Technical Report Documentation Page

1. Report No. TX-98/2900-S	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle STATUS REPORT ON OPERATIONS FROM SEPTEMBER 1996 TO AUGUST 1997: FINAL REPORT		5. Report Date September 1997
		6. Performing Organization Code
7. Author(s) Gene P. Ritch and David W. Fenno		8. Performing Organization Report No. Research Report 2900-S
9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. Study No. 7-2900
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Office P. O. Box 5080 Austin, Texas 78763-5080		13. Type of Report and Period Covered Project Summary: September 1996 to August 1997
		14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with the Texas Department of Transportation.
Research Study Title: Interim Traffic Monitoring System on U.S. 59 (Eastex) Freeway Using Alternative Sensor Technologies

16. Abstract

Four alternative (to loop detection) sensor types were tested in freeway construction areas in Houston. The Whelen Doppler radar units, once attuned to the local conditions, appear to render acceptable speed measures. The side fire microwave ranging sensor (RTMS from EIS) appears to be very suspectable to creating multiple reflections when exposed to hard vertical surfaces (as found in concrete median barriers, abbreviated as CMB). The TraffiCam is a visual imaging device known primarily as an inexpensive, publicly available VIVDS product. Based on the performance of the unit tested, the software and hardware requires substantial improvements before utilization as an acceptable freeway alternative detector. The SmartSonic sensors were installed in an advantageous position for passive monitoring of two lanes of traffic, one sensor per lane. The short-term test indicated that occlusion occurs in sonic as well as VIVDS devices. The Sonic sensor would work best when positioned directly over the lane. The many calibration parameters and expansive range limits may confuse the operator before acceptable volume and speed measures for three length vehicle classes.

17. Key Words Doppler Radar, Ranging Microwave, Smart Sonic and Visual Imaging Sensors–Short-Term Tests	18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service 5285 Port Royal Road Springfield, Virginia 22161

19. Security Classif.(of this report) Unclassified	20. Security Classif.(of this page) Unclassified	21. No. of Pages 56	22. Price

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

STATUS REPORT ON OPERATIONS FROM SEPTEMBER 1996 TO AUGUST 1997: FINAL REPORT

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Research Report 2900-S
Research Study Number 7-2900
Research Study Title: Interim Traffic Monitoring System on U.S. 59 (Eastex) Freeway Using Alternative Sensor Technologies

Sponsored by the
Texas Department of Transportation

September 1997

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IMPLEMENTATION STATEMENT

The Whelen radar product has demonstrated long-term speed detection proficiency when applied to two and three lane sections. The problem with "ghost" vehicles proved solvable and successfully so by Whelen. If the general group speeds of a traffic stream are sufficient, the Whelen radar unit can provide a consistent speed measure (which may be plus/minus of the true vehicular speed) over time.

The RTMS units under the physical conditions applied in this test appears to be susceptible to vertical appendages within the detection zones, which creates multiple microwave reflections and overwhelms the processing software. The more successful application using the RTMS unit happens with the nearest three lanes.

The TraffiCam visual imaging sensor does not provide acceptable detection when the sensor installation is not directly over the lane to be detected. No tests were conducted with TraffiCam directly over the detected lanes. Testing revealed that lighting contrast extremes cannot be solved by the present equipment and software. To date, Rockwell has made no move to solve any of these problems. Rockwell sold the technology to Odetics which already has a VIVDS product. The TraffiCam future is unknown.

International Road Dynamics (IRD) Corporation purchased the sonic sensor technology from American Telephone and Telegraph Corporation. The sonic sensor testing did not provide the sensors directly over the lane. Minimal testing indicated the sonic sensor's susceptibility to experience occlusion (top of a large vehicle entering into the next lane zone). The testing yielded inconclusive operations, however, IRD continues to improve the sensor detection software.

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The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Texas Department of Transportation (TxDOT). This report does not constitute a standard, specification, or regulation. It is not intended for construction, bidding, or permit purposes.

ACKNOWLEDGMENT

This report was developed as part of study 7-2900 "Interim Traffic Monitoring System on U.S. 59 (Eastex) Freeway Using Alternative Sensor Technologies" conducted by the Texas Transportation Institute (TTI) and sponsored by the Texas Department of Transportation (TxDOT). The TxDOT staff at the TranStar Center is given appreciation in assisting the TraffiCam testing on I-45 and North Main.

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SUMMARY

The Whelen Doppler radar unit represented the easiest sensor tested to physically install and operate. An aiming device on the sensor head would help. For applications where normal electrical service is difficult to obtain, the radar sensor can operate from solar powered rechargeable gel cell batteries. The drawbacks are speed measures are not indicated by vehicle; speeds only register down to 8 km/h (then zero registered), and accuracy is limited to 8 km/h. The RTMS unit requires minimum vertical abutments that reside perpendicular to the microwave pathway. The sensor must be installed at the required height above the roadway and distance from the nearest traveled lane. Determining the location of each lane detection zone requires patience. Only three lanes in one direction and two lanes in the other direction were tested. Detection at the extreme limit of the sensor produces minimal results. The SmartSonic sensor contains many parameters for calibration which may become confusing. The sensor yields the best service when placed directly above the lanes at the suggested height. The TraffiCam video imaging sensor provided better detection results for approaching traffic than receding traffic, but was unacceptable as a freeway volume detection device. Iris control and its effects on detection accuracy appeared to be a problem. The sensor technology was sold to another manufacturer which already has a video imaging product.

WHELEN DOPPLER RADAR UNITS

The Whelen Doppler radar units (Tracker Models) were initially installed in pairs at three sites (Sparks, East Mount Houston, and Aldine Bender) on the U.S. 59 (Eastex) Freeway (Figure 1). Due to the freeway construction progression, the Aldine Bender site required dismantling and relocation. The Beltway 8 cantilever sign was targeted as the replacement site of the Whelen units (see SmartSonic). The cantilever sign mounting added height and somewhat closer alignment to the speed detector's vehicular movement (Appendix A). A problem developed in supplying power to the units. In the previous installations, the cable connecting the sensor head to the power supply was less than 6.1 m. At the Beltway 8 cantilever sign site, the power supply had to reside in the roadside cabinet installed on a wooden pole at the right-of-way (ROW) boundary. The horizontal distance between the wooden pole and the cantilever sign support column is slightly greater than 20 m. The cantilever sign support is installed 3 m from the inside lane curb and the retaining wall of the freeway. The top of the wooden pole extends 9.75 m above ground level. A small enclosed all-weather termination box was installed on a truss member of the cantilever sign. To connect the direct current (DC) power supply in the cabinet (where AC power is available) to the all-weather termination box required a continuous multi-conductor cable of 29 m. Based on Whelen's specifications and recommendations, an 18 gauge wire should provide ample current carrying capabilities. A bucket truck reaching to 17 m was required to install the sensors on the cantilever sign supports and rig the multi-conductor cable and span cable across the frontage road. While the bucket truck was on site, the continuity of each wire pair was tested. At a later date, a 13.5 volt direct current (VDC) power supply was installed in the roadside cabinet. When the bucket truck was called out for another trial run, the Whelen sensors were installed, connected to the assigned wire pairs, and placed into operation. The sensors, however, did not function properly. Discussions with Whelen representatives (via mobile telephone) yielded two possible solutions: 1) obtain 13.5 VDC power supply that supplied more current; or 2) use two or more wire pairs to deliver the DC voltage to the sensors. Whelen offered the explanation that a relatively large instantaneous current surge is required when the sensor switches on to transmit the radar signal. Receiving the returning wave pattern does not require as much instantaneous current. Because of the expense to rent the 17 m bucket truck and the fact that the contractor had to reorganize his company (ex-partner retained the 17 m bucket truck), the testing of the Whelen Doppler radar units

