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ABSTRACT

A general evaluation design was developed to examine the effectiveness of a computer-based, multimedia simulation test on California smog check mechanics. The simulation test operated on an Apple Macintosh IIci, with a single touchscreen color monitor controlling a videodisc player; it had three parts: introduction-tutorial-help, data, and test. It was compared to a hands-on, actual vehicle test. The two tests were as equivalent as possible. The hands-on test was essentially a printout of the nine test items and specific questions from the simulation test. The evaluation gathered two kinds of data: test performance and subjective responses to the test experience. Currently certified smog check mechanics were recruited and paid to participate in the study. This sample was randomized between the two testing methods; 38 were tested in each group. A Rasch analysis was chosen for a reliability study of the test. The high item separation reliability indicated that, in general, persons responded consistently to the test according to their performance capabilities. The comparison of the performance between the simulation test group and the hands-on test group indicated the difference was not statistically significant. Data showed that the probability was very high that the differences between the group means were the result of chance. (Appendixes which comprise at least half of the document include the following: background and simulation test documents, mechanics survey, sample selection documents, raw data score sheets, and test proctors' observations/recommendations.) (YLB)

THE B.A.R. DEMONSTRATION PROJECT: A COMPARATIVE EVALUATION TRIAL OF COMPUTER-BASED, MULTIMEDIA SIMULATION TESTING AND "HANDS-ON", ACTUAL EQUIPMENT TESTING

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The author wishes to express his appreciation to Mrs. Rita Bode for her computer work on the Rasch calibration and statistics.

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THE OPINIONS AND RECOMMENDATIONS EXPRESSED HEREIN ARE SOLELY THOSE OF THE AUTHOR.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

INTRODUCTION AND BACKGROUND

In January of 1988, a B.A.R.-funded study, Hands-On Verification Of Mechanics Training: A Cost-Effectiveness Study Of Videodisc Simulation (Maher, 1988), recommended to the Bureau of Automotive Repair (B.A.R.) that:

1. B.A.R. should no longer actually conduct mechanic training, but should continue to test, certify and license.

2. B.A.R. should test, certify and license mechanics through comprehensive "hands-on" simulation testing.

The California State Polytechnic University at Pomona (Cal Poly) received two subsequent contracts from B.A.R., parts of which were designated to implement a demonstration project of computer-based, multimedia simulation testing.

This document reports on the experimental evaluation trials of the prototype simulation test, as compared to a "hands-on" test using actual vehicles.

GENERAL DESCRIPTION OF THE SIMULATION TEST

The simulation test operates on an Apple Macintosh IIci, with a single touchscreen color monitor, controlling a videodisc player. The primary software controlling the simulation is MacroMedia Director ver 3.1.

The simulation test has three parts. Introduction-Tutorial-Help Section: This section orients the mechanic to the operation of the display device by introducing the computer and explaining the methods of both presentation and appropriate mechanic response. This "Tutorial" section is then used as the "Help" section. Data Section: The data section of the test is unavailable to the mechanic. It contains the mechanics' logon information, including B.A.R. certificate number, the touchscreen/keyboard entry responses of the mechanic to test questions, etc. Test Section: The essential framework of this simulation examination is a smog check, including a visual inspection, functional check, and diagnosis of emission problems. Three vehicles were used. The actual test consists of nine test "items" divided into a total of 44 individual questions. Questions are fully simulated through audio/video/graphic displays.

EVALUATION DESIGN

The general evaluation design was developed to examine the effectiveness of a computer-based, multimedia simulation test on California smog check mechanics. The simulation test was compared to a "hands-on", actual vehicle test. The two tests were as equivalent as possible. The "hands-on" test itself was essentially a "printout" of the nine test items and specific questions from the simulation test. The evaluation gathered two kinds of data, test performance and subjective responses to the test experience.

Currently certified smog check mechanics were recruited and paid to participate in the study. This sample was randomized between the two testing methods.

The purpose of the evaluation was the comparison of those two testing methodologies, not validating either test for use with the entire population. In the current case both groups are considered the same. The question of interest is whether there is no significant difference in performance between the groups, suggesting that the two methods of examination are essentially equal, and yield equal results.

RESULTS AND ANALYSIS

To properly evaluate the performance of the two groups on the simulation examination and the "hands-on" version, the test itself had to be analyzed for reliability. A Rasch analysis was chosen for the reliability study. The final calibration was made after eliminating "misfitting" items.

Original Calibration:	Person Separation Reliability	=.52
	Item Separation (Test) Reliability	=.82
Final Calibration:	Person Separation Reliability	=.60
	Item Separation (Test) Reliability	=.86

The high item separation reliability, or test reliability, indicated that, in general, persons responded consistently to the test according to their performance capabilities.

Once the test reliability was determined, all items and all scores were used in the comparison of the performance between the simulation test group and the "hands-on" test group. The summary statistics for the raw scores are shown below:

RAW SCORES	Number	Mean	Standard Deviation
Simulation Test	38	44.184	3.525
"Hands-On" Test	38	43.737	3.117
t = .586	Degrees of Freedom = 74		Probability = .560

The difference between the two groups is not statistically significant. These data show that the probability is in fact very high that the differences between the group means is the result of chance.

The summary statistics for the survey averages are shown below:

	Number	Mean	Standard Deviation
Simulation Test	10	2.258	.443
"Hands-On" Test	10	2.050	.437
t = 1.056	Degrees of Freedom = 18		Probability = .305

These statistics show that the differences between the two groups is not significant.

DISCUSSION AND RECOMMENDATIONS

The purpose of the B.A.R. Demonstration Project was to examine the feasibility of creating a computer-based multimedia simulation examination that could provide B.A.R. with the same level of confidence in assessing the ability level of mechanics as a "hands-on" actual vehicle examination, but in a more cost-effective manner. The statistical comparison of the certified smog check mechanics that were examined with the prototype simulation test as compared with an equivalent "hands-on" test indicate that the simulation test is not significantly different from the "hands-on" test.

The survey results indicated that there was no significant difference between the opinions of the simulation and "hands-on" groups concerning their respective testing experiences. The subjective reaction of the simulation group to their experience does not seem to contain any issues that would inhibit the acceptance of simulation testing as a new test methodology for B.A.R. These findings are congruent with, and supported by, the general literature on simulation training and testing (Maher, 1988).

General Recommendations:

1. B.A.R. should convert its current written examination to a computer-based multimedia simulation examination, using the current demonstration design documents and simulation test, with at least the modifications discussed below, as the working prototype.

However, B.A.R. should be cautioned that the power of this computer-based multimedia simulation examination rests in the degree to which it accurately simulates the work on an actual vehicle and workplace environment.

2. B.A.R. should include extensive reliability analysis, through Kuder-Richardson formulas, Rasch analysis and calibration or other widely recognized and appropriate statistical method, in any future simulation test development, in order to insure the quality of the many elements of individual test questions.

This study also contains important design recommendations.

INTRODUCTION AND BACKGROUND

In May of 1986, the California State University system released a Memo of Understanding (#4), part of an Interagency Agreement with the California Department of Consumer Affairs, Bureau of Automotive Repair (#12IA0077-B5), requesting

> **a study be conducted on the feasibility of training smog check mechanics via hands-on verification of mechanics ability to inspect and repair vehicles. The study should include recommendations on the most cost effective approach for conducting hands-on training, retraining and testing.**

The report produced from that contract, Hands-On Verification Of Mechanics Training: A Cost-Effectiveness Study Of Videodisc Simulation (Maher, 1988), recommended to the Bureau of Automotive Repair (B.A.R.) that:

> 1. B.A.R. should no longer actually conduct mechanic training, but should continue to test, certify and license....the Bureau should concentrate its resources on setting quality and performance standards for both the public and private institutions whose business it is to train and educate. These standards should include task lists of the knowledge, skills and abilities required by qualified mechanics to test, diagnose and repair emissions systems and the standards for instructors delivering training at public and private institutions.
>
> 2. B.A.R. should test, certify and license mechanics through comprehensive "hands-on" simulation testing. While removing itself from the delivery of training, the Bureau should maintain control over the quality of mechanics through the use of the testing, certification and licensing function. ...Therefore, this study recommends Model 2, "Simulation Testing", as being the most effective method of insuring a hands-on, quality control capability for B.A.R., provided in the most cost-efficient manner....[Simulation Testing] offers the advantages of standards setting, comprehensive testing and some insurance that mechanics can perform in a realistic environment. Because of the economies of delivery, this is the most cost-effective model ...comparing the total costs of all the models and the total costs per student....the Bureau should [also] seek expert advice at the time of their actual solicitation. That advice would consist of the writing of very detailed specifications of the work to be performed for B.A.R., evaluating the submitted proposals, and reviewing work-in-progress.

These recommendations were adopted by B.A.R., and began to be implemented by the development of a new, comprehensive Smog Check Certification Examination by B.A.R. in conjunction with the California Department of Consumer Affairs' Central Testing Unit. In addition, the California State Polytechnic University at Pomona (Cal Poly) received two subsequent contracts from B.A.R., parts of which were designated to implement a "demonstration project" of computer-based, multimedia simulation testing for smog check mechanics. Part of the contract "Smog Check Program for the 90's" (Contract #12SA8101-B8, T. Maher, Project Director, November, 1988) was designated for the planning of a prototype of this simulation. The primary work product of that effort was a treatment document for the design and evaluation of the prototype simulation test (Maher & Harty, 1992, Appendix A-1.).

Under a portion of the contract "Smog Check 2000: The 1991-1994 Bureau of Automotive Repair-Cal Poly Production Agreement" (Contract #12IA9040-C1, L. Harty, Project Director, August, 1991), Cal Poly was to produce and evaluate the simulation test. Using B.A.R. personnel and others as content experts, Cal Poly initiated a process of test item development that resulted in a set of test item scenarios. In addition, two flow charts were developed, one for the actual paths of the examinee within each item and one for the progress of the entire test (Maher & Harty, 1992, Appendix A-2). In the fall of 1992, Cal Poly contracted with StatMedia (Gary W. Birch, President, Yorba Linda, CA) to develop and program the actual test, from this basic document set.

This document reports on the experimental evaluation trials of the prototype simulation test, as compared to a "hands-on" test using actual vehicles. It is divided into major sections including this Introduction and Background, General Description of the Simulation Test, Evaluation Design, Results and Analysis, Discussion and Recommendations, References and Appendices.

GENERAL DESCRIPTION OF THE SIMULATION TEST

Simulation Test Components

Software and Hardware Components

The simulation test operates on an Apple Macintosh IIci, with a single touch screen color monitor, controlling a videodisc player. The primary software controlling the simulation is MacroMedia Director ver 3.1. An entire list of all the individual software and hardware components of the simulation test is in Appendix B-1.

Simulation Test Sections

Introduction, Tutorial and Help: This section orients the mechanic to the operation of the display device by introducing the computer and explaining the methods of both presentation and appropriate mechanic response. The "Tutorial" is limited to a description and demonstration of the interface components such as buttons and the "tools". In addition, this section shows very simple example questions and requires the mechanic to respond properly, whether by pushing a touch screen button or using a simulated tool. This "Tutorial" section is then used as the response to the "Help" button throughout the test section.

Data Section: The data section of the test is unavailable to the mechanic. It contains the mechanics' logon information, including B.A.R. certificate number, the touch screen/keyboard entry responses of the mechanic to test questions, the completion time of each major item, the elapsed time for the entire tutorial and test, and the procedural sequence for question #23. At logoff, this data is exported by the MacroMedia Director program to a Microsoft EXCEL file.

Test Section: The essential framework of this simulation examination is a smog check, including a visual inspection, functional check, and diagnosis of emission problems. Three vehicles were used: a 1989 Toyota Tercel, a 1990 Buick Riatta, and a 1992 Ford Taurus. The actual test consists of nine test "items" divided into visual inspection, functional inspection and diagnostic groups, with a total of 44 individual questions. The 44 questions were worth a total of 50 points. The items provide a general framework and beginning and end point for the mechanic. For example, "Item" #1, with 17 specific questions, provides the mechanic with a framework or context of the initial contact with a vehicle. In addition, all of these questions require the mechanic to "look-up" information located on the vehicle itself, and/or in standard manuals provided at the test site. Appendix B-2, "Test Item Summary", provides a quick reference to the general content of the test items. Appendix B-3, "Smog Check Technician Checklist", is a complete listing of the items and the full text of individual questions, with correct answers. In each area the examination includes "look-up" questions that require the use of actual manuals that were available at the test site. The list of manuals is contained in Appendix B-4.

An on-screen "host" character acts as the guide through the exam, presenting questions verbally to the mechanic. The mechanic can also read the specific test question from the screen. Also, the host figure provides some transition between major elements of the test, and additional realism to the simulation environment. The host appears from both analog video from the videodisc, presented in a large window, or from digital video files stored on the computer hard disc, in a smaller window to the side.

