Specification

CONTROLLERS SYSTEMS AUTOSCOPE ACCESSORIES SIGNALS

PYRAMIDS™

Advanced Traffic Control System

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ECONOLITE
Solutions that Move the World®

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System Overview

The Advanced Traffic Control System (ATCS) shall be suited to monitor and control transportation devices in many traffic control applications, from a small city to a large state-wide deployment. The typical application for this ATCS shall be for monitoring and controlling remote intersections and coordinated corridors and has been specifically designed to manage congestion, provide an intuitive traffic engineering interface, aid in community information distribution, and allow inter-departmental integration.

System Description

The system software shall not be a prototype or software custom-developed for this project.

The system software shall communicate directly with the local intersection controllers. The ATCS shall interface with the Wapiti MicroSystems W41KS (rev. 55a) local software packages, employing Econolite's enhanced protocol. In addition, the ATCS shall interface with OASIS/OSM 2070 Master/Local controller program from Econolite. The ATCS shall be designed to mix and match different controllers seamlessly into one system.

The system software shall be compatible and compliant with emerging industry standards for system interconnectivity, interoperability, and expandability. The system shall use a client-server design based on distributed, open architecture concepts.

The new ATCS system shall be designed to operate 24 hours per day, unattended with operator attention required only periodically. Operator intervention requirements shall be limited to defining system components, modifying system timing, responding to alarms or malfunction indicators, diagnosing component failures, and manually "fine-tuning" new timing plans.

The ATCS software shall provide central monitoring of up to 1000 intelligent controllers. The system design shall accommodate future expansion. The addition of new intersections and detectors in the field, shall not require additional software or central hardware, except for modems, data concentrators, or communications concentrators and shall require only modification of the control database. The software design shall facilitate the easy, future incorporation of additional control strategy, software logic, and additional system features.

All changes to the system, including adding new controllers, configuring communications, modifying maps and intersection displays, etc., shall be performed through the ATCS graphical user interface or by updating files in the system software folders. The use of initialization files and external editors shall not be required.

A laptop utility program shall provide on-street accessibility to off-line controllers.

ATCS Hardware Requirements

General

The overall architecture of the system shall be a client server design based on distributed open architecture concepts. Processing shall be distributed and "open" communications protocols shall be used for all interfaces. Client workstations shall access networked file servers that perform traffic management, system communications, database management, and system graphics.

The system shall be implemented using standard, commercially available computer hardware. Windowing Graphical User Interfaces (GUI) using object-oriented design and geographically coded database components shall be an integral part of the system design. These elements shall form the basis of all user interactions with the system. They shall be integrated using industry standard Application Programming Interfaces (API) and Protocols.

The software shall be portable, at a minimum, across multiple PC hardware platforms and shall be designed to integrate with off-the-shelf PC software. For example, the system shall provide the ability to exchange files with common Geographic Information Systems (GIS), databases, Computer Aided Design (CAD), and the Microsoft® Office Suite of products.

Local Area Network Requirements at Central

A 10/100 Base-T Ethernet, Local Area Network (LAN) shall support the distributed client/server architecture. The LAN shall be installed and tested. The LAN shall be connected to the central hardware via full duplex 100 Base-T links, 10 Base-T links/100 Base-TX auto-sensing links, and RS-232, and RS-485 links. These links from the central hardware shall be interconnected via the Ethernet LAN switch. The LAN shall also include network performance management software and remote access to the system. The LAN shall be configured in a star topology centered on the Ethernet LAN switch. All connections to the LAN shall be made using Cat5 cables.

The ATCS software shall allow for a minimum of sixteen (16) simultaneous users (including remote users) of the traffic signal system applications software. No degradation in system performance shall occur when sixteen operators use the system simultaneously. Each user, subject to his or her security level, shall have full access for system control, database entry/examination, malfunction diagnosis, system operation evaluation, and measures of effectiveness analysis. Access by any particular user to any particular command shall be allowed or disallowed based upon that user's assigned security level.

All equipment furnished for the LAN shall comply with IEEE standard 802.3 U. The Ethernet LAN Switch and the Ethernet hub shall be supplied from a common manufacturer.

All network hardware shall operate in 0 to +50 degrees Celsius environment at 5 to 95 percent relative humidity. All network hardware power supplies shall operate from a 115 VAC ± 10 percent at 60 Hz power feed.

Ethernet LAN Switch

Provide an Ethernet LAN switch as a central interface point for connectivity to all system hardware. LAN switch shall feature each of the following attributes:

- A minimum of sixteen (16) 10 Base-T/100 Base-T auto-sensing ports that automatically configure each port for dedicated 10 Mbps or 100 Mbps operation.
- Be rack mountable. The switch shall not exceed 6U panel space and shall not exceed 460 mm in depth.

At a minimum, the front panel shall include the following:

- Power On/Off indicator
- At a minimum, the front panel shall include the following per-port status LED indications:
- Link integrity
- Disabled
- Activity
- Speed
- Full-duplex

- RJ-45 type connectors for all interface ports

Network Interface Cards

Provide 100 Base-T Network Interface Cards (NIC) in the distributed system server, communications server, and all workstations. The NICs shall have a 32-bit bus architecture, be easy to install, and support plug-and-play.

When connected to the LAN, the 100 Base-T NICs shall auto-negotiate to full-duplex 100 Base-T operation.

The system provider shall furnish category 5 cables to connect the NICs, within the peripheral devices to the corresponding switch. All cables shall have RJ-45 connectors with boots and be color-coded.

Category 5 Cable

The system provider shall furnish plenum-rated, Category 5 cabling that meets the requirements of TIA/EIA 568B.

Computer Hardware and Peripherals

Install communications head-end equipment, distributed system server(s), workstations, printers, and any other peripherals at the agency's Traffic Operations Center (TOC).