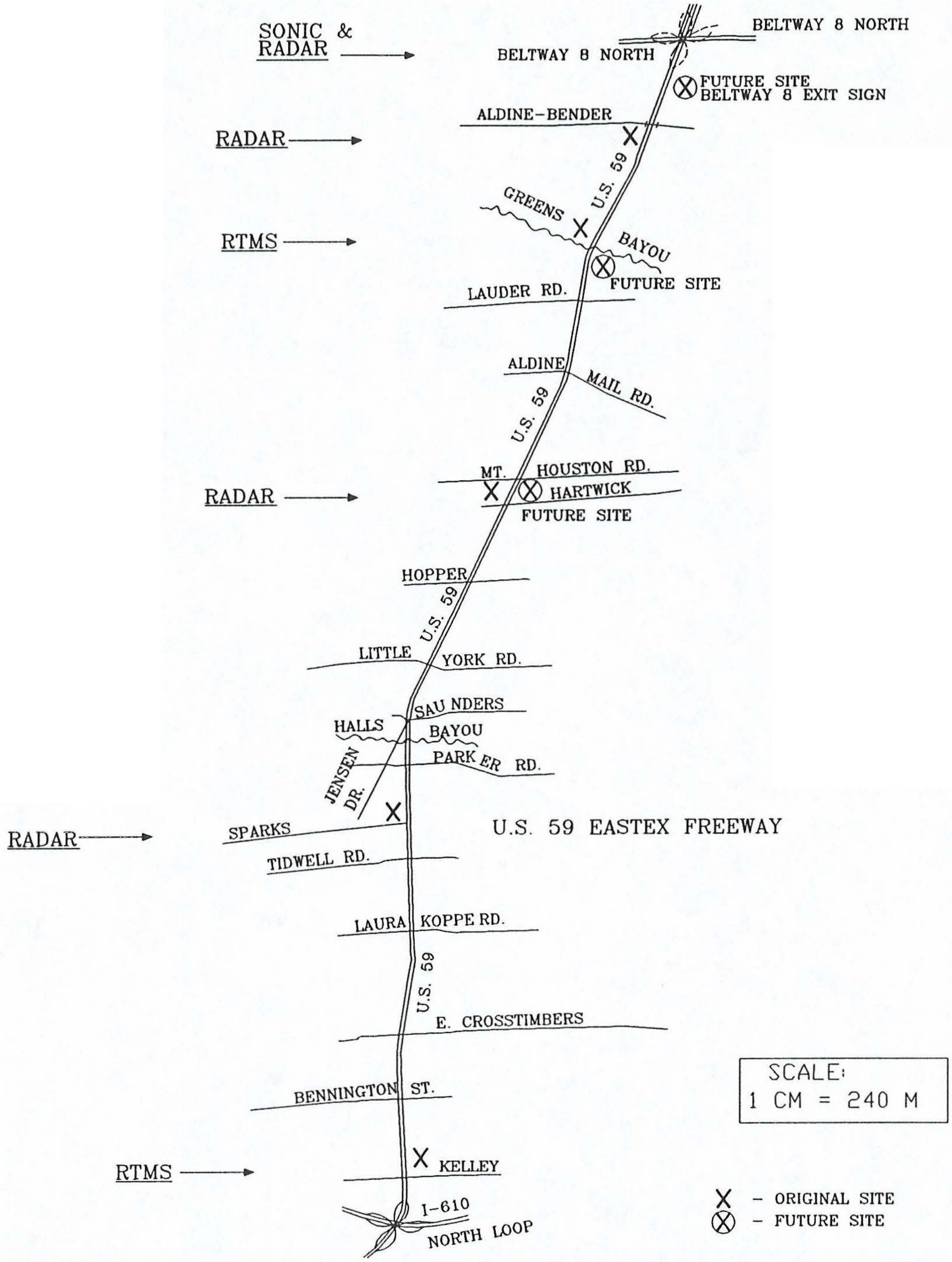

Figure 1. Initial and Final Detection Sites on U.S. 59 (Eastex) Freeway in Houston, Texas

along with the SmartSonic sensors remained unaccomplished. The purpose of the installation of the Whelen units on the cantilever sign was primarily to compare Sonic speeds to Whelen speeds. The lack of Whelen unit installation, however, did not prevent Sonic testing.

The completion of local freeway construction segments nearby required the East Mount Houston Whelen sensor site to be relocated. An excellent location existed two blocks south and on the outbound (east) freeway side. A high mast lighting standard installation required extensive upstream guard fence construction to protect the site. The sensor's wooden pole was installed next to the guard fence and upstream of the light. The solar panel, Whelen sensors, and the communications cabinet were installed on this pole. Dual 12 VDC gel cell batteries were used in the communications cabinet as used earlier at the East Mount Houston location. The sensors were connected to the multiplexor and the radio frequency (RF) modem. At the intersection of the northbound Eastex Freeway frontage road and Hartwick, a wooden pole was installed at the ROW boundary. The previously used cabinet was reinstalled with AC power and the telephone line. Into this cabinet were placed the PC, telephone modem, and RF modem. When the AC power was connected, everything worked just as it had before. Vandals cut about 1.2 m of the weaved naked copper cable that connected the lightning rod to the earth ground rod. The replacement copper cable was installed inside conduit for the last 3 m at the ground end. No further vandalism occurred at this location.

Two events occurred that affected the operations at this site. The first event requiring special processing was the change of telephone area codes for several of the sites from 713 to 281. The local PC and the master computer needed revised dialing sequences which, when implemented, worked just fine. The second item dealt with total failure of both gel cell batteries at the same time at this site only. At first, a lightning strike was thought to have caused the problem, however, none of electronics in the radar units, RF modem, or multiplexor were damaged. The energy recycling of the storage batteries must have caused the failures as both units indicated direct shorts. Processing at several sites halted due to low battery energy that occurred after a week to 10 days of heavy overcast weather. Only twice had this battery pair gone down. The battery set used at Aldine Bender was installed at Hartwick. After one week of solar panel charging without any energy use, the complete system was started and ran without failure(s). The damaged batteries were delivered to TxDOT which, in turn, transferred the units to a contracted recycling service company.

The third Whelen radar site was located on the southbound (inbound) Eastex Freeway side at the intersection of the frontage road and Sparks Street. The ROW pole was installed with nearby AC and telephone service available and implemented. The PC telephone modem and RF modem were installed inside the pole mounted cabinet. The sensor pole installed on a nearby embankment contained its radar units, multiplexor, solar panels, dual batteries, and RF modem. The installation site initially installed where only new pavement sections resided did not require traffic lane changes throughout the project's term. This site functioned throughout the study in a generally positive manner. The Whelen radar units maintained calibrations for a year without a maintenance service call.

