Research Report
KTC-05-37/LFUCG-02-1F

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## LEXINGTON INCIDENT DETECTION SYSTEM EVALUATION REPORT

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# LEXINGTON INCIDENT DETECTION SYSTEM EVALUATION REPORT

(Final Report)


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16. Abstract

This report describes the evaluation of an experimental incident detection system implemented within the Lexington / Fayette County area by the Lexington Fayette Urban County Government Department of Traffic Engineering. The incident detection system includes 5 different types of traffic monitors on 10 different locations throughout the county including interstate and limited access facilities and signalized urban arterials. The evaluation of the system was performed over a period of three months between June and August 2005. This report summarizes the implementation strategy and provides recommendations for future implementation and expansion of the system.

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# Executive Summary

The Lexington-Fayette Urban County Government (LFUCG) Division of Traffic Engineering deployed an Automated Incident Detection System to assist with the detection and identification of incidents in the Lexington-Fayette County area. This report is the summary of an independent evaluation of the system conducted by the Kentucky Transportation Center at the University of Kentucky. This report includes an assessment of the system and makes recommendations for further deployment and evaluation.

The initial deployment included 10 locations with multiple detectors at each location. Three different incident detection technologies, acoustic, microwave/radar, and video detection, were deployed for this study. Five different detection manufacturers were included in the study:

- ITERIS Vantage Edge Video Detection System
- EIS Remote Traffic Microwave Sensor (RTMS) Radar
- SmartTrek Systems Acoustic Sensor (SAS) Version 1
- AutoScope Video Detection
- Wavetronix SmartSensor

Data was examined with respect to vehicular count and speed reported by each detector. Statistical analysis was conducted, in the form of a t-test, to determine similarities in reported count, speed and interval change in speed data between detectors at each study location. The goal of this analysis was to identify similarities in the performance of different detectors in order to identify potential outliers. Based upon this analysis no similarities were found between any of the detector pairs examined, except for consistent similarities among at one location.

Descriptive statistics were also examined for each detector at each location. Detectors having the lowest standard deviation at each location are highlighted. Both the RTMS Radar and ITERIS video are shown to have the lowest normalized standard for both count and speed data at the majority of locations.

In order to determine the reliability of the equipment, the total number of data points collected by each detector was determined. On average, all detectors recorded between 8 and 16 percent of the entire study period. A significant portion of the “missing” data may be attributed to disruptions in communication or downtime of the central server during maintenance and not due to the local detection equipment. However, based upon this analysis the ITERIS video and RTMS Radar detectors provide a consistently higher reliability when compared to the other equipment deployed.

Based upon the procedures and analysis presented above, the following conclusions are made in the evaluation of the Lexington Automatic incident Detection System.

1) Detector Installation should be tailored to optimize the individual performance of each detector used in the system with respect to its intended application. This would include utilizing side-fire orientation for SAS-1 acoustic detectors and forward-looking orientation for RTMS radar and ITERIS Video detectors.

2) The acoustic detector may provide the simplest and cost effective solution in terms of installation due to its ability to be placed in a side-firing orientation from the roadside. Radar and Video equipment may have some limitations in this configuration. Video and Radar deployments may require more units to cover the same number of lanes in order to achieve a forward-looking installation. More extensive support infrastructure may also be required to place the detectors over the lanes being observed.

3) An improved configuration over the "intersection" presence mode currently deployed, would be to establish a "speed-trap" using pulse detection mode and consecutive detection zones.

4) The preferred configuration for each detector would be to utilize specific software provided by each manufacturer, which is designed for the purposes of traffic monitoring and speed detection.

5) Should the presence or pulse mode be chosen for implementation, extreme care should be used in determining the detector zone size for each detector application to provide for accurate speed data based upon vehicle occupancy. It is necessary to calculate the individual detector zone size based upon the specific orientation of the detector to the roadway and the characteristics of the individual detectors.

6) Real-time communication should be established between detector locations to provide useful and relevant data for implementation into an incident detection system.

7) Due to the errors in the system deployment and configuration, direct evaluation of the performance of each of the detector types was not possible.

8) Statistical analysis did not identify consistencies between any of the data points, except at Location 8 (Richmond Road and Shriners Lane) where Autoscope products were deployed. Better installation techniques may have contributed to the improved performance of this location.

9) Analysis of the Standard Deviation of the data points from each detector indicated that RTMS Radar units and ITERIS video provided a consistently smaller standard deviation than other units at most locations.

10) Examination of the reliability of the detectors indicated that data was recorded for only 10 to 15 percent of the study period. The majority of the "missing" data may be attributed to communication and server issues. ITERIS Video and RTMS Radar detectors provided the highest reliability.

11) Before full deployment of the incident detection system, improved installation and configuration procedures should be developed and tested to improve the accuracy and reliability of the system. To achieve this, it is imperative to determine detailed data flows from field deployed equipment to the PYRAMIDS central server and to understand the operations of each piece of equipment and the impact of those operations on the final data output/quality. In addition, the operation of each detector installed should be fully understood in order to facilitate proper installation and configuration. Communication problems between the field equipment and the central server should be resolved in order to improve the reliability of the system.

12) It is recommended that a decision on detector type for implementation be postponed until the configuration problems have been resolved. Further deployments of the AutoScope products should be included in additional evaluation due to the high level of performance indicated by the statistical analysis.

13) Due to variations in equipment calibration, it is recommended that, when the system is fully implemented, an initial period of observation should be used to identify baseline speed and count data for that location. Speed thresholds used to indicate an incident should be based on the average baseline condition for each location and not an arbitrary speed threshold such as 35 or 45 mph, in order to account for specific variations in the installation, configuration and location of each site.

# Introduction

The Lexington-Fayette Urban County Government (LFUCG) Division of Traffic Engineering deployed an Automated Incident Detection System to assist with the detection and identification of incidents in the Lexington-Fayette County area. This report is the summary of an independent evaluation of the system conducted by the Kentucky Transportation Center at the University of Kentucky. This report includes an assessment of the system and makes recommendations for further deployment and evaluation.

Three different incident detection technologies were deployed for this study. These technologies are acoustic, microwave/radar, and video detection. The initial deployment included 10 locations with multiple detectors at each location.

## *System Goals*

The goals of the automated incident detection system are as follows:

1) To reduce the time for incident detection, response, and clearance,
2) To improve the dissemination of real-time roadway incident information to motorists, and
3) To share incident and traffic-related information with agencies involved in local, regional and state incident management activities.

## *Evaluation Goals*

The goal of this evaluation is to determine which of the detection technologies deployed are most beneficial in terms of:

1) Providing Reliable Data
2) Detecting incidents
3) Deployment/Installation
4) Maintenance
5) Lifetime Cost

In addition, the overall deployment of the system will be evaluated to assess its abilities to meet the overall system goals.

## Detection Equipment Description

Five different detection technologies were evaluated as part of the incident detection system evaluation. These are:

- ITERIS Vantage Edge Video Detection System
- EIS Remote Traffic Microwave Sensor (RTMS) Radar
- SmartTrek Systems Acoustic Sensor (SAS) Version 1
- AutoScope Video Detection
- Wavetronix SmartSensor

### *ITERIS Vantage Edge Video Detection*

The Vantage Edge system can be installed to provide permanent or temporary vehicle detection applications without embedded loops in all types of weather, 24-hours a day. The integrated software of the Vantage Edge system is used to draw detection zones on the video camera image defining detection zones, and zone properties. The processor module analyzes the camera image to determine when a vehicle is present in a zone. Vehicular detection information is passed to the traffic control equipment. Vehicle detection may be in either "presence" or "pulse" mode; Presence mode was used in all applications for this study. The Vantage Edge system is typically deployed to provide detector applications for intersection operations. (1)

Additional software, Vantage Express, is available for data collection applications for count, classification and speed studies. Vantage Express was not deployed in the evaluation due to the necessity of an independent communication link.

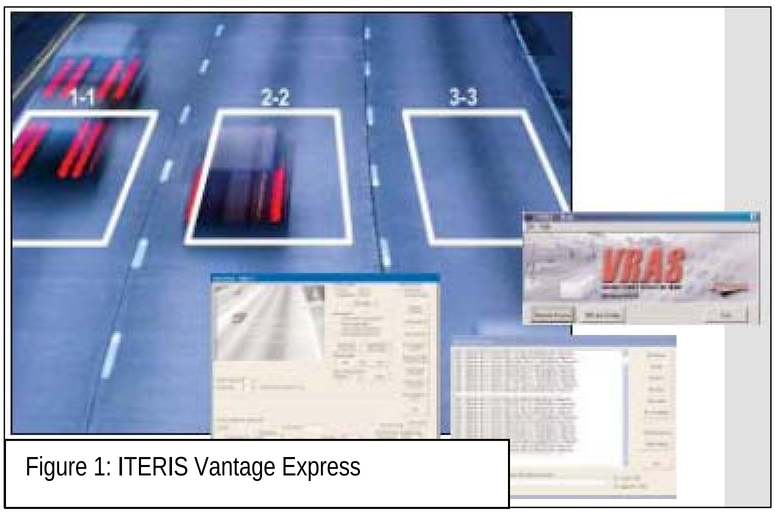
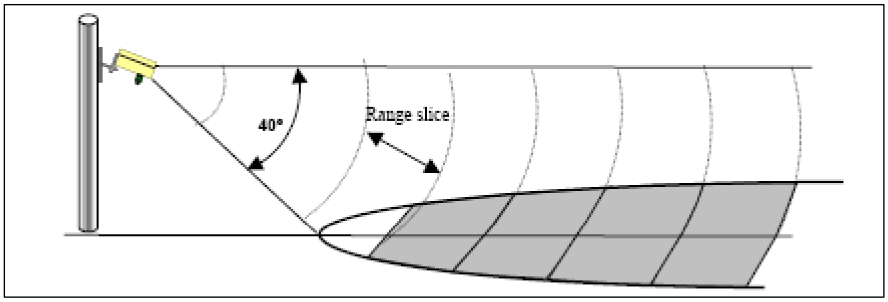



Figure 1: ITERIS Vantage Express

### *Electronic Integrated Systems Inc*
### *Remote Traffic Microwave Detection System (RTMS)*

The RTMS is a true RADAR (RAdio Detection And Ranging) device, specially designed for traffic sensing applications. It measures the distance to objects in the path of its microwave beam. The ranging capability allows the RTMS to detect stationary and moving vehicles in multiple detection zones.

Figure 2: RTMS Detection Zone




The RTMS microwave beam is approximately 40° high and 15° wide. Its range of 60m (200 feet) is divided into 32 range-slices, each 2m (7ft.) wide. When pointed onto a roadway, it projects an oval footprint, in which detection zones can be defined using the range slices. (2)

The detection of a vehicle in any zone is registered in two independently operating outputs (2):

1) Zone Contacts: 8 contact pairs corresponding to the detection zones are closed for as long as detection persists. They can be connected to Traffic Controllers to indicate presence (in intersection applications) or to Counters for traffic measurement.

2) Data Port: Detection status in each range slice is transmitted via “target” messages sent 10 times per second. RTMS internal firmware uses vehicle detection to accumulate Volume, Occupancy, Average Speed and Classification by length over a user-defined Period.

For the purposes of this study only the Zone Contact output was utilized. The Data Port output was not deployed in the evaluation due to the necessity of an independent communication link.

### *SmartTrek Systems Acoustic Sensor (SAS) Version 1*

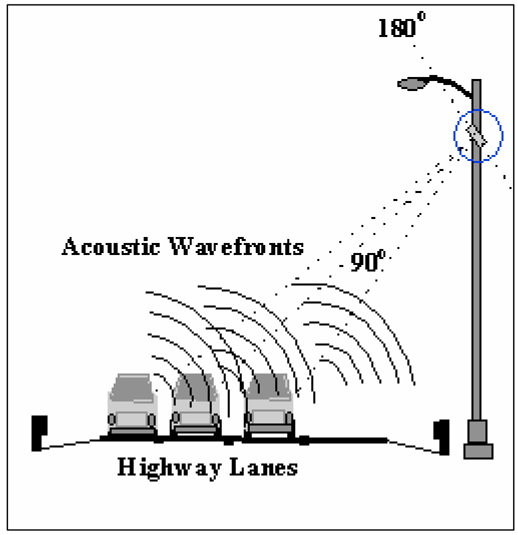
The SmarTek Systems Acoustic Sensor -Version 1 (SAS-1) is a multi-lane traffic monitoring system based on detecting the acoustic signals motor vehicles create and radiate during operation. The SAS-1 is a passive acoustic sensor, mounted on overhead or roadside structures.

The SAS-1 is designed to provide effective and accurate vehicle presence detection and associated traffic flow measures on a lane by lane basis for vehicles passing the sensor station at any reasonable (and allowable) speed from stop and go to free flow. The SAS-1 provides a detection zone equivalent to that of a 6 foot loop in the direction of traffic flow (up/down road) and a completely selectable zone size in the cross road direction (less than 6 feet to an entire lane width or even multiple lane widths) (3).

The SAS-1 may be deployed in two separate configurations.

1) Speed trap mode between two installations via a relay interface to measure speed and volume data on the roadway.
2) Intersection reports true presence of the vehicle for as long as it is in zone to the local controller.

Figure 3: SAS-1 Installation




The SAS-1 is capable of storing per lane volume, occupancy, and average speed in integrated memory on the unit. The SAS Monitor and Setup software provides the interface to gather these statistics and decode them into spreadsheet-ready files.

For the purposes of this study the SAS-1 detectors were deployed in intersection mode transmitting occupancy data directly to the controller. The internal data processing information of the SAS-1 was not used due to the necessity of an independent communication link.

## *AutoScope Video*

Autoscope Video detection delivers a high performance alternative to loops and other detection technologies for many ITS applications. This includes intersection control, incident detection for bridges, tunnels, and highways, as well as surveillance applications. Quick mouse and keyboard commands can create more than 50 virtual detection zones for count, presence, speed and incident detection applications for each camera installation.

Autoscope Video detection provides real-time or stored traffic data; including volume, occupancy, speed and vehicle class over specified time periods. In addition, the Autoscope Software Developer's Kit (SDK) allows traffic data from the Autoscope system to be integrated into other applications.

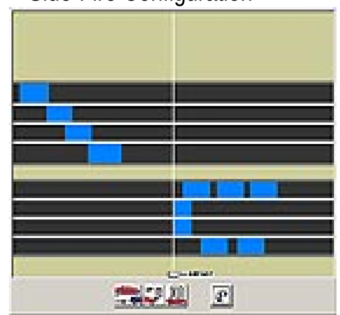
One installation of an AutoScope Video detector was deployed by the Econolite Control Products, Inc. for inclusion in the evaluation.

### *Wavetronix SmartSensor*

The Wavetronix SmartSensor provides traffic detection with patented Digital Wave Radar to measure vehicle volume, occupancy, speed and classification in up to eight lanes of traffic simultaneously.

