the system shall transmit a clock update in conjunction with the command for implementation of a different timing plan.

2.3.3 Verification of Field Clocks

The ATMS software shall also upload, on a periodic basis selectable by the operator, the date/time from local controller and other field clock. If the time/date in the field clock has drifted beyond an operator-defined amount, then:

- The system shall automatically download the true time to the field clock; or
- The system shall report the clock drift to the operator.

In either case, the event and action taken shall be logged.

2.3.4 Accommodation of Daylight Savings Time, Leap Year, etc.

The ATMS software shall also have the ability to disable daylight savings functions and handle leap years.

2.4 Control Modes

2.4.1 General

The ATMS software shall operate in a distributed mode, fully making use of the intelligence in the local intersection controllers. The intelligent local controllers shall be programmed with timing plans, time-of-day/day-of-week (TOD/DOW) schedules, and all other parameters required to operate the local intersection. All intersection controllers shall be monitored on a real-time basis by the ATMS software. Upon system startup, the ATMS software shall establish communications with all intersection controllers and begin real-time monitoring. The ATMS software shall start to process both incoming data and operator requests. Any upload, download, or time/date requests shall take precedence over real-time monitoring. The ATMS shall be designed for unattended operation 24 hours per day, seven days a week, without requiring an operator to be logged into the system.

The ATMS shall provide system control by coordinating intersection operation on an individual, section, or system-wide basis. The software shall include at least the following control modes, which shall be operator-selectable from the GUI.

Upon system startup, the control mode shall always be local TOD/DOW. If the event scheduler is calling for traffic responsive mode at the time of system restart, the system shall transfer to traffic-responsive mode after an operator-selectable amount of time.

For commanding an intersection to a timing plan different than the TOD/DOW, either by manual override or through the traffic-responsive algorithm, the controller shall be commanded to the appropriate plan. In the event that, while in software-commanded override, a controller does not receive a valid timing plan number from the ATMS software within an operator-defined time frame, it shall revert back to its local TOD/DOW schedule. The central override shall be allowable on an intersection, section, or system-wide basis.

2.4.2 Manual Control

The operator shall be able to invoke manual override of the plan currently in effect for the entire system, for a subsection of the system, or for individual intersections. Manual selection of timing plans shall have a higher priority than all other modes of timing plan selection.

The operator shall have two options for implementing manual override:

- Setting the manual override and later releasing the override manually; and
- Setting the manual override with a specified time frame for automatic termination.

Under the second option, the manual override shall terminate automatically at the end of the specified time. When manual override is terminated, each affected controller shall revert to its previous mode of operation.

2.4.3 Time-Of-Day/Day-Of-Week Control

TOD/DOW mode shall be used for controlling traffic conditions that occur regularly. In this mode, each controller shall automatically select and implement traffic signal timing

plans in accordance with the defined schedule, locally stored, on a TOD/DOW basis. TOD/DOW plans shall be downloadable from the ATMS software to the controller in the field. The number of timing plans available in the ATMS database shall be limited only by the amount of disk space available. Any plan located at the ATMS shall be downloadable to any slot in the local controller's database. The timing plans that are being stored in the local controller shall be tagged in the ATMS database so that the ATMS software always knows which plans are stored at the controller. In order to download a timing plan to a controller, the operator shall select the plan from the ATMS database and the controller memory slot where the plan will reside. The user interface shall allow the operator to choose timing plans for all available memory slots at once. This shall enable the operator to initiate one download per controller to download all timing plans and time-of-day events.

2.4.5 Free Operation/Remote Flash Mode

In the free mode, the controller shall run uncoordinated. To initiate flashing operation remotely, the controller shall be commanded to flash from the ATMS software.

2.5 Signal Timing Plan Implementation and Monitoring

2.5.1 Control Sections (Subsystems)

The new ATMS shall enable the operator to define a minimum of 100 control sections, or subsystems, each of which shall be completely independent of the connection of any particular intersection to the communications network. The number of intersections in a particular subsystem shall be programmable from a minimum of one to a maximum of the total number of intersections in the system. It shall be possible to have intersections and detectors assigned to different sections by time of day, either by operator command or through the event scheduler.

2.5.2 Local Intersection Control and Control Modes

Local traffic signal control functions shall be provided by the local controller firmware. The intersection controller shall determine the coordination cycle synchronization point from the current time-of-day. All offset, split, and transition timings shall be determined and implemented locally.

Under normal operation, intersection control shall follow local controller TOD/DOW schedule. When operator or ATMS software determines that a different timing plan should be implemented, the system shall download timing plan, if required, and command intersection to that plan by sending plan number to the controller. If communication is lost between the intersection and the ATMS software, the intersection shall revert back to its original TOD/DOW schedule. The downloaded special plan shall not overwrite any plans that are used by the TOD/DOW schedule. The operator shall be able to select controller timing plan slots to be used as *temporary* locations and the remaining slots for TOD/DOW usage.

