# Development of A System to Collect Loop Detector Event (Individual Vehicle) Data

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## Abstract

Typical freeway inductance loop detection systems, under normal operation, aggregate individual loop detector actuations sampled at 60 Hz into 20 second or 30 second average velocity, flow, and lane occupancy measurements. While such aggregations are appropriate for serving as inputs to control system algorithms, and save disk space for archiving loop data, much useful data regarding individual vehicles are lost. For single loop detectors, the lost information includes individual vehicle arrival, departure and presence times. For speed traps, the lost information also includes the calculated individual vehicle speed and length. Yet this information about individual vehicles is very desirable for transportation researchers and planners. Furthermore, the unavailability of this information makes in-depth investigation of detector errors difficult or even impossible.

In this paper, a detector event data collection (DEDAC) system is proposed. This system is able to sample loop actuations with sampling rates of 60 Hz or higher and then save, process and present the collected event data in real time without interfering with the detector controller's normal operation. The authors have developed a stand-alone Windows program for performing real-time high-frequency loop event data collection. A system reliability test and a field application indicate that the system has the capability of collecting real-time detector event data at a high sampling rate (60 Hz or higher). Additionally, this system makes real-time loop data quality evaluation, loop malfunction identification, and loop error correction feasible.

Keywords: freeway traffic, inductive loop detectors, event data collection, error detection.

### BACKGROUND

Inductance loop detectors are widely used in the U.S. to provide traffic data for Advanced Traffic Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS). Loops are frequently deployed as single detectors, i.e., one loop per lane per detector station, or as speed traps (also called dual loop detectors), i.e., two adjacent loops a few meters apart per lane per detector station. Single detectors are used to measure volume and lane occupancy, while speed traps also measure speeds with vehicle lengths as a byproduct.

The loops operate in presence mode (that is, they turn on and stay on as long as a vehicle is occupying the loop). At each station, the field microprocessor (usually a Model 170 controller, an 8-bit 6808-based machine) checks or scans the loop actuations 60 times each second. Typical freeway loop detection systems, under normal operation, aggregate individual loop detector actuations sampled at 60 Hz into 20-second or 30-second averages of velocity, flow, and lane occupancy measurements.

While such aggregations are appropriate for serving as inputs to control system algorithms, and save disk space for archiving loop data, much useful data regarding individual vehicles are lost. For single loop detectors, the lost information includes individual vehicle arrival, departure and presence times. For speed traps, the lost information also includes the calculated individual vehicle speed and length. Yet this information about individual vehicles is very desirable for transportation researchers and planners. For instance, members of the Berkeley Highway Laboratory (BHL) group collected an extensive amount of 60 Hz loop event data from 19 detector stations during the I-880 Field Experiment in 1993 (1). The availability and the richness of this 60 Hz loop data set made in-depth and improved speed, link travel time, and error identification studies (2,3,4) possible.

As one of the leading resources for traffic research around the world, the collection of the BHL group's 60 Hz loop event data was labor-extensive. The standard California Department of Transportation's (Caltrans) detector station uses a Model 170 controller. Since the 60 Hz event data are internal to the controller, Caltrans had to develop new controller software for the I-880 Field Experiment that preserved the 60 Hz event data. The I-880 Field Experiment used a laptop computer, in conjunction with each controller, to collect and store this data stream in the field. Because of the limited capability of a Model 170 controller, simply outputting this 60 Hz data stream through the controller would exhaust its processing power, and seriously obstruct its normal operation. Therefore, the type of individual vehicle (event) data set collected by the BHL group in the field cannot be easily reproduced by existing freeway data collection systems. To perform this type of detector event data collection, an additional, complementary system that can be introduced at the controller site is needed.

Transportation Northwest (TransNow), the USDOT University Transportation Center for Federal Region 10 and the Washington State Department of Transportation (WSDOT) are sponsoring a project with the final objective of improving the quality of WSDOT dual-loop detector vehicle classification data and thereby the performance of the WSDOT loop detection system. The first stage of the project is to collect loop event data to identify and investigate the causes of dual-loop errors. The standard WSDOT loop detector uses a Model 170 controller that samples the detector actuations at 60 Hz. Since outputting 60 Hz loop event data from the controller would consume all of a controller's processing power and thus interrupt it's normal operation, a system of collecting real-time loop event data without interfering with a station's normal operation is needed.

The current paper describes the design and implementation of such a detector event data collection (DEDAC) system recently developed by a TransNow research team at the UW. The system combines digital data collection techniques, a multimedia high-resolution timer, and multi-threaded programming techniques to deliver an easy-to-employ, reliable, and practical high frequency event data collection system.

## SYSTEM DEVELOPMENT

### System Design

Since raw loop actuation signals are accessible from the Input File in the Model 170 controller cabinet (5), the TransNow UW research team was able to collect 60 Hz or higher frequency detector event data without interrupting the controller's normal operation. In the DEDAC system, instead of obtaining data from the controller, a digital Input/Output (I/O) card was connected to the wiring terminals of the controller's Input File. By polling the data address of the I/O card with a 60 Hz (or higher) sampling rate, high-frequency loop event data could be obtained.

