EXPANDING THE CITY OF MOSCOW FIELD LAB DATA COLLECTION CAPABILITIES

Final Report

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16. Abstract

The city of Moscow signal integration project, completed at the end of 2009, improved the city's traffic signal system by connecting the city's seventeen signalized intersections with a fiber optic network, upgrading the cabinets to TS2 Type 1 cabinets and the controllers to NEMA TS2 IP-based controllers, and installing centralized control software to manage the city's traffic signal system. As part of the project, NIATT traffic controller labs were connected to the city's traffic signal system through a direct fiber optic link to create a field lab environment capable of collecting real-time traffic operation data. As an expansion to the project, six of the city's seventeen intersections are equipped with closed-circuit television (CCTV) cameras connected to the state communications system. In this project, we expanded the city of Moscow's field lab data collection capabilities by instrumenting the intersections in the city to record high resolution signal and detector status data.

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EXECUTIVE SUMMARY

The city of Moscow signal integration project, completed at the end of 2009, was a joint effort between the University of Idaho's National Institute for Advanced Transportation Technology (NIATT), the Federal Highway Administration (FHWA), the city of Moscow, and the Idaho Transportation Department (ITD). As a result from this collaborative project, the city's traffic signal system was upgraded by connecting the city's seventeen signalized intersections with a fiber optic network and by upgrading the cabinets to TS2 Type 1 cabinets and the controllers to NEMA TS2 IP-based controllers. In addition, centralized control software was installed to manage the city's traffic signal system. As an expansion to the project, six of the city's seventeen signalized intersections were equipped with closed-circuit television (CCTV) cameras connected to the state communications system.

As part of the city of Moscow's signal integration project, NIATT traffic controller labs were connected to the city's traffic signal system through a direct fiber optic link to create a field lab environment capable of collecting real-time traffic operation data from the city's seventeen signalized intersections. In this project, we expanded the city of Moscow's field lab data collection capabilities by instrumenting the traffic controllers in the city with a utility that is capable of recording, storing, and transmitting high resolution signal and detector status data.

The proposed high-resolution monitoring system is expected to be fully functioning by the end of 2012. It will improve NIATT's research infrastructure in the area of traffic operations and control and offers research grade field data from video, traffic signal controllers, and sensors. Such data will support advances in different research areas including traffic control and operation and driver behavior. It also provides opportunities for traffic signal system education-based visualization applications.

EXPANDING THE CITY OF MOSCOW FIELD LAB DATA COLLECTION CAPABILITIES

1. Overview

One of the major components of the University of Idaho's National Institute for Advanced Transportation Technology (NIATT) strategic plan is to develop traffic control technologies that are useful to small and medium-sized cities. In the city of Moscow signal integration project, a project conducted jointly by the Federal highway Administration (FHWA), Idaho Transportation Department (ITD), the city of Moscow, and NIATT, the city's traffic signal system was upgraded by connecting the city's seventeen signalized intersections with a fiber optic network, and by upgrading the cabinets to TS2 Type 1 cabinets and the controllers to NEMA TS2 IP-based controllers. In addition, centralized control software was installed to manage the city's traffic signal system. As an expansion to the project, six of the city's seventeen signalized intersections were equipped with CCTV cameras connected to the state communications system.

As part of the city of Moscow's signal integration project, NIATT traffic controller labs were connected to the city's traffic signal system through a direct fiber optic link to create a field lab environment capable of collecting real-time traffic operation data from the city's seventeen signalized intersections. The fiber optic routing schematic for the city of Moscow's traffic network is shown in Figure 1.

In this project, we expanded the city of Moscow's field lab data collection capabilities by instrumenting the signalized intersections in the city with a utility that is capable of recording, storing, and transmitting high resolution signal and detector status data. We examined two different alternatives to achieve the high-resolution data collection capability: a hardware alternative that is based on a data-logging device connected to the traffic cabinet and software-based alternative through the system's centralized control software. Both alternatives are discussed in this report. The software-based alternative, however, has been chosen for field implementation due to its lower implementation cost.

The proposed high-resolution monitoring system is expected to be fully functioning by the end of 2012. Once completed, the high-resolution data collection and monitoring system will improve NIATT's research infrastructure in the area of traffic operations and control and offers research grade field data from video, traffic signal controllers, and sensors. Such data will support advances in different research areas including traffic control and operation and driver behavior. It also provides opportunities for traffic signal system education-based visualization applications.

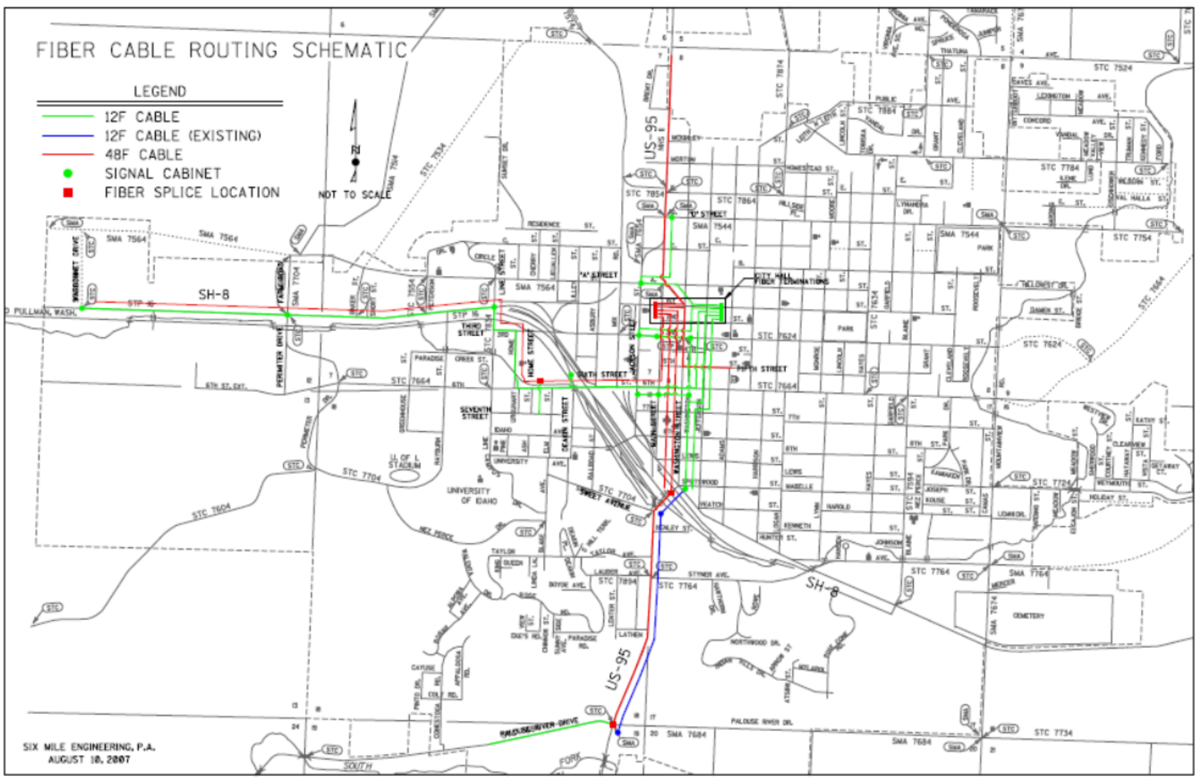


Figure 1: Fiber Optic Routing Schematic for the City of Moscow Traffic Network [Courtesy ITD]

2. Alternative 1 - Data Logging Device

Two different alternatives to achieve the high-resolution data collection capability were examined. The first alternative is hardware-based and involves the use of a data-logging device connected to the traffic cabinet. The second alternative is software-based through the system's centralized control software. The following sections provide description of the hardware-based alternative.

