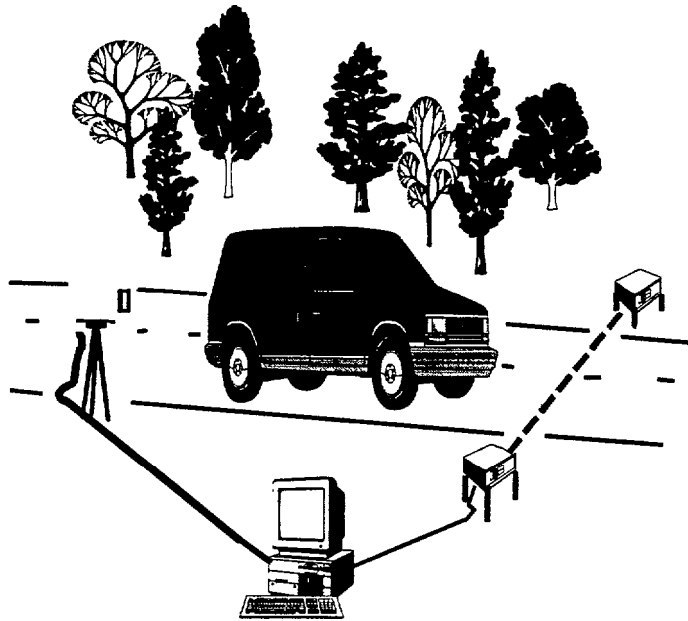


**Ada
Planning
Association**

No. 16-96

Individual Evaluation Test Plan Report #2

Emissions Monitoring of All Vehicles in Ada County



**Final Report
April 1996**

**Clair M. Bowman
Executive Director**

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Deputy Director**

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List of Acronyms

ACHD	Ada County Highway District
APA	Ada Planning Association
AQB	Air Quality Board
C O	Carbon Monoxide
DEQ	Division of Environmental Quality
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
FTP	Federal Test Procedure
I&M	Inspection and Maintenance
ITD	Idaho Transportation Department
ITS	Intelligent Transportation Systems
LPR	License Plate Recognition
MOE	Measures of Effectiveness
RSD	Remote Sensing Devices



April 22, 1996

108807.OT

Cathy Gamer
Federal Highway Administration
3050 Lake Harbor, Suite 126
Boise, ID 83703

Subject: Independent Review of the Individual Evaluation Test Plan Report #2 for the
Travel Demand Management -- Emissions Detection ITS Operational Test

Dear Cathy:

Ada Planning Association (APA) is conducting the subject project and CH2M HILL is providing independent evaluation services to APA. As Independent Evaluators, we are required to review the final analyses/reports and provide comments to be incorporated as part of the final documents. The review is complete and this letter represents the results.

Introduction

The Independent Evaluation Team included Dr. Michael Kyte (University of Idaho) and Dr. Patrick Shannon (Boise State University), and was led by Fred Kitchener (CH2M HILL). The evaluation model for this ITS Operational Test, approved by FHWA, was for the primary team members conducting the test (APA, Idaho Transportation Department, and the Air Quality Board) to also conduct the analyses of the test data. The role of the Independent Evaluation Team was one of observation, review, and participation where appropriate. This included the opportunity to perform separate analyses of the data, with the intent of confirming or rejecting the conclusions of the project team.

The Independent Evaluation Team has been actively involved in this project helping to guide the planning, conduct, and data analyses of this ITS test. During the planning process, we played an active support role assisting in the development of the detailed evaluation test plan documents. In addition, we observed the data collection and provided input to the data analyses throughout the conduct of the test phases.

Independent Evaluation Approach

Specific to this final report, the Independent Evaluation Team performed the following activities in support of the test evaluation:

- Observed the conduct of test data collection at multiple sites on separate testing days. This included participating in a phone interview to determine public perceptions regarding this data collection approach.
- Participated in review meetings discussing preliminary test results in an effort to determine the primary conclusions.
- Reviewed drafts of this report and provided comments
- Conducted analyses of selected test data and provided input to APA.
- Reviewed the final version of this report and provided the Independent Evaluation Team response contained in this letter.

The Project Team which conducted this test were open and responsive to the thoughts, ideas, inputs, and suggestions from the Independent Evaluators throughout the entire performance of this project.

Findings and Conclusions

As with any project that attempts to implement advanced technology in a new application, this project was confronted with significant challenges not known at the time of planning and required adjustments to test data collection approaches and expansion of the level of data analyses in order to clearly understand the conclusions. This in one sense limited the evaluation of the test, however, in another sense provided insight into previously unknown and unanticipated results. These challenges and limitations are defined in the final test report.

Having said this, the team which conducted the tests and analyzed the data did an excellent job adjusting to the test conditions in order to achieve the project goals. The operations of the test and management of the data was well organized which led to meaningful results. We believe the methods of analysis used were appropriate and conducted effectively. What was the primary reason for this commitment? Our observation is that the parties involved believed the benefits of this technology application (to provide useful information to solve transportation problems) were important enough to justify the extra effort. This is important to note in light of many other ITS Operational Tests which have not been able to meet the challenges confronting them which resulted in either significantly reducing the extent of testing or, in extreme cases, terminating the project. **This project should be recorded as a successful example of what can be accomplished when a group of people from different agencies are determined to work together to accomplish common goals.**

The primary question being asked/answered in this final report (Phase III) is:

Can the LPR/RSD technology tested be deployed to augment the vehicle emissions testing program in such a way that would contribute to improving the cost effectiveness of the testing program without jeopardizing the automobile pollutant levels in Ada County?

The answer to this question (Phase III) is less clear than the questions addressed in Phases I and II. Based on the test data analyzed during this phase, it appears the answer is yes, however, the Independent Evaluation Team supports the recommendation of this report to conduct further testing and analysis before a recommendation for implementation could be supported.

Other noteworthy findings and conclusions are as follows:

- Further testing should include the changes to the equipment configuration as discussed in the final report to increase the reliability and improve the system performance to provide meaningful emissions data.
- Further testing of this technology to more definitively answer the above question should address at a minimum the following issues:

Through the implementation of additional technology, how many readings of the same vehicle would be required to obtain accurate emissions data? Is three still the correct number?

Is it reasonable to assume that 50% of the vehicles would be seen by the LPR/RSD equipment providing the required information to support emissions testing? Is 50% enough?

How many SMOG DOG vans would be required to obtain the required coverage to support the emissions testing program? What would be the refined cost savings estimate?

Although this testing was unable to determine a model where the heavy polluters could be more easily identified, through additional testing is this still true? Is there a way to focus on the 5% - 10% emitting the majority of the emissions?

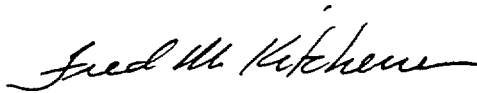
- No significant legal or institutional issues arose during or after this test. The majority of people surveyed support the use of this technology to collect the test specific data and did not find it an invasion of their privacy,
- This test supports the specific national ITS goals to enhance productivity/efficiency of existing transportation systems, and reduce harmful environmental impacts. The results of this should be referenced prior to consideration of similar ITS applications in other cities.

Cathy Gamer
Page 4
April 22, 1996
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In conclusion, we support the conduct, evaluation, and conclusions as described in this final report. We have appreciated the opportunity to contribute to the success of this project.

Sincerely,

CH2M HILL



Fred M. Kitchener
ITS, Project Manager



Patrick Shannon
Boise State University

Michael Kyte
University of Idaho

c Jeff Fuller, CH2M HILL
Ali Bonakdar, APA

Executive Summary

Ada County was chosen to be a part of the national Operational Test for Intelligent Transportation Systems (ITS). ITS applies new technologies and concepts to improve transportation systems, efficiency, mobility, energy and environmental impacts, and create a viable industry.

During the month of May 1995, the last of a three-phase Operational Test was conducted in Ada County. This phase is discussed in this document, ***Individual Evaluation Test Plan Report #2, Emissions Monitoring of All Vehicles in Ada*** County. The other two phases are addressed in another document, ***Individual Evaluation Test Plan Report #1 Origin and Destination Survey and Emissions Monitoring at External Stations***.

This test was designed to determine if Remote Sensing Devices (RSD) can be used to enhance the existing idle emissions testing program in Ada County. Both the technological and economical feasibility of using this new technology were evaluated.

RSD used infrared sensors to measure pollutant levels in an auto's exhaust while the auto was moving at normal speed on roadways. This technology also used a video camera to take a picture of the auto's license plate. With this data, an auto and its emissions could be identified.

This executive summary identifies key results and conclusions of the chapters in this Individual Evaluation Test Plan Report: 1) emissions monitoring of all vehicles in Ada County; and 2) institutional, legal, and public acceptance issues.

1.0 Emissions Monitoring

Results and findings of emissions monitoring are divided into four sections: 1) performance of the RSD system; 2) transportation system impacts; 3) RSD system benefits, specifically effects on CO emissions; and 4) RSD system costs.

1.1 Performance of the RSD System

Overall, the RSD system performed well. Key results and findings for performance of the RSD system follow. The Evaluation Team for this project indicated they were impressed with the overall performance and operations of RSD and would use it again.

- License plate recognition equipment (LPR), a component of the RSD system, transcribed video images of license plates into text output. Over 85 % of the license plates were readable by LPR equipment with minimal staff assistance. (Few revisions to the text output needed to be done by the data operator.)

- RSD recorded over 92 % of valid carbon monoxide (CO) readings and 80 % of CO and acceleration readings.
- The percent uptime for the equipment was approximately 89 % . Mean time between failures was 11.6 hours. Modal repair time was 5 minutes.
- A strong relationship between a single RSD and idle emissions test readings could not be developed. This does not reflect upon the accuracy of RSD readings. Cutpoints to identify “clean” vehicles and exclude them from testing within an acceptable level of confidence can be developed. With further analysis, cutpoints can be refined to include vehicle age, make, and model.
- Electronic interchange (downloading, storing, sorting, and retrieving data) and matching license plate data with Air Quality Board (AQB) idle emissions data base was performed efficiently without any problems.
- The LPR computer software needed additional programming to better identify license plate characters.
- LPR technology was capable of reading license plates of cars and delivery truck during this test.
- The majority of roadways were monitored with adequate traffic control. Each roadway needs to be reviewed for traffic congestion, traffic control, and RSD equipment set-up with the responsible transportation engineering agency.

1.2 Transportation System Impacts

Transportation impacts were minimal. RSD technology provides opportunities to enhance current I&M programs. Results and findings of the transportation system impacts were as follow:

- No noticeable platooning of vehicles through the test sites were observed by the technicians.
- Several issues needed to be considered when selecting sites: pedestrian routes (equipment blocks pedestrian walkway); congestion created by signalized intersections (impacts operation); locations of driveways and parking lots adjacent to the site (impacts operation), and left-turning volumes from center-turn lanes (impacts operation of roadway and adjacent businesses).
- Driver performance through the sites would be expected to be similar to the previous individual tests (Phases I & II). Speed reductions ranged from 9% to 38%. Average speed reduction was 19%. This would be expected with any type of construction or traffic control along the roadside.

1.3 RSD System Benefits; Effect on CO Emissions

Data for this analysis were insufficient to provide exact criteria to determine a definite pass or fail. More data is needed. However there was evidence that RSD screening of a vehicle fleet, using the average of multiple readings, could provide for the identification of vehicles having a high probability of passing an idle emissions test. Those vehicles could be exempted from emissions testing. Inconvenience and costs to a large percentage of vehicle owners with “clean” vehicle is eliminated. This group may constitute 90% or more of all vehicles in Ada County. Other results and findings of the RSD/idle emission testing program were:

- Emissions reductions under a hybrid RSD/idle emissions testing program would be the same as long as the percent of the adjusted vehicle fleet remain the same. A monitoring system could be implemented to track the adjustment rate in case any refinements are needed to the program.
- The capability of LPR equipment to identify “out-of-area” vehicles which were not subject to emissions testing would make it possible to include them in the emissions testing program.
- The ability to identify “high emitting” vehicles would allow earlier detection and emissions tests for those vehicles.
- The exemption of “clean” vehicles from emissions testing would eliminate the inconvenience to a significant percentage of vehicle owners in the non-attainment area.

1.4 RSD System Costs

A hybrid emissions program using RSD/idle emissions testing methods could reduce program costs and save vehicle owners money. Key results and findings for RSD system costs were:

- Cost savings per registered vehicle using RSD technology to enhance/augment/supplement the existing vehicle testing program would range between \$0.28 and \$2.19 depending upon the percentage of vehicles observed sufficient times to be evaluated (three times or more) and the percentage of vehicles exempted from testing.

2.0 Institutional, Legal, and Public Acceptance Issues

Overall, policy makers and the public gave LPR/RSD technology a favorable rating to implement its use to monitor vehicle emissions. Key results and findings for institutional, legal, and public acceptance issues were:

- No legal or institutional issues arose before, during, or after the Operational Test.

- The majority of telephone survey participants and policy makers did not consider RSD technology to be invasion of privacy.
- Approximately 72% of the telephone survey participants preferred to have their vehicle's emissions tested using RSD method rather than the idle emissions test station method. Over 82 % indicated this method would encourage more support for emissions testing.

National ITS Goals

Six goals were developed for the National ITS Project. Three of the six goals relate specifically to this individual test. These goals were: 1) reduce energy and environmental costs associated with traffic congestion; 2) enhance present and future productivity; and 3) create an environment in which the development and deployment of ITS can flourish. Findings of **this** test in relation to the three ITS goals were:

Reduce Energy and Environmental Costs Associated with Traffic Congestion: RSD technology provides the opportunity to identify “high emitting” vehicles earlier than an annual emissions test program. Identifying these “high emitting” vehicles sooner and requiring them to be repaired or adjusted will reduce air pollution and its associated costs. The ability of LPR equipment to identify “dirty out-of-area” vehicles and vehicles of owners who try to “cheat” the emissions testing system could reduce the CO levels in the non-attainment area. Once these vehicles are repaired/adjusted, then these vehicles will operate more efficiently and will reduce gasoline consumption.

Enhance Present and Future Productivity: By identifying “high emitting” vehicles sooner and requiring better operational efficiency of these vehicles, they will use less fuel per mile of operation.

Create an Environment in Which the Development and Deployment of ITS Can Flourish: This test provided an opportunity to use and evaluate RSD technology in “real world” situations. During this test, valuable insights in its use were identified and will assist in the advancement of ITS. Improvements to the LPR system were identified. A wide range of roadway configurations were used and evaluated. This test identified numerous ways to enhance existing emissions testing programs using RSD technology and possibly reduce CO emissions in non-attainment areas. RSD technology provided the opportunity to identify “dirty” vehicles sooner, vehicles which their owners claim to be undriveable or outside the area, and vehicles illegally registered outside the non-attainment area.

Conclusions

The results of the emissions analysis of using RSD technology to enhance the existing Inspection and Maintenance (I&M) program will be forwarded to Ada County Air Quality Board for

their consideration. This analysis provides the basis for future consideration of enhancements to the existing idle emissions testing program.

Data collected during this test created a starting point to identify cutpoints for “clean” vehicles and exclude them from testing with an acceptable level of confidence. With further data collection and analysis, cutpoints can be refined to include vehicle age, make, and model. Development of an emissions testing program which excludes “clean” vehicles from required idle emissions test received support from the public. The public acceptance survey revealed that 72% preferred to have their vehicles’ emissions tested using RSD method rather the idle emissions test method. Also, over 82% indicated this method would encourage more support for emissions testing.

Other enhancements to the existing idle emissions test program could include: 1) vehicles of out-of-county commuters; 2) vehicles illegally registered outside the non-attainment area; and 3) vehicles claimed to be undriveable or outside the area.

Introduction

Northern Ada County was designated by the Environmental Protection Agency (EPA) as a “not classified non-attainment area” for carbon monoxide (CO). This meant the CO levels in the area were neither “Moderate” nor “Serious” according to EPA’s classification of non-attainment areas. Rapid growth in the county which affected both air quality and transportation management was a significant issue to both policy makers and the public. A Travel Demand Management/Emissions Detection Operational Test for Ada County will help planners and policy makers manage traffic growth and air quality in a more efficient manner.

In November 1994, **an** overall **Evaluation Test Plan** was developed for and approved by Federal Highway Administration (FHWA) for this ITS project. This Operational Test included three distinctive phases (or individual tests). A Detailed Operational/Evaluation Plan which incorporated four **Individual Evaluation Test** Plans was developed and submitted to FHWA. In April 1995, FHWA approved this plan to allow the local participants; Ada Planning Association (APA), Ada County Air Quality Board (AQB), Ada County Highway District (ACHD), and Idaho Transportation Department (ITD), to proceed with the Operational Test. This document is the final report for the third phase of Ada County’s ITS Operational Test Project.

Organization of Document

This Evaluation Test Plan Report used the **Intelligent Vehicle Highway Systems Operational Test Evaluation Guidelines**, prepared by the MITRE Corporation, as a guideline in the document preparation. Performance of the RSD system, transportation system impacts, system benefits on air quality, and the system’s costs were evaluated. Three of the six national ITS goals that relate specifically to this test are addressed. In addition, institutional, legal, and public acceptance issues are assessed. The final report answered the following questions:

- What were the test configurations and conditions?
- What data and information was collected?
- When and how was the data and information collected?
- What data and information was analyzed?
- When and how was the data and information analyzed?
- What are the results and conclusions from the data analysis?

The Evaluation Research Team in concurrence with the Independent Evaluator determined that four separate Individual Evaluation Test Plans were needed to address the three phases of this project and additional evaluation elements. The four Individual Evaluation Test Plans guided the Evaluation Research Team through the Operational Test and were used to monitor the progress of the test.

After reviewing the first draft evaluation documents for Phases I and II, the Evaluation Research Team decided the two documents should be combined. These two phases were

conducted simultaneously and had similar objectives and measures of effectiveness. Phase III would remain a separate document. Institutional, legal, and public acceptance issues would be incorporated into both documents.

This test report includes the project goals, description and summary of the individual test, data analysis, conclusions, and recommendations for Phase III, Emissions Monitoring of All Vehicles in Ada County. An overview of this test follows:

Phase III Emissions Monitoring of All Vehicles In Ada County

Ada County has an existing Inspection and Maintenance (I&M) program which requires all 1965 and older autos to have annual idle emissions tests at test stations throughout the County. This test will determine if Remote Sensing Devices (RSD) can be used to provide reliable CO emissions data for the purpose of determining whether certain “clean” vehicles can bypass the annual idle emissions test. Emissions results from RSD technology were compared to current idle emissions data. This was done to assess the potential of RSD as a very important component of a more efficient I&M program. Cost/benefits were compared between an enhanced RSD/idle emissions program and the current I&M program.

This test evaluated the technological and economical feasibility of using RSD technology to enhance the existing idle emissions testing program in Ada County. Data collection primarily occurred during the month of May 1995. Data analysis was conducted from October 1995 through February 1996.

Institutional, I Leg, and Public Acceptance Issues

As with any transportation and air quality management program, institutional, legal, and public acceptance issues needed to be addressed in the development and implementation of a program. Jurisdictional coordination and cooperation, legal opinions, and public acceptance are required to implement transportation and air quality programs with the consensus of policy makers and the public. To ensure the Operational Test ran smoothly, all affected transportation and air quality agencies in Ada County participated in the test planning and conducting the test. Legal opinions were obtained from appropriate representatives. A public awareness campaign included presentations to policy makers in the affected cities and counties and media coverage before and during the test.

This test evaluated the effects of institutional, legal, and public acceptance issues of using RSD technology to monitor vehicle emissions during the Operational Test and for future deployment. Data collection occurred March through August 1995. Data analysis was conducted from July 1995 through January 1996.

Description of RSD Technology

RSD technology included a freeze-frame video camera, acceleration equipment (radar gun), infrared source and receiver (emissions sensors), and a computer system housed in a van. The infrared source shot a beam of light across a travel lane to a sensor in the receiver. When a vehicle broke the beam, the receiver was activated. As soon as the beam was re-established, the receiver measured the exhaust pollutants, cataloged them, and stored them for permanent documentation in the computer. At the same time, a video camera took a snapshot of the license plate number which was read by the computer in the van. In addition, the radar gun read the speed at the instant the infrared beam was broken. A subsequent speed reading was taken and compared to the first one to give the acceleration. Both speed and acceleration readings of each vehicle were recorded as it passed the test site. Test site locations, time and date, emissions, speed, acceleration data, and text output of the license plate were stored on a computer disk to be transferred to a data base.

The license plate recognition (LPR) subsystem was an integral component of RSD equipment used in this study. It consisted of the video camera, service monitor, separate computer and software, and triggering device for the video camera.

A more detailed description is available in Appendix A - Basic Information about Remote Sensing.

Schedule of Events

The Operational Test began March 1, 1995 when APA staff members met with all elected and appointed officials and administrative staff within Ada County and its surrounding counties to distribute stakeholder surveys. Stakeholder surveys assessed the public's acceptance of this new technology to monitor CO emissions. Emissions data collection for this phase occurred during the month of May 1995. Additional data were collected through August for the various follow-up stakeholder and public acceptance surveys. Data analysis was conducted from July 1995 through February 1996. A final report for Phase III was completed in April 1996 at the end of the Operational Test. Detail schedules of test activities are included in this final report,

Chapter 1 - Feasibility of Monitoring Vehicle Emissions in Ada County

1.0 Purpose of Test

Completion of the national highway system and urban portions of the roadway system increased Americans' levels of mobility. With this increased mobility and America's dependence on the automobile, many quality-of-life issues have been raised. Air quality is one of these issues.