Figure 1 illustrates an overview of the DEDAC system design. As can be seen in Figure 1, the Input File is located right under the controller unit in the loop station cabinet. Loop actuation signals flow from loop detectors installed beneath the freeway pavement to the Input File, from where the signals flow to the Model 170 controller in the cabinet and the digital I/O card installed in the team's computer simultaneously. Meanwhile, the event data collection software installed in the computer polls the data address of the I/O card with a 60 Hz (or higher) sampling rate in real time and saves the event data on a local disk. With this architecture, the DEDAC system collects the exact real-time detector event data seen by the controller without interfering with the controller's normal operation (or requiring controller CPU time.)

**System Implementation**

Before data collection and testing could occur, it was necessary to develop the detector event data collection program. The program was developed to run on a 32-bit Windows platform. The API functions used for the implementation of the program are contained in the Microsoft® Platform Software Development Kit.

*High Resolution Timer*

Since the DEDAC system developed by the research team had to poll the data addresses of the digital I/O card at least 60 times per second, it was necessary to use a high-resolution timer for polling interval control and resolution control to make sure that the sampling rate was equal or higher than 60 Hz.

A multimedia timer was used for accurate polling interval control. A multimedia timer runs on its own thread (a path of execution through a program). Multimedia timer services allow applications to schedule periodic timer events (request and receive timer messages) with the greatest resolution possible for the hardware platform. For example, the utilization of a multimedia timer in the Musical Instrument Digital Interface (MIDI) sequencer maintains the pace of MIDI events within a resolution of 1 millisecond (6).

*Multithreading*

A multithreading programming technique was employed to complete parallel tasks control for the system. A thread is basically a path of execution through a program. It is also the smallest unit of execution that Win32 schedules. A thread consists of a stack, the state of the CPU registers, and an entry in the execution list of the system scheduler. Each thread shares all of the process's resources. In this program, aside from the threads generated by the operating system, some user-defined threads (a WRITE thread and multiple detector-status threads) also run in parallel.

Since disk operations are slow and the system polls data at a very high frequency, writing and reading data must be conducted in parallel. The system uses two buffers for temporary data storage. The event data read from digital I/O card data registers are saved in one of the buffers temporarily. Once the buffer is full, the other buffer takes over immediately. The WRITE thread then writes data in the buffer full of data from memory to a computer hard disk. The two buffers are used alternatively to guarantee the reception of detector event data at high frequency.

The number of detector-status threads is equal to the number of speed traps or single loop detectors from which the system collects event data. Each of the threads checks the status of its associated speed trap (or single loop detector) to see whether the status (on or off) has changed based on the latest input data. If the status does change, the associated indicator within the software will change correspondingly.

## Equipment Needs

The 60 Hz (or higher) frequency DEDAC system consists of three parts:

- Desktop computer and its accessories, including: monitor, keyboard, and mouse. The field test was performed using a desktop computer configured with a Pentium III processor, running at an 850 MHz processing speed, and 256 MB of random-access memory (RAM).

- Digital I/O card
  A digital I/O card was required to provide input interface for a PCI-Bus computer. Since most freeway segments have five or fewer lanes in each direction, the digital I/O card should have at least 10 input channels in order to be able to collect data from five lanes simultaneously. Another consideration when choosing a digital I/O card is that the upper limit of input voltage must be higher than 24 volts, which is the upper limit of output voltage from the Input File.
  PCI-IDIO-16, a digital I/O card recommended by WSDOT was used in the system development. The PCI-IDIO-16 is a half-size card that provides an isolated digital input and output interface for PCI-Bus computers (7). The card has sixteen optically isolated digital inputs for AC or DC control signals and sixteen solid-state switch outputs. For the purpose of this study, only ten isolated inputs were actually used for the data collection and system testing. Digital I/O signals are connected to the I/O card via a 78-pin D type connector that extends through the back of the computer case.

- Connectors
  A "Y" cable that divides the 78-pin D-type I/O connector down to two 37-pin DF-type connectors and two 37-pin DM-type connectors were used to make the connections between the digital I/O card and Cabinet Input File.

## User Interface

The main dialog box and the setting menu comprise the user interface for the DEDAC system.

### *Main Dialog Box*

Figure 2 is the main dialog box of the program. It consists of four functional components:

1. Parameter Setting
   Users are allowed to set up the following parameters:
   - The time the data collection starts and the time it ends.
   - Preferred timer resolution. The resolution ranges from 0 to 5 milliseconds according to the needs of different applications.

- Polling Interval. This determines the polling rate of the program. For example, if the polling interval were set as 10, the polling rate would be 100 Hz.

2. Control Panel
   The control panel contains all the control buttons used to start or stop the program. A digital clock is implemented to indicate the current system time.