2.1.1. Components and Communication Architecture

The proposed data logging instrumentation is based upon the "Opto 22" family of ultimate input/output (I/O) and "SNAP IDC 5" modules (4 Channel10-24 VDC Inputs). The data logging device components include:

- wiring harness that connects to the 24 volt terminals
- wiring harness that terminates on the modular connector of the IDC 10-24 module
- IDC 10-24 modules monitoring different functions in the cabinet
- power supply for the Ultimate I/O Brain Module
- serial connection for updating the firmware
- 10/100 BaseT connection for Ethernet IP access

2.1.2. Traffic Cabinets: An Overview

A traffic cabinet is essentially a platform within which modular components can be added to serve a variety of applications at the intersection. It provides the communication infrastructure between the various subsystems, as well as a system to monitor their operation. Further, the cabinet provides power supplies suitable for the various electronic subassemblies mounted throughout the cabinet.

Cabinet assemblies consist of a controller cabinet, controller unit, back panel, malfunction management unit, bus interface units, switches, detectors, load switchers, flashers, and connectors. The National Electrical Manufacturers Association (NEMA) family of cabinets include: NEMA TS1, NEMA TS2 Type 1, and NEMA TS2 Type 2 cabinets. NEMA TS1 cabinets include a controller along with the conflict monitor, detectors' connection matrix, load switches, other peripheral equipment, and the necessary internal wiring. NEMA TS2 standard defines two types of controllers and cabinet architectures, the TS2 Type 1 and TS2 Type 2. The NEMA TS2 controller assembly is nearly identical to the TS1. The two primary differences are the change in controller unit and the conflict monitor being replaced by a Malfunction Management Unit (MMU). The NEMA TS2 Type 1 cabinet is unique in the sense that it uses a RS-485/SDLC data link connection to the peripheral devices, with a separate power connector. The TS2 Type 2 provides the same connectors as the TS1 but includes the data link connector. The TS2 cabinet also uses a Bus Interface Unit (BIU) for communication between the various control components and detectors. The BIU provides simplification in cabinet wiring as well as flexibility and power. The TS2 assembly contains a shelf-mounted power supply unit that provides the appropriate power to each of the controller devices. The detectors in the TS2 cabinet are rack-mounted. The TS2 standard defines advanced traffic signal operations, such as coordination and preemption, and developed standards for actuated and pre-timed operations plus advanced cabinet monitoring and diagnostics. Details of NEMA TS2 Type 1 and NEMA TS2 Type 2 cabinets are shown in Figure 2 and Figure 3, respectively.

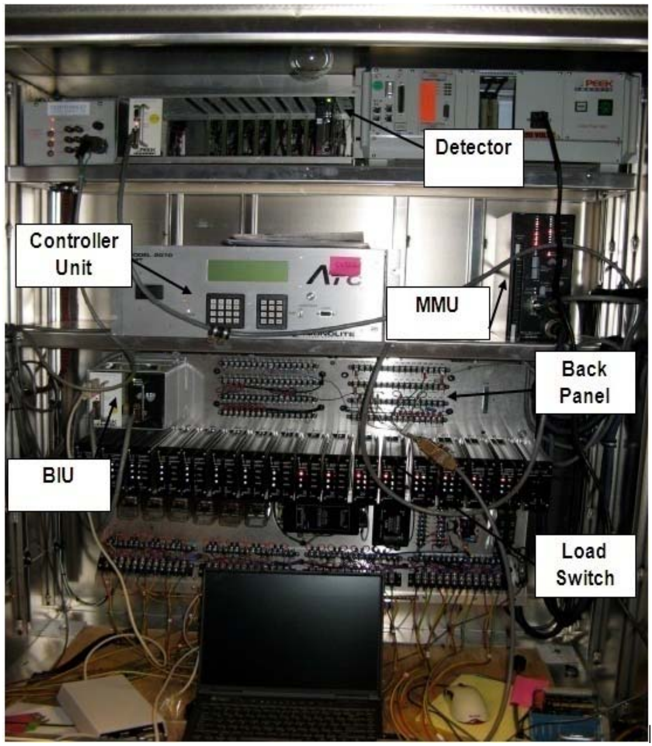


Figure 2: NEMA TS2 Type 1 Traffic Control Cabinet

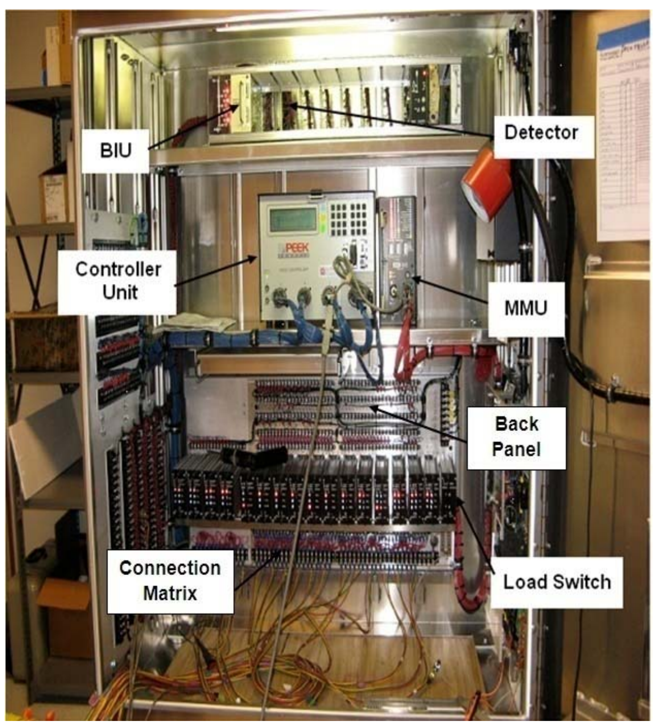


Figure 3: NEMA TS2 Type 2 Traffic Control Cabinet

In terms of interface approach with the traffic controllers, the NEMA TS1 and NEMA TS2 Type 2 standards use the four connectors A, B, C, and D on the front of the controller. The A connector provides power to the controller as well as inputs and outputs with the cabinet. The B and C connectors provide various inputs and outputs for control. The A, B, and C connector pin outs are standardized by NEMA and are interchangeable among all manufacturers. Each connector is different, preventing cables from being inserted in the wrong connection port. The D connector provides communication, preemption, and expanded detection capabilities that are used in more advanced systems. Typical controllers have eight available detection inputs, however, TS2 provides for much greater than eight detector inputs in both a Type 1 and Type 2 mode. The D connector provides input for eight additional detectors. The D connector pin out is not standardized by NEMA; therefore, it may not be interchangeable.