As appropriate, questions are fully simulated through audio/video presentations from the videodisc, and/or from digital audio/video/graphic files on the computer, shown on the single computer monitor. Mechanics are prompted for answers to questions on identification, selection of tools and methods, location of hookups for tools, and application of tools and methods, from the computer audio/video/graphic files, from a combination of computer-generated and videodisc sound and images, or directly from the videodisc source alone. Simulated tools that are available include vacuum gauge, timing light, oscilloscope with three optional display modes, and an exhaust gas analyzer. Also provided are simulated tachometer and temperature readings, engine starter, and accelerator pedal. In addition, the mechanic has the ability to move around the vehicle, and to "zoom in" to a number of areas inside both the engine and the passenger compartments, to obtain closer views.

EVALUATION DESIGN

General Design Considerations

The general evaluation design was developed to examine the effectiveness of a computer-based, multimedia simulation test on California smog check mechanics. Both common sense and the research literature showed that a computer-delivered simulation test would be superior to a written examination. Consequently, comparing the simulation test to the current paper-and-pencil testing mode was not seriously considered. While not practical, the ideal testing methodology, given unlimited time and resources, would be to examine every mechanic with a "hands-on" test on an actual series of vehicles. Since the purpose of the simulation test was to approach this ideal testing environment, yet maintain a sense of practicality and cost-efficiency, the simulation test was compared to a "hands-on" test.

In addition, it was self-evident that the test population had to be current smog check mechanics, in order for the results of the comparison to have any validity with that group. Since both the prototype simulation test and the "hands-on" comparison test were outside the usual channels of B.A.R. examinations, currently certified smog check mechanics were to be recruited and paid to participate in the study. While this would be a self-selected, non-random sample of the population of certified smog check mechanics, the sample would be randomized between the two testing methods. The purpose of the evaluation was the comparison of those two testing methodologies, not validating either test for use with the entire population.

It should also be noted that most quasi-experimental designs with two groups are usually interested in comparing a "control group" with an "experimental group", where a "treatment" that is the object of interest has been added to the conditions of the experimental group. In general, the question to be answered is whether there is a statistically significant difference in performance between the groups, a difference that might then be attributed to the treatment. However, in the current case both groups are considered the same. The question of interest is whether there is no significant difference in performance between the groups, suggesting that the two methods of examination are essentially equal, and yield equal results.

Finally, the evaluation gathered two kinds of data. In addition to the performance of the mechanics on the actual test questions, each group completed an identical, Likert-scaled questionnaire that asked them about their subjective response to the particular test methodology they used ("Survey for Mechanics-BAR Demonstration Project", Appendix C).

Description of the "Hands-On" Actual Vehicle Test

The creation of the "hands-on" actual vehicle test was based on one essential criterion: that it and the simulation test be as equivalent as possible. The major exception to this approach was that the "hands-on" test would not artificially restrict a mechanic's normal operating alternatives. Clearly, the simulation test did not provide the mechanic with **all** possible views of the vehicle, or **every** potential tool, or **any** test procedure desired, etc. The simulation did have a much more restricted set of options for the mechanic than the actual vehicle. However, for the "hands-on" test to reflect an actual work environment, it was determined that the mechanic could not be restricted, even if this became a source of differential performance between the test methods.

The "hands-on" test did not contain a formal "Tutorial" or "Help" section. The test was continuously observed by the B.A.R. proctor, who would only answer procedural questions about the test process, but not about the content of questions.

The test itself was essentially a "printout" of the nine test items and specific questions from the simulation test described earlier ("Smog Check Technician Checklist", Appendix B-3). The content, wording and order of the questions were the same. (Anomalies that appeared in the questions during the test administration are discussed under Data Collection below.) The exact three vehicles that were used to create the visuals for the simulation test were used for the "hands-on" test. With the exceptions noted in Data Collection below, the vehicles presented the same configurations, and required the same answers, as they did in the simulation test. In addition, all the tools that were available in simulated form on the "simulation" test were available and displayed for the mechanic, including a B.A.R. 90 TAS analyzer. In this "hands-on" test environment the mechanic also had available an entire set of standard shop hand tools in a tool chest approximately five feet high. The same set of manuals available for the simulation was also available. The actual vehicle components photographed for the identification questions in the simulation test were displayed for identification questions in the "hands-on" test.

The performance data were collected by having the mechanic fill out the blanks on the list of test questions ("Smog Check Technician Checklist", Appendix B-3). The checklist attached in the appendix also includes the correct answers. In addition, upon completion of the test each mechanic completed the "Survey for Mechanics", (Appendix C).

When the mechanics arrived at the test site, they were given the same introduction to the test situation that was part of the opening narration on the simulation test. They were given the test form to complete, shown the tools, manuals and displayed items for identification, and told to begin. The test had no time limit.

Sample Selection and Randomization

The central issue in this study was the question of the equivalency of the simulation and "hands-on" tests. Consequently, the primary focus of sample selection was on randomizing the two test groups, rather than attempting to select test groups that would mirror the population of Smog Check mechanics throughout California. In addition, practical constraints of time and money made the use of a statewide sample impossible. For the purposes of this study, the basic assumption was made that there are no significant differences in the general abilities of Smog Check mechanics based strictly on their geographic location in California. Consequently, B.A.R. derived a random sample of 1,500 Smog Check technicians from a total of approximately 8,500 in Los Angeles, Orange, Riverside, San Bernardino and Ventura Counties. (Appendix D-1, Memo Adelsperger to Harty, describes this process in detail.)

B.A.R. then mailed letters (Appendix D-2, sample letter) to each of these 1,500 technicians, asking them to indicate interest in participating in the BAR Smog Check Project by calling the Instructional Technology Office at the California State Polytechnic University at Pomona (Cal Poly). Approximately 250 technicians called in to express interest in participating in the project. At that time their current addresses were confirmed. Letters of response, with the form "**Confirmation of Intention to Participate,**" (Appendix D-3, sample letter/form) and a self-addressed stamped envelope, were mailed to responding mechanics, requesting that they fill out and return the form by December 10, 1992.

The 180 technicians who returned the confirmation form became the basic sample. This group was divided in half, based on the last digit of their Social Security numbers: Odd numbers were assigned to the "hands-on" test; even numbers were assigned to the simulation group. The first forty technicians from the unordered list of each group were scheduled. "Hands-on" test subjects were scheduled at four per day beginning on January 25, 1993, ending February 8, 1993; simulation test subjects were scheduled at six per day, beginning February 5, 1993 and ending February 15, 1993.

At this time, four additional names were chosen as Beta test subjects for the simulation test.

Letters with enclosed maps were sent to selected technicians, giving them time and location assignments (Appendix D-4, sample letter). Letters of regret were sent to those not chosen to participate in the project (Appendix D-5, sample letter).

Trials were conducted at Citrus Community College (hands-on test) and Cal Poly Pomona (simulation test). Thirty-eight subjects were actually tested in each group.

Data Collection and Presentation-Tests

As described earlier, the raw performance data from the simulation test were accumulated during the testing process and exported to a Microsoft EXCEL file. The record for each individual contained the unprocessed keystroke responses to each question. Some of those responses could have multiple word and number strings, making automated scoring by columns impossible. Consequently each record was manually scored and transferred to an answer grid (Appendix E-1). On that answer grid the raw scores from the nine test items are translated into 44 specific question responses. All answers were scored one point for a correct response, except for question #21 which was scored either two points for a correct answer, or zero points for an incorrect answer. Question #35 was worth six points, and scores could range from zero to six. Each of the individual checklists from the "hands-on" test was also manually scored, and transferred to an answer grid in the same way (Appendix E-2).

This manual scoring was also required of both tests because of specific problems that emerged with some questions. The initial question under item #5 of the "Smog Check Technician Checklist" (Appendix B-3), never actually appeared on the simulation test. Consequently the response was eliminated from the "hands-on" test group during the hand scoring phase, and is noted as an "X" in the checklist. Because of problems of interpretation, on both the simulation and the actual vehicle, of whether a part is "missing" or "disconnected", and of contradictory information in commercial automotive manuals, questions #18 and #22 could have either of two correct answers.

Because of technical problems in creating the actual defects in the "hands-on" vehicle for question #35, the malfunctioning cylinders were different in the simulation (cylinders 4&5) than in the "hands-on" test (cylinders 2&6). Because questions #36-#41 depend on this cylinder data, the answer order of the "hands-on" test was shifted to match the simulation. The number of problem cylinders and the nature of the problems remained constant in both tests. In scoring, the answer order was conformed so that now question #39 and #40 refer to malfunctioning cylinders on both the simulation and the "hands-on" answer grids.

Because of an undetected wording difference between the simulation test and the "hands-on" test in question #43, both groups were scored correct if the mechanic was able to download any of the appropriate trouble codes. Because question #44 was dependent on that answer, it was scored correct for both groups if the mechanic was able to correctly find in the reference materials the meaning of a downloaded code.

Data Collection and Presentation-Survey

The data from the surveys for the simulation testing group (Appendix E-3) and for the "hands-on" testing group (Appendix E-4) were manually transferred to answer grids similar to those used for the test data. In addition to the responses to the ten Likert-scaled survey items, each mechanic was asked for their date of birth, their years of experience as a mechanic and as a certified smog check mechanic. Those data were also transferred to the answer grids.

RESULTS AND ANALYSIS

Test Reliability Results

To properly evaluate the performance of the two groups on the simulation examination and the "hands-on" version, the test itself had to be analyzed for reliability. If the test was not reliable, and contained excessive misfitting and unreliable items, then the performance comparison would not be very reliable.

A Rasch analysis (Wright & Linacre, 1993) was chosen for the reliability study. This technique is currently used to norm examinations by the National Board of Medical Examiners and the American Society of Clinical Pathologists, among others. The basic specification of the Rasch analysis is that "The more able the person, the more likely a success on any item. The more difficult the item, the less likely a success for any person" (Wright & Linacre, 1989). In addition to its currency. speed and simplicity, the Rasch analysis was also chosen because it could accommodate weighted items, such as questions #21 and #35. The more traditional Kuder-Richardson formulas for test reliability require dichotomous scoring (right or wrong) (Borg & Gall, 1983).

The process began by analyzing the items for the simulation test and the "hands-on" test independently. No items fell outside the range of $\pm$ two standard errors of measure. Consequently the groups were combined for additional analysis. The analysis also confirmed the visual inspection of the data that the test was relatively "easy" for both groups, because several items were correctly answered by all.

The first analysis of the combined data found two items that significantly "misfit": questions #23: "Results of the functional EGR system test"; and #26, "Identifying component C, the EGR position sensor". The items "misfitting" had inconsistent responses that were outside the range of responses expected of items of that difficulty. Also, three persons were found to significantly "misfit". Persons "misfitting" responded inconsistently outside the range of responses expected for persons of their ability. These items and individual were subsequently removed from the analysis. In addition, items that were answered correctly by all, and individuals who answered all items correctly, were eliminated.

The test was then recalibrated. The original results of the first analysis of the combined group, and the final combined recalibration are shown below:

Original Calibration:	Person Separation Reliability	=.52
	Item Separation (Test) Reliability	=.82
Final Calibration:	Person Separation Reliability	=.60
	Item Separation (Test) Reliability	=.86

The person separation reliability illustrates the earlier comment that the test was relatively easy. This would, however, be expected in this type of mastery testing situation with a self-selected sample. In addition, the test was designed specifically to illustrate various types of item possibilities, and not to discriminate and distribute abilities among this group.

The high item separation reliability, or test reliability, indicated that in general persons responded consistently to the test according to their performance capabilities.

Test Group Comparison Results

Once the test reliability was determined, all items and all scores were used in the comparison of the performance between the simulation test group and the "hands-on" test group. The summary statistics for the raw scores are shown below:

RAW SCORES	Number	Mean	Standard Deviation
Simulation Test	38	44.184	3.525
"Hands-On" Test	38	43.737	3.117
t = .586	Degrees of Freedom = 74		Probability = .560

The Rasch analysis provides a calibrated measure equivalent for each raw score. The summary statistics for the measures are shown below:

MEASURES	Number	Mean	Standard Deviation
Simulation Test	38	2.766	1.253
"Hands-On" Test	38	2.616	1.238
t = .525	Degrees of Freedom = 74		Probability = .601

Based on the relatively low "person separation" reliability noted above, there was some concern about the possibility that the test contains too many "easy" items, and that the "inflated" scores by both groups would mask any differences in the presentation and delivery methodology. As a check against this possibility, any question on which there was a combined score between groups of 76 (all correct: 38 & 38) or 75 (1 incorrect in either group) was eliminated from the total individual scores. A total of 14 questions were eliminated: #1, 4, 5, 6, 7, 8, 11, 14, 15, 16, 19, 22, 27, and 28. The concern about the degree of difficulty of the test was unfounded, as the scores of the two groups actually became closer.