3. Display Field
   The display field presents real-time vehicle presence information. For each lane, when the speed trap detects a vehicle passing by, the associated indicator will change its color to blue indicating the presence of the passing vehicle. The number of vehicles that have passed through the speed trap is also recorded and shown below the indicator in the display field.

4. Status Report
   The status report shows the progress of the data collection process. It records the times the data collection starts and ends. It also records the time when the two buffers switch. All this information is saved in a log file for future reference once the program terminates.

*Setting Menu*

As shown in Figure 3, two dialog boxes were designed and implemented under the setting menu. The dialog box named Loop Information provides an interface for users to input some background information such as loop station number, loop ID, data collection site, weather, etc. The dialog box named Personnel Information is used to input names of the data collection participants. This information will be saved at the beginning of the data file as a header for future reference.

## SYSTEM TESTING

### Simulation Tests

The reliability of the system was tested in-house at the WSDOT's Traffic System Management Center (TSMC) using a loop-detector simulator. The simulator takes traffic parameters such as flow rate and occupancy value as inputs and outputs the corresponding loop actuation signals to simulate a loop's "on" or "off" state. By examining these "on" and "off" states researchers can obtain the following individual vehicle data: 1) time each vehicle arrives at the loop detector, 2) time each vehicle departs from the loop detector, and 3) presence time of each vehicle on the loop detector.

The simulation reliability check consisted of two parts: a connection test and a system effectiveness test. These are described below.

*Connection Test*

Connection refers to the physical input channel through which the signal flows from the Input File in the controller cabinet to the digital I/O card, which is then read by the system program. Sixteen signal indicators were implemented for the connection test; each of them was associated with an input channel. If the DEDAC system detected a signal at one of the channels the indicator associated with that channel would turn blue; otherwise it would turn white. First, the simulator sent a signal to a randomly selected input channel; the indicator associated with that channel turned blue. This test was repeated until all sixteen channels had been tested with all associated indicators turning blue. The simulator then sent a signal to each of the sixteen input channels of the I/O card sequentially and the result was that all sixteen indicators turned blue accordingly. From these results, it was determined that all sixteen input channels were detecting signals properly. It was also concluded that all sixteen input channels passed the connection test successfully.

### *Effectiveness Test*

After passing the connection test, the effectiveness of the DEDAC system was tested under different traffic conditions. The loop detector simulator was given flow rate and occupancy parameters that were used to create corresponding traffic event signals for the simulated loop detectors. The event data collection system being tested collected traffic event data from the simulated loops (i.e., vehicle arrival, departure, and presence times) and calculated the corresponding flow rates and occupancy values.

All 16 input channels were tested simultaneously. The input flow rate and occupancy values obtained for each channel are listed in Table 1. In this table, "Simulated" stands for the parameters that were input to the simulator to produce the simulated event signals, while "Calculated" refers to the data obtained from the data collection system calculations using the event data generated by the simulator. Since the simulator created the event data based on flow and occupancy data that were given inputs, the ability of the data collection system calculations to match these original input parameters was used as a test of the collection system's accuracy.

The input flow rates ranged from 3 to 18 vehicles per minute and the input occupancy values ranged from 6% to 36%. The simulated loop actuations samples were collected for 20 minutes. The collected data were then processed to obtain flow rate and occupancy values for each of the 16 channels. As shown in Table 1, the calculated flow rate and occupancy values perfectly matched those of the simulated parameter inputs for each channel.

The results from the two tests described above indicated that the DEDAC system was able to accurately collect loop detector actuation signals with high sampling rates under a variety of traffic conditions.

## Freeway Field Test

The DEDAC system was used to collect data in the field to further verify its reliability. A description of the freeway field test is given in this section.

### *Data Collection Site*

Two criteria had to be met when choosing the data collection site. First, the freeway segment where the loops were located (detector zone) had to be in the researchers' field of view so that it was possible for the researchers to do consistency checking, i.e., examine whether or not the traffic information displayed in the program interface was reflecting what was really happening in the detector zone. Second, there should be a WSDOT traffic surveillance video camera available for traffic data recording. The videotaped traffic information would be processed to obtain ground truth data for verification purposes.

Keeping these considerations in mind, loop station ES-163R on Interstate 5, located at NE 130$^{th}$ street of Seattle was chosen as the data collection site. Figure 4 shows a snapshot of the test site. This particular freeway section has four general-purpose lanes and one HOV lane in the southbound direction. Each of the five lanes has a speed trap installed beneath the pavement. Additionally, there is an on ramp in the same direction. The station cabinet is approximately 20 meters away from the freeway shoulder and the cabinet is approximately aligned with the five speed traps. For the freeway field test, the five lanes were numbered 1 to 4 and HOV with the rightmost lane (next to shoulder) identified as lane 1 and the leftmost lane (next to median) as HOV. The close alignment between the speed traps and station cabinet eased the real-time consistency checking.

*Field Vehicle Presence Checking*

The DEDAC system collected loop event data from 2:00 pm to 3:00 pm on May 16, 2002. During this data collection period, when the system detected a vehicle occupying a speed trap, the indicator corresponding to that lane on the screen's display field would turn blue signaling the vehicle's presence. The volume count for that lane would also increase by one. If the DEDAC system were working properly, it would be able to detect every vehicle passing over the detector zone in real time.