In NEMA TS2 cabinets, the BIU links the controller to the cabinet input/output (I/O) elements. It can also be used as a detector interface device. The BIU is responsible for controlling load switches, receiving and isolating pedestrian calls, analyzing detector faults, time-stamping detector calls, and providing detector resets. By design, the BIU is free of operator controls. The BIU performs its I/O functions based upon a pre-wired card rack address. The MMU is a more advanced intersection/controller monitoring device, not only monitoring all of the conflict voltages, but also communicating with the controller, providing an additional element of monitoring. The Type 16 MMU is usually used in a NEMA TS2 standard cabinet that monitors up to 16 traffic signal channels for conflicting inputs, improper sequencing, incorrect timing, and invalid signal voltage levels. The MMU is also capable of operating in older TS1 type cabinets and is compatible with 12-channel Conflict Monitor Units (CMU) conforming to the TS1 standard. All connectors, indicators, and operator controls are located on the front panel of the MMU. Channel and control input signals and relay output connections are made through two connectors. Indicators on the front of the MMU provide status and fault information. The MMU performs continuous diagnostic tests during all operating modes.

2.1.3. Connecting the Data Logging Device to Different Cabinet Assemblies

In a standard NEMA TS1 style cabinet, the connections to the controller are made through the connection terminal blocks on the back panel of the cabinet. These terminals are the only available connection points for the data logging device (DLD). The proposed connection is shown in Figure 4. The DLD cables should have non-locking spade lug terminals that can be connected to the matrix. The connection is done by loosening the screws on the back panel then connecting the DLD cable terminals. This should not interfere with the cabinet operations and should not cause any malfunction within the cabinet.

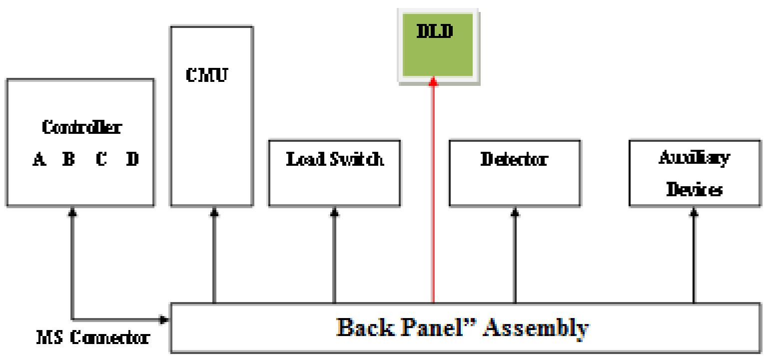


Figure 4: Proposed Data Logging Device Connection to NEMA TS1 Cabinets

In a NEMA TS2 Type 1 style cabinet, the DLD connection is rather challenging as the availability of a connection matrix in the cabinet assembly depends on the application and main panel type. The controller communicates with the cabinet using a serial connection through the cabinet's BIUs. The communication link from the controller uses the RS-485 serial interface that uses the synchronous data link control (SDLC) communication protocol in combination with the NEMA standard TS2 command frames. There are two possible connection options. The first option is to connect via the DLD to the terminals on the back panel of the cabinet. The second option is to connect the cabinets' BIUs that are hardwired to this back panel. This will likely require cooperation with the cabinet vendors. TS2 defines all the connection points from the standard Terminals and Facilities and Detector Rack BIUs. However, these are defined at the connector point on the BIU. As such these might not be easily accessible without a detailed cabinet wiring diagram. The first mode of connection represented uses a solid line and the second mode represented uses dashed lines in Figure 5.

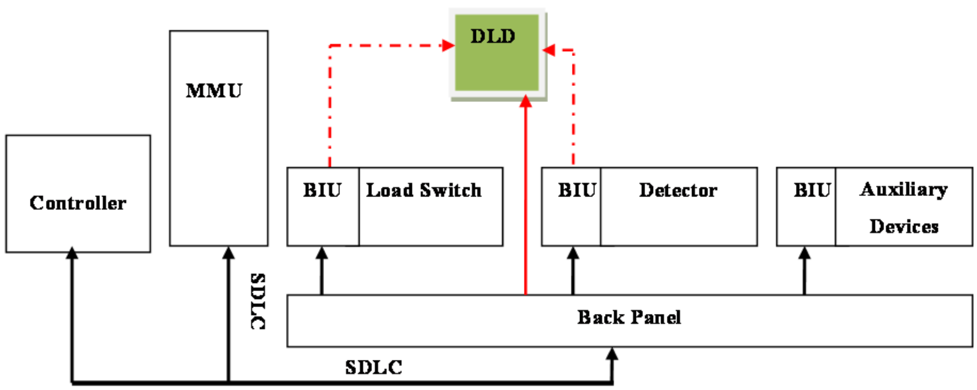
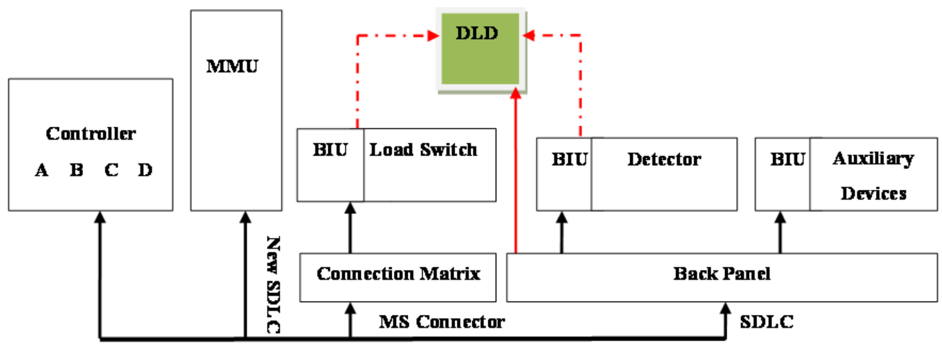
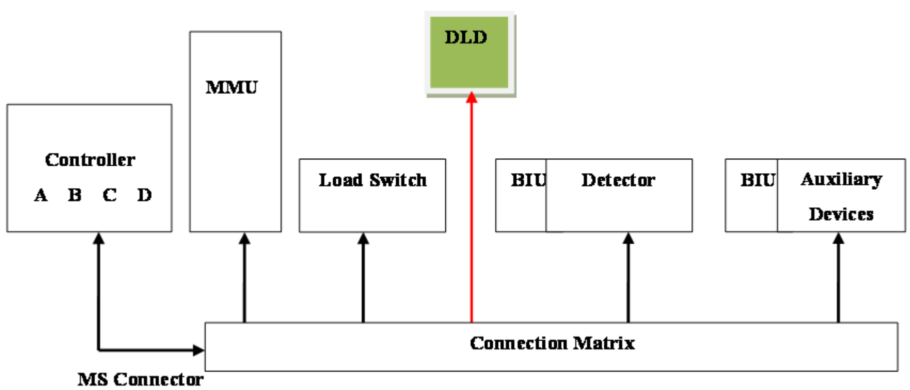