SmartSensor requires no "tweaking" or "tuning" and operates accurately in both side-fire and forward-fire installations. With a detection range of over 200 feet, SmartSensor provides true eight-lane capacity that is unaffected by wind, weather or by changes in temperature and light. Digital Wave Radar also reduces lane "splashing", works over barriers and can accurately detect partially occluded vehicles.

Figure 4: SmartSensor Side-Fire Configuration



One installation of an Wavetronix SmartSensor was also deployed by Econolite Control Products, Inc. for inclusion in the evaluation.

## System Implementation

Ten (10) study locations were selected throughout the Lexington-Fayette County jurisdiction for the initial implementation of the incident detection system. These ten locations were selected to provide a representative selection of the roadway types within the county. Additionally each location was established so as to allow for observation of a free-flow segment of the roadway that would not be affected by traffic control devices under typical operation. Multiple detectors were deployed at each site to cover multiple lanes and directions with overlapping fields for all equipment, thus providing for direct comparison of measurements. Detection equipment was installed on the roadside in a “sidefiring” (perpendicular to flow) configuration at all locations.

**Table 1** identifies each study location, equipment deployed at that location and the lane coverage for each detector.

The initial deployment of the incident detection system was determined to be operational on June 1, 2005. At this time, the majority of sites were providing consistent data from all equipment. Detector log files for all locations and equipment that were available were collected between June 1 and August 21, 2005 to serve as the data sample for the evaluation.

Table 1: Study Locations

| Detector | ***Lane Coverage*** |
|---|---|
| **Location 1: Man O' War Blvd at Boston Road** | |
| *ITERIS Video* | 1,2,3,4 |
| *RTMS Radar* | 3,4 |
| *SAS Acoustic* | 3,4 |
| **Location 2: Versailles Road at Van Meter Road** | |
| *ITERIS Video* | 2,3,4 |
| *RTMS Radar* | 2,4 |
| *SAS Acoustic* | 1,2 |
| **Location 3: Newtown Pike at Citation Blvd** | |
| *ITERIS Video* | 1,3,4 |
| *RTMS Radar* | 1,3 |
| *SAS Acoustic* | 1,4 |
| **Location 4: Leestown Road at Forbes Road** | |
| *ITERIS Video* | 1,2 |
| *RTMS Radar* | 1,2 |
| *SAS Acoustic* | 1,2 |
| **Location 5: Interstate 75 at milepost 111** | |
| *ITERIS Video* | 1,2,3 |
| *RTMS Radar* | 1,2,3 |
| *SAS Acoustic* | 1,2 |
| **Location 6: New Circle Road at Versailles Road** | |
| *ITERIS Video* | 1,3,4 |
| *RTMS Radar* | 1,4 |
| *SAS Acoustic* | 1,3,4 |
| **Location 7: New Circle Road at Tates Creek Road** | |
| *ITERIS Video* | 1,3,4 |
| *RTMS Radar* | 1,4 |
| *SAS Acoustic* | 1,4 |
| **Location 8: Richmond Road at Shriners Lane** | |
| *ITERIS Video* | 1,4 |
| *SAS Acoustic* | 1,4 |
| *AutoScope Video* | 1,4 |
| *Wavetronix SmartSensor* | 1,4 |
| **Location 9: Richmond Road at Ashley Woods** | |
| *ITERIS Video* | 1,3,4 |
| *RTMS Radar* | 1,2,4 |
| *SAS Acoustic* | 1,4 |

One of the critical functions of the incident detection system is that it must communicate directly and continuously with the PYRAMIDS central server to provide real-time data. In order to maintain low deployment costs it was necessary bring all data from each piece of equipment through a single controller and communication link. Therefore, each of the detectors was set up on a unique channel into a Model 170 traffic controller.

The controller setup was similar to an intersection deployment with each detection zone from the equipment representing a unique loop(s) on a separate channel. Count and occupancy data for each channel was then stored in the controller and binned in 15 minute intervals in a detector log. The central server then requested the detector log from the controller on an automatic polling period. For the purposes of this deployment a 15 minute polling period was used.

The detector logs include the following data

- Time stamps
- Detector ID Numbers
- Sampling Length
- Detector Types

- Detector Status
- Volume
- Occupancy

Based upon the count and occupancy data provided in the detector log, speed is calculated by the central server software according to the algorithm logic stated in the PYRAMIDS *Incident Management Module Functional Specification* document. The speed calculation is dependent upon the average occupancy of the loop during the interval, detector size and average vehicle length to calculate the speed for each vehicle. Detector size and average vehicle length are variables entered into the initial setup of each location on the central server. Once calculated, speed is then added to the detector log on the central server.

*Note: Specific documentation of the data flows, algorithm logic, and setup of the Incident Detection System was not provided or available for this evaluation. The data flow procedures documented here are inferred based on review of the individual equipment manuals and specifications, W4IKS User's Manual for the Model 170 Controller, PYRAMIDS User's Guide Version 3.00 and through analysis of the data. The PYRAMIDS Incident Management Module Functional Specification may document this data flow with greater detail and accuracy.*

## System Deployment Evaluation

In addition to the performance of the detection equipment, which will be discussed in later sections of this report, the performance and effectiveness of the incident detection system also depends upon the deployment and configuration of the system. System deployment and configuration were evaluated with respect to the following:

- Equipment Installation
- Operating Mode
- Detection Equipment Configuration
- System Configuration

### *Equipment Installation and Setup*

All equipment deployed by LIDS was mounted on the roadside, configured in a sidefiring configuration, perpendicular to the traffic stream. This setup was chosen due to the ease and low cost of installation, which allowed for each piece of equipment to cover the entire cross-section of the roadway. The sidefiring configuration is the preferred setup for the SAS-1 acoustic detector. This configuration is also supported by the RTMS RADAR detector; however, a forward looking configuration is the preferred setup for traffic monitoring applications with the use of a speed trap configuration to determine vehicular speeds. Due to the video analysis algorithms used by the ITERIS Vantage

System, this is not a supported configuration.  The video detection processor uses unique algorithms to detect vehicles as they move up and down the screen, which are not as effective in detecting motion across the view range.

To provide the optimum setup for each piece of equipment, it would be necessary to reorient the RTMS RADAR and ITERIS Video longitudinally with the traffic stream.  This may be accomplished from the roadside, provided the offset is not too great.  However, the preferred installation would be directly overhead with traffic moving away from the camera.  With this configuration it would only be possible to monitor one direction off traffic at a time, especially on wider roadways such as New Circle Road and Versailles Road, which may increase the amount of equipment needed to effectively monitor a roadway.

### *Operating Mode*

Currently the system and all equipment is deployed in a setup typically used in intersection operations, with all detectors operating in “presence” mode. Therefore, the detectors detect presence/occupation time and report that as an input back to the controller, which aggregates the data and relays it to the central server.  A potentially better way to operate the system would be to operate a "speed trap," using two detectors a known distance apart, operating in PULSE mode.  The PYRAMIDS User's Guide (ver. 3.0) indicates that this configuration is supported.  This configuration is the preferred operating mode for the ITERIS video and RTMS RADAR.

Additionally, all equipment deployed has independent software for calculating speed, classification, etc, that is specifically designed for that piece of equipment. The accuracy provided by the individual software packages would most likely exceed the current setup that is deployed.  The primary reason that the individual traffic monitoring features of each detector were not used is due to the necessity of independent communication links to each piece of detector to retrieve this data.  Should the incident detection program be carried forward with a single detector at each location, this issue would not be relevant.  It is therefore recommended that integration of the individual firmware of each piece of equipment with the PYRAMIDS server be explored for future deployment of the incident detection system.

### *Detection Equipment Configuration*

The PYRAMIDS software uses the occupancy time, detector size, and average vehicle length to calculate the speed for each vehicle.  Therefore, the detector sizes that are used in the calculation of the speed are critical to providing reliable and accurate data.  Upon review of several deployment sites and the detector log data it is suspected that there is an inconsistency between the detector size in the field and the detector size recorded in the PYRAMIDS database and used in the speed calculations.

The size of the detector zones varies for each piece of equipment and is primarily based on the position and orientation of the equipment at the site. Determinants of detector sizes for each piece of equipment are identified below.

*Video Detection*—Detector sizes are determined by user when drawn with video interface. Detectors zone size is also affected by angle of incidence between camera and traffic stream. Providing a ground reference when drawing loops would be beneficial in establishing zone size, which should be corrected based on projected loop size at vehicle height based on pole orientation.

*Radar*—Detector size is determined by microwave beam approximately 40° high and 15° wide, resulting in parabolic shape across cross section of road. (See Figure X). Zone size should be calculated using beam spectrum and orientation of radar with respect to lanes.

*Acoustic Detector*—Monitors a 6-foot long detection zone across all lanes observed.

In further deployment of the incident detections system, significant care should be taken when installing detection equipment and documenting the orientation of the equipment and roadway observed so that an accurate determination of the detector zone size can be determined. Without determining the actual detector zone size, speed and classification data will not be accurate, as is the case for the evaluation data analyzed within this report. Utilization of the individual traffic monitoring software programs for each piece of equipment would eliminate the need for these calculations.

## *System Configuration*

The current configuration of LIDS provides 15-minute polling of each location controller providing detector logs of aggregate data. This configuration has several limitations. First, precision of the data may be lost through averaging effects of aggregation, which may delay detection of an incident if a location is operating at or near the threshold. Secondly, the longer the interval, the longer the notification time of an incident, which will increase response times. Those locations that are not automatically polled place a significant demand on the operator if the most current information is to be used in monitoring traffic conditions. In order to provide a meaningful incident detection system, it will be necessary to provide accurate and precise data in real-time, so that when an incident is detected a response can be implemented before total breakdown of the system occurs.

It is recommended that real-time communication be maintained with each controller and that aggregation limits be kept to a minimum to improve the timeliness and accuracy of the data. Review of the PYRAMIDS User's Guide indicates that this configuration can be maintained with the current system.

## Data Collection and Evaluation

The initial deployment of the incident detection system was determined to be operational on June 1, 2005. At this time, the majority of sites were providing consistent data from all equipment. Detector log files for all locations and equipment that were available were collected between June 1 and August 21, 2005 to serve as the data sample for the evaluation.

Data was reviewed to identify inconsistencies either from communication failures, server downtime, or equipment failure. All inconsistent data, based upon an inconsistent interval length and those records having a recorded vehicular count or speed of zero (0), was removed from the data set. During the study period communication was never achieved at Location 10, Interstate 75 at milepost 105, and data from this location is not included in the analysis.

Data was examined with respect to vehicular count and speed reported by each detector. As discussed previously, the deployment of the detectors within LIDS did not accurately record the loop detector sizes to allow for direct calculation of speeds at each of the locations. Without the ability to examine speed data with respect to a known reference point, it was necessary to identify another factor capable of providing reference between the three detector types. Therefore, the relative change between successive intervals, termed the "interval change in speed," was determined by the relationship $S_{i+1}/S_i$; where $S_i$ is the recorded speed for interval i. This methodology allowed for the comparison of the change in speeds between intervals amongst each of the detector types, even if the actual speed reported was different between detectors. Average daily count, speed, and interval change in speed data is shown in **Figures A1 though A27** in **Appendix A**.

Statistical analysis was conducted, in the form of a t-test, to determine similarities in reported count, speed and interval change in speed data between detectors. The goal of this analysis was to identify similarities in the performance of different detectors in order to identify potential outliers. This may signify that two detectors, which routinely produce similar results to each other, provide more accurate data than those detectors which do not match other sources.

Only data points from intervals in which detector pairs reported a count and speed greater than zero for common observations were used in the comparative statistical analysis. **Table 2** shows the number of common observations for each detector pair at the 9 study locations, which were available for analysis.

Table 2: Summary of Detector-Pair Data Points by Location

**Location 1: Man O' War Blvd at Boston Rd**

| Detector | *ITERIS Video* | *RTMS Radar* | *SAS Acoustic* |
|---|---|---|---|
| *ITERIS Video* | | 0 | 0 |
| *RTMS Radar* | | | 2 |
| *SAS Acoustic* | | | |

**Location 2: Versailles Rd at Van Meter Rd**

| Detector | *ITERIS Video* | *RTMS Radar* | *SAS Acoustic* |
|---|---|---|---|
| *ITERIS Video* | | 0 | 4035 |
| *RTMS Radar* | | | 0 |
| *SAS Acoustic* | | | |

**Location 3: Newtown Pike at Citation Blvd**

| Detector | *ITERIS Video* | *RTMS Radar* | *SAS Acoustic* |
|---|---|---|---|
| *ITERIS Video* | | 0 | 0 |
| *RTMS Radar* | | | 0 |
| *SAS Acoustic* | | | |

**Location 4: Leestown Rd at Forbes Rd**

| Detector | *ITERIS Video* | *RTMS Radar* | *SAS Acoustic* |
|---|---|---|---|
| *ITERIS Video* | | 1617 | 1593 |
| *RTMS Radar* | | | 2564 |
| *SAS Acoustic* | | | |

**Location 5: I-75 at milepost 111**

| Detector | *ITERIS Video* | *RTMS Radar* | *SAS Acoustic* |
|---|---|---|---|
| *ITERIS Video* | | 17164 | 0 |
| *RTMS Radar* | | | 0 |
| *SAS Acoustic* | | | |

**Location 6: New Circle Rd at Versailles Rd**

| Detector | *ITERIS Video* | *RTMS Radar* | *SAS Acoustic* |
|---|---|---|---|
| *ITERIS Video* | | 4920 | 0 |
| *RTMS Radar* | | | 0 |
| *SAS Acoustic* | | | |

**Location 7: New Circle Rd at Tates Creek Rd**

| Detector | *ITERIS Video* | *RTMS Radar* | *SAS Acoustic* |
|---|---|---|---|
| *ITERIS Video* | | 0 | 4115 |
| *RTMS Radar* | | | 4713 |
| *SAS Acoustic* | | | |

**Location 9: Richmond Rd at Ashley Woods**

| Detector | *ITERIS Video* | *RTMS Radar* | *SAS Acoustic* |
|---|---|---|---|
| *ITERIS Video* | | 9243 | 9198 |
| *RTMS Radar* | | | 11418 |
| *SAS Acoustic* | | | |

**Location 8: Richmond Rd at Shriners Ln**

| Detector | *ITERIS Video* | *SAS Acoustic* | *AutoScope Video* | *Wavetronix SmartSensor* |
|---|---|---|---|---|
| *ITERIS Video* | | 4444 | 5345 | 5630 |
| *SAS Acoustic* | | | 4449 | 4300 |
| *AutoScope Video* | | | | 5356 |
| *Wavetronix SmartSensor* | | | | |

Based upon this analysis no similarities were found between any of the detector pairs examined, except for consistent similarities among the interval change in speed between all detectors at the Richmond Road/Shriners Lane location. The mean interval change in speed for all detectors at this location was between 1 and 1.06. In addition, the following detector pairs at this location showed common interval change in speed observations within a 95 percent confidence interval.