Since it was extremely difficult for the researchers to check every passing vehicle in real time, only the vehicles that traversed through the rightmost lane (lane 1) were checked in the field during the first 20 minutes of data collection. During the first 20 minutes, 243 vehicles traversed the freeway segment through lane 1 according to the researchers' manual count. All of them were successfully detected and signaled by the DEDAC system. After the first 20 minutes, researchers randomly checked vehicles that traversed the detector zone through any of the five lanes. The system successfully detected and indicated the presence of these vehicles.

Loop event data were collected by the system during the one-hour field data collection. The traffic passing over all 5 lanes during that hour was also videotaped by the WSDOT video camera. For system synchronization purposes, the clock times for the loop detection system and the event data collection system were recorded with a digital video camera during the test.

*Results Verification With Video Ground-Truth Data*

The field data collection results were further verified by comparison with video ground truth data. After the field data collection, the videotape provided by the WSDOT that had also recorded the one-hour traffic was manually processed, frame-by-frame, to get individual vehicle information such as the time each vehicle appeared at a speed trap and what the classification of that vehicle was (for estimation of length). The detector event data collected during the one-hour field test were also processed by applying TransNow dual-loop algorithm to get individual vehicle arrival and departure times on both the upstream and downstream loops of each of the speed traps. Speed and length were also calculated for each vehicle. The individual vehicle information obtained from these two data sources was compared for the first 20 minutes for each of the five lanes. (Note: When a vehicle traversing the detector zone was observed on the videotape, the time stamp and its estimated length were recorded. The information was then compared to the vehicle information calculated by the system using the collected event data. If the calculated information showed that a vehicle passed over the detector at the same time through the same lane with its calculated length close to what was observed from the videotape, that vehicle was marked as "detected")

As can be seen from Table 2, all vehicles that passed over the detector zone during this period were successfully detected. In the remaining 40 minutes, individual vehicles were randomly chosen from the videotape. All of them were found in the individual vehicle information generated by the event data collection system. Since there did not exist a means to obtain completely accurate vehicle length information from the videotape, an accuracy comparison of vehicle lengths with the field data was not performed. It was concluded from the data collection and presence and volume checking that the DEDAC system was indeed able to collect accurate loop detector event data from real traffic.

## USING THE SYSTEM TO CHECK THE ACCURACY OF VEHICLE CLASSIFICATION COUNTS

Since the proposed DEDAC system collects loop detector event data from the Input File in a station cabinet directly without interrupting the controller's normal operation, it can be applied to any standard loop detector stations for loop detector event data collection. Therefore, this system can make such event data available at any desired location at any desired time to support a variety of transportation research and applications.

As aforementioned, one of the most important motivations of developing this system is the need of using loop detector event data to identify errors of dual-loop detection systems. The WSDOT dual-loop detection system was not consistently reporting accurate truck volumes. (Truck volumes estimates by basic length category are developed from the vehicle length measurements produced by the dual-loop detectors.) Here, using an application, the authors show how the collected event data can be used to identify the accuracy of vehicle classification counts measured by the dual-loop system. The analysis concentrated on comparing the presence-times for each of the paired detectors that comprised the speed trap, because it was suspected that problems with these measurements were affecting the truck volume counts.

The time a vehicle occupies a loop detector, the vehicle presence-time, also known as detector on-time, can be calculated by simply subtracting the time the vehicle leaves the detector from the time the vehicle arrives at the detector. When a vehicle traverses a speed trap, it occupies the paired single loops that comprise the speed trap sequentially. Let $OT_1$ denote the total on-time at the upstream loop, and $OT_2$ the on-time at the downstream loop. The percentage difference (diff) between these two on-times with respect to $OT_1$ can be calculated using the equation below.

$$\text{diff} = \frac{OT_2 - OT_1}{OT_1} \times 100 \tag{1}$$

The on-time percentage difference check is one of the checks that the WSDOT dual-loop algorithm applies to check the validity of the detector data. For an individual vehicle that passes over a speed trap, if the on-time percentage difference is larger than 10, the vehicle information is discarded and an error flag signaled. The WSDOT speed traps only collect length information from vehicles that pass over the detector zone with no flag signaled. Therefore, the effectiveness of the WSDOT's speed traps in collecting vehicle classification data can be evaluated based on the on-time percentage difference information. Possible causes of large on-time percentage differences, indicating potential speed trap malfunctions, can also be investigated.

Table 2 shows the results of the analysis of the data collected during the field test discussed above. The absolute mean percentage difference in on-time values from the 5 lanes examined ranged from 7.01 to 57.51, with Lane 3 having the smallest absolute percentage difference value and Lane 2 the highest value. The on-time percentage difference distributions for Lanes 3 and 2 are plotted in Figure 5(a) and Figure 5(b), respectively. In each of the two plots, the histogram represents the occurrence frequency for each on-time percentage difference. The normal curve depicts the mean and standard deviation of the on-time percentage difference distribution.