The system hardware at the TOC shall be sufficient such that expansion of the ATCS may be accommodated without requiring any additional hardware for:

- Intersections
- Workstation
- Dial-up lines for remote workstations

All furnished hardware shall operate at 115 VAC ± 10 percent at 60 Hz. All furnished hardware shall operate in a +5 to +50 degrees Celsius environment at 20 to 80 percent relative humidity.

All workstations and servers shall be from the same manufacturer, unless otherwise approved by the system provider.

Surge Protection

All computer hardware and peripherals, LAN, and central communications equipment not connected to an Uninterruptible Power Supply (UPS) shall be connected to a surge suppression power strip. Each surge suppression power strip shall be equipped with an on-off switch, an indicator lamp, isolating filter banks, and a minimum of six (6) 120 VAC, 60 Hz outlets. At a minimum, the filter banks shall attenuate high frequency noise.

Uninterruptible Power Supply (UPS)

The following components in the TOC shall be connected to an UPS unit as part of the final system:

- Distributed System file server (both server and monitor)
- All workstations (both workstations and monitors)
- Ethernet LAN switch
- Communications server
- System communications rack cabinet

The UPS units shall be capable of detecting a power failure and providing back-up power to the listed components within twenty (20) milliseconds. The transition to the UPS source from primary power shall occur without loss of data or damage to the equipment being provided with back-up power.

The UPS unit shall be sized such that each is capable of providing back-up power for the total load of all equipment connected to the UPS, plus an additional load of twenty-five percent of the total load for at least thirty (30) minutes of operation. The UPS units shall be capable of interfacing with the distributed system software through an RS-232 or USB connection such that upon sensing a loss of power, a system shutdown can be initiated and completed within the specified UPS span of operation.

The UPS unit shall include:

- Commercial 115 VAC, 60 Hz power interconnection and power loss sensing and alarm report via the Distributed system software
- Power protection and filtering
- Power conversion for battery charging
- Batteries to support thirty (30) minutes of operation with loss of power
- Battery status sensing and low battery alarm reporting via the System Software
- Battery charging and charge management
- Battery power conversion and filtering as necessary for interface compatibility with installed equipment. UPS units shall be connected to commercial power. The UPS units and power interconnect shall comply with article 645 of the National Electric Code (NEC)

Distributed System File Server

The Distributed System file server shall feature a modular, upgradeable architecture with Intel® Pentium IV or greater processors. The distributed system file server shall support RS-232 serial communications. The distributed system file server shall have the following features:

Minimum monitor size shall be 15”, 14” viewable, 1,024 × 768 resolution, SVGA.

- A minimum clock running speed of 2.0 GHz
- 400 MHz front end bus
- 512KB of integrated L2 ECC cache
- 1 Gig of error checking and correcting (ECC) RAM (with expansion capacity to 1GB)
- Upgradeable to dual processors
- 4 PCI expansion slots
- 24X speed CD ROM drive
- Hard disk drive storage capacity to accommodate all LAN software, office productivity software, distributed system software and databases, ten days of traffic monitoring data at the ultimate distributed system size of 512 intersections and 500 system detectors, and 4GB of unused capacity (minimum of three 36GB drives)
- A Redundant Array of Inexpensive Disks (RAID) with the chassis, hardware, and interfaces necessary to implement Level 5 RAID storage over three disks.
- The ability to “hot-swap” any single hard disk drive unit without interruption of the server or the LAN.
- RAID storage capacity expandable to 144GB.
- Ultra-wide SCSI controllers, with a minimum of 160 Mb/s per channel of data through put as needed to accommodate the RAID disk drive units.
- Ultra-narrow SCSI controllers as needed to accommodate SCSI peripheral devices.
- One 90mm 1.44MB floppy disk drive.

- Two (2) 100 Base-T network interface cards
- A minimum of two (2) Universal Serial Bus (USB) ports (2.0).
- Microsoft mouse.
- Full function, 104 keyboard with separate numeric and cursor control keys.

Modems (and software) capable of operating at line Bit Per Second (bps) transfer rates ranging from 1,200 to 56,000. The modem shall be capable of automatically adjusting to the maximum bit transfer rate of the device it is dialing to or has been dialed from. The modem shall have standard features such as auto-answer, auto-dial, and phone number storage.

Operating System

The operating system for the signal system distributed server shall be Microsoft® Windows 2000 or 2003 Server. The release used shall be the latest revision available as recommended by the supplier of the system software.

The Network Operating System (NOS) shall be Microsoft Windows 2000 or 2003, as required by the supplier of the traffic signal system software and as approved by the agency.

The NOS and operating system shall be compatible with the traffic signal system software.

Additional Software

The distributed file server shall be furnished with all necessary software required to operate the ATCS properly, which includes Microsoft SQL Server 2000, and all applicable licenses.

Modems

The modem shall meet the following ITU-T standards:

- Data Compatibility: V.34, V.FC, V.32, V.32bis. V.22. V.22bis. V.90
- Fax compatibility: V.17, V.29, V.27ter
- Error Control and Data Compression: V.42/MNP 24 error control (hardware based)
- V.42bisiMNP 5 data compression (hardware based)

Tape Back-up

The back-up tape drive shall be a fast dependable back-up solution. This tape drive shall store a minimum 40 GB of compressed data on a single cartridge at a rate of 21.6 GB/hr (assuming 2: 1 data compression). It shall read and write DDS-4, DDS-3, and DDS-2 formats, with the added capability of reading DDS-1 90m tapes as well. The tape back-up system shall be provided with an easy-to-use back-up and disaster recovery package and tape drive management utilities.

Communications System Server

The system shall be provided with a communications server that has the same provision and requirements of the distributed file server. This server may be used as the distributed file server if that server fails.