2.5.4 Number of Timing Plans Required

The new ATMS shall provide for a minimum of sixteen (16) timing plans for each intersection to be stored in the central database. At any one time, it shall be possible for a minimum of twelve (12) of these plans to be stored in the local controller's database and implemented upon command by the new ATMS. The number of available cycle lengths shall be at least six (6). Each timing plan shall include uniquely programmable values for cycle length and offset, a uniquely programmable phase sequence, and uniquely programmable split values. The software shall provide both the automatic calculation of permissive periods (based on splits values) and the ability for the operator to input desired values for the beginning and end of permissive periods.

The new system shall also provide the capability to handle special signal and/or timing plans to accommodate unusual traffic flow patterns during special events, parades, etc. These special event timing plans may be included within the thirty-two timing plans.

2.5.5 Accommodation of Phase Sequences

The new ATMS software shall provide for the independent control of each phase of an eight-phase, dual-ring controller. For example, in normal quad-left operation, it shall be possible to program the force-off for Phase 1 independently from the force-off for Phase 5. The new ATMS shall also provide for the control of lead-lag phase sequences. In conjunction with each timing plan, the software shall enable the independent programming of each odd numbered phase to be either leading or lagging with respect to its associated even numbered phase. (i.e.: for each timing plan, it shall be possible to program the lead-lag status of the 1-2 phase pair independently from that of the 5-6 phase pair, the 3-4 phase pair, and the 7-8 phase.)

2.5.6 Preemption

The new ATMS software shall recognize the occurrence of locally-initiated preemption (emergency vehicle or bus) and thereby not erroneously diagnose a coordination failure because the local controller has been preempted.

2.5.7 Accommodation of Pedestrian Services Which Violate Normal Split Times

At locations where the major street is wide, the cross-street split times (which are based on vehicular needs) may not be long enough to accommodate a pedestrian service. Accordingly, whenever a pedestrian actuation does occur, the intersection will get out of step. The ATMS software shall not fail the intersection as a result of a normal force-off time being exceeded to service a pedestrian call. It shall be permissible for such a pedestrian call to be treated as a preemption for the purpose of accomplishing this requirement.

2.5.8 Special Functions

The ATMS shall accommodate the control and monitoring of the on/off status of a minimum of four (4) special functions to be implemented by the intelligent local controller.

2.5.9 Remotely-Requested Download of Local Database

The maintenance technician shall have the ability, from the local controller, to effect a download of the local controller database from the central database without the need for an operator to be present at the TMC.

2.5.10 Timing Plan Compliance Monitoring

The ATMS software shall monitor each intersection to ensure that its operation is within proper constraints of the timing plan that is in affect.

Through compliance monitoring, the error conditions which shall be detected include the following:

- The controller is not using the proper timing plan;
- The controller time clock is out of synchronization;
- The controller is not sequencing;
- The phase sequence is improper; and
- Phase time compliance.

The ATMS software shall automatically inhibit monitoring if feedback is not being received from the controller.

2.5.11 Intersection Measures of Effectiveness

The ATMS software shall collect and store data on intersection measures of efficiency (MOEs). The software shall process and maintain intersection MOE data on a continuous basis to be used for various timing analysis and reporting tasks. Intersection feedback shall be stored on a per-phase basis. The intersection MOEs which shall be stored include, but not be limited to, the following:

- Percent of green time used versus split;
- Percent of detector calls (relative to a threshold value);
- Number of times the phase maxes out or is forced off prior to gap-out; and
- Number of pedestrian calls.

The system software shall automatically record intersection data in the ATMS database, and periodically archive the data onto removable optical media. Up to four (4) weeks of intersection data for each intersection shall be stored on the ATMS database by the database program. If bad data or no data are received from the intersection, the data will be tagged as questionable or not available in the ATMS database.

In case of failure during a database write process, the database program shall not leave a partially written block. Any missing blocks shall be tagged as unavailable. The operator shall have the capability to enable or disable data collection on an individual intersection basis.

The time increment between writing of data to the optical disk drive and start time shall be operator-selectable with defaults of 24 hours and midnight, respectively. Data shall be automatically compressed when written to the removable optical media. Each history file shall be date and duration tagged via file naming convention. The data storage feature shall have the ability to append intersection data to the removable optical media, enabling full usage of the media. When the removable optical media does not have enough storage space left for a full time interval of intersection data, the system shall notify the operator that a new storage disk is required. The operator shall have the ability to enable and disable archiving on an individual intersection basis.

Intersection data shall be retrievable from the removable optical media for use with the relational database and traffic modeling packages. Upon retrieval, the intersection data from the optical disk shall be automatically expanded from the compressed format.

2.6 ATMS Database

2.6.1 Database Generation and Maintenance

The Contractor shall furnish and implement an Engineer-approved, off-the-shelf database package. The Contractor shall provide a database interface, which shall be integrated into the ATMS software to provide seamless operation for the operator. The resulting combination of ATMS software and database software shall provide for off-line and online database generation and maintenance.