- ITERIS Video and SAS Acoustic
- SAS Acoustic and AutoScope Video
- SAS Acoustic and Wavetronix SmartSensor
- AutoScope Video and Wavetronix SmartSensor

Installation of the AutoScope products was performed by the AutoScope Vendor. Improved installation techniques and technical assistance provided during the setup may have contributed to the overall performance of this location.

Due to the lack of findings provided by the t-test analysis, the data was examined with respect to basic descriptive statistics, primarily concentrating on the standard error and standard deviation. The goal of this analysis was to identify detectors which experienced significant standard deviations which may be an indication of inconsistent readings provided by the detector. The results of this analysis are provided in **Table 3**.

Table 3: Descriptive Statistics by Detector

| **Variable** | **Detector** | **Sample size (n)** | **Mean (μ)** | **Standard Deviation (σ)** | **Standard Error** | **σ/μ** |
|---|---|---|---|---|---|---|
| Vehicular Count | *ITERIS Video* | 81623 | 111.3 | 450.8 | 1.6 | 4.05 |
| | *RTMS Radar* | 65379 | 111.3 | 385.4 | 1.5 | 3.46 |
| | *SAS Acoustic* | 29502 | 61.0 | 398.2 | 2.3 | 6.53 |
| | *AutoScope Video* | 5306 | 69.1 | 49.8 | 0.7 | 0.72 |
| | *Wavetronix SmartSensor* | 5637 | 73.7 | 48.5 | 0.6 | 0.66 |
| | | | | | | |
| Speed | *ITERIS Video* | 81623 | 71.695 | 49.660 | 0.174 | 0.69 |
| | *RTMS Radar* | 65379 | 85.444 | 45.026 | 0.176 | 0.53 |
| | *SAS Acoustic* | 29502 | 76.959 | 22.462 | 0.131 | 0.29 |
| | *AutoScope Video* | 5306 | 41.188 | 7.081 | 0.097 | 0.17 |
| | *Wavetronix SmartSensor* | 5637 | 54.775 | 6.957 | 0.093 | 0.13 |

When examining the data statistics, the AutoScope Video and Radar equipment is shown to have a significantly lower standard deviation and Standard error, compared to the other equipment types for both count and speed data.. However, this equipment also had some of the lowest average speeds, which may contribute to a lower standard deviation. Therefore the standard deviation was divided by the mean to provide a normalized measure of the deviation. The normalized deviation is shown under column heading $\sigma/\mu$. However, the apparent superior performance of these detectors may be due to the fact that these were only deployed at 1 location and therefore saw a limited range of speeds. The perceived superior performance may also be due to the assisted installation process as discussed above.

Therefore descriptive statistics were examined for each detector at each location. This analysis is shown in **Table 4**. Detectors having the lowest standard deviation at each location are highlighted.

Table 4: Descriptive Statistics by Detector and Location

| **Variable** | ***Detector*** | **Sample size (n)** | **Mean ($\mu$)** | **Standard Deviation ($\sigma$)** | **Standard Error** | $\sigma/\mu$ |
|---|---|---|---|---|---|---|
| **Location 1: Man O' War Blvd at Boston Road** | | | | | | |
| Count | *ITERIS Video* | 7639 | 95.5 | 11.30 | 990.70 | 0.1183 |
| | *RTMS Radar* | 7890 | 93.5 | 12.10 | 1071.70 | 0.1294 |
| Speed | *ITERIS Video* | 7639 | 125.3 | 0.38 | 33.14 | 0.0030 |
| | *RTMS Radar* | 7890 | 46.6 | 0.12 | 10.87 | 0.0026 |
| **Location 2: Versailles Road at Van Meter Road** | | | | | | |
| Count | *ITERIS Video* | 12688 | 108.5 | 7.26 | 817.40 | 0.0669 |
| | *SAS Acoustic* | 6382 | 37.4 | 10.30 | 823.60 | 0.2754 |
| Speed | *ITERIS Video* | 12688 | 78.6 | 0.24 | 27.05 | 0.0031 |
| | *SAS Acoustic* | 6382 | 83.6 | 0.21 | 17.03 | 0.0025 |
| **Location 3: Newtown Pike at Citation Blvd** | | | | | | |
| Count | *ITERIS Video* | 7560 | 50.2 | 0.62 | 54.14 | 0.0124 |
| Speed | *ITERIS Video* | 7560 | 78.4 | 0.66 | 57.54 | 0.0084 |
| **Location 4: Leestown Road at Forbes Road** | | | | | | |
| Count | *ITERIS Video* | 1485 | 40.0 | 0.85 | 32.90 | 0.0214 |
| | *RTMS Radar* | 2560 | 55.0 | 0.80 | 40.51 | 0.0146 |
| | *SAS Acoustic* | 2570 | 51.5 | 0.77 | 38.81 | 0.0149 |
| Speed | *ITERIS Video* | 1485 | 43.9 | 0.82 | 31.73 | 0.0187 |
| | *RTMS Radar* | 2560 | 64.0 | 0.31 | 15.65 | 0.0048 |
| | *SAS Acoustic* | 2570 | 44.2 | 0.45 | 22.86 | 0.0102 |
| **Location 5: Interstate 75 at milepost 111** | | | | | | |
| Count | *ITERIS Video* | 17161 | 148.0 | 0.56 | 73.81 | 0.0038 |
| | *RTMS Radar* | 17223 | 108.8 | 0.56 | 73.48 | 0.0051 |
| Speed | *ITERIS Video* | 17161 | 30.1 | 0.03 | 4.49 | 0.0011 |
| | *RTMS Radar* | 17223 | 81.4 | 0.16 | 21.18 | 0.0020 |
| **Location 6: New Circle Road at Versailles Road** | | | | | | |
| Count | *ITERIS Video* | 6580 | 204.2 | 1.65 | 133.68 | 0.0081 |
| | *RTMS Radar* | 9355 | 186.5 | 1.69 | 163.60 | 0.0091 |
| Speed | *ITERIS Video* | 6580 | 47.6 | 0.24 | 19.40 | 0.0050 |
| | *RTMS Radar* | 9355 | 133.3 | 0.90 | 87.21 | 0.0068 |

| Variable | *Detector* | Sample size (n) | Mean (μ) | Standard Deviation (σ) | Standard Error | σ/μ |
|---|---|---|---|---|---|---|
| **Location 7: New Circle Road at Tates Creek Road** | | | | | | |
| Count | *ITERIS Video* | 10360 | 126.5 | 1.29 | 131.01 | 0.0102 |
| | *RTMS Radar* | 11165 | 152.3 | 1.09 | 114.82 | 0.0072 |
| | *SAS Acoustic* | 4689 | 109.3 | 1.35 | 92.19 | 0.0124 |
| Speed | *ITERIS Video* | 10360 | 120.5 | 0.75 | 75.86 | 0.0062 |
| | *RTMS Radar* | 11165 | 111.6 | 0.14 | 15.08 | 0.0013 |
| | *SAS Acoustic* | 4689 | 48.4 | 0.19 | 12.92 | 0.0039 |
| **Location 8: Richmond Road at Shriners Lane** | | | | | | |
| Count | *ITERIS Video* | 5610 | 80.7 | 0.73 | 54.37 | 0.0090 |
| | *SAS Acoustic* | 4440 | 70.8 | 0.58 | 38.49 | 0.0082 |
| | *AutoScope Video* | 5306 | 69.1 | 0.68 | 49.81 | 0.0099 |
| | *Wavetronix SmartSensor* | 5637 | 73.7 | 0.65 | 48.50 | 0.0088 |
| Speed | *ITERIS Video* | 5610 | 42.3 | 0.11 | 8.08 | 0.0026 |
| | *SAS Acoustic* | 4440 | 74.9 | 0.21 | 13.90 | 0.0028 |
| | *AutoScope Video* | 5306 | 41.2 | 0.10 | 7.08 | 0.0024 |
| | *Wavetronix SmartSensor* | 5637 | 54.8 | 0.09 | 6.96 | 0.0017 |
| **Location 9: Richmond Road at Ashley Woods** | | | | | | |
| Count | *ITERIS Video* | 12540 | 71.0 | 0.51 | 57.51 | 0.0072 |
| | *RTMS Radar* | 17186 | 62.8 | 0.33 | 43.02 | 0.0052 |
| | *SAS Acoustic* | 11420 | 51.2 | 0.34 | 36.42 | 0.0067 |
| Speed | *ITERIS Video* | 12540 | 73.7 | 0.21 | 23.96 | 0.0029 |
| | *RTMS Radar* | 17186 | 67.5 | 0.07 | 9.78 | 0.0011 |
| | *SAS Acoustic* | 11420 | 93.1 | 0.04 | 3.88 | 0.0004 |

When examined by location, a more consistent standard deviation is shown across all detector types. Both the RTMS Radar and ITERIS video are shown to have the lowest normalized standard for both count and speed data at the majority of locations.

## Equipment Reliability

After the beginning of the study period on June1, 2005, limited maintenance was performed on the incident detection equipment. In order to determine the reliability of the equipment, the total number of data points greater than zero collected by each detector was determined. This number was normalized by the total number of lanes observed by each detector and divided by the total number of intervals during the analysis period (22,320). The results of this analysis are presented in **Table 5**.

Table 5: Equipment Reliability

| Detector | No. of Data Points | No. of Observed Lanes | Avg No. of Data Points per Lane | Percent of Total Observations |
|---|---|---|---|---|
| *ITERIS Video* | 97559 | 26 | 3752.3 | 0.168 |
| *RTMS Radar* | 74211 | 22 | 3373.2 | 0.151 |
| *SAS Acoustic* | 34641 | 18 | 1924.5 | 0.086 |
| *AutoScope Video* | 5306 | 2 | 2653.0 | 0.119 |
| *Wavetronix SmartSensor* | 5637 | 2 | 2818.5 | 0.126 |

On average, all detectors recorded between 8 and 16 percent of the entire study period. A significant portion of the “missing” data may be attributed to disruptions in communication or downtime of the central server during maintenance and not due to the local detection equipment. However, based upon this analysis the ITERIS video and RTMS Radar detectors provide a consistently higher reliability when compared to the other equipment deployed.

The AutoScope Video and Radar detectors may be at a disadvantage since only 1 of each detector was deployed at a single location. However, when the Richmond Road location is examined independently, the ITERIS video provides a reliability reading of 14.3 percent which is still greater than the Autoscope products.

## Summary

Based upon the procedures and analysis presented above, the following conclusions are made in the evaluation of the Lexington Automatic incident Detection System.

14) Detector Installation should be tailored to optimize the individual performance of each detector used in the system with respect to its intended application. This would include utilizing side-fire orientation for SAS-1 acoustic detectors and forward-looking orientation for RTMS radar and ITERIS Video detectors.

15) The acoustic detector may provide the simplest and cost effective solution in terms of installation due to its ability to be placed in a side-firing orientation from the roadside. Radar and Video equipment may have some limitations in this configuration. Video and Radar

deployments may require more units to cover the same number of lanes in order to achieve a forward-looking installation. More extensive support infrastructure may also be required to place the detectors over the lanes being observed.

16) An improved configuration over the “intersection” presence mode currently deployed, would be to establish a “speed-trap” using pulse detection mode and consecutive detection zones.

17) The preferred configuration for each detector would be to utilize specific software provided by each manufacturer, which is designed for the purposes of traffic monitoring and speed detection.

18) Should the presence or pulse mode be chosen for implementation, extreme care should be used in determining the detector zone size for each detector application to provide for accurate speed data based upon vehicle occupancy. It is necessary to calculate the individual detector zone size based upon the specific orientation of the detector to the roadway and the characteristics of the individual detectors.

19) Real-time communication should be established between detector locations to provide useful and relevant data for implementation into an incident detection system.

20) Due to the errors in the system deployment and configuration, direct evaluation of the performance of each of the detector types was not possible.

21) Statistical analysis did not identify consistencies between any of the data points, except at Location 8 (Richmond Road and Shriners Lane) where Autoscope products were deployed. Better installation techniques may have contributed to the improved performance of this location.

22) Analysis of the Standard Deviation of the data points from each detector indicated that RTMS Radar units and ITERIS video provided a consistently smaller standard deviation than other units at most locations.

23) Examination of the reliability of the detectors indicated that data was recorded for only 10 to 15 percent of the study period. The majority of the “missing” data may be attributed to communication and server issues. ITERIS Video and RTMS Radar detectors provided the highest reliability.

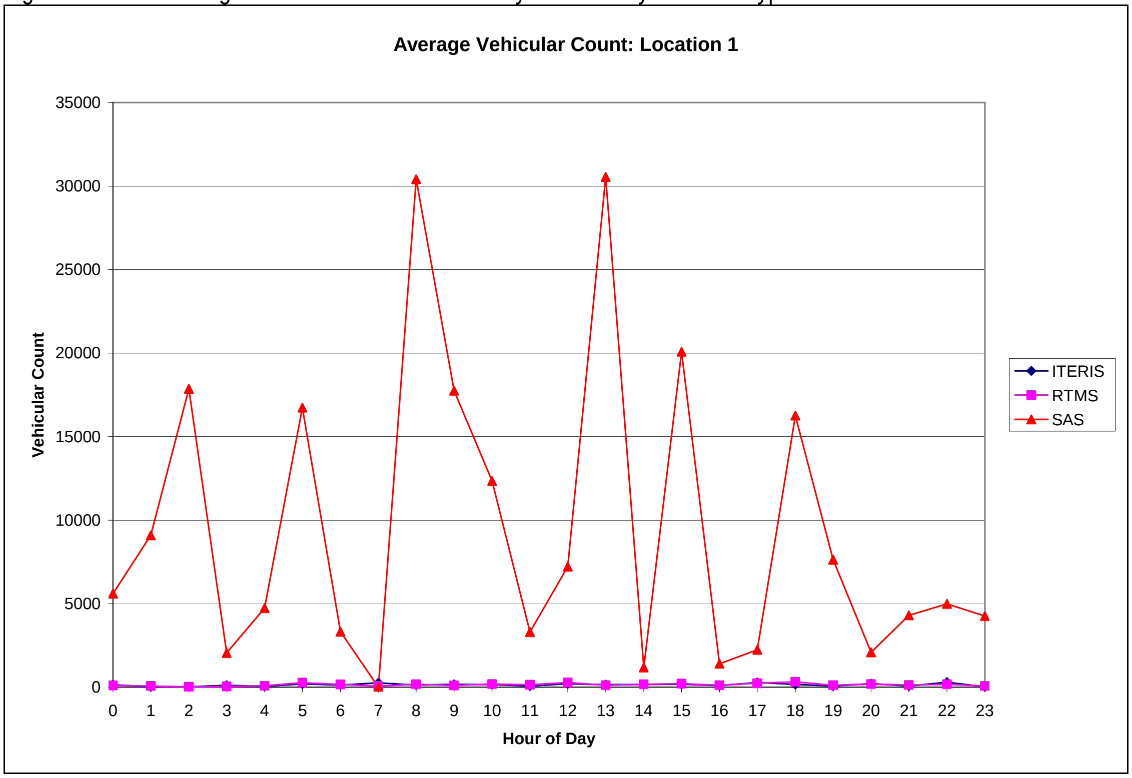
24) Before full deployment of the incident detection system, improved installation and configuration procedures should be developed and tested to improve the accuracy and reliability of the system. To achieve this, it is imperative to determine detailed data flows from field deployed equipment to the PYRAMIDS central server and to understand the operations of each piece of equipment and the impact of those operations on the final data output/quality. In addition, the operation of each detector installed should be fully understood in order to facilitate proper installation and configuration. Communication problems between the field equipment and the central server should be resolved in order to improve the reliability of the system.