SERVICE CALIBRATION

The Sparks and Hartwick Whelen radar sites were tested by comparing speeds: 1) taken with a laser gun; and 2) recorded by the Whelen radar unit. Since the Whelen unit measures by Doppler radar techniques, selecting large trucks simplified which vehicle to choose. Also, individual vehicles that clearly would be the only possible vehicle to pass through the detection zone at the point in time that both the laser and the radar units both recorded. To accomplish the dual speed recording in one direction at the time required one observer at the roadside that could clearly see vehicles in all lanes that could target a large truck or singular vehicle. The laser unit requires singular vehicle tracking (approaching or receding) for at least two seconds before registering the speed via an LED readout. The first observer would radio out (via low powered CB frequency) the registered vehicle's speed. The second observer resides in a project vehicle (minivan) with the second CB radio and the PC that normally resides in the cabinet. The AC power and sensor lead in are connected to the PC along with a video monitor. With this setup, the second observer is watching the video screen which registers each speed measured by the Whelen radar. The second observer records the speed reading sent by the field observer via CB radio and then records the next Whelen registered speed as shown on the video monitor. The field observer takes the vehicle's speed as close to the detection zone as practical. Being inside the van muffles the freeway noise, enabling the second observer to hear the RF transmission. While this process is tedious, it insures correctly matching speeds measuring independently by two devices on the same vehicle.

Appendix B contains samples of speed comparisons at both Sparks and Hartwick. The equipment at both sites has operated for over two years. Except for a bent horn in one of the radar units (which was repaired at the factory without service charge) and the "ghost vehicle" problem (revised software which disabled opposite direction vehicles being detected primarily due to hard vertical surfaces causing reflections), the software and hardware worked. Only one direction at Sparks had not had the processor chip exchanged. As shown, the accuracy improved once the processor chip was changed.

For applications where: 1) the sensor can be placed near and above the roadway; 2) only speeds to be measured can be the fastest and largest vehicle; and 3) not all vehicle speeds will be measured, the Whelen Doppler radar product can be used.

REMOTE TRAFFIC MICROWAVE SENSOR

Two study sites (Greens Bayou and Kelley) had the Remote Traffic Microwave Sensor (RTMS) installed. The Greens Bayou initial location had to be removed and reinstalled on the opposite side of the freeway because of construction completion activities. The initial site had several disadvantages including uneven ground, vertical abutments, and narrow lanes (1). The second site presented a much cleaner detection area as the installed roadside pole resided at grade with the mainlanes. Only two concrete median barriers (CMBs) were in the detection areas and each lane was 3.3 to 3.6 m wide. While some performance measures were collected at the second site, final testing was prohibited by the theft of the PC and modem at the site (1).

On Halloween night, November 1, 1996 at 12:22 a.m., the cabinet door handle was broken and the door forced open. The PC and telephone modem were disconnected and orderly removed from the cabinet. A four outlet power strip was also broken due to attempts to remove it. The exact time and date were available at the central computer due to minute by minute data collection activities for all study sites on Eastex Freeway. Since the site is outside Houston city limits, the Harris County Sheriff's Department was contacted and a theft report filed. Serial numbers for all stolen property were passed along but no report back from Harris County has been received. As a precaution, each field cabinet was visited and warnings were written on the outside of the cabinet as well as posting information on each PC, telephone modem, RF modem, etc. With the exception of gang graffiti at Sparks ROW cabinet, no other gang or vandalism activities occurred during the study period. The cabinet lock and handle were repaired.

The Kelley site for the RTMS equipment installation did not change in the detection area of interest during the study period. This site required considerable time to set up due to the opposite directional freeway lanes being 62 m away with construction activities in between. At this distance, the only vehicles detected were large trucks. The nearby lanes were within the suggested vendor's distances (Appendix B). As such, only the near lanes were studied.

Evaluation of operation of RTMS devices over the study period provided the advantage and disadvantage items shown in Table 1. Some of the listed items may be unique to the microwave detection algorithms, but remain most difficult to work around especially if the equipment must match the Texas Department of Transportation's (TxDOT) master surveillance, communications, and control (SC&C) plan.

Table 1. RTMS Pros and Cons
Problem Areas
Blips on screen <u>are not directional</u>.
CMBs may cause "ghost" vehicles to show and be counted.
Setting TOD very difficult–hit and miss.
Turning unit off 90 °F seemed to help but no quantitative measures to compare.
There is no aiming fixture to assist in setting up the detection zone(s).
Individual vehicular performance values are not always available.
Positive Features
RTMS user manual quite thorough.
Having all intelligence in sensor head is both plus and minus.

Typical volume counting performance as shown in Table 2 indicates that the vendor's advertised volume accuracy of plus or minus 5 percent may be reasonable (Appendix C). The comparisons of vehicle speeds were somewhat hampered by the fact that the RTMS device does not identify individual vehicles. The unit provides a time interval where all vehicles within this time period are averaged including volume, lane occupancy, and speed. The field person would target the vehicle approximately two to five seconds before the RTMS detection zone. If a platoon of vehicles were traveling at approximately the same speed, only one vehicle would be identified and the speed passed along to the second observer. The second observer recorded the speed and number of vehicles from the CB radio call along with the average speed output value for the time period. The reason for more inside lane data (towards center of roadway) than the outside lane had to do with determining if vehicular occlusion was occurring due to large trucks in the outer lanes. Many attempts were exercised but since individual speeds were not possible during most of the daylight hours, no acceptable occlusion test was applicable. The speed tables (Table 3) by lane for the RTMS study confirms the limits stated by EIS.

Table 2. RTMS Volume Comparison Test Results for Lanes 1, 2, and 3

VOLUME COUNT

LOCATION: RTMS (Remote Traffic Microwave Sensor) @ KELLEY

DATE: 8/8/97

DONE BY: Gene Ritch and Curt Hamilton

Count of Vehicles Traveling Northbound on the Eastex Freeway Mainlanes.

Minute Intervals	Inside Lane		Middle Lane		Outside Lane	
	Manual Count	Computer Count	Manual Count	Computer Count	Manual Count	Computer Count
	Int.	Int.	Int.	Int.	Int.	Int.
1	21	19	29	34	27	25
2	28	26	21	24	20	24
3	11	11	28	30	22	22
4	17	17	29	26	25	22
5	26	26	24	25	31	30
6	16	15	27	21	17	20
7	31	30	11	17	24	22
8	27	26	22	23	----	----
9	----	----	25	27	----	----
10	----	----	25	24	----	----
Totals	177	170	241	251	166	165
	Cum. Difference = 177-170 = 7		Cum. Difference = 241-251 = -10		Cum. Difference = 166-165 = 1	
	Cum. Percent Difference = 4.1%		Cum. Percent Difference = -4.0%		Cum. Percent Difference = 0.6%	
	Cum. Percent Accuracy = 95.9%		Cum. Percent Accuracy = 96.0%		Cum. Percent Accuracy = 99.4%	

TOTAL FOR ALL THREE LANES	
Manual Count	584
Computer Count	586
Cum. Difference	-2
Cum. Percent Difference	-0.3%
Cum. Percent Accuracy	99.7%

Table 3. RTMS Speed Comparison Test Results for Lanes 1, 2, and 3

LOCATION: RTMS (Remote Traffic Microwave Sensor) on EASTEX @ KELLEY
DATE: 8/8/1997
DONE BY: Gene Ritch and Curt Hamilton

This test was to check the accuracy of the speed recorded from the RTMS reading.
The program used provides a choice between a 10 second to 100 minute interval of data collection of vehicles. The following data was collected in 10 second intervals. The program collects the speed and volume of each vehicle in the 10 second interval and calculates the number of vehicles and average speed for the 10 second interval.

Speed of Vehicles Traveling Northbound on the Eastex Freeway Mainlanes in the Outside Lane (Lane 1).