This shall include loading, modifying, examining, copying, and retrieving the data used to operate the system. These data include traffic system configuration, timing plans, TOD/DOW schedules, operator databases, and alarm databases. Traffic system configuration shall include channel assignments, communication parameters, included intersections, etc. Any database changes shall be achievable without having to restart the ATMS software.

Data entry forms shall be designed for easy data preparation by the operators. Electronic copies of these forms shall be placed on each workstation, laptop, and personal data assistant (PDA). All tables in the database shall be printable in the proper format for use by the traffic engineers and maintenance technicians in the field. In order to alleviate repetitive data entry, the system shall allow the operator to copy data tables for use with other devices.

Database generation of traffic control operations shall include safeguards to preclude dangerous or undesirable intersection operation. These safeguards shall, as a minimum, include range-checking and timing plan verification.

2.6.2 Database Recovery

All database backup and recovery shall be through the ATMS software user interface. The operator shall be able to do the following:

- Automatically compress and back-up the database on an operator-specified time-of-

day setting or upon operator command; and

- Restore the back-up copy of the database to the ATMS database.

2.6.3 Database Reports

The operator shall be able to generate custom reports using the relational database custom report utility supplied with the database package. The ATMS shall provide a seamless interface to this utility.

2.7 Reporting Capabilities

2.7.1 General

The reporting capability and monitor screen displays shall be obtainable from the same menu options. The operator shall be able to click on a menu of report names and choose the display to be shown on the monitor screen. The operator shall be able to print any of these screens to any network printer or to a file at any time during the process by simply clicking a button on the report screen. If sending to the printer, the text shall be reformatted as necessary in order to be produce a legible printout. Unnecessary information shall not be printed. All report formats shall be approved by the TOWN.

Unless noted below, the displays/reports shall be available system-wide, by section, by channel, or by single device.

2.7.2 Types of Reports Required

As a minimum, the following displays/reports shall be available.

- System Status. This display shall be an overview of the present condition of all devices in the traffic system. This shall include intersection controllers, detectors, communication channels, and other categories of devices. The conditions shall include all possible status conditions (e.g., on-line, failed, etc.) and modes (e.g., TOD/DOW, On Flash, etc.) as described in this specification. By clicking on a particular category on the system status report, the operator shall be able to initiate the display of an associated detailed report screen. For example, by clicking on the field which indicates the number of intersections failed, the operator would initiate the display of a detailed screen listing the failed intersections and other details (e.g., time of failure).
- Real-Time Monitor. This display/report will show the request and reply to and from a single intersection. This monitor shall display the command being sent to an intersection along with the feedback data received back from the intersection. The display shall be continuous until stopped by the operator. The data shall be displayed in an easily understood format. The data displayed shall not be displayed in hex format. This display is required on an intersection basis only.
- Communication Statistics. This display/report shall show the communications throughput. The display shall include number of communication attempts, number of successes, number of failures, and percentage of successful communications per intersection, per channel, and per system.

- Intersection Operation. This display/report shall show the detailed intersection operation in real-time mode. This display shall be available on an intersection basis only.
- Detailed Intersection Failure Status. This display/report shall display the failure information for all failed intersections. This information shall include as a minimum: intersection location, reason for failure, and time of failure.
- Detailed Detector Failure Status. This display/report shall display the failure information for all failed detectors. This information shall include as a minimum: detector location, reason for failure, and time of failure.

2.7.3 Report Output Requirement

Reports and displays may be output to the ATMS operator station monitors or any network printer. Reports and displays may also be requested by remote computers, whether LAN-connected or dial-in.

2.8 System Log Requirements

2.8.1 Traffic System Log

The traffic system log shall record, in order of occurrence, all traffic-related messages. As a minimum, this shall include:

- Operational events (including occurrences of local preemption);
- Traffic device failures/repairs;
- Communication failures/repairs;
- Traffic data transfer messages;
- Manual override changes; and
- Operator log-on and log-off.

Unless printing has been suppressed by the operator, log messages shall be automatically output to a designated printer. The operator shall be able to filter which messages are logged to the printer and shall be able to suppress all log output to a printer. An on-line file of all log messages shall also be maintained with all messages logged to the on-line file. This file shall be of fixed length and circular format, overwriting at the beginning when reaching the end of the file.

2.8.2 Log of Current Operators

The ATMS software shall maintain a continuous record of the operators who are currently logged onto the system. The system shall add to this log any operator who logs onto the system and, upon log-off, shall delete the name of that operator from this log.

2.8.3 Operating System Log

The operating system log shall log all central system related events that occur in order of occurrence. As a minimum, it shall include the following:

- Internal system errors;
- System hardware failures;
- System network errors; and
- Software fatal errors.