RAW SCORES minus "Easy" Items			
	Number	Mean	Standard Deviation
Simulation Test	38	30.211	3.378
"Hands-On" Test	38	29.974	2.936
t = .326	Degrees of Freedom = 74		Probability = .745

Clearly, the differences between the two groups are not statistically significant. These data all show that the probability is in fact very high that the differences between the group means are the result of chance.

The "***t*** test" is a standard formula for statistical analysis to compare the differences between two groups, and can be found in almost any inferential statistics textbook. These textbooks usually have tables of the basic ***t*** values. The tables also indicate various "degrees of freedom" and various probability levels. The degrees of freedom for a statistical test relates to the number of persons or scores used in the test computations. In general, fewer persons/scores require higher computed ***t*** values for any differences to be significant. In the actual analysis, the ***t*** value is computed from the scores of the groups. The degrees of freedom in the two-sample case are the number of persons in each group (38) added together (76) minus two, one for each sample (74). Also, it should be noted here as a reference point on the probability figures that if the research question was focused on finding a difference between groups, in order, for example, to support the worth of a particular treatment received by one of the groups, then the probability level would typically be set at $p < .05$, or even $p < .01$. That is, in advance of the experiment, the researcher would require that the probability (p) be less than (<) .05, or even .01, that whatever differences may be found are the results of chance influences. In these cases ***t*** values that would yield larger probabilities, such as .06 in the first case or .02 in the second, would be considered non-significant differences because of the potential influence of chance. Consequently, ***t*** values with probabilities of the magnitude in this study ($p = .560$, $p = .601$, $p = .745$) indicate unambiguously that the differences are non-significant.

Survey Results

The results of the opinion survey for both groups are listed below as the average response value:

1= strongly agree 2= agree 3= undecided 4= disagree 5= strongly disagree

	Simulation	Hands-On
a. This test gave me a fair chance to show my skills as a "Smog Check" mechanic.	1.95	1.66
b. This test was very easy for me.	2.50	2.24
c. Most of the questions on this test were very much like the things that I really do on my job.	1.84	1.87
d. This test gave me a fair chance to show my knowledge of the "Smog Check" program.	1.87	1.68
e. Most mechanics that are certified for the "Smog Check" program would say that this was a hard test.	2.79	2.95
f. I think that all the "Smog Check" testing should be done just like the test that I just took.	**2.45**	**1.92**
g. The best kind of "Smog Check" test is the method using a written test, pencil and answer sheets.	**3.55**	**3.97**
h. The way that the test I just took was given to me was very confusing.	**3.55**	**4.03**
i. I enjoyed taking a test using this method.	1.76	1.63
j. Most of the things that this test asked me about I don't usually do on my job.	*3.89*	*3.55*

In addition, the descriptive information about the mechanics is summarized below:

Age (as of Dec. 31, 1992)	**38.2**	**37.3**
Years as a mechanic:	**14.1**	**13.5**
Years as a certified smog check mechanic:	**8.21**	**8.41**

The summary statistics for the survey averages are shown below:

	Number	Mean	Standard Deviation
Simulation Test	10	2.258	.443
"Hands-On" Test	10	2.050	.437

t = 1.056 Degrees of Freedom = 18 Probability = .305

In order to compile these summary statistics, the actual values for the "negatively" stated items, #e, #g, #h, and #j, were reversed for the computations only. Otherwise the higher values for these "negative" items would have masked positive values.

These statistics show that the differences between the two groups is not significant. However, an initial Rasch analysis of the individual survey response items indicated significant differences between the groups on items #f, #g, and #h. Item #j, which was the direct reverse of item #c, was apparently confusing and was also a misfit in the analysis.

DISCUSSION AND RECOMMENDATIONS

Discussion of Test Results

The purpose of the B.A.R. Demonstration Project was to examine the feasibility of creating a computer-based multimedia simulation examination that could provide B.A.R. with the same level of confidence in assessing the ability level of mechanics as a "hands-on" actual vehicle examination, but in a more cost-effective manner. The statistical comparison of the certified smog check mechanics that were examined with the prototype simulation test, as compared with an equivalent "hands-on" test, indicate that the simulation test is not significantly different from the "hands-on" test. These findings are congruent with, and supported by, the general literature on simulation training and testing (Maher, 1988):

> In summary, it seems clear that computer-controlled videodiscs can be an effective method for delivering training and creating simulations. ...Videodisc training has been shown to work effectively within the automotive industry in the delivery of training to auto mechanics. Finally, state agencies have used videodiscs in both their training and licensing functions....Videodiscs are the least expensive delivery method because of the elimination of instructors and the reduced training time required to complete coursework. These conclusions are confirmed by the reviews of literature that discuss cost-effectiveness issues (Azia, 1986; Bosco, 1986; Russ-Eft, 1985; Orlansky & String, 1979, 1981; Spuck, 1981; Van der Drift, 1981; Wilkinson, 1980). Videodiscs therefore provide the most cost-effective delivery method for hands-on mechanic training and ***verification testing***. [italics added]

In addition, there were no data in the survey results discussed below to indicate any extreme opinions expressed by the mechanics concerning resistance to the simulation examination method. As noted in the B.A.R cost-effectiveness study (Maher, 1988) that originally discussed the advantages of simulation testing,

> B.A.R. should continue in its quality control function by creating a comprehensive examination procedure to verify the attainment of those standards of performance. That examination should be a

videodisc-based, vehicle simulation test that will enable the Bureau to verify mechanics' ability to operate in the vehicle environment.

Consequently, since the performance data between the simulation and "hands-on" methods of testing have now been shown to be not significantly different to a high level of confidence, this evaluator recommends that:

1. B.A.R. should convert its current written examination to a computer-based multimedia simulation examination, using the current demonstration project design documents and existing simulation test, with at least the modifications recommended below, as the working prototype.

However, B.A.R. should be cautioned that the power of this computer-based multimedia simulation examination rests in the degree to which it accurately simulates the work on an actual vehicle and workplace environment. While obviously more convenient, and with other administrative advantages, the use of the computer only to deliver what is essentially a "text" examination, with a few visual embellishments, is to continue to use a "written" test, without the strengths of multimedia simulation.

The analysis of the test items found two questions that were significantly "misfitting" in relationship to the rest of the questions, and several of the questions that did not discriminate, this is, everyone answered them correctly. Because of the potential for difficulty in understanding parts of the computer simulation interface, as well as to document that only appropriate and useful questions become part of any future simulation test item bank, this evaluator recommends that:

2. B.A.R. should include extensive reliability analysis, through Kuder-Richardson formulas, Rasch analysis and calibration or other widely recognized and appropriate statistical method, in any future simulation test development, in order to insure the quality of the many elements of individual test questions.

Discussion of Survey Results

While no statistical tests were used, observation would indicate that the data on the age, average years of experience as a mechanic and as a certified smog check mechanic, show the two groups to be essentially equal on those measures, confirming the success of randomizing the original sample.

The survey results indicated that there was no significant difference between the opinions of the simulation and "hands-on" groups concerning their respective testing experiences. In this case the opinions of the "hands-on" testing group acted as a "control" group for those of the simulation group. The importance of this finding is that the general subjective reaction of the simulation group to their experience does not seem to contain any issues that would inhibit the acceptance of simulation testing as a new test methodology for B.A.R.

Both groups tended to either strongly agree or agree with the statements that said:

- This test gave me a fair chance to show my skills as a "Smog Check" mechanic;

- Most of the questions on this test were very much like the things that I really do on my job;

- This test gave me a fair chance to show my knowledge of the "Smog Check" program; and

- I enjoyed taking a test using this method.

Both groups tended to be undecided, on average, about statements that said:

- Most mechanics that are certified for the "Smog Check" program would say that this was a hard test; or that

- This test was very easy for me.

In addition, both groups were apparently confused about the reversed, negative wording of the following statement and responded inconsistently:

- Most of the things that this test asked me about I don't usually do on my job.

However, the groups did diverge on three of the statements. First of all, the simulation group tended to be, on average, more undecided than the "hands-on" group about agreeing that:

- I think that all the "Smog Check" testing should be done just like the test that I just took.

In addition, the simulation group tended to be, on average, more undecided than the "hands-on" group about *disagreeing* with the statements that:

- The best kind of "Smog Check" test is the method using a written test, pencil and answer sheets; and that

- The way that the test I just took was given to me was very confusing.

Taken together, the reaction of the simulation group to these three statements would seem to indicate some reduced acceptance of, and some increased confusion about, the simulation testing method compared to the reactions of a similar group of mechanics to the "hands-on" method. Given the general and long-term familiarity of smog check mechanics with the "hands-on" testing environment of working on actual vehicles with real tools, and the "newness" and/or "strangeness" of the computer simulated environment, it is somewhat surprising that the magnitudes of these differences of opinion between the groups are actually not much greater. However, because the functioning of the simulated vehicle environment, the methods of working with simulated tools, and the other necessary constraints of the simulation test, have the clear potential to increase the test resistance and heighten the confusion of some mechanics, however small that increase might be, this evaluator recommends that:

3. B.A.R. should insure that the fully configured simulation test incorporate a completely developed tutorial and help section, with at least the features described in the original design document (Appendix A-1).

A completely developed tutorial and help section would also assist B.A.R. by increasing the probability that the fully configured simulation test would be able to function as a "stand-alone" examination workstation, without the need for full-time test proctors. Additional support for this recommendation is discussed in the first two items below under Evaluator's Observations.

It should be noted that the simulation test proctors, Sam Hay and Larry Harty, who were also the prime test developers from The California State Polytechnic University at Pomona, have indicated that they feel that the "Tutorial" section can be significantly reduced (Appendix F-1, item #7).

Evaluator's Observations and Recommendations on Simulation Test Design

(On February 4-5, 1993 the evaluator visited the sites of both the "hands-on" test and the simulation test. He observed one "hands-on" examination and all or most of six simulation examinations. In addition, the evaluator went through the entire simulation examination process as an examinee. Observations by the Cal Poly test proctors, and the "hands-on" proctor, Phil DeLeon, a B.A.R. employee and test developer, are attached in Appendices F-1 and F-2 respectively. *These documents also present a number of important, additional design recommendations.)*

A. When a mechanic was unable to complete an item, for whatever reason, yet continued to make attempts, the proctors for both the "hands-on" and simulation tests would eventually interrupt the process, fail the mechanic on that question, and have the mechanic proceed with the test. These were generally subjective judgments made by the proctors. This behavior was observed in both test groups. While the action of the proctors could have theoretically had an influence on the eventual outcomes of the tests, discussions with the proctors led to the conclusion that any possible effects canceled between groups. An expanded "Tutorial" section should provide instructions to the examinee concerning appropriate behavior in these kinds of situations.

B. The simulation test proctors were occasionally required to coach mechanics through the "Help" module itself, as well as to provide assistance to the mechanics with the operation of the computer interface during the actual examination. Difficulties were observed in both the use of the buttons, and with the "point-and-drag" simulated tools. Part of the interface problem is the result of the relatively slow response speed of the simulation test when compared to the quicker responses on the B.A.R. 90 TAS analyzers with which these mechanics are all familiar. Speeding up the responsiveness of the simulation would be very helpful. However, many of the interface problems were the result of an underdeveloped "Tutorial" section at the opening of the test. As noted in the original design document, examinees should not be able to proceed to the actual test until they have successfully demonstrated mastery of the interface through completion of example questions in the "Tutorial" section.

Both this and the previous item provide additional support to the recommendation made above concerning the expansion of the "Tutorial" section.

C. Both tests contained an "experimental" test question that required the mechanics to complete a work order form based on information developed to answer the questions numbered #35-#41. It became clear very early in the administration of the examination that not only was the computer programming not refined enough at that point to score this text question on the simulation test, but that the wording of the question itself made scoring problematic even on the "hands-on" test. This question was disregarded before formal scoring began. However, the results were such that a different kind of question that required a more precise "fill-in-the-blank" text response could be computer scored. In addition, another computing experiment was attempted in which the number of steps and the sequence of steps were recorded by the computer for a mechanic's progress through the EGR procedure required in question #23 of the simulation test. Also, the computer recorded the start and stop times for each item. Since there was no comparable records for the "hands-on" test, these data were not used, but indicate some of the wide range of additional information that can be collected through computer delivery of tests. Therefore this evaluator recommends that:

4. B.A.R. should insure that the fully configured simulation test incorporate as much data collection, and as wide a variety of simulation test questions, as they think may be useful, without prejudging the actual feasibility of either.

D. With the exceptions noted earlier for the "experimental" questions, the "Data Collection" section of the simulation test provided a file that contained only raw data. Consequently, each person had to be manually scored. This is obviously a costly and time-consuming process. While it is critically important for the raw score data to be available for quality control in the scoring process, this evaluator recommends that:

5. B.A.R. should insure that the fully configured simulation test incorporate a "Data" section that at least scores correct answers to questions, and also may provide various reports on both questions and examinees, such as subscores on visual inspection, functional inspection, diagnosis, etc., all available via remote telecommunications access.