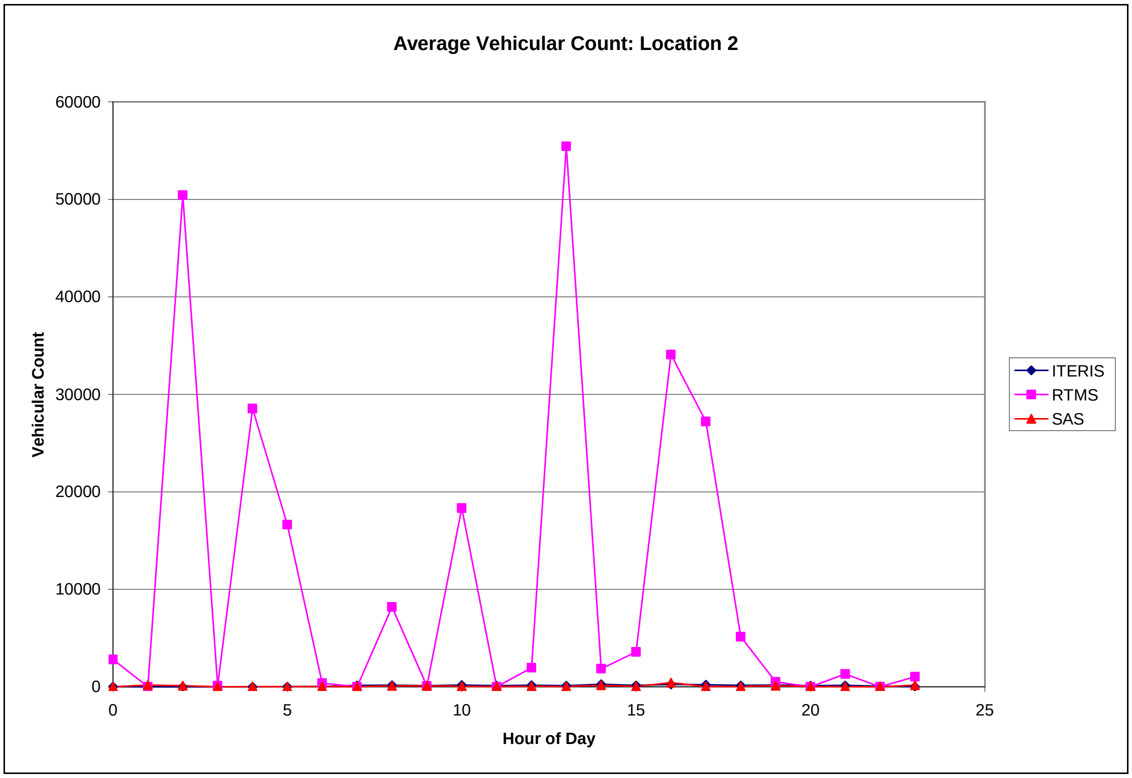
25) It is recommended that a decision on detector type for implementation be postponed until the configuration problems have been resolved. Further deployments of the AutoScope products should be included in additional evaluation due to the high level of performance indicated by the statistical analysis.

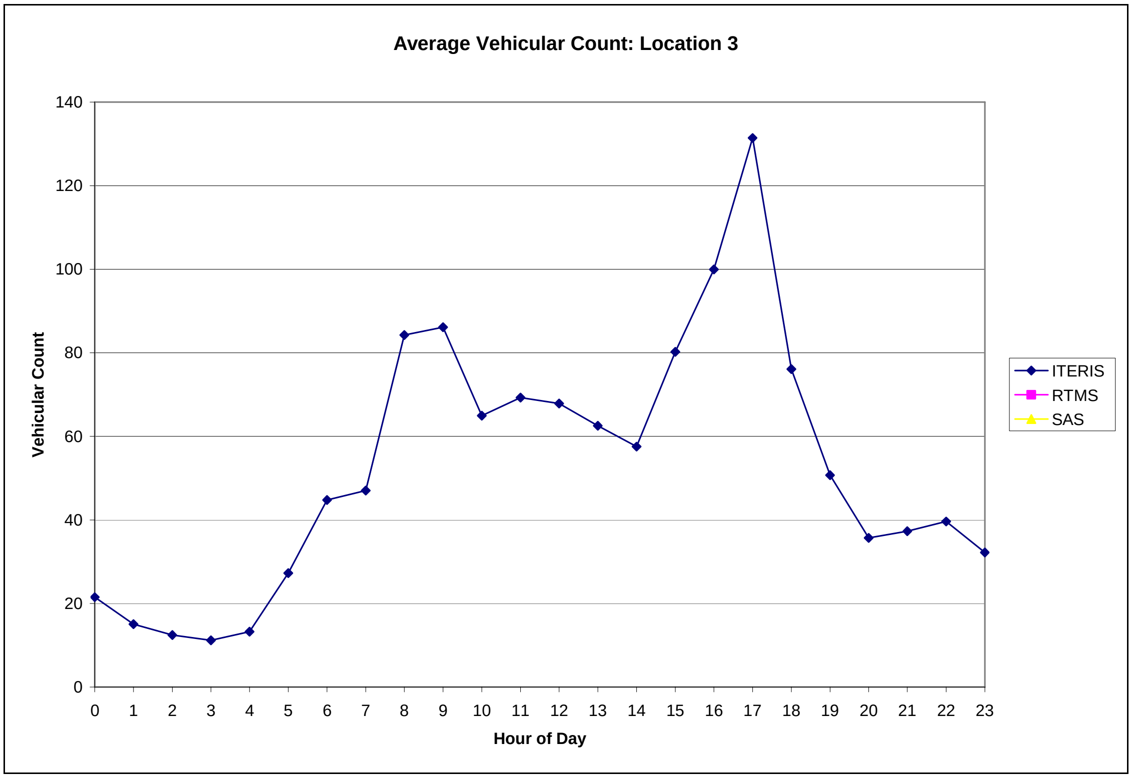
26) Due to variations in equipment calibration, it is recommended that, when the system is fully implemented, an initial period of observation should be used to identify baseline speed and count data for that location. Speed thresholds used to indicate an incident should be based on the average baseline condition for each location and not an arbitrary speed threshold such as 35 or 45 mph, in order to account for specific variations in the installation, configuration and location of each site.

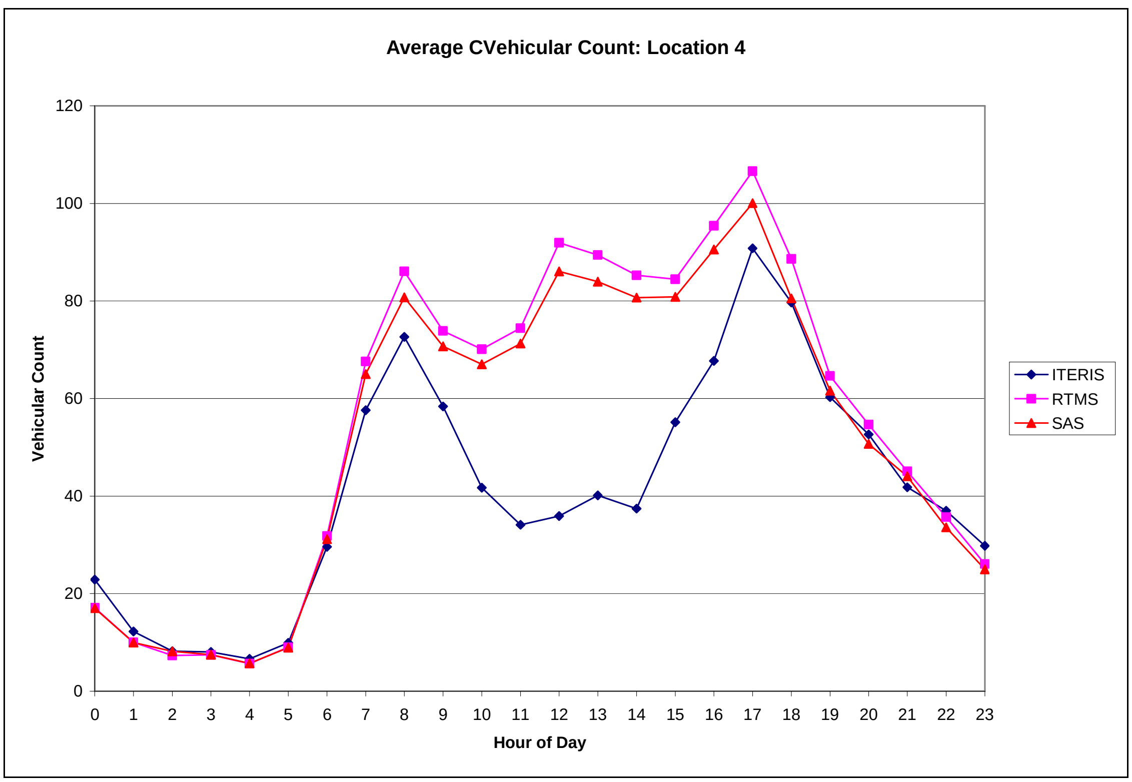
# APPENDIX A: AVERAGE COUNT AND SPEED DATA BY LOCATION

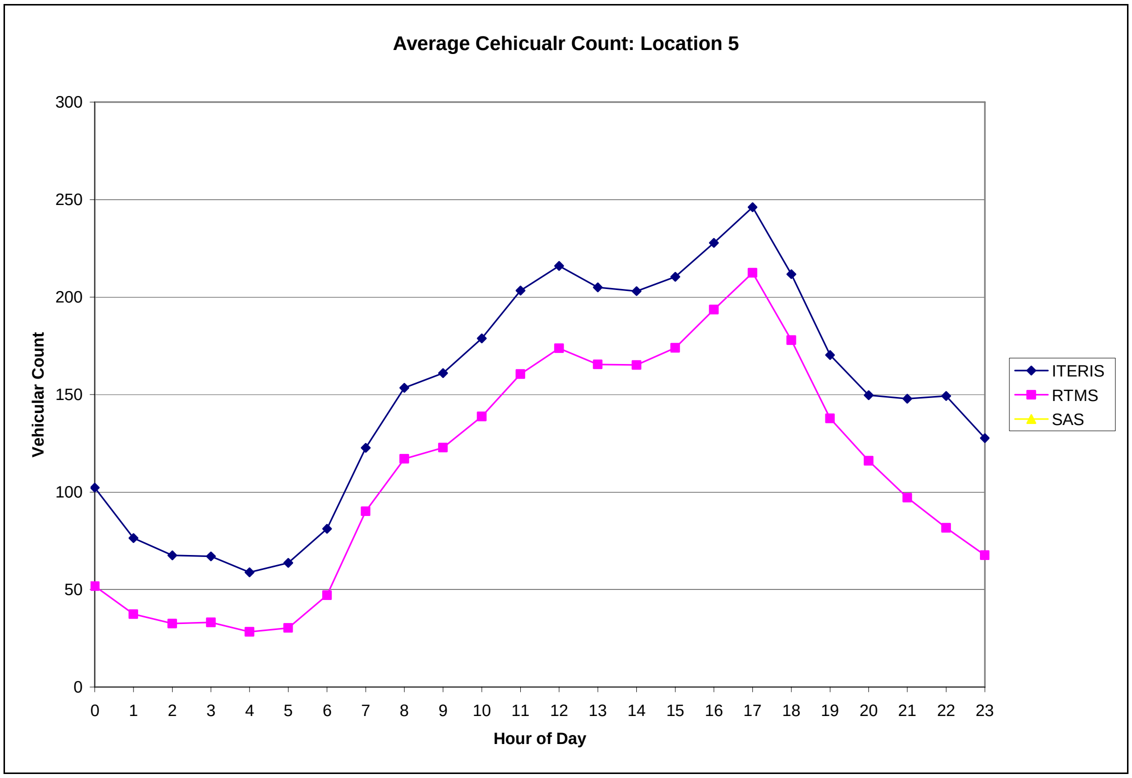
Figures A1-A9: Average recorded Vehicular Count by Hour of Day/Detector Type and Location