Figure 5(a) illustrates the results from Lane 3, the "best" lane. For Lane 3, the majority of the absolute on-time difference was smaller than 10 percent. This means that the WSDOT dual-loop detection system should be able to detect most of the vehicles that passed the detector zone in lane 3 during the 60-minute system test. This conclusion was confirmed by the statistic in bold face in Table 2 that 96.95 percent of the passing vehicles were detected by this dual-loop detector installation. (The 60-min WSDOT dual-loop data used for this study are available in electronic form at the University of Washington ITS website http://www.its.washington.edu/tdad/tdad_top.html)

These results are contrasted with the distribution curve in Figure 5(b). The normal curve spans from –80 to 0 indicating that almost every on-time at the downstream loop of the speed trap in Lane 2 was consistently shorter than its matching on-time at the upstream loop. It is obvious from the curve that most of the on-time percentage differences were larger than 10 percent, the threshold for discarding event data. Thus, almost all of the vehicles that passed over the freeway segment in lane 2 were not counted by the speed trap. This conclusion can be further verified by the 60-minute volume data shown in Table 2. According to the videotaped ground-truth data, 1315 vehicles passed over the detector zone through lane 2 during the 60-minute testing period, of which only 2 (0.15%) were detected by the dual-loop detection system. Based on these results, it was strongly suspected that the downstream loop might be operating in an incorrect mode. An experienced traffic operator at WSDOT concluded that the downstream loop must have been operating in "pulse mode", where a detector produces a short output pulse when a vehicle enters the sensor loop zone of detection. The mistake was corrected several days after the field test.

This experience drew attention to another advantage of the DEDAC system. Comparisons of the occupancy data from the two single loops of a speed trap can quickly identify malfunctioning loops in need of service by traffic operators. Additionally, comparisons between the occupancy data calculated by this system with those from the controller (averaged every 20-second intervals) can help judge if the controller works correctly.

## CONCLUSIONS AND RECOMMENDED FUTURE IMPROVEMENTS

Based on the results of the simulation tests and the freeway field test, the authors conclude that the proposed DEDAC system is able to provide reliable high frequency loop detector event data. This system makes individual vehicle data collection possible. It also provides an approach for readily identifying loop malfunctions in the field. A prevailing advantage of the proposed system over the current system that uses controller's computing power for event data collection is that it makes the collection of loop detector event data independent of the controller's computing resource. This feature makes the system easy-to-employ at any loop station cabinets from which the detector event data need to be collected. Therefore, it is a reliable and practical system for transportation practitioners and researchers to collect accurate event data from loop detectors, and such high frequency loop event data enable various kinds of traffic research and applications that could not otherwise be possible.

Future research objectives of the current project include: 1) improving the system so that it can become an integral part of the TSMC information system with the objective of providing real-time event data to TSMC operators and transportation researchers; 2) combining real-time loop event data collection with real-time accuracy checks, error identification, and correction functions to provide transportation researchers and traffic operators with a much-needed tool for enhancing the effectiveness of loop detection systems.

## ACKNOWLEDGEMENTS

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**List of Figures and Tables**