Microcomputer Workstations

Each microcomputer workstation shall be upgradeable and shall meet the following requirements:

- Minimum monitor size shall be 19" , 18.5" viewable with a 1,600 × 1,200 resolution
- Minimum clock running speed shall be 1.8 GHz
- A minimum of 512MB of ECC SDRAM shall be provided, expandable to 2GB of RAM
- SVGA video card with advanced graphics processor (AGP) and 3-D graphics with at least 64MB of video memory, a 64-bit graphics chip, upgradeable to 128MB of video memory, with display resolutions up to 1600 × 1200 and support for up to 16.7 million colors
- A 100 Base-T Network Interface Card (NIC), as described in the LAN section of the these specifications, and all software and hardware required for interface with the LAN shall be provided
- 300-watt power supply
- Mini-Tower chassis
- Intel Pentium IV processor with 2x AGP support
- 80 GB hard drive
- 1.44MB floppy
- 12/32X speed DVD/CD-RW drive
- Microsoft 2-button/scroll mouse
- Full function, 104 keyboard with separate numeric and cursor control keys
- A minimum of two (2) universal serial bus (USB) ports
- Six (6) expansion slots, with a minimum or:
    - One (1) AGP slot
    - Five (5) PCI slots
- Internal Modem, (optional)

Operating System

The operating system for the signal system workstation(s) shall be Microsoft™ Windows® XP Professional or Windows® 2000. The release used shall be the latest revision available as recommended by the supplier of the system software.

The operating system shall provide for true multi-tasking and GUI. It shall be possible for workstation users to run Windows-based programs in one or more windows while the traffic signal system applications software continues in full operation.

Printer(s)

A laser printer shall be provided which accommodates fast print speeds up to 45 ppm and less than 8 seconds for the first page out. It shall include a 460 MHz processor, expandable memory, and internal networking. Connectivity shall be provided through the internal network, 1 x parallel - IEEE 1284 (EPP/ECP), 36 pin Centronics 1 x Hi-Speed USB, or 4 pin USB Type B. Embedded web server and tools shall assist in the overall manageability of the printer, allowing administrators to change settings and run upgrades.

The printer shall accommodate a maximum paper capacity up to 3000 pages. The printer must be able to print on envelopes, transparencies, labels, plain paper, cards, and recycled paper using the following sizes:

- Letter (8.5 x 11")
- Legal (8.5 x 14)

- Envelopes (US #10)

ATCS System Software Requirements

Start-Up and Shut-Down

Initial Start-Up

The traffic control system shall provide for the initial start-up of the system by initializing all operational and failure arrays within the software. The initialization routines shall be used not only at the true initial start-up of the system, but whenever it is desired to reinitialize the system without prior status information.

Automatic System Restart

The software shall be configurable to re-boot to the log-in screen upon the restoration of primary power.

Planned Shutdown

The traffic control system shall accommodate a planned shutdown of the monitoring functions of the traffic control software.

Backup Intersection Operation

The ATCS shall provide for back-up intersection operation in case of failure of the distributed system file server, communications server, or the communication system. This back-up shall be accomplished by means of Time-Based Coordination (TBC) provided by the local controller software. The local controllers shall automatically implement TBC, according to the day plan programmed into the controller whenever communication is absent.

Clock Updates

Upon login, each workstation clock shall be automatically updated by the Microsoft Windows™ operating system to the current time of the distributed system server clock.

Remote Access

The ATCS shall allow full access to the system for a multiple user by means of remote dialup facilities, or Ethernet access through a secured firewall, using Microsoft Terminal Services. The remote user shall be allowed to perform any functions, permitted by Terminal Services, and available to any other user with the same level of security regardless to where the user is physically located.

Paging

The ATCS shall provide auto-dial, numeric paging. The alarm conditions that initiate a page shall be user-programmable, as shall be the telephone numbers to be auto-dialed in response to a particular type of alarm. The pager shall provide a numeric message that informs the user of the type of error and its location.

Alphanumeric paging shall be available, but requires a TAP service to be provided by the agency

The paging system shall be configurable to the extent that each alarm can initiate a call to a unique specified phone number, and also be configured to call different numbers at different periods. A third-party Commercial Off-The-Shelf (COTS) software product may be used for this operation, and any license required for this software shall be furnished by the system provider.

Modules

The system provider shall provide the following required modules on the ATCS:

- Traffic Management Module – also know as the *Pyramids*™ module
- Synchro® Interface Module – for importing data from and exporting data to Synchro®

The system provider shall also make available, as options, the following modules which are not necessary to normal system operation:

- Closed Circuit TV (CCTV) module
- Automated Incident Management (AID) module
- Virtual Communications Link (V-Link) module
- Weather station module

Other (optional) Software

The system provider shall furnish the latest release of the Microsoft Office Suite. Professional edition, including Excel, Access, Word, and PowerPoint. A license shall be provided for each workstation and notebook furnished with the project. This software shall not be required for the system to function properly.

The system provider shall furnish, as an option, the latest version of Crystal Reports®. A licensed copy shall be required for each workstation upon which this software is loaded. This software shall be provided only for user's who need to create custom reports. This software shall not be required for the system to function properly.

The system provider shall furnish, as an option, the latest version of Synchro®. A licensed copy shall be required for each workstation upon which the software is loaded. This software shall be provided only for user's who need to create custom reports. This software shall not be required for the system to function properly.

ATCS Operational Requirements

Field Communications

The ATCS software shall communicate with a minimum of eight (8) traffic signal controllers on a fault-tolerant communications channel at a minimum data rate of 1200 kilobits per second. A channel communicates using EIA-232 protocol and utilizes any of the following communications media:

- Spread spectrum radio transmitters w/ EIA-232 interface
- Fiber optic modems w/ EIA-232 interface
- Full-duplex FSK modem using two twisted pairs of copper wire (22awg) or larger, via EIA-232 interface
- IP connectivity using terminal servers w/ EIA-232 interface

Database Preparation

The ATCS system provider shall complete all data entry necessary to implement the operation of the system software.

The agency will furnish intersection timing information and coordination parameters (cycle, split, and offset). Any custom intersection displays will also be provided by the agency. Otherwise, default intersection timing data and standard intersection maps will be utilized when configuring intersections onto the ATCS.