Cities which were identified as currently or not previously able to meet National Ambient Air Quality Standards are required to implement mitigation measures to "clean up the air." Most of these cities instituted Inspection and Maintenance (I&M) programs which require annual or biennial vehicle emissions tests at emissions test stations. A supplement method, applying Remote Sensing Devices (RSD) technology to monitor vehicle emissions, was examined to determine whether this technology could augment current emissions testing practices. RSD technology is capable of monitoring emissions, speeds, and acceleration and recording license plates from moving vehicles.

Several completed studies showed that RSD equipment can identify "high emitters" of carbon monoxide (CO). Previous comparisons of emissions readings that used RSD technology (monitoring moving vehicles) versus idle emissions test readings were hampered by the inability of RSD equipment to assess mode-of-operation of a vehicle passing the test site. Heavy acceleration of a vehicle greatly affects the amount of pollutants being produced. By incorporating accurate measures of acceleration, it was proposed that RSD could accurately determine which vehicles would either pass or fail an idle emissions test.

This test evaluated the technological and economical feasibility of using RSD technology to enhance the existing idle emissions testing program in Ada County while reducing program costs.

2.0 Duration

Data collection, processing, and analysis occurred over a 12-month period beginning in March 1995 and ending in February 1996. The following project schedule shows the duration of each major work task conducted during this test.

Project Schedule

Task	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	
Conduct stakeholder surveys	█				█										
RSD software verification	█														
Public awareness campaign		█													
Collect & process emissions data			█												
Conduct public acceptance survey			█												
Analysis of public acceptance survey					█										
Analysis of stakeholder survey							█								
Analysis of data for MOEs						█									
Data analysis of emissions data								█							
Preparation & publication of report									█						

3.0 Summary of Test Configuration and Test Conditions

This test used RSD technology available with Hughes “Smog Dog” van to monitor emissions, speeds, and acceleration, and to read license plates of vehicles traveling in Ada County. Data were used to determine the feasibility of supplementing the current I&M program. Four additional goals were to evaluate: 1) RSD system performance; 2) transportation system impacts; 3) RSD system benefits; and 4) RSD system costs. Three hypotheses were identified which required further data analysis. Evaluation goals, findings, and recommendations were related to national Intelligent Transportation Systems (ITS) goals.

3.1 Test Operations

During the month of May, field technicians collected license plate and emissions data from moving vehicles on primary and secondary roadways in the City of Boise. They also documented weather changes, equipment calibrations and problems, and traffic incidents that occurred during this test. This was done to evaluate the performance of the RSD system, transportation systems impacts, RSD system benefits, and effects on CO emissions levels. The following section describes test operations for this phase.

Each morning prior to data collection, either Ada County Highway District (ACHD) staff or “Smog Dog” technician set up traffic control signs and cones at each test site. The monitored roadways were primarily three-lane facilities. Only one travel lane was able to be monitored during this test. The “Smog Dog” van was positioned outside the travel lanes, usually on the right shoulder, parking lane, or in an adjacent parking lot.

The RSD system consisted of a video camera, an infrared source and receiver (emissions sensors), radar gun, a RSD computer system, a service monitor, and a separate license plate recognition (LPR) computer system housed in the van. The video camera and radar gun were placed upstream of the van. The infrared source and detector were located downstream of the van (see Figure 1). The infrared source shot a beam of light across one travel lane to the detector. For this test, emissions sensors were located: 1) one on the right shoulder; and 2) the other one either in

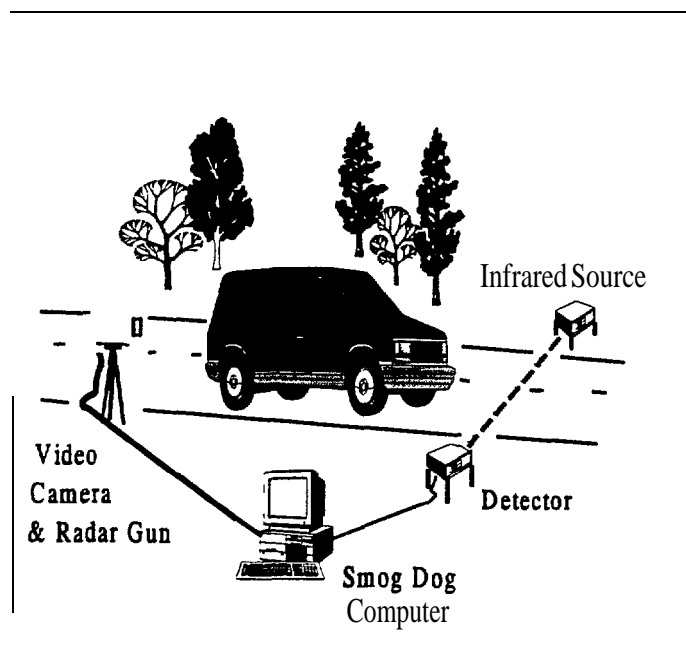


Figure 1 - Remote Sensing Devices System

the center-turn lane, in the center median (landscaped), or on the left shoulder of a freeway ramp. When a vehicle broke the beam, the emissions detector was activated. As soon as the beam was re-established, the emissions detector measured exhaust pollutants, cataloged them, and stored them for permanent documentation. At the same time, the video camera was triggered and took a snapshot of the rear license plate.

The computer in the “Smog Dog” van used LPR software to “read” license plates from photo images and transcribe them to a computer readable text file. In addition, the radar gun read the vehicle speed the instant the beam was broken. A second speed reading was taken and compared to the first one to determine the acceleration. Both the speed and acceleration of each vehicle were recorded as it passed the test site. Emissions readings, speed and acceleration data, and text output of the license plate were displayed on computer monitors. These data were stored in the computer to be transferred into a relational data base program for processing at the Air Quality Board’s (AQB) office.

Technicians at the test site:

- Monitored RSD software, hardware, traffic control equipment, and data recordings;
- Calibrated the emissions detector and radar gun when necessary;
- Adjusted hardware such as camera angle and lens; and
- Maintained a data log.

Data logs documented weather condition changes, operators’ shift changes, traffic incidents such as traffic delays, traffic accidents, and RSD operating times, calibrations, and other problems. This information was used to assess performance of the operational system and transportation system impacts, and is discussed within Section 4.0, Data Analysis.

At the end of each day’s observation, collected data (emissions, speeds, acceleration, and license plates) were downloaded from the “Smog Dog” computer system onto removable hard disks. Disks were then delivered to the AQB office where data were imported into the data base program for processing. An operations data log was maintained to record any data processing or data transfer problems which arose throughout this phase. Once data were transferred to the AQB computer, two copies of the data base existed.

Each license plate record was manually reviewed for accuracy in transcribing the video license plate image to a digitized license plate number stored in the data base. After each license plate record was reviewed, the data base was sorted to remove all unreadable, dealer, out-of-state, and non-Ada County license plates.

Readable Ada County license plates were matched with AQB idle emissions data base to identify vehicle manufacture year, the date, CO emissions reading, and the result (i.e., whether the vehicle passed or failed) of the last emissions reading. This information was then added to the data base matching the appropriate vehicle license plate.

**Table 1
Test Site, Weather, and Locations**

Test Day	Test Hours	Operating Time (Hr.)	Weather Conditions	Roadway And Direction*	Location	Number of Travel Lanes	ADT*** (Yr. of count)	Posted Speed (MPH)	Roadway Characteristics
May 3 (Wed.)	9:20 a.m. to 6:00 p.m.	8.33	Cloudy	Curtis Rd. -SB	South of Union Pacific Railroad Tracks (s/o Emerald St.)	Three	15,040 (1990)	30	Urban industrial setting – straight/flat roadway.
May 4 (Thurs.)	7:20 a.m. to 6:00 p.m.	10.67	Cloudy	Curtis Rd. -SB	South of Union Pacific Railroad Tracks (s/o Emerald St.)	Three	15,040 (1990)	30	Urban industrial Setting – straight & flat roadway.
May 8 (Mon.)	1:00 p.m. to 7:00 p.m.	6.00	Rain in morning. Cloudy in Afternoon	Federal Way - SB	Southeast of Bergeson St.	Three	11,050 (1990)	45	Urban industrial Setting – uphill Section of roadway.
May 9 (Tues.)	8:40 a.m. to 7:00 p.m.	10.33	Cloudy with Intermittent sun.	Federal Way – SB	Southeast of Bergeson St.	Three	11,050 (1990)	45	Urban industrial setting – uphill section of roadway..
May 10 (Wed.)	2:20 p.m. to 7:00 p.m.	4.67	Cloudy with Intermittent sun.	Federal Way – SB	Southeast of Bergeson St.	Three	11,050 (1990)	45	Urban industrial setting – uphill section of roadway.
May 11 (Thurs.)	1:00 p.m. to 7:00 p.m.	6.00	Intermittent rain thought day	Boise Ave. - EB	West of Apple St.	Three	9,560 (1995)	30	Urban setting – straight & flat roadway.
May 12 (Fri.)	7:25 a.m. to 6:00 p.m.	10.42	Cloudy with intermittent sun.	Boise Ave. - EB	West of Apple St.	Three	9,560 (1995)	30	Urban setting – straight & flat roadway.
May 15 (Mon.)	8:00 a.m. to 6:00 p.m.	10.00	Cloudy with rain in the evening.	Fairview Ave. - EB	On-ramp to I-184	One	6,200 (1990 ITD Count)	35 on Fairview Ave.	Urban commercial setting – ramp between Fairview Ave. & I-184.
May 16 (Tues.)	6:25 a.m. to 6:15 p.m.	11.83	Cloudy with intermittent sun.	Fairview Ave. – EB	On-ramp to I-184	One	6,200 (1990 ITD Count)	35 on Fairview Ave.	Urban commercial setting – ramp between Fairview Ave. & I-184.

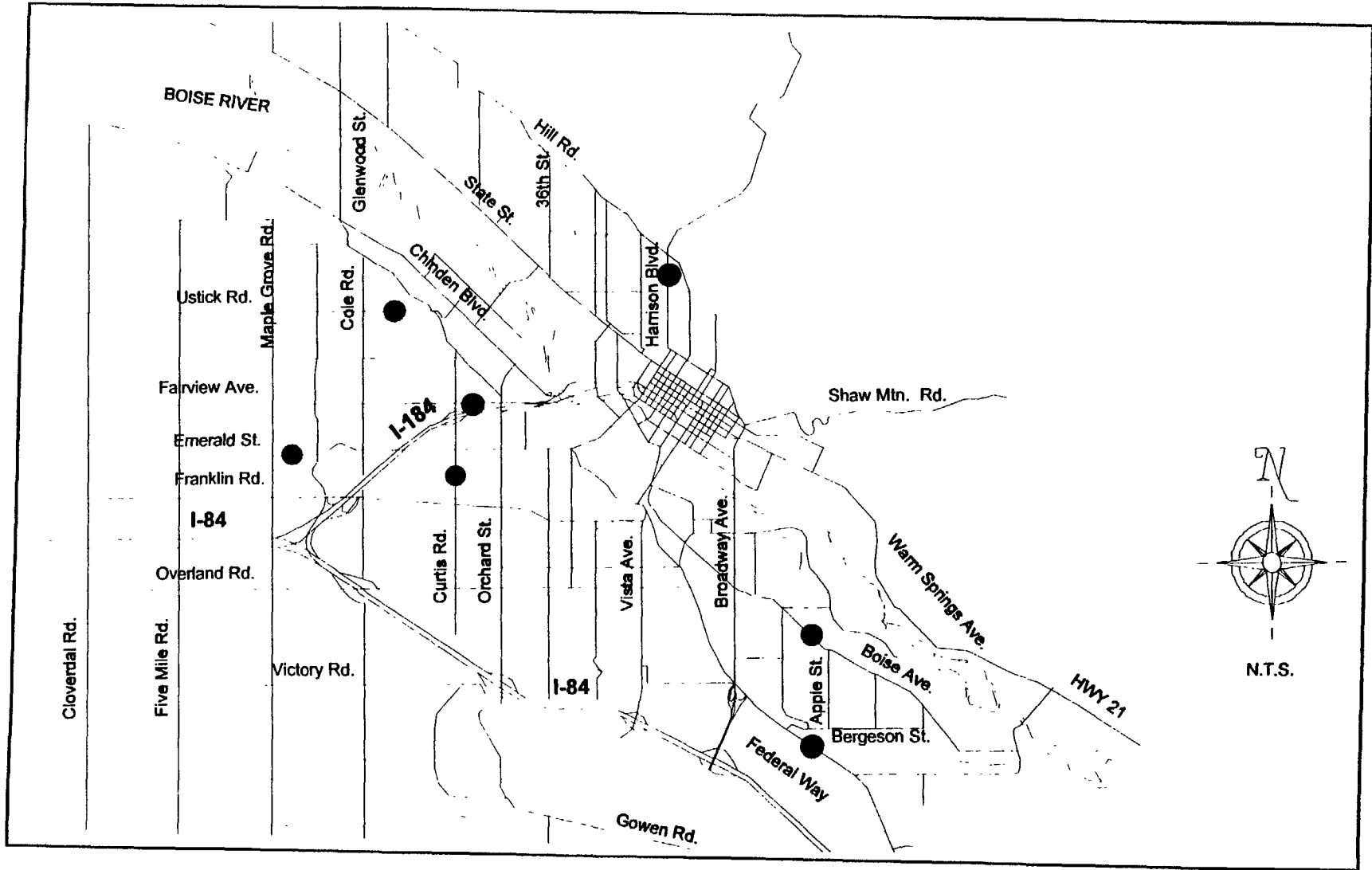
Test Day	Test Hours	Operating Time (Hr.)	Weather Conditions	Roadway And Direction*	Location	Number of Travel Lanes	ADT*** (Yr. of count)	Posted Speed (MPH)	Roadway Characteristics
May 17 (Wed.)	6:20 a.m. to 6:30 p.m.	12.17	Sunny	Fairview Ave. – EB	On – ramp to I-184	One	6200 (1990 ITD Count)	35 on Fairview Ave.	Urban commercial setting – ramp between Fairview Ave. & I-184
May 18 (Thurs.)	7:00 a.m. to 6:30 p.m.	10.50	Sunny	Harrison Blvd. – NB	South of Hill Rd.	Two travel lanes with landscape median	12,770 (1993)	30	Urban residential setting – straight & flat roadway
May 19 (Fri.)	6:30 a.m.. to 6:10 p.m.	11.67	Sunny	Harrison Blvd. - NB	South of Hill Rd.	Two travel lanes with landscape median	12,770 (1993)	30	Urban residential setting – straight & flat roadway.
May 23 (Tues.)	7:30 a.m. to 1:50 p.m.	6.33	Sunny	Ustick Rd. - EB	East of Cole Rd.	Three	22,550 (1994)	30	Urban residential & commercial setting – straight & flat roadway.
May 25 (Wed.)	11:10 a.m.. to 6:30 p.m.	7.33	Sunny with intermittent clouds.	Ustick Rd. - EB	East of Cole Rd.	Three	22,550 (1994)	30	Urban residential & commercial setting – straight & flat roadway
May 26 (Thurs.)	7:00 a.m.. to 6:30 p.m.	11.50	Sunny	Ustick Rd. - EB	East of Cole Rd.	Three	22,550 (1994)	30	Urban residential & commercial setting – straight & flat roadway.
May 31 (Wed.)	7:30 a.m. to 6:30 p.m.	11.00	Sunny with intermittent clouds.	Emerald St. – WB	East of Maple Grove Rd.	Three	16,180 (1995 count w/o Cole Rd.)	30	Urban commercial setting _ straight & flat roadway
June 1 (Thurs.)	7:00 a.m. to 6:00 p.m.	11.00	Sunny with intermittent clouds.	Emerald St. - WB	East of Maple Grove Rd.	Three	16,180 (1995 count w/o Cole rd.)	30	Urban commercial setting – straight & flat roadway.

NOTE: * Direction: SB = Southbound, NB = Northbound, EB = Eastbound, and WB = Westbound

**** Three lanes include a continuous left turn lane.**

***** ADT = Average Daily Traffic**

Map 1 Test Site Locations



3.2 Test Schedule, Weather, and Site Location

The test for this phase occurred primarily throughout the month of May 1995, Monday through Friday. Seven test sites were monitored for multiple days over a 17-day period. A “Smog Dog” van and technician were used to monitor each site (see Table 1, Test Site Schedule, Weather, and Locations, and Map 1, Test Site Locations, on the previous pages).

Weather played a role in the quantity and quality of data collected at the test sites. The first two test days experienced rain and no data were collected. The first half of the month experienced rainy periods which caused test operations to cease periodically or terminate early (i.e., near the end of the test day). Table 2 reflects weather conditions affecting data collection. Otherwise, weather conditions were mixed with sun and intermittent clouds throughout the remainder of this test. (See Appendix B - Preliminary Local Climatological Data for May 1995 from the National Weather Service.)

Lighting conditions created by sun and clouds required field technicians to manually adjust the aperture on the video camera. The aperture controls the amount of light into the camera. One day the technician made a longer camera hood from cardboard to shade the sunlight coming into the camera lens. If the license plate image was either too light or too dark, the LPR computer had difficulty transcribing them.

Table 2
Weather Conditions Affecting Data Collection

Test Site Location	Date of Problem	Time of Problem	Time Back in Operation	Down Time (Hr.)	Weather Condition/ Problem
Curtis Rd.	May 5, 1995	6:00 a.m.		13.0	Rained all day
Federal Way	May 6, 1995	6:00 a.m.	12:30 p.m.	6.5	Rained
Boise Ave.	May 11, 1995	6:00 a.m.	1:00 p.m.	6.0	Rained
Boise Ave.	May 11, 1995	2:15 p.m.	3:40 p.m.	1.4	Rained
Boise Ave.	May 11, 1995	6:00 p.m.		1.0	Rained
Fairview On-ramp	May 15, 1995	6:00 p.m.		1.0	Rained

Wind also played a role in the quantity and quality of emissions data collection. More calibrations were required during windy conditions in order to keep emissions sensors calibrated.

4.0 Data Analysis

This section describes data collected and the data analysis used to evaluate goals and objectives. It evaluates performance of the RSD system, transportation system impacts, and RSD system benefits and costs.

4.1 Evaluation Goal 1: Evaluate the Performance of the System

Objective A1: Assess LPR system's overall reliability for data collection.

Findings

Findings of the LPR system reliability for data collection were:

- LPR equipment transcribed video images of license plates into text output.
- Over 85 % of the license plates were readable by LPR equipment with minimal staff assistance.
- Lighting conditions, location, and condition of vehicle license plates and equipment set up affected the readability of license plates.
- LPR technology was used to read license plates of passenger and delivery vehicles.
- Special identifier codes had to be manually entered to the data for those duplicate license plate numbers/characters with different license plate types (i.e., Wildlife, Purple Heart, National Guard, etc. for Idaho license plates). This was an oversight which could be addressed with additional LPR programming.

Data Analysis

During this test, vehicle license plates were captured as moving vehicles passed the LPWRSD system at the test site. The LPR computer was programmed to identify characters on Idaho license plates. The program calculated a confidence factor for how well it read each license plate and included this confidence factor with the stored data record. A separate program was used later in non-real time to review or "truth" all transcribed data. Confidence levels as assigned by the LPR program were generally reliable indicators of how accurately the license plate number was transcribed to computer readable characters.

Table 3, Summary of License Plate Collection, provides a summary of the number of observed license plates. It was broken down by readable license plates (Ada County, Non-Ada County, No County Identified) and by unreadable license plates (Out-of-State, Dealer Plate and No Plate). “No plate” contained video snapshots of the rear of the vehicles (taillights, bumpers, bumper stickers, decals, etc.) where a license plate was not located or was unreadable, or the license plate number was obstructed by a ball hitch or another object.

Over 59,000 license plates were observed at the seven test sites. Over 85 % were readable by LPR equipment with minimal assistance from staff. (Few revisions to the text output were needed to be done by the data operator.) Less than 15% were not transcribed into digitized license plate numbers. These were snapshots of bumpers, taillights, bumper stickers, or decals.

Table 3
Summary of License Plate Collection

License Plates	Total	Percent of Total Observed
I. Total Observed	59,048	
II. Unreadable		
No Plate	8,648	14.6%
Total	8,648	14.6%
III. Readable		
Ada County	43,189	73.2%
Non-Ada County	3,513	5.9%
No County Identified	1,933	3.3%
Out-of-State	1,611	2.7%
Dealer Plate	154	0.3%
Total	48,635	85.4%
Note: “No Plate” category contained those video snapshots of the back end of vehicles [taillights, bumpers, etc.] where a license plate was not located or readable or the license plate number was obstructed. “No County Identified” category contained those license plates without the county identifier codes such as Wildlife, Purple Heart, Centennial, etc.		

Most of Idaho license plates consisted of a county identifier and up to six digits. County identifiers were less than half the size of the regular license plate characters and had the first letter of the county. When more than one county started with the same letter, the identifier was a small number over the first letter of the county. Due to a misunderstanding early in preparation for the field test, the vendor’s programmers did not originally program the LPR software to recognize county codes on license plates. This error was discovered just one week

prior to the start of the initial phase of this test. (This was the last of a three-phase operational test.) The vendor managed to include the computer recognition of local county identifiers (i.e., Ada County and its adjacent counties) with the exception of one surrounding county. It was anticipated the LPR program would have difficulty distinguishing between some of the county identifiers which are very similar (such as 6B and 8B or 2C and 20) due to its small size. During “truthing” of the data, it was observed that the LPR program, when it assigned a high confidence factor, had indeed identified the difference between these problem characters. However, there were more lower confidence numbers for these problem identifiers.

In addition to the uniqueness of the county identifier, Idaho also issued duplicate numbers on different types of license plates. The same three digit number could be on a Wildlife, National Guard, or Purple Heart license plate. While the LPR system could transcribe the characters, it could not transcribe the background or type of license plate. Table 4 identifies types of Idaho license plates and characters. To ensure that these license plates were matched to the correct vehicle owner, data operators reviewed the data and entered a special code for license plate type.