Figure 1. Overview of the detector event data collection (DEDAC) system design

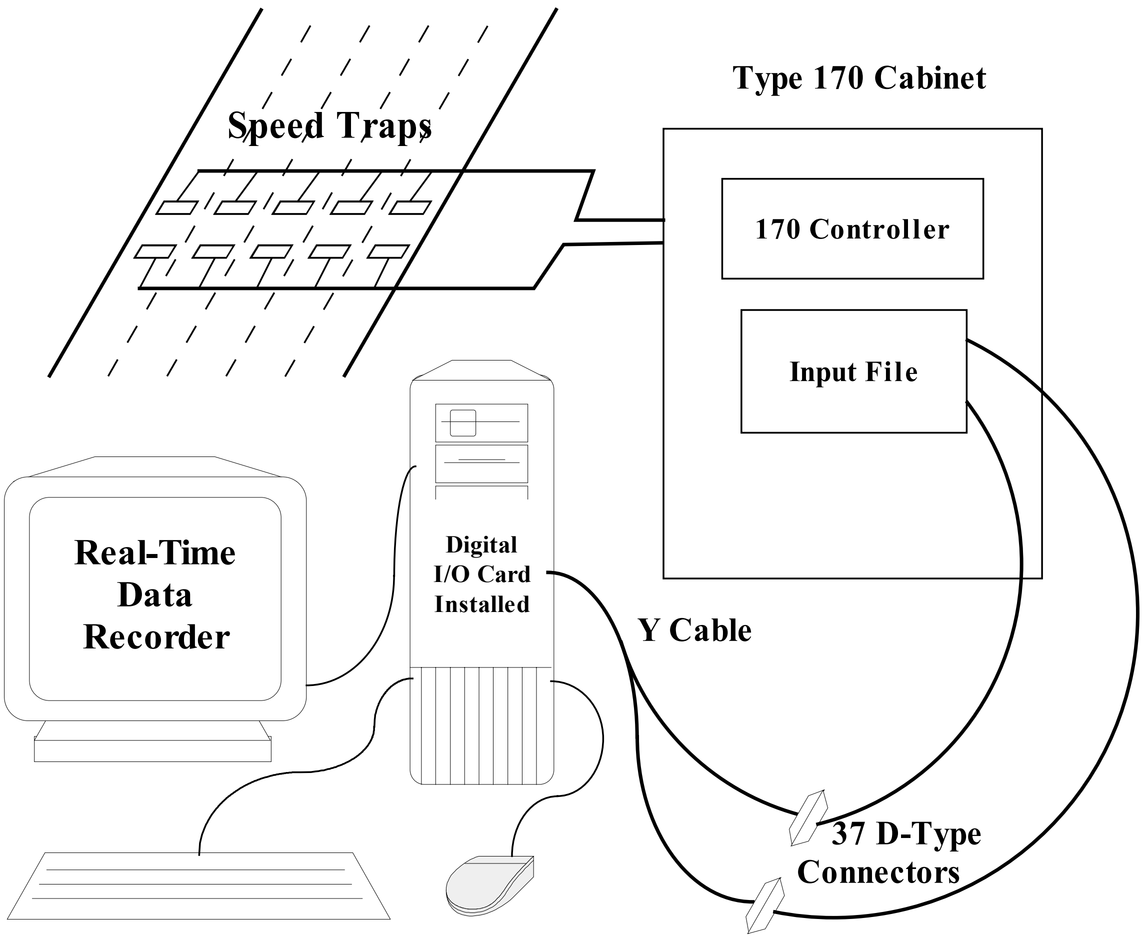


Figure 2. Program main interface

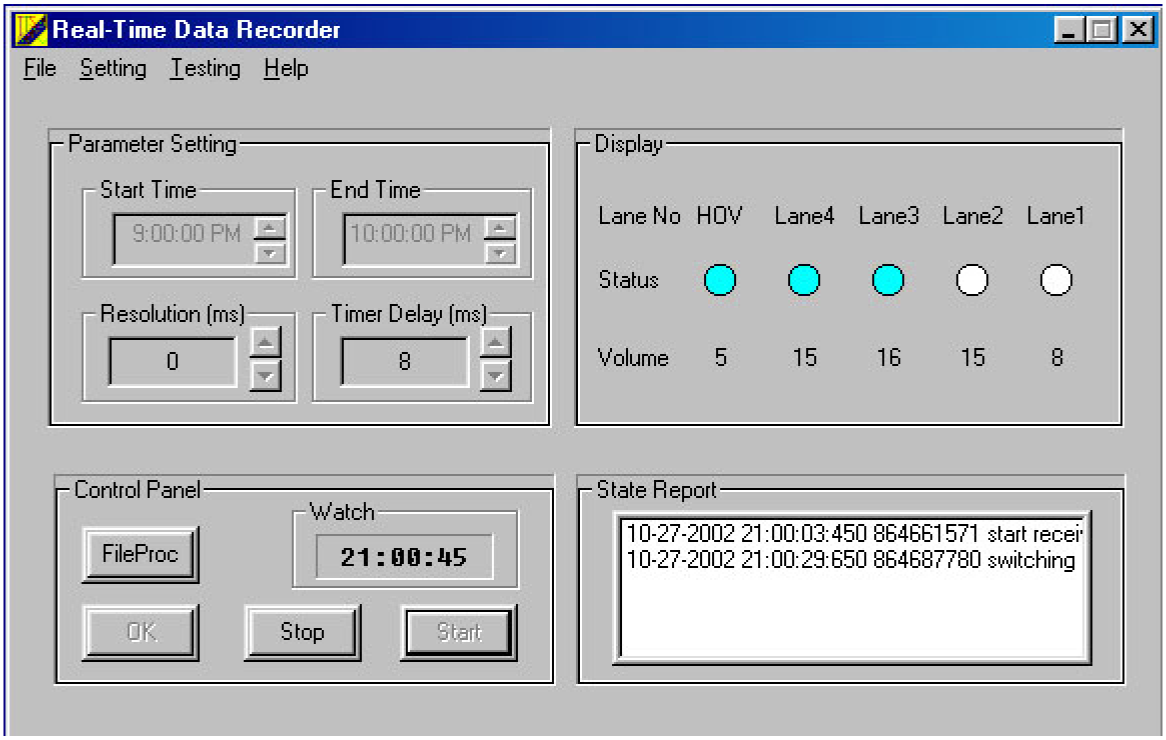
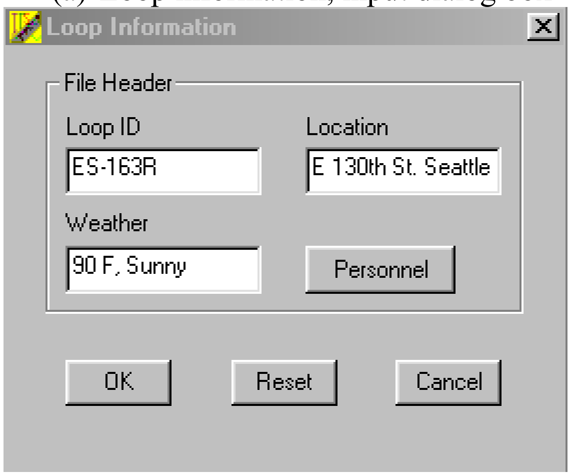


