DRISI

CALTRANS DIVISION OF RESEARCH, INNOVATION AND SYSTEM INFORMATION

Research Results

TIRTL Evaluation

Comparing the detection accuracy of The Infra-Red Traffic Logger (TIRTL) to inductive loop detectors at a vehicle count station.

Traffic Operations

FEBRUARY 2024

Project Title:
Evaluation of Vehicle Detection Systems Compared to Inductive Loops and Video Ground Truth Using the C1 Reader

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WHAT WAS THE NEED?

The California Department of Transportation (Caltrans) has traditionally used inductive loop detectors for vehicle count stations on freeways, but installation and maintenance of loops requires lane closures that are disruptive to traffic. Caltrans engineers would like the option of using less intrusive types of detection systems in their designs.

Caltrans District 4 has installed two TIRTL (The Infra-Red Traffic Logger, by CEOS Pty Ltd) vehicle detectors at count stations on southbound Interstate 680. These count stations already had functional inductive loop detectors, and the TIRTL devices were installed with their detection zones adjacent to those of the loops. The district requested that Caltrans' Division of Research, Innovation and System information (DRISI) test the detection accuracy of the pilot TIRTL installations against the adjacent loops to determine whether TIRTL detectors could be used effectively instead of loops for future count station installations.

WHAT WAS OUR GOAL?

The goal of this task is a report that quantifies the accuracy, in terms of "sensitivity" (defined later), of a recently installed TIRTL infrared vehicle detection system in District 4 by comparing its detection accuracy to that of existing proximate inductive loop detectors at a vehicle count station using video ground truth.

WHAT DID WE DO?

DRISI installed the "C1 Reader," a signal sampling and data acquisition device developed by DRISI, between the input file and

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the controller in the vehicle count station cabinet located on the southbound (West) side of I-680 in Walnut Creek at the South Main Street exit and on ramps. The C1 Reader recorded timestamps for each passing vehicle from the outputs of both the TIRTL detectors and the inductive loop detectors. DRISI focused Caltrans' on-site surveillance camera on the loops and the TIRTL detection zone. Video was recorded on a digital video recorder (DVR) concurrently with the detector output data. Approximately one week of C1 data and video were collected from August 9th to August 16th, 2023.

DRISI then analyzed the captured C1 detection data and video using "VideoSync" software developed by DRISI. VideoSync displays "ground-truth" video alongside a graphical representation of the output signals from detectors, which were TIRTL and loops in this case. VideoSync includes a pattern recognition algorithm that looks at the spacing of vehicles in platoons and matches them to corresponding detection signals with like spacing. Once the detection output signals and video are synchronized, erroneous detections, i.e., "false positives" and missed detections, i.e., "false negatives," are readily visible.

DRISI analyzed data from the most congested hour: Wednesday, August 9th, from 5 to 6 PM. DRISI thought that this period would be the most challenging for the TIRTL, since the more congestion, the more chance for vehicles being occluded by others in front of, or behind them. The analysis of the congested hour included a total of 11,196 individual vehicles. DRISI defines the degree of accuracy of a vehicle detector as its "Sensitivity," where:

$$\text{Sensitivity} = \frac{\text{True Positive}}{\text{False Positive + False Negative + True Positive}} \times 100.0$$

According to this definition, the detector is penalized equally and cumulatively for each false positive and false negative. The more of either, the lower the Sensitivity. If there are none of either, the Sensitivity equals 100%.

WHAT WAS THE OUTCOME?

The overall Sensitivity of the inductive loops was slightly higher than that of the TIRTL, but the difference was only 0.37%. This difference is much lower than that of microwave radar and machine vision detectors that DRISI has tested in the past, which typically have Sensitivity values from about 3% to 7% lower than loops. The only other detection system that DRISI has tested with Sensitivity values as close to that of loops is the wireless magnetometers from Sensys Networks, which require lane closures for all lanes in which they are installed, although the procedure is typically significantly faster per lane than that of loop installation.

WHAT IS THE BENEFIT?

This study provides Caltrans districts with a quantified account of the accuracy of TIRTL vehicle detection systems relative to inductive loops. District electrical design engineers now have justification, based on the performance demonstrated by this research task, to specify this system in their designs. Caltrans now has an option for out-of-pavement detection to replace inductive loop detectors for vehicle count stations that is almost as accurate as loops.