Table 4
Type of Idaho License Plates

Type of License Plate	Type of Characters
Centennial	Three numbers and three letters.
County	County designation (one letter & one number), and one to six letters.
Wildlife	One to four numbers.
Personalized	Seven characters (combination of letters and/or numbers).
Military Reservist	Type of Service (Army, US Coast Guard, etc.), and one to three numbers.
National Guard	Four numbers.
Disabled Veterans	DV and four numbers.
Purple Heart	Two to four numbers.

As the LPR system was not programmed to recognize all county codes and as Idaho issued duplicate numbers on different license plate types, it was decided to “truth” all observed license plates. Because of this extensive review, an in-depth knowledge of types of transcription problems likely to occur was developed. Table 5 on the next page lists problems which occurred repeatedly. It should be noted that the majority of these listed problems were accompanied by confidence levels which would have triggered a review by the “truthing” process.

Table 5
Observed Readability Problems of LPR System

Type of Problem	Description of Problem
Condition of License Plate	Mud covered license plates. License plates were warped. Plastic license plate covers created a glare.
Location of License Plate	Vehicles lacked license plate on the back bumper. License plates were on an unconventional location such as rear window or one side of the bumper. Hitch ball covered a portion of the license plate. Shadow of spare tire covered license plate (usually utility vehicles). License plate mounted at an angle. Deep seated plates created shadows.
Location of Vehicle in Travelway	Vehicle did not travel in the center of the lane. One vehicle tailgated another. Spacing between vehicles was inadequate due to traffic congestion (i.e., traveling too slow or stop and go traffic).
Lighting Conditions	Lighting conditions changed rapidly due to weather changes. The angle of the sun created shadows. Glare from the sun washed out the image.
Readability of Images on License Plates	License plate with a tree on the right side was interpreted as the letter "L". Some letters interpreted as numbers and vice versa such as the letter "B" and the number "8." License plate type or county identifier was not programmed into the LPR computer.

Also, this developed knowledge could be used to improve the LPR program and increase the number of license plates read correctly. No records were maintained of the actual number of license plates numbers modified during the review or "truthing" process.

Objective A2: Assess RSD system's overall reliability for data collection.

Findings

Findings of RSD system's overall reliability for data collection were:

- RSD recorded 92.5 % valid CO emissions readings and 80.1% valid CO emissions and acceleration readings at the test sites.

Data Analysis

In addition to collecting license plate data of moving vehicles, emissions readings were collected at each test site. Table 6, Valid Emissions and Acceleration Readings from Idaho Vehicles, provides a breakdown of emissions readings in two categories: valid CO readings and valid CO and acceleration readings from Idaho vehicles with readable license plates. The RSD computer was programmed to calculate a confidence factor for reading emissions and

acceleration. If the computer determined it was not adequate, the computer entered nines in the CO or acceleration field for that record.

Table 6
Valid Emissions and Acceleration
Readings from Idaho Vehicles

Site Location	Total Idaho Useable Licenses	Valid CO		Valid CO & Acceleration	
		Number	Percent	Number	Percent
Curtis Rd.	4,859	4,369	86.7%	3,845	77.1%
Federal Way	6,763	6,460	95.1%	5,114	78.5%
Boise Ave.	2,271	2,130	91.1%	1,881	79.7%
Fairview On-ramp	12,240	11,727	97.4%	10,041	82.6%
Harrison Blvd.	4,888	4,593	94.4%	4,213	87.6%
Ustick Rd.	8,245	7,265	82.1%	6,268	70.7%
Emerald St.	9,366	8,450	90.8%	7,604	82.3%
Total	48,635	44,994	92.5%	38,966	80.1%

For this analysis, 48,635 Idaho vehicles (Ada, Non-Ada, and No County Identified as defined in Table 3) identified with readable license plates were used for the analysis. The test sites recorded 92.5 % valid CO readings and 80.1% valid CO and acceleration readings of the total Idaho vehicles with readable license plates.

Objective B: Assess RSD system's overall operational reliability.

Findings

Findings of useable RSD system's overall operational reliability were:

- The malfunction of the generator for 11/2 days (16.2 operating hours) created 84 % of the total down time for the test period.
- Mean time between failures was 11.6 hours.
- Mean time to repair was 1.3 hours.
- The modal repair time was 5 minutes.
- The percent uptime was approximately 89%.

Table 7
RSD Problems and Associated down Time

Location	Date	Description of Problem	Action of Resolved Problem	Failure Time		Down Time (Min.)
				Starting Time	Ending Time	
Boise Ave.	12-May-95	License plate will not record to RSD computer screen	Rebooted computer system.	02:15 PM	02:20 PM	5
Fairview On-ramp	15-May-95	RSD computer froze up	Rebooted RSD computer.	12:30 PM	12:31 PM	1
Fairview On-ramp	16-May-95	LPR froze up	Rebooted LPR computer	01:10 PM	01:13PM	3
Fairview On-ramp	16-May-95	LPR froze up	Rebooted LPR computer.	04:45 PM	04:47 PM	2
Fairview On-ramp	17-May-95	LPR froze up	Rebooted LPR computer	10:35 AM	10:37 AM	2
Fairview On-ramp	17-May-95	Auxiliary generator had cycling problems, then quit	Restarted auxiliary generator	06:25 PM	06:26 PM	1
Harrison Blvd.	18-May-95	LPR froze up.	Rebooted LPR computer	07:28 AM	07:32 AM	4
Ustick Rd.	23-May-95	Generator cycling problems	Changed air filter, did not resolve problem.	12:50 PM	12:54 PM	4
Ustick Rd.	23-May-95	Generator won't turn	Plugged extension cord into van.	01:30 PM	01:35 PM	5
Ustick Rd.	23-May-95	Generator malfunction.	Shut down for rest of day.	01:50 PM	06:30 PM	970
Emerald St.	24-May-95		Took it to a generator repair shop. Down all day	07:00 AM	06:30 PM	
Emerald St.	25-May-95	Camera tripod mounting bar broke	Install new mounting bar.	09:20 AM	11:10 AM	110
Emerald St.	26-May-95	LPR froze up.	Rebooted LPR computer.	09:50 AM	09:52 AM	2
Emerald St.	31-May-95	Sensor would not calibrate	Removed and reconnected all power & signal cables.	06:50 AM	07:30 AM	40
Emerald St.	1-June-95	RSD computer locked up	Rebooted RSD computer	05:25 PM	05:30 PM	5
Emerald St.	1-June-95	LPR computer locked up	Rebooted LPR computer	05:40PM	05:45 PM	5
Total						1,159
Mean Time to Repair						77.3

Data Analysis

Field technicians maintained data logs that documented equipment problems and calibrations at each test site. Equipment problems ranged from generator malfunctions to the computer system crashing. Table 7, RSD Problems and Associated Down Time, on the previous page documents types of equipment problems, actions to resolve problems, and down time to repair problems.

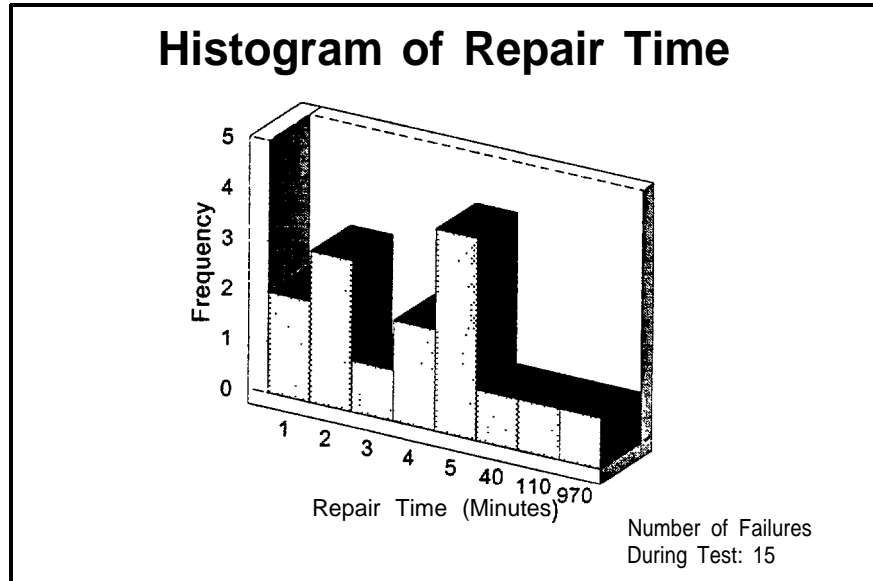


Figure 2 - Histogram of Repair Time

Approximately 15 equipment problems occurred at seven test sites over a 17-day period. It required approximately 19.3 hours to repair them. Repair time ranged from 1 to 970 minutes. The frequency of the repair times is reflected in Figure 2.

Table 8, Summary of Mean Time between Failures and Mean Time to Repair, provides a breakdown of the number of failures, mean time between failures, down time, and mean time to repair the RSD equipment for the test period. A failure was defined as any RSD or LPR equipment problem that stopped the operation of the test. Two of the seven test sites (Curtis Road and Federal Way) did not experience any equipment failures. These two roadways were the first two sites monitored during this test.

Table 8
Summary of Mean Time between Failures and Mean Time to Repair

Test Sites with Equipment Failures	Operating Hours	Number of Failures	Mean Time between Failures (Hr.)	Down Time (Hr.)	Mean Time to Repair (Hr.)
Boise Avenue (1), Fairview On-ramp (6), Harrison Boulevard (1), Ustick Road (3), and Emerald Street (5)	173.7	15	11.6	19.3	1.3

Mean time between failures was 11.6 hours. Mean time to repair was 1.3 hours. The mean time to repair was high due to the generator malfunctions. It required approximately 1 1/2 days (or 16.2 operating hours) to repair at a local generator repair shop. The vendors are currently working on eliminating the generator as a component of RSD technology.

It may be more appropriate to use the statistical modal repair time and the percent uptime for the equipment, since the generator malfunction created 84 % of the total down time. Modal repair time was 5 minutes. The percent uptime was 89%.

Objective C: Assess the accuracy of RSD technology to monitor CO emissions of vehicles operating in the Ada County non-attainment area.

Findings

Findings of the accuracy of RSD technology to monitor CO emissions were:

- A strong relationship between single RSD and idle emissions test readings under strictly controlled conditions is unlikely. This does not reflect upon the accuracy of the RSD readings.
- Cutpoints to identify “clean” vehicles and exclude them from testing within an acceptable level of confidence can be developed. With further data collection and analysis, cutpoints can be refined to include vehicle age, make, and model.

Data Analysis

A key objective of Phase III was to determine whether RSD technology could be used as an effective device in vehicle emissions testing. Specifically, the study was interested in determining whether RSD emissions readings, and other data collected through the RSD process, could be used to accurately predict idle emissions test results for individual vehicles. Two approaches were used in an attempt to answer this question: 1) multiple discriminant analysis (MDA); and 2) cutpoint analysis using multiple readings. These two approaches are discussed in this section.

1. Multiple Discriminant Analysis (MDA)

In an attempt to address this question, a total of 20,465 case studies were conducted during the test period. Each case study involved a vehicle which was tested at an Ada County idle emissions test site within seven months after capturing a RSD reading. The case study vehicles

were measured by the RSD equipment at any one of several locations within Ada County. It should be noted, in some instances, the same vehicle was the subject of two or more case studies. In those instances, the current idle CO reading was also compared to multiple RSD CO readings. To ensure sufficient number of emissions samples were available to address this question, selected data from Phase II, Emissions Monitoring at External Sites, were included.

The RSD equipment measured CO levels, vehicle acceleration rates, and vehicle speed. The year of the automobile was determined through AQB idle emissions data base. AQB received this data from Idaho Transportation Department records. In cases where a vehicle had been through the idle emissions test process more than one time during the test period, the idle emissions reading taken closest to the RSD readings were used.

The initial step in determining whether the RSD readings could be used to predict whether or not the vehicle would pass or fail the idle emissions test involved the application of MDA. Discriminant analysis is a statistical technique that uses data on two or more discriminator variables in an attempt to optimally classify a case into one of two or more mutually exclusive categories. In this application, the two categories were PASS and FAIL at the idle emissions test. The discriminatory variables used were, RSD CO reading, speed, acceleration, and vehicle manufacture year.

In order to correctly test the classification ability of an MDA model, it was appropriate to hold out a sample of cases to be used as test cases. In the initial MDA run based on 10,023 case studies, a random sample of 1,888 cases were held back. The discriminant model was then constructed from the remaining 8,135 cases. Of these, a total of 7,911 (97.25 %) were vehicles which “passed” the idle emissions test.

MDA attempts to use the information from the four discriminator variables to separate the cases into two groups. SPSS/PC + , the Statistical Package for the Social Sciences, was used to perform the analysis. A key part of SPSS/PC+ output consists of the classification matrix for the hold-out sample. It was preferable to analyze the classification ability of a MDA model using the hold-out cases, since these were not used in developing the original classification model.

Table 9, Classification Matrix, shows that the MDA model successfully classified 97.7% of the vehicles which actually passed the idle emissions test (i.e., classified as PASS and Actually PASSED). Only 2.3 % of those passing the idle emissions test would have been incorrectly classified as failing the test. If the RSD technology were to be used as a screen to determine whether a vehicle needs to be tested at an idle emissions test site, the false FAIL error rate for these data would have been 2.3 % .

Table 9
Classification Matrix
Hold-Out Data (n=1,888)

	Classified as FAIL	Classified as PASS	Total
Actually FAILED	6 (12.2%)	43 (87.8%)	49
Actually PASSED	42 (2.3%)	1797 (97.7%)	1839
Total	48	1840	1888

However, when the analysis was reversed to look at the error rate for vehicles which actually failed the idle emissions test but were classified by the MDA model as passing, the error rate was 87.8 % . Clearly, the MDA model based on RSD CO reading, acceleration rate, speed, and vehicle manufacture year was not capable of recognizing the vehicles which will fail the idle emissions test with any reasonable level of accuracy. The overall error rate (both false FAIL and false PASS) was 4.5% (85 of 1888 vehicles misclassified.) Although the overall error rate wasn't too bad, the error rate for passing vehicles which would fail the idle emissions test is extreme. Several replications of this analysis were conducted using different hold-out samples with similar classification results.

One factor that may have contributed to the failure of MDA in this instance was the MDA classification results were based on both the discriminator variables and the prior probability of group membership. This meant the classification of a given vehicle as either passing or failing depended on both data values as measured by RSD technology and the original likelihood a vehicle passed or failed the idle emissions test as determined by the pass-fail ratio in the sample data. Since over 97% of all vehicles in the cases used to develop the model passed the idle emissions test, the tendency was for the model to classify a vehicle as passing unless the RSD data were overwhelming. The MDA was biased toward classifying vehicles as PASS.

If instead of using the MDA to classify vehicles as PASS or FAIL, all vehicles were classified as PASS regardless of their RSD data, the overall error rate would be only 2.7% (49 of 1888 vehicles misclassified). This is actually an improvement over the results when the MDA is used. However, the error rate for vehicles which fail the idle emissions test would be 100%.

To address the issue of dominant prior probabilities, several individual analyses were made using samples which were more balanced between vehicles that passed and vehicles that failed the idle emissions test. The same four discriminator variables were used in the discriminant analysis. Typical of the runs was one in which the overall sample size was 1,012 cases. Of these, 187 cases were randomly selected as hold-out data for classification purposes. Of the 825 cases used to develop the discriminant model, 560 (67.8%) had passed the idle emissions

test. Table 10 shows the classification results when the hold-out data were classified by the discriminant model,

Table 10
Classification Matrix
Hold-Out Data (n=187)

	Classified as FAIL	Classified as PASS	Total
Actually FAILED	24 (40.0%)	36 (60.0%)	60
Actually PASSED	9 (7.1%)	118 (92.9%)	127
Total	48	1840	187

Of the 187 vehicles, 45 were misclassified for an overall error rate of 24 % . This was substantially higher than achieved by the MDA model based on the entire data set. However, the MDA model based on the more balanced sample was somewhat more successful in classifying the vehicle which would fail the idle emissions test. Comparing the upper middle quadrants of Tables 9 and 10, the false PASS rate is 60% in Table 10 compared with 87.8% in Table 9. While this was an improvement, the false PASS rate was still unacceptable. Replications of this format with different samples from the original data produced similar results.

The conclusion reached was that multiple discriminant analysis was not effective at separating the vehicles which will pass the idle emissions test from those that will fail based on readings from RSD. However, the analysis did show that CO and vehicle manufacture year were the two most significant variables in separating the passes from the fails. Neither acceleration nor speed showed any statistical relationship to the idle emissions test results.

Part of the reason that MDA proved unacceptable as a method for predicting the idle emissions test results was that it was asked to identify both the vehicles that would pass and those that would fail the idle emissions test. As indicated earlier, due to the pass to fail ratio in the vehicle population, the tendency was for the model to classify vehicles as pass unless overwhelming evidence existed to suggest otherwise. However, of the two types of errors (false PASS and false FAIL), the false PASS is considered to be the biggest concern by AQB officials. They were less concerned with requiring a “clean” car to be tested than they were in allowing a “dirty” car to go untested. Therefore, a second form of analysis was undertaken to determine whether RSD readings could be of value.

2. Cutpoint Analysis Using Multiple Readings

The second approach was to determine whether RSD and vehicle manufacture year could be used to define a rule for excluding vehicles from the idle emissions process. Specifically, the study was interested in determining whether certain levels of CO and/or vehicle manufacture year could serve to accurately predict vehicles which would pass the idle emissions test while minimizing the number of “dirty” vehicles which would be misclassified (minimize the false PASS rate). This was to be a one-sided effort in that no emphasis would be placed on minimizing the false FAILS.

A further difference between this second approach and the MDA was that only vehicles with two or more RSD readings were included in the study. Then instead of using an individual CO observation from RSD to predict the idle emissions test result, an average of the multiple CO readings would be used. The effect of this was to mitigate any variability in RSD readings that might occur for reasons such as engine temperature or climate differences. The bottom line question to be answered was whether a meaningful number of vehicles could be allowed to bypass the idle emissions test based on RSD readings and/or vehicle manufacture year without allowing an unacceptable number of “dirty” cars to bypass idle emissions testing.

The results that follow indicate that the answer to this question is “probably yes.” The “probably” comes only from the fact that this study did not have as an objective of gaining multiple observations for the same vehicle. As a consequence, it was not possible to directly determine the rate at which multiple observations were generated through normal RSD data collection efforts. However, the results showed that for those vehicles where multiple observations were obtained, cutpoints involving RSD CO data and/or vehicle manufacture year data could be defined which would provide for sizable numbers of “clean” cars to bypass the idle emissions test at the same time minimizing the number of “dirty” cars that would be bypassed.

The objective of this analysis was to find some indicator, based on RSD readings, which would predict, with a reasonable degree of certainty, that a vehicle would “pass” an idle emissions test. One problem faced in this study was the time lapse between the RSD observation and the idle emissions test. RSD data were gathered on all vehicles and then compared to subsequent, regularly scheduled emissions test results. The time lapse between RSD reading and idle emissions tests induced errors into the comparisons since some vehicles would be expected to malfunction after the RSD reading and prior to the emissions test. Since there was no way of determining exactly when a vehicle malfunctioned, all cases where a vehicle “passed” a RSD cutpoint and later failed an idle emissions test were considered false PASSES -- potential exempting in error. Vehicles which were repaired between RSD and idle emissions test were irrelevant since our focus is on exempting “clean” vehicles with a minimum of “dirty” vehicles being exempted by mistake. A high RSD reading precluded the vehicle from being exempted and forced an emissions test which it would pass (false FAIL -- not exempted). In order to minimize the effects of the delay between RSD readings and idle emissions tests (and still have a sufficient number of samples), the analysis was limited to vehicles which received an idle emissions test within 100 days of the RSD reading.

Table 11 illustrates the relationship between single RSD readings (all collected data) and idle emissions testing. It was evident that lower RSD readings indicate a greater likelihood of passing a subsequent idle emissions test. A vehicle observed by RSD as emitting 4.0% CO or higher was at least 17.5 times as likely to fail its emissions test as was a vehicle showing 0.0 % CO on an RSD observation. However, there was no clear point at which a vehicle could be predicted to pass an idle emissions test without having false PASSES. Sixty-one of the 4320 vehicles indicating 0.0% CO on the RSD observation went on to fail their idle emissions tests.

Table 11
Single RSD Readings
Predictor of Idle Emissions Test Results

RSD CO Reading	Number of Vehicles Observed	Number of Vehicles Failed Subsequent Idle Test	Percent of Vehicles Failed Subsequent Idle Test
0.0 %	4320	61	1.4%
0.1%	3958	64	1.6%
0.2%	2623	52	1.9%
0.3%	1674	41	2.4%
0.4%	1133	30	2.6%
0.5%	854	28	3.2%
0.6%	626	25	3.9%
0.7%	512	25	4.8%
0.8%	422	25	5.9%
0.9%	334	13	3.8%
1.0 - 1.9%	1748	160	9.1%
2.0 - 2.9%	855	122	14.2%
3.0 - 3.9%	534	102	19.1%
4.0 - 4.9%	310	76	24.5%
5.0 - 5.9%	221	55	24.8%
6.0 - 6.9%	152	39	25.6%
7.0 - 7.9%	79	23	29.1%
8.0 - 8.9%	47	21	44.6%
9.0 - 9.9%	28	6	21.4%
10% +	35	16	45.7%

NOTE: Data include all vehicles which were observed during the test. Approximately 80% of these vehicles had a RSD CO reading from 0.0% to 0.9%. These data were broken down into .1% increments for further analysis to determine a cutpoint for "clean" vehicles. The focus was to identify "clean" vehicles and exempt them from testmp. with a minimum of "dirty" vehicles being exempt by mistake.