System Function Monitoring

Verification of on-street system operation shall be incorporated in the new ATCS. Operation of all controller equipment shall be monitored with current displays and malfunctions reported in near real-time. Continuous, polled communication shall occur from the local controller to a data concentrator interface. Each data concentrator shall support up to sixty-four (64) controllers. The polled communications rate shall be dependent upon the number of controllers per data concentrator and the channel baud rate.

Database Back-up and Restoration

The system shall include a CD-RW and tape back-up or simple means of copying the database files from the hard disk to diskette(s), CD, or to a magnetic tape storage device. All files required to restore the system to operation without the need to manually re-enter data shall be included on the back-up diskette(s), CD, and magnetic tape.

Files containing records of logged events and detector data shall be saved on hard disk. The system shall enable an operator to copy all logged events, within a user-specified date range, to either the recordable CD system or the tape back-up drive (as selected by the user). The system shall enable an operator to copy all selected detector data, to either the recordable CD system or the tape drive (as selected by the operator).

The software shall provide simple, straightforward means for restoring system operation from the back-up database files.

Graphical User Interface (GUI)

An object-oriented, GUI shall be provided to control and access all systems displays, reports, and dialogue boxes. All workstation user interface functions shall be implemented using GUI concepts conforming to Windows standards. The GUI shall provide access to all signal system monitoring and control options from a single screen.

Graphical icons shall be used on the displays to represent system devices. The icons shall provide easy access to traffic control data (signal timing, geometric, etc.), real-time data (intersection, link status, etc.), the database, and graphical image files.

The GUI shall include an intersection/link base map with windowed table reports and management input windows. The GUI shall provide interactive mechanisms to assist in creating, editing, and modifying editable dynamic graphic screens that are linked to system dynamic elements. As a result, all operator actions shall be immediately visible as a change in the system graphic.

The workspace session window shall display a toolbar near one of the window borders. The toolbar shall contain buttons and other controls for creating document windows, importing and exporting data, setting session parameters, or invoking any other action or activity that affects the entire session. Actions supported by and pertaining to a single window shall be invoked through that window's action bar menu or controls internal to the window itself.

Action bar menus shall support a set of keyboard equivalent accelerators, arrow key navigation of the menu bar, and individual pull-down menus.

Menu and dialogue box options that are not appropriate in a particular context or not available to a given user shall be "grayed-out" and unavailable for selection.

Traffic engineering terminology shall be used throughout the programming displays. Display organization and data entry approach shall allow system operators to operate the distributed signal system software without using reference cards or manuals.

The user interface shall include an object library that contains dynamic icon objects for system control and monitoring devices. The basic system shall include, at a minimum, objects for traffic signals (ISIS, W4IKS and *Oasis*™).

The library shall also include an interactive editor for placing these objects within dynamic graphic screens.

The system shall allow the user to link dynamic graphics objects directly to system database elements without low level code programming, use of initialization files, or program recompilation. The library shall also include dynamic objects allowing the user to define directional roadway links using a simple vector drawing facility. Proper representation of directional status attributes shall be available at all zoomed levels on the system map.

All information shall be shown simultaneously and continuously displayed until canceled by the operator. Displays shall not affect system operation. All displays shall have a maximum refresh rate of one second.

System Graphics

These dynamic condition maps shall provide a simple mechanism for system navigation, presentation of status, and selections within the user interface.

Backgrounds for the system-wide graphic shall be capable of containing commercial vector images of geographically accurate maps or scanned images. These images shall be compatible with common GIS packages such as ARCWEW, ARCINFO, and MAPINFO. These images shall be used as the display layers of real-time graphics displays. The graphics for the entire system shall be developed in the ESRI map objects embedded environment, or approved equivalent.

Backgrounds for the control section and intersection displays shall be .bmp or .jpg formats. Resolution or file size shall not be limited.

Zooming, scrolling and automatic control layers of graphic presentations shall be included with the system.

System Map

The raster-based system-wide map shall provide a dynamic display of the entire surveillance area and any layers the agency requires, including but not limited to interstate highways, major arterial roads, railroads, jurisdiction boundaries, and bodies of water. It shall be possible to "zoom in" and "drill down" to any specific area of the map using the pointing device to select one corner of an area to view, and then select the opposite corner of the area to view (zoom out capability shall also be provided). The window containing the system-wide map shall be capable of being dynamically sized by a workstation user.

It shall be possible to display intersection icons in different formats, using the menu bar. The system map shall provide a dynamic display of the signal system signalized intersections in the following two modes:

- Intersection phasing ("Rubik's Cube")
- Intersection plan

The graphic shall also dynamically display the status of the controllers (e.g., coordination, emergency vehicle preemption, railroad preemption, transition, free operation, flashing, failure, and intersection phase status). Intersection status and roadway links shall change color dynamically based on user-definable color selection.

Intersection phase status (green, yellow, and red) shall be displayed in real-time on the intersection phasing icon, as one of the 8 outer cubes of the "Rubik's Cube". The intersection control status shall be displayed as either the background color on the intersection plan icon or the center section of the "Rubik's Cube". Intersection plan information shall be displayed as a number on the intersection plan icon.

Link status shall be shown as different (user defined) colors for differing traffic flow conditions.

The system display shall be capable of being dynamically sized by a workstation user. Resizing the window shall not reduce the amount of data displayed on a workstation monitor and the same aspect ratio shall be monitored as before the resizing.

Intersection Display

The intersection graphic shall display both static and dynamic information. The static information shall include the intersection name, geometrics of the intersection (including a graphic display of the number of lanes and their associated use), adjacent land use, the location of the controller, and a layout of the intersection with the intersections signal locations and number of heads. The dynamic information to be displayed shall include:

- All vehicle signal indications for each active phase, and up to sixteen (16) overlaps with red, yellow, and green indicators
- All pedestrian signal indications, up to sixteen (16) active phases. WALK, flashing DONT WALK, and steady DONT WALK shall be shown
- Vehicle and pedestrian detector actuations for each active phase
- Cycle timer (master and local clocks)
- Timing plan in effect (with cycle length and offset)

Operational status of the intersection shall include the following, but not be limited to:

- Timing in effect (in coordination, TOD, TR, etc.)
- Status mode (transition, free operation, flash, pre-emption (railroad or emergency vehicle)
- Control mode (manual control, local control, failed, etc.)