10 Second Interval	Speeds Recorded from the Laser (mph)								# of Laser Speeds	RTMS Volume Count	Volume Difference (RTMS - Laser)	Laser Avg. Spd. (mph)	RTMS Speed (mph)	Absolute Speed Difference	Absolute Percent Difference
1	45	49	50	51					4	5	1	48.8	49	0.3	0.5%
2	49	63							2	3	1	56.0	48	8.0	14.3%
3	57	46	47	54	56				5	5	0	52.0	43	9.0	17.3%
4	50	49							2	3	1	49.5	49	0.5	1.0%
5	63	53	55	55					4	5	1	56.5	42	14.5	25.7%
6	56	56	66	63	63				5	5	0	60.8	66	5.2	8.6%
7	57	54	62	56					4	4	0	57.3	53	4.3	7.4%

Mean =	6.0
Average of Absolute Deviation =	3.9
Standard Deviation =	5.0

Speed of Vehicles Traveling Northbound on the Eastex Freeway Mainlanes in the Middle Lane (Lane 2).

10 Second Interval	Speeds Recorded from the Laser (mph)								# of Laser Speeds	RTMS Volume Count	Volume Difference (RTMS - Laser)	Laser Avg. Spd. (mph)	RTMS Speed (mph)	Absolute Speed Difference	Absolute Percent Difference
1	54	62	66	56	58				5	6	1	59.2	56	3.2	5.4%
2	58	64	62	57					4	5	1	60.3	36	24.3	40.2%
3	62	59	59						3	2	-1	60.0	67	7.0	11.7%
4	67	68	63						3	3	0	66.0	61	5.0	7.6%
5	56	58							2	4	2	57.0	53	4.0	7.0%
6	57	61							2	2	0	59.0	49	10.0	16.9%
7	61	59							2	2	0	60.0	60	0.0	0.0%
8	61	57	60						3	3	0	59.3	65	5.7	9.6%
9	59	56	61	73	63				5	5	0	62.4	59	3.4	5.4%
10	50	50	52	54	52				5	6	1	51.6	52	0.4	0.8%
11	69	68	57	57	57				5	6	1	61.6	57	4.6	7.5%
12	62	54	53	58					4	7	3	56.8	50	6.8	11.9%
13	55	55	55	55	54	57	59	55	8	8	0	55.6	48	7.6	13.7%
14	53	60	73						3	3	0	62.0	60	2.0	3.2%
15	71	61	63	61	63				5	6	1	63.8	61	2.8	4.4%
16	59	65	52	56	59	60	60		7	8	1	58.7	68	9.3	15.8%
17	54	58	58	60	60	63	59		7	8	1	58.9	60	1.1	1.9%
18	64	57	52						3	3	0	57.7	46	11.7	20.2%
19	61	65	57	65	68				5	5	0	63.2	64	0.8	1.3%
20	56	68	54						3	3	0	59.3	65	5.7	9.6%

Mean =	4.8
Average of Absolute Deviation =	3.5
Standard Deviation =	4.3

Table 3. RTMS Speed Comparison Test Results for Lanes 1, 2, and 3

LOCATION: RTMS (Remote Traffic Microwave Sensor) on EASTEX @ KELLEY
DATE: 8/8/1997
DONE BY: Gene Ritch and Curt Hamilton

Speed of Vehicles Traveling Northbound on the Eastex Freeway Mainlanes in the Inside Lane (Lane 3).

10 Second Interval	Speeds Recorded from the Laser (mph)								# of Laser Speeds	RTMS Volume Count	Volume Difference (RTMS - Laser)	Laser Avg. Spd. (mph)	RTMS Speed (mph)	Absolute Speed Difference	Absolute Percent Difference
1	66	60	60						3	3	0	62.0	60	2.0	3.2%
2	60	63	63	66					4	4	0	63.0	61	2.0	3.2%
3	67	67	57	68					4	4	0	64.8	53	11.8	18.1%
4	62	61	63	61					4	3	-1	61.8	61	0.8	1.2%
5	58	55	58	55	55				5	5	0	56.2	55	1.2	2.1%
6	67	61							2	2	0	64.0	60	4.0	6.3%
7	63	62	67	68					4	4	0	65.0	61	4.0	6.2%
8	62	62	64	62					4	4	0	62.5	61	1.5	2.4%
9	68	65							2	4	2	66.5	63	3.5	5.3%
10	66	68	83						3	3	0	72.3	54	18.3	25.3%
11	66	70	62						3	4	1	66.0	60	6.0	9.1%
12	60	64	65	68	67				5	6	1	64.8	57	7.8	12.0%
13	62	62	62	63	63	66	64		7	7	0	63.1	64	0.9	1.4%
14	64	64	66						3	3	0	64.7	60	4.7	7.2%
15	62	55	57	61	61				5	5	0	59.2	60	0.8	1.4%
16	61	60	60	64	63	63	61	62	8	9	1	61.8	63	1.3	2.0%
17	56	56	56						3	3	0	56.0	53	3.0	5.4%
18	63	56	53	55	55	53			6	6	0	55.8	47	8.8	15.8%
19	66	63	63						3	3	0	64.0	51	13.0	20.3%
20	57	61	61	65					4	4	0	61.0	49	12.0	19.7%
21	67	67	70	68					4	4	0	68.0	57	11.0	16.2%
22	66	63	63						3	2	-1	64.0	53	11.0	17.2%
23	63	63	62	62	61				5	4	-1	62.2	58	4.2	6.8%
24	72	64	64						3	3	0	66.7	70	3.3	5.0%
25	64	66	64	63	63	62			6	7	1	63.7	60	3.7	5.8%
26	64	64	71	71					4	5	1	67.5	64	3.5	5.2%
27	66	66	66	61	61				5	5	0	64.0	60	4.0	6.3%
28	64	67	65	64					4	4	0	65.0	66	1.0	1.5%
29	56	56	54	58	58	54			6	7	1	56.0	67	11.0	19.6%
30	55	53	53	53	54				5	6	1	53.6	49	4.6	8.6%
31	42	42	42	42	39				5	5	0	41.4	41	0.4	1.0%
32	40	40	49	49	46				5	3	-2	44.8	46	1.2	2.7%
33	45	45	45	44	45				5	6	1	44.8	42	2.8	6.2%
34	39	39	37	37	40				5	7	2	38.4	47	8.6	22.4%
35	42	42	35	35					4	4	0	38.5	37	1.5	3.9%
36	44	44	40	39	39				5	5	0	41.2	37	4.2	10.2%
37	43	43	44	44					4	4	0	43.5	38	5.5	12.6%
38	56	56	53						3	3	0	55.0	55	0.0	0.0%
39	57	57	57	53					4	4	0	56.0	51	5.0	8.9%
40	52	54	62	62	62				5	5	0	58.4	55	3.4	5.8%

Mean =	4.9
Average of Absolute Deviation =	3.3
Standard Deviation =	4.3

SMARTSONIC SENSORS

The SmartSonic sensors were added to the test list of alternative sensor devices after the study start. At the close of the 1995-96 study period, the sonic equipment was just being placed into operation. The project programmer resigned in October and another person was assigned the software development tasks. The programming tasks were: 1) to enable the Sonic unit to communicate with a PC where the Sonic unit would be calibrated to local conditions; 2) to merge the data collection activities of the Sonic and radar units so that both sensors could store data in the field PC; and 3) to provide communications between the Beltway 8 exit site PC and the central PC so that timely reportings from the field PC could be stored on the central PC. Electrical power aberrations caused problems in that the Sonic unit would not reinitiate communications. Likewise, PC hardware problems prohibited reaching software operation (i.e., an input/output card developed intermittent communications errors; the telephone modem likewise developed hardware errors only in the field site's harsh environment and the field environment may have caused substandard operation performance within the PC unknown and unshown in the normal operation range). Experiencing the testing made it very difficult to feel positive about the performance of the sensor. Because the sensors were placed offset from the lanes to be tested (as opposed to directly above the lane in question), the influence of lane changes and occlusion may have complicated the calibration process. The 23 parameters (some by lane) and various range limits presented a challenge to calibrate each vehicle type to the appropriate speed range.