Table 12
Average RSD CO Readings
Predictor of Idle Emissions Test Results

RSD CO Reading (%)	Single RSD Reading			Average of 2 or More RSD Readings			Average of 3 or More RSD Readings		
	Cumulative			Cumulative			Cumulative		
	Number Observed by RSD	Number Failed Idle Test	Percent Failed Idle Test	Number Observed by RSD	Number Failed Idle Test	Percent Failed Idle Test	Number Observed by RSD	Number Failed Idle Test	Percent Failed Idle Test
0	1743	23	1.3%	248	2	0.8%	35	0	0.0%
0.1	3440	42	1.2%	664	5	0.8%	139	0	0.0%
0.2	4545	66	1.5%	948	9	0.9%	204	0	0.0%
0.3	5219	88	1.7%	1107	10	0.9%	247	0	0.0%
0.4	5681	99	1.7%	1231	10	0.8%	275	0	0.0%
0.5	5992	107	1.8%	1311	12	0.9%	298	0	0.0%
0.6	6249	115	1.8%	1375	14	1.0%	314	1	0.3%
0.7	6456	127	2.0%	1430	17	1.2%	327	2	0.6%
0.8	6635	138	2.1%	1479	21	1.4%	336	3	0.9%
0.9	6775	142	2.1%	1508	22	1.5%	347	4	1.2%
1.0	6878	147	2.1%	1533	24	1.6%	350	4	1.1%
1.1	6980	155	2.2%	1556	26	1.7%	358	4	1.1%
1.2	7076	162	2.3%	1572	26	1.7%	366	4	1.1%
1.3	7138	166	2.3%	1585	27	1.7%	371	4	1.1%
1.4	7215	170	2.4%	1602	29	1.8%	374	4	1.1%
1.5	7279	182	2.5%	1617	30	1.9%	381	5	1.3%
1.6	7346	187	2.5%	1643	34	2.1%	388	6	1.5%
1.7	7397	191	2.6%	1657	36	2.2%	393	7	1.8%
1.8	7453	204	2.7%	1677	39	2.3%	397	7	1.8%
1.9	7493	207	2.8%	1686	39	2.3%	399	7	1.8%

NOTE: Data include only vehicles which were observed 100 days of the idle emissions reading. Approximately 89% of the vehicles has a RSD CO reading from 0.0% to 1.9%. This data were used to determine a cutpoint for "clean" vehicles for possible exemption from testing.

Table 12 on page 22 shows the results of averaging multiple RSD readings to differentiate “clean” vehicles from “dirty” vehicles. As more readings were taken, variations in RSD readings for a particular vehicle tended to average out resulting in an average CO level which more accurately reflected the vehicle’s pollution level. Using three or more RSD readings, all vehicles averaging less than 0.6% CO could be excluded from testing without any false PASSES. Since 67.9% of all vehicles in this sample fell into this category, fully two-thirds of the vehicles observed three or more times could have been exempted from emissions testing.

“Exemption” cutpoints used for this analysis were very crude and based on the fleet as a whole. Given collection of more data and further analysis, cutpoints could be refined to include factoring in vehicle age and even specific vehicle makes and models (i.e., a 1994 Chevrolet could have one criteria; whereas, a 1975 Volkswagen could have a different criteria). Even after “clean” vehicles were being exempted, a random sampling of exempted vehicles could provide additional, up to date, data for refining cutpoint criteria.

Data in this study indicated that RSD technology provided emissions readings having a high degree of variability. This was consistent with Federal Test Procedure (FTP) plots of emissions over time during simulated driving conditions and with actual readings taken from vehicles during normal operations. In other words, the variability of RSD readings was a natural outcome of normal engine performance during the changing conditions of normal driving. A high correlation between RSD readings and idle emissions test readings taken under strictly controlled conditions was unlikely. Some conditions that affect emissions readings were engine temperature and environmental factors. The lack of a high correlation between the RSD readings and idle emissions test readings did not reflect upon the accuracy of the RSD readings.

Objective D: Assess the performance of the electronic data interchange.

Findings

Findings of the performance of the electronic interchange were:

- Electronic interchange (downloading, storing, sorting, and retrieving data) was performed very efficiently without any problems.
- No problems were encountered when matching license plate data with AQB idle emissions data base.

Data Analysis

At the end of each day, data were downloaded from the “Smog Dog” computer onto removable hard disks. It was delivered immediately to the AQB office where data were imported into a data base for processing. Each license plate record was then manually reviewed for accuracy in transcribing the video license plate image to digitized license plate

number stored in the data base. Once records were reviewed, the data base was sorted to remove all unreadable, dealer, out-of-state, and non-Ada County license plates. Ada County data were used to query AQB emissions data base to add vehicle manufacture year and the date. As vehicles had idle emissions tests over the next seven months, CO readings, date, and results of the idle tests were added.

Field technicians and the project data operator maintained data logs to document any electronic data interchange or data processing problems. No incidents were recorded.

The project data officer also indicated no problems occurred retrieving data. The data base operated efficiently in storing and retrieving collected data. Data were sorted, matched, and retrieved to perform data operations of this test. Data were tallied to obtain summaries and breakdowns on specified data (i.e., like the number of readable/unreadable license plates and valid/invalid emissions readings for Ada and non-Ada County registered vehicles). In addition, floppy disks containing RSD/AQB emissions data base were provided to the statistician to conduct the emissions analysis.

Over 59,000 observations were recorded during this test. Data recorded by the “Smog Dog” computer system is shown in Appendix C. Most readable Ada County license plates were matched with information in the AQB emissions data base. Number of matches were high because this data base is updated monthly, and Idaho law does not allow the transfer of vehicle license plates to another vehicle owner. Individual selling their vehicles keep the license plates.

Objective E: Assess the transferability of the system, as implemented in the Operational Test, to other localities.

Findings

Findings of the transferability of the RSD system to other localities were:

- LPR computer had to be pre-programmed and verified to identify license plate characters.
- LPR technology was capable of reading license plates. Additional manual effort was required when the same license plate number was issued for different types of license plates (i.e., Wildlife, Purple Heart, etc.).
- The majority of roadways were monitored. The RSD equipment used in this test could only monitor one travel lane. Each roadway had to be reviewed for traffic congestion, traffic control, and RSD equipment set up with the responsible transportation engineering agency.
- Weather conditions, both sunny and rainy, created problems for LPR. An automatic aperture and longer camera hood (shading the lens) should be added to the video camera to regulate the amount of light into the camera.

- The current RSD system used for this study did not identify vehicles with “cold starts. ”

Data Analysis

The RSD system allowed this local jurisdiction to monitor emissions from moving vehicles while minimizing inconvenience to vehicle owners. In most cases, other motorists on the roadway system were also not inconvenienced. Potential issues that need to be addressed to use RSD technology in other localities were identified as:

1. Roadway Characteristics

Traffic volumes and number of travel lanes had a major impact upon the transferability of the RSD system. RSD technology was capable of monitoring license plates and capturing tailpipe emissions of moving vehicles on the following types of roadways on this test:

- Two-lane roadways with landscaped center medians where the source generator and infrared sensor can be placed in the median,
- Three-lane roadways where the source generator and infrared sensor can be placed in the center left-turn lane, and
- Freeway ramps with wide shoulders.

The RSD equipment used during this test could only monitor one travel lane at a time.

This test did not use five-lane arterials (with continuous left-turn lane) or multi-lane highways. Five-lane arterials could possibly be used with appropriate traffic control. Existing traffic congestion should be considered when determining whether the roadway is suitable to use. Traffic control details need to be designed and approved by the responsible transportation engineering agency. “Smog Dog” vans and RSD equipment should be positioned outside the travel lanes. Field technicians need experience working in traffic, specifically, if primary arterials/highways are considered. RSD equipment needs to be set up before peak travel periods.

2. RSD Equipment

Prior to using RSD equipment to transcribe license plates, LPR computer system needed to be programmed to identify license plates characters. The program calculated a confidence factor for how well it read each license plate and included this confidence factor with the stored data record. A separate program was used later in non-real time to review or “truth” all transcribed data with a confidence factor below a selected value. Confidence levels as assigned by the LPR program were generally reliable indicators of how accurately the license plate number was transcribed to computer readable characters.

Different types of license plates and the duplicate issuance of license plate numbers impacted the readability of the license plates by the LPR system. While the LPR system transcribed license plate characters, the graphic background of the license plate was not interpreted by the computer. If a locality has several different types like Idaho, additional programming of the LPR or additional effort to review the license plate data and to re-enter the information is required.

A primary obstacle of using the existing RSD/“SmogDog” system was the source generator which provided power to emissions sensors. The source generator located approximately 20-30 feet from the infrared sensor was gas powered and required filling approximately every four hours. Performing this task on high-volume arterials created numerous safety concerns for the field technician crossing traffic.

The source generator and infrared sensor placement need to be considered when selecting test sites. On two-lane roadways, one-lane freeway ramps, three-lane roadways, the source generator and infrared sensor can be placed in a landscaped median, on roadway shoulders, or in a center-turn lane, respectively. On five-lane roadways or multi-lane highways, location of the source generator and infrared sensor creates some traffic control and safety concerns. Equipment needs to capture only one travel lane, usually requiring the equipment placement on the centerline. A gas powered generator in the middle of the roadway unprotected is not desirable. Recent discussions with the vendor indicate they are working on eliminating the gas powered generator.

In addition, current technology does not allow identification of “cold start” vehicles. Test site locations are critical in the elimination of this factor on emissions readings. To obtain large volumes of emissions readings, high-volume roadways need to be monitored. Usually these roadways are adjacent to shopping centers/malls and large employment centers and capture vehicles in a “cold start” condition.

3. Weather Conditions

Weather conditions played a major role in the use of RSD equipment. Rain can interrupt emissions monitoring periodically or terminate it. Windy conditions require calibration of emissions equipment more regularly.

Intermittent cloudy days affected readability of the license plates. Lighting conditions can require the technician to manually adjust the amount of light into the camera. This task can be very tedious if lighting conditions constantly change. An automatic aperture on the video camera can minimize this effort.

4.2 Evaluation Goal 2: Evaluate the Transportation System Impacts

Objective A: Assess the impacts on the transportation system of using RSD equipment for emissions monitoring.

Findings

Findings for the system impacts on the transportation system were:

- No noticeable platooning of vehicles was seen by the technicians.
- When selecting a site, consider the impacts on walking routes for pedestrians, of traffic congestion created by signalized intersections, of driveways and parking lots adjacent to the site, and on traffic turning left accessing businesses.

Data Analysis

Observations by field technicians indicated that RSD equipment in the roadway had no noticeable impacts on the platooning of vehicles (groups of vehicles). Roadways monitored during this test were: three-lane arterials with continuous center-left turn lane; a two-lane roadway with center landscaped median; and a freeway ramp with wide shoulders. A 11-14 foot travel lane was always maintained which kept the traffic moving through the test site.

The field technicians indicated the majority of test sites worked well. Three test sites were identified with concerns which needed to be addressed when selecting future sites.

- **Walking Routes for Pedestrians** - The site at Curtis Road created a concern when school children walking on the roadway shoulder were required to walk around the “Smog Dog” van in traffic. Curtis Road was a three-lane arterial with six-foot wide gravel shoulders (no sidewalks). The “Smog Dog” van blocked the use of the shoulder.
- **Traffic Congestion Created by Signalized Intersections** - During the evening peak period, the site at Emerald Street experienced traffic congestion created by a signalized intersection. The site was mid-block between two signalized intersections which were less than a mile apart. Traffic backed up from the intersection to the site which created “stop-and-go” traffic. No problems occurred during morning or afternoon peak periods.

- **Driveways and Parking Lots Adjacent to Sites** - The site on Ustick Road experienced several vehicles driving through an adjacent parking lot to avoid being monitored. The parking lot was part of a small commercial retail/office complex with numerous driveways. The “Smog Dog” van was parked in the parking lot. Ustick Road at this site was a three-lane arterial with curbs and sidewalks.
- **Turn Lanes** - Three-lane roadways with a continuous left-turn lane worked the best in set-up of the RSD equipment. Left-turn volumes need to be considered in order not to impact access to adjacent businesses.

Objective B: Assess the change in driver performance at the test sites.

Findings

Findings for the change in driver performance at the test sites were:

- Data to analyze the change in driver performance were not collected during this individual test. Phase I and II of Ada County’s ITS Project collected data to analyze driver performance. The results would be expected to be similar for this phase. Travel speed reductions ranged from 9 % (on the Interstate) to 38 % (on a low-volume roadway). Average speed reduction was 19%.

Data Analysis

Traffic/speed equipment was not placed at each test site to capture vehicle speeds on the test day and its surrounding days to determine the change in driver performance. This was done during the first two phases of this operational field test. The results are discussed in **individual Evaluation Test Plan Report#1**. The results would be similar if speed equipment were placed on these roadways. During Phases I and II, travel speed reductions ranged from 9% to 38 % . The 38%, speed reduction occurred once on a low-volume roadway which was used for training. The average speed reduction was approximately 19 % ,

Driver performance through the test sites were affected by APR/RSD equipment and traffic control during these other phases. Normally, traffic engineers would target driving speeds within 10 mph of the posted speeds (high or low). On a 35 mph roadway, the traffic engineer would target 25 mph to 45 mph driving speeds. This would be approximately 30% more or less than the 35 mph posted speed. Any type of construction or traffic control along the roadway would have similar impacts on travel speeds.

4.3 Evaluation Goal 3: Evaluate the System Benefits; Assess the Effect on CO Emissions

Objective A: Assess the change in CO emissions for vehicles in the non-attainment area.

Findings

Findings for the change in CO emissions for vehicles in the non-attainment area were:

- Insufficient data were available to quantify the impact of RSD technology on the increase or decrease of CO emissions for vehicles in the non-attainment area.
- The capability of identifying “dirty out-of-area” vehicles (which are not subject to emissions tests) and vehicle owners who try to “cheat” the emissions testing system (i.e., vehicle registered outside the non-attainment area, or vehicle is claimed to be undriveable or outside the area) would reduce CO emissions in the non-attainment area.

Data Analysis

Because this analysis produced insufficient numbers of vehicles with multiple RSD readings, highly reliable cutpoints for exempting “clean” vehicles from testing and/or early testing of “dirty” vehicles were unable to be determined. Quantifying actual increases and/or decreases in emissions was therefore not possible. However, if vehicles were exempted from testing, some loss of emissions reductions may occur depending upon the pass/fail rate. The magnitude of these losses should be small and could be offset by earlier testing of apparently “dirty” vehicles and inclusion of apparently “dirty out-of-area” vehicles in emissions testing programs. In addition, the use of RSD would make it more difficult for vehicle owners to “cheat” the system. Vehicle owners would have a harder time claiming their vehicles were undriveable or outside the area. Also, RSD would facilitate the identification of vehicles which are illegally registered outside the non-attainment area to avoid emissions testing requirements. The mere presence of RSD sites would act as a deterrent to such cheating.

For established emissions testing programs with a record of passed/failed vehicles, determining criteria in the effectiveness of the program was the number of “high emitting” vehicles identified and required to fix the problem(s). Any program which assures the same percentage of the vehicle fleet is adjusted will provide similar emissions reductions. At program start-up, the cutpoint using the average of multiple RSD readings should be set conservatively to minimize the number of vehicles exempted which would have failed an idle emissions test. As more data are accumulated, cutpoint criteria should be adjusted to improve cost effectiveness of the program without increasing emissions reduction losses.

Objective B: Assess the potential impacts of using RSD technology to enhance, augment, or partially replace the current I/M program.

Findings

Findings of the potential impacts to enhance or augment the current I/M program were:

- Exemption of the majority of “clean” vehicles from emissions testing would eliminate inconvenience to a significant percentage of vehicle owners.
- Emissions reductions under a hybrid RSD/idle emissions testing program would be the same as long as the percent of the adjusted vehicle fleet remain the same. A monitoring system should be implemented to track the adjustment rate in case any refinements are needed to the program.
- The capability of RSD technology to identify “high emitting” vehicles would allow earlier detection and emissions tests for those vehicles.
- The availability to identify “out-of-area” vehicles which were not subject to emissions testing would provide for their possible inclusion in the emissions testing program.

Data Analysis

Emissions testing programs’ main contribution to improving air quality comes from identifying “high emitting” vehicles and/or vehicles with tampered emissions controls and requiring a reduction in the vehicle’s emissions levels. Currently, emissions test programs test 100% of a vehicle fleet in order to identify problem vehicles. In a mature, basic emissions testing program (one which has been testing vehicles for several test cycles), the number of vehicles identified for adjustment or repair is typically less than 10%. Most emissions reductions are a result of adjustments/repairs to this 10% of the vehicle fleet. (The only other factor effecting emissions reductions being an unquantifiable “reduction” from deterring vehicle owners from tampering with their vehicle’s emissions controls.) Therefore, 90% of the vehicles are tested with little or no improvement in air quality. Stated another way, 90% of the cost of emissions testing is non-productive. A more efficient way to identify “high emitting” vehicles is needed.

RSD offered a start in this direction. RSD readings were extremely variable in comparison to standardized emissions testing using controlled conditions. Without a means of determining exact operating conditions of sampled vehicles, single RSD readings could not adequately differentiate “high emitting” vehicles from “clean” vehicles. This was to be expected since a perfect operating vehicle in heavy, loaded acceleration, could produce higher pollutant readings than an extremely “dirty” vehicle operating in its cleanest mode-of-operation. Just as an FTP test (or **IM240** test) took emissions samples during various operating conditions and

produces an assessment of the vehicle's overall emissions levels, a series of RSD readings, along with proper assessment, could make a differentiation of "clean" and "dirty" vehicles.

Such a differentiation is neither totally accurate, nor symmetrical with respect to its distribution of vehicles on a "clean" versus "dirty" scale. There is greater likelihood a "clean" vehicle will appear "dirty" than a "dirty" vehicle will appear "clean." If always sampled in its cleanest operating mode, some "dirty" vehicles may be displaced on the scale toward the clean end. A far more likely occurrence would be an aggressive driver who consistently travels through the RSD sensors in "high emissions" mode and the vehicle appears to be "dirty." When vehicles are ordered by average multiple readings, "clean" vehicles will generally gravitate to the clean end of a continuum with "dirty" vehicles gravitating toward the opposite end. Assuming a reasonably accurate continuum can be determined, it becomes possible to exempt the cleanest vehicles on the continuum with a minimal number of "high emitting" vehicles being exempted. Likewise, vehicles appearing on the dirty end of the continuum can be given special consideration for early testing or more stringent testing standards. The use of RSD to identify "high emitting" vehicles has been used in several emissions testing programs, but real benefits of RSD technology are the identification of "clean" vehicles. This bears repeating, ***the greatest benefit derived from RSD technology is in screening vehicles and exempting "clean" vehicles from being tested.*** Because there is no benefit of testing "clean" vehicles, costs are incurred without benefit. The more "clean" vehicles that are exempted, the lower the costs.

The objective of this analysis was to find some indicator, based on RSD readings, which would predict, with a high degree of certainty, that a vehicle will pass an idle emissions test. When analyzing the relationship between ***single*** RSD and idle emissions test readings, there was no clear point at which a vehicle could be predicted to pass the idle emissions test without false PASS. This was discussed in detailed in Evaluation Goal 1, Objective C, about the accuracy of RSD technology to monitor CO emissions.

The analysis of ***multiple*** RSD readings had more positive results which was reflected in Table 12 on page 22. This table shows how averaging multiple RSD readings tend to differentiate "clean" vehicles from "dirty" vehicles. The more readings that were taken and averaged tended to more accurately reflect the pollution level of the vehicle. Using three or more RSD readings, all vehicles with an average less than 0.6% CO could be excluded from testing without any fail PASS decisions. In this study, 67.9% of all vehicles fell into this category. Thus, fully two-thirds of the vehicles observed three or more times could have been exempted from emissions testing.

"Exemption" cutpoints used for this analysis could be enhanced through further research. Given the collection of more data and further analysis, cutpoints could be refined to include factoring in vehicle age and even specific vehicle makes and models (i.e., a 1994 Chevrolet could have one criteria whereas a 1975 Volkswagen could have a different criteria). Even after "clean" vehicles are being exempted, a random sampling of exempted vehicles could provide additional, up to date, data for refining cutpoint criteria.

An emissions testing program supplemented by RSD technology could start with very conservative "exemption" cutpoints and monitor the program effectiveness by measuring vehicle adjustments as a percentage of vehicle fleet. Since emissions reductions are primarily a

result of vehicles adjusted, reductions would remain the same as long as the percent of vehicles adjusted remains the same. The capability of RSD readings to identify “high emitting” vehicles, even though possibly less accurate than identification of clean vehicles, allows the possibility of bringing vehicles in early for emissions tests and enhancing the effectiveness of the program. In addition, RSD readings could be used to screen “out-of-area” vehicles which are not normally subject to emissions testing and require the apparent “high emitting” vehicles be tested.

In conclusion, data for this analysis were insufficient to provide exact criteria to determine a definite pass or definite fail. More data is needed. However, there is evidence that RSD screening of a vehicle fleet, using the average of multiple readings, could provide for the identification of vehicles having a high probability of passing an idle emissions test. Those vehicles could be exempted from emissions testing. Inconvenience and costs to a large percentage of vehicle owners with “clean” vehicles is eliminated. This group may constitute 90 % or more of all vehicles in Ada County.

The question then becomes one of cost effectiveness. Example: A current fleet of 100,000 vehicles was tested. Assuming that all 100,000 were observed a minimum of three times, based on the initial findings of this study, approximately 68,000 would be exempted as “clean.” Idle tests would be acquired for the remaining 32,000. Assuming a .1 % false PASS using the cutpoint 0.5 % CO, only 32 “dirty” vehicles would be exempted. The other 9,768 “dirty” vehicles would be subject to the idle test.