Figure 5: Two Proposed Data Logging Device Connection Options to TS2 Type 1 Cabinet

As shown in Figure 6a and 6b, there are two options to connect the DLD in a NEMA TS2 Type 2 style cabinet since this cabinet combines standards for the TS1 and TS2 Type 1. The first is to connect the device to the connection matrix on the back panel, like that of the NEMA TS1 cabinet. The second is through a connection through either the cabinet's back panel or the BIUs similar to that for TS2 Type1 cabinets.



a. Connection Via the Back Panel and/or BIUs



b. Connection Via Connection Matrix

Figure 6: Data Logging Device Proposed Connection to TS2 Type 2 Cabinet

2.1.4. Data Logging Device Output Files

The DLD monitors and records the communication exchanged between the detector and the controller and between the controller and signal heads. It also records any other special calls sent to the controller such as preemption calls. In essence, the device monitors activities in all input and output communication channels to and from the controllers. In each sampling interval, it scans the status of all input/output channels and records the state of each channel (on or off). The data are then stored in a log file which can be accessed through the Ethernet port. The sampling interval for data logging can be as small as 10 milliseconds (ms). However, since BIUs are updated every 100 ms per the TS2 requirements, a resolution time ranging from 100 ms to 1000 ms can more easily be used in traffic signal system monitoring applications.

Data recorded by the DLD include date, time, and the status of each communication channel on the sampling interval. Figure 7 shows a sample of the DLD files for the status of detector and signal indication I/O communication channels. A value of "-1" represents when the communication channel is "On," a value of "0" represents when the communication channel is "Off."

Figure 7a shows the status of different vehicle detectors using a 100 ms resolution. Detector occupancy and vehicle count can be directly calculated from these raw detector data principally based on the discontinuity distribution of occupancy time followed by un-occupancy time. Figure 7b shows the signal indication status for different phases. The average cycle length and the duration of green, red, and yellow intervals can be directly calculated from the raw signal state and timing data.

	A	B	C	D	E	F	G
1	Date	Time	Ph1_Veh_Call	Ph2_Veh_Call	Ph2_Veh_Call	Ph3_Veh_Call	Ph4_Veh_Call
2	3/13/2008	17:02:04.30	0	-1	0	0	0
3	3/13/2008	17:02:04.40	0	-1	0	0	0
4	3/13/2008	17:02:04.50	0	-1	0	0	0
5	3/13/2008	17:02:04.60	0	-1	0	0	0
6	3/13/2008	17:02:04.70	0	-1	0	0	0
7	3/13/2008	17:02:04.80	0	-1	0	0	0
8	3/13/2008	17:02:04.90	0	-1	0	0	0
9	3/13/2008	17:02:05.00	0	-1	0	0	0
10	3/13/2008	17:02:05.10	0	-1	0	0	0
11	3/13/2008	17:02:05.20	0	-1	0	0	0
12	3/13/2008	17:02:05.30	0	-1	-1	0	0
13	3/13/2008	17:02:05.40	0	-1	-1	0	0
14	3/13/2008	17:02:05.50	0	-1	-1	0	0
15	3/13/2008	17:02:05.60	0	-1	-1	0	0
16	3/13/2008	17:02:05.70	0	-1	-1	0	0
17	3/13/2008	17:02:05.80	0	-1	-1	0	0
18	3/13/2008	17:02:05.90	0	-1	-1	0	0
19	3/13/2008	17:02:06.00	0	-1	-1	0	0
20	3/13/2008	17:02:06.10	0	-1	-1	0	0
21	3/13/2008	17:02:06.20	0	-1	-1	0	0
22	3/13/2008	17:02:06.30	0	-1	-1	0	0
23	3/13/2008	17:02:06.40	0	-1	-1	0	0
24	3/13/2008	17:02:06.50	0	-1	-1	0	0

a. Status of Detector Input Channels

	A	B	C	D	E	F	G	H
1	Date	Time	Ph1_Green	Ph1_Red	Ph1_Yellow	Ph2_Green	Ph2_Red	Ph3_Yellow
2	3/13/2008	17:02:04.30	-1	0	0	0	0	-1
3	3/13/2008	17:02:04.40	-1	0	0	0	0	-1
4	3/13/2008	17:02:04.50	-1	0	0	0	0	-1
5	3/13/2008	17:02:04.60	-1	0	0	0	0	-1
6	3/13/2008	17:02:04.70	-1	0	0	0	0	-1
7	3/13/2008	17:02:04.80	-1	0	0	0	0	-1
8	3/13/2008	17:02:04.90	-1	0	0	0	0	-1
9	3/13/2008	17:02:05.00	-1	0	0	0	0	-1
10	3/13/2008	17:02:05.10	-1	0	0	0	0	-1
11	3/13/2008	17:02:05.20	-1	0	0	0	0	-1
12	3/13/2008	17:02:05.30	-1	0	0	0	0	-1
13	3/13/2008	17:02:05.40	-1	0	0	0	0	-1
14	3/13/2008	17:02:05.50	-1	0	0	0	0	-1
15	3/13/2008	17:02:05.60	-1	0	0	0	0	-1
16	3/13/2008	17:02:05.70	-1	0	0	0	0	-1
17	3/13/2008	17:02:05.80	-1	0	0	0	0	-1
18	3/13/2008	17:02:05.90	-1	0	0	0	0	-1
19	3/13/2008	17:02:06.00	-1	0	0	0	0	-1
20	3/13/2008	17:02:06.10	-1	0	0	0	0	-1
21	3/13/2008	17:02:06.20	-1	0	0	0	0	-1
22	3/13/2008	17:02:06.30	-1	0	0	0	0	-1
23	3/13/2008	17:02:06.40	-1	0	0	0	0	-1
24	3/13/2008	17:02:06.50	-1	0	0	0	0	-1

b. Status of Signal Indication Output Channels

Figure 7: Sample of Data Logging Device Output Files

3. Alternative 2 – Software-based Option

The second alterative to collect and store the high-resolution traffic signal and detector status data considered in this project is software-based through the Econolite ASC-3 traffic controllers and the Centracs advanced transportation management system and control software. In this alternative, a utility in the ASC-3controller firmware collects and stores signal and detector status event data with a 100 milliseconds resolutions. This data is then sent to ITD and NIATT servers through the fiber optic communication network. The proposed communication architecture and data access for this alternative is shown in Figure 8. An example of high-resolution event-based data collected by the ASC-3 traffic controllers is presented in Figure 9. The full description of high resolution controller data collection is presented in the Appendix.

