Project Summary Report 0-2119-S
Project 0-2119: Evaluation of Vehicle Detection Systems

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PROJECT SUMMARY REPORT

Summary Report on Evaluation of Vehicle Detection Systems

Advances in non-intrusive vehicle detection systems and the well-documented problems with inductive loops provide strong incentives to pursue evaluation of loop alternatives. The Texas Department of Transportation (TxDOT) is concerned about safety issues, costs and aggravation associated with the current vehicle detection systems that it uses for collecting both historical and real-time data. These concerns include: exposure of employees to traffic, costs of lane closures to maintain loops, damage to pavements through the loop cutting process, and the inflexibility of loops (e.g., where lanes shift).

What We Did...

Research staff formulated a plan for collecting information from various jurisdictions and for testing new or improved vehicle detection systems. Then they presented the plan to the project director, the program coordinator, and the Project Monitoring Committee (PMC). Knowledge of the research team from previous detector research was instrumental in identifying and recommending systems that had not been thoroughly tested in the Texas environment or had received close scrutiny only in limited ways on low-volume roadways.

At the outset of the project, the research team was asked to evaluate a sophisticated inductive loop system that was designed to serve as a vehicle classifier. The test plan included its evaluation

Photo of IH-35 Testbed

and further use as the ground truth system for non-intrusive devices. Beyond this test, direction from the PMC generally focused on non-intrusive detectors, while also seeking "success stories" involving inductive loops, since they form the basis of the existing TxDOT detection system. Non-intrusive detectors included in the test plan were:

- *SAS-1* by SmarTek (acoustic),
- *RTMS* ™ by EIS (microwave radar),
- *Solo Pro* by Autoscope (video image processor),
- *Vantage*™ by Iteris (video image processor), and
- *non-invasive microloops* by 3M (magnetic).

In the final analysis, this project was unable to test 3M microloops because of construction delays at the site where they were to be installed. The baseline system that was also part of the list of devices to be tested was a Peek *ADR-6000*, once known as the *Idris* or *Smart Loop system*.

The research then focused on carrying out full-scale field tests on selected devices. The first step was to design and install a field testbed in Austin using the southbound lanes of IH-35 near 47th Street. Early tests also used an existing testbed in College Station for selected devices. Traffic conditions at the IH-35 site typically range from free flow during off-peak periods to slow speeds or even stop-and-go conditions during peak periods. The site was conducive to testing not only because of the range of traffic conditions and five traffic lanes to monitor, but also because of:

- an overhead sign bridge,
- existing inductive loops (used for presence detection),
- luminaire poles in the proper location,
- minimal sight obstructions,
- existing phone service and 110VAC power, and
- support from the Austin District through the project director.

Devices or services installed specifically for this research included:

- new inductive loops for the Peek *ADR-6000*;
- two new equipment cabinets;
- new conduit and wiring for monitoring both southbound and northbound traffic;
- monitoring equipment like charged couple display (CCD) cameras, computers, and classifiers;
- a digital video quad for recording video;
- a weather station; and
- a digital subscriber line (DSL) service for Internet access.

Non-intrusive devices were configured to generate contact closure output for most speed and count measurements. The output was sent to a Peek *ADR-3000* classifier and a local control unit (LCU) for comparison. Without a near-flawless clock on each unit or a means to synchronize clocks, simultaneous comparisons would be almost impossible.

What We Found ...

Peek *ADR-6000* Accuracy

The baseline speed and count device, the Peek *ADR-6000*, is a vehicle classifier that was adapted from a toll application to a roadside application at the outset of this research. Not until Peek ownership changed did the device get the attention it warranted to address the needed changes. Even then, the modification process continued to the very end of this three-year project. There were three reasons why the *ADR-6000* was not eliminated early in the project:

1) TxDOT needed a device to classify vehicles in all traffic conditions, even stop-and-go, and this device demonstrated promise in early tests. Also, there were no known competitors on the market.
2) The research sponsor wanted a device that could simultaneously collect both historical data and real-time data, and Peek claimed from the beginning that the *ADR-6000* could do both.
3) The detection system could measure vehicle counts and speeds with near perfect accuracy. Its occupancy measure was probably accurate as well, but the test site's architecture precluded monitoring this parameter simultaneously with speed and count output. As an example of actual results, in one of several 15-minute datasets examined, the ADR's speed accuracy was within 2 mph 99 percent of the time, and it miscounted four vehicles in this dataset of more than 3000 vehicles. For classification (ignoring classes 1, 2, and 3), the ADR had 15 errors in a dataset of 1923 vehicles.

Non-intrusive Detector Accuracy

The accompanying graph shows a plot of 15-minute vehicle count percent error in lane 1 (farthest from detectors) for each non-intrusive device compared against the baseline system. It shows an indication of count accuracy of the devices as a function of prevailing freeway speeds. During free-flow conditions, all counts were generally within 10 percent of the baseline system. During congested flow conditions, all device count errors in lanes 1 and 2 were high. In this dataset, the sidefire *RTMS* was configured to generate count data directly from contact closure output due to repeated problems with its interface cards.