Unless its printing has been suppressed by the operator, log messages shall be automatically output to a designated printer. An on-line file of all log messages shall also be maintained. This file shall be of fixed length and circular format, overwriting at the beginning when reaching the end of the file.

2.9 Graphic Display Subsystem (GDS)

2.9.1 General

The Graphical Display System (GDS) shall follow the same graphical user interface guidelines as the ATMS software. The interface to the GDS shall be an integrated module of the ATMS software. All commands for manipulating the GDS shall be available directly from the ATMS user interface. All graphic file generation shall occur within the ATMS. Any remotely stored graphic files shall be automatically updated by the system.

The graphic system shall have a base map that covers the entire extent of the City limits. The base map will be a TOWN-furnished CAD or GIS-generated graphic file serving as a static background map. The dynamic layers of the GDS shall be incorporated onto the base map by the Contractor. As a minimum, the base map will show the roadway centerlines of arterials and collector streets, freeway centerlines, rail lines, and major landmarks.

2.9.2 Pan/Zoom Requirements

It is desired that the dynamic mapping provided by the Contractor incorporate full pan/zoom capability. In such case, the operator shall be able to set up both dynamic and static informational layers that are displayed at different view scale levels by defining the view scale levels in a zoom level set-up configuration database table. By setting up the zoom scale range and appropriately enabled/disabled layers, the operator shall be able to control which layers display at different zoom scales. For example, at the citywide scale level the operator might enable roadway centerlines (static information) as well as a communication status indication (dynamic information) for each intersection controller across the city. When zooming in to a group of intersections (i.e. changing the view scale), the roadway centerlines would be disabled from view and the roadway curb lines would be enabled (become visible), and perhaps all phases of all the intersections in the displayed group shall become visible.

An alternative which would be considered as meeting the minimum required functionality (in lieu of full zoom capability) would be to provide a minimum of three discrete levels of displays:

- System-wide display, which shall include the entire City. This level shall include, as a minimum, centerlines of major roadways (including all which include a signal), freeway centerlines, rail lines, and major landmarks. At this level, signalized intersections, system detector stations, and other field devices shall be depicted as dynamic symbols (e.g., circles, squares, etc.). The operator shall have pan/zoom capability within the system-wide display.
- Area displays, which shall include portions of the system-wide display. (An example would be an area display of the central business district.) At this level, roadways may still be depicted as centerlines but all minor streets shall be included. At this level, it shall be possible to view the green status of the coordinated phase green. The operator shall have pan/zoom capability within each area display.
- Intersection displays, which shall depict roadway curb lines and lane lines and shall include static displays of the following (as a minimum):

  a. Street names;
  b. Intersection number;
  c. Phase numbering;
  d. Special function definition; and North arrow.

The intersection display shall also include dynamic indicators as follows (as a minimum):

a. Controller operational mode (e.g., TOD/DOW, traffic responsive, manual, free, or remote flash);
b. Controller status (e.g., in transition, preempted, conflict flash, etc.);
c. Communications status (e.g., on-line, bad communication, or no communication);
d. Timing parameters currently effect (e.g., control mode, transition status, control section assignment, timing plan number, cycle length, offset, and split values);
e. Color status of all vehicular phases and overlaps (including the circular red, yellow and green indications and all arrows);
f. Color status of all pedestrian phases (including walk, flashing don't walk, and steady don't walk);
g. Actuation status of all local detectors (vehicular and pedestrian) and all system detectors associated with the intersection;
h. Special function status;
i. Count-up of cycle clock; and
j. Countdown of the number of seconds remaining for the split of the phase in service.

Common icons shall be used as much as possible for all display levels. All colors shall be selectable by the operator. The same colors and icons shall also be used in display/report screens. A legend shall be available within the display window, defining the meaning of each icon and color.

If discrete display levels are used in lieu of full zoom capability, icons shall be provided on each level's display to select the view of the other levels.

The Contractor-furnished software shall include a library of standard intersection drawings (e.g., standard four-legged intersection, standard tee intersection, etc.).

2.9.3 Graphics Generation

As mentioned above, the system-wide base map will evolve from TOWN-furnished databases. The Contractor shall provide a user-friendly utility for import and generation of these graphic images for the GDS. Detailed intersection displays representative of AutoCAD-based and Microstation DGN design files shall also be able to be imported and generated for the GDS. From this graphic generation utility, the operator shall be able to create and revise all the maps and intersection drawings displayed by the GDS.

The actual creation of the graphic displays shall be a shared responsibility. As part of the required training:

- The Contractor shall develop the system-wide display and demonstrate how it can be edited in the future;
- The Contractor shall develop at least one area display and oversee the creation, by TOWN staff, of other area displays; and
- The Contractor shall develop approximately 20 intersection displays (encompassing a range of different intersection types) and shall oversee the creation, by TOWN staff, of approximately 20 other intersection displays.