Figure 3. Background information: input dialog boxes

(a) Loop information, input dialog box




(b) Personnel information, input dialog box

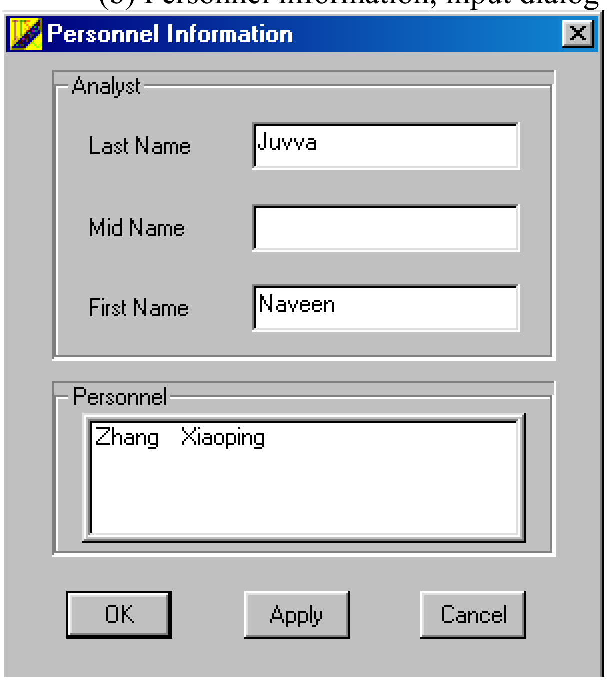


Figure 4. Event data collection system test site
I-5 NE 130th Street, southbound

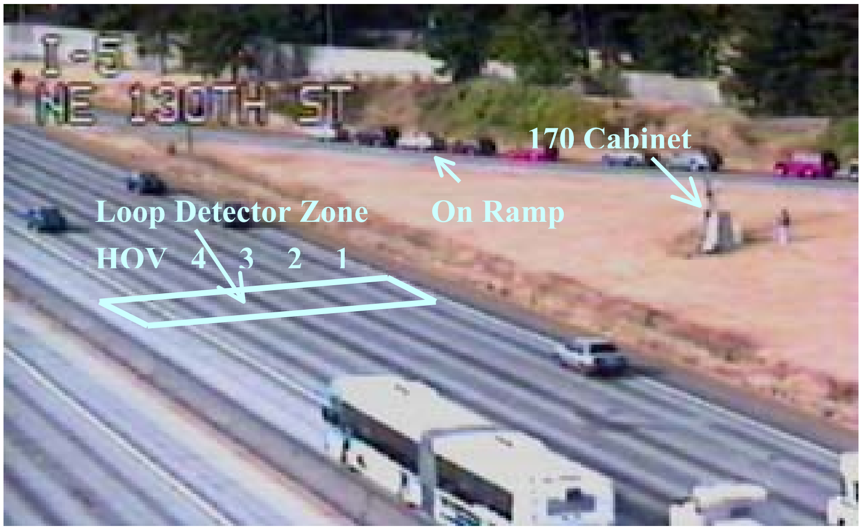
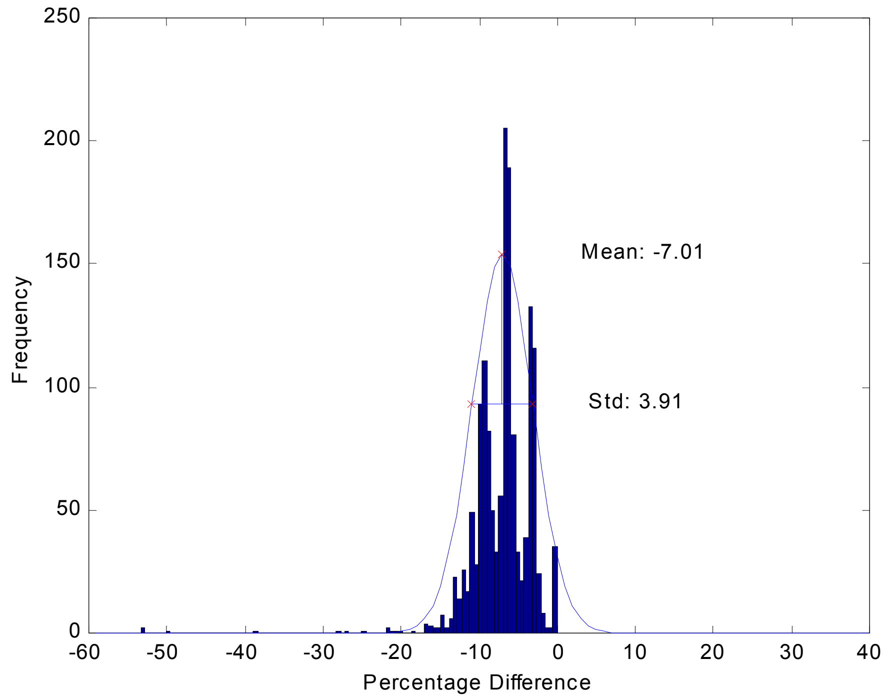