The intersection display shall accommodate all standard Wapiti and *Oasis*™ phasing.

The intersection display shall be capable of being dynamically sized by a workstation user. Resizing the window shall not reduce the amount of data displayed on a workstation monitor.

Intersection Monitoring

The status of each controller shall be monitored and any detected error condition shall be logged. Error conditions shall be stored in a form that specifies the type, date, and time of the error. Error processing shall be performed during both coordinated and free operations.

The software shall monitor for the following conditions:

Communications Status

The system software shall report the present status of the communication system at the controller. Changes in status of the communication system shall be recorded in the system log.

Communication Error

If communication between the communications server and local intersection is lost for a number of consecutive seconds, a failure shall be identified and an error message shall be logged and the intersection shall be dropped from system monitoring. Upon identification of a communications error, the software shall continuously attempt to re-establish communications to the intersection and regain monitoring of the intersection.

Flash Conditions

The system shall have the following flash mode capabilities:

- *Central Flash*: Individual intersections and control sections shall be capable of being placed on flash by operator command or schedule entry.
- *Cabinet Flash*: Cabinet flash mode shall be indicated when a controller enters flash via manual selection at the cabinet.
- *Conflict Flash*: Conflict flash shall result from a tripped conflict monitor at the local intersection. Conflict flash shall be logged as a failure by the software system.

The type of flash mode (central, cabinet, or conflict), the intersection name, date and time shall be logged for each entry or exit from flash.

Local Preemption

The system shall monitor and recognize the occurrence of preemption at each local intersection. Accordingly, a preempted intersection shall not be erroneously diagnosed as having experienced a coordination failure. System log messages shall be recorded to note the beginning and ending times of local preemption and the type of preemption (e.g. emergency vehicle, railroad, etc.).

Implemented Local Manual Control

Local manual control shall be initiated and controlled by hardware at the intersection. The software shall identify any intersection that is in local manual control by means of a status message. Accordingly, an intersection being operated under manual control shall not be erroneously diagnosed as having experienced a coordination failure. When the local manual control status has been removed, the local software shall initiate the transition back to normal operation and the system log messages shall be recorded at the start and end of local manual control condition.

Local and System Detectors

The ATCS system shall allow users to set up and gather detector data from local and system detectors for traffic responsive operation or other analytical purposes.

The software shall be able to recognize and report failed detectors (e.g. constant call, no calls, etc.). A detector shall be automatically suspended from use if it is failed. Parameters for determining under counting, over counting, maximum presence shall be adjustable by the user. Detectors classified as marginal shall remain in use, but shall be

identified. A change in classification to either failed or marginal and the reason for the change shall be reported to the operator and automatically entered in the system log, also a reclassification to acceptable shall also be logged. This feature is available for local detectors supported by the *Oasis* program only. System detector activity reported from any local controller type shall be monitored for under counting, over counting, and maximum presence.

Regardless of the classification status of any detector, detector status reporting shall continue unless inhibited by an operator command. A detector that has been suspended from use due to a failure shall remain suspended until its operation has been reclassified as either acceptable or marginal, or until the operator enters a command that releases it from suspension.

Detector data smoothing shall be provided to prevent short-term fluctuations from incorrectly influencing traffic-responsive control algorithms. The system software shall automatically use historical data for the traffic-responsive control algorithms when detectors have been classified as failed.

Timing Plans

An intersection timing plan shall be defined as a unique combination of cycle length, split, and offset at an intersection. The ATCS software shall monitor a minimum of sixty-four (64) timing plans for *Oasis* controllers and eighteen (18) plans for Wapiti controllers. In addition, the software shall enable selection of both flashing and free operation of any intersection.

Cycle lengths, offsets, and splits shall be reported in one-second increments, or as a percentage of the cycle length if selected by the user.

Whenever a new timing plan is implemented, each controller shall achieve the new offset by implementing a transition with respect to the new cycle clock reference. For each intersection on the system, the software shall recognize and display a message that local transition is in effect.

Phase Movements

The system shall monitor each independent movement of up to sixteen (16) phases, for the quad-ring *Oasis* controller. The system shall monitor each independent movement of up to eight (8) phases, for the dual-ring Wapiti controller. This monitoring shall include force off points and permissive periods for each phase.

Clock Updates

Intersection clocks shall be updated at a minimum of once per day. At a user programmable interval, the software loaded on the communications server shall provide for the automatic updating of the universal time by means GPS receiver or Internet time sync. Following each update of the clock on the communications server, the system shall update the clocks in each local controller and the distributed system server.

Intersection Control

The ATCS software shall allow any user to control and implement changes to any intersection controller via the GUI, either through scheduled events, manually controlled events, or time-of-day plans programmed in the local controller. All parameters and events that can be programmed from the controller front panel shall be available at central for remote implementation. Any aspect of the controller timing shall be assessable from central, and shall allow editing of all timings. Full upload and download of timings to controllers shall also be allowed.

Central Scheduler

It shall not be necessary to use a special function to implement any of the local controller's basic functions. These functions shall be inherited from the timing plans associated with each type of controller.

The system shall include a centrally based event scheduler that issues scheduled commands to local and master controllers. The set of schedulable events shall include:

- Coordination plans
- Software flash
- Free operation
- Local Time-of-Day (TOD)
- Traffic Responsive Operation (TRO)
- Special functions (supported by local controller type)

The event scheduler shall support the following features:

- Day plans: The scheduler shall support scheduling of up to 100 unique day plans. Each day plan shall support up to 300 individually schedulable events. The individual events shall be implemented for a specific controller or a control section. The time resolution of each event shall be one minute.
- Week plans: The scheduler shall support up to 52 week plans. Each week plan shall support individual day plan selection for each day of the week.
- Annual calendar: An annual calendar shall support both week plan and individual day plan selection. The calendar shall automatically roll permanently scheduled events from one year to the next.
- Individual event scheduler: The scheduler shall support up to 500 Individual events to be scheduled at a higher priority than the Calendar events.
- Manual command/temporary event scheduler: The scheduler shall support implementation of temporary events. These events shall be programmed to begin immediately or within a scheduled timeframe. These events shall be automatically deleted from the system upon completion.