The creation of the remaining area and intersection displays shall be the responsibility of the City. The Contractor shall, however, provide telephonic guidance and support as needed by the City. All custom and commercially available software required for operation and modification of the graphics generation utility package shall be supplied by the Contractor, who shall also supply any additional hardware required for use of the graphics generation utility package.

2.9.4 Refresh Rates

All real-time dynamic data that are to be displayed on a graphic map shall be refreshed as frequently as the feedback data are being returned from the field equipment. If feedback data are not received from the field because of higher priority communication, a message shall be displayed to the operator of the affected display.

All static graphic displays shall be designed and developed in such a way as to ensure instantaneous redraw of the graphic display. This display includes the background map and the real-time feedback data. For example, if the operator pans to the left, the entire screen needs to be redrawn. All displays shall be drawn as quickly as possible. The draw time for the largest map (system-wide) shall not take longer than two (2) seconds. All other displays shall not take longer than one (1) second.

2.10 Scratch Pad Capability. The system shall have a method to leave messages electronically on the operator stations for personal reminders or messages to other operators. The scratch pad facility shall be available in a separate window integrated with the ATMS interface.

2.11 System Installation and Failure Recovery

2.11.1 Software Installation

The installation of the ATMS software from storage media shall be completely automated. From the operating system command line, no more than two typed commands shall be required to fully install all software required onto the computers. Once the software is installed, configuration screens shall allow the system administrator to set distinct operating features of the system.

2.11.2 System Startup and Shutdown

The ability of the ATMS components to interact with each other shall not be governed by a structured start-up order. That is, if a component fails to operate or is powered down, the remainder of the system shall not have to be shut down and restarted to re-establish a working system. The unaffected components should simply wait for the missing component to be returned to the system. When returned, all components should automatically revert to normal operations.

The system shall be designed such that it will not need to be shut down. Hardware that is removed from active duty by power-down or cable-disconnect shall be reported by other components of the system to be non-responsive. When such equipment is powered up or reconnected, the system should respond by recognizing the return to normalcy and resume regular operations without operator interaction.

The Contractor-furnished documentation shall include published procedures for accomplishing, in a logical fashion, a complete, system-wide power-down (such as for purposes of moving the system).

2.11.3 System Failure and Recovery

The beginning and ending of the following system failures should be signified by paging appropriate personnel in addition to other reporting requirements detailed below.

- Power Failure. Each lifeline and non-essential component of the ATMS and central communications apparatus shall be configured with automatic shutdown software which shall, upon switch-over to UPS, initially allow for up to one minute of blackout before non-essential components begin an automatic shutdown procedure. After ten (10) minutes of blackout, the lifeline communication and ATMS components shall initiate their shutdown procedures. When power is restored, the system shall return to duty.
- Non-fatal Failure. If the ATMS software detects a non-fatal error within one or more of its processes, it shall alert the operator via an alarm and log a message to the system log. The ATMS shall continue to operate in a degraded state. The operator shall have final determination on what is considered a non-fatal failure.
- Fatal Failure. If the ATMS detects a fatal error within one or more of its processes, it shall alert the operator via an alarm on and log a message to the system log. The

ATMS shall then attempt an orderly shutdown of the system.

2.12 Software Documentation

2.12.1 General

The delivered ATMS software shall be fully documented. This documentation shall consist of pertinent technical documentation and operator documentation including the following:

- Proprietary source code escrow option;
- Database definitions and file structures;
- Variable descriptions, variable cross-references and subroutine calling sequences;
- Interface specifications;
- Requirements traceability matrix;
- Communication protocols including field device protocol;
- Security documentation;
- System backup and recovery procedures;
- System operational procedures and error handling;
- Hard copy user manual segregated into chapters (or volumes) which group topics according to whether the software is used from TMC operator stations, from remote computers, and from either of the above;
- On-line user manual or help facility;
- Warrantees on software; and
- Licenses and liens.

The Contractor may use different methods for documentation if it provides sufficient information as determined by TOWN staff. All documentation shall be submitted to the TOWN for final approval.

2.13 Testing

2.13.1 System Software Acceptance Test

All software furnished shall be subject to monitoring and testing to determine conformance with all applicable requirements and to ensure an orderly implementation of the system. The Contractor shall provide a proposed acceptance test procedure to the TOWN for approval at least thirty (30) days before the acceptance test is to begin. The test procedures shall be structured to exercise each element of the system and to verify the successful implementation of each required feature and element of functionality.

Based on the approved procedures, the TOWN shall perform an extensive test of the delivered software. The Contractor shall correct any problems which may be encountered and resolve any omissions discovered during the software acceptance tests.

2.13.2 NTCIP Verification/Testing

The test procedures shall verify conformance with all of the NTCIP standards and objects identified in this specification. Verification shall be established by two means. Each means shall be based on written test plans developed by the Contractor and approved by the TOWN, within the parameters described herein. The test plans shall provide a means of documenting each standard element and a means of indicating its proper operation.