4.4 Evaluation Goal 4: Evaluate the System costs

Objective A: Document the costs for the Operational Test: RSD capital costs, operating costs, staff costs, and supervision costs.

Findings

• RSD costs (leasing one “Smog Dog” van)	\$22,000
• Operating costs (renting one cellular phone, purchasing hard drive, removable disk drive, and back up tapes, repairing generator, purchasing insurance for van)	1,262
• Labor costs (local technicians & staff, consultants)	<u>68,233</u>
Total	\$91,495

Objective B: Estimate cost of theoretical emissions testing system using RSD.

Findings

Findings of the cost of theoretical emissions testing system using RSD were:

- Cost savings per registered vehicle using a hybrid RSD/idle emissions testing program would range between \$0.28 and \$2.19 depending upon the percentage of vehicles observed sufficient times to be evaluated (three times or more) and the percentage of vehicles exempted from testing.

Data Analysis

Ada County currently has a basic emissions testing program using BAR90 analyzers to perform idle emissions tests on all gasoline powered vehicles, 1965 and newer and weighing 1500 pounds gross vehicle weight or greater. Enforcement is by computer matching. A vehicle owner who fails to get a required emissions test has their vehicle registration revoked. It cannot get re-registered until the vehicle is tested. Table 13 on the next page shows the annual administrative and operational costs for the current program. This table also shows the projected costs of a combined RSD/idle emissions testing program.

Figure 3 on page 35 shows the process of and costs associated with the current idle emissions testing program and a hypothetical hybrid program (RSD/idle emissions testing). The hybrid program includes vehicles with an average CO emissions of 0.5 % or less (three or more readings required) and exempts “clean” vehicles from idle emissions testing. The left side of the diagram relates to the current idle test program. On top of the fixed administration and operational costs for the current system is an \$8.50 cost per vehicle tested. Assuming a total testable vehicle count of 195,000 and a test rate of 93%, the total idle emissions test program is \$1.7 million.

Table 13
Comparison of Administrative Costs

	Current Idle Test Program	Proposed Hybrid Program	Remarks
Personnel Payroll	\$224,090	\$332,017	Added 5 personnel to run RSD and process data.
Vehicle Expenses	\$2,986	\$9,500	Increased cost of operating RSD equipment.
Insurance	\$2,388	\$4,000	Increased liability.
Supplies	\$3,222	\$5,000	Increased supplies for operation of RSD.
Other Expenses	\$1,309	\$2,000	Increased miscellaneous costs associated with running administrative functions.
RSD Financing		\$59,404	Added finance payments for 3 "Smog Dog" vans/RSD equipment.
Equipment Maintenance	\$1,290	\$2,000	Increased maintenance costs.
Office Costs	\$57,438	\$55,744	Remained the same.
Computer Processing	\$4,808	\$4,808	Remained the same.
Totals	\$297,531	\$474,472	

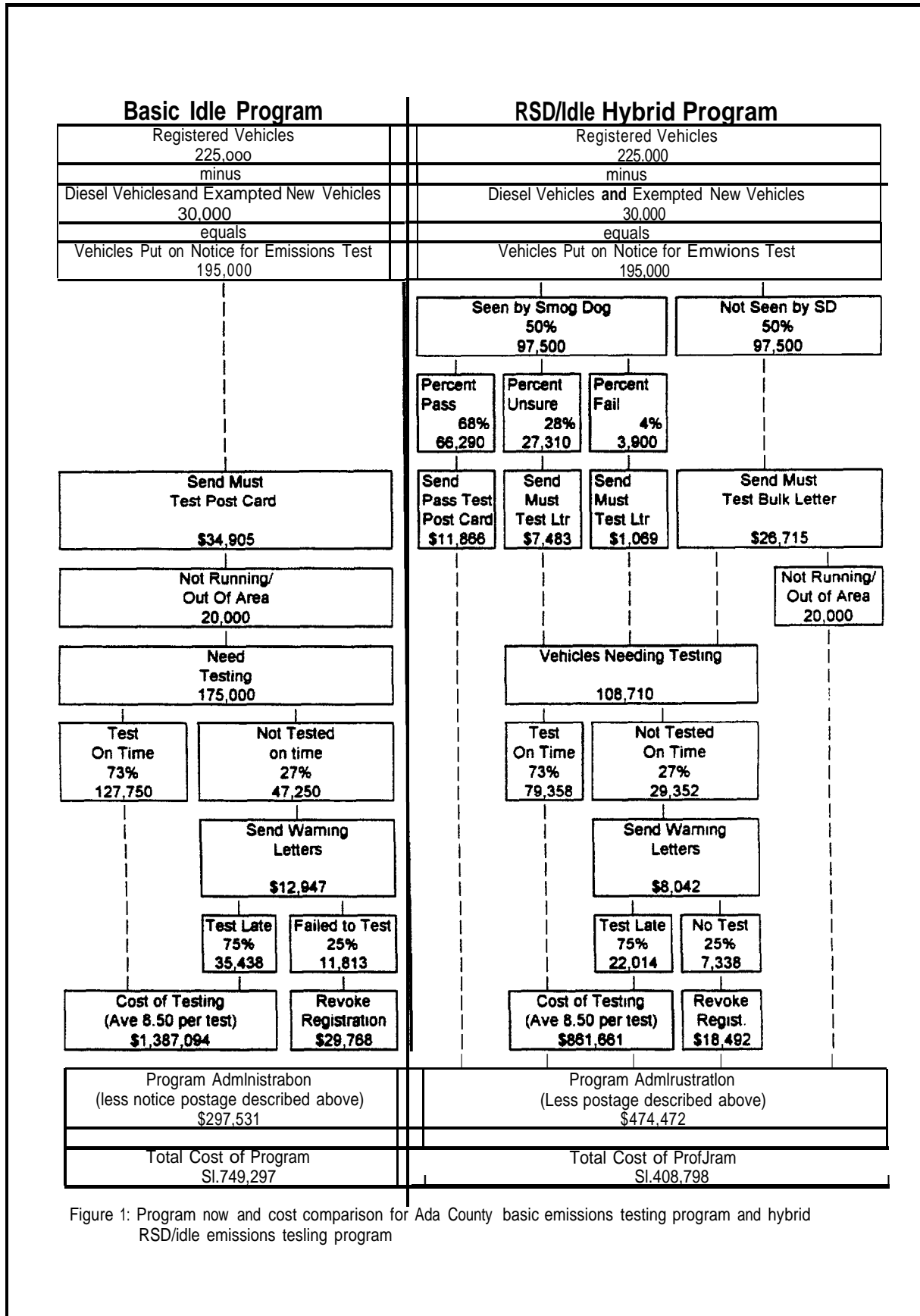


Figure 1: Program now and cost comparison for Ada County basic emissions testing program and hybrid RSD/idle emissions testing program

Figure 3 - Basic Idle Program and RSD/Idle Hybrid Program Process and Cost Comparison

Table 14 illustrates the cost savings associated with the RSD/idle hybrid testing program over the current program. The percentage of total vehicles with three or more readings would be obtained was varied from 25% to 65%.

Table 14
Proposed Hybrid Program Savings

Percent of Vehicle Fleet Observed Three Times or More	Total Hybrid Program costs	Savings Over Basic Idle Emissions Testing Program	Savings Per Registered Vehicle	Vehicles Exempted from Testing
25%	\$1,683,754	\$65,543	\$0.29	17.3%
30%	\$1,628,963	\$120,334	\$0.53	20.7%
35%	\$1,574,172	\$175,125	\$0.78	24.2%
40%	\$1,519,381	\$229,916	\$1.02	27.6%
45%	\$1,464,590	\$284,707	\$1.27	31.1%
50%	\$1,409,799	\$339,498	\$1.51	34.5%
55%	\$1,355,008	\$394,289	\$1.75	38.0%
60%	\$1,300,217	\$449,080	\$2.00	41.4%
65%	\$1,245,426	\$503,871	\$7.34	44.9%

This analysis was based on the cutpoint of 0.5 % CO (average of three or more readings). It provides a reasonable cutpoint that allowed for the exemption of 67.9% of the vehicles observed at least three times. As additional data are collected, the cutpoint criteria could be refined to increase the percent of vehicles exempted. In order to avoid losses in emissions reductions, percentage of adjusted vehicles should be closely monitored. Note, as the percentage of vehicles measured three or more times increases, the potential savings rate increases. The observation rate depends on the number of RSD units, their location, and the period of time allowed to collect observations.

5.0 Hypotheses

As part of this evaluation, three hypotheses were identified to be tested. These hypotheses are briefly discussed below.

5.1 Hypothesis A - There is a RSD-generated carbon monoxide (CO) emissions measurement below which a passing reading on an idle emissions test is predicted with 95% accuracy.

Findings

- Insufficient data were available to address this hypothesis through statistical analysis. Using multiple readings, cutpoints to identify “clean” vehicles and exclude them from testing with an acceptable level of confidence can be developed. With further data collection and analysis, cutpoint can be refined to include vehicle age, make, and model.

Data Analysis

Although an insufficient amount of data (specifically enough vehicles with multiple RSD readings) precluded a definitive answer to this hypothesis which would stand up to statistical analysis, the trend in the collected data indicated that one or more criteria could be developed with a reasonable level of accuracy.

5.2 Hypotheses B - There is a RSD-generated carbon monoxide (CO) emissions measurement above which a failing reading on an idle emissions test is predicted with 95% accuracy.

Findings

- Insufficient data were collected to provide statistically reliable results.

Data Analysis

Insufficient data collection precluded a rigorous statistical analysis that could address this hypothesis. Although the use of multiple RSD readings tends to differentiate “clean” vehicles from “dirty” vehicles, the reverse was not as clear. It was more difficult for “dirty” vehicles to pass the RSD site in the right condition to show a low CO reading than it was for a “clean” vehicle to pass the site in a “high emitting” mode.

5.3 Hypotheses C - Revising the current idle emissions testing methodology to incorporate RSD testing methodology will reduce total program costs and maintain and/or improve air quality.

Findings

- Results of this analysis suggested that incorporating RSD technology into an emissions testing program has the potential to produce monetary savings and maintain air quality in the non-attainment area.
- Incorporating RSD technology into an emissions testing program would also reduce the inconvenience to registered vehicle owners in the non-attainment area.

Data Analysis

The limited data collection for this analysis tended to indicate that RSD screening of a vehicle fleet could be used to exempt a significant portion of the vehicle fleet from emissions testing requirements. Even the worst case projections - low percentage of multiple vehicle observations and conservative cutpoints - presented a modest monetary savings while substantially reducing inconvenience to registered vehicle owners in the non-attainment area.

6.0 National ITS Goals

Six goals were developed for the National ITS Program. The following section will address three of the six goals which relate to this specific phase of the ITS Project for Ada County.

6.1 Reduce Energy and Environmental Costs Associated with Traffic Congestion

As more vehicles travel roadways and travel demand exceeds roadway capacity, travel conditions become more congested. With this congestion, higher levels of air pollution are produced and energy consumption is increased. Emissions monitoring of moving vehicles creates an opportunity to reduce air pollutants produced by vehicles and energy consumption.

This analysis produced insufficient numbers of vehicles with multiple RSD/“Smog Dog” readings to determine highly reliable cutpoints for exempting “clean” vehicles from testing and/or early testing of “dirty” vehicles. Quantifying actual increases or decreases in emissions

were not possible. If vehicles were exempted from testing, some loss of emissions reductions may occur. The magnitude of these losses would be small and could be offset by earlier testing of apparently “dirty” vehicles and inclusion of apparently “dirty out-of-area” vehicles (not subject to emissions testing requirements). Inclusion of RSD in the emissions testing program would make it more difficult for vehicle owners to claim their vehicle is undriveable or outside the area. Additionally: it would identify vehicles which are illegally registered outside the non-attainment area to avoid the emissions testing requirements. Therefore, RSD technology could maintain or actually improve air quality by identifying “dirty- vehicles earlier, “dirty out-of-area” vehicles, vehicles which owners claim to be undriveable or outside the area, and illegally registered vehicles outside the non-attainment area.

A vehicle which produces higher levels of emissions is also not operating efficiently. An inefficient vehicle will use more fuel which impacts local, state, and national energy supplies. Identifying these high polluting vehicles and having vehicle owners repair or adjust the vehicle will produce a positive effect on energy conservation.

6.2 Enhance Present and Future Productivity

This objective was to reduce transportation costs for all users of the transportation system. By identifying high emitting vehicles and requiring the vehicle owner (individual or business) to adjust or repair the vehicle, the operation efficiency of the vehicle increases and reduces the demand on the energy supply. Demand for fuel decreases, energy costs decrease. Both individuals and businesses reap the rewards, better operating efficiency and cost-effectiveness of their vehicles. RSD technology provides the opportunity to identify “high emitting” vehicles earlier than idle emissions testing. In addition, it provides the opportunity to incorporate other “dirty” vehicles into the emissions program which are unable to be identified with the current emissions testing methods. Earlier detection and expanding the vehicle test population provide the opportunity to correct the emissions problems sooner.

6.3 Create an Environment in Which the Development and Deployment of ITS Can Flourish

An objective of the national ITS program was to assist public/private agencies in hardware, software, and services development and the deployment of this technology. Through this program, the U.S. can achieve substantial domestic market penetration and strong international presence.

Use of RSD technology in Ada County provided valuable insights in this new technology which will assist in its advancement. First, the existing camera system required manual adjustments of the aperture to control the amount of light into the camera. When cloudy conditions existed, the technician needed to regularly adjust the aperture to ensure the quality of the license plate image. The camera system can be improved by incorporating an automatic

aperture and a longer camera hood to regulate the amount of light into the camera. This improvement would reduce the number of unreadable license plates and the need to manually enter them into the data base. It also would improve safety on the roadway by minimizing the amount of time the technician works in traffic.

Second, this test occurred on various types of roadways within the urban area. Most recently, the roadways were a two-lane arterial with landscaped median, three-lane arterials, and a freeway on-ramp. Existing traffic conditions need to be reviewed carefully when selecting sites. Pedestrian routes, traffic congestion created by signalized intersections, and driveways and parking lot locations need to be considered.

Third, improvements need to be made in the set up of the source generator and sensors. Placement of the source generator in the center of the roadway near the infrared sensor created numerous safety concerns for both motorists and technicians. Motorists can easily hit them. Technicians needed to periodically fill them which required them to work in traffic.

Lastly, RSD technology can expand the existing emissions program to capture other “dirty” vehicles which cannot be identified with the current emissions testing methods or are not included in the testing program. RSD technology provides an opportunity to identify out-of-county commuters and determine whether these vehicles contribute to the air quality problems in a non-attainment area. With this information, jurisdictions have valuable data to support any needed changes in existing air quality programs. Other vehicles can now be monitored:

- “Dirty” vehicles which are identified earlier;
- Vehicles which their owners claim the vehicle was undriveable or outside the area; and
- Vehicles illegally registered outside the non-attainment area.

RSD technology provides opportunities for program enhancements which other emissions testing methods do not provide. In addition, it eliminates inconvenience to the vehicle owner. Chapter 2, Institutional, Legal, and Public Acceptance Issues, discusses public acceptance of RSD technology. However, through a public acceptance survey, over 82 % of the survey respondents indicated the RSD method would encourage more support for emissions testing.

7.0 Conclusions

This test was to determine whether RSD technology can be used to enhance an existing idle emissions testing program while reducing costs. Two issues arose during the data analysis of this test.

- Insufficient data were available to quantify the increase or decrease of CO emissions for vehicles in the non-attainment.
- A direct relationship between a single RSD and idle emissions test readings could not be developed. This does not reflect upon the accuracy of the RSD readings.

The analysis took a new, more positive approach to enhancing its existing idle emissions testing program. Multiple RSD readings were averaged to differentiate “clean” vehicles from “dirty” ones. As more readings were taken, the variations in RSD readings for a particular vehicle tend to average out which more accurately reflects the CO level of the vehicle. With these average RSD readings, a certain percentage of vehicles can be exempted from idle emissions testing without any false PASSES. Given more data and further analysis, cutpoints could be refined to include vehicle age, make, and model. Further analysis should be done. Screening the vehicle fleet to exempt “clean” vehicles would eliminate inconvenience to the majority of vehicle owners and would encourage more support for emissions testing programs. Public acceptance of RSD technology is discussed further in Chapter 2.

Use of RSD could also enhance the emissions testing program by expanding the vehicle population which it tests. “Dirty” vehicles could be identified, possibly not as accurately as “clean” vehicles, and required to be tested sooner which would enhance the program’s effectiveness. “Dirty out-of-area” vehicles which are not subject to emissions testing could now be included into the testing program. Vehicle owners who try to “cheat” the emissions testing system by registering their vehicle outside the non-attainment area or by claiming their vehicle is undriveable or is outside the area could be identified with this technology. All these vehicles could be tested. These possible enhancements to the idle emissions testing program could reduce CO emissions in the non-attainment area. Phase II of this Operational Test concluded that non-tested vehicles have higher CO emissions levels than tested vehicles (approximately 10-15 %). By monitoring emissions of those vehicles which are not tested today for some reason, CO emissions levels could be reduced in the non-attainment area.

Chapter 2 - institutional, Legal, and Public Acceptance issues

1.0 Purpose of Test

As with any transportation and air quality management program, institutional, legal, and public acceptance issues need to be addressed in order to guide in the development and implementation of a program. Jurisdictional coordination and cooperation, legal opinions, and public acceptance need to be obtained to implement transportation and air quality programs with consensus of policy makers and the public. The purpose of this test was to evaluate possible institutional and legal barriers toward the implementation and to assess the public's acceptance of Intelligent Transportation System (ITS) technology.

In most metropolitan areas, traffic and air quality management is scattered across political jurisdictions. This creates institutional barriers. In some cases, these responsibilities are also dispersed across separate agencies within that jurisdiction. If communication and cooperation among these public agencies is limited, then implementation of public projects is much more difficult. This may be the case when public agencies try to coordinate and implement an ITS Program.

Besides these institutional issues, some ITS programs employ automated surveillance technologies which raise concerns over public privacy. The Harris-Equifax Consumer Privacy Survey (1991) revealed that Americans are ambivalent about their feelings towards privacy issues. Individuals want their privacy protected, but they also want benefits that require everyone's privacy be reduced.

Determination of public acceptance was an important element that participating agencies integrated into the ITS Project for Ada County. New technology is changing society and the world. Government must be sensitive to the fact that dealing with such fundamental changes can have profound effects, positive and negative, on the public. Remote Sensing Devices (RSD) technology can have such an effect. The public must be provided a basic understanding of the technology if they are to accept it.

Transportation and air quality agencies in Ada County and the State of Idaho formed a partnership to conduct an Origin & Destination (O/D) study and to monitor vehicle emissions using RSD. These governmental agencies tested this advanced technology to assess whether an O/D survey and vehicle emissions tests can reduce costs and transportation system impacts of current methods, minimize the inconvenience to the public, and improve the overall efficiency of the projects.

2.0 Test Operations

As part of the ITS Project for Ada County, a three-phase operational test was developed and implemented to test RSD technology. RSD can read vehicle license plates and monitor vehicle emissions. Phases I and II were conducted simultaneously during the last week of April 1995. Phase I used video imaging technology to conduct an O/D survey. Phase II used the video imaging technology, plus emissions sensors to determine emissions levels of non-tested vehicles entering Ada County, as compared to Ada County vehicles which are tested regularly.

Phase III occurred primarily during the month of May 1995. It used the RSD technology to determine the feasibility of enhancing the current Inspection and Maintenance (I&M) program in Ada County.

As stated in Section 1.0, Purpose of Test, an important element of the ITS Project was to evaluate institutional and legal barriers that may arise before, during, and after the Operational Test. Some institutional and legal (i.e., privacy) issues which arose were:

Institutional Barriers

- The need for cooperation among all local and state transportation agencies;
- The need for cooperation among those transportation agencies and the air quality agency; and
- The need for cooperation of City, County, and State law enforcement and emergency agencies.

Legal (Privacy) Barriers

- Taking a photograph of the vehicle license plate;

Transportation and air quality agencies in Ada County and the State of Idaho formed a partnership to conduct the travel survey and to monitor vehicle emissions using RSD technology for the ITS Project for Ada County. Ada Planning Association (APA) was the coordinating agency. Participating agencies included: Air Quality Board (AQB); Ada County Highway District (ACHD); Idaho Transportation Department (ITD); Federal Highway Administration (FHWA); Environmental Protection Agency (EPA); and Idaho Division of Environmental Quality (DEQ). Other participants included Hughes Santa Barbara Research Center, “Smog Dog” vendor, and CH2M-Hill, the independent evaluator. The participating public agencies had a good working relationship on regional issues prior to the Operational Test. Each of these agencies had a large stake in its success to ensure any institutional issues were resolved as soon as possible.

During the initial development of this ITS Project, a legal opinion was requested from ITD legal counsel before the project proceeded. They identified no legal issues to refrain from

proceeding with the Operational Test. While a legal opinion was obtained from the State's Transportation Department, the Evaluation Research Team suggested another legal opinion be obtained from the State Attorney General prior to the Operational Test.

A letter from the State Attorney General's office restated the legal opinion from the ITD legal counsel. To proceed further is solely a policy action of the planning agency (see Appendix D) .

A public awareness campaign targeted elected and appointed officials, public administrators, vehicle owners, and the general public was developed and implemented prior and throughout the Operational Test. The public awareness campaign included:

- Notification about the specific operational hours and test sites to all emergency agencies in Ada County and its surrounding counties (prior to test).
- Distribution of a press release kit which included information on the ITS Project for Ada County and on other published ITS articles was distributed to all regional newspapers, radio and television stations (prior to the Operational Test).
- Newspaper, radio and television interviews which were aired (during the test).
- A press conference for news media (first day of the Operational Test).
- Distribution of press releases prior, during, and after the Operational Test.
- Responding to public inquiries as soon as possible about the ITS Project.