Time-of-Day (TOD) Operating Mode

The Time-of-Day/Day-of-Week/Day-of-Year (TOD/DOW/DOY) mode of operation shall allow the advance scheduling of the signal plan and timing plan to be implemented in each section. TOD/DOW/DOY scheduling shall be performed based on the schedule data stored locally at the controller and updated by upload/download operations.

Coordination Plan and Scheduler Resolution

Events in the scheduler (both turn-on and turn-off) shall be adjustable in minimum increments of one minute.

Section (zone) control

The software shall achieve coordinated operation across the boundaries of all control sections operating on the same cycle length or on multiples of the same cycle length by ensuring that all such control sections are synchronized to a common reference.

Timing plan selection shall not be limited to entire sections. Timing plans, at the discretion of the system operator, shall be implemented for a single intersection, section of intersections, or system-wide. The timing plan shall be selectable by the operator (Manual mode), by a time clock scheduler (Time-of-Day/Day-of-Week mode), or by the

local controller itself.

Traffic-Responsive Operation (TRO)

In TRO, the system software implements a V+kO pattern matching algorithm, and shall select the timing plan based upon system detector information and coordination threshold parameters that have been defined by the user.

The system database shall identify the system detectors that are assigned to each control section for TRO. System detectors may be assigned to more than one control section.

In TRO, the software shall use weighted volume and occupancy from the active system detectors. When the system is running TRO, it shall monitor the control section for failed detectors. Upon detection of failed detectors, TRO will continue to function until the percentage of failed detectors exceeds an operator-specified threshold. The section shall then automatically switch to the TOD/DOW/DOY timing plan. This plan shall remain in effect until the percentage of failed detectors is below a different operator specified threshold and at this time TRO shall automatically resume.

Minimum plan execution time and threshold hysteresis shall be established by the operator to prevent excessive switching between timing plans. The minimum time between timing plan changes for any given section shall be measured in one-minute increments; this value shall be separately defined for each section. The TRO shall use algorithms developed by the US Department of Transportation.

The user shall have the ability to run Traffic Responsive (TR) as a background process wherein a Traffic Responsive plan is selected, but not implemented. This shall allow the user to verify TRO in an off-line mode.

Database Management

The system shall be built around a multi-user COTS database software product. The database shall be used to store, retrieve, and maintain system data and parameter files and shall be available for common computer hardware platforms. The database system shall use Structured Query Language (SQL) and conform to Microsoft's open database standards.

The software shall provide user-friendly database facilities that allow changes to be put into effect, while the system remains fully operational.

The database management software shall allow programming of the intersection controller databases. Each intersection controller shall have separate database programming pages. These pages shall contain all the programming options unique to each intersection.

All programming entries shall primarily consist of numerical values, “Yes” or “No” entries, and bit data. During configuration data entry, the new data shall overwrite the old data. If the data is in error, changes shall not be permitted and the user shall be alerted by either an error message on the display or a warning tone.

All data items entered from any workstation shall be tested for data type (numeric or text) and allowed range. All string data items shall be tested to ensure that they do not exceed the allowed length. The program shall not terminate because any data item is incorrectly entered. When errors or potential errors are detected, the program shall either display a specific diagnostic message on the screen or shall give an audible alarm and shall place the cursor in the proper field. In any case, the system shall allow the operator to re-enter the item. Prior to or simultaneously with reentry, the diagnostic message, if any, shall be erased.

Whenever a logical grouping of data (such as a full screen or the complete database file) has been entered or edited satisfactorily, that data shall be written to the proper record. This may take place upon return to the main menu or alternatively, it may take place as the entry or editing of each distinct file is ended.

The screen organization and data entry/edit method shall enable the operator to use all functions without the need to use reference manuals or cards. The software shall minimize the use of mnemonics to interface with the user on the screen, in printed reports, and in the system's documentation or worksheets. Only mnemonics consisting of Engineer approved traffic engineering abbreviations and other straightforward abbreviations shall be acceptable.

All field descriptions and inputs shall be simple and all text shall be in simple English and common traffic engineering terminology. It shall not be necessary to perform any decoding to read the information. All necessary field descriptions shall be specifically and discretely provided on the same display screen as they are needed.

Copy Facility

It shall be possible to copy from within the database software all logical segments of the database to other like segments of the database using menu commands. It shall be possible to copy an entire controller database (except for intersection name and identification number) from one controller database to another controller.

Upload/Download of Database

Any workstation shall provide for uploading (copying) the database, and logical segments thereof, from any Wapiti or *Oasis* local controller. The software shall similarly provide for downloading (copying) the database, and logical segments thereof, to a 170 controller using Wapiti or 2070 controller using *Oasis* firmware from any workstation.

The upload/download feature shall use block transfer techniques with a Cyclic Redundancy Check (CRC) to ensure data integrity. Non-verified data shall cause termination of the upload or download operation, with no transfer of the corrupted block occurring. A status message shall be displayed when improper termination of the upload or download operation occurs.

Database Comparison

Following an upload, the system shall allow the operator to compare the database of any intersection controller to the database stored for that intersection on the file server. This comparison shall identify any differences between the uploaded and stored file data. The system operator shall be able to correct, use, or substitute data values and proceed with further comparison.