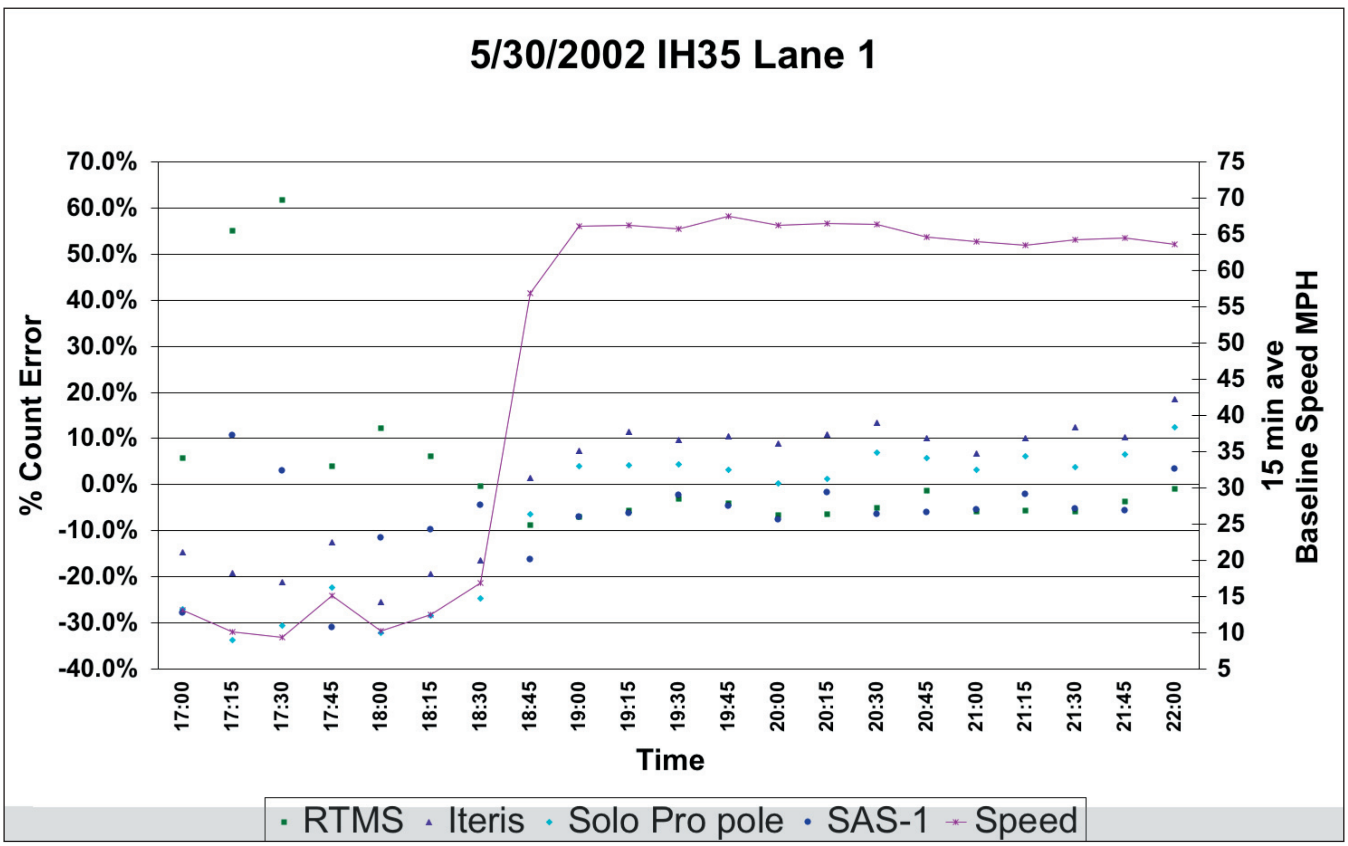
Speed accuracy on the *RTMS* overhead improved significantly over its sidefire orientation. Slow speeds and distance from sensor to detection lane further reduced speed accuracy on sidefire radar, and slow speeds reduced speed accuracy on all detectors except the Autoscope *Solo Pro*. Rain reduced speed accuracy of the *SAS-1* acoustic sensor, but even heavy rain did not affect the *RTMS* or the two video image detectors. Occlusion and traffic congestion reduced count accuracy for all test devices.

Of detectors tested for occupancy, the Autoscope *Solo Pro* had the highest overall accuracy, followed by the Iteris *Vantage* and *SAS-1*. Researchers were unable to accurately compare *RTMS* occupancy with other devices, and the *Iteris* occupancy evaluation was limited. Occupancy error increased for all test detectors during congested traffic conditions.

The Researchers Recommend...

The accuracy of the *ADR-6000* is impressive, but it still needs an improved user-interface and an auto-polling feature, and it needs to be hardened. The Iteris *Vantage* video image detector needs further refinement as well. Problems discovered in this research with the *RTMS* contact closure interface cards are already being addressed.

Based on cost and accuracy, the sidefire *RTMS* and the *SAS-1* are competitive for freeway applications with up to five lanes. However, the most consistently accurate count, speed, and occupancy measurements came from the Autoscope *Solo Pro*. It costs $6,000, whereas the RTMS costs $3,950, the SAS-1 costs $4,500, and the Iteris costs $3,700.



Recommended Utility Accommodation Alternatives.

For More Details . . .

The research is documented in the following report: Report 2119-1, *Vehicle Detector Evaluation*

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TxDOT Implementation Status
June 2003

This research project involved the evaluation of vehicle detection systems, which included the examination of the performance characteristics, reliability, and cost of these technologies. The detection technologies included in this study were video image detection, radar, Doppler microwave, passive acoustic, and a system based on inductive loops. One product was required for this project: a specification for the procurement, installation, testing, validation, verification, calibration, and maintenance of vehicle detection systems and components. The specification is being submitted as an appendix in research Report 2119-1. This functional specification can be used immediately in procurement of two types of new devices: 1) a sophisticated (probably intrusive) vehicle classifier and 2) a non-intrusive detector using a variety of technologies.

The information gathered from this project will also serve as an aid for further research into newer vehicle detection technologies.

For more information, contact Mr. Wade Odell, P.E., RTI Research Engineer, at (512) 465-7403 or email wodell@dot.state.tx.us.

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