6. Minor Design Recommendations: The following are some less critical observations on the simulation test, and corrective suggestions.

Unlike the "hands-on" test, where the answers to previous questions were always available, the simulation prevented looking at earlier answers. That restriction caused some unnecessary delays because that earlier information was needed to answer later questions.

- **The fully configured simulation test needs a continuing "title bar" or other on-screen prompt on data already gathered and "known," such as vehicle model, engine size etc. This could even be a "pop-up" electronic "scratch pad" on which the mechanic could write notes.**

Because of understandable restrictions in the prototype simulation test, questions do not remain on the screen when any of the "tools" are used. There were occasions when the mechanic was unsure of the exact question wording. Also, the "Help" button is often replaced with other information.

- **The fully configured simulation test needs to have the question present on screen at all times until it is answered, and the "Help" button present on screen at all times.**

Finally there is the broad design issue of how much to "focus" or "restrict" the choices of the examinee, relative to an actual vehicle environment. In the "real" environment, mechanics may have a large number of possibilities for arriving at a "correct" answer to a problem. While it might initially appear that the goal of the test is correct answers, B.A.R. would seem to want those "correct" answers found by the use of a particular, specified "correct" procedure. For example, on an actual vehicle some mechanics could "cheat" the EGR test of vacuum by pressing with their fingers on the EGR diaphragm, instead of using a vacuum gauge. Another example is the use of a paper clip to pull basic trouble codes. However, this method misses much of the electronic diagnostics available through factory methods of accessing trouble codes. The point is that while not exactly the same as the actual vehicle work environment, the simulation test could exclude these possibilities.

- **The fully configured simulation test should provide B.A.R. the opportunity to enforce its interest in the use of recommended and appropriate smog check and diagnostic procedures, even at the expense of causing the simulation work environment to differ from the actual work environment.**

Summary of Recommendations

General Recommendations:

1. B.A.R. should convert its current written examination to a computer-based multimedia simulation examination, using the current demonstration design documents and simulation test, with at least the modifications discussed below, as the working prototype.

2. B.A.R. should include extensive reliability analysis, through Kuder-Richardson formulas, Rasch analysis and calibration or other widely recognized and appropriate statistical method, in any future simulation test development, in order to insure the quality of the many elements of individual test questions.

Design Recommendations

3. B.A.R. should insure that the fully configured simulation test incorporate a completely developed tutorial and help section, with at least the features described in the original design document (Appendix A-1).

4. B.A.R. should insure that the fully configured simulation test incorporate as much data collection. and as wide a variety of simulation test questions, as they think may be useful, without prejudging the actual feasibility of either.

5. B.A.R. should insure that the fully configured simulation test incorporate a "Data" section that at least scores correct answers to questions, and also may provide various reports on both questions and examinees, such as subscores on visual inspection, functional inspection, diagnosis, etc., all available via remote telecommunications access.

6. Minor Design Recommendations:

- **The fully configured simulation test needs a continuing "title bar" or other on-screen prompt on data already gathered and "known," such as vehicle model, engine size etc. This could even be a "pop-up" electronic "scratch pad" on which the mechanic could write notes.**

- **The fully configured simulation test needs to have the question present on screen at all times until it is answered, and the "Help" button present on screen at all times.**

- **The fully configured simulation test should provide B.A.R. the opportunity to enforce its interest in the use of recommended and appropriate smog check and diagnostic procedures, even at the expense of causing the simulation work environment to differ from the actual work environment.**

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Appendix A

Background Documents

SMOG CHECK FOR THE 90'S

DEMONSTRATION PROJECT

Treatment Statement for
Simulation Testing

Submitted by:

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November 21, 1991

APPENDIX A-1

SMOG CHECK FOR THE 90'S

DEMONSTRATION PROJECT

Treatment Statement for Simulation Testing

I. ASSUMPTIONS

A. General

1. This treatment is for a demonstration of the ability of computer-assisted, videodisc-based media to create simulations of the elements of a smog inspection to test smog check mechanics for certification. With these videodisc simulations, it will be possible to test and evaluate the ability of this particular delivery method to assess the knowledge, skills and abilities of smog check mechanics, as compared to assessing the same general level of performance of mechanics by using actual vehicles. If the test hypothesis is correct, that the videodisc simulation method is at least equivalent to the actual vehicle method of assessment, then BAR can use certification testing through videodisc simulation, without the time and expense of testing mechanics on actual vehicles.

2. This testing methodology will allow mechanics to answer questions at their own pace in an individual setting. This will permit the mechanic to test in more than one session, and at a time convenient to the mechanics and their employers.

3. This demonstration will be evaluated by comparing the performance of mechanics in the videodisc simulation test environment to the performance of mechanics in similar test situations on actual vehicles. This general evaluation procedure will require that actual smog check mechanics be hired (approximately $80 per mechanic as recommended by BAR) to participate as evaluation subjects, and that the evaluation occur outside the normal paper testing cycle.

B. Hardware Components

The original working assumption of this treatment is that the final demonstration will operate on an Apple Macintosh II with color computer monitor, controlling a videodisc player with a separate, color video monitor.

However, recent advances in the display of video material within the computing environment, i.e. on the same monitor as computer data, may be more cost effective. Nothing in this treatment is meant to require a two-monitor display situation, nor require the use of videodisc over any other optical storage media such as CD-ROM, DVI, etc. It is hoped that only minor modifications, if any, would be needed in this treatment to accommodate these optional presentation situations.

C. Software Components

The working assumption of this treatment is that the final demonstration will be written completely in Apple's Hypercard 2.0 (or higher) software.

However, because of the requirements of test scoring and data collection it may be necessary to use a secondary database program to perform these functions within the Hypercard shell. Such a database would of course be transparent to the mechanic user.

II. MODULES IN THE DEMONSTRATION TEST PACKAGE

A. General Requirements

The customized software components that will be created for this demonstration project will function in support of the following set of tasks and knowledge requirements originally developed by BAR:

BAR OBJECTIVES

Vehicle I.D.

1. Identify engine configuration and Smog Check requirements by examining underhood emissions label.

2. Identify engine and required ECS by referring to VIN and manuals if emissions label is missing.

3. Determine vehicle certification status (federal, California, Canadian, none) by referring to underhood label, reference manuals and emission control equipment.

4. Review emission label to determine ECS and emission devices required on the vehicle.

Visual Inspection

1. Inspect vehicle for missing, modified, disconnected or defective (MMDD):
   a. PCV system
   b. Thermostatic air cleaner
   c. Evaporative controls
   d. Catalyst
   e. 3-way catalyst
   f. Exhaust gas recirculation system
   g. Ignition spark controls
   h Feedback/computer control system
   i. Air injection systems

Functional Test

1. Perform timing check to determine if engine timing is within specifications.

2. Test EGR system for proper functioning by applying vacuum, blocking exhaust, etc.

3. If engine failure light is in operation, extract codes and enter into TAS.

Diagnosis

1. Interpret results of TAS printout to determine cause for test failure.

2 Interpret wiring and vacuum diagrams.

3. Determine cause for high HC emissions by checking electrical, vacuum, or mechanical systems.

4. Determine cause for high CO emissions by checking fuel components.

5. Perform mechanical diagnosis of engine by checking for leaking valves, worn piston rings, clank, smoke, oil drip, etc.

6 Diagnose/repair the following systems:
   a. exhaust gas recirculation (EGR)
   b. computer control
   c. fuel injection
   d. ignition

7. Perform closed loop confirmation test.

In addition, all the modules in this test package should have the following on-screen navigational devices to help users:

1. An on-screen graphic device on the border of the computer frame and the matching video frame, orienting users to their place in the program at all times;

2. Constant and consistent on-screen "command line" icons that will allow the user to go to "help", to escape/quit, to return, etc., from every frame in the program. The user should not feel "trapped" at any point in the program.

B. Mechanics Use Only

1. Logon/Logoff: This is a very short module (subroutine) that would present a screen for the mechanic requesting identification data, providing a start/stop time for that session on the test system, and routing the mechanics to the appropriate section of the test based on their previous logon history.

2. Introduction: This module would orient the mechanic to the operation of the display device by introducing the Apple Macintosh equipment and explaining the methods of both presentation and appropriate mechanic response. In addition, this module will show very simple example questions and require the mechanic to respond with the proper device such as keyboard or mouse. The mechanic will not be able to enter the actual test module without having responded in a way that shows an understanding of the test and correct response method. This introductory module will be mandatory for first-time users, but can be bypassed at latter logons.

3. Help: Based on the material from the introduction, as well as additional material that may be required as specific test items within the test scenario are developed, this module should always be available to the student throughout the test. To the degree that it is feasible, the help should be context-sensitive. However, the help should not provide any additional information about any specific question on the examination, but only on the method of the exam and appropriate response options. The help should not favor those who may be computer literate enough to use it to gain an advantage, but rather the help should be designed to remove any "interference" in the test process caused by the computer-assisted videodisc methodology. The goal is to put the mechanic in as direct a contact as possible with the content of the simulations.

4. Test Scenario: This module will take the mechanic through much of a "standard" inspection scenario, and require the mechanic to

answer questions throughout. (This is described in detail in section III. below.)

C. Bar Use Only

1. Data module: This module will have several component parts, such as

a. Individual identification and logon data. This material will track how many sessions were required to complete the test, how long each session was, what time of day the sessions occurred, how often and where the mechanic used "help", etc.

b. Scoring. The test will be divided into sections that correspond to the current categories in the BAR certification examination, and the computer will track and report the mechanics' scores in each section at the end of the test. The report should be at a level of detail that includes the identification of the missed test item(s), and the category of each missed item.

c. Data analysis. If feasible, this part of the module should be able to compute and report some elementary score analysis to BAR for a particular duration of time, for a particular number of mechanics, etc.

2. Security: This module would insure the overall integrity of the examination by such actions as preventing mechanics from returning to previous questions and to previous sections of the exam in subsequent logons, insuring the security of individual test scores as well as of the answer keys, and other related security issues.

3. Communications module (Optional for demonstration): This module would provide the ability for each testing system that is eventually distributed around the state to communicate online with BAR. The primary use of this communications would be to send the information from the data module to BAR. However, it could be possible to use this long-distance communications channel to update the computer portions of the test by changing the screen graphics. Because of the potential for additional software and hardware expense that may not have been anticipated in the development and production budget, it should be noted that this communications module is not required for the demonstration. It might become a component on the testing package only in a full, state-wide implementation. In the demonstration, the data could be collected manually from the hard disc

III. DESCRIPTION OF THE TEST SCENARIO

The essential framework of this simulation examination will be a smog check, including a visual inspection and functional check. In each area the examination will include "look-up" questions that require the use of actual manuals that will be available at the test site.

The smog check scenario would be anchored in a specific garage environment, using a specific make and model of automobile to perform the check. In addition, a "host" or automotive supervisory character would act as the guide through the exam, presenting questions verbally to the mechanic as well as having the mechanic read them from the screen. Also, the host figure will be able to provide transitions between major elements of the test, and provide additional realism to the simulation environment.

As the mechanic proceeds through the smog check sequence, the "supervisor" will ask appropriate questions about the vehicle that has been brought in for the check. However, the supervisor can also ask additional questions about the same problem on other vehicles, which can be shown directly to the mechanic. For example, after asking the mechanic to identify a tamper of the PCV system on the original scenario smog check vehicle, the supervisor could then ask about the same system on a different vehicle, which could be shown to the mechanic. The framework would be a simple hypothetical "What if this were a 1984 Toyota Celica...."

The specific manufacturer, model and year of vehicles to be used, as well as detailed descriptions of the problem conditions to be tested within this scenario framework, will be provided by BAR.

Since the mechanic cannot return to earlier questions in the test, the supervisor is able to ask additional questions that might of necessity provide information about an earlier test item.

The actual test questions would be fully simulated through audio/video presentations on the videodisc, shown on the television monitor. Prompts as appropriate for questions on identification, selection of tools and methods, location of hookups for tools, and application of tools and methods, could come from a combination of the computer screen or directly from labels in the video material.

Finally, the use of the TAS could be integrated into the entire smog check sequence. Mechanics might also have the option of selecting the TAS analyzer that they work with. The combination of computer prompts, and sound and picture information on the videodisc, could eliminate the potential differences that might exist in screen displays and layouts of the various models of TAS analyzers that the mechanic could encounter in the actual work environment.

IV. EVALUATION

This plan describes the evaluation of the capability of computer-assisted, videodisc-based media to create realistic simulations of the elements of a smog inspection, for the purpose of testing smog check mechanics for certification. The working hypothesis is that this particular delivery method (videodisc simulation) will permit as accurate an assessment of the knowledge, skills and abilities of smog check mechanics as having them examined by using actual vehicles with BAR examiners. If this hypothesis is correct, that the videodisc simulation method is equivalent to the actual vehicle method of assessment, then BAR can conduct certification testing through videodisc simulation without the time and expense of testing mechanics on actual vehicles.