Prior to the Operational Test, APA presented a synopsis of the ITS Operational Test to all stakeholders; elected and appointed officials and administrative staff from Idaho Transportation Board, AQB, five affected counties, seven affected highway districts, and twelve affected cities. During this presentation, stakeholders were asked to complete a stakeholder survey to assess public acceptance of using RSD/LPR technology. APA received 145 completed surveys.

In August 1995, a follow-up survey was distributed by mail to these same stakeholders. This was done to determine whether their opinions had changed over the course of the Operational Test. A total of 28 stakeholders completed the follow up survey. Only 11 of the 28 stakeholders completed both surveys.

In May and June 1995, a telephone survey was conducted with 811 vehicle owners who passed through the test sites during the Operational Test (all three phases). These 811 vehicle owners were randomly selected from the collected test data. Participants were residents in Ada County or its surrounding counties. The interviewing process occurred as soon after the actual RSD data collection as possible.

3.0 Data Analysis

This section describes the data collected during the Operational Test and the data analysis used to evaluate the goals and objectives identified in the Individual Evaluation Test Plan 4, Institutional, Legal, and Public Acceptance Issues.

3.1 Legal Barriers

3.1 .1 Evaluation Goal 1: Effects of legal issues on the Operational Test and future deployment.

Objective A: Identify all legal issues encountered and appraise the extent of their impacts.

Findings

The findings of the legal issues encountered were:

- No legal issues arose before, during, or after the Operational Test.

Data Analysis

As mentioned previously, a legal opinion was obtained from both the Idaho Department of Transportation legal counsel and the State Attorney General's office. Both legal counsels did not indicate any legal problems with capturing license plate information and monitoring vehicle emissions. No legal issues arose during or after this test.

Objective B: Assess citizens' perception of legal issues.

Findings

The findings of citizens' perception of legal issues were:

- Prior to the Operational field Test, over 70% of the stakeholders indicated RSD technology was not too intrusive to use.
- The second stakeholder survey did not receive a large response, only 28 surveys returned. Approximately 50% of these stakeholders indicated that the use of RSD was not too intrusive. Of the 28 returned surveys, approximately 21% were from stakeholders representing an Ada County community which is not participating in the existing I&M program.

- Approximately 75 % of the telephone survey participants indicated they did not consider taking a video of the license plate, and identifying their name and address in the motor vehicle records to aid in efforts to clean up the air as an invasion of their privacy.
- Of the 23 % survey respondents who indicated a seriousness in the invasion of privacy, approximately 60% indicated that it was somewhat or not very serious.
- In addition, these survey respondents indicated that video taping the license plate (50%) followed by obtaining their name from DMV (41%) was the most serious invasion of privacy.

Data Analysis

Public inquiries and comments were logged throughout the Operational Test. Most of these inquiries occurred during Phases I and II (O/D Survey and Emissions Monitoring at External Stations, respectively). Less than 1% of the vehicle owners passing through the test sites contacted the APA office. Half of these vehicle owners inquired about the Operational Test or asked questions pertaining to the O/D survey. The remaining half voiced negative comments about the Operational Test. Approximately half of these comments pertained to “Big Brother” watching you.

The 811 telephone survey participants, who drove through the test sites, were asked whether taking a video of their license plate, identifying their name and address in the Division of Motor Vehicles data base, and sending them a survey to aid in transportation planning and to clean up the air is considered an invasion of their privacy. Approximately 75 % indicated that it was not an invasion of privacy and 23% indicated that it was an invasion. The remaining 2% had no opinion.

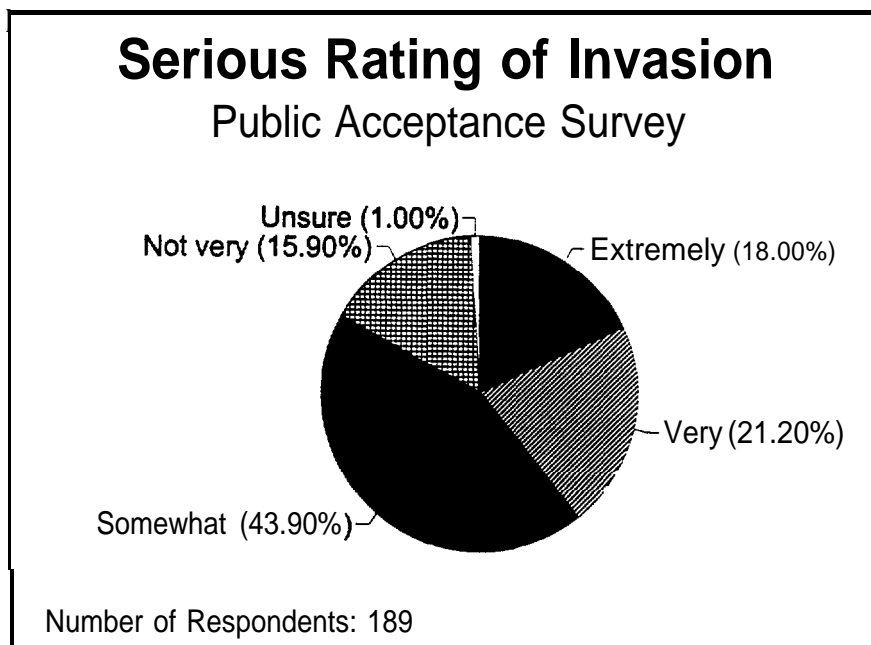


Figure 4 - Serious Rating of Invasion

Survey participants who indicated the RSD technology was an invasion of privacy were asked another question. This related directly to how serious they felt the invasion of privacy. Figure 4 shows these results. Approximately 40% stated the invasion of privacy was extremely or

very serious. These survey participants were then asked what do they consider the MOST SERIOUS invasion of privacy. Fifty percent indicated the video taping of the license plate was the most serious invasion of their privacy, and getting their name from DMV followed (see Figure 5).

A stakeholder survey was distributed to elected and appointed officials and administrative staff from Ada County and its surrounding counties prior to the Operational Test.

This was done to assess public acceptance of using RSD/LPR technology. APA received 145 completed stakeholder surveys which were distributed prior to the Operational Test.

Stakeholders were asked whether they thought using RSD technology is too intrusive for a public agency to use. Seventy-one percent of the respondents indicated that RSD technology is not too intrusive for a public agency to use (see Figure 6 on the next page). Twenty-one percent of the stakeholders felt the technology was too intrusive with 8% having no opinion. Overall, the majority of elected officials in both Ada County and its adjacent counties did not think RSD technology was too intrusive.

In August 1995, a follow-up survey was distributed by mail to the previous survey participants. APA received only 28 completed surveys. Only 11 of these survey participants completed the first survey. The same question was asked on this survey about whether RSD technology is too intrusive for a public agency to use. Fifty-one percent of the stakeholders felt RSD technology was not too intrusive (see Figure 7 on the next page). Approximately 29% indicated it was intrusive and 20% had no opinion.

Closer review of the data from the second survey revealed that 21% of the respondents were from the only Ada County community which is not currently participating in the I&M program. Since only a small number (28) of stakeholders completed and returned the surveys to APA and 21% were from this non-I&M participating community, the results tend to weigh towards the intrusiveness of this test.

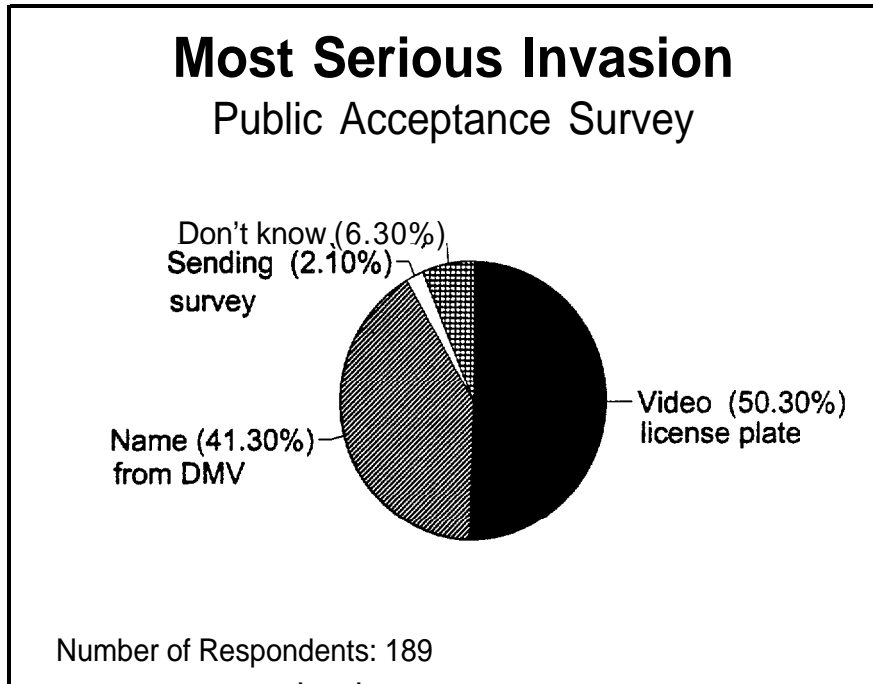


Figure 5 Most serious invasion

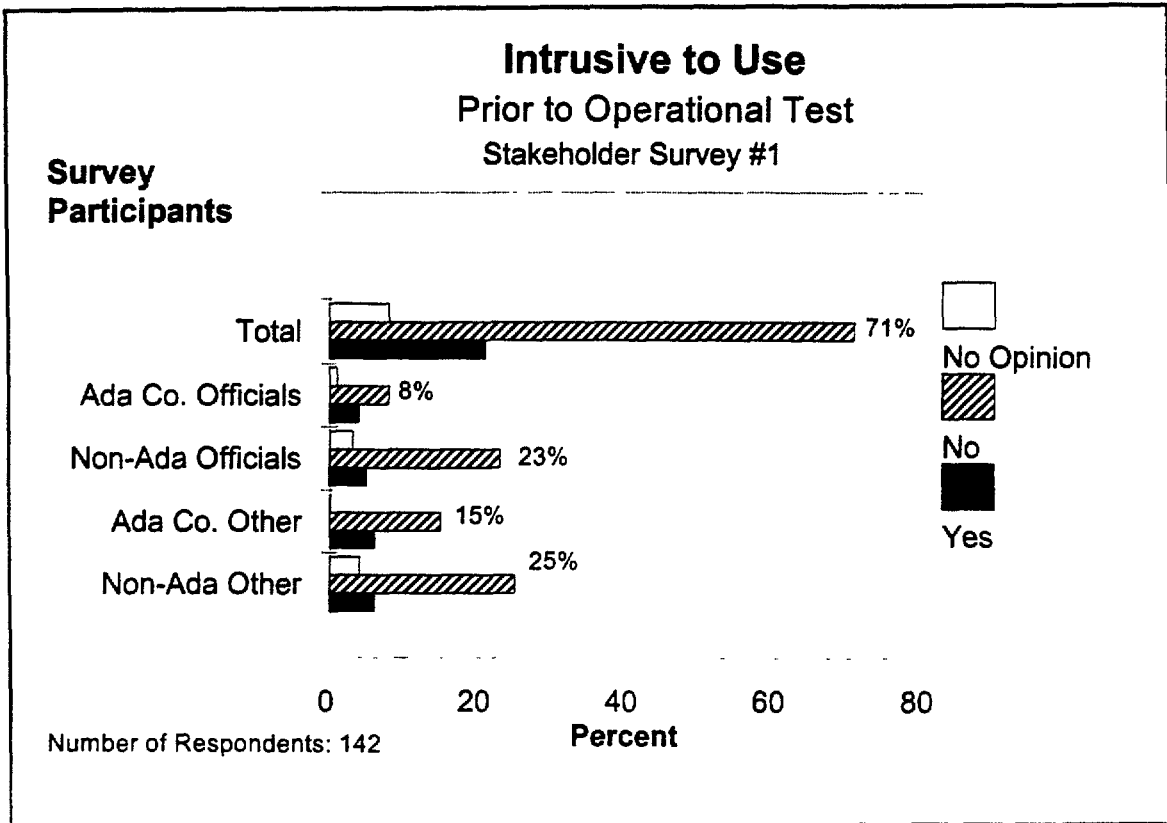


Figure 6 - Intrusive to Use: Prior to Test

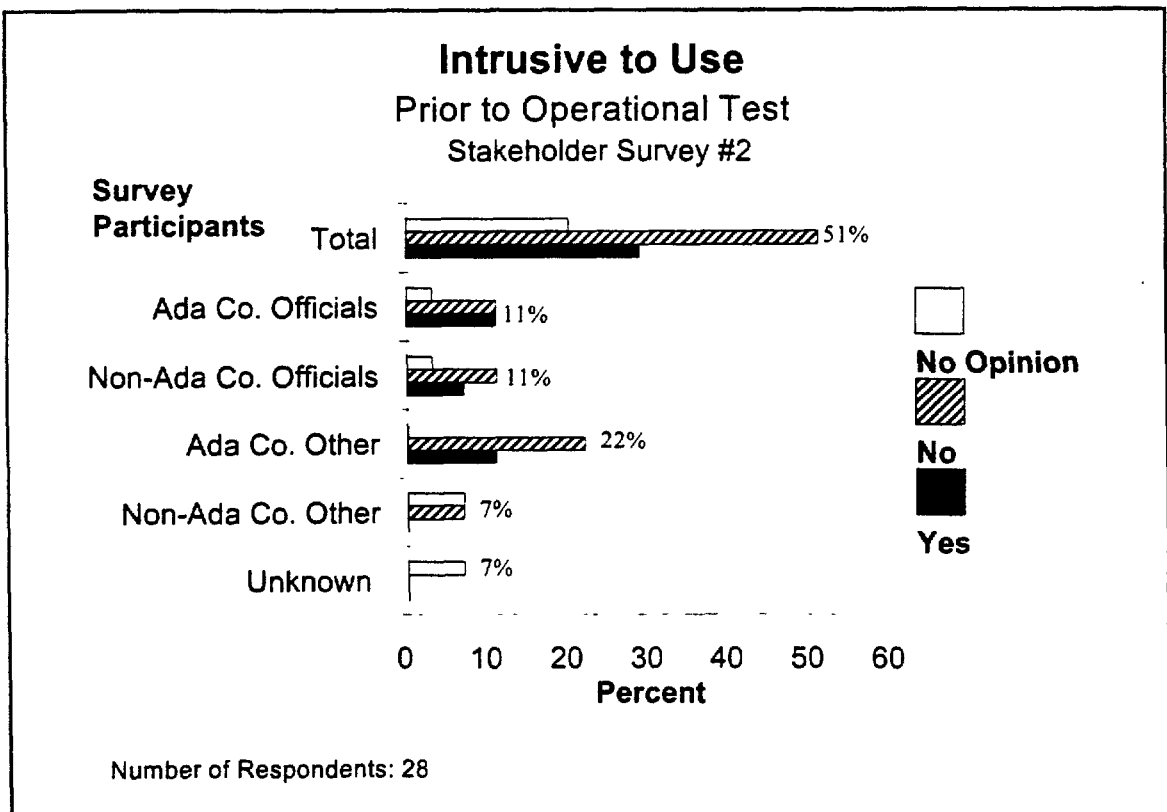


Figure 7 - Intrusive to Use: After Test

3.2 Institutional Barriers

Transportation and air quality agencies in Ada County formed a partnership to monitor vehicle emissions using RSD technology for this test. APA coordinated and analyzed the data for this test. AQB and ACHD coordinated the field operations. Staff from AQB collected the emissions data and assisted in the emissions data analysis. CH2M-Hill, the independent evaluator, assisted in the evaluation of the emissions data and provided comments on the various reports. Other participants who reviewed and commented on the draft reports were: ITD, F'HWA, EPA, and DEQ.

Meetings were held regularly with these participants to plan the operations/evaluation activities and to review draft reports of the Operational Test .

3.2.1 Evaluation Goal 1: Effects of Institutional issues on the Operational Test and future RSD deployment.

Objective A: Identify all institutional issues encountered and appraise the extent of their impacts.

Findings

The findings of the institutional issues encountered were:

- No institutional issues were encountered before, during, or after this test.

Data Analysis

Meetings to discuss details of this test were held. No institutional barriers were identified prior, during, or after the test. This phase primarily involved data collection and analysis by APA, AQB, and CH2M-Hill, the independent evaluator. ACHD and AQB coordinated the identification of test sites and traffic control.

The partnership of the participating agencies is unique in that one agency is responsible for: the local and county roadway system (ACHD); the county-wide air quality program (AQB); and all the transportation planning in Ada County (APA). Such cooperation requires a history of good working relationships. Over the years, these agencies worked effectively and successfully on numerous transportation and air quality issues. Each agency had a large stake in the success of the project.

While no institutional issues arose during this test, coordination among air quality and transportation agencies is needed to implement any future emissions testing program using RSD technology. Issues that need to be addressed:

- Site criteria,
- Traffic control,
- RSD equipment set up, and
- Technician training for working in traffic.

3.3 Public Acceptance

Initially, 145 surveys were returned by the stakeholders. Only 28 stakeholders returned the second survey, of which 11 had completed the first survey. It was difficult to determine why the response during the second survey was so low. The first survey was distributed by APA staff and either completed and returned during ITS presentations to stakeholder groups or immediately mailed back to APA. The second survey was mailed to the stakeholders. A follow-up telephone contact was made to each jurisdiction to ensure they distributed them to the appropriate officials. Many officials may have felt their initial survey completion was adequate as their opinions had not changed.

A second survey was conducted with 811 vehicle owners who passed through the test sites. They were asked by telephone survey to evaluate their perceptions of this new technology. The survey included over 400 vehicle owners each (Ada County and its surrounding counties) from Phases I/II (Origin and Destination Survey and Emissions Testing at External Stations) and Phase III (Emissions Monitoring of All Vehicles in Ada County). The interview was conducted soon after the actual RSD testing by a private research consultant.

Public inquiries and comments were logged during the Operational Test. Most of the calls were received during Phase I and II (O/D Survey and Emissions Monitoring at External Sites, respectively), the first test week. Very few were received during this phase (individual test).

Less than 1% of vehicle owners passing through the test sites called the APA office. Most asked questions about how to complete the O/D survey or said they were unable to complete the survey as they couldn't track their business vehicles' origins and destinations at the time on the survey. However, APA did receive some negative contacts about the use of RSD technology and the impacts upon the roadway system. These contacts, either by telephone or by mail, were responded to and documented.

This section uses the survey responses to assess public acceptance of using RSD technology.

3.3.1 Evaluation Goal 1: Users' acceptance as reflected in expressed attitudes and frequency of response rates.

Before asking specific questions about the Operational Test, determining prior opinions about air quality monitoring was needed. Two surveys were conducted. One survey involved elected and appointed officials and administrative staff from Ada County and its adjacent counties. The second survey involved vehicle owners who drove through the test sites.

During the telephone survey, the participants were asked the importance

of monitoring air quality in Southwest Idaho. Survey participants viewed this to be important. More than 93 % of the respondents viewed monitoring air quality as somewhat, very, or extremely important (see Figure 8).

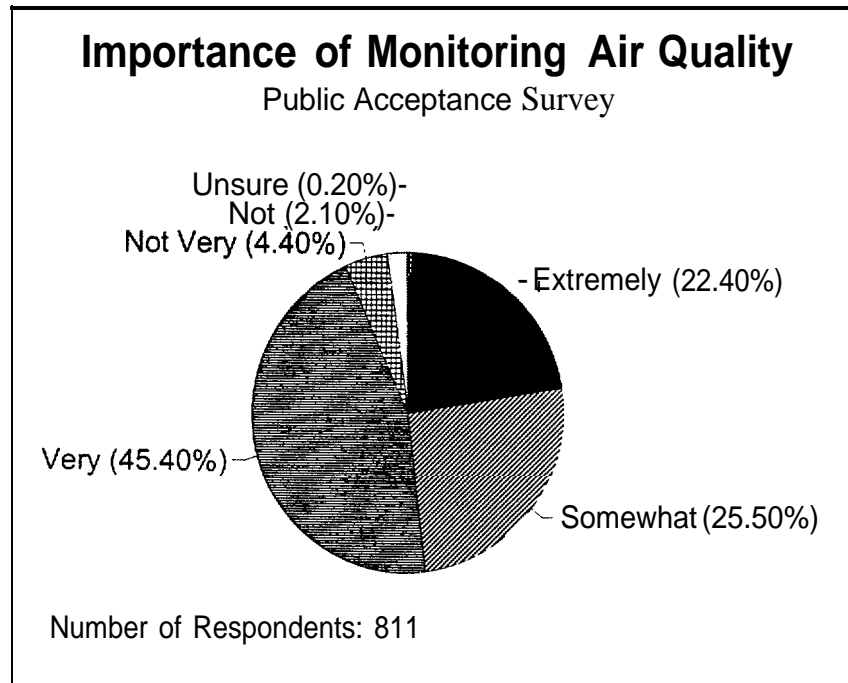


Figure 8 - Importance of Monitoring Air Quality

Objective A: Assess vehicle owners, elected or appointed officials and/or public administrators estimates of value of using RSD technology for air quality management.

Findings

The findings of the importance and convenience of using RSD technology were:

Telephone survey participants

- Approximately 49% thought RSD technology would reduce emissions and improve air quality.

- Less than 11% who saw the RSD equipment were inconvenienced. Most were only slightly inconvenienced.
- Over 78% who saw the RSD equipment on the roadside indicated it was not a safety hazard.