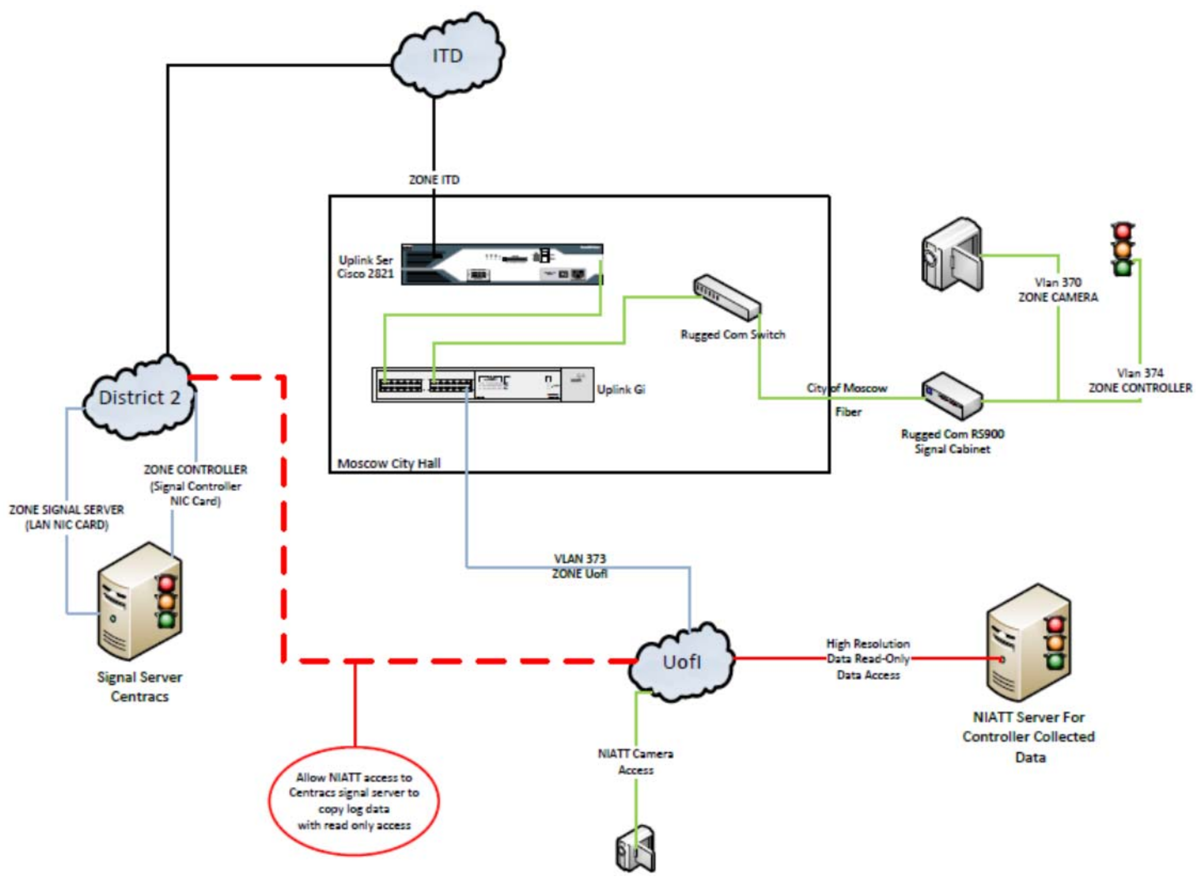


Figure 8: Proposed Communication Architecture for High-Resolution Data Collection

	A	B	C	D	E
1	SignalID	Timestamp	EventCodeID	Param	Event Description
2	327683	2011-10-06 09:28:15.9	32	2	Phase Min Complete
3	327683	2011-10-06 09:28:15.9	32	6	Phase Min Complete
4	327683	2011-10-06 09:28:16.4	9	8	Detector Transition On
5	327683	2011-10-06 09:28:18	9	5	Detector Transition On
6	327683	2011-10-06 09:28:18.9	8	5	Detector Transition Off
7	327683	2011-10-06 09:57:22	8	2	Detector Transition Off
8	327683	2011-10-06 09:57:22.7	9	5	Detector Transition On
9	327683	2011-10-06 09:57:23.5	8	5	Detector Transition Off
10	327683	2011-10-06 09:57:23.6	9	2	Detector Transition On
11	327683	2011-10-06 09:57:24.1	8	6	Detector Transition Off
12	327683	2011-10-06 09:57:24.2	9	6	Detector Transition On
13	327683	2011-10-06 09:57:25.4	8	6	Detector Transition Off
14	327683	2011-10-06 09:57:26.7	9	6	Detector Transition On
15	327683	2011-10-06 09:57:27.8	8	6	Detector Transition Off
16	327683	2011-10-06 09:57:30.3	8	2	Detector Transition Off
17	327683	2011-10-06 09:57:33.2	2	2	Begin Phase Yellow
18	327683	2011-10-06 09:57:33.2	2	6	Begin Phase Yellow
19	327683	2011-10-06 09:57:33.2	33	2	Phase Term Gap Out
20	327683	2011-10-06 09:57:33.2	33	6	Phase Term Gap Out
21	327683	2011-10-06 09:57:36.2	3	2	Begin Phase Red Clear
22	327683	2011-10-06 09:57:36.2	3	6	Begin Phase Red Clear
23	327683	2011-10-06 09:57:37.2	0	2	Begin Phase Off
24	327683	2011-10-06 09:57:37.2	0	6	Begin Phase Off
25	327683	2011-10-06 09:57:37.2	1	4	Begin Phase Green
26	327683	2011-10-06 09:57:37.2	1	8	Begin Phase Green
27	327683	2011-10-06 09:57:40.7	9	2	Detector Transition On

Figure 9: Example of ASC-3 High-Resolution Event-Based Data

CONCLUSIONS

As part of the city of Moscow's signal integration project, NIATT traffic controller labs were connected to the city's traffic signal system through a direct fiber optic link to create a field lab environment capable of collecting real-time traffic operation data from the city's seventeen signalized intersections. In this project, we expanded the city of Moscow's field lab data collection capabilities by instrumenting the signalized intersections in the city with a utility that is capable of recording, storing, and transmitting high resolution signal and detector status data. We examined two different alternatives to achieve the high-resolution data collection capability: a hardware alternative that is based on a DLD connected to the traffic cabinet and software-based alternative through the system's centralized control software. Both alternatives are discussed in this report. The software-based alternative, however, has been chosen for field implementation due to its feasibility and lower implementation cost.

The proposed high-resolution monitoring system is expected to be fully functioning by the end of 2012. Once completed, the high-resolution data collection and monitoring system will improve NIATT's research infrastructure in the area of traffic operations and control and offers research grade field data from video, traffic signal controllers, and sensors. Such data will support advances in different research areas including traffic control and operation and driver behavior. It also provides opportunities for traffic signal system education-based visualization applications.

APPENDIX: HIGH RESOLUTION CONTROLLER DATA COLLECTION[1]

Data Collection Procedure

Intent

Traffic Signal Controller shall have the ability to log and store high resolution (1/10 second) controller event data. This procedure specifies the data storage, formats, elements, retrieval and translation. This data will be ingested into the traffic management center (TMC) relational database. The TMC relational database will be used to calculate performance measures (such as those defined by NCHRP 3-79a) for tactical and strategic management of the Indiana Department of Transportation (INDOT) traffic signals.