A positive aspect of the SmartSonic sensor is that there appears to be enough typical minute by minute variations (as shown in Table 4) of over and under counting that longer time period traffic counts will settle around an accuracy range. The manufacturer's documentation does not cover the performance standards. While the volume data appears to provide dependable measures, speed calculations were non-calibrative. Of the speed tests attempted, when the regular size automobile's Sonic speed measured in the same range as the laser unit, the tractor trailer speed measure would be well above the laser collected speed. The reverse was also true. When the tractor trailer speed was in the near laser range, the normal automobile's speed would be much lower than laser measures. The manufacturer has worked on software solutions as indicative of the revised processing chip. The presence of the CMB near the travel lanes may have created multiple reflections not experienced by the manufacturer in pre-release testing.

Table 4. SmartSonic's Typical Volume Comparisons

VOLUME COUNT

LOCATION: SMARTSONIC TSS-1 SENSOR @ BELTWAY 8

DATE: 8/11/97

DONE BY: Gene Ritch and Curt Hamilton

Count of Vehicles Traveling Northbound on the Eastex Freeway Mainlanes in the Inside and Outside Lanes.

	Inside Lane		Outside Lane	
Minute	Manual Count	Computer Count	Manual Count	Computer Count
Intervals	Int.	Int.	Int.	Int.
1	17	17	16	14
2	27	25	22	16
3	14	13	6	17
4	24	20	13	17
5	23	27	13	15
6	19	18	17	18
7	24	21	12	15
8	21	22	14	15
9	19	17	13	10
10	27	31	12	10
11	21	19	12	11
12	22	24	10	8
13	20	18	22	17
14	22	23	----	----
15	13	15	----	----
16	19	21	----	----
TOTALS	332	331	182	183
	Cum. Difference = 332-331 = 1		Cum. Difference = 182-183 = -1	
	Cum. Percent Difference = 0.3%		Cum. Percent Difference = -0.5%	
	Cum. Percent Accuracy = 99.7%		Cum. Percent Accuracy = 99.5%	

TOTAL FOR BOTH LANES	
Manual Count	514
Computer Count	514
Cum. Difference	0
Cum. Percent Difference	0%
Cum. Percent Accuracy	100%

ROCKWELL'S TRAFFICAM SENSOR

TTI conducted an evaluation of the TraffiCam sensor in project year 1996-97. This operational test evaluated the accuracy of the sensor with respect to detecting approaching traffic. The TxDOT requirement for the acceptance of VIVDS products states that the unit must count vehicles at a 95 percent level of accuracy or greater. Testing of the TraffiCam unit with approaching traffic demonstrated that the unit met the TxDOT requirement only 10 percent of the time (1). These tests were conducted during the AM peak period, PM peak period, and at nighttime. The results of these tests were based on 76 comparisons of TraffiCam counts versus manual counts from video of the site.

In June 1997, the sensor was repositioned to evaluate its performance with respect to detecting receding traffic. Vendor representatives stated that the performance of the unit would be degraded when detecting receding traffic in comparison with approaching traffic. This degradation of performance was reported to be significantly higher at night when the unit relies on detecting vehicle tail lights, which are much less intense than vehicle headlights.

The inability of the sensor to compensate for shadows within the field of view contributed to the high error rates experienced during the evaluation of approaching traffic. These shadows resulted from several roadside elements, including an overpass, a retaining wall (site in a depressed freeway section), inside lane median barrier, and vehicles traveling through the section. During testing of receding traffic, however, shadows due to the overpass and retaining wall were eliminated from the field of view. Although shadows from the median barrier were still present during portions of the day, these shadows were limited to the inside lane, whereas all lanes were effected by shadows from the overpass and retaining wall in the approaching view.

Changing the view of the sensor required the creation of new detector zones. Data collection and analysis at this time allowed minor modifications of detector zones in an effort to optimize the performance of the sensor. In July and August, data were collected to evaluate the accuracy of the system in an environment of receding traffic. The results of comparisons between manual volume counts and TraffiCam counts confirmed vendor statements of degraded performance in detecting receding traffic.

Table 5 presents a typical six minute sample of data recorded by the TraffiCam sensor along with corresponding manual counts. Data collection took place between 10:30 a.m. and 12:00 p.m. under dry conditions and high contrast lighting. The selection of this time period reduced the effect of shadows as a potential error source, as no shadows from the median barrier infringed upon lane 1 during this time of day. Furthermore, vehicular shadows were also minimized. Even given these favorable conditions, the sensor performed inconsistently, often with a high percentage of errors.

Table 5. Sample TraffiCam and Manual Count Comparison

Lane	Minute	Manual	TraffiCam	Difference	Percent Error
1 (inside)	1	12	9	3	25%
	2	17	11	6	35%
	3	11	17	-6	55%
	4	17	25	-8	47%
	5	18	12	6	33%
	6	13	13	0	0%
2	1	27	11	16	59%
	2	24	19	5	21%
	3	31	20	11	35%
	4	32	26	6	19%
	5	21	23	-2	10%
	6	22	26	-4	18%
3	1	21	21	0	0%
	2	29	17	12	41%
	3	21	28	-7	33%
	4	21	21	0	0%
	5	26	32	-6	23%
	6	24	20	4	17%
4 (outside)	1	21	21	0	0%
	2	13	16	-3	23%
	3	17	19	-2	12%
	4	19	17	2	11%
	5	15	19	-4	27%
	6	19	29	-10	53%

A test of the TraffiCam sensor performance at night revealed the inability of the sensor to detect receding traffic under low levels of illumination. The presence of high mast lighting in this section of freeway prevents the site from becoming completely dark, but rather provides illumination comparable with dusk lighting conditions. At the time of data collection in August, the onset of dusk occurred at approximately 8:00 p.m. Table 6 presents a sample of TraffiCam volume data prior to and after dusk. As identified in the shaded portion of Table 6, a dramatic drop off in the number of detected vehicles occurred at dusk, or approximately 8:00 p.m. In many cases, no vehicles were detected within the one minute time intervals. Manual field counts conducted between 8:00 p.m. and 9:00 p.m., however, showed consistent flows of 10 to 15 vehicles per minute per lane. Nighttime testing confirmed vendor statements that the TraffiCam sensor accuracy degraded significantly at night when detecting receding traffic.

Table 6. TraffiCam Nighttime Data Log Sample

Date	Time	Lane 1	Lane 2	Lane 3	Lane 4
8/14/97	19:50:56	12	15	12	6
8/14/97	19:51:56	10	12	14	6
8/14/97	19:52:56	4	10	9	9
8/14/97	19:53:56	14	9	7	2
8/14/97	19:54:56	16	10	16	8
8/14/97	19:55:56	9	15	7	10
8/14/97	19:56:56	6	12	6	11
8/14/97	19:57:56	4	10	10	12
8/14/97	19:58:56	9	7	13	9
8/14/97	19:59:56	7	7	0	7
8/14/97	20:00:56	4	3	0	12
8/14/97	20:01:56	1	0	0	2
8/14/97	20:02:56	0	0	0	0
8/14/97	20:03:56	0	0	1	1
8/14/97	20:04:56	0	0	0	0
8/14/97	20:05:56	0	0	0	0
8/14/97	20:06:56	0	0	0	0
8/14/97	20:07:56	2	0	0	0
8/14/97	20:08:56	1	2	0	0
8/14/97	20:09:56	0	0	0	0
8/14/97	20:10:56	0	1	1	1
8/14/97	20:11:56	1	0	0	0
8/14/97	20:12:56	0	0	0	0
8/14/97	20:13:56	0	0	0	1
8/14/97	20:14:56	0	0	0	0
8/14/97	20:15:56	2	0	0	1
8/14/97	20:16:56	1	3	0	2
8/14/97	20:17:56	0	1	1	0
8/14/97	20:18:56	0	3	0	0
8/14/97	20:19:56	1	0	0	1
8/14/97	20:20:56	0	3	0	1

REFERENCES

1. Ritch, Gene P. and David W. Fenno. "Status Report on Operations from September 1995 to August 1996: Second Yearly Report," Texas Transportation Institute, Research Report 2900-2, June 1997.