Figure 5. Paired loops on-time percentage difference distribution (lane 3 and lane 2)

(a) Paired loops on-time percentage difference distribution (lane 3)




(b) Paired loops on-time percentage difference distribution (lane 2)

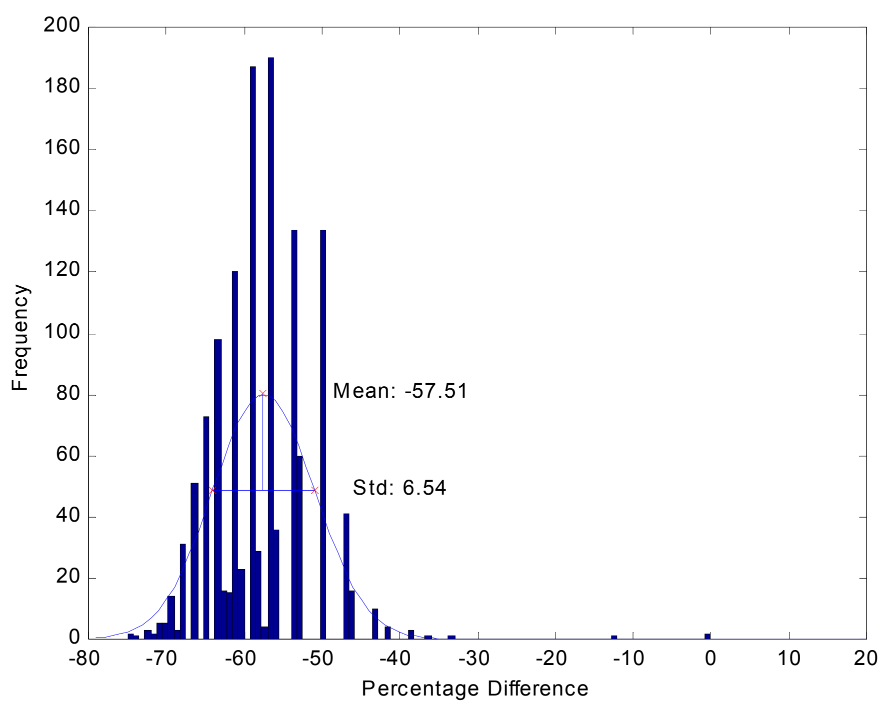


Table 1. Flow Rate and Occupancy Test Results (100% Accuracy)

| Channel No. | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Occupancy | Simulated (%) | 24 | 6 | 30 | 30 | 12 | 30 | 30 | 30 | 12 | 12 | 24 | 18 | 30 | 36 | 24 | 18 |
| | Calculated (%) | 24 | 6 | 30 | 30 | 12 | 30 | 30 | 30 | 12 | 12 | 24 | 18 | 30 | 36 | 24 | 18 |
| Flow Rate | Simulated (vehs/min) | 12 | 3 | 15 | 15 | 6 | 15 | 15 | 15 | 6 | 6 | 12 | 9 | 15 | 18 | 12 | 9 |
| | Calculated (vehs/min) | 12 | 3 | 15 | 15 | 6 | 15 | 15 | 15 | 6 | 6 | 12 | 9 | 15 | 18 | 12 | 9 |

Table 2. Freeway Application Results

| | Lane No. | Lane 1 | Lane 2 | Lane 3 | Lane 4 | HOV |
|---|---|---|---|---|---|---|
| Volume Count (20-min Interval) | Calculated Based On Detector Event Data | 243 | 435 | 506 | 546 | 99 |
| | Observed By Processing Videotape | 243 | 435 | 506 | 546 | 99 |
| Volume Count (60-min Interval) | Downloaded From UW ITS Website (UWITS) | 123 | 2 | 1463 | 1291 | 153 |
| | Observed By Processing Videotape (Video) | 817 | 1315 | 1509 | 1652 | 357 |
| | $\frac{UWITS}{Video} \times 100$ | 15.06 | <u>0.15</u> | **96.95** | 78.15 | 42.86 |
| On-Time Percentage Difference (60-min Interval) | $\frac{OT_2 - OT_1}{OT_1} \times 100$ Mean | 17.11 | -57.51 | -7.01 | 11.52 | -12.71 |
| | Std | 10.40 | 6.54 | 3.91 | 10.71 | 7.50 |