Project needs require the following data to be retrieved and managed from the local traffic controller:

- Setup information:
  - Controller IP address: e.g. 128.46.170.89
  - Phases (1-16) in use
- Real-time data collection with timestamps:

Data Storage Methodology

Controller may have the ability to enable/disable the data collection (logging) but if so equipped shall default to data collection enabled. Data shall be logged by the controller and stored in individual flat (binary) files for each hour. Each file shall contain all of the data from the start of the hour (i.e.: 15:00:00.0) thru the end of the same hour (i.e.: 15:59:59.9). The controller shall provide storage for a minimum of 24 of these data files each with a minimum of 250,000 event records for a combined data storage capacity of a minimum of 6,000,000 records. The controller shall utilize a FIFO (first-in-first-out) method of file management, once the allowed memory buffer is full, the oldest data file can be deleted to free memory space for the new file.

[1] The high-resolution controller data collection description in this Appendix is based on the specification developed by Econolite for Indiana DOT implementation [Courtesy Econolite, Inc.]

Data File Format

The controller data file format is proprietary for each manufacturer. It is however very important that each manufacturer provide a Linux and Microsoft data translation application to convert their propriety binary data file into a pre-defined enumerated common delimited (csv) file for INDOT to use with their current system.

Filename format:

XXXX_255.255.255.255_yyyy_mm_dd_hhhh.dat, where:

- the four digit manufacturer code (ex. PEEK, SIEM, ECON, etc), followed by the text character "_"
- the UNIT IP ADDRESS (0-255. 0-255. 0-255. 0-255), followed by the text character "_"
- the four digit YEAR, followed by the text character "_"
- the two digit MONTH, followed by the text character "_"
- the two digit DAY, followed by the text character "_"
- the four digit TIME (HOUR [0-23]/MIN [00]), the start of the file
- the text character ".dat" denotes the file extension as a binary format

Example: File name for data collected at intersection with IP 10.1.10.70 on Jan 9th 2006 between the hours of 23:00:00.0 and 23:59:59.9 by an Econolite controller:

"ECON_10.1.10.70_2006_01_09_2300.dat"

Data to Collect

The following transitional events shall be logged in such a way that the timestamp with 1/10 second accuracy, event code and parameter can be correctly parsed into a comma delimited (csv) file by the translation application described later.

Event Code	Event Descriptor	Parameter	Description
Active Phase Events:			
0	Phase On	Phase # (1-16)	Set when NEMA Phase On becomes active, either upon start of green or walk interval, whichever occurs first.
1	Phase Begin Green	Phase # (1-16)	Set when either solid or flashing green indication has begun. Do not set repeatedly during flashing operation.
2	Phase Check	Phase # (1-16)	Set when a conflicting call is registered against the active phase (marks beginning of MAX timing).
3	Phase Min Complete	Phase # (1-16)	Set when phase min timer expires.
4	Phase Gap Out	Phase # (1-16)	Set when phase gaps out, but may not necessarily occur upon phase termination. Event may be set multiple times within a single green under simultaneous gap out.
5	Phase Max Out	Phase # (1-16)	Set when phase MAX timer expires, but may not necessarily occur upon phase termination due to last car passage or other features.
6	Phase Force Off	Phase # (1-16)	Set when phase force off is applied to the active green phase.
7	Phase Green Termination	Phase # (1-16)	Set when phase green indications are terminated into either yellow clearance or permissive (FYA) movement.
8	Phase Begin Yellow Clearance		Set when phase yellow indication becomes active and clearance timer begins.
9	Phase End Yellow Clearance		Set when phase yellow indication becomes inactive.
10	Phase Begin Red Clearance	Phase # (1-16)	Set only if phase red clearance is served. Set when red clearance timing begins.
11	Phase End Red Clearance	Phase # (1-16)	Set only if phase red clearance is served. Set when red clearance timing concludes. This may not necessarily coincide with completion of the phase, especially during clearance of trailing overlaps, red revert timing, red rest, or delay for other ring terminations.
12	Phase Inactive	Phase # (1-16)	Set when the phase is no longer active within the ring, including completion of any trailing overlaps or end of barrier delays for adjacent ring termination.
13-20	Phase events reserved for future use.	Phase # (1-16)	
Active Pedestrian Events:			
21	Pedestrian Begin Walk	Phase # (1-16)	Set when walk indication becomes active.

Event Code	Event Descriptor	Parameter	Description
22	Pedestrian Begin Clearance	Phase # (1-16)	Set when flashing don't walk indication becomes active.
23	Pedestrian Begin Solid Don't Walk	Phase # (1-16)	Set when don't walk indication becomes solid (non-flashing) from either termination of ped clearance, or head illumination after a ped dark interval.
24	Pedestrian Dark	Phase # (1-16)	Set when the pedestrian outputs are set off.
25-30	Pedestrian events reserved for future use.		
Barrier / Ring Events:			
31	Barrier Termination	Barrier #(1-8)	Set when all active phases become inactive in the ring and cross barrier phases are next to be served.
32	FYA – Begin Permissive	FYA # (1-4)	Set when flashing yellow arrow becomes active.
33	FYA – End Permissive	FYA # (1-4)	Set when flashing yellow arrow becomes inactive through either clearance of the permissive movement or transition into a protected movement.
34-40	Barrier events reserve for future use.		
Phase Control Events:			
41	Phase Hold Active	Phase # (1-16)	Set when phase hold is applied by the coordinator, preemptor, or external logic. Phase does not necessarily need to be actively timing for this event to occur.
42	Phase Hold Released	Phase # (1-16)	Set when phase hold is released by the coordinator, preemptor, or external logic. Phase does not necessarily need to be actively timing for this event to occur.
43	Phase Call Registered	Phase # (1-16)	Call to service on a phase is registered by vehicular demand. This event will not be set if a recall exists on the phase.
44	Phase Call Dropped	Phase # (1-16)	Call to service on a phase is cleared by either service of the phase or removal of call.
45	Pedestrian Call Registered	Phase # (1-16)	Call to service on a phase is registered by pedestrian demand. This event will not be set if a recall exists on the phase.
46	Phase Omit On	Phase # (1-16)	Set when phase omit is applied by the coordinator, preemptor, or other dynamic sources. Phase does not necessarily need to be actively timing for this event to occur. This event is not set when phase is removed from the active sequence or other configuration-

Event Code	Event Descriptor	Parameter	Description
			level change has occurred.
47	Phase Omit Off	Phase # (1-16)	Set when phase omit is released by the coordinator, preemptor, or other dynamic sources. Phase does not necessarily need to be actively timing for this event to occur. This event is not set when phase is added from the active sequence or other configuration-level change has occurred.
48	Pedestrian Omit On	Phase # (1-16)	Set when ped omit is applied by the coordinator, preemptor, or other dynamic sources. Phase does not necessarily need to be actively timing for this event to occur. This event is not set when phase is removed from the active sequence or other configuration-level change has occurred.
49	Pedestrian Omit Off	Phase # (1-16)	Set when ped omit is released by the coordinator, preemptor, or other dynamic sources. Phase does not necessarily need to be actively timing for this event to occur. This event is not set when phase is added from the active sequence or other configuration-level change has occurred.
50-60	Phase Control Events reserved for future use.		
Overlap Events:			
61	Overlap Begin Green	Overlap # (as number A=1 B=2, etc)	Set when overlap becomes green. Do not set repeatedly when overlap is flashing green. Note that overlap colors are consistent to the GYR intervals resultant from the controller programming and may not be indicative of actual signal head colors.
62	Overlap Begin Trailing Green (Extension)	Overlap # (as number A=1 B=2, etc)	Set when overlap is green and extension timers begin timing.
63	Overlap Begin Yellow	Overlap # (as number A=1 B=2, etc)	Set when overlap is in a yellow clearance state. Note that overlaps which drive yellow field indications during a dwell state may be reported as green or inactive (common to mid-block signals).
64	Overlap Begin Red Clearance	Overlap # (as number A=1 B=2, etc)	Set when overlap begins timing red clearance intervals.
65	Overlap Off (Inactive with Red Indication)	Overlap # (as number A=1 B=2, etc)	Set when overlap has completed all timing, allowing any conflicting phase next to begin service.