The first means shall be the development of a test plan that incorporates the use of a third party testing suite and/or protocol analyzer to determine if a specific object is transmitted from and can be received by the central software. The test suite shall also be required to determine the value that is being passed and be capable of testing the complete range of values called for in the NTCIP standards and the PICS form completed by the Contractor and submitted as part of his/her proposal. The testing plan must test under conditions that replicate the physical plant (twisted pair copper), subnetwork, transport, application, and information level standards utilized by the central software furnished under this Project.

2.13.3 60-day Observation Period

A 60-calendar day observation period shall be required. This observation period shall commence upon successful completion of the system software acceptance test and all hardware components are operational. The observation period shall be a minimum of 60 calendar days in duration. Any major software component deficiency can (negotiable based upon type of failure) reset the calendar to day number 1.

2.14 Software and System Operational Training. The Contractor shall provide a minimum of forty (40) hours of training for TOWN personnel on the functional application and operation of the system software supplied. As a minimum this shall include the following:

- Use of operator interface;
- Use of graphical map generation and animation;
- Database use and manipulation;
- System parameter and database entry;
- Error messages and troubleshooting techniques;
- Database custom report generation;
- Overview of system structure and interfacing;
- Priority scheme setup;
- Configuration setup;
- System maintenance;
- System startup and shutdown; and
- System backup and recovery procedures.

The training shall include the creation of area and intersection graphic displays. The training shall also include integration of additional intersection/subsystems in to the ATMS. The training shall discuss integration of intersections currently connected directly by direct fiber optic communication links as well as intersections currently connected by dial-up modem communications.

The training shall consist of both formal classroom presentation and hands-on workshops.

The training shall be provided after full installation of the ATMS and publication of an approved user manual, but before the system software acceptance test procedure. Each training program shall be scheduled at the mutual convenience of the Contractor and the TOWN. All training shall be conducted during the normal TOWN business hours unless specifically noted otherwise. The TOWN shall reserve the right to videotape any and all training sessions. All training courses, lectures, and demonstrations shall be presented in person by qualified instructors. The training shall be conducted at a facility provided by the TOWN. The Contractor shall assume for budget purposes that the training will be conducted in blocks of not more than six (6) hours per day and on not more than three (3) consecutive days in any one calendar week.

2.15 Automatic Detection of Changes in Field Databases

2.15.1 Monitoring of Controller Access

Because field technicians have access to the intersection controllers, there is the opportunity for the local controller database to be changed without such change being commanded from the TMC. It is desired that the local intersection controller report four (4) feedback bits (door open, portable computers connected, front panel accessed, and power out) that communicate to the TMC when there is such activity at the controller. When the ATMS detects any of these bits, it shall automatically respond as follows.

- Power Out - Upon restoration of power, log that a power outage occurred and the time at which power was restored.
- Door Open - Log that the door is open and when the door returns to a closed position.
- Door Open and either the portable computer is connected or the front panel is accessed – The ATMS software shall log the event. After door closed signal is received, the ATMS software shall upload and compare the local controller's database with the ATMS's central database, which shall be considered to be the master database.

2.15.2 Periodic Upload of Field Databases

It is desired that the ATMS perform periodic, automatic upload of all field databases and compare such field databases with the ATMS's central database, which shall be considered to be the master database.

2.15.3 Correction of Database Discrepancies

Whenever a discrepancy is discovered between a field database and the ATMS's central database, it is desired that the ATMS software shall initiate one of two actions as defined by the operator:

- Automatically download the ATMS database, overwriting the local controller; or
- Alert the operator of discrepancy.

When comparing field and central database parameters, the ATMS software shall display

the two data sets side by side and highlight the discrepancies between the two data sets. Alternately, the new ATMS software shall highlight the discrepancies in the currently displayed database (central or field) and enable the operator to toggle to the other database. The operator shall have the option of saving the uploaded field database or downloading the central database to the field.

2.16 Generation and Display of Time-Space Diagrams. The new ATMS software shall enable the operator to generate time-space diagrams based on the timing stored in the central database and to display such time-space diagrams on-screen. The operator should then be able to perform on-screen fine-tuning, using click and drag methods to adjust the offsets, with the resulting changes in the widths of the progression bands being displayed. The operator should then be able to save to the database the resulting changes in offset for that timing plan.

To fine-tune crossing arterial progression, it is desired that the operator be able to generate and display the time-space diagram for each street in a separate window. The on-screen adjustment of the offset of the common window should result in changes in the widths of the progression bands in both windows.

2.17 Automatic Generation of Timing Plans. It is desired that the new ATMS software provide automatic generation, editing, and downloading of timing plans. Desirably, this would include the following:

- A Windows-based analysis package such as Synchro 5.0 (or later version);
- The means by which the generated timing plans can be edited on-screen in a manner similar to that described above in Subsection 2.3.4.
- The means by which an edited timing plan can be automatically downloaded to the ATMS database.