APPENDIX A. RADAR SPECIFICATIONS

TDS-40 PARAMETERS

Output:

One opto-isolator, 1 RS-232C serial port.

Solid state opto-isolator is rated at 40V holdoff voltage, ON voltage <1V @ 50mA.

Opto 1 generates a 1 second pulse when vehicle speed exceeds the thumbwheel threshold.

The serial data port is a subset of the RS-232C standard, capable of 1200 or 2400 baud operation. Real time speed information is available, in ASCII format, at this port.

Detection:

Microwave based radar detection of any licensed motor vehicle. Detection occurs as a vehicle moves through the narrow beam detection zone. The detection area is approximately 300 to 600 feet from the detector, covering up to 4 lanes.

Mounting height of 10 to 18 feet.

Detection is based on the Doppler principle and is accurate for speeds from 5 to 85 miles per hour. (Typical accuracy is +/- 2 MPH, over the full range.)

Installation:

The unit can be mounted to any stable structure, such as a message sign or pole. Mounting is typically done by strapping or bolting to an alignment plate.

Mechanical:

Corrosion resistant, high impact plastic, weather-tight enclosure.

Dimensions: 10.0" x 9.75" x 10.5" plus the mounting brackets.
Weight: 8 lbs.

Electrical:

14 VDC +/- 20%, 200 mA Max.
12 VDC, 160 mA, 1.8 Watts Nominal
Transient protection.

Environmental:

Temperature: -30 degrees F to +158 degrees F. (-34°C to +70°C).
Humidity: 0 to 98% relative.

Radar:

Frequency: 10.525 GHz

Designed to meet FCC and OSHA requirements for power, frequency, stability, and emissions.

Maintenance and Adjustments:

Not required.

Whelen Engineering Company reserves the right to upgrade or change specifications without notice.

APPENDIX B. RADAR AND LASER SPEED COMPARISONS AT SPARKS AND HARTWICK

WHELEN RADAR DETECTORS U.S. 59 (EASTEX) FREEWAY @ SPARKS Date: 7/25/97 (Old CPU chip) **Southbound**			WHELEN RADAR DETECTORS U.S. 59 (EASTEX) FREEWAY @ SPARKS Date: 7/28/97 (New CPU chip) **Southbound**		
Whelen radar detector speed (mph) (1)	Radar gun speed (mph) (2)	Difference in speeds (mph) [(1) - (2)]	Whelen radar detector speed (mph) (1)	Radar gun speed (mph) (2)	Difference in speeds (mph) [(1) - (2)]
56	60	-4	60	59	1
62	60	2	58	59	-1
60	64	-4	55	54	1
56	59	-3	50	51	-1
51	46	5	57	62	-5
43	45	-2	70	69	1
48	56	-8	58	58	0
59	53	6	56	56	0
59	53	6	58	58	0
69	64	5	64	66	-2
64	60	4	62	61	1
56	60	-4	66	66	0
53	45	8	56	59	-3
51	45	6	63	62	1
60	59	1	54	54	0
54	44	10	60	51	9
56	61	-5	60	60	0
63	59	4	55	54	1
60	54	6	56	50	6
53	55	-2	57	55	2
54	51	3	53	54	-1
58	60	-2	63	67	-4
55	56	-1	59	62	-3
56	62	-6	54	53	1
62	63	-1	62	61	1
56	56	0	60	59	1
58	56	2	57	58	-1
63	66	-3	54	55	-1
63	61	2	66	62	4
55	58	-3	59	61	-2
59	58	1	61	60	1
61	63	-2	63	64	-1
67	66	1	55	54	1
65	59	6	56	57	-1
44	54	-10	66	55	11
58	57	1	57	54	3
58	60	-2	58	58	0
59	57	2	65	68	-3
70	63	7	62	66	-4
59	65	-6	60	61	-1
53	56	-3	62	61	1
59	65	-6	52	51	1
59	55	4	52	54	-2
60	63	-3	51	53	-2
64	59	5	59	59	0
58	58	0	57	56	1
65	58	7	57	56	1
62	68	-6	51	55	-4
59	55	4	62	63	-1
64	61	3	59	66	-7
69	66	3	52	51	1
65	63	2	55	55	0
61	62	-1	59	56	3

63	65	-2
56	60	-4
63	63	0
56	54	2
60	59	1
61	62	-1
56	62	-6
58	63	-5
55	58	-3
57	51	6
62	55	7
51	51	0
53	53	0
52	53	-1
61	61	0
63	57	6
58	59	-1
57	64	-7

SUMMARY		
Sample	=	71
Mean	=	0.296
Average of Absolute Deviation	=	3.612
Standard Deviation		4.322

56	57	-1
63	57	6
66	63	3
59	61	-2
54	55	-1
60	58	2
59	60	-1
54	56	-2
59	58	1
64	60	4
58	57	1
63	60	3
55	55	0
56	55	1
63	64	-1
59	61	-2
63	65	-2
55	54	1
67	59	8
57	59	-2
57	57	0
64	63	1
61	64	-3
57	57	0
59	57	2
59	61	-2
67	65	2
65	64	1
55	54	1
64	60	4
63	62	1
56	58	-2
61	61	0
54	54	0
57	55	2
60	61	-1
60	62	-2
57	58	-1
56	55	1
64	66	-2
49	52	-3
58	55	3
53	55	-2
48	52	-4
56	57	-1
70	66	4
59	63	-4
59	58	1
56	57	-1
71	67	4
59	61	-2
57	57	0
65	59	6
58	59	-1

SUMMARY		
Sample	=	107
Mean	=	0.206
Average of Absolute Deviation	=	2.006
Standard Deviation	=	2.777

WHELEN RADAR DETECTORS U.S. 59 (EASTEX) FREEWAY @ SPARKS Date: 7/29/97 **Northbound**		
Whelen radar detector speed (mph) (1)	Radar gun speed (mph) (2)	Difference in speeds (mph) [(1) - (2)]
61	61	0
58	55	3
54	55	-1
44	42	2
56	57	-1
56	57	-1
66	68	-2
57	57	0
61	59	2
60	63	-3
58	58	0
60	61	-1
57	56	1
64	64	0
60	60	0
54	57	-3
59	61	-2
57	56	1
57	56	1
56	57	-1
64	58	6
64	63	1
57	55	2
58	58	0
54	55	-1
60	57	3
58	57	1
65	67	-2
62	65	-3
70	72	-2
58	60	-2
54	58	-4
58	58	0
65	65	0
73	73	0
68	65	3
53	54	-1
60	60	0
60	61	-1
57	61	-4
59	59	0
63	64	-1
63	64	-1
67	68	-1
61	59	2
57	57	0
59	56	3
54	57	-3
62	64	-2
64	65	-1
65	66	-1
56	56	0
58	59	-1
64	62	2
64	62	2
59	56	3
56	55	1
60	60	0