Stakeholder survey participants

- About 89% who answered the second survey indicated that RSD technology was a convenient way to monitor vehicle emissions

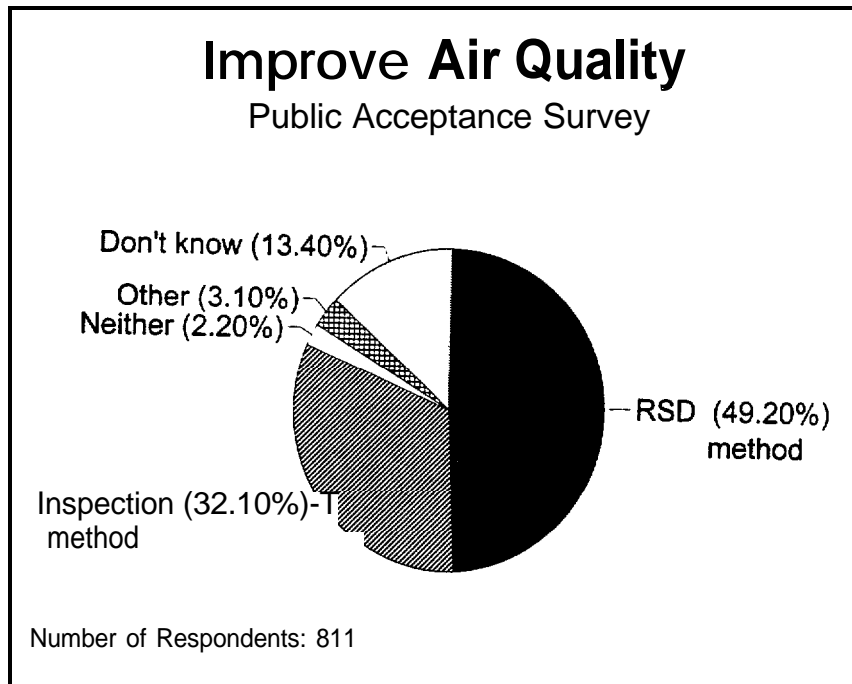


figure 9 - Improve Air Quality

Data Analysis

Telephone survey respondents were asked which emissions testing method would be the most effective in reducing emissions and improving air quality. Approximately 49% thought RSD technology would reduce emissions and improve air quality (see Figure 9).

Approximately 68% of the survey respondents indicated they read or heard about RSD equipment. Of these, 50% had seen the “Smog Dog” equipment on the roadside. They were asked if the “Smog Dog”/RSD equipment caused them any inconvenience. Less than 11% indicated they experienced an inconvenience (see Figure 10). Most of these respondents were

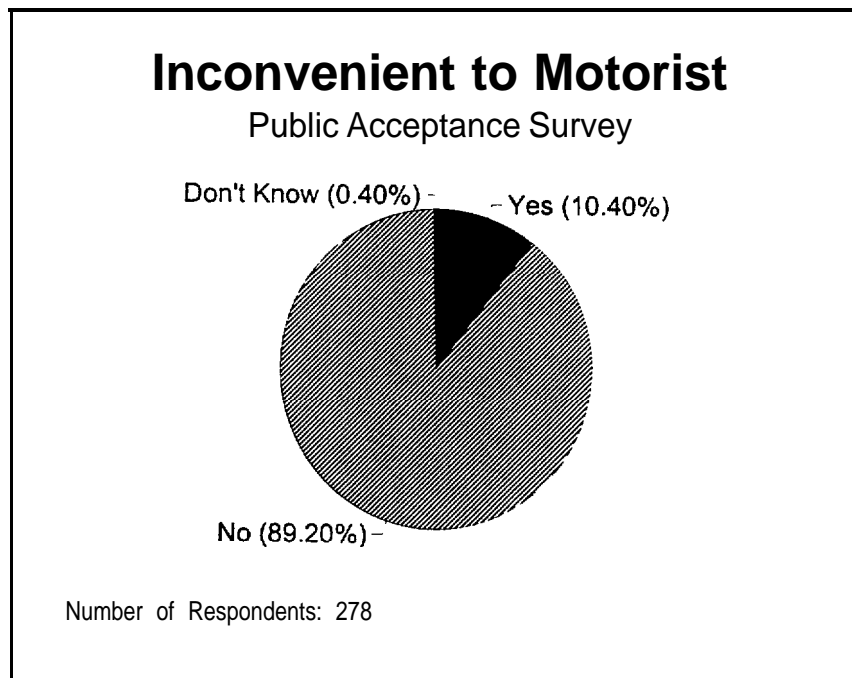


figure 10 - Inconvenient to Motorist

only slightly inconvenienced. In addition, inconvenienced respondents were asked if they consider the equipment on the roadside to be a hazard. Over 78% stated the equipment was not a safety hazard (see Figure 11).

Stakeholders were asked after the operational field test whether monitoring vehicle emissions using RSD technology was convenient. Only 28 stakeholders responded to this survey. Over 89% indicated that monitoring air quality using RSD technology was convenient to the idle emissions test (see Figure 12).

**Objective B:
Assess vehicle owners, elected officials and/or public administrators estimates of preference for using RSD technology.**

Findings

The findings for preference for using RSD technology were:

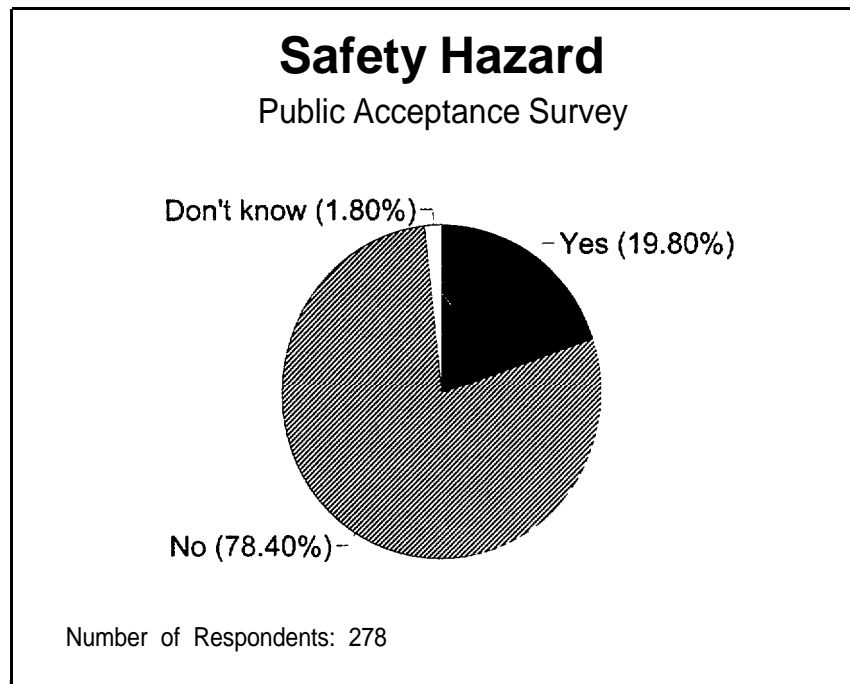


Figure 11 - Safety Hazard

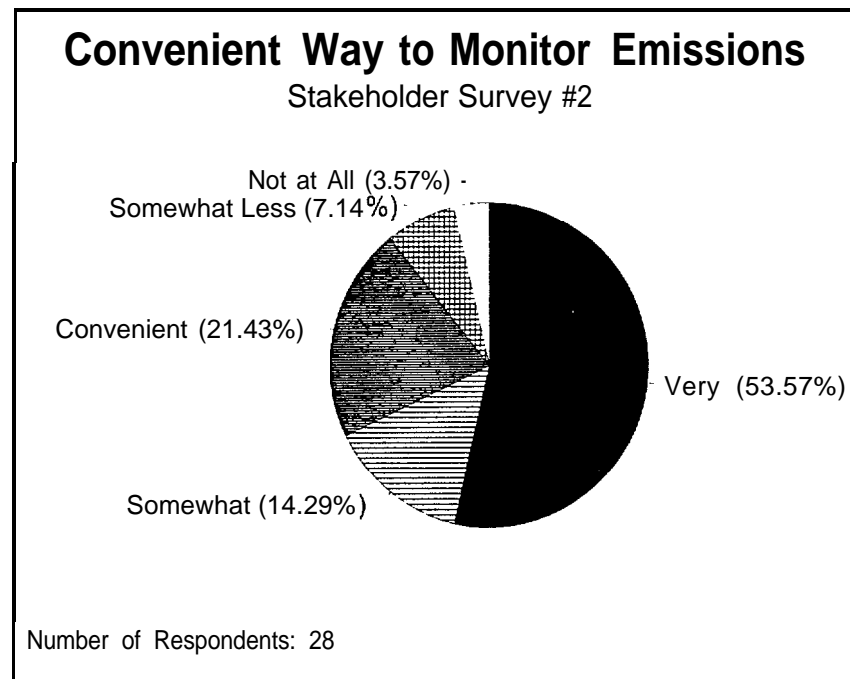


Figure 12 - Convenient Way to Monitor Emissions

- Approximately 72% of the telephone survey participants preferred the RSD method over the idle emissions test station method. Over 82% indicated this method would encourage more support for emissions testing.
- Stakeholders from both the before and after surveys thought approximately 50% or less of the public would prefer using the RSD technology.

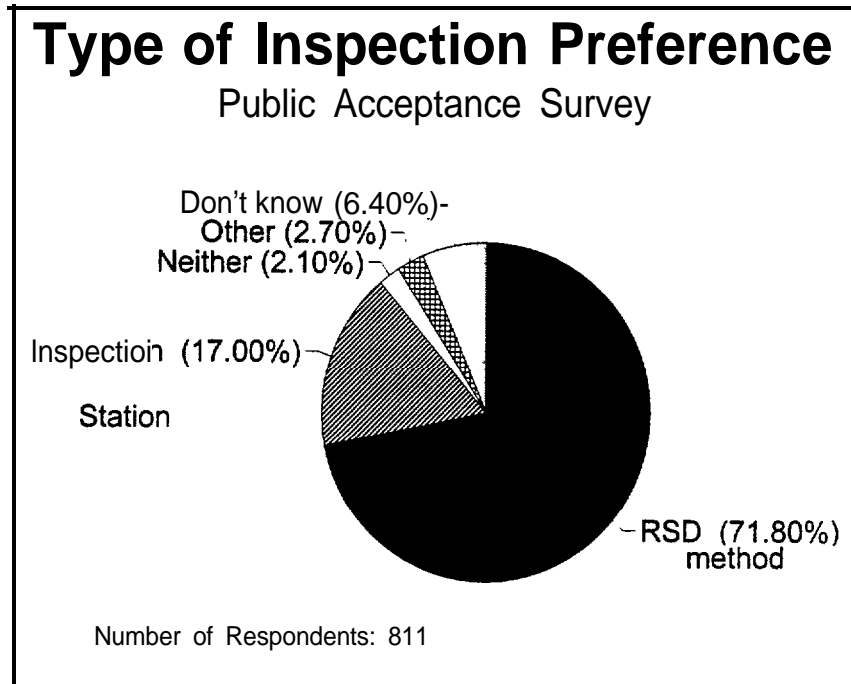


Figure 13 -Type of Inspection Preference

Data Analysis

The telephone survey respondents (vehicle owners passing through the test sites) were asked several questions about their preference for using RSD technology to monitor vehicle emissions. In addition, stakeholders were asked before and after the Operational Test their perception of the public’s preference to either use RSD technology or traditional methods to monitor vehicle emissions.

Over 72% preferred using the RSD method for emissions monitoring than the traditional idle emissions testing (see Figure 13). Approximately 82% indicated this method would encourage support for emissions testing (see Figure 14).

Stakeholders were asked their perception of public preference on using RSD technology to monitor vehicle emissions. Prior to the operational field test,

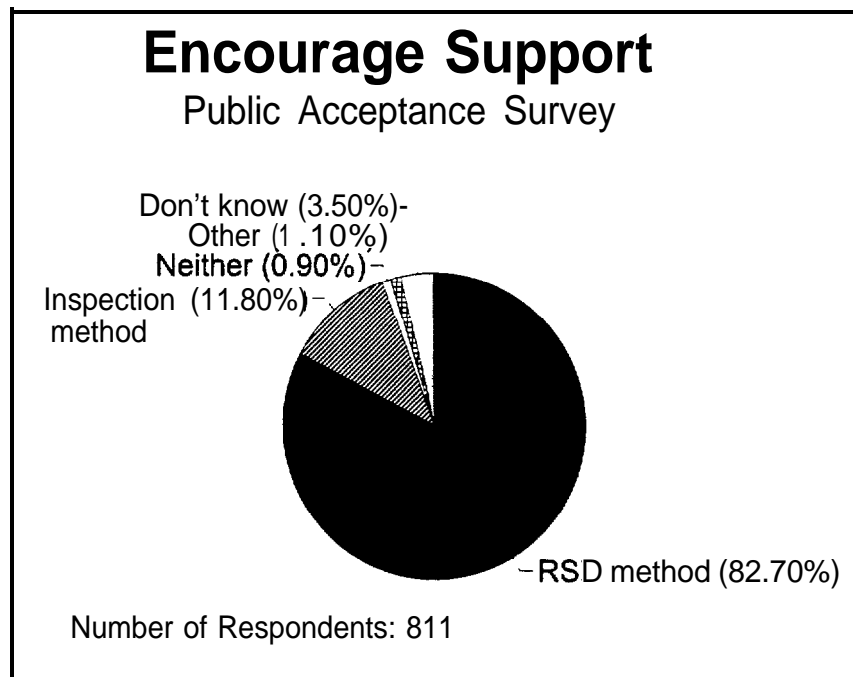


Figure 14 - Encourage Support

52% thought the public would prefer RSD technology over the idle emissions test (see Figure 15 on the next page). Twenty-nine percent either had no opinion or did not answer the question. The second survey did not reveal a large difference between the RSD and idle emission testing (see Figure 16 on the next page). Over 46% of the stakeholders had no opinion or did not answer the question.

4.0 Hypotheses

As part of this evaluation, three hypotheses were identified about institutional, legal, and public acceptance issues.

4.1 Hypothesis A: There is no impediment in the way of collaboration of cognizant transportation and air quality agencies to implement/LPR technology.

Findings

- No institutional barriers were encountered before, during, or after the Operational Test.

Data Analysis

This test experienced no institutional barriers. Three local agencies worked together to conduct this test. APA coordinated the test. AQB and ACHD coordinated the identification of and traffic control at the test sites. AQB collected the emissions data. APA, AQB, and CH2M-Hill conducted the data analysis. A history of good working relationships exists among these agencies. These agencies have worked effectively and successfully over the years on numerous transportation and air quality issues.

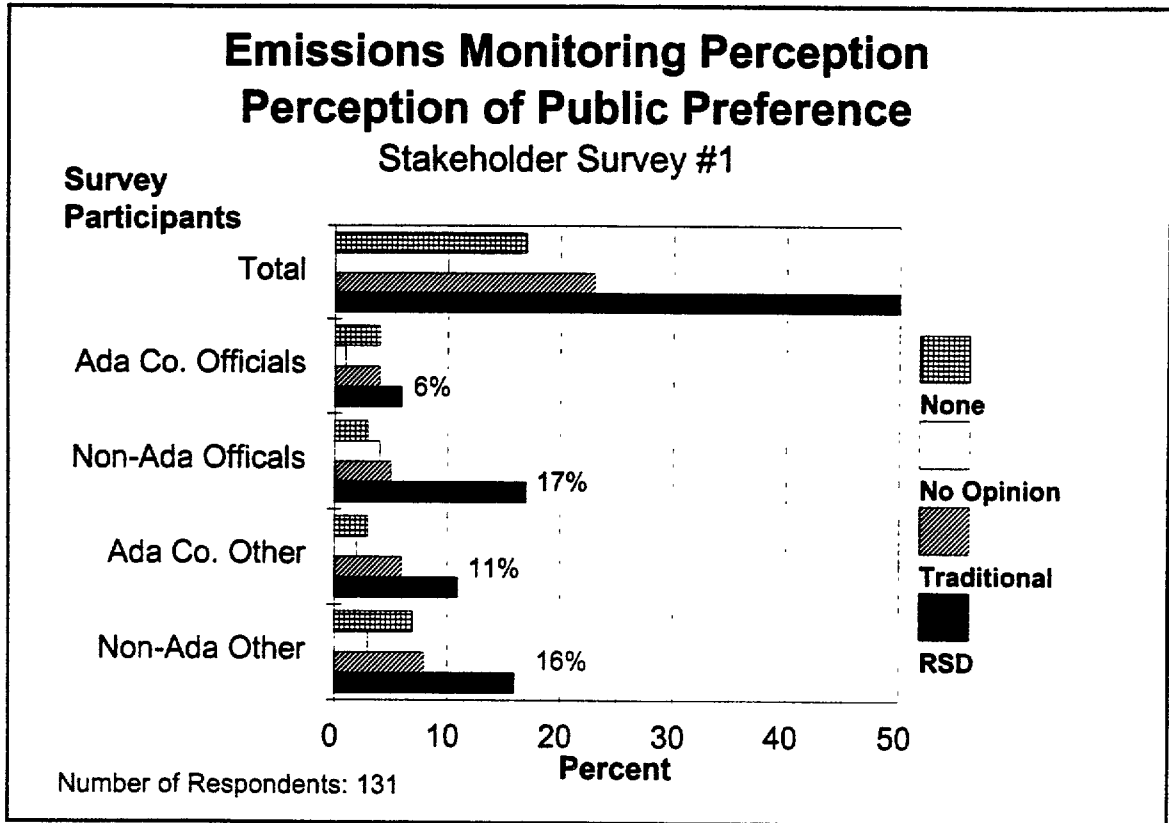


Figure 15 - Perception of Public Preference (Survey #1)

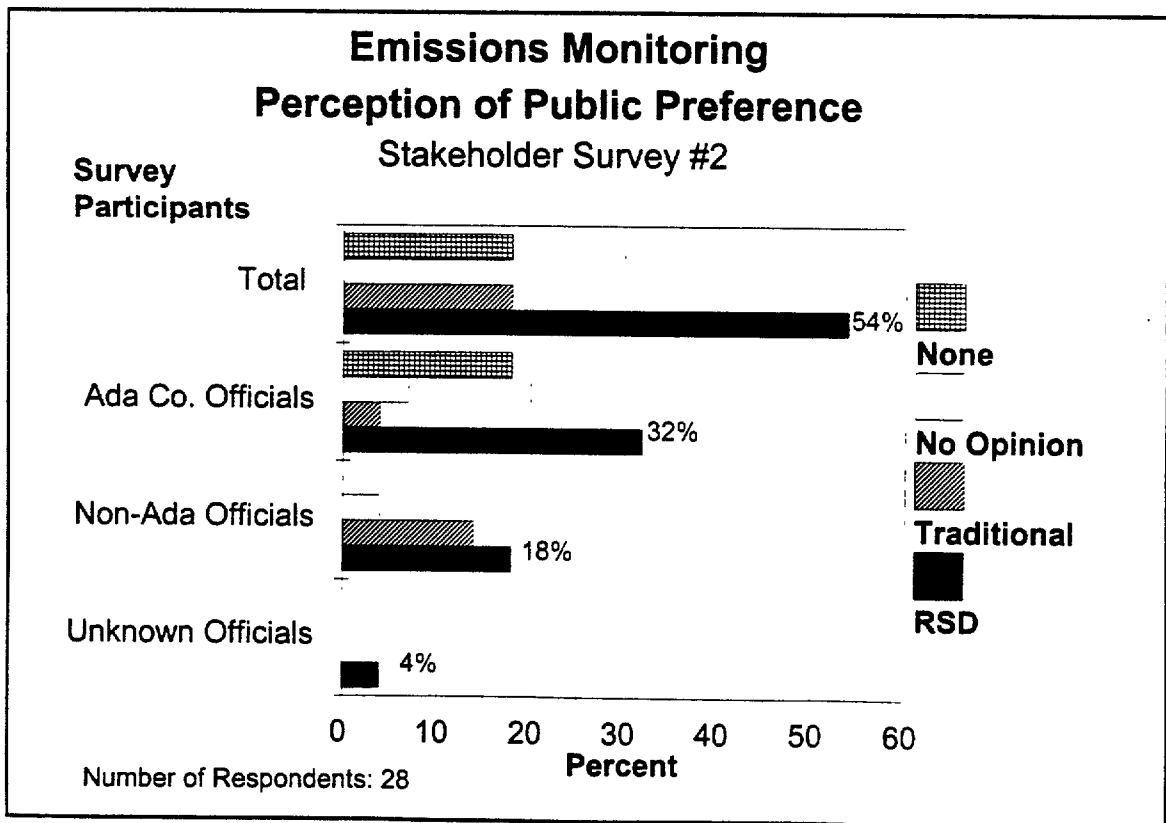


Figure 16 - Perception of Public Preference (Survey #2)

5.0 Conclusion

This chapter identified and evaluated data to determine whether institutional, legal, and public acceptance issues created concerns about using RSD technology to monitor vehicle emissions.

No legal issues arose before, during, or after the Operational Test. Both legal counsels for the ITD and the State Attorney General's office did not indicate any legal problems with capturing license plate information or monitoring vehicle emissions. Approximately, 70% of elected/appointed officials and administrative staff indicated that RSD technology was not too intrusive to use (prior to the Operational Test). During the Operational Test, less than 1/4 of one percent of the telephone contacts from the public referenced an invasion of privacy using RSD technology. Of the telephone survey respondents, approximately 75 % did not consider using RSD an invasion of privacy. Of the remaining respondents who indicated a seriousness in the invasion of privacy, approximately 60% indicated that it was somewhat or not very serious.

No institutional issues were encountered before, during, or after the Operational Test. The three agencies (APA, AQB, and ACHD) primarily responsible for the data collection and analysis have a history of good working relationships. These agencies have worked effectively and successfully over the years on numerous transportation and air quality issues. Each agency had a large stake in the success of this project.