2.18 Graphical Reports. The new ATMS software shall include graphical reports. As an option, the following graphic reports should be available:

- Detector MOE Report. This graphic reports both real-time and archived measure of efficiency (MOE) data and should include the following:

  a. Present volume versus historical volume;
  b. Present occupancy versus historical occupancy; and
  c. Present speed versus historical speed.

Time frames for display should be operator-selectable.

- Intersection MOE Report. This graphic should report both real-time and archived MOE data and include the following:

  a. Percent of green time used;
  b. Percent of detector calls (relative to a threshold value);
  c. Number of max-outs (or force-offs); and

d. Number of pedestrian calls.

2.19 Detailed Graphics Displays. The system shall accommodate the following detailed graphics displays:

2.19.1 System-wide Display

The system-wide display shall be part of the static base map. At the top level, all intersections shall be displayable within one window. The operator shall be able to configure the different displayable layers along with the displayed map scale that these layers become visible. If real-time information is not available for display at certain top level displays the default condition for that layer shall be disabled.

The GDS software shall be capable of displaying system detector (or link) icons at the area wide level. When the zoom level allows for the display of system detectors, the data shall be displayed instead of the corresponding link data. Note that when traffic conditions are requested for the area-wide display, decisions shall be based upon link parameters rather than detector parameters. The operator shall be able to select the time interval to display the detector data. These data shall be displayable in either raw or smoothed form (operator-selectable).

The operator shall be able to display all detector measures of efficiency (MOEs) available at the area-wide map level. These include volume, occupancy, speed, and delay. A legend shall be displayed showing which MOE is being displayed, the time interval and the thresholds that the displayed colors are based on.

The operator shall specify which MOE is to be displayed and the time interval and thresholds that shall be used for projected averages. A minimum of four conditions shall be defined as unfavorable, intermediate, favorable, or unknown (i.e. detector failed). The condition shall be determined by comparing the stored data against the default high and low thresholds set by location and time-of-day.

The operator shall also be able to display detector status. The detector status classifications which shall be depicted include the following:

- Not failed;
- No activity;
- Erratic output;
- Maximum presence;
- Failed communication; and
- Real-time feedback preempted.

2.19.2 Detailed Intersection Display

By double clicking on the intersection icon on the overview map at any zoom level, the operator shall be able to display an individual detailed intersection in a window of the traffic display. The window size shall default to one-quarter size of the available display

screen size. The operator shall be able to change this default. The intersection display shall depict the intersection in an easy to understand display. Multiple intersection display windows shall be available for the operator, without restriction to communications channels. The number of display windows shall only be restricted to the number that can be feasibly displayed on the monitor. The operator shall be able to minimize and maximize a detailed intersection display. This shall enable the operator to have multiple displays available. The information available for intersection displays shall include all information available for that intersection.

The MOE information displayed on a detailed intersection window shall be operator-selectable. Thresholds shall be dynamically operator-changeable. A legend shall be displayed depicting what MOE is being displayed, the threshold values, and the color definition. If real-time feedback is not available because of higher priority communications, the graphic shall display an appropriate color and/or a message notifying the operator.

3.0 Documentation

3.1 General. Manuals shall be bound, and consist of minimum 8-1/2" x 11" with 11" x 17" minimum schematics. Operating instructions and maintenance manuals shall be provided for all Contractor-furnished equipment. Four (4) sets of manuals shall be provided for each item of Contractor-furnished equipment.

Four (4) copies of draft documentation shall be submitted to the TOWN for written approval no later than the delivery of the corresponding Contractor-furnished equipment. Upon written approval by the TOWN, final documentation for field hardware shall be submitted by the Contractor prior to the end of the 60-day Observation Period.

3.2 Computer/Peripheral Hardware (Contractor-furnished). The Contractor shall furnish four (4) copies of manuals detailing routine maintenance requirements, troubleshooting procedures, interface drawings and parts lists for each piece of Contractor-furnished equipment. This documentation material shall be submitted to the TOWN for review and approval a minimum of sixty (60) days prior to the beginning of the 60-day Observation Period.

3.3 Computer/LAN/Peripheral Manufacturer Supplied Software. The Contractor shall submit four (4) copies of standard documentation for the operating system and all Contractor-furnished computer/LAN/peripheral manufacturer-supplied software. This documentation shall be submitted to the TOWN a minimum of sixty (60) days prior to the start of the 60-day Observation Period.

3.4 ATMS Software. The Contractor shall provide and submit to the TOWN for written approval, full and complete documentation of the ATMS Software that has been furnished and installed by the Contractor.

New flow charts and descriptive graphics shall be prepared and furnished as necessary, indicating connection to and relationship to existing program modification, additions and changes to the base software and their programs or routines.