This evaluation will be done by comparing the performance of mechanics in the videodisc simulation test environment to the performance of mechanics in similar test situations on actual vehicles. This general evaluation procedure will require that actual smog check mechanics be hired (approximately $80 per mechanic, as recommended by BAR) to participate as evaluation subjects, and that the evaluation occur outside the normal paper testing cycle.

For the purpose of this evaluation plan, it is assumed that the computer-assisted, videodisc simulation software will be able to accumulate and report the responses of each mechanic to each test item.

A. General Methodology

The effectiveness of the evaluation rests on the ability to compare the group doing the simulation testing with a similar population that was tested on the same content, but delivered through a different methodology. This is a straightforward, quasi-experimental design that will require an experimental group and a control group. The experimental group will be tested using the computer-assisted, videodisc simulations, the control group will be tested on actual vehicles, and the results of the groups will be statistically compared and analyzed. The experimental hypothesis is that there will be no difference between groups.

1. Sample Size, Selection and Randomization

a. The minimum recommended size for the sample is 80 smog check mechanics, divided into the two groups of 40 each. In this type of evaluation design, the statistically important minimum number is usually considered to be 30 per group. The additional ten individuals in each group provide a practical cushion for absentees or other participation problems. Larger groups would increase the ability of the evaluation to detect differences in performance between groups, but at a significant increase in cost in both participant fees and test administration. Fewer than 30 participants per group may cause the masking of performance differences between groups.

b. The practical problems concerning the number of videodisc systems to deliver simulation, and the locations where it is feasible to set up an actual vehicle test site, limit the geographic area that can be used to select a sample. While this geographic limitation, and the necessity of recruiting a paid sample, may introduce some theoretical problems in generalizing from the results of this evaluation design to the entire population of smog check mechanics, these potential sources of error are minimal. On logical grounds it can be argued that the motivations of the self-selected mechanics who participate for the money will balance out across the population. In addition, it will be possible to examine the demographics of the sample population (i.e.; age, years of experience, type of employer, geographic location of employment) against the demographics of the entire population to note any large scale deviations in the make-up of the sample. Finally, the randomization of the sample into the experimental and control groups will provide the rationale to compare their performance in each situation, which is the point of the evaluation.

c. It is recommended that the selection of the sample begin with a letter from BAR soliciting participation, noting the fee, explaining the time parameters of participation, and indicating that only the first 80 that respond with be selected. Once the entire group of 80 has been identified, they must randomly be divided into experimental and control groups. **This randomization into groups is a critical phase for the validity of the evaluation.** Consequently, the randomization must be done with strict adherence to a formal table of random numbers, or some other equally formal and reliable method. It should also be noted that the administrators of the evaluation should maintain contact with the selected mechanics with follow-up letters and phone calls, confirming their willingness to participate, the time(s) and location for the test, etc., in order to maintain the integrity of the sample size during the evaluation process.

2. Test Content

a. Another critical issue in the evaluation process is the translation of the simulation test items to an actual vehicle. Because of the nature of the simulation technology, it may be a "temptation' to create interesting test items that work well in simulation, test an important knowledge, skill or ability, but which may be very awkward, cumbersome, time-consuming, difficult and expensive to recreate in an actual vehicle environment. In order to eliminate problems in the evaluation, test items must be carefully analyzed in the <u>development</u> phase to insure their feasibility and practicality on a vehicle. In addition, it is assumed that all the simulated test items will be part of the actual vehicle test, and will parallel the simulated items as closely as possible. This extends to the necessity of writing explicit and matching instructions that the vehicle test administrator will deliver to the subject, and training the vehicle test administrators in the degree of help, if any, that they are allowed to provide, and the necessity to strictly adhere to the uniform delivery of instructions to all subjects in the control group. This problem does not exist for the experimental group because they will be uniformly tested by the computer-assisted simulation system itself.

b. In addition to the results for the smog check test items, each group should be asked to complete a series of 10-15 Likert-scaled items that pose questions to the participants about their subjective impressions of the test. The primary purpose of this questionnaire is to gather data about the feelings of the subjects to their experience with the videodisc simulation delivery. However, for general purposes of comparison, and to provide a baseline on how these individuals would react to the test experience, the same questionnaire should also be administered to the control group.

3. Statistical Analysis

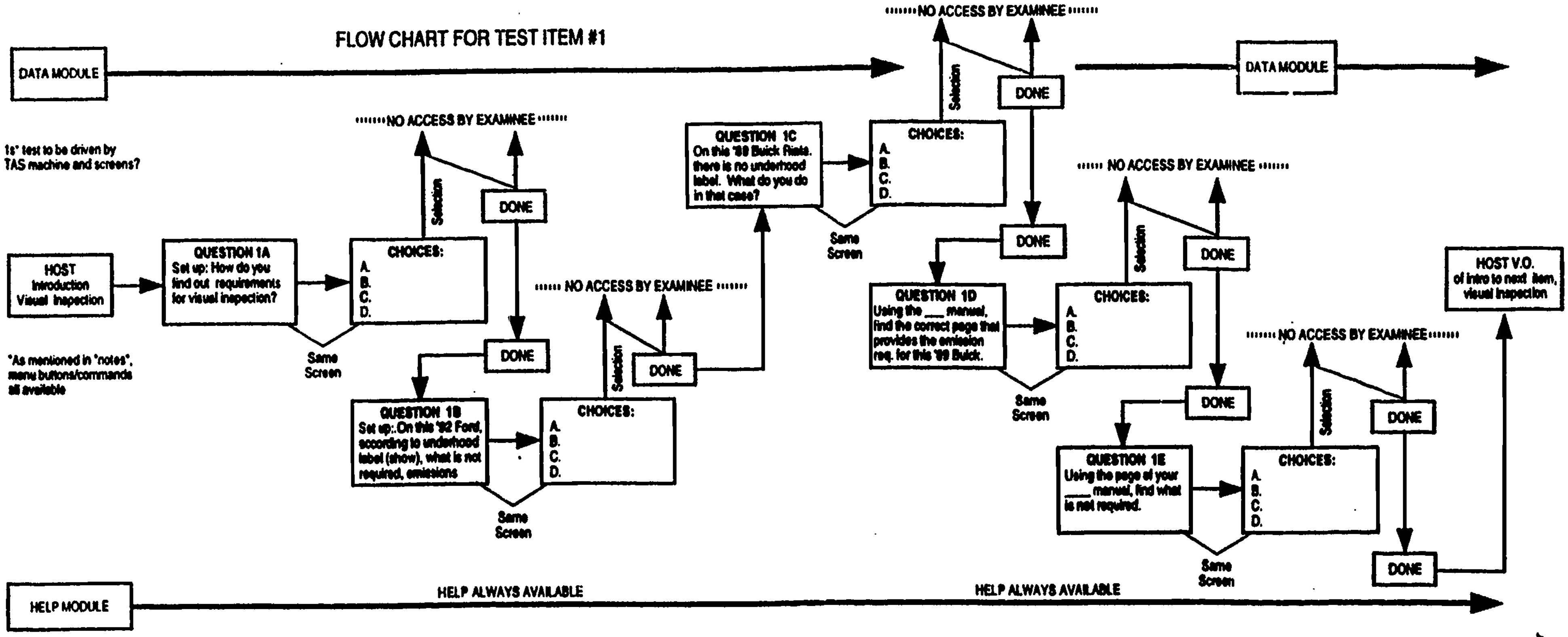
Statistical comparisons of the groups on both the test and questionnaire items should be done with a standard "F" test. While not a critical component of this study, simple reliability analysis could be run on the test items to see if there are any particular items that had flaws, or that have great performance differences between delivery media. This reliability analysis will be done by manually scanning the data on the individual items.

B. Cost Of The Evaluation

Eighty individuals, each paid $80, will make the baseline cost for the evaluation $6,400. In addition, the cost of the evaluation will include the translation of the simulation test items to actual vehicles, the "rental" of the vehicles, and the personnel time of BAR staff to set-up the test problems on the vehicles and administer the test to the 40 participants in the control group.

C. Summary

It should be noted in conclusion that the purpose of the evaluation is to find out if any significant differences in performance exist between the experimental group of mechanics tested through simulation and those in the control group tested on actual vehicles. Regardless of the outcome of the statistical analysis of the data, the results of this evaluation will be logically analyzed in relationship to the initial purpose of the study. This process will include a discussion of the size and implications of any differences that may be detected between groups, and a comparison of the test scores of the groups with the questionnaire data. For example, if there is no performance difference, or if the control group tested on vehicles does only slightly better, then it would seem that the simulation testing does perform its function of determining the knowledge, skills and abilities of smog check mechanics. Markedly different results will require additional analysis of sample selection, test construction and administration, and other factors that could have a confounding effect.



39

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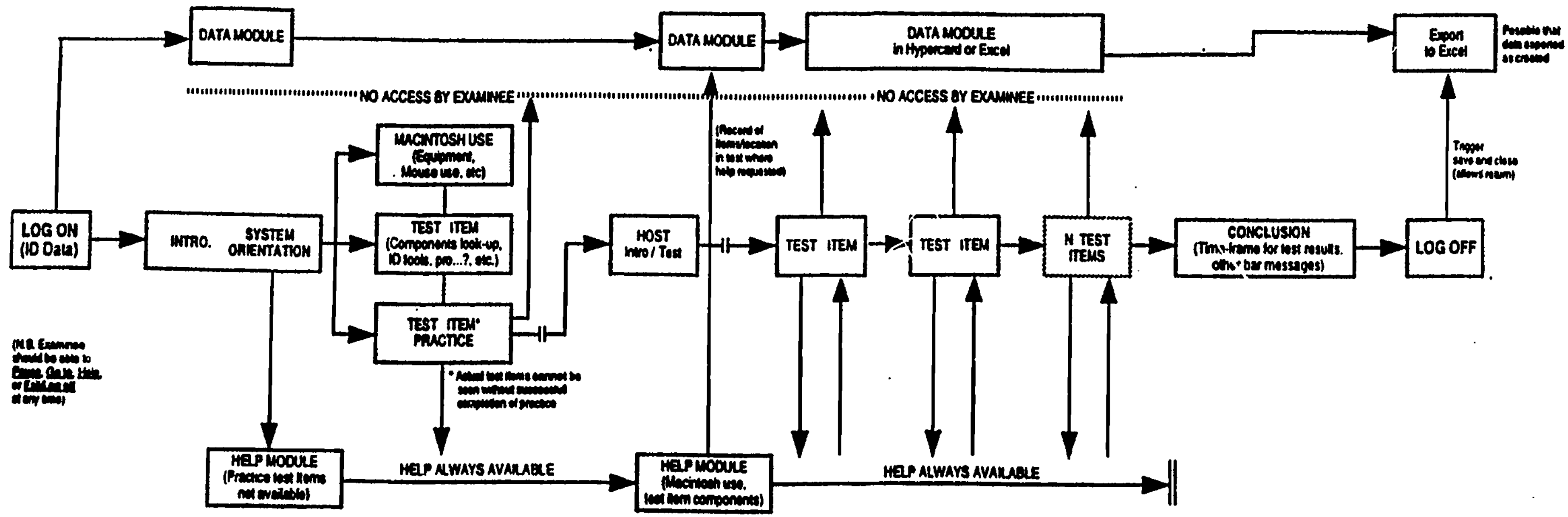
GENERAL FLOW DIAGRAM — SMOG CHECK DEMONSTRATION



41

42

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Appendix B

Simulation Test Documents

Software and Hardware used in Producing the BAR Demo Project

MacroMedia Director 3.1
MacroMedia Model
Adobe Photoshop 2.0.1
Nikon LS-3510AF 35mm Slide Scanner
Claris MacDraw Pro 1.0
Microsoft Excel 3.0
Microsoft Word 5.1
CoSa PACo
VideoLogic MIC System II
SuperMac Video Spigot
Premier 2.0
Sound Edit Pro
Troll Touch
Pioneer XObject
Trig XObject
MIC XObject
Macromedia MacRecorder

Hardware Configuration for BAR Demo Project

Apple Macintosh IIci, 8meg RAM, 120 meg hard drive
SuperMac SuperMatch 17 multimode monitor with Troll Technoligies
Touch screen
VideoLogic DVA4000 video and graphics board
Pioneer 4400 Video Disc Player
Sony Headphones
Vaniman Custom Audio Mixer

TEST ITEM SUMMARY

VISUAL INSPECTION

1. Test Item 1:
   89 Toyota Tercel
   Engine Configuration, required ECS, use of reference material in absence of underhood label.