Reports

The system shall generate a number of pre-configured reports. The ATCS database software shall permit the operator to use Structured Query Language (SQL) to retrieve data and develop custom reports. The user shall be able to define the format of those reports. The list of pre-configured reports shall include, but not be limited to, the following:

- *Communications Status Failure Report* - The communications status failure report shall display the collected data for the communications concentrators and show failures. Such a report shall show the concentrator number, the port number, the logical port number, the status, communication attempts, errors, and percent of failures.

- *System Error Report* – The system error report shall display the collected data of the system errors. Such a report shall show the error date and time, the user ID number, user login name, workstation ID number, error, error description, application ID number, module name, and procedure name.
- *System Events Report* – The system event report shall display the collected data of system events. Such a report shall display the date and time of the event, user ID number, user login name, asset ID number, main street, cross street, event description, and workstation Id number.
- *System Status Report* – The system status report shall display the various conditions of the entire system. Such a report shall show the date and time, the control section, the asset ID number, the main street, cross street, asset type and status, communications status, timing plan, cycle length, present offset, and master ID number.
- *Detector Status Report* – The detector status report shall display the operation of detectors. The user shall be able to select from all detectors in the entire system, for each section for an individual asset or an individual detector. In addition the operator shall be given a choice of start and end dates to display detector data. Such a report shall show the section ID number, section name, intersection ID number, main street, cross street, link ID number, link name, detector ID number, detector name, detector direction, detector, phase, time and date, detector activity, status, and specific failures
- *Measures of Effectiveness Reports (MOE)* – MOE reports shall permit the operator to gauge the effectiveness of the local controller's timing and coordination settings. The following MOE shall be available:
    - *Smoothed Volume* – The smoothed volume report shall display smoothed volume calculations of system detectors. The user shall be able to select from all detectors in the entire system, for each section for an individual asset or an individual detector. In addition the operator shall be given a choice of start and end dates to display the smooth data. Such a report shall show section ID number, section name, intersection ID number, main street, cross street, link ID number, link name, detector number, detector name, detector direction, detector phase, date and time, sample length, class 1-4 volume, and smoothed volume.
    - *Smoothed Occupancy* – The smoothed occupancy report shall display smoothed occupancy calculation of system detectors. The user shall be able to select from all detectors in the entire system, for each section for an individual asset or an individual detector. In addition the operator shall be given a choice of start and end dates to display the smooth data. Such a report shall show section ID number, section name, intersection ID number, main street, cross street, link ID number, link name, detector number, detector name, detector direction, detector phase, date and time, sample length, class 1-4 volume, and smoothed occupancy.
    - *Smoothed Queues* – The smoothed queues report shall display smoothed queues calculation of system detectors. The user shall be able to select from all detectors in the entire system, for each section, for an individual asset or an individual detector. In addition the operator shall be given a choice of start and end dates to display the smooth data. Such a report shall show section ID number, section name, intersection ID number, main street, cross street, link ID number, link name, detector number, detector name, detector direction, detector phase, date and time, sample length, class 1-4 volume, and smoothed queues.
    - *Smoothed Stops* – The smoothed stops report shall display smoothed stops calculation of system detectors. The user shall be able to select from all detectors in the entire system, for each section for an individual asset or an individual detector. In addition the operator shall be given a choice of start and end dates to display the smooth data. Such a report shall show Section ID number, section name, intersection ID number, main street, cross street, link ID number, link name, detector number, detector name, detector direction, detector phase, date and time, sample length, class 1-4 volume, and smoothed stops.
    - *Smoothed Delays* – The smoothed delays report shall display smoothed delays calculation of system detectors. The user shall be able to select from all detectors in the entire system, for each section for an individual asset or an individual detector. In addition the operator shall be given a choice of start

and end dates to display the smooth data. Such a report shall show section ID number, section name, intersection ID number, main street, cross street, link ID number, link name, detector number, detector name, detector direction, detector phase, date and time, sample length, class 1-4 volume, and smoothed delays.

- *Smoothed Intersection Level of Service (LOS)* – The intersection LOS report shall display the LOS calculation from the intersection detectors factoring in waiting, delays, and stops. The user shall be able to select from all detectors in the entire system, for each section, for an individual asset or an individual detector. In addition the operator shall be given a choice of start and end dates to display the smooth data. Such a report shall show section ID number, section name, intersection ID number, main street, cross street, link ID number, link name, detector number, detector name, detector direction, detector phase, date and time, sample length, class 1-4 volume, and intersection LOS.
- *Smoothed Approach LOS* – The approach LOS report shall display the LOS calculation from the intersection detectors factoring in waiting, delays and stops for each approach. The user shall be able to select from all detectors in the entire system, for each section, for an individual asset or an individual detector. In addition the operator shall be given a choice of start and end dates to display the smooth data. Such a report shall show section ID number, section name, intersection ID number, main street, cross street, link ID number, link name, detector number, detector name, detector direction, detector phase, date and time, sample length, class 1-4 volume, and approach LOS.
- *Pedestrian Calls* – The pedestrian call report shall display the number and date when pedestrian calls have occurred on an intersection basis. The user shall be able to select on an intersection basis. In addition the operator shall be given a choice of start and end dates to display the smooth data. Such a report shall show asset ID number, main street, cross street, asset description, time and date, pedestrian calls, detector reference, and count.

Links Report

The links report shall display the link information and the detectors that have been assigned to that link. Such a report shall show the asset ID number, the main street, cross street, link ID number, link name, and detector ID number.

Intersection Status Report

The intersection status report shall display operations parameters of the intersection selected. Such a report shall show in a header the intersection ID number, section ID number, main street, cross street, cycle length, on-line/off-line, timing plan, offset, status, and control mode.

Intersection Operation Report

The intersection operation report shall display the operation status of any intersection. This report shall be filtered by intersection asset ID number and by date. Such a report shall show the following information as a header:

The asset ID number, main street, cross street, asset type, master ID number, section ID number, plan, cycle, and offset.