The Contractor shall supply four (4) copies of the traffic control applications software documentation to the TOWN 60 days before the initial applications software test. Until acceptance of the project, the Contractor shall be responsible for updating the software documentation within two (2) weeks of performing any software changes. If the software documentation does not reflect the current software operation, the TOWN may stop all work on the project until the software documentation is updated. Once initially delivered and installed, the Contractor shall maintain on-site at all times, on CD-ROM or DVD, one (1) debugged and current backup version of the software. Failure to maintain this documentation shall be grounds for the TOWN to halt the project until it is provided. The Contractor must demonstrate that source code has been properly escrowed.

Prior to acceptance of the project, the Contractor shall provide four (4) final ATMS software documentation manuals, two (2) copies of the ATMS software on CD-ROM or DVD, and two (2) copies of program listings. The Contractor shall also demonstrate to the TOWN that the backup version of the program on CD-ROM or DVD is debugged and current. This backup version shall remain after acceptance of the project.

3.5 Color Graphics Subsystem Software. The Contractor shall provide and submit to the TOWN for written approval, full and complete documentation of the color graphics subsystem software that has been furnished and installed by the Contractor.

New flow charts and descriptive graphics shall be prepared and furnished as necessary, indicating connection to and relationship to existing program modification, additions and changes to the base software and their programs or routines.

The Contractor shall prepare and supply complete and fully debugged assembled listings of all source coding provided with and used by the Contractor in the development of this system.

The Contractor shall supply two (2) copies of the current color graphics subsystem software documentation to the TOWN thirty (30) days before the central hardware is delivered on-site. From the date of initial delivery until acceptance of the project, the Contractor shall be responsible for updating the software documentation within two (2) weeks of performing any software changes. If the software documentation does not reflect the current software operation, the TOWN may stop all work on the project until the software documentation is updated. The Contractor shall maintain on-site at all times, one (1) debugged and current backup version on CD- ROM or DVD. Failure to maintain this documentation shall be grounds for the TOWN to halt the project until it is provided.

Prior to acceptance of the project, the Contractor shall supply to the TOWN three (3) final color graphics subsystem software documentation manuals and two (2) copies of program listings. The Contractor shall also demonstrate to the TOWN that the backup version of the program on CD- ROM or DVD is debugged and current. This backup version shall remain after project completion.

3.6 ATMS User's Manual. The Contractor shall submit four (4) copies of the system user's manual for review and approval by the TOWN 60 days prior to the initial acceptance test.

These manuals shall consist of two (2) volumes:

- Procedures for equipment setup, program loading, operating procedures, operational options, program monitoring, recovery procedures, and error message definition and corrections.
- Procedures for preparing, updating, and troubleshooting the database and pattern histories.

The operation of the LANs, file servers, microcomputers, workstations, and peripheral devices shall be described in detail with respect to display of program information and parameters, changing of input parameters, and operation of special keys and other equipment.

Sample output formats shall be provided. They shall be reproductions of laser printer and display outputs. The computer information required to provide such a display shall be illustrated with the appropriate output format.

A complete list of error messages associated with the software operation shall be provided for both the system operation and the database and pattern history. Each error message that could appear during system operation shall be defined as to the actual meaning, cause, and corrective action to be taken. This information shall be in addition to the basic troubleshooting and malfunction information that shall be provided.

Throughout the project, the system user's manual shall be continually updated on a monthly basis to reflect the current applications software. Failure by the Contractor to perform this task shall allow the TOWN to halt work on the project until this task is corrected and demonstrated to the satisfaction of the TOWN.

Immediately prior to the acceptance of the project, the Contractor shall submit to the TOWN four (4) final copies of the system user's manuals. These manuals shall be updated to reflect the current system operation and the TOWN's comments. The TOWN shall approve in writing these manuals before final acceptance is complete.

3.7 Training Manuals. The Contractor shall prepare a set of training manuals individually ring-bound for use during the training sessions. The manuals shall be developed for each of the training sessions and shall be specifically directed at the subject matter required to be covered. Each training manual shall specifically state the purpose of the manual. The manuals shall be revised following the training sessions as required to correct any major errors or deficiencies noted in the training effort.

Two (2) copies of each manual shall be submitted to the TOWN for review sixty (60) days prior to the preliminary scheduled start of the appropriate training session. The appropriate training session shall not start until two (2) weeks after approval by the TOWN of the training manual and the training dates. The number of manuals furnished for each training session shall be not less than the maximum number of participants for that session up to a maximum of ten (10).

The TOWN shall reserve the right to reproduce additional copies of manual(s) for future use of TOWN employees or TOWN contractors engaged in the operation and/or maintenance of the ATMS.

4.0 Warranty

The traffic control system software and all peripheral devices shall be fully warranted for parts and labor for a minimum of two (2) years from the date of acceptance.

5.0 Measurement and Payment

1.0 The work performed, materials furnished and all labor, tools, equipment and incidentals necessary to complete the work under this Item, will be paid for at the lump sum price for "Traffic Control System." This price is for installation of software and hardware, cables and connectors; documentation and testing; and labor, materials, warranty, training and incidentals necessary for operation of a complete Advanced Traffic Control System.