Event Code	Event Descriptor	Parameter	Description
66	Overlap Dark	Overlap # (as number A=1 B=2, etc)	Set when overlap head is set dark (no active outputs). The end of this interval shall be recorded by either an overlap off state or other active overlap state.
67	Pedestrian Overlap Begin Walk	Overlap # (as number A=1 B=2, etc)	Set when walk indication becomes active.
68	Pedestrian Overlap Begin Clearance	Overlap # (as number A=1 B=2, etc)	Set when flashing don't walk indication becomes active.
69	Pedestrian Overlap Begin Solid Don't Walk	Overlap # (as number A=1 B=2, etc)	Set when don't walk indication becomes solid (non-flashing) from either termination of ped clearance, or head illumination after a ped dark interval.
70	Pedestrian Overlap Dark	Overlap # (as number A=1 B=2, etc)	Set when the pedestrian outputs are set off.
71-80	Overlap events reserved for future use.	Overlap # (as number A=1 B=2, etc)	
Detector Events:			
81	Detector Off	DET Channel # (1-64)	Detector on and off events shall be triggered post any detector delay/extension processing.
82	Detector On	DET Channel # (1-64)	
83	Detector Restored	DET Channel # (1-64)	Detector restored to non-failed state by either manual restoration or re-enabling via continued diagnostics.
84	Detector Fault- Other	DET Channel # (1-64)	Detector failure logged upon local controller diagnostics only (not system diagnostics).
85	Detector Fault- Watchdog Fault	DET Channel # (1-64)	Detector failure logged upon local controller diagnostics only (not system diagnostics).
86	Detector Fault- Open Loop Fault	DET Channel # (1-64)	Detector failure logged upon local controller diagnostics only (not system diagnostics).
87	Detector Fault- Shorted Loop Fault	DET Channel # (1-64)	Detector failure logged upon local controller diagnostics only (not system diagnostics).
88	Detector Fault- Excessive Change Fault	DET Channel # (1-64)	Detector failure logged upon local controller diagnostics only (not system diagnostics).

Event Code	Event Descriptor	Parameter	Description
89	PedDetector Off	DET Channel # (1-16)	Ped detector events shall be triggered post any detector delay/extension processing and may be set multiple times for a single pedestrian call (with future intent to eventually support ped presence and volume).
90	PedDetector On	DET Channel # (1-16)	
91	Pedestrian Detector Failed	Ped Det # (1-16)	Detector failure logged upon local controller diagnostics only (not system diagnostics).
92	Pedestrian Detector Restored	Ped Det # (1-16)	Detector failure logged upon local controller diagnostics only (not system diagnostics).
93-100	Detector events reserved for future use.		
Preemption Events:			
101	Preempt Advance Warning Input	Preempt # (1-10)	Set when preemption advance warning input is activated.
102	Preempt (Call) Input On	Preempt # (1-10)	Set when preemption input is activated (prior to preemption delay timing). May be set multiple times if input is intermittent during preemption service.
103	Preempt Gate Down Input Received	Preempt # (1-10)	Set when gate down input is received by the controller (if available).
104	Preempt (Call) Input Off	Preempt # (1-10)	Set when preemption input is de-activated. May be set multiple times if input is intermittent preemption service.
105	Preempt Entry Started	Preempt # (1-10)	Set when preemption delay expires and controller begins transition timing (force off) to serve preemption.
106	Preemption Begin Track Clearance	Preempt # (1-10)	Set when track clearance phases are green and track clearance timing begins.
107	Preemption Begin Dwell Service	Preempt # (1-10)	Set when preemption dwell or limited service begins or minimum dwell timer is reset due to call drop and reapplication.
108	Preemption Link Active On	Preempt # (1-10)	Set when linked preemptor input is applied from active preemptor.
109	Preemption Link Active Off	Preempt # (1-10)	Set when linked preemptor input is dropped from active preemptor.
110	Preemption Max Presence Exceeded	Preempt # (1-10)	Set when preemption max presence timer is exceeded and preemption input is released from service.
111	Preemption Begin Exit Interval	Preempt # (1-10)	Set when preemption exit interval phases are green and exit timing begins.
112	TSP Check In	TSP #(1-10)	Set when request for priority is received.

Event Code	Event Descriptor	Parameter	Description
113	TSP Adjustment to Early Green	TSP #(1-10)	Set when controller is adjusting active cycle to accommodate early service to TSP phases.
114	TSP Adjustment to Extend Green	TSP #(1-10)	Set when controller is adjusting active cycle to accommodate extended service to TSP phases.
115	TSP Check Out	TSP #(1-10)	Set when request for priority is retracted.
116-130	Preemption Events reserved for future use		
Coordination Events:			
131	Coord Pattern Change	Pattern # (0-255)	Coordination pattern that is actively running in the controller. (Highest priority of TOD, system or manual command). This event will not be reapplied if coordination is temporarily suspended for preemption or other external control.
132	Cycle Length Change	Seconds (0-255)	This event shall be populated upon selection of a new coordination pattern change that selects a new cycle length. Cycle lengths in excess of 255 shall record this event with a 255 parameter, requiring controller database lookup for this actual value.
133	Offset Length Change	Seconds (0-255)	This event shall be populated upon selection of a new coordination pattern change that selects a new cycle length. Offsets in excess of 255 shall record this event with a 255 parameter, requiring controller database lookup for this actual value.
134	Split 1 Change	New Split Time in Seconds (0-255)	Split change events shall be populated upon selection of a new coordination pattern as well as during a split change to an active pattern via ACS Lite or other adaptive control system.
135	Split 2 Change	New Split Time in Seconds (0-255)	
136	Split 3 Change	New Split Time in Seconds (0-255)	
137	Split 4 Change	New Split Time in Seconds (0-255)	
138	Split 5 Change	New Split Time in Seconds (0-255)	
139	Split 6 Change	New Split Time in Seconds (0-255)	
140	Split 7 Change	New Split Time in Seconds (0-255)	
141	Split 8 Change	New Split Time in	

Event Code	Event Descriptor	Parameter	Description
		Seconds (0-255)	
142	Split 9 Change	New Split Time in Seconds (0-255)	
143	Split 10 Change	New Split Time in Seconds (0-255)	
144	Split 11 Change	New Split Time in Seconds (0-255)	
145	Split 12 Change	New Split Time in Seconds (0-255)	
146	Split 13 Change	New Split Time in Seconds (0-255)	
147	Split 14 Change	New Split Time in Seconds (0-255)	
148	Split 15 Change	New Split Time in Seconds (0-255)	
149	Split 16 Change	New Split Time in Seconds (0-255)	
150	Coord Cycle State Change	Parameter (0-6) Defined as: 0 = Free 1 = In Step 2 = Transition - Add 3 = Transition - Subtract 4 = Transition - Dwell 5 = Local Zero 6 = Begin Pickup	
151	Coordinated Phase Yield Point	Phase # (1-16)	
152-170	Coordination events reserved for future use.		
Cabinet / System Events:			
171	Test Input On	Test Input # (as Number A=1 B=2, etc)	Cabinet test or special function input as defined by the local controller.
172	Test Input Off	Test Input # (as Number A=1 B=2, etc)	
173	Unit Flash Status Change	NTCIP Flash State # (0-255)	See NTCIP 1202 2.4.5 for definition.