Overall, the majority of the public and stakeholders indicated that RSD technology provided important emissions data and was a convenient way to monitor vehicle emissions. Approximately 49% of the survey participants thought RSD technology would reduce emissions and improve air quality.

Less than 11% of the survey participants who saw the LPR/RSD equipment on the roadway were inconvenienced. The majority of these respondents were only slightly inconvenienced. Of these survey participants who saw the LPR/RSD equipment on the roadway, approximately 20% indicated that it was a safety hazard. The perception of safety by the motorists should be improved during future operations.

This may have been a drawback of combining two different types of tests, a travel survey and emissions monitoring, during this operational test. The O/D survey required capturing license plates at the county boundary. This included survey sites on the Interstate. Other sites than the Interstate could have been used to capture emissions data of out-of-county vehicles. The RSD equipment could have used a different triggering device for the video camera such as road tubes. With road tubes, both westbound travel lanes on the Interstate could have remained open. Due to the use of the emissions sensors, the traffic control required closing one lane down. The traffic control and other factors (i.e., technicians setting up equipment during the morning peak period) created traffic congestion and early termination at the test site. This experience created negative perceptions by the public about safety.

Most importantly, the majority of the telephone (public) survey respondents preferred the LPR/RSD method to monitor vehicle emissions when compared to traditional methods. Approximately 72 % preferred the RSD method over the idle emissions test method. Over 82 % indicated the RSD method would encourage more support for an emissions testing program.

In conclusion, stakeholders and the public gave LPR/RSD technology a favorable rating to implement its use to conduct a travel survey and to monitor vehicle emissions.

mh/ivhs/reports/testrept.d3

Appendix A

Basic Information about Remote Sensing

What is Remote Sensing?

Remote sensing is a way to measure pollutant levels in a vehicle's exhaust while the vehicle is traveling down the road. Unlike most equipment used to measure vehicle emissions today, remote sensing devices (RSD) do not need to be physically connected to the vehicle. The concept of RSD as an efficient tool to monitor the vehicle fleet and identify excessive polluters has great appeal as a complement to traditional mobile source emission control programs. A number of instrument manufacturers are actively developing RSD systems.

What Pollutants are Measured by RSD?

RSD systems can measure hydrocarbons, carbon monoxide, and oxides of nitrogen in the exhaust stream. RSD cannot, however, measure: "evaporative" emissions - gasoline vapors that vent into the air from hot engines and fuel systems. Fuel evaporation is a very significant source of hydrocarbon pollution that can exceed tailpipe emissions on hot days.

How does Remote Sensing Work?

Commercial RSD systems employ an infrared absorption principle to measure HC and CO emissions. These systems operate by continuously projecting a beam of infrared radiation across a roadway. It is expected that RSD systems for NO_x will use either a beam of ultraviolet light, or light from a tunable diode laser projected across the road.

As a vehicle passes through the RSD beam, the device measures the ratio of CO (and exhaust HC) to carbon dioxide (CO₂) in front of the vehicle and in the exhaust plume behind. The system uses the "before" measurement as a base and calculates the vehicle's CO emission rate by comparing the "behind" measurement to the expected ratio for ideal combustion. Exhaust HC is calculated in a somewhat similar manner by comparing the total carbon content of exhaust HC, CO, and CO₂ to the total carbon content of the gasoline the vehicle burns. The CO₂ : CO ratio determined by current RSD systems will still be needed to calculate NO_x emissions.

RSD systems employ a freeze-frame video camera and equipment to digitize an image of the license plate number so that it can be processed by a computer. This allows the computer to store emissions information for each monitored vehicle, based on the license plate number. Appropriate authorities can then identify and contact owners of vehicles with high RSD readings.

Methods to measure a vehicle's speed and acceleration as it passes through the infrared beam may also be used. This is important because the operating mode (e.g. acceleration, cruise, etc.) can significantly affect the instantaneous emission level from a vehicle. Some types of operation during a RSD test may be cause for invalidating a particular test,

Computerized diagnostic technologies may also play a role in future RSD systems. Vehicle onboard diagnostic systems, capable of identifying certain malfunctions in a vehicle's emission control system, are required beginning with 1994 models. The malfunctions could be reported to roadside RSD systems by a small electronic device on the vehicle called a radio frequency transponder. Similar transponder concepts have been used to time runners in marathons and transponder systems are being used to assess toll road fees in some areas.

Will Enhanced Inspection and Maintenance Programs Include RSD?

Yes. RSD and other "on-road" emission measurement methods will be an important part of state strategies to reduce emissions from motor vehicles. The Act requires that enhanced I/M programs include on-road emission testing of a portion of the eligible vehicle fleet. RSD technology is expected to play a major role in these supplemental emission measurements:

- RSD will likely be used to identify vehicles with malfunctioning emission controls between scheduled I/M tests. Air quality benefits can result from early repair of vehicles that would otherwise not be identified or repaired until the next annual or biennial test.
- EPA studies have shown that properly repaired vehicles maintain low emissions for a long time. However, some individuals may tamper with their vehicle's emission control systems. The mobility of the RSD provides a way to identify tampered vehicles between periodic I/M tests and a way to enforce repair requirements on those vehicles found to be dirty. Other studies have found that RSD is more effective in identifying tampered vehicles than the currently used random roadside pull-overs.
- SD can detect unregistered or improperly registered vehicles. This will allow authorities to pick out drivers who cheat on registration or register out of the area to avoid participating in an I/M program.
- To take advantage of RSD's potential to identify dirty cars, EPA is requiring enhanced I/M programs to conduct supplemental emission measurements on at least 0.5% of vehicles subject to I/M testing each year. Vehicles that fail an RSD test would be required to be retested by the regular I/M test. Repairs would be required for any vehicle failing this out-of-schedule I/M emissions check.

Can RSD Replace Enhanced inspection and Maintenance Programs?

No. The Clean Air Act provides for use of RSD as a supplement to enhanced I/M programs but not as a substitute for periodic emission testing. While RSD can be extremely useful, it does have some limitations:

- RSD fails vehicles that do not need repair and passes many that do. Studies by EPA, the California Air Resources Board, and others have found that when RSD measurements are compared to emissions measurements made by accepted testing methods, the RSD incorrectly fails vehicles that are not in need of repair.

- The Clean Air Act mandates that enhanced I/M programs include an interrogation of the onboard diagnostic system to check for emission control system malfunctions on 1994 and newer vehicles. Current RSD systems cannot access the onboard diagnostic system.
- The emission reductions from the evaporative emission tests are essential to meeting the enhanced I/M performance standard. RSD cannot conduct this test.

The RSD false failure rate has been around 20% or more for CO and as high as 60% for HC. More importantly, for clean air, EPA studies indicate that RSD does not identify 80% to 90% of the dirty vehicles that need repair. This means RSD alone could not be used to meet the enhanced I/M performance standard. EPA believes that these results do not reflect on the instantaneous measurement accuracy of the RSD. Rather, EPA believes these results are indicative of changes in vehicle emission levels that typically occur when a vehicle is operated under driving conditions different than those observed by the RSD.

Implementing RSD in Inspection and Maintenance Programs

There are a number of administrative factors to consider in establishing I/M programs that include RSD. Some RSD advocates have suggested that RSD is capable of monitoring much more than 0.5 % of the fleet. EPA agrees that RSD could be used by the I/M programs to measure emissions from more cars, given adequate resolution of the following issues:

. Placement of Roadside Monitors

Current RSD technology can only measure emissions of vehicles driving in a single lane of traffic. It is not easy to find enough sites where appropriate single traffic lanes exist to monitor the majority of vehicles subject to I/M testing. Restricting multiple lanes to a single lane for RSD measurement may not be practical in many cases, particularly during times of heavy traffic such as rush hour. Yet RSD testing during peak traffic periods would probably be necessary to avoid missing high-emitting vehicles that could be parked during business hours.

EPA has successfully used RSD monitors along multiple lane roadways in some studies without restricting traffic to a single lane. But pylons had to be placed between the lanes to protect some of the RSD equipment. With such a set-up, drivers could choose not to drive through the measuring lane.

Another issue involves limiting RSD placement to locations where representative vehicle operation will be observed. It will be important for I/M programs to avoid creating situations where a measurable portion of vehicles fail RSD monitoring at one location but pass at another location. For example, sites of high acceleration would likely be avoided because emissions tend to be higher during acceleration than during steady-speed driving.

• **Appropriate Pass/Fail Levels**

A difficult issue involves selecting an emission standard (cut point) for the RSD that will identify vehicles that need repair while minimizing false failures. EPA studies indicate that RSD misidentification of clean vehicles as dirty is substantially reduced by measuring emissions from the same vehicle several times. However, multiple measurements also result in more dirty vehicles passing the test.

• **Notification**

Administrative systems need to be established so authorities can follow up with owners of vehicles that register high emissions during an RSD check. Whether vehicle owners are pulled over immediately at the time of the check or notified later by mail, oversight will be necessary to ensure that dirty vehicles undergo further testing and repair if necessary.

• **Driver Behavior**

To date, RSD emissions testing has occurred only in demonstration type projects with no consequences for drivers whose vehicles fail the test. In the future, RSD failures in enhanced I/M programs will result in mandatory retesting and repair. These consequences may prompt drivers to change their driving route or regime (e.g., observing RSD testing in the opposite lane on the way to work, and choosing a different route home), or otherwise alter their driving behavior to avoid passing an RSD monitor. The political implications of ailing motorists, especially falsely, with this type of program may be a significant problem.

The prototype studies conducted to date do not provide the type of practical information I/M program managers need to effectively use RSD on a day-to-day basis. However, EPA believes that most of these administrative issues will be resolved with experience, as states begin to integrate RSD into actual I/M programs. By starting out with a small fraction of the fleet (0.5 %), I/M program offices can begin to develop administrative systems that will allow RSD to achieve its potential as a full player in the vehicle emission control program of the future.

Appendix B

Preliminary Local Climatological Data for May 1995

Preliminary Local Climatological Data (WS Form: F-6)

Station: WSFO BOISE, IDAHO

Month: MAY

Year: 1995

Latitude

+43.57

Longitude

+116.22

Gnd Elev. 2858 ft.

Std Time: MST

Temperature in Fahrenheit				:Precip(in.)			Snow : Wind :			Fastest 2-Min :		Sunshine :		Sky :		Peak Wind		
				Columns														
-1-	-2-	-3-	-4-	-5-	-6a-	-6b-	-7-	-8-	-9-	-10-	-11-	-12-	-13-	-14-	-15-	-16-	-17-	-18-
Day	Max	Min	Avg	Dep	HDD	CDD	Water	Snow	Depth	Avg	Speed	Dir	Mins	%PSBL	SR-SS	Weather	Speed	Dir
1	58	46	52	-1	1	0	0.44	0.0	0	11.8	22	13	61	7	10	3,5	32	SE
2	60	45	53	0	1	0	0.38	0.0	0	12.5	14	35	76	9	9	1.5	32	NW
3	63	35	49	-5	1	0	0.00	0.0	0	5.1	13	34	438	51	8		20	NW
4	64	43	54	0	1	0	T	0.0	0	8.6	15	23	27	3	10		29	SW
5	52	47	50	-4	1	0	0.40	0.0	0	8.8	16	32	0	0	10	1	20	NW
6	50	45	48	-7	1	0	0.57	0.0	0	11.0	21	31	0	0	10	1	25	NW
7	61	45	53	-2	1	0	T	0.0	0	4.7	12	32	104	12	9		15	NW
8	65	46	56	1	9	0	0.09	T	0	5.5	10	19	286	33	9		21	W
9	72	44	58	3	7	0	0.01	T	0	7.7	13	25	562	65	7		21	W
10	68	46	57	1	8	0	0.01	0.0	0	4.0	14	33	320	37	8		15	NW
11	59	45	52	-4	1	0	0.16	0.0	0	7.8	17	27	117	13	9		38	S
12	58	37	48	-8	1	0	0.00	0.0	0	13.2	22	325	405	46	7		28	NW
13	60	36	48	-9	1	0	0.07	0.0	0	6.8	12	18	359	41	9		17	S
14	68	41	55	-2	1	0	0.02	0.0	0	6.3	12	17	731	83	2	3	23	S
15	73	45	59	2	6	0	0.18	0.0	0	8.4	23	13	644	73	7		30	S
16	68	51	60	3	5	0	0.03	0.0	0	8.3	16	28	609	69	7		20	NW
17	72	45	59	1	6	0	0.00	0.0	0	9.5	20	32	885	100	5		24	NW
18	69	43	56	-2	9	0	0.00	0.0	0	8.3	17	32	855	96	0		21	NW
19	73	38	56	-2	9	0	0.00	0.0	0	6.5	12	31	858	97	3		16	NW
20	80	43	62	3	3	0	0.00	0.0	0	6.7	12	13	856	96	2		14	NW
21	77	46	62	3	3	0	T	0.0	0	7.0	14	32	727	81	9		20	NW
22	74	47	61	-2	4	0	T	0.0	0	9.4	16	16	719	80	10		29	S
23	71	48	60	0	5	0	0.00	0.0	0	5.6	09	12	806	90	9		16	SW
24	73	52	63	3	2	0	0.00	0.0	0	5.7	08	28	680	76	10		21	W
25	76	46	61	1	4	0	0.00	0.0	0	8.8	24	30	714	79	7		36	W
26	69	45	57	-3	8	0	0.00	0.0	0	14.7	23	32	881	98	2		32	NW
27	71	38	55	-6	1	0	0.00	0.0	0	5.0	12	27	871	96	1		16	W
28	78	43	61	0	4	0	0.00	0.0	0	5.9	12	28	906	100	0		16	NW
29	84	49	67	6	0	2	0.00	0.0	0	6.9	14	32	830	92	1		20	NW
30	87	54	71	9	0	6	T	0.0	0	7.4	16	33	861	95	2		23	NW
31	86	52	69	7	0	4	0.00	0.0	0	5.8	17	22	730	80	9		29	W
Sum	2139	1386			255	12	2.36	0.0		280.9			16918	201				

Avg	69.0	44.7						7.7		Fast		Dir.	Psbl	%	6.5		Max	(mph)
							Misc	—————)		24		30	27328	62			038	S

Notes:
 Column 9 readings are taken at 0500
 Column 17 Peak Wind in M.P.H.

Appendix C

Format of Collected Data by RSD Technology

Data Name	Data Description	Type	Structure
License Plate Number	This is the actual automobile license number as resolved from the video of each license plate	Alpha	Integer 10
TCODE	County code.	Alpha	2
Observation Date	This is the day of the year on which the RSD observation was made.	Date	
Observation Time	This is the time of day during which the RSD observation was completed.	Time	
Location	This is the number assigned to each RSD location (01-18 were at the County perimeter, 19-26 were internal to Ada County).	Alpha	2
Speed 1	This is the first speed of travel observation made by the RSD monitors.	Fixed Numeric	2.2
Speed 2	This is the second speed of travel recorded by the RSD technology.	Fixed Numeric	2.2
Acceleration	This is the computed acceleration of the vehicle based upon speed 1 and speed 2.	Fixed Numeric	3.2
Carbon Monoxide	This is the observed CO recorded as a percentage of total exhaust emissions.	Fixed Numeric	5.5
Carbon Dioxide (CO ₂)	This is the observed CO ₂ in exhaust emissions recorded as a percent of total emissions.	Fixed Numeric	5.5
Hydrocarbon n (HC)	This is the proportion of hydrocarbon in the exhaust emissions recorded as a percent of total emissions.	Fixed Numeric	5.5
Sensor	This is the van and sensor number to tracked the equipment used.	Fixed Numeric:	6
Slope CO	This is technical data used to validate the emissions readings.	Fixed Numeric	5.5
Slope HC	This is technical data used to validate the emissions readings.	Fixed Numeric	5.5
Code CO	This is technical data used to validate the emissions readings.	Alpha	3
Code HC	This is technical data used to validate the emissions readings.	Alpha	3
Max. CO	This is technical data used to validate the emissions readings.	Fixed Numeric	5.5

Appendix D

Attorney General's Letter



ADAPLANNINGASSOCIATION

APR 17 1995

STATE OF IDAHO

OFFICE OF THE ATTORNEY GENERAL
Statehouse Room 210
P.O. Box 83720

BOISE 637204010

April 14, 1995

ALAN G. LANCE
ATTORNEY GENERAL

TELEPHONE (208) 334-2400
FAX (208) X34-2630

Criminal Law Division
Fax (208)334-2942

Natural Resources Division
Fax (208) 334-2690

*via Facsimile 345-52 79 and 384-4420
and regular U.S. Mail*

Brent Coles, Chairman
Ada Planning Association Board of Trustees
413 W. Idaho, Suite 100
Boise, Idaho 83702

Dear Mayor Coles:

The Attorney General recently received a letter from Clair Bowman concerning a proposed questionnaire that the Ada Planning Association wishes to send to selected motor vehicle users throughout Ada County. Apparently, motor vehicle owners would be selected by placing a remote video-tape camera on selective roadways. The Ada Planning Association would then use the license plate number recorded on the video-tape, along with information from the Department of Transportation, to determine the owner's address. The owner would then be sent a questionnaire from the Ada Planning Association. The question presented was whether or not this violates the vehicle owner's right of privacy.

It does not appear that any constitutionally recognized right to privacy would be violated by this method of gathering data. Whether or not the Ada County Planning Association wishes to do this is solely a policy decision.

If you have any questions, or would like to discuss this matter further, please do not hesitate to call upon me.

Yours very truly,

A handwritten signature in black ink, appearing to read "William A. von Tagen".

WILLIAM A. VON TAGEN
Director, Governmental and
Public Affairs

Appendix E

Public Acceptance Survey Tables

The following tables correspond to the graphic figures in the institutional, legal, and public acceptance section (i.e., starting with Figure 2 in this final report). The PublicAcceptance survey was conducted by a private research consultant. The consultant prepared a report, *Remote Sensing Device Testing Program Survey* which summarized the results of the survey.

The stakeholder surveys were conducted by APA and the results are incorporated into this document.

Serious Rating Invasion	
	Percent
Extremely	18.0
Very	21.2
Somewhat	43.9
Not very	15.9
Unsure	1.0
Total	100.0
Public acceptance survey Number of Respondents = 189	

Figure 4

Most serious Invasion	
	Percent
Video license plate	50.3
Name from DMV	41.3
Sending survey	2.1
Don't know	6.3
Total	100.0
Public Acceptance Survey Number of Respondents = 189	

Figure 5

Intrusive to Use – Prior to Operational Test (in percent)			
	Yes	No	No opinion
Ada Co. Officials	4.0	8.0	1.0
Non-Ada Co. Officials	4.0	23.0	4.0
Ada Co. Other	6.0	15.0	0.0
Non-Ada Co. Other	6.0	25.0	4.0
Total	20.0	71.0	9.0
Stakeholder Survey #1 Number of Respondents = 142			

Figure 6

Intrusive to Use – After Operational Test (in Percent)			
	Yes	No	No opinion
Ada Co. Officials	11.0	11.0	4.0
Non-Ada Co. Officials	7.0	11.0	4.0
Ada Co. Other	11.0	22.0	0.0
Non-Ada Co. Other	0.0	7.0	7.0
Unknown Officials	0.0	0.0	7.0
Total	29.0	51.0	20.0
Public Acceptance Survey Number of Respondents = 28			

Figure 7

Importance – Monitoring air Quality	
	Percent
Extremely	22.4
Very	45.4
Somewhat	25.5
Not very	4.4
Not	2.1
Unsure	0.2
Total	100
Public acceptance survey Number of Respondents = 811	

Figure 8

Improve Air Quality	
	Percent
RSD Method	49.2
Stop & Ask Method	32.1
Neither	2.2
Other	3.1
Don't Know	13.4
Total	100.0
Public Acceptance Survey Number of Respondents = 811	

Figure 9

Inconvenient to Motorist	
	Percent
Yes	10.4
No	89.2
Don't Know	0.4
Total	100.0
Public Acceptance Survey Number of Respondents = 278	

Figure 10

Safety Hazard	
	Percent
Yes	19.6
No	78.4
Don't Know	1.8
Total	100.0
Public acceptance Survey Number of Respondents = 278	

Figure 11

Importance – Monitoring air Quality		
	Number	Percent
Very	15	53.6
Somewhat	4	14.3
Convenient	6	21.4
Somewhat less	2	7.1
Not at all	1	3.6
Total	28	100
Stakeholder Survey #2 Number of Respondents = 28		

Figure 12

Type of Emissions Inspection Preference	
	Percent
RSD Method	71.8
Inspection Stations	17.0
Neither	2.1
Other	2.7
Don't Know	6.4
Total	100.0
Public Acceptance Survey Number of Respondents = 811	

Figure 13

Encourage Emission Testing Support	
	Percent
RSD Method	82.7
Inspection Test	11.8
Neither	0.9
Other	1.1
Don't Know	3.5
Total	100.0
Public Acceptance Survey Number of Respondents = 811	

Figure 14

Emissions Monitoring: Perception of Public Preference				
Percent				
	RSD	Traditional	No Opinion	None
Ada Co. Officials	8.0	4.0	1.0	4.0
Non-Ada co. Officials	17.0	5.0	4.0	3.0
Ada Co. Other	11.0	6.0	2.0	3.0
Non-Ada Co. Other	16.0	8.0	3.0	7.0
Total	50.0	23.0	10.0	17.0
Stakeholder survey #1 Number of Respondents = 131				

Figure 15 – Stakeholder Survey #1

Emission Monitoring: Perception of Public Preference				
Percent				
	RSD	Traditional	No Opinion	None
Ada Co. Officials	32.0	4.0	7.0	18.0
Non-Ada Co. Officials	18.0	13.0	4.0	0.0
Unknown	4.0	0.0	0.0	0.0
Total	54.0	17.0	11.0	18.0
Stakeholder Survey #2 Number of Respondents = 28				

Figure 16 = Stakeholder Survey #2