61	60	1
59	58	1
60	61	-1
59	61	-2
55	56	-1
63	66	-3
56	56	0
55	55	0
55	55	0
60	59	1
60	60	0
64	63	1
57	58	-1
64	64	0
58	58	0
56	60	-4
67	66	1
62	63	-1
53	53	0
61	60	1
57	57	0
58	59	-1
65	64	1
63	64	-1
65	66	-1
51	51	0
55	55	0
57	57	0
59	60	-1
62	61	1
54	55	-1
55	54	1
55	55	0
59	63	-4
59	59	0
61	62	-1
61	59	2
63	62	1
56	57	-1
62	62	0
53	55	-2
58	58	0
65	65	0
64	64	0
55	54	1
61	62	-1
60	59	1
60	62	-2
58	58	0
62	63	-1
68	65	3
59	61	-2
61	62	-1
58	58	0
58	59	-1
59	60	-1
57	58	-1
53	58	-5
61	61	0
61	63	-2

SUMMARY		
Sample	=	118
Mean	=	-0.280
Average of Absolute Deviation	=	1.262
Standard Deviation	=	1.694

WHELEN RADAR DETECTORS
U.S. 59 (EASTEX) FREEWAY @ HARTWICK
Date: 7/29/97
SOUTHBOUND

Whelen radar detector speed (mph) (1)	Radar gun speed (mph) (2)	Difference in speeds (mph) [(1) - (2)]
75	75	0
63	63	0
59	56	3
59	59	0
66	66	0
63	62	1
63	64	-1
65	65	0
62	62	0
60	59	1
53	54	-1
63	65	-2
61	61	0
62	64	-2
70	70	0
71	70	1
73	75	-2
62	62	0
61	64	-3
56	55	1
61	62	-1
63	64	-1
61	64	-3
60	50	10
66	66	0
53	53	0
56	57	-1
59	60	-1
67	66	1
58	60	-2
66	64	2
69	65	4
66	68	-2
59	60	-1
54	57	-3
56	53	3
68	70	-2
59	62	-3
56	53	3
61	64	-3
54	55	-1
62	62	0
69	70	-1
60	60	0
64	64	0
67	67	0
66	65	1
72	68	4
59	60	-1
63	67	-4
61	61	0
67	71	-4
58	60	-2
63	63	0
63	62	1
59	59	0
64	64	0
63	64	-1

60	64	-4
62	64	-2
65	63	2
62	62	0
59	62	-3
68	71	-3
60	61	-1
62	66	-4
54	53	1
60	61	-1
61	63	-2
59	64	-5
67	66	1
66	65	1
70	68	2
63	63	0
61	63	-2
68	68	0
45	45	0
56	55	1
59	59	0
62	63	-1
60	73	-13
61	65	-4
59	58	1
60	61	-1
61	63	-2
57	57	0
62	64	-2
66	66	0
64	65	-1
62	62	0
56	56	0
62	60	2
62	66	-4
61	60	1
60	60	0
64	63	1
63	63	0
56	60	-4
63	63	0
59	59	0
70	72	-2
62	64	-2
63	64	-1
57	65	-8
55	55	0
59	58	1
67	68	-1
63	65	-2
57	57	0
51	51	0

SUMMARY		
Sample	=	110
Mean	=	-0.664
Average of Absolute Deviation	=	1.633
Standard Deviation		2.447

WHELEN RADAR DETECTORS
U.S. 59 (EASTEX) FREEWAY @ HARTWICK
Date: 7/28/97 & 7/29/97
NORTHBOUND

Whelen radar detector speed (mph) (1)	Radar gun speed (mph) (2)	Difference in speeds (mph) [(1) - (2)]	
61	61	0	7/28/97
60	60	0	
64	60	4	
57	53	4	
65	65	0	
59	60	-1	
62	65	-3	
61	60	1	
66	66	0	
55	57	-2	
63	62	1	
62	61	1	
69	67	2	
57	57	0	
68	68	0	
72	71	1	
68	70	-2	
68	70	-2	
68	65	3	
58	57	1	
66	66	0	
67	67	0	
62	62	0	
56	53	3	
62	62	0	
55	58	-3	
58	59	-1	
67	66	1	
64	64	0	
58	57	1	7/29/97
56	55	1	
59	57	2	
63	64	-1	
58	58	0	
61	61	0	
60	61	-1	
62	61	1	
58	60	-2	
61	61	0	
62	64	-2	
58	57	1	
64	65	-1	
62	62	0	
63	65	-2	
47	45	2	
56	57	-1	
62	62	0	
56	55	1	
67	67	0	
69	70	-1	
63	63	0	
61	61	0	
64	64	0	

58	57	1
55	53	2
68	66	2
59	59	0
68	71	-3
56	55	1
58	57	1
61	59	2
61	61	0
64	63	1
54	54	0
61	60	1
65	66	-1
70	71	-1
58	57	1
64	70	-6
69	73	-4
64	65	-1
68	68	0
57	57	0
59	59	0
58	58	0
55	54	1
64	64	0
70	71	-1
67	68	-1
63	63	0
52	51	1
52	54	-2
50	50	0
49	49	0
62	61	1
56	54	2
56	57	-1
57	58	-1
73	72	1
65	65	0
60	62	-2
61	60	1
55	55	0
64	66	-2
64	63	1
61	61	0
59	60	-1
63	63	0
60	60	0
56	56	0
64	64	0
65	66	-1

SUMMARY		
Sample	=	102
Mean	=	-0.020
Average of Absolute Deviation	=	1.028
Standard Deviation	=	1.515

APPENDIX C. EXCERPTS FROM RTMS USER MANUAL

2. Specifications

2.1 Area coverage

The RTMS field of view covers the area defined by its oval-shaped beam and its maximum detection range as follows:

ELEVATION BEAM-WIDTH	50 degrees
AZIMUTH BEAM-WIDTH	15 degrees
RANGE	from 3 to 60 meters (10 - 200 ft.)

2.2 Measurement resolution

The field of view can be divided into detection zones in which vehicle detection and measurements are performed. Each zone is defined by its range limits.

DETECTION ZONES Up to 12 zones. The range limits of each zone are user-defined in 2 meter (7 ft.) resolution and with a fine-tune positioning capability. A zone may include lanes with traffic which is either approaching the detector, receding or crossing the detector line of sight in either direction.

AZIMUTH Detection zones Azimuth (width) resolution corresponds to the antenna beam's footprint width. It is controllable (by the tilt and gain) and can vary from 1 to 10 meters (7 - 30 ft.)

RANGE Vehicle presence and range resolution is 2 meters (7 ft.).

TIME Time of events is measured at 10 mSec resolution. Response time for presence indication is programmable from 20 to 300 mSec. Extension delay time is programmable from 90 mSec to 3 Seconds.

2.3 Measurement accuracy

PRESENCE in a detection zone at better than 98% certainty.

DIRECTION and MAGNITUDE of RADIAL SPEED at less than 10% error. Of Transverse speed at less than 15% error.

QUEUE SIZE and LENGTH in a detection zone at 2 meter (7 ft.) accuracy.

TRAFFIC VOLUME and OCCUPANCY in a zone at less than 5% error.