Event Code	Event Descriptor	Parameter	Description
174	Unit Alarm Status 1 Change	NTCIP Alarm Status 1# (0-255)	See NTCIP 1202 2.4.8 for definition.
175	Alarm Group State Change	NTCIP Alarm Group State (0-255)	See NTCIP 1202 2.4.12.2 for definition.
176	Special Function Output On	Special Function # (0-255)	Special function output as defined by the local controller.
177	Special Function Output Off	Special Function # (0-255)	Special function output as defined by the local controller.
178	Manual Control Enable Off/On	Manual Control Enable Off/On # (0,1)	
179	Interval Advance Off/On	Interval Advance Off/On # (0,1)	Leading edge on (1), lagging edge (0) optional.
180	Stop Time Input Off/On	Stop Time Input Advance Off/On # (0,1)	Set when stop time input is applied or removed, regardless of source of stop.
181	Controller Clock Updated	Optional Parameter: Time Correction in Seconds (0-255)	Set when the controller OS clock is adjusted via communications, OS command, or external input.
182	Power Failure Detected	True (1)	Line voltage drops between 0-89 volts AC for more than100 ms.
184	Power Restored	True (1)	Line voltage applied/reapplied greater than 98 volts AC.
185	Vendor Specific Alarm	Vendor Defined Parameter	Placeholder for generic failure/alarm types as defined by vendor.
186-199	Cabinet/System events reserved for future use.		
200-255	Reserved for future use.		

Initial Status events

In addition to transitional events, the status of the following events shall be logged daily at midnight as the beginning status of each day as part of the 00:00 hour file starting the day. The Timestamp for each Initial Status event shall be 00:00:00.0 however, the actual logging of the events may occur as late as 00:05 allowing time for higher priority system activities.

- 84- Detector Fault- Other
- 85- Detector Fault- WatchDog Fault

- 86- Detector Fault- Open Loop Fault
- 87- Detector Fault- Shorted Loop Fault
- 88- Detector Fault- Excessive Change Fault
- 91- Ped Detector Failed
- Unit Flash Status Change (1-8 or 0-255) (2.4.6 Unit Flash Status)
- Alarm Status 1 Change (0-255) (2.4.8 Unit Alarm Status 1)
- Special Function Output On
- Special Function Output Off
- Alarm State On
- Alarm State Off

The following events shall be logged at midnight as described above and at each coordination pattern change (event 131) as a complete coordination status event set not as a duplication of events. Every individual event shall be logged even if they do not individually change in value

- 131- Coordination pattern change
- 132- Cycle length change
- 133- Offset length change
- 134-149- Phase split change (used phases only)

Data Retrieval Methodology

- The traffic controller shall support a TCP/IP network connection with a traffic management server. It will be the responsibility of the traffic management server to upload these files via FTP from the traffic controller on a periodic basis. The FTP server within the traffic controller shall host these files. The data files uploaded from the controller shall not cause the file to be deleted from the controller. The data file may only be deleted as part of the data management process.

Data Translation Application

The binary data within the .dat file shall be parsed into comma delimited values for user management.

Command line applications shall be provided to each run natively in Linux and Microsoft DOS to translate the data files retrieved from the controller. Each application shall output a comma delimited (.csv) file. The Data Translation Application shall have at least but not limited to the following capabilities:

- .Command line application that takes arguments
  - Path and file names (w/ wildcards) of data files to be processed.
  - Path of output folder to write the csv files.
- .csv File Format

The .csv files created shall adhere to the following conventions.

- The output csv file name shall match the input data file name except for filename extension (.csv) following the same convention as the binary file:
  - XXXX_10.1.10.70_2006_01_09_2300.csv where 10.1.10.70 is the ip of the controller followed by the date and hour interval logged to this file

- Output file timestamp format shall be a standard m/d/yyyy hhmmss.s format defined as:
  - m = 1 or 2 digit month
  - d= 1 or 2 digit day
  - yyyy= 4 digit year
  - hh= 2 digit hour
  - mm= 2 digit minute
  - ss.s= 3 digit second with 1/10 second resolution

  There shall be a standard – or / delimiter between the month and day and also between the day and year. There shall be a 1 space delimiter between the year and the hour. There shall be no delimiter in the hour minute seconds.

  The timestamp data shall be stored as an ASCII string. Midnight shall be represented as 00:00:00.0 not 24:00:00.0.

- Header
  There shall be a 7 line ASCII file header containing the following information as defined:

  The following header structure, delimiters and special characters shall be strictly adhered to, with exception to the timestamp format as described above.

  1. Timestamp,Event Type,Parameter
  2. 1-9-2006 12:02:51.0,,ECON_10.1.10.70_2008_05_30_1200.csv
  3. 1-9-2006 12:02:51.0,,Intersection #,255.255.255.255
  4. 1-9-2006 12:02:51.0,,IP Address:,255.255.255.255
  5. 1-9-2006 12:02:51.0,,MAC Address:,1,2,3,4,5,6
  6. 1-9-2006 12:02:51.0,,Controller Data Log Beginning:,5/30/2008,12:02.0
  7. 1-9-2006 12:02:51.0,,Phases in use:,1,2,3,4,5,6,7,8

- Event Data
  The event initial states (see initial state events) and transitional event data shall be listed following the file header. The data shall be formatted in the .csv file as shown below.

  Timestamp,Event Code,,Parameter

  …<<header>>…

  1-9-2006 12:02:51.0,0,1

  1-9-2006 12:02:51.0,4,1

1-9-2006 12:02:51.0,0,2

1-9-2006 12:02:51.0,4,2

1-9-2006 12:02:51.0,0,3

1-9-2006 12:02:51.0,4,3

1-9-2006 12:02:51.0,0,4

1-9-2006 12:02:51.0,4,4

1-9-2006 12:02:51.0,0,5

1-9-2006 12:02:51.0,4,5

1-9-2006 12:02:51.0,0,6

1-9-2006 12:02:51.0,4,6

1-9-2006 12:02:51.0,0,7

1-9-2006 12:02:51.0,4,7

1-9-2006 12:02:51.0,0,1

(continued for all events)

- Data File Footer- There shall not be a footer to the .csv data file.