2. Test Item 2:
   89 Toyota Tercel
   Visual inspection of TAC

3. Test Item 3:
   90 Buick Reatta
   Visual Identification of EGR type and visual inspection of EGR system.

FUNCTIONAL INSPECTION

4. Test Item 4:
   92 Ford Taurus
   Functional Timing Test

5. Test Item 5:
   89 Toyota Tercel
   EGR Functional Test

DIAGNOSTIC

6. Test Item 6:
   Various Components
   Computer-related components and categorization by "sensor/actuator."

7. Test Item 7:
   92 Ford Taurus
   Diagnostis of high HC/CO problem.

8. Test Item 8:
   92 Ford Taurus
   Repair Order entries for parts and labor to repair problems found in Test Item 7.

9. Test Item 9:
   90 Buick Reatta
   Diagnostic Trouble Code. Tech should be able to use vehicle's On Board Diagnostic (OBD) system and identify definition of fault code.

SMOG CHECK TECHNICIAN CHECKLIST

Answer Key

NAME:________________ **DRIVERS LIC#:**________________

BAR LIC. #:________________ **DAYTIME PHONE:**________________

ITEM # 1 (1989 TOYOTA)

Quest#	Points	
1	1	VIN NR:_*JT2EL31D4K0425393*_
2	1	LICENSE NR:___*OS*__________
3	1	MODEL:_____*TERCEL*________
4	1	ENGINE SIZE: *1.5 or 1500 or 88.9* UNIT OF MEASURE: *L or CC or CID*
5	1	CERTIFICATION STATUS (CHECK ONE BELOW):
6	1	_X__CALIFORNIA EMISSION CERTIFIED
		_____FEDERAL EMISSION CERTIFIED
		_____BAR CERTIFED
		_____GREY MARKET
7	1	WHAT TYPE OF TRANSMISSION DOES THIS VEHICLE HAVE?
8	1	MANUAL TRANS:__X__ AUTOMATIC TRANS:_______

WHICH OF THESE DEVICES ARE REQUIRED ON THIS VEHICLE? (CHECK ALL APPROPRIATE ITEMS):

			Item#	Points	
8	1	PCV:_*Y*_	13	1	FUEL INJECTION:_*N*_
9	1	AIS:_*Y*_	14	1	TAC:_*Y*_
10	1	FUEL RESTRICTOR:_*Y*_	15	1	EVAP SYSTEM:__*Y*_
11	1	TWC:_*Y*_	16	1	EGR:_*Y*_
12	1	SPARK ADVANCE:_*Y*_	17	1	CCO:_*Y*_

ITEM # 2 (1989 TOYOTA)

Quest#Points

18 1 VISUAL INSPECTION OF TAC: (CHECK ONE)

PASS ( ) MISSING (X) MODIFIED ( )

DISCONNECTED (X) DEFECTIVE ( ) NOT APPLICABLE ( )

ITEM # 3 (1990 BUICK RIATTA)

19 1 VISUAL INSPECTION OF EGR: (CHECK ONE)

PASS (X) MISSING ( ) MODIFIED ( )

DISCONNECTED ( ) DEFECTIVE ( ) NOT APPLICABLE ( )

20 1 TYPE OF EGR VALVE: (CHECK ONE BELOW):

CONVENTIONAL:______

BACK PRESSURE: ______

ELECTRONIC/DIGITAL:__X__

NOT APPLICABLE:______

ITEM # 4 (1992 FORD TAURUS)

21 2 FUNCTIONAL TIMING TEST: (ENTER YOUR FINDINGS)

DEGREES:____*10*______ BTDC (X) ATDC ( )

ITEM # 5 (1989 TOYOTA TERCEL)

X X DOES THIS VEHICLE REQUIRE AN EGR SYSTEM? YES ( ) NO ( )

22 1 IF REQUIRED, WHAT TYPE OF EGR SYSTEM?(CHECK ONE):

CONVENTIONAL__X___ ELECTRONIC/DIGITAL______
BACK PRESSURE__X___ NOT APPLICABLE______

23 1 RESULTS OF FUNCTIONAL EGR SYSTEM TEST (IF REQUIRED):

PASSED (X) FAILED ( )

ITEM # 6 (COMPUTER COMPONENTS)

Quest#Points

CHECK THE CORRECT NAME FOR EACH COMPONENT:

24	1	COMPONENT A:	
		MASS AIR FLOW SENSOR ( )	MAP SENSOR (X)
		VOLTAGE REGULATOR ( )	COMPUTER PROCESSOR UNIT ( )
25	1	COMPONENT B:	
		OXYGEN SENSOR ( )	TEMPERATURE SENSOR ( )
		MASS AIR FLOW SENSOR ( )	THROTTLE POSITION SENSOR (X)
26	1	COMPONENT C:	
		IDLE AIR CONTROL ( )	EGR POSITION SENSOR (X)
		CANISTER PURGE ( )	OXYGEN SENSOR ( )
27	1	COMPONENT D:	
		MASS AIR FLOW SENSOR ( )	KNOCK SENSOR ( )
		OXYGEN SENSOR (X)	CRANKSHAFT TIMING SENSOR ( )
28	1	COMPONENT E:	
		FUEL INJECTOR (X)	COOLANT TEMP. SENSOR ( )
		MAP SENSOR ( )	OXYGEN SENSOR ( )

CHECK THE APPROPRIATE CLASSIFICATION FOR EACH COMPONENT:

29	1	MAP:	ACTUATOR ( )	SENSOR (X)	N/A ( )
30	1	MASS AIR FLOW:	ACTUATOR ( )	SENSOR (X)	N/A ( )
31	1	FUEL INJECTOR:	ACTUATOR (X)	SENSOR ( )	N/A ( )
32	1	COMPUTER PROCESSING UNIT:	ACTUATOR ( )	SENSOR ( )	N/A (X)
33	1	CANISTER PURGE SOLENOID:	ACTUATOR (X)	SENSOR ( )	N/A ( )

ITEM # 7 (1992 FORD TAURUS)

Quest#Points

34 1 **RECORD THE FIRING ORDER OF THIS VEHICLE IN THE SPACE BELOW:**

FIRING ORDER: __1__---___4__---___2__---___5__---__3___---___6__

35 6 **WHICH OF THE ENGINE'S CYLINDER OR CYLINDERS IS/ARE CAUSING THE TAILPIPE EMISSIONS TO BE SO HIGH?**

ANSWER:__*2&6 HANDS-ON*_____*4&5 INTERACTIVE*_____

FOR EACH CYLINDER THAT YOU INDICATED ABOVE, IDENTIFY WHAT IS THE MOST LIKELY CAUSE: (MATCH CAUSE TO CYLINDER NUMBER)

CAUSES:	Quest#	Points	CYLINDERS	HO	INT
A. BURNED EXHAUST VALVE	36	1	1		
	37	1	2	*C*	
B. EXCESSIVE FUEL IN THE CRANKCASE	38	1	3		
	39	1	4		*C*
C SPARK PLUG SHORTED	40	1	5		*D*
D DISCONNECTED OR OPEN SPARKPLUG WIRE	41	1	6	*D*	

42 1 **WHAT IS THE REPAIR COST LIMIT FOR THIS VEHICLE? $____*300*_____**

ITEM # 8 (1992 FORD TAURUS)

BASED UPON YOUR EXAMINATION AND RECOMMENDED REPAIRS ON THE FORD TAURUS, PLEASE COMPLETE THE PARTS AND LABOR SECTIONS OF THE ATTACHED REPAIR ORDER.

YOU ARE NOT REQUIRED TO MAKE ANY ENTRIES REGARDING COSTS.

STAT AUTO REPAIR

0001158

10240 Systems Pkwy
Pomona, CA 90000-0000
(714) 929-0000
BAR #AA000000

Parts installed are new unless otherwise specified.

*CODE N=NEW U=USED R=REBUILT

QTY	*	[illegible]	[illegible]	

NAME	DATE
ADDRESS	TELEPHONE(S)
CITY ZIP	LICENSE PLATE #
YEAR-MAKE-MODEL	ODOMETER

Repair Order — Labor Instructions	Labor Cost

Estimate

Original Estimate $ Date: Time: By:

Revised Estimate $ Date: Time: By:

Authorization

I hereby authorize the above repair work to be done along with the necessary material.
I have read and understand the above and acknowledge receipt of an estimate.

Customer Signature ______________________

$

By law, you may choose another authorized facility to perform any needed repairs or adjustments which the smog check deem necessary.

APPENDIX B-3

ITEM # 9 (1990 BUICK REATTA)

Quest#Points

ASSUME THE "CHECK ENGINE" LIGHT WAS ON CONTINUOUSLY DURING YOUR ROUTINE SMOG CHECK.
DOWNLOAD THE TROUBLE CODES FOR THIS VEHICLE TO DETERMINE IF ANY WERE SET.
IF ANY TROUBLE CODES WERE FOUND, ENTER THEM BELOW :

43 1 TROUBLE CODE(S):__*E022H* OR *b333c HO__E021c* OR *b112c*
INTERACTIVE__

IF THERE WAS AN EMISSION RELATED TROUBLE CODE(S), WHAT WAS THE MEANING OF THAT CODE?

44 1 ________COOLANT SENSOR TEMP HIGH
____X__TPS SIGNAL VOLTAGE LOW
________LOSS OF SIR DATA
________OPEN 02 SENSOR CIRCUIT

Manual List for BAR Demo Test Station

1. 1989 Toyota Tercel Repair Manual
2. 1992 Ford Car/Truck Service Manual, Powertrain Control/Emissions Diagnosis
3. 1990 Buick Service Manual--Riviera/Reatta
4. State of California Licensed SMOG Check Inspection Manual, Revision 2
5. 1992 Edition Emission Control System Application, Cascade Automotive Resources, Inc.
6. 1992 Motor Emission Control Manual 12th Edition
7. 1989-92 Motor Chrysler/Ford Auto Engine Tune-Up & Electronics Manual, 8th Edition
8. 1989-92 Motor General Motors Auto Engine Tune-Up & Electronics Manual, 8th Edition
9. 1992 Mitchell Engine Performance Service & Repair, Domestic Cars
10. 1990 Mitchell Engine Performance Service & Repair, Domestic Cars
11. 1989 Mitchell Engine Performance Service & Repair, Imported Cars, Light Trucks & Vans

Appendix C

Survey for Mechanics

SURVEY FOR MECHANICS -- BAR DEMONSTRATION PROJECT

NAME:____DATE OF BIRTH:_______________

SOC. SECURITY NUMBER:__________________LOCATION:________________________

DATE OF TEST:________________YEARS AS A PROFESSIONAL MECHANIC___________

YEARS AS A CERTIFIED SMOG CHECK MECHANIC ______

We are very interested in how you feel about the testing experience that you have just completed. To the right of the statements listed below are the numbers 1-5. #1 means that you strongly agree with the statement next to it. #2 means you agree with the statement; #3 means you're undecided; #4 means you disagree; and #5 means you strongly disagree with the statement.

Please think about each statement and circle the number to the right that best describes your personal feelings about that statement.

1= strongly agree 2= agree 3= undecided 4= disagree 5= strongly disagree

a. This test gave me a fair chance to show my skills as a "Smog Check" mechanic.	1	2	3	4	5
b. This test was very easy for me.	1	2	3	4	5
c. Most of the questions on this test were very much like the things that I really do on my job.	1	2	3	4	5
d. This test gave me a fair chance to show my knowledge of the "Smog Check" program.	1	2	3	4	5
e. Most mechanics that are certified for the "Smog Check" program would say that this was a hard test.	1	2	3	4	5
f. I think that all the "Smog Check" testing should be done just like the test that I just took.	1	2	3	4	5
g. The best kind of "Smog Check" test is the method using a written test, pencil and answer sheets.	1	2	3	4	5
h. The way that the test I just took was given to me was very confusing.	1	2	3	4	5
i. I enjoyed taking a test using this method.	1	2	3	4	5
j. Most of the things that this test asked me about I don't usually do on my job.	1	2	3	4	5

APPENDIX C

Appendix D

Sample Selection Documents

State of California

MEMORANDUM

Department of Consumer Affairs

Date: March 9, 1993

To: Larry Harty, Director
Instructional Technology Center
California State Polytechnic University, Pomona

From: Bureau of Automotive Repair
George Adelsperger, Manager
Standards and Training Branch

Subject: RANDOM SELECTION METHOD

In mid-October, 1993 you were provided with a list of 1500 Smog Check technicians. They had been sent a letter from me asking them to contact you if interested in participating in the study. All of the letters were mailed in the same week. No record of the names has been kept by BAR.

The list was generated by using a computer program to randomly select 1500 names from a pool of about 8,600 names. The pool consisted of all of the Unlimited (EU) licensees whose licenses were "clear" in the five counties listed below.

A "clear" license is one that is not expired, and has no pending enforcement actions. An Unlimited (EU) license allows the technician to perform inspections, diagnoses and repairs on all model years of vehicles. The Limited license category allows such actions on only 1979 and older vehicles, and would not have been appropriate for this study. The quantity of Limited licensees is very small.

The counties used were Los Angeles, Orange, Riverside, San Bernardino, and Ventura.