2.4 Power requirement

SOURCE:115 +/-20 Volts AC 60Hz @ 0.15A or 195 - 275 Volts AC 50Hz @ 80mA
Surge protection complies with IEEE Std. 587-1980 Category C (outside power lines).
Power failure recovery: automatic recovery after a power failure. The RTMS becomes fully active within 5 seconds and achieves full accuracy in 3 minutes.

2.5 Transmission

FREQUENCY BAND	10.525 GHz +/- 25 MHz
INSTANTANEOUS BANDWIDTH	45 MHz
TRANSMITTER POWER	10 mW

2.6 Interface

A single MS multi-pin connector provides power to the unit and output signals:
- Twelve isolated NPN open collector contact pairs sinking 50 mA at up to 50 Volts.
- An isolated serial RS-232 data port operating at 9600 baud rate.

2.7 Mechanical

- The unit is encased in a weather-proof cast aluminum box.
- A universal ball-joint bracket for securing of unit to poles or walls, tilting in both axes and quick locking into place.
- SIZE 16 X 24 X 25 cm. (6 X 9 X 10 inches)
- WEIGHT 4.5 Kg (10 Lbs.)

2.8 Reliability

The unit is designed and built in accordance with the State of California General Specifications for Traffic Signal Control Equipment, to achieve a 90,000 hours (10 years) MTBF (Mean Time Between Failures).

2.9 Maintainability

A 20-second self test BIT (Built-In Test) program is included in the software, for testing the unit in the field or shop. Activated by a command from the Lap-top PC, it fully tests the unit's performance and provides diagnostic information.

Field replacement of a unit can be done in 5 minutes.

A faulty unit can be maintained by replacing one of its internal subsystems or components at the manufacturer's facility.

2.10 Environmental conditions

The unit is designed to operate under the following conditions:

TEMPERATURE RANGE	-37 to +74° C
HUMIDITY	to 95% RH
VIBRATION	2g up to 200 Hz sinusoidal
SHOCK	5g 10 mSec half sine wave
RAIN,SNOW,WIND	rain (or snow) up to a rate of 100 mm/h (4 inch/h) or Wind-loads up to 160 Kph will not degrade the performance.

2.11 Installation

MOUNTING HEIGHT	From 17 to 30 feet above the roadway. Standard height is 5 m (17 ft.). Higher installation are not recommended unless pole is very far from the roadway
REQUIRED EQUIPMENT	Bucket truck, hand tools, laptop PC.
POLE STABILITY	Any pole which does not flex more than 5°.
ROAD TYPE	Any road.
FIXED OBSTACLES	Provided they do not completely mask the traffic.

2.12 Interference

Meets U.S. FCC Rules part 15 and Canadian DOC GL06. Does not interfere with any known equipment. Not susceptible to interference from any other known equipment. Two RTMS units at least 0.5 m (1.5 ft.) apart pointed at 90 degrees or at least 1 m (3 ft.) apart pointed in the same direction will not interfere with each other.

In the FWD LOOKING HIGHWAY mode, there are parameters related to the speed-trap and speed calculation. The speed trap is defined by zone 1 and zone 2.
The declared distance between them in dm (or 4 inch) units can be defined. The average speed will be displayed every 30 seconds. The SPEED TRAP LENGTH can be fudged to give correct readings in either Kph or mph.
In the SIDEFIRED HIGHWAY mode, there are parameters related to the speed calculation. The speed is calculated based upon measurement of the dwell time of vehicles in the zone, assuming a certain zone length and an average vehicle length. The AVERAGE VEHICLE LENGTH (dm) is common to all lanes. The ZONE LENGTH (dm) can be defined specifically for each lane. Thus good Kph and mph readings can be obtained in each lane by playing with these parameters even when some lanes have a different mix of trucks and cars.

Note: For convenience in setup, the SPEED and VOLUME reports are shown in these screens. Obviously, the larger the VOLUME, the more accurate the AVERAGE SPEED measurement. If no legitimate speed readings were made during the collection period, a 240 is displayed to indicate illegitimate speed value.

Note: Mode selection is crucial for proper operation of the sensor. If you do not operate at the correct mode, the RTMS may not operate as desired.
Note: During normal operation, both serial port messages should be left ON. Turning them OFF is not required for most applications and may lead to confusion because they will not show on the VIEW and MODIFY SETUP screens.

Tips on selecting the right poles and mounting position

1. Select a pole from which all desired detection zones on the road are clearly visible from the RTMS and are all lined up in the direction of the RTMS. There should be no major obstacles in between to mask the vehicles. Low rail-guards are OK. High fences are not. Avoid trees, high bushes or moving signs and signal heads between the RTMS and the detection zones. The RTMS can see through fixed metal structures which have openings of 1 ft. e.g. sign-bridge support structures.

2. Do not select a pole which is closer than 3 m (10 ft.) from the nearest zone. The width of the RTMS beam's elliptic footprint on the ground widens with distance from 1 m up close, to 10 m at far ranges. If you require wide zones, select a far pole. In intersection control applications using a side-fired configuration to replace stop-bar loops, select a pole approximately in line with the stop-bar. Farther poles (on the other side of the road) are preferred, as their zones are wider and deviations from right angles smaller.

3. Select a stable pole. Long and thin extension arms may not be stable enough.

4. Select a pole which has convenient access by cable from the controller cabinet, and which you can access with a bucket truck WITHOUT STOPPING OR DIVERTING TRAFFIC. Normal traffic movement is essential to the setup procedure.

5. Do not mount the RTMS too high. The RTMS operates best when its beam illuminates the sides of vehicles. Mounting the unit high and close to the nearest lane may cause reduced resolution because the RTMS will see the vehicles tops as well as their sides. A height of 5.0 m (17 ft.) is optimal for most applications.

Setup Procedure for sidefire mount

1. Angle the RTMS so that its beam is close to right angles with the lanes. Tilt it down so that its boresight is approximately in line with the middle of the group of lanes to be detected. Make sure that the unit is level and not tilted to the side.
2. Connect the RTMS to the Laptop PC and start the RTMS setup program.
3. Go to MODIFY SETUP FROM RTMS. Make sure that you see all vehicles in the lanes you are interested in as blips appearing when vehicles cross the footprint. Wait for moments when there is only one vehicle in the footprint and watch for the location of its blip. Lock the ball-joint bolt and set the sensitivity via SET GAIN.
4. Go into SET PARAMETERS and set the number of zones to the number of lanes you wish to report. You will see several "zone boxes" collapsed on top of one another at the left side of the screen.
5. Go into DEFINE ZONES and pull the zones one by one (first left bracket, then right bracket) into the locations where vehicle blips keep showing, one zone per lane.
6. EXIT back into MODIFY SETUP FROM RTMS and observe vehicle blips and their relation to the defined zones. Make sure that the vehicles in each lane appear within its allocated zone and that adjacent lanes' vehicles do not. If you see splashing between adjacent lanes, your setup is incorrect. You may enter FINE TUNE. Use the UP ARROW key to push the vehicle blips to a farther range, or the DOWN ARROW key to pull the blips to lower ranges.
7. EXIT to the main menu and LOAD SETUP TO RTMS.
8. In counting applications, verify the setup by going to VIEW SETUP FROM RTMS and compare lane by lane manual counts to the RTMS total counts. The RTMS counts should agree with the manual count to within +/-5%. Repeat the verification for each lane. If some of the lanes do not agree with the manual counts go back to step 6.
9. In speed measurement applications, go to SET MODE, SIDEFIRE HIWAY, SET PARAM and watch the speed reports on each lane. Using the arrow keys, set the values of AVERAGE VEHICLE LENGTH and each lane's ZONE LENGTH to obtain speed readings consistent with the real traffic speed.