Under the header there shall be six (6) tabs used to select additional information, the display shall be:

- Detector Tab – The detector tab shall display the detector information for the previously selected intersection. Such a report shall show section ID number, section name, intersection ID number, link ID number, detector ID number, detector name, detector direction, detector phase, time and date, sample length, class 1-4 volumes, occupancy, average stops, average wait, average. speed, status, and detector active.

- Event Tab – The event tab shall display the status and information of the events for the select intersection. Such a report shall show date and time, user ID number, user login name, asset ID number, and event description.
- Command Tab – The command tab shall display the status of the commands associated with the select intersection. Such a report shall show date and time, command type, type description, command code, code description, asset ID number, section ID number, section name, detector ID number, detector name, detector type, detector phase, detector direction, and communication status.
- Failure Tab – The failure tab shall display system failures for the intersection selected. Such a report shall show the date and time, section ID number, section name, asset ID number, failure code, failure description, serial number, detector name, detector type, detector phase, detector direction, and port number.
- Plan Tab – The plan tab shall display the status of the plan operational at the intersection. Such a report shall show the time and date, section ID number, section name, asset ID number, plan number, plan number description, and plan reason description.
- Phase Tab – The phase tab shall display the phase green and other parameters of the phase operation for the intersection selected. Such a report shall show phase ID number, Direction, minimum green, maximum green, and initial variable allowed.

Active Intersection Report

The active intersection report shall display the intersections that are active in the system. Such a report shall show the concentrator address, logical port, physical port, asset ID number, main street, cross street, and activity.

Inactive Intersection Report

The inactive intersection report shall display the intersections that are not active in the system. Such a report shall show the concentrator address, logical port, physical port, asset ID number, main street, cross street, and activity.

Split Monitor Report

Splits and offsets shall be displayed in a graphical format to facilitate the fine-tuning of timing plans. The software shall also include a program that shall run in stand-alone or background mode to access the system database and output time-space diagrams of stored timing plans for selected intersections. Provisions shall be included in the program to output these diagrams to a networked laser printer.

The split monitor report shall display as a graphic the actual green times for each phase of the selected intersection versus the actually timing at the controller. The user shall be able to select from an individual asset and be given a choice of start and end dates to display the split monitor report. The graphics shall display, at a minimum, the actual split times, the programmed split times, and additional times not used by each phase.

Under the graphics shall be a table that shall show the following data collected and updated once per cycle; plan, cycle length, primary phase, primary extended green, secondary phase, secondary extended green, and phases 1-16 greens used.

Time-of-Day (TOD) Scheduler Report

The TOD scheduler report shall display the actual operation of the scheduler. Such a report shall show the date and time, section ID number, section name, asset ID number, main street, cross street, plan number, plan number description, plan reason code, and plan reason description.

System Operations Summary Report

The system operation summary shall display four separate reports that describe:

Equipment and Communication Failures – The system operational summary for equipment and communication shall display a list of equipment failures and communications within the system. The user shall be able to select from all in the entire system, for each section, or an individual asset. In addition the operator shall be given a choice of start and end dates to display detector data. Such a report shall show date and time, asset ID number, and failure description.

- *Controller Failures* – The system operational summary for controller failures shall display failures for controllers. The user shall be able to select from all in the entire system, for each section, or an individual asset. In addition, the operator shall be given a choice of start and end dates to display detector data. Such a report shall show date and time, section name, asset ID number, asset description, main street, cross street, and failure description.
- *Detector Failures* – The system operational summary for detector failures shall display failures for detectors. The user shall be able to select from all in the entire system, for each section, or an individual asset. In addition the operator shall be given a choice of start and end dates to display detector data. Such a report shall show date and time, asset ID number, detector ID number, failure, special failures, phase, direction, main street, and cross street.
- *System Activity Logs* – The system operational activity logs shall display which events have been activated. Such a report shall show event date and time, asset ID number, parent event, event type, and event description.

Schedule Upload of Field Tables Report

The schedule upload of filed tables report shall display the time and assets that are scheduled to have their data base uploaded and compared to the database for accuracy.

Such a report shall show upload times, asset ID number, main street, cross street, asset type, upload status, compare status, and table status.

Security

In addition to the network security features provided by the Windows® Operating System, the software shall provide customizable levels of access security. Each user must enter a login name a password before gaining access to the ATCS software.

The system shall accept any number of users to be configured onto the database. The system shall have 3 default levels of security, as follows:

- Admin user
- Read write
- Read only

The top level (Admin User) shall provide for total access (i.e. permit the operator to view and change all information in the system). Only users with this authorization shall be permitted to view or change access security codes, add new users, and delete existing users.

A bottom level (Read Only) shall permit viewing of all information (except access security codes) yet not permit the

operator to make any changes to the database.

The system shall also provide the ability to customize each user's privileges with respect to system functionality. Specific privileges shall be configurable for each user, with respect to each of the following system permissions:

- User setup (Admin User Only)
- Asset group
- Location
- System preferences
- Archive logs
- Export logs
- Restore logs
- Purge logs

Specific privileges shall be configurable for each user, with respect to each of the following traffic permissions:

- Communications server setup
- Detectors
- Sections
- ICM port configuration
- Scheduler
- Traffic responsive
- Time space diagram
- AEM
- W4 special functions
- Traffic preferences

Specific privileges shall be configurable for each user, with respect to each of the following alarm assignments:

- Central communications failure
- Field communications failure
- Technician flash
- Monitor/conflict flash
- Controller error
- Stop time
- Detector failure
- Police switch
- Door open
- Local clock failure
- Special function 1
- Special function 2
- Special function 3
- Special function 4

Each user shall have separate privileges to each asset group (a group of intersections defined within the system, which may cross jurisdictional boundaries, allowing multiple agencies to use a single system). Specific privileges shall be configurable for each user, with respect to each of the following asset group functions:

- Properties

- Delete
- Graphics editor
- Timing tables
- Upload
- Download
- Manual commands
- Real time clock

Help

The signal system software shall have comprehensive, online help screens. The help screens shall be context sensitive, providing information specific to the highlighted fields or windows displayed.

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