APPENDIX D-1

STATE OF CALIFORNIA · STATE AND CONSUMER SERVICES AGENCY Pete Wilson, Governor

State of California Department of Consumer Affairs

BUREAU OF AUTOMOTIVE REPAIR
10240 SYSTEMS PARKWAY, SACRAMENTO, CA 95827

SAMPLE

I.D.# EU042501

GARCILAZO MIGUEL ANGEL
P O BOX 7081
ORANGE CA 92613

We wish to invite you to help us develop a new and more meaningful way of licensing Smog Check technicians in the future.

The Bureau of Automotive Repair (BAR) has been working with the California State University system to develop a simulation of a hands-on examination by using the latest in computer and television technology. In order to show the usefulness of this technology, we need to compare the performance of two groups of technicians like you.

Members of one randomly selected group will be asked to perform typical Smog Check tasks (inspection, diagnosis, repair) on actual cars. This would be similar to the hands-on exercises you may have been asked to do by a Quality Assurance Inspector. Members of another group will be asked to perform computer simulations of the same tasks. This experience would be a lot like using a Smog Check analyzer.

The study will be performed by the California State Polytechnic University (Cal-Poly), Pomona. All performance information will be strictly confidential and controlled by Cal Poly, and will not be given to BAR.

Your participation should take less than a half day and will have absolutely no effect upon your license. You will receive $80.00 compensation for your efforts.

This study is scheduled for January 18th to February 12th, 1993. We will be needing only 80 participants so your prompt reply is encouraged.

If you are interested, please call Cal Poly at (714) 869-3922 as soon as possible. Inform the person who answers that you wish to sign up for the BAR Demonstration Project.

We hope you can give us a hand.

Sincerely,

George Adelsperger, Manager
Standards and Training Branch

APPENDIX D-2

CALIFORNIA STATE POLYTECHNIC UNIVERSITY
1938
POMONA

3801 West Temple Avenue
Pomona, California 91768-4049
Telephone (909) 869-3920

Instructional Technology Center

Hello!

Thank you for your quick response to the BAR letter of invitation.

This is to inform you that your name has been entered into a pool of approximately three hundred Smog Check technicians like yourself. One hundred finalists will be randomly selected from the pool on December 10th. You will be informed soon thereafter if you have or have not been selected.

If selected, you will be asked to appear at a time and date at Cal Poly Pomona or on the campus of Citrus College in Glendora. If possible, we will accommodate your morning or afternoon scheduling needs. The site choice is part of our random selection.

If you continue to be interested, please complete the following form and return this letter in the enclosed envelope.

BAR Smog Check Study

CONFIRMATION OF INTENT TO PARTICIPATE

I would definitely be available to participate in the BAR Smog Check Study, at either location, during the period of Jan 18 thru Feb. 12, 1993. I understand that if I am chosen for this project, my participation should take less than half a day and that I will receive $80.00 in compensation for my time.

____

Circle one to indicate preference: *8-12 AM* *1-5 PM* *Either*

Mailing address:______________________________________.

Telephone Number:(____)__________(Day)______________(Eve)

BAR License No: EU______________**Social Sec. No:**____--________--______.

Please print your name:______________________________________.

Signature:____________________________ **Date:** ______________.

APPENDIX D-3

CALIFORNIA STATE POLYTECHNIC UNIVERSITY
1938
POMONA

3801 West Temple Avenue
Pomona, California 91768-4049
Telephone (909) 869-3920

Instructional Technology Center

January 4, 1993

Congratulations!

You have been selected to participate in the Bureau of Automotive Repair Smog Check Study.

We ask that you appear promptly at 1:00 pm on February 8, 1993, at the campus of California State Polytechnic University, Pomona (map enclosed).

We look forward to seeing you and we appreciate your willingness to help us in this important endeavor.

Best Wishes,
The BAR Smog Check Study Staff

APPENDIX D-4

CALIFORNIA STATE POLYTECHNIC UNIVERSITY
1938
POMONA

3801 West Temple Avenue
Pomona, California 91768-4049
Telephone (909) 869-3920

Instructional Technology Center

January 4, 1993

Congratulations!

You have been selected to participate in the Bureau of Automotive Repair Smog Check Study.

We ask that you appear promptly on February 9,1993 at 1:30 pm, at the Citrus College campus (map enclosed).

You will be looking for the Automotive Technology Department at Citrus College. Use the Barranca St. entrance to the parking lot just North of the Athletic field.

PLEASE CALL (909) 869-3922 TO CONFIRM YOUR INTENTIONS TO PARTICIPATE ON THIS DATE AND TIME.

We look forward to seeing you and appreciate your willingness to help us in this important endeavor.

Best Wishes,
The BAR Smog Check Study Staff

APPENDIX D-4

CALIFORNIA STATE POLYTECHNIC UNIVERSITY
1938
POMONA

3801 West Temple Avenue
Pomona, California 91768-4049
Telephone (909) 869-3920

Instructional Technology Center

January 14, 1993

We're Sorry!

We appreciate your willingness to help us with the Bureau of Automotive Repair Smog Check Study, but regret to inform you that, due to the large number of applicants, your name did not come up in the random selection process.

We will keep your name on file in case we need emergency substitutes or do a follow-up program. Thank you again for your response.

Best Wishes for the New Year,
The BAR Smog Check Study Staff

APPENDIX D-5

Appendix E

Raw Data Score Sheets

Hands-On Test Scores

		Item #1***																	#2	#3*****		#4
Name		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
HO1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO2		1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0
HO3		1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO4		1	0	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
HO5		1	0	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO6		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO7		1	0	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	2
HO8		1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	2
HO9		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
HO10		1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	2
HO11		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO12		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0
HO13		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO14		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
HO15		1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1	1	0
HO16		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO17		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO18		1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO19		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	2
HO20		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO21		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
HO22		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO23		1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	2
HO24		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	2
HO25		1	1	1	1	1	1	1	1	0	1	1	1	0	0	1	1	0	1	1	1	2
HO26		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO27		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO28		1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1	1	2
HO29		1	0	1	1	1	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	0
HO30		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO31		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO32		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO33		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	2
HO34		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO35		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO36		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO37		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
HO38		1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0
NO. CORRECT		38	24	35	37	36	38	38	37	36	36	37	34	36	37	37	38	33	34	37	38	58

APPENDIX E-1

Hands-On Test Scores

#5***		#6***********************************										#7*********************************									#9*****		Total
22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	
1	1	1	1	0	1	1	1	0	1	1	1	1	5	1	1	1	0	1	1	1	0	0	44
1	1	1	0	1	1	1	0	1	1	1	1	1	4	0	1	1	0	1	1	1	0	0	38
1	1	1	1	1	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	0	1	1	48
1	1	1	1	1	1	1	1	1	1	0	1	1	5	1	1	1	0	0	1	0	1	1	41
1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	0	0	0	1	0	0	39
1	1	1	1	1	1	1	1	1	1	0	1	1	6	1	1	1	1	1	1	1	1	1	49
1	1	1	1	0	1	1	1	1	1	1	1	1	2	1	1	1	0	0	0	0	1	1	38
1	1	1	1	1	1	1	1	1	0	0	0	1	4	1	0	1	0	1	1	1	1	0	41
1	1	1	1	1	1	1	1	1	0	0	1	1	6	1	1	1	1	1	1	1	1	1	45
1	1	1	1	0	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	1	1	0	47
1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	0	1	1	1	0	0	45
1	0	1	1	1	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	1	1	1	45
1	1	1	1	1	1	1	1	1	1	0	1	1	4	1	0	1	0	0	1	1	1	0	43
1	0	1	1	1	1	1	1	1	0	0	1	1	6	1	1	1	1	1	1	1	0	0	43
1	1	1	1	1	1	1	1	1	1	0	1	1	3	1	1	0	0	0	1	1	1	1	39
1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	0	0	1	0	1	1	46
1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	0	0	1	1	1	1	1	46
1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	0	1	0	0	1	1	1	1	43
1	1	1	1	1	1	1	1	1	1	1	1	0	6	1	1	1	1	1	1	1	1	1	47
1	0	1	1	0	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	1	0	0	46
1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	0	0	1	1	1	1	45
1	1	1	1	0	1	1	1	1	1	1	1	1	5	1	1	1	0	1	1	1	1	1	47
1	1	1	1	1	1	1	1	1	1	0	1	1	2	1	1	1	1	1	1	1	0	0	40
1	0	1	1	1	1	1	1	1	1	1	0	1	5	1	1	1	0	1	1	1	0	0	43
1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	0	1	1	0	1	1	1	1	41
1	0	1	1	1	1	1	1	1	1	1	1	1	6	1	1	1	1	0	1	1	0	0	45
1	1	1	1	1	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	1	1	1	50
1	1	1	1	0	1	1	1	1	0	1	1	1	5	1	1	1	1	1	1	1	0	0	43
1	0	1	1	1	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	1	1	1	43
1	1	1	0	0	1	1	1	1	1	0	1	1	5	0	0	0	1	1	0	0	1	1	41
1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	0	1	1	1	1	47
1	1	1	1	0	1	1	0	1	0	0	0	1	5	1	1	1	0	1	1	1	1	0	41
1	1	1	1	0	1	1	1	1	0	1	1	1	6	1	1	1	1	1	1	0	1	1	46
1	0	1	1	0	1	1	1	1	1	1	1	1	3	1	0	1	0	0	1	1	1	1	41
1	0	0	1	1	1	1	1	1	1	0	1	1	6	1	1	1	1	1	1	1	1	1	47
1	0	1	1	0	1	1	1	1	1	0	1	1	6	1	1	1	1	1	1	1	1	1	46
1	0	0	1	1	1	1	1	1	1	0	1	1	5	1	1	1	0	0	1	0	1	1	43
1	0	0	1	1	1	1	1	1	1	1	1	1	5	1	1	1	0	1	1	1	0	0	40
																							Average
38	27	35	36	27	38	38	36	37	32	25	35	37	184	36	32	35	19	25	35	31	27	23	43.74

APPENDIX E-1

Simulation Test Scores

		Item #1																	#2	#3		#4
Name		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
SM1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM2		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM3		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM4		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
SM5		1	0	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	2
SM6		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM7		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM8		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM9		1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
SM10		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM11		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM12		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0
SM13		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM14		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM15		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM16		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0	0	0
SM17		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM18		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
SM19		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0
SM20		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM21		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM22		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
SM23		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
SM24		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
SM25		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM26		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM27		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM28		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM29		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM30		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	2
SM31		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM32		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM33		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM34		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
SM35		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM36		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
SM37		1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
SM38		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
NO. CORRECT		38	22	37	38	38	38	38	38	38	38	38	37	38	38	38	38	37	35	37	36	54

APPENDIX E-2

Simulation Test Scores

	#5***		#6**********************************										#7**********************************									#9*****		Total
	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	
	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	0	1	1	1	1	1	48
	1	1	1	1	0	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	1	1	1	49
	1	1	1	1	0	1	1	1	1	1	0	1	0	6	1	1	1	0	0	1	1	0	0	42
	1	1	1	1	0	1	1	1	1	1	1	1	1	5	1	1	1	0	0	1	1	1	1	43
	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	0	1	1	1	1	1	46
	1	1	1	1	0	1	1	1	1	1	1	1	1	5	1	1	1	0	1	1	1	1	1	46
	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	0	0	0	0	1	0	1	1	40
	1	0	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	0	1	1	1	1	0	46
	1	0	0	1	1	1	1	1	1	1	1	1	1	5	1	1	1	0	0	1	1	0	0	40
	1	0	1	1	1	1	1	1	1	0	1	1	1	5	1	1	1	0	1	1	0	0	0	42
	1	1	1	1	0	1	1	1	1	0	0	1	1	6	1	1	1	1	1	1	1	0	0	45
	1	1	1	0	0	1	1	1	0	1	0	1	1	5	1	1	1	0	0	0	1	0	0	36
	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	0	1	0	0	1	1	1	1	45
	1	1	1	1	0	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	1	1	1	48
	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	0	1	0	0	1	1	0	0	43
	0	1	1	0	0	1	1	1	1	1	0	1	1	6	1	1	1	1	1	1	0	0	0	37
	1	1	1	1	1	1	1	1	1	1	0	1	1	6	1	1	1	1	1	1	0	1	1	48
	1	1	1	1	1	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	1	1	1	48
	1	1	1	1	1	1	1	1	1	1	0	1	1	4	1	0	1	0	0	1	1	1	1	40
	1	1	1	1	0	1	1	1	1	1	0	1	1	6	1	1	1	1	1	1	1	1	1	47
	1	1	1	1	0	1	1	1	1	1	1	1	1	4	1	0	1	0	0	1	1	1	1	43
	1	1	1	1	1	1	1	1	1	1	1	1	1	5	1	0	1	0	0	1	0	0	0	40
	1	1	0	1	0	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	1	1	1	46
	1	1	1	1	1	1	1	1	1	1	1	1	1	4	0	1	1	0	1	1	1	1	1	44
	1	0	1	1	1	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	0	1	1	48
	1	0	1	1	0	1	1	1	1	1	1	1	1	6	1	1	1	1	1	1	1	1	1	48
	1	0	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	1	1	0	0	1	1	46
	1	0	1	1	1	1	1	1	1	1	1	1	1	4	1	0	1	0	0	1	0	1	1	43
	1	1	1	1	1	1	1	1	1	1	0	1	1	6	1	1	1	1	1	1	1	1	1	48
	1	1	1	1	1	1	1	1	1	0	1	1	1	6	1	1	1	1	1	1	1	1	1	48
	1	0	1	1	1	1	1	1	1	1	1	1	1	5	1	1	1	0	1	1	1	1	1	47
	1	1	1	0	0	1	1	1	1	1	1	0	1	5	1	1	1	1	0	1	1	1	1	45
	1	1	1	1	0	1	1	1	1	1	1	1	1	5	1	1	1	0	0	1	1	1	1	46
	1	0	1	1	0	0	1	1	1	1	1	1	1	5	1	1	1	0	1	1	1	1	1	43
	1	1	0	1	0	1	1	1	1	0	0	1	1	4	1	0	1	0	0	1	1	1	1	40
	1	1	1	1	0	1	1	1	1	1	1	1	1	2	0	1	0	0	0	1	1	1	1	38
	1	1	1	1	0	1	1	1	1	1	0	1	0	5	1	1	1	0	0	1	1	0	0	41
	1	0	1	1	0	1	1	1	1	1	0	1	1	6	1	1	1	1	1	1	0	0	0	44
																								Average
	37	28	35	35	19	37	38	38	37	34	27	37	36	191	36	30	36	15	22	36	29	28	27	44.13