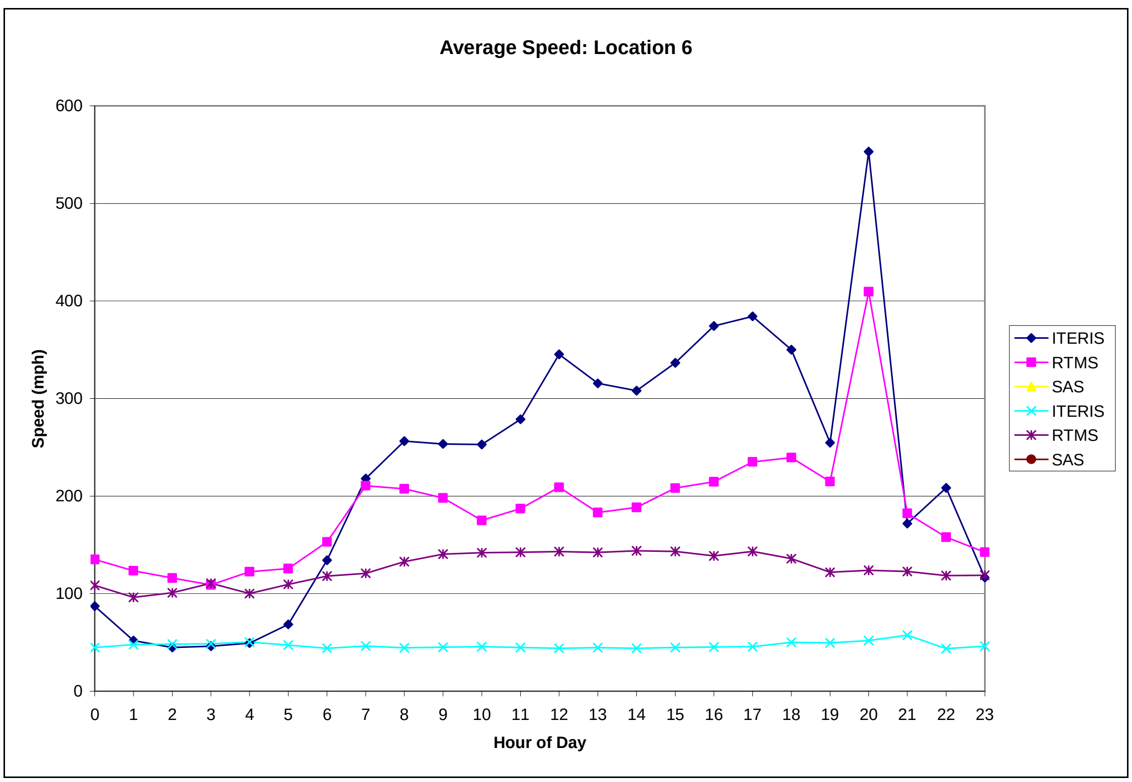


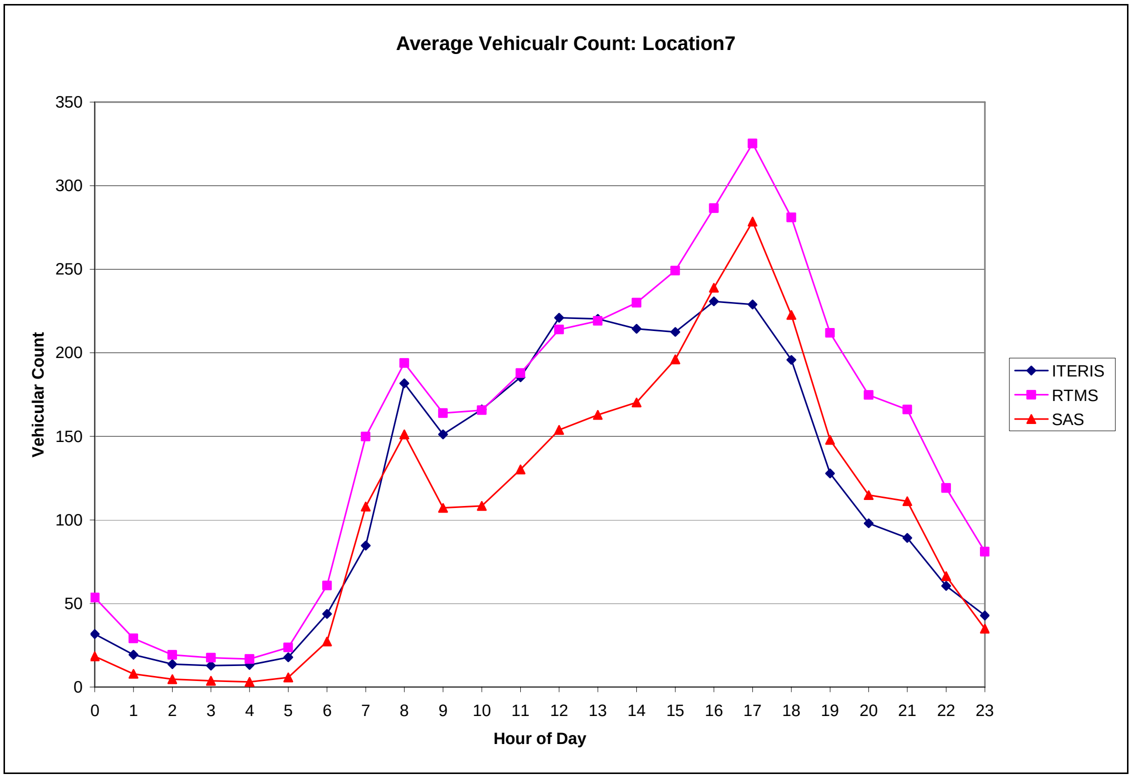



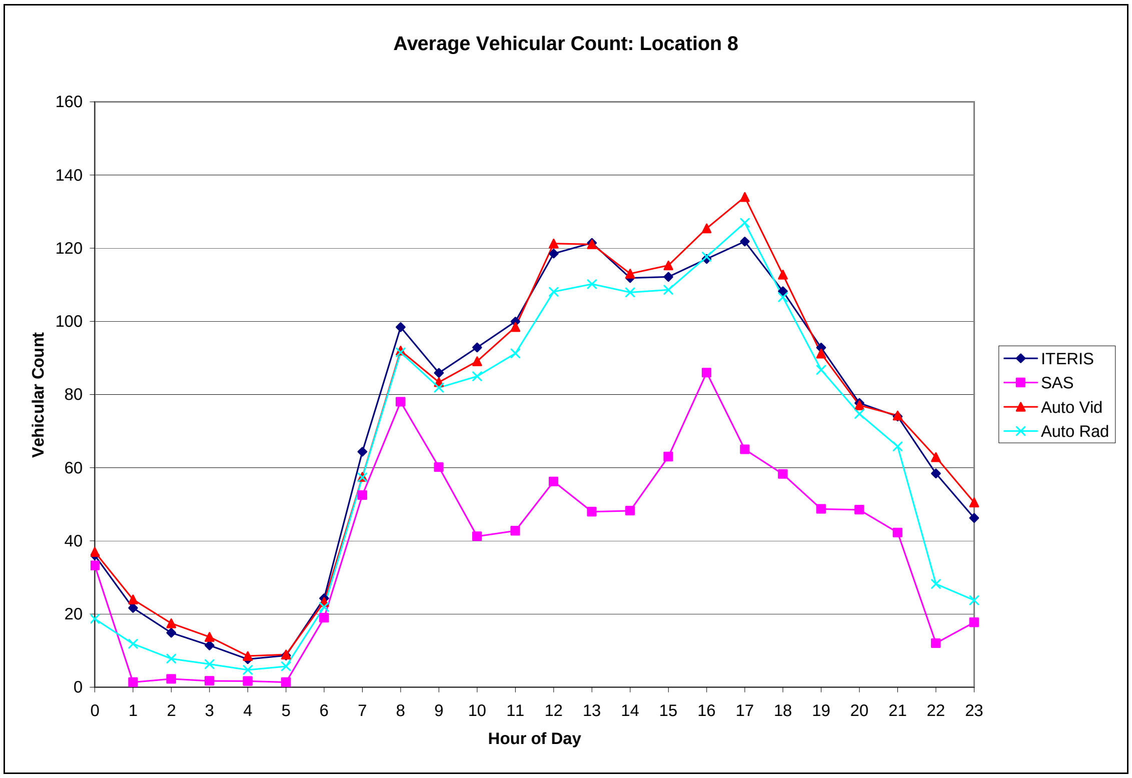

Average Vehicular Count: Location 3
Vehicular Count
Hour of Day
ITERIS
RTMS
SAS
0
20
40
60
80
100
120
140
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

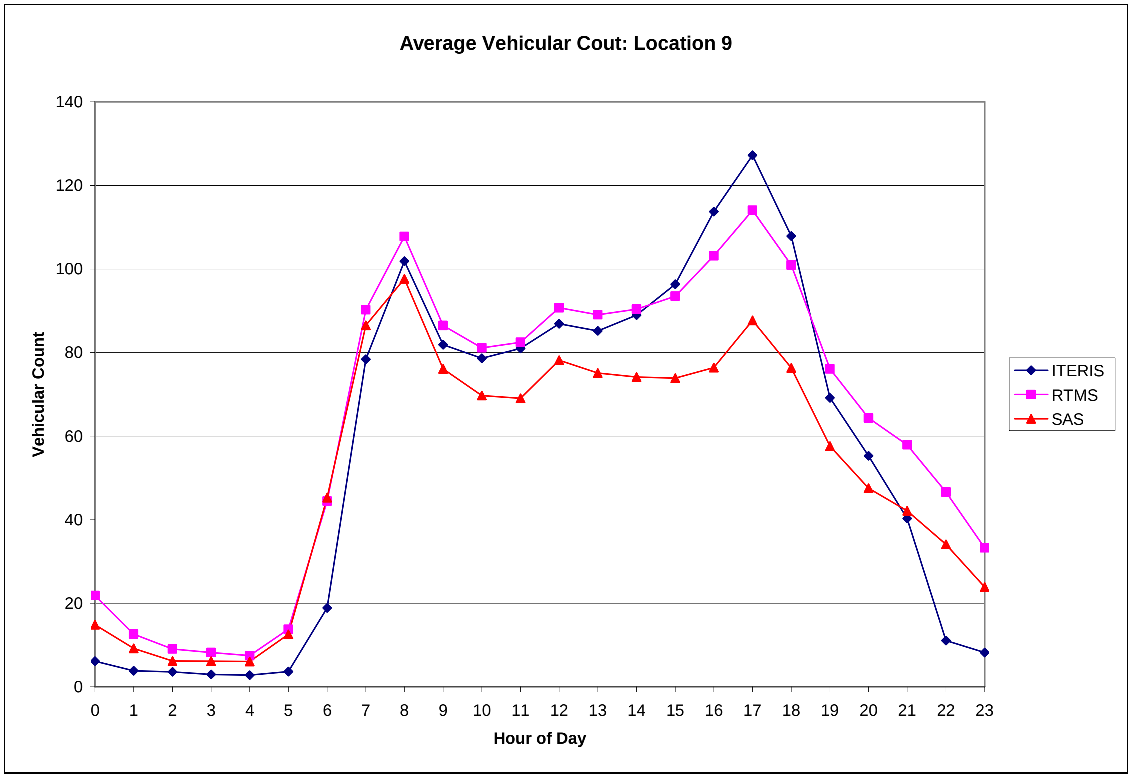

Average CVehicular Count: Location 4
Vehicular Count
Hour of Day
ITERIS
RTMS
SAS
0
20
40
60
80
100
120
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23


Average Cehicualr Count: Location 5
Vehicular Count
300
250
200
150
100
50
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour of Day
ITERIS
RTMS
SAS


Average Speed: Location 6
Speed (mph)
600
500
400
300
200
100
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour of Day
ITERIS
RTMS
SAS
ITERIS
RTMS
SAS

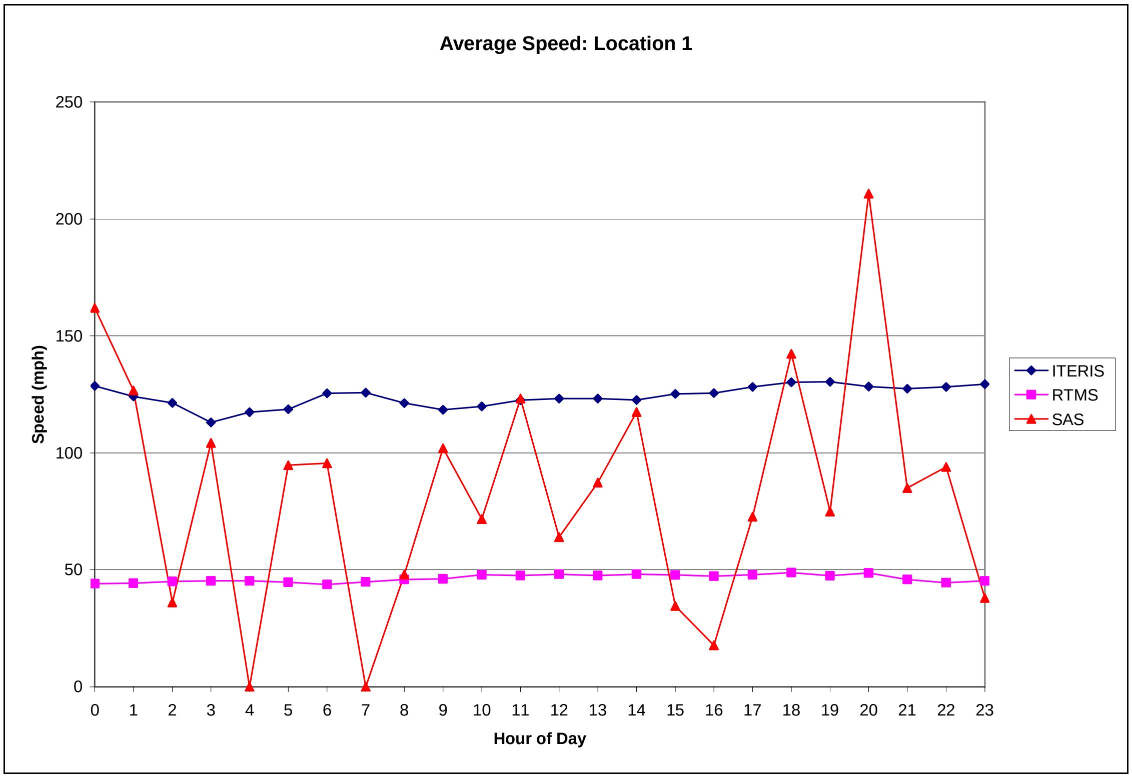

Average Vehicualr Count: Location7
Vehicular Count
Hour of Day
ITERIS
RTMS
SAS

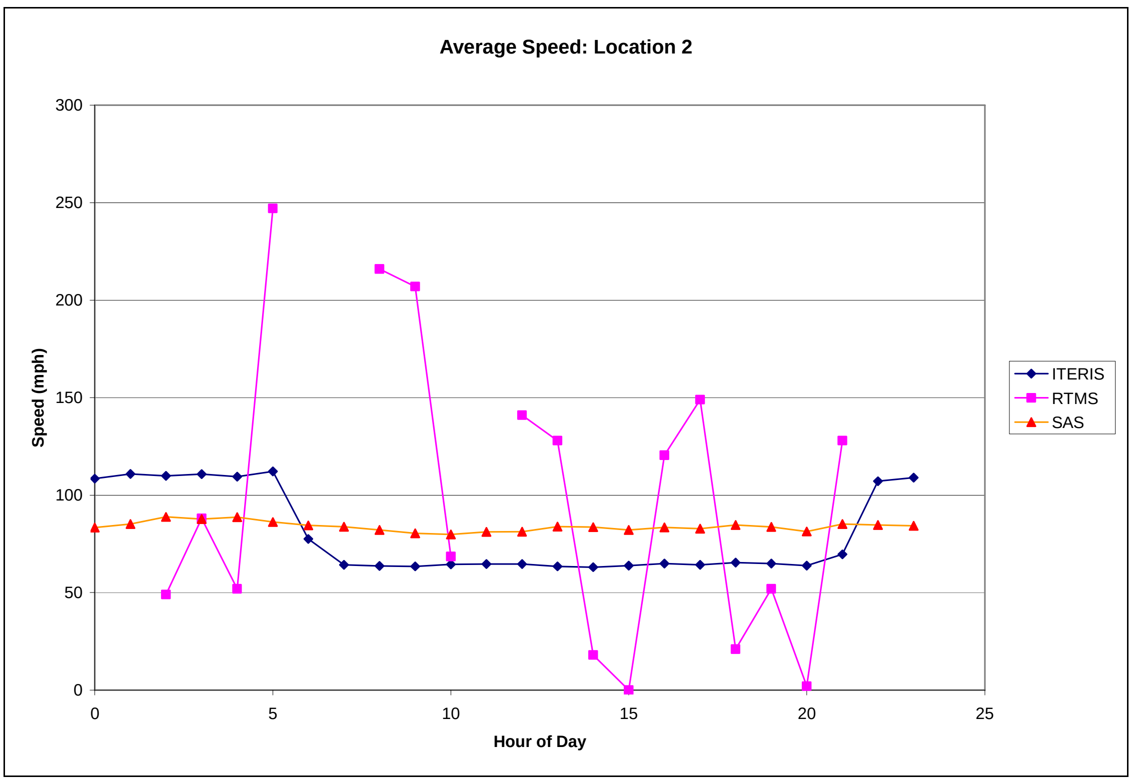

Average Vehicular Count: Location 8
Vehicular Count
Hour of Day
ITERIS
SAS
Auto Vid
Auto Rad