IMAGES

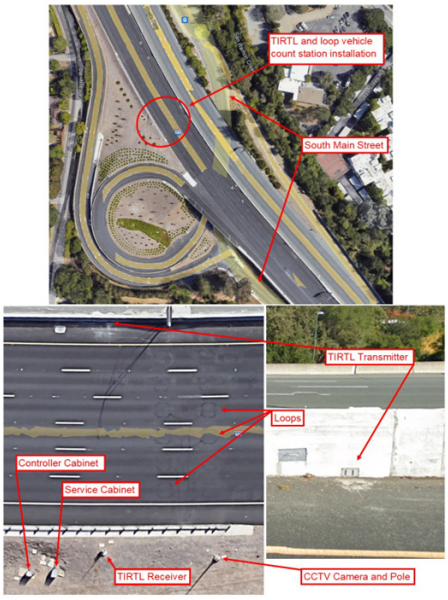

Image 1: South Main Street count station site (aerial view)

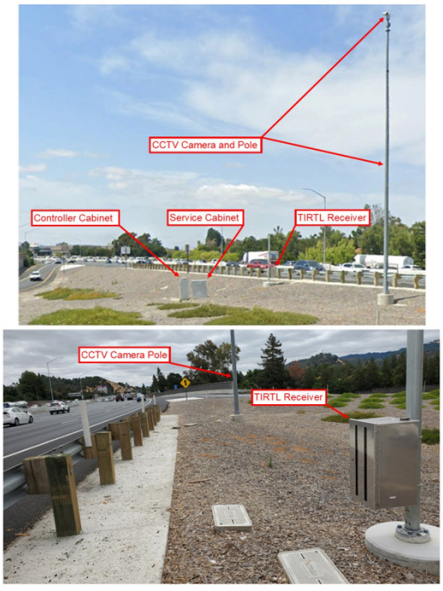

Image 2: South Main Street count station site (side view)

Image 3: Video and graphical display of corresponding detection signals in VideoSync

Detection Zone	Loops	TIRTL	Difference
All lanes combined	99.54%	99.17%	0.37%
Lane 1 upstream	96.03%	99.34%	-3.31%
Lane 1 downstream	99.83%	99.34%	0.49%
Lane 2 upstream	99.94%	99.49%	0.45%
Lane 2 downstream	98.80%	99.55%	-0.75%
Lane 3 upstream	100.00%	99.20%	0.70%
Lane 3 downstream	99.92%	99.20%	0.72%
Lane 4 upstream	100.00%	98.74%	1.26%
Lane 4 downstream	100.00%	98.74%	1.26%
Lane 5 upstream	100.00%	98.52%	1.48%
Lane 5 downstream	100.00%	98.52%	1.48%
Lane 6 upstream	99.43%	99.61%	-0.18%
Lane 6 downstream	99.62%	99.61%	0.01%

Image 4: Detector Sensitivity

Detection Zone	False Positives		False Negatives	
	Loops	TIRTL	Loops	TIRTL
All lanes combined	48	8	4	85
Lane 1 upstream	24	0	1	4
Lane 1 downstream	0	0	1	4
Lane 2 upstream	0	0	1	8
Lane 2 downstream	18	0	1	7
Lane 3 upstream	0	1	0	9
Lane 3 downstream	1	1	0	9
Lane 4 upstream	0	2	0	10
Lane 4 downstream	0	2	0	10
Lane 5 upstream	0	1	0	10
Lane 5 downstream	0	1	0	10
Lane 6 upstream	3	0	0	2
Lane 6 downstream	2	0	0	2

Image 5: False Positives and Negatives

Detection Zone	True Number of Vehicles	Vehicles Counted by Loops	Percent Difference	Vehicles Counted by TIRTL	Percent Difference
All lanes combined	11,196	11,240	+0.393	11,119	-0.688
Lane 1 upstream	606	629	+3.795	602	-0.660
Lane 1 downstream	606	605	-0.165	602	-0.660
Lane 2 upstream	1,561	1,560	-0.064	1,553	-0.512
Lane 2 downstream	1,561	1,578	+1.089	1,554	-0.448
Lane 3 upstream	1,252	1,252	0.00	1,244	-0.639
Lane 3 downstream	1,252	1,252	0.00	1,244	-0.639
Lane 4 upstream	919	919	0.00	911	-0.871
Lane 4 downstream	919	919	0.00	911	-0.871
Lane 5 upstream	741	741	0.00	732	-1.215
Lane 5 downstream	741	741	0.00	732	-1.215
Lane 6 upstream	519	522	+0.578	517	-0.385
Lane 6 downstream	519	521	+0.385	517	-0.385

Image 6: Differences in Vehicles Counted