Hands-On Group Survey Data													
Name	AGE	MechEX	SmogEX	a	b	c	d	e	f	g	h	i	j
	yrs	yrs	yrs										
HO1	32	2	1	2	2	2	1	2	1	5	5	1	5
HO2	23	4	1	1	3	4	2	4	2	5	4	2	2
HO3	29	12	9	2	1	1	2	2	2	3	5	3	5
HO4	53	35	28	2	2	1	2	2	2	3	4	2	1
HO5	56	25	12	1	1	1	1	4	3	4	4	1	5
HO6	32	12	6	1	2	1	2	4	3	3	5	2	2
HO7	42	21	1	2	4	1	2	3	3	4	4	1	4
HO8	31	15	11	2	2	3	3	4	3	4	4	2	2
HO9	48	17	17	1	2	1	1	2	1	5	5	1	5
HO10	30	6	1.25	4	3	3	4	2	2	2	1	4	2
HO11	30	6	4	1	4	1	1	4	2	4	2	2	5
HO12	26	10	7	2	3	2	4	2	1	5	4	1	4
HO13	24	4.5	2.5	2	2	3	2	2	4	5	4	2	4
HO14		20	10	1	1	3	1	2	2	2	3	1	2
HO15	35	15	9	2	2	1	3	3	1	3	4	2	4
HO16	38	18	6	2	2	2	2	3	2	4	4	2	4
HO17	37	3	3	4	4	4	2	3	2	2	2	4	2
HO18	42	14	8	5	2	1	1	4	1	4	4	1	1
HO19	22	3.5	2.5	1	2	1	1	4	1	5	4	1	5
HO20	38	17	9	2	4	4	2	2	3	4	2	2	2
HO21		5	2	2	3	1	2	4	1	5	5	1	5
HO22	37	20	12	1	1	1	1	2	2	5	5	1	5
HO23	30	5	5	2	2	1	2	3	2	4	4	2	5
HO24	33			1	1	1	1	5	1	3	4	1	5
HO25	33	6	1.75	1	2	1	1	3	2	4	5	1	5
HO26	66	30	25	1	3	5	1	4	3	5	5	1	1
HO27	35	8	3	1	2	1	2	2	1	4	2	2	5
HO28	65	45	20	1	2	1	1	4	1	4	4	1	5
HO29	26	0.66	0.66	1	2	1	1	4	2	3	4	2	4
HO30	31	10	10	2	2	2	2	1	1	4	4	2	3
HO31	28	8	5	1	3	2	2	3	4	5	4	1	5
HO32	58	30	28	1	2	2	1	2	1	4	5	1	2
HO33	38	20	14	1	2	2	1	2	2	4	4	2	2
HO34	40	12	7	1	2	1	1	5	2	5	5	1	5
HO35	42	3	3	1	2	3	1	2	2	3	5	1	2
HO36	47	32	20	2	2	3	2	1	1	5	5	2	1
HO37	38	6	6	1	1	1	1	5	1	5	5	1	5
HO38	28	0.5	0.5	2	3	2	2	2	3	3	4	2	4
AVE.	37.3	13.545	8.4097	1.66	2.24	1.87	1.68	2.95	1.92	3.97	4.03	1.63	3.55

Simulation Group Survey Data													
Name	AGE	MechEX	SmogEX	a	b	c	d	e	f	g	h	i	j
	yrs	yrs	yrs										
SM1	40	11	8	2	1	1	2	4	3	3	5	1	5
SM2	36	19	10	2	3	3	2	2	3	4	3	2	3
SM3	38	15	7	3	3	2	4	3	4	3	4	3	4
SM4	44	24	24	4	3	2	4	2	4	1	1	4	4
SM5	46	27	16	1	2	1	1	2	1	3	3	1	5
SM6	55	4	2	1	2	1	1	2	1	3	5	1	1
SM7	35	8	8	1	2	1	1	2	1	2	3	1	3
SM8	28	10	2	3	1	1	2	3	3	5	5	1	5
SM9	53	0	0.33	1	2	1	1	3	1	5	3	1	5
SM10	28	11	7	1	1	1	1	5	1	5	4	1	5
SM11	37	22	3	1	3	1	1	3	3	4	4	2	5
SM12	52	35	15	2	4	2	2	4	2	4	4	2	3
SM13	26	6.5	3.5	1	2	1	1	4	2	3	4	2	5
SM14	31	5	3.5	2	3	3	1	3	1	3	3	1	2
SM15	29	5	4	2	2	3	2	2	4	1	3	2	5
SM16	62	30	7	2	4	2	2	2	3	4	2	2	4
SM17	37	20	7	1	4	1	1	1	1	5	4	1	5
SM18	22	5	5	2	3	1	2	3	2	2	2	2	4
SM19	39	16	2	1	2	1	1	2	2	3	5	1	5
SM20	31	12	6	1	3	1	1	2	3	4	4	2	4
SM21	26	7	1	2	2	3	2	3	2	5	4	2	4
SM22	42	22	19	2	3	4	2	3	3	5	3	2	2
SM23	52	15	5	1	2	2	1	2	2	4	4	1	2
SM24	38	21	21	2	3	4	1	3	2	4	3	1	3
SM25		12	12	2	3	1	2	2	2	5	2	1	4
SM26	46	23	12	2	3	3	2	4	3	4	4	2	3
SM27	35	15	12	3	3	2	3	1	3	5	3	3	4
SM28	34	15	6	4	2	1	4	4	2	4	4	1	1
SM29	36	16	8	2	1	1	2	3	3	4	4	1	5
SM30	38	11	5	2	3	4	2	4	4	4	5	1	4
SM31	31	9	9	1	2	1	1	4	2	4	4	1	5
SM32	36	15	10	2	4	2	2	4	2	3	4	2	2
SM33	35	1	1	2	2	1	1	3	2	3	4	2	5
SM34	45	15	12	5	5	5	5	3	3	5	3	3	5
SM35	58	35	25	1	2	2	2	4	1	3	4	1	4
SM36	28		8	3	3	2	2	2	4	3	2	2	5
SM37		3	3	2	1	1	3	2	3	2	2	4	3
SM38	27	3	2.5	2	1	1	1	1	5	1	5	4	5
AVE.	38.2	14.149	8.2061	1.95	2.50	1.84	1.87	2.79	2.45	3.55	3.55	1.76	3.89

Appendix F

Test Proctors' Observations/Recommendations

BAR Demo Project: System Trials

Anecdotal Observations

Made by Sam Hay and Larry Harty

1. Several subjects remarked that they had "learned something" as a result of taking the test. These comments were usually linked to the EGR functional test and the on-board computer capabilities of the Buick Reatta.

2. The vast majority of the technicians commented that the interactive nature of the exam had made the experience "enjoyable and fun".

3. Several technicians who initially expressed that they were intimidated by computers seemed to lose their fear when they found the subject matter familiar and the interface simple.

4. Most subjects were quite comfortable with the medium. But those who displayed some slight anxiety appeared to quickly adapt and accept the interface when they discovered how user friendly it was.

5. Several of the more computer literate participants expressed their surprise at the advanced state of the interface and the ability to move freely within and about the "environment".

6. For many of the subjects, determining the location of and navigating to a particular part or area of a vehicle appeared to be quite intuitive through the use of the touch-screen. In items such as the disconnected TAC, people touched on it and were rewarded with discovering that they had obtained additional useful information.

7. It became quite apparent that the participants were learning to use the touch-screen and other interface elements as they answered the first few questions. We feel that instructional and positive reinforcement experiences in the use of the interface devices could be designed into the initial test items and thus, allow for the abreviation of the current "tutorial" section.

8. Detailed items such as underhood labels should be either very legible or very obviously obscured. To provide "almost legible" screens that tantalize the technician tends to frustrate and create negative reactions. The system interface should not be suspected as a cause of obscurity.

9. In many places instructions were repeated unnecessarily causing unneeded delay and frustration in the participants. Future versions should require programming features that prevent "looping-back" through instructions unless requested by the technician.

10. A majority of the subjects were observed "thinking ahead" of the system. Future versions should incorporate response times and programming guards to insure that technicians are not inhibited or penalized in any way for responding too soon.

11. Several people remarked that they were guessing at component "C" on test item 6 (Ford EGR position sensor, answer key #26). We are not quite sure why this occurred unless it was caused by the two dimensional nature of the display.

12. Most participants did not seem to be mentally fatigued after the 1-1/2 to 2 hour testing period.

13. Most of the participants seemed confident and self assured with their abilities and skills as smog check technicians.

14. The age and experience of the participants varied widely from young technicians who had their smog check license for only a few months to older ones who had been licensed since the state began the program.

15. The professional working environment of the participants was extremely diverse. There were educators, dealer mechanics, fleet mechanics, shop owners, service managers and those who did general mechanics as well as those who only did smog checks. One person had only worked on Jaguars completed the test and performed very well.

16. The ethnic mix of the persons in the test pool was quite diverse.

17. All participants were male.

18. It was interesting to note that the interactive group scored consistently better than the hands-on group in answer key items 8 through 17. Since these questions were essentially pencil and paper type items we did not expect to see a difference in the two groups. Perhaps, the novel, interactive nature of the medium was more engaging and thereby resulted in better performances.

3/16/93

Anecdotal Notes of Hands-On Exam

by Philip DeLeon, State of California
Department of Consumer Affairs, Bureau of Automotive Repair

1. Of the 38 randomly selected technicians, four of them were Certified Smog Check Instructors, one worked for a Chevrolet dealership, two for Cadillac, one for Honda, one for Lexus, one worked for the BAR referee, and another as a representative for BAR. Of the 38 technicians, one was female.

2. Several of the technicians expressed that they were pleased BAR was planning to implement some type of hands-on examination. They felt that this would improve the quality of service that consumers would receive from a shop.

3. One primary difference between the hands-on and the interactive versions was that the hands-on group could remove parts from the engine (e.g., spark plugs) to confirm suspect problems.

4. Some were confused in that different reference manuals supplied conflicting information (as in the real world). This was particularly dependent as to which manual (e.g., Motor Manual vs Mitchell Manual) they referenced.

5. Some had difficulty determining the actual readings (e.g., timing marks) due to poor vision or poor visibility. Others had difficulty interpreting the letters or digits (e.g., mistaking a "b" for a "6" or an "H" for a "4" when reading the trouble codes). I think that the interactive exam may yield better control over these types of extemporaneous conditions.

6. A couple of individuals said they would have preferred the word "retrieve" instead of "download" when it came to downloading the trouble codes from the Reatta.

7. Upon completion of the exam, many reported that they learned at least one thing that they did not previously know.

8. A few technicians are intimidated by using reference manuals when they ran into an area unfamiliar to them.

9. A good number of technicians did not always follow manufacture's instructions when performing tasks. Sometimes they would opt to perform a more generic test.

10. Some used "creative" methods to perform certain tasks such as looking at the arrangement of spark plug wires on the distributor cap as opposed to looking up the answer in the reference manuals when they didn't know the answer outright. Other things included looking at the doorpost label for a VIN instead of looking at the lower left hand corner of the windshield (the preferred method).

11. A similar adaptation of this interactive and multimedia technology could be used as an educational tool to compliment the interactive exam. The information recorded from the exam results could be used as a means to strengthen areas identified as common weak areas for technicians.