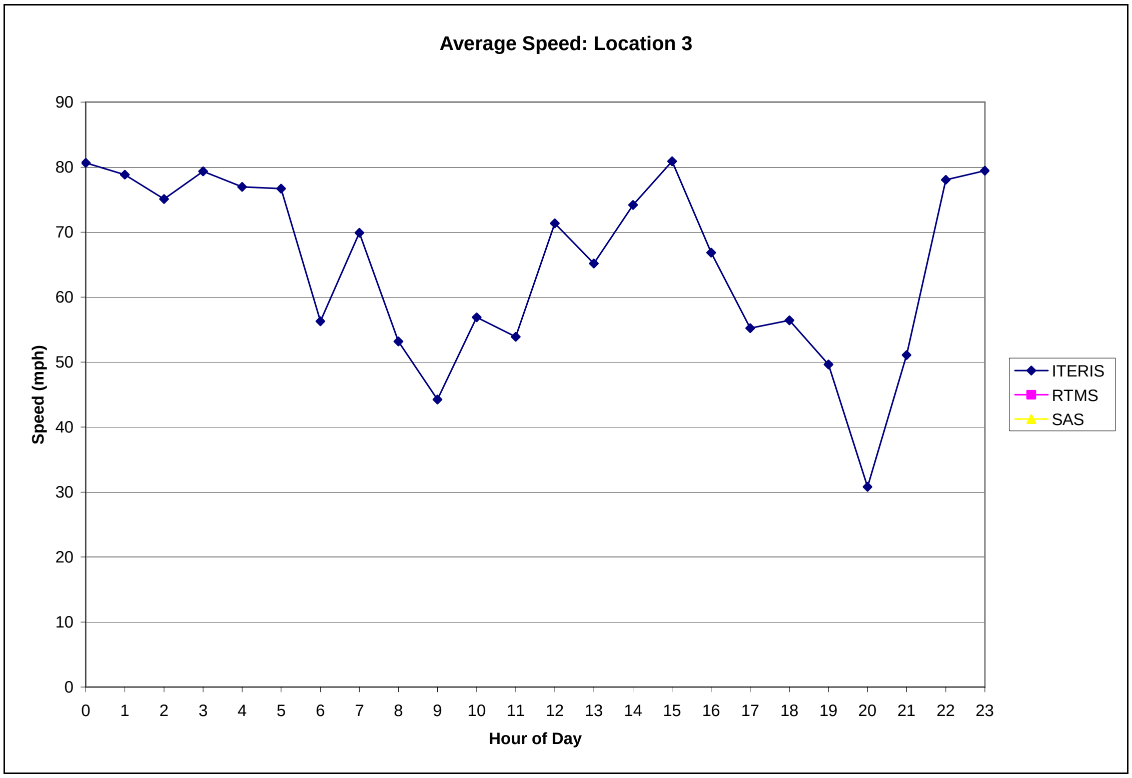


Average Vehicular Cout: Location 9
140
120
100
80
60
40
20
0
Vehicular Count
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
Hour of Day
ITERIS
RTMS
SAS

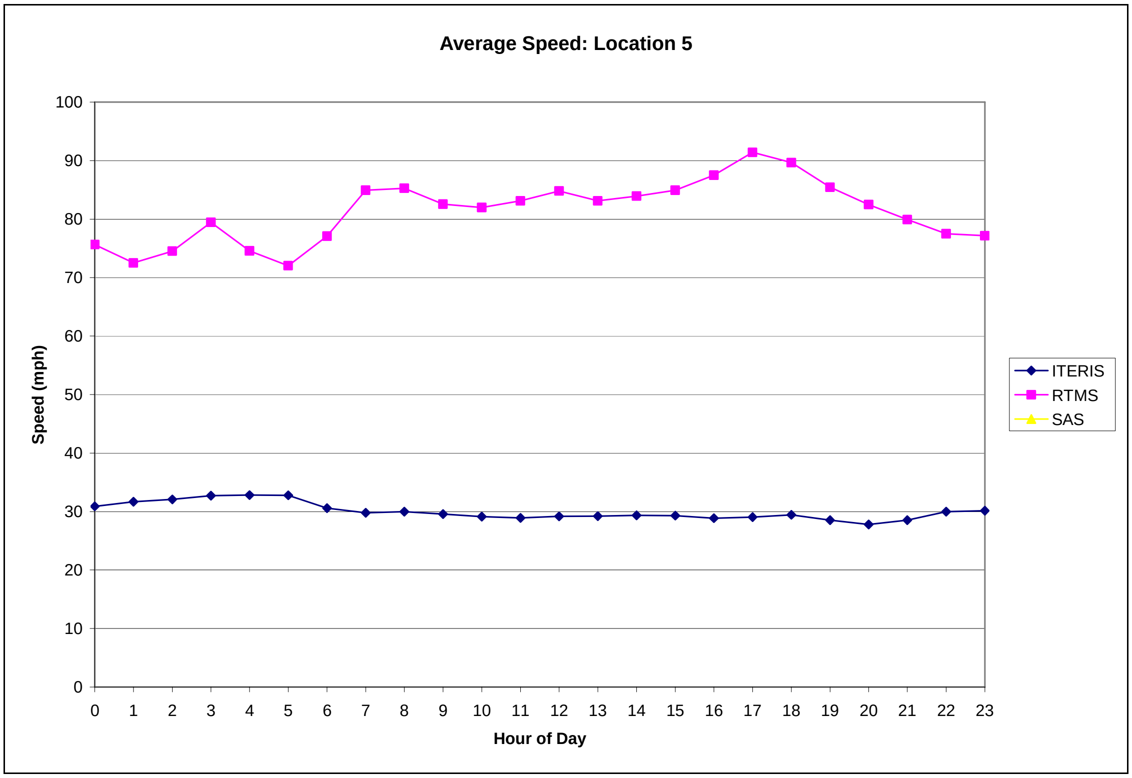
Figures A10-A18: Average Recorded Vehicular Speed by Hour of Day, Detector Type and Location

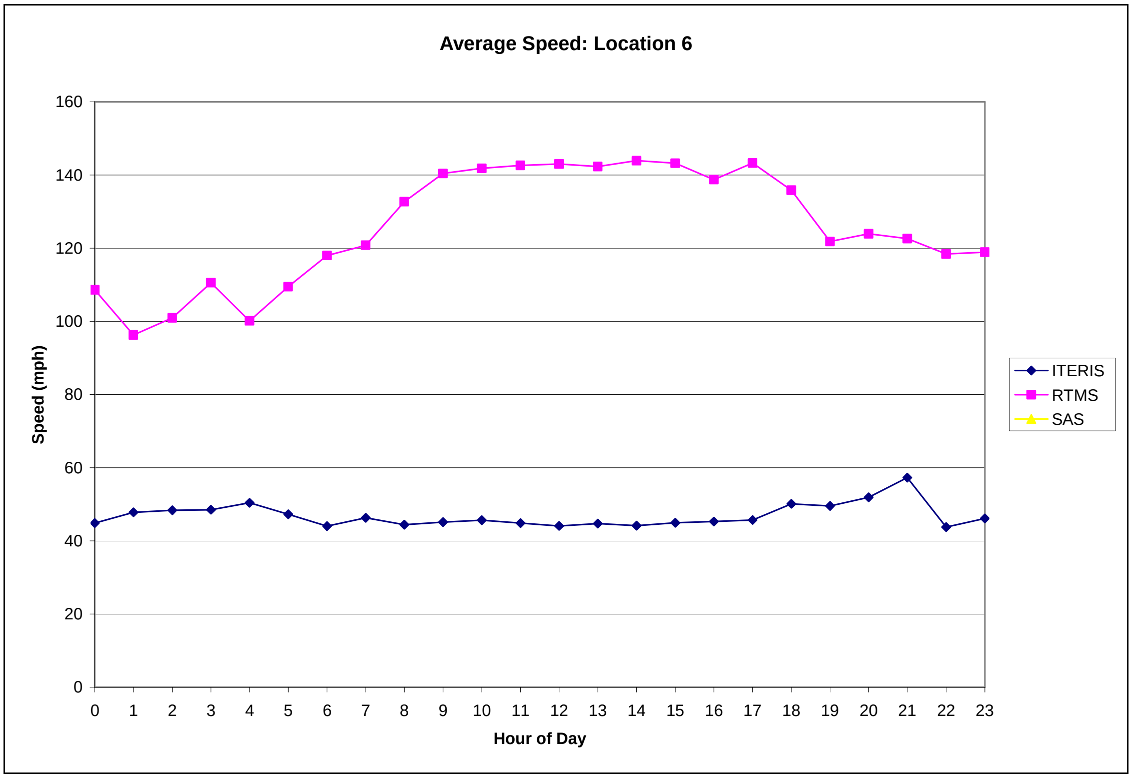


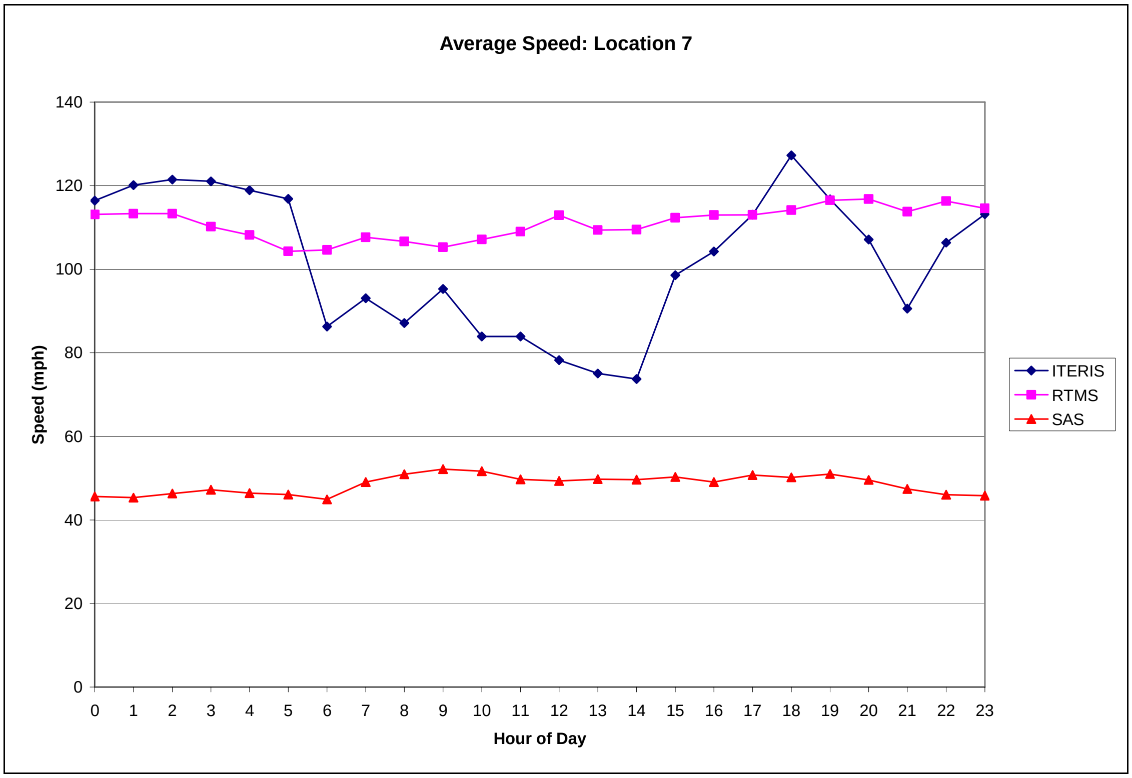



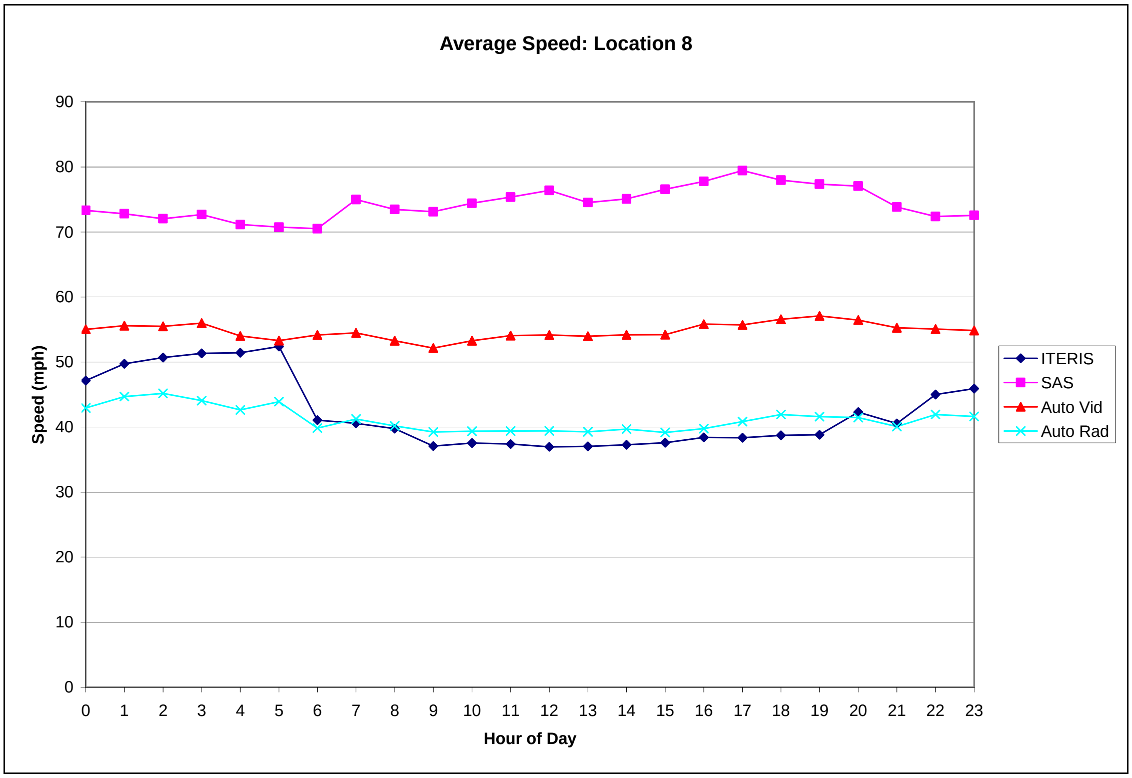

Average Speed: Location 3
Speed (mph)
Hour of Day
ITERIS
RTMS
SAS
0
10
20
30
40
50
60
70
80
90
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

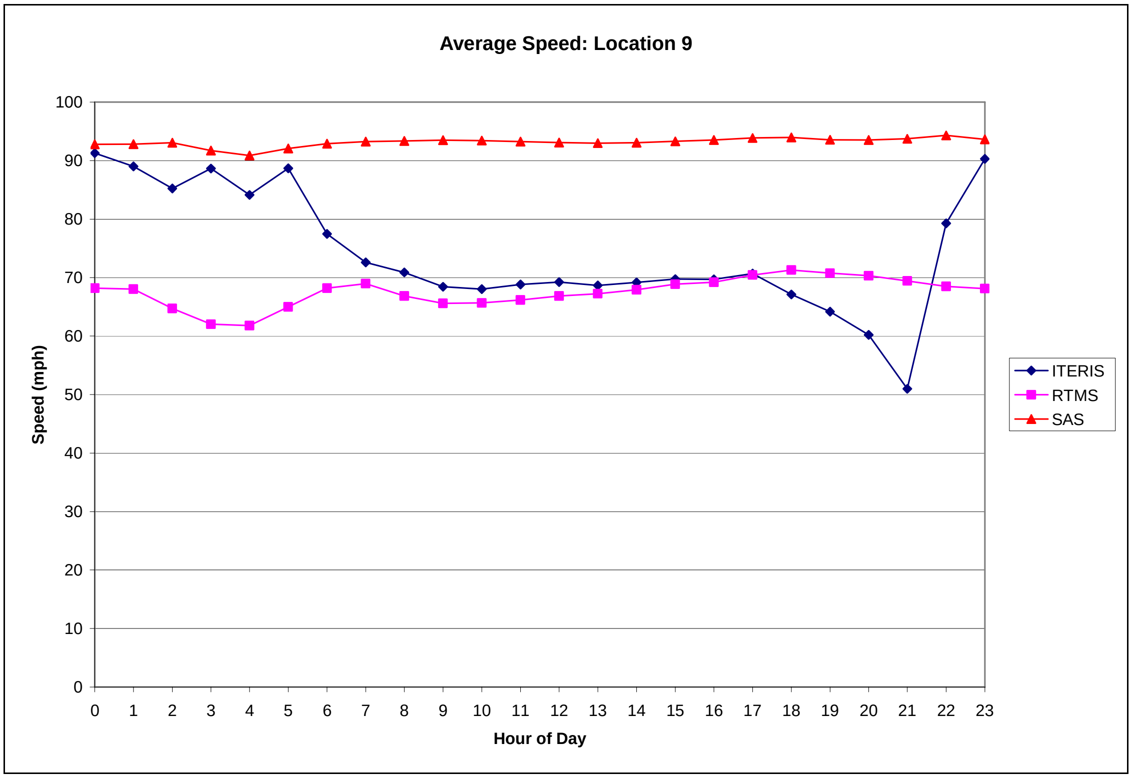

Average Speed: Location 4
Speed (mph)
Hour of Day
ITERIS
RTMS
SAS
0
10
20
30
40
50
60
70
80
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23


Average Speed: Location 5
Speed (mph)
Hour of Day
ITERIS
RTMS
SAS

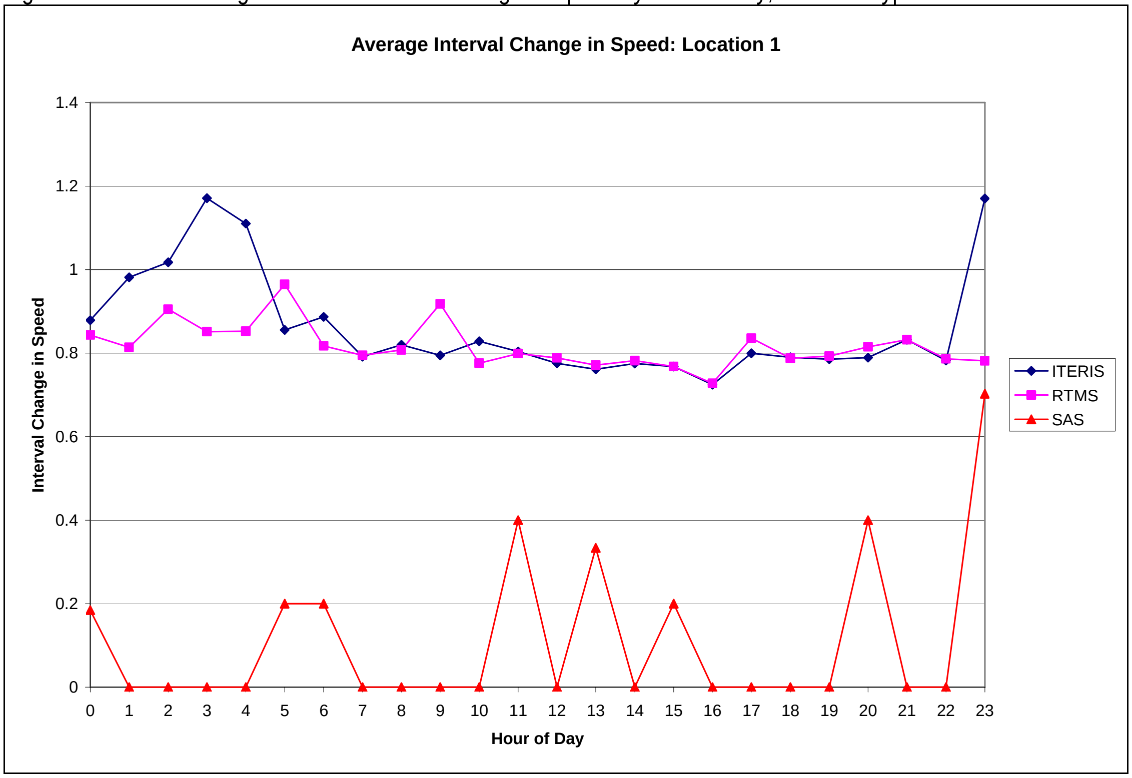

Average Speed: Location 6
Speed (mph)
Hour of Day
ITERIS
RTMS
SAS

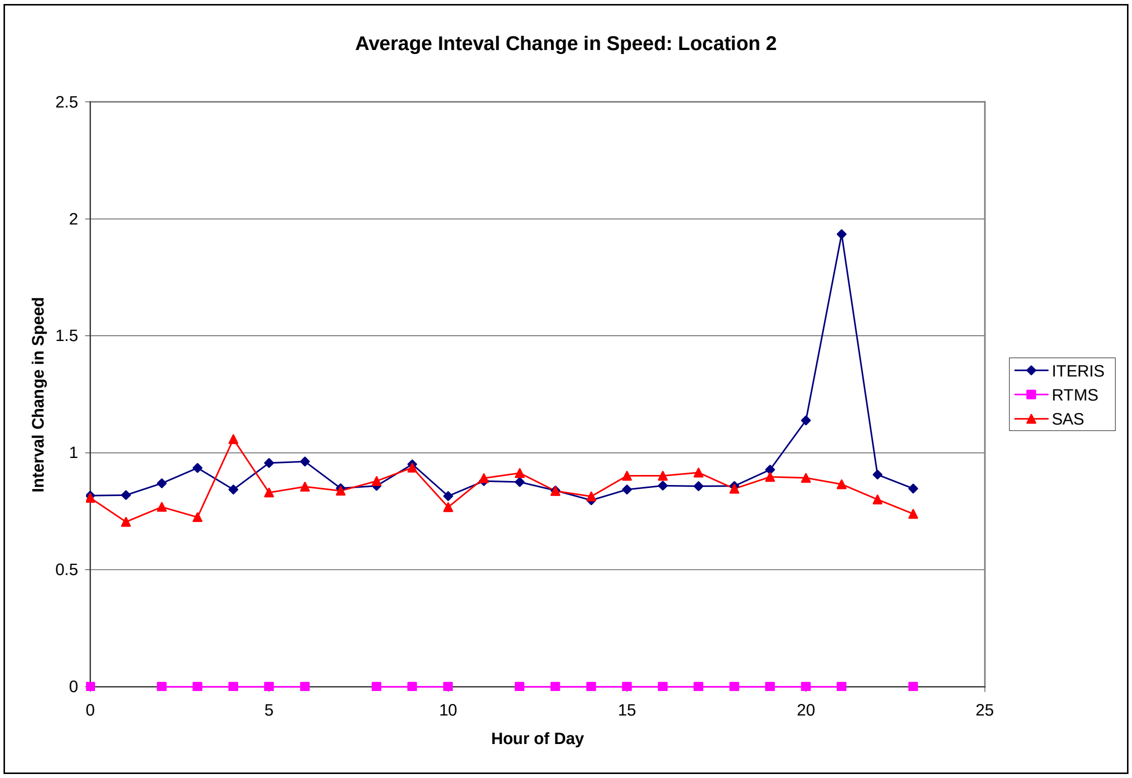

Average Speed: Location 7
140
120
100
80
60
40
20
0
Speed (mph)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour of Day
ITERIS
RTMS
SAS

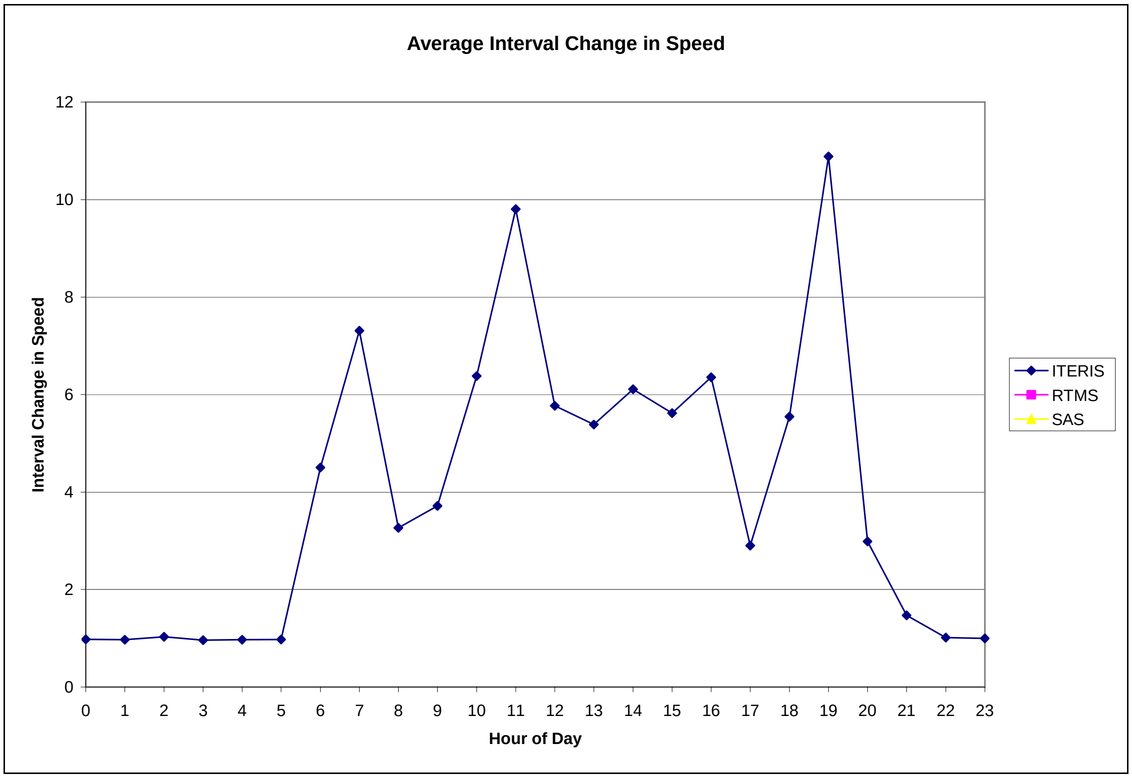

Average Speed: Location 8
90
80
70
60
50
40
30
20
10
0
Speed (mph)
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour of Day
ITERIS
SAS
Auto Vid
Auto Rad

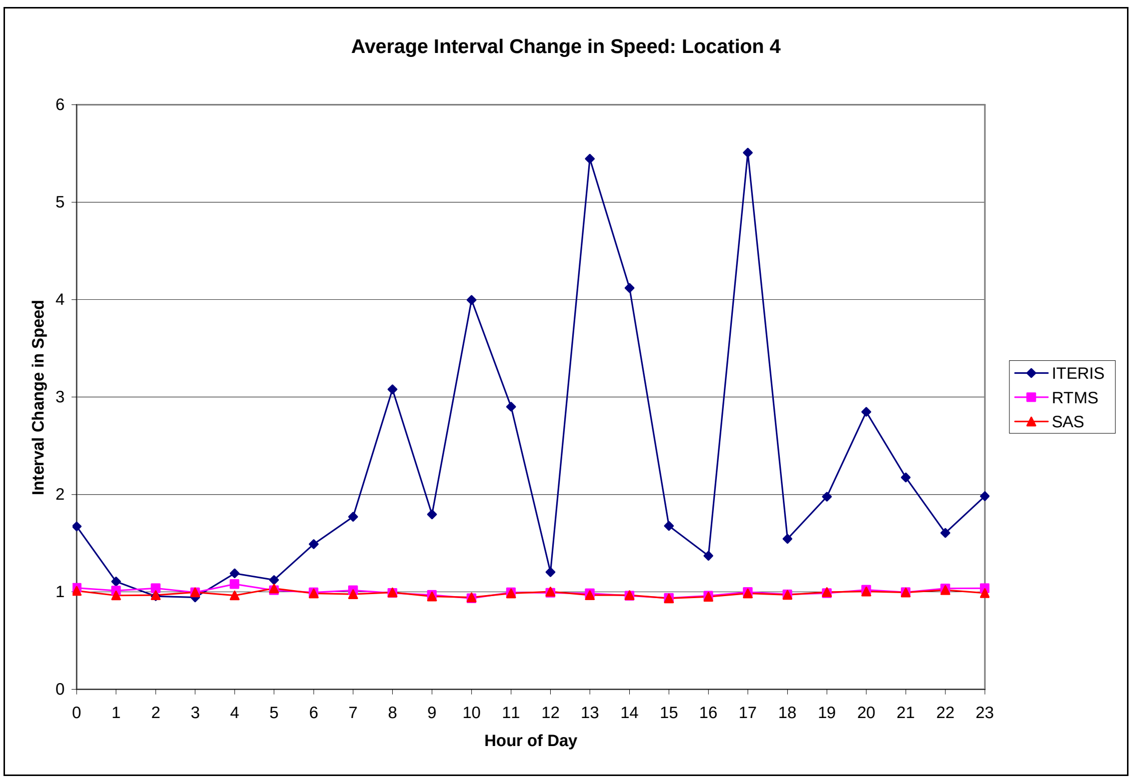

Average Speed: Location 9
Speed (mph)
Hour of Day
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
ITERIS
RTMS
SAS

Figures A19-A27: Average Recorded Interval Change in Speed by Hour of Day, Detector Type and Location




Average Interval Change in Speed
Interval Change in Speed
Hour of Day
ITERIS
RTMS
SAS
0
2
4
6
8
10
12
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23


Average Interval Change in Speed: Location 4
Interval Change in Speed
Hour of Day
ITERIS
RTMS
SAS
0
1
2
3
4
5
6
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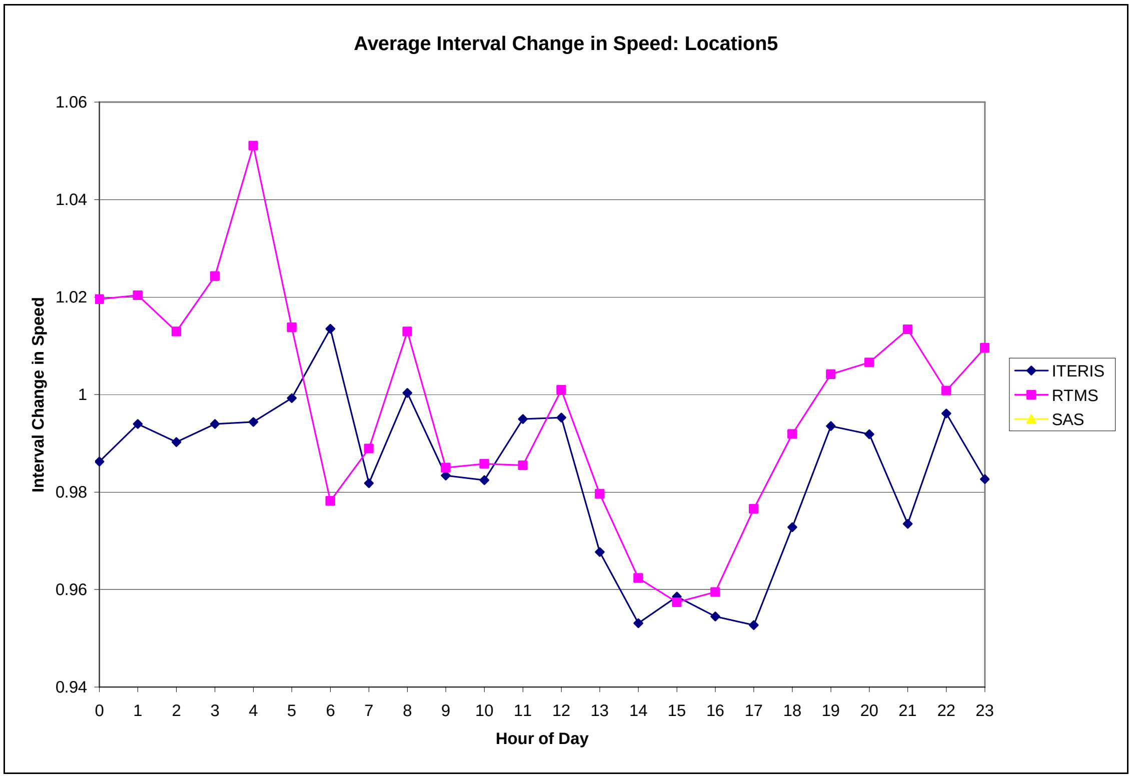
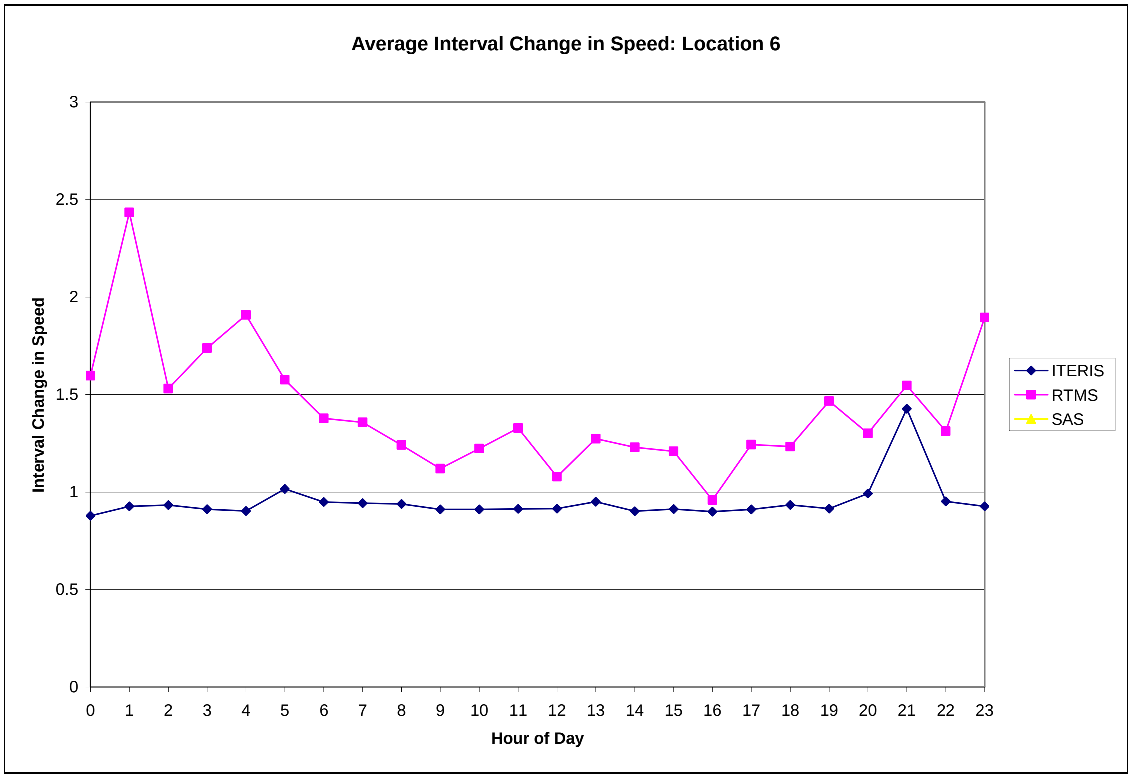
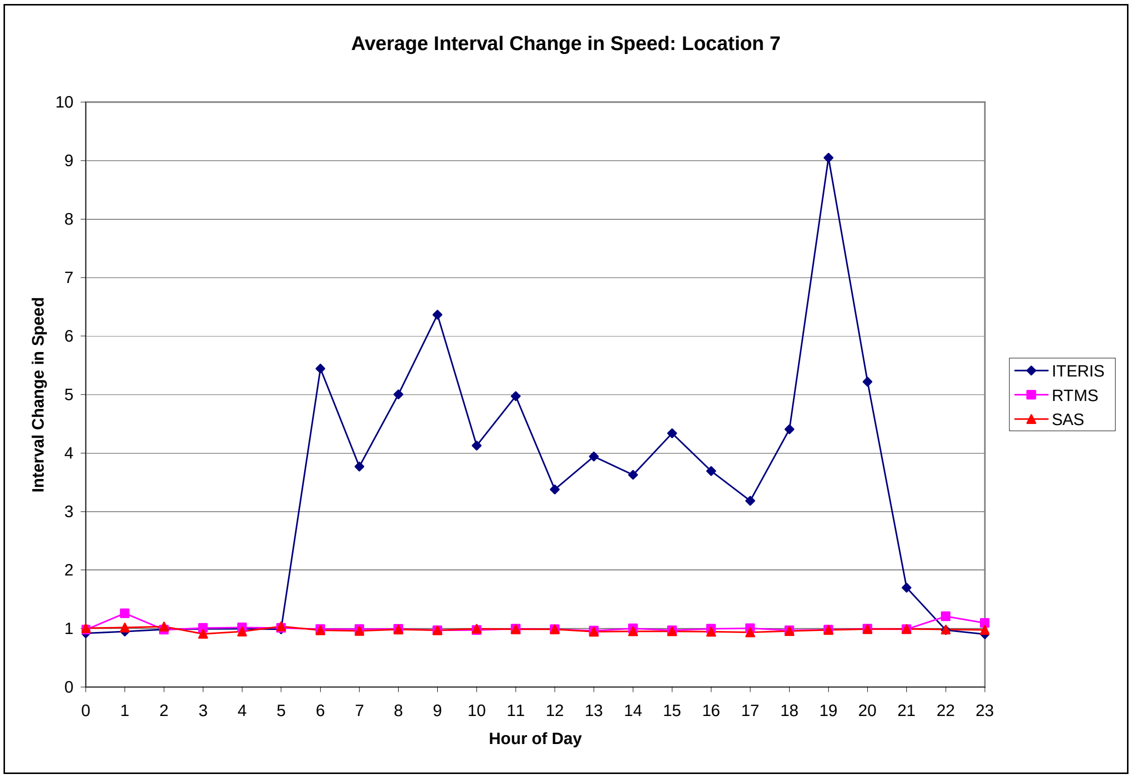
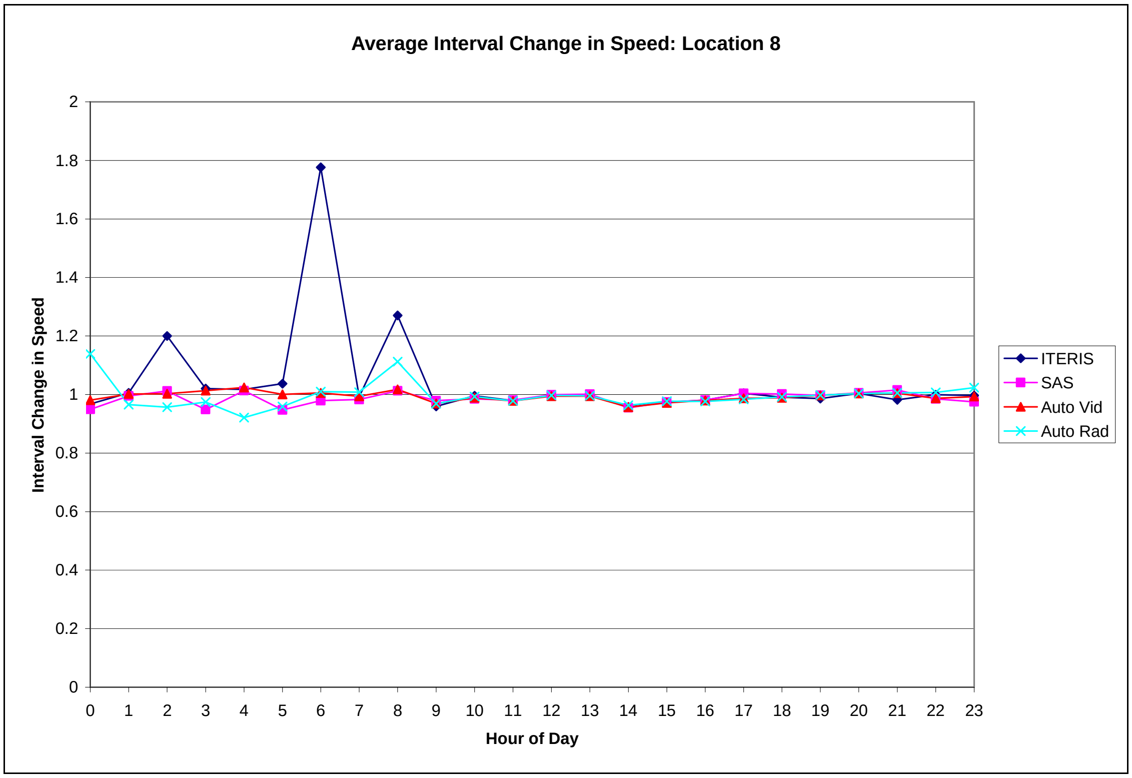
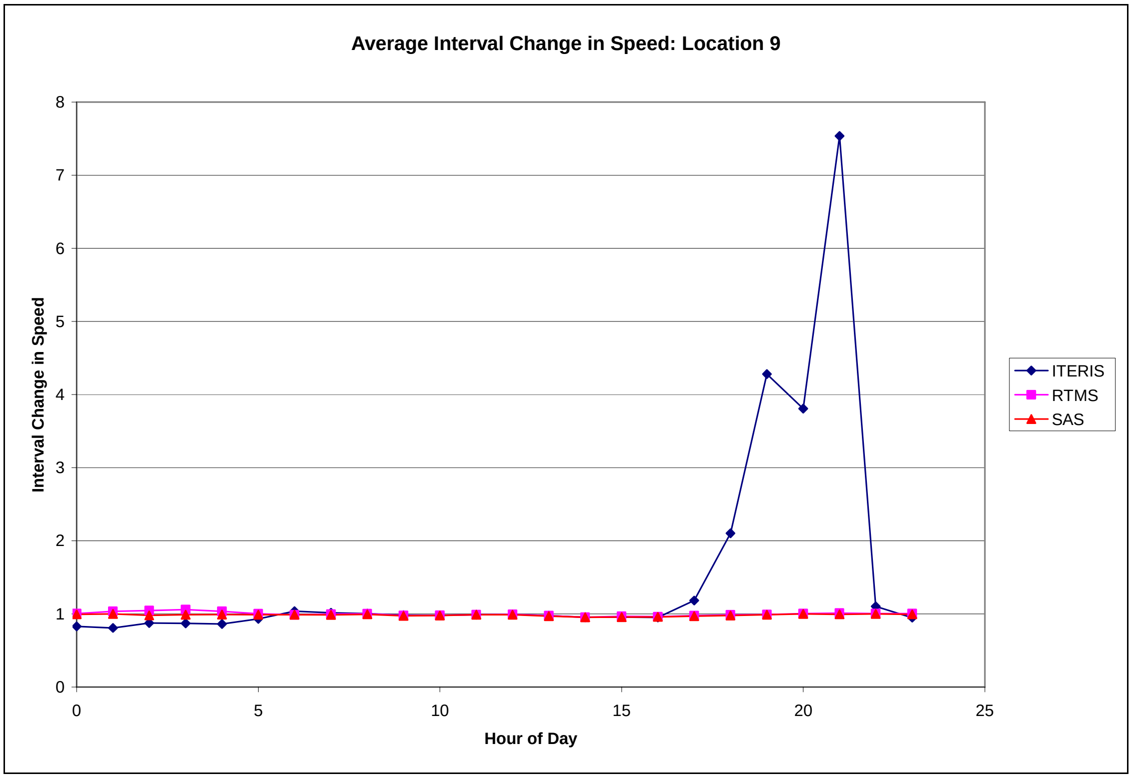

Average Interval Change in Speed: Location5
Interval Change in Speed
1.06
1.04
1.02
1
0.98
0.96
0.94
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour of Day
ITERIS
RTMS
SAS


Average Interval Change in Speed: Location 6
Interval Change in Speed
3
2.5
2
1.5
1
0.5
0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
Hour of Day
ITERIS
RTMS
SAS


Average Interval Change in Speed: Location 7
Interval Change in Speed
Hour of Day
ITERIS
RTMS
SAS


Average Interval Change in Speed: Location 8
Interval Change in Speed
Hour of Day
ITERIS
SAS
Auto Vid
Auto Rad


Average Interval Change in Speed: Location 9
Interval Change in Speed
Hour of Day
0
1
2
3
4
5
